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Dynamic Respone of RCC High Rise Building for Different Types of Sub-structure System

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Abstract:

This research work focuses on comparison of seismic analysis of G+15 building stiffened with soil interaction.. The performance of the building is analysed in Zone IV. The study include soil interaction for three different soil hard ,medium ,soft by fixed conventional method, FEMA 356, Wrinkler spring analysis. The study is extended for isolated footing and raft foundation . The analysed structure symmetrical,G+15,ordinary RC moment-resisting frame(OMRF). Modellimg of the structure is done as per Staad pro.V8i software. The lateral seismic forces of RC frame is carried out using dynamic static method as per IS 1893:2016 for earthquake zone. The scope of present work is to understand that the structure need to have suitable earthquake resisting features for different soil conditions. The result of the performance and the analysis of the model are the graphically represented and also in a tabular form and is compared for determining the best performance of building against lateral stiffness by arrangement of three different types of soil. A comparative analysis is done in term of base shear, displacement.

Keywords
Response Spectrum, Base Shear , Displacement.

1. Introduction

Th Earthquake is known to be one of the most destructive phenomenon experienced on earth . It is caused due to a sudden release of energy in the earth’s crust which results in seismic waves. When the seismic waves reach the foundation level of the structure, it experiences horizontal and vertical motion at ground surface level. Due to this, earthquake is responsible for the damage to various man-made structures like buildings, bridges, roads, dams, etc. It also causes landslides, liquefaction, slope-instability and overall loss of life and property. Most of the time earthquakes are caused by the slippage along a fault in the earth’s crust. When the fault ruptures in the earth’s crust, the seismic waves will travel away from the source known as focus, in all direction to the ground surface. As they travel through different geological materials, the waves are reflected and refracted. Throughout the whole journey from the bedrock to the ground surface, the waves may experience amplification [1]. Seismic wave amplification may cause large acceleration to be transferred to the structures, especially when the resulting seismic wave frequencies match with the structure resonant frequencies. This phenomenon may result in catastrophic damages and losses. Thus, with respect to the possible risk of earthquake hazard, it is essential to estimate the peak ground acceleration at the ground surface in order to produce appropriate response spectra for the purpose of structural design and structural safety evaluation. An earthquake is a ground vibration due to the rapid release of energy.

Though the structures are supported on soil, most of the designers do not consider the soil structure interaction and its subsequent effect on structure during an earthquake. Different soil properties can affect seismic waves as they pass through a soil layer. When a structure is subjected to an earthquake excitation, it interacts the foundation and soil, and thus changes the motion of the ground. It means that the movement of the whole ground structure system is influenced by type of soil as well as by the type of structure [3].Tall buildings are supposed to be of engineered construction in sense that they might have been analyzed and designed to meet the provision of relevant codes of practice and building bye-laws. IS 1893: 2016 “Criteria for Earthquake Resistant Design of Structures” gives response spectrum for different types of soil such as hard, medium and soft soil.s

The complete protection against earthquakes of all sizes is not economically feasible for structures. The seismic design should be such that it prevents loss of life and minimize the damage to the property. The concept of earthquake resistant design is that the building should be designed to resist the forces which arises due to Design Basis Earthquake, with only minor damages and the forces, which arises due to Maximum Considered Earthquake with some accepted structural damages but no collapse [4].The method of analysis commonly used by structural engineers assumes the structure to be attached rigidly to the ground, but as the foundation of the structure rests on the soil, it is apparent that the response depends on the properties of the structure as well as the soil. Hence the method of analysis based on soil-structure interaction gives more realistic and reasonable results.

1.1 Soil-Structure Interaction (SSI)

Soil-Structure Interaction (SSI) is phenomena in the response of structures caused by the flexibility of the foundation soils, as well as in the response of soils caused by the presence of the structures. Analytic and numerical models for dynamic analysis typically ignore SSI effects of the coupled in nature structure foundation-soil system. It has been recognized that SSI effects may have a significant impact especially in cases involving heavier structures rest on soft soil condition.

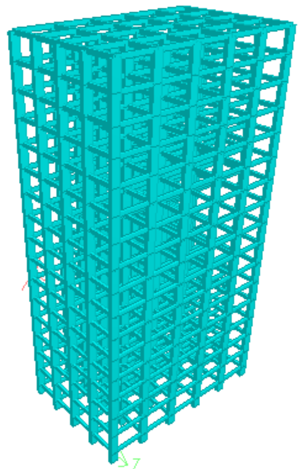
2. Objective Of Study

Study of soil structure interaction due to seismic load with different types of soil viz. hard, medium, soft using software consisting FEMA356 and wrinkle analysis.

3. Problem Formulation

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):2016 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 STAAD Pro. Effects of soil interaction on different parameters are studied i.e. Natural Time Period, Roof Displacement, Shear force and Bending moment.

3.1 Models Model Of The Project



Model 1: Fixed based hard soil

1.1 Data for All Models

Table 1. Gravity loads Assigned to RC Building.

No. of stories	15
Floor to Floor Height	3000mm
Beam size	500*300mm
Column size: Hard Medium Soft	1000*500mm 1200*600mm 1300*600mm
Thickness of slab	125mm
Density of concrete	25kN/m^3
Soil Type	Hard, Medium, Soft
Zone Factor (Z)	0.24
Important factor (I)	1.2
Response reduction factor (R)	3
Grade of Concrete	M35
Grade of Steel	Fe500

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Table 2. Gravity Loads Assigned to RC Building

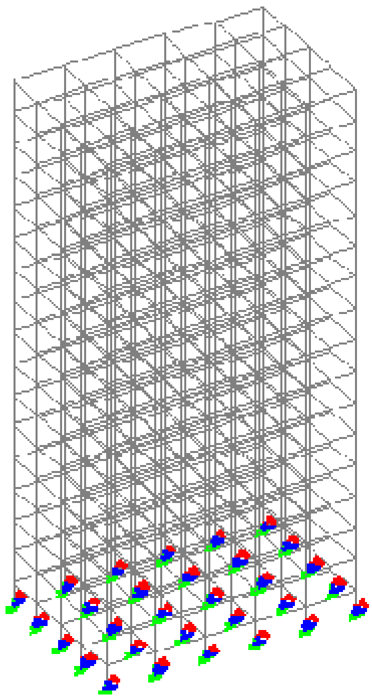
Gravity Load	Value
Slab Load (dead load)	3.75 kN/ m^2
Floor Finish	1.0 kN /m^2
Roof Finish	1.0 kN/m^2
Live Load	2.5kN/m^2
Roof Live	1.5kN/m^2
Wall Load	13.8kN/m

Table 3. Foundation size for isolated footing and raft footing.

Soil Type	Isolated footing	Raft footing
Hard soil	L=4.8m B=4.3m d=0.6m D=1.5m	L=32m B=21m d =0.6m D=1.5m
Medium soil	L=6m B=5.4m d =0.7m D=1.5m	L=40m B=26m d =0.7m D=1.5m
Soft soil	L=7.84m B=7.14m d=0.8m D=1.5m	L=53m B=34m d=0.8m D=1.5m

Table 4. Calculation of FEMA 356 spring constraints for isolated footing.

Degree of freedom	Hard Soil	Medium Soil	Soft Soil
Translation along x-direction [Kx]	60355462.02 kN/m^2	14844913 kN/m^2	4965737.7 kN/m^2
Translation along y-direction[Ky]	45428320.41 kN/m^2	14709186 kN/m^2	5378429.7 kN/m^2
Translation along z-direction[Kz]	67007544.17 kN/m^2	19227147 kN/m^2	7160214.4 kN/m^2
Rocking about x-aixs	73324406.25 kN-m	28884227 kN-m	19981192 kN-m
Rocking about y-aixs	12130695.06 kN-m	25053242 kN-m	23057858 kN-m
Rocking about z-aixs	121147282.8 kN-m	3752860kN-m	23977208 kN-m

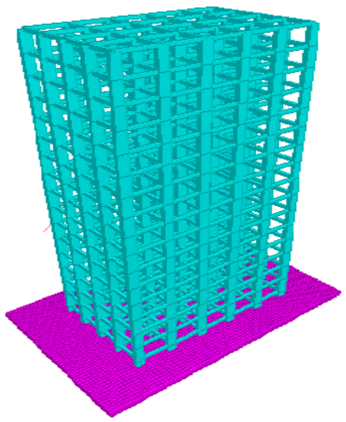


MODEL 2 OF FEMA356 Isolated Footing With Different Type Of Soil.

Table 5. Calculation of FEMA 356 spring constraints for raft footing.

Degree of freedom	Hard Soil	Medium Soil	Soft Soil
Translation along x-direction [Kx]	998035.7 kN/m^2	216785.4545 kN/m^2	24681.67kN/m^2
Translation along y-direction [Ky]	737679.8 kN/m^2	107329.1579 kN/m^2	24681.67kN/m^2

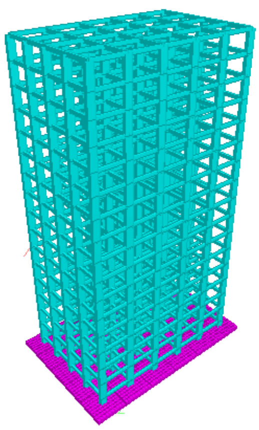
Translation along z-direction [Kz]	11808257 kN/m^2	177303.159 kN/m^2	45265.96kN/m^2
Rocking about x-aixs	355957kN-m	8411.5384 kN-m	2147488 kN-m
Rocking about y-aixs	33204.61 kN-m	7846.5042 kN-m	2003.233 kN-m
Rocking about z-aixs	33341.18kN-m	6828.27325kN-m	1475.08 kN-m



Model 3 of Raft footing

Table 6 Calculation for wrinkler spring in isolated footing

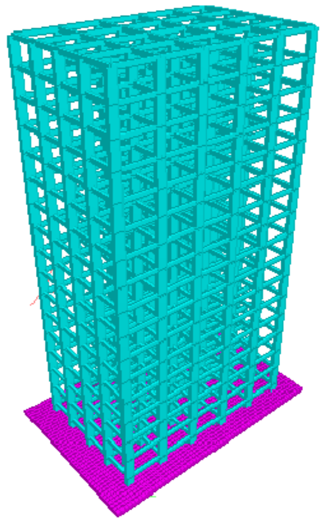
Model	Soil Type	SBC (kN/m^2)	Load(kN)	Subgrade modulus (kN/m^2)
	Hard Soil	250	142	14200
G+15	Medium Soil	180	121.5	12150
	Soft Soil	110	75.603	7560.3



Model 4 Wrinkler fixed spring

Table 7 Calculation for wrinkler spring in Raft footing

Model	Soil Type	SBC (kN/m^2)	Load(kN)	Subgrade modulus (kN/m^2)
	Hard Soil	250	64.5	6450
G+15	Medium Soil	180	48.6	4860
	Soft Soil	110	30.8	3080



4. Result And Discussion

Response Spectrum Analysis is carried out for Bare Farme. The models are checked for base shear and maximum top displacement.

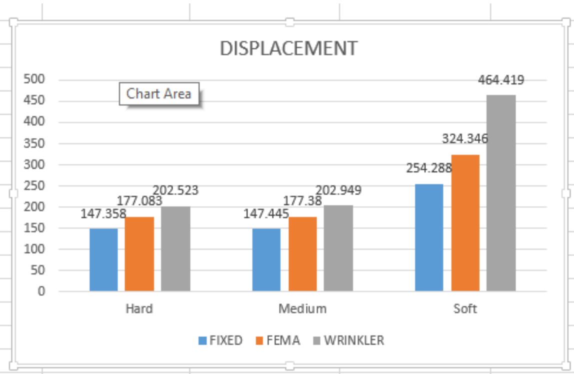


Chart 1 Comparison of Top Storey Displacement isolated footing for different type of soil interaction.

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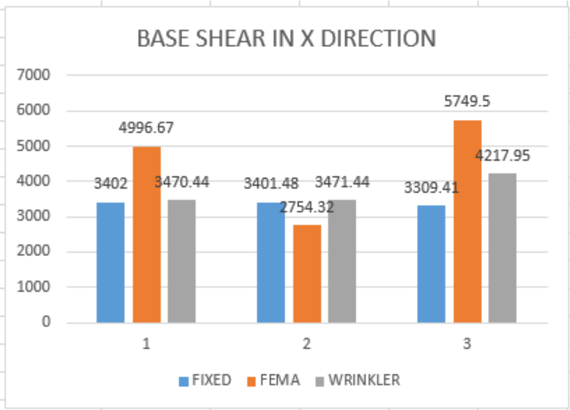

Chart 2 Comparison of Base shear in X Direction for different type of soil.

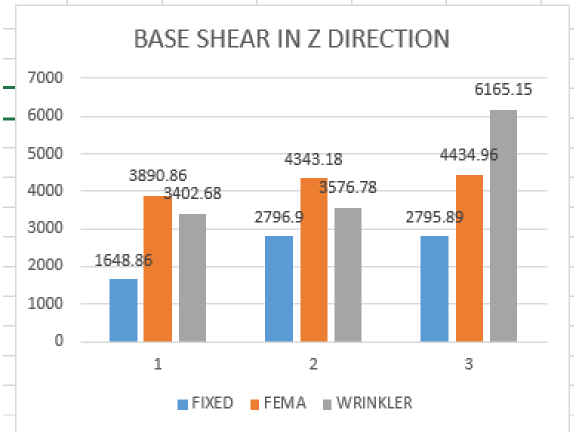

Chart 3 Comparison of Base shear in Z direction for different type of soil.

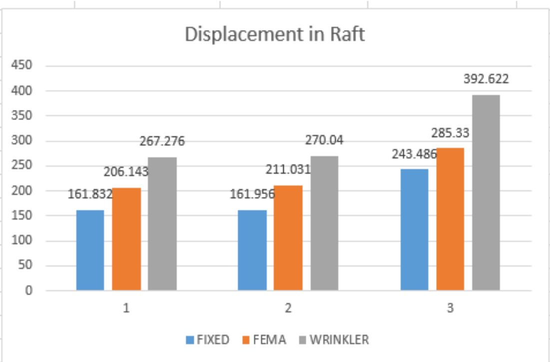

Chart 4. Comparison of Top Storey Displacement Raft footing for different type of soil interaction.

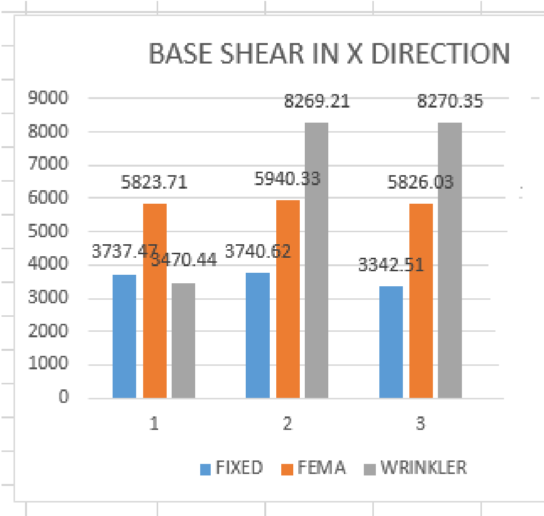

Chart 5 Comparison of Base shear in X Direction for different type of soil.

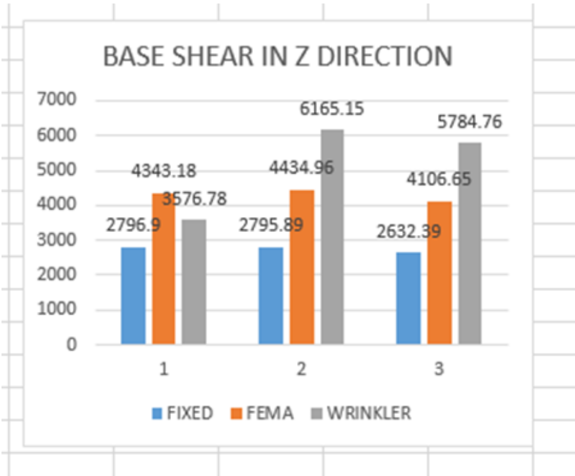

Chart 6 Comparison of Base shear in Z direction for different type of soil.

1. From chart 1 , found that the displacement in the isolated footing of soft soil is much higher then then hard and medium soil by using the method of FEMA356 and Wrinkler spring analysis.

2. From chart 2 found that base shear in X direction of isolated footing is increasing in the medium soil through FEMA 356 analysis as compared to hard and soft soil.

3. From chart 3,base shear in Z direction is increasing in medium soil whereas in soft soil the shear is increasing through Wrinkler analysis.

4. From chart 4, found that displacement in raft footing is higher in soft soil by wrinkle analsiys.

5. From chart 5-6,found that base shear in x direction using raft foundation shear is higher in

fixed medium soil by FEMA356 analysis whereas in soft soil shear is higher by wrinkle analysis

5. Conclusion

1. Wrinkler spring shows the maximum displacement than fixed based method and FEMA356 analysis.

2. Hard soil shows the minimum and soft soil shows maximum displacement.

3. Percentage of reduction is 15-30% variation in displacement by Wrinkler method than fixed and FEMA356 analysis.

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