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Responses of SMRF Raft Foundation for Soil Structure Interaction Under Seismic Effects.

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ABSTRACT: *In the present work effect of flexibility is considered for the seismic analysis of a RCC building frame structure with raft foundation on different types of soil in seismic Zone III .Modal analysis of building system is carried out in software for the analysis multiple bays irregular RC building model for G+10 storey is considered and the soil beneath the structure is modeled as equivalent soil springs connected to the raft foundation. The response spectrum analysis of the soil structure model was carried out using Staad Pro-V8i software. In both the cases when soil is considered to be fixed and when soil flexibility is considered for the modeling of the structure. The earthquake records have been scaled according to the IS1893-2016 for each type of soil (i.e. I, II, & III) and applied to the SMRF with seismic zone III.*
KEYWORDS: *Fixed and Flexible footing, Spring value, Response spectrum analysis , hard, medium and soft soil*.

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I. INTRODUCTION

From last 50 year, considerable progress has been made in understanding the nature of earthquakes and how they could cause the structure damages and improving the seismic performs of the built structure. However, much remains unknown regarding the prevention or mitigation of earthquake damages in worldwide, leaving room for studies. During the past and recent earthquakes, it was realize that Soil Structure Interaction (SSI) effect play an important role in determining of the behavior of the building structures. The behavior of structure to earthquake shaking is affected by the interaction between three linked system is the structure, the foundation and surrounding of the foundation. Soil structure interaction analysis evaluates the collective behavior of the systems to specified ground motion.

Earlier the structural engineer was only concerned about the structural configuration on the system and he hardly care about soil other than the allowable bearing capacity and its nature, provided foundation design within his scope of work. On the other hand the geotechnical engineer remained the focused on the soil characteristic like cohesion, angle of internal friction, capillarity, permeability, elasticity, compressibility etc. and recommending the type of foundations like isolated, mat, pile foundation etc. or at best sizing and designing the same. The condition of this scenario was that nobody got the overall information, while in reality under static or dynamic loading the foundation and the structures do behave in tandem. In general design practice for dynamic loading assumes the building frames to be fixed at their bases. In reality, supporting soil medium allows moment to some extent due to its natural ability to deform. This may decrease the overall stiffness of the structural system and hence, may increase the natural period of the system. Such influence of practical rigidity of the structures at the foundation level due to soil flexibility in turn alters the response. On the other hand, the extent of fixity offered by soil at the base of the structure depend on the load transferred from the structure to the soil as the same decides the type and size of foundation to be provided. Such as interdependent behavior between soil and structure regulating the overall response is referred to as soil structure interaction.

II. OBJECTIVE AND SCOPE OF WORK:

i. To check the soil structure interaction in seismic zone.
ii. To determine the effect of lateral load over different type of soil.
iii. To determine the variation in forces, stability displacement and other important criteria for safe structure.
iv. To understand the importance of soil structure interaction in designing the footing of structure and to make structure safe and economical.

III. LITERATURE SURVERY

1. **Bhojegowda VT(2015)** Studied that a soil structure interaction of framed structure supported on different types of foundation. They studied for a building with isolated, mat &pile foundation for different soil condition like soft medium hard strata and comparison between regular and irregular type of buildings with change in natural period by using response spectrum method. In this study they concluded that, there is no much variation in time period for frame model with pile foundation of flexible base in comparison with fixed base model. Response of structure increases with change in soil type from hard to medium and soft irrespective of height of structure and type of foundation. Bending moment and displacement increases from fixed base analysis to flexible base analysis, but not much variation for 15 storey frame with pile resting on hard and medium soil.

2 **Janardhan shanmugam (2015)** analyzed soil structure interaction in frame structure by using Analysis software. They analysis the effect of soil structure interaction on a four storied two bay frame resting on pile and embedded in the cohesive soil. They have concluded that, the effect of soil structure interaction on top displacement is less for the conventional analysis, I,e., fixed base condition and increases in the range of210%-441% when effect of SSI is taken into consideration. The displacement at top of frame decreases with increase in pile diameters considered in this investigation is that horizontal displacement is on higher side when the effect of soil structure interaction (SSI) is considered for 300mm pile diameter at top of the subsequent storey's the percentage increase in displacement is found to be 441% & 304% for 400mm diameter of piles and 211% for 500mm diameter of piles.

3 **Ebrahim Nazarimofrad (2016)** studied seismic control of irregular multistory buildings using active tendon considering soil structure interaction effect. In this paper, a mathematical model is developed for calculating the seismic response of an irregular multistory building equipped with active tendons. The SSI effect is then introduced by changing structure mass, stiffness and damping matrices. The model is employed to obtain the seismic response of 10 storey building using active tendons with LQR algorithm.

4 **Vivek gargand M.s. Hora(2012)** They have studied interaction behavior of structure foundation soil system. Soil structure interaction is interdisciplinary field which involves structural and geotechnical engineering, in the conventional non-interaction analysis of building frame structural designers assumed that columns are resting on affixed support similarly, in foundation design foundation settlements are calculated without considering the influence of the structural stiffness. The present study author has studied the possible alternative solutions proposed by various researchers to evaluate the effect of soil structure interaction from time to time.

5 **Mohamed M. Ahmed (2015)** evaluated that soil foundation structure interaction effects on seismic response demands of multistory MRF buildings on raft foundation. The SSI analysis of multistory buildings is the main focus of this research; the effects of SSI are analyses for typical multistory building resting on raft foundation. They use three types of seismic analysis method like equivalent static method response spectrum and time history method. After this evaluation they have concluded that the soil spring stiffness increases, the fundamental period for the structural model decrease story drift response ratio increases as the soil stiffness decreases. Story drift response ratio increases with the increasing number of stories. This effect is amplified as the soil stiffness decreases the story displacement response increases as the soil stiffness decreases.

6 **Anantha Kavya Supriya(2019)** studied that soil interaction of building frame resting on clayey soil. Effect of change of footing size by using Ansys16.0 Software they had analyzed the single bay single storied building frame resting on soil (clay soil). The parameters change is modulus of subgrade reaction from 0.01 to 0.050N/mm^2 and also the varying of footing size between 1m x 1m to 4.5m x 4.5m the effect of SSI is evaluated using finite element method. They concluded that the analysis is predicting that percentage different in bending moment in the beam, column and footing are at lower effective foundation stiffness (EFS) value i.e. 0.010 N/mm^2 at lower footing size 1m x 1m is greater that compared to higher EFS value i.e. 0.050N/mm^2 at higher footing size 4.5m x 4.5m which considers soil interaction but in case of the footing they undergo some settlement the percentage difference of settlement is 14.41% and 6.72% at lower EFS value i.e. 0.010N/mm^2 at 1m x 1m size of footing and 0.050N/mm^2 for 4.5m x 4.5m size of footing.

7 **C. Sumitha et al (2018)** studied soil interaction of building frame resting on dense sand: effect of change of bay length, the numerical analysis is carried out using Ansys by assuming that the base of the frame is resting on dense sand when the length of the bay of the frame changes from 3m to 10m. The conventional analysis which assumes that the frame is resting on rigid support is carried out using STAAD by assuming the fixed base for the columns in the building frame when the bay length changes from 3m to 10m from the numerical study, it is found that the shear force value in the column from conventional method is less than that of the value from finite element analysis. This paper presented the analysis of single bay single storied building resting on dense sand. From above analysis they concluded that there is percentage difference in shear force that is 25.27%. the axial load values in the column and beam for various bay length of the frame obtained from both conventional and finite element analysis are not having considerable difference. There is maximum difference in percentage values of bending moment in the column and beam for finite and conventional analysis is 69.34%, 23.03% respectively.

8 **Magade S.B. ET. Al (2018)** this research paper presented different parameter such as soil structure interaction, types of soil, stiffness of infill walls and location of walls influences time period, displacement and base shear of building frame considerably. Hence it was important to consider to all these parameters in the analysis of structures shear walls located in the central part of the multistoried building gives lesser displacement and more base shear compared to other locations.

IV. METHODOLOGY

Force Based analysis a traditional approach to Seismic and wind analysis of a building. Analysis is done by using response spectrum analysis with wind load and seismic load condition. there is comparison of structure with fixed soil condition and flexible soil condition. For the flexible base, use of spring to show rotation . these spring value is find out by using RICHART AND LYSMER method. Comparison parameter are : base shear , time period , shear stress on column and plate , bending moment of plate and column . For seismic analysis used zone III.

Spring value in three direction :

DIRECTION	UNIT	SOFT SOIL	MEDIUM SOIL	HARD SOIL
Vertical,Kz	kn/m	8679.07	45897.75	644502.27
Horizantal,Kx	kn/m	5786.05	36936.76	580052.04
Horizantal,Ky	kn/m	5786.05	36936.76	580052.04
Rocking,Køx	knm/degree	84384449.4	446252294.6	6266332982
Rocking,Køy	knm/degree	24381749.4	128938586.4	1810572463
TwistingKøz	knm/degree	57204229.9	393268838.8	6371921975

MODEL DETAILS :

GEOMETRICAL DATA:

Shape of Building: - L type building
Length of Building(X): - 40m
Width of Building (Z): - 42m
Floor to Floor Height: - 3.2m
No. Of Storeys: - 12
Total Height of Structure: - 38.40m
Type of Footing: - Raft Footing
Beam Size: - 400 mm X 400 mm
Column Size: - 800mm X 800mm
Raft Thickness: - 600 mm
External wall: - 230mm
Internal wall: - 150mm

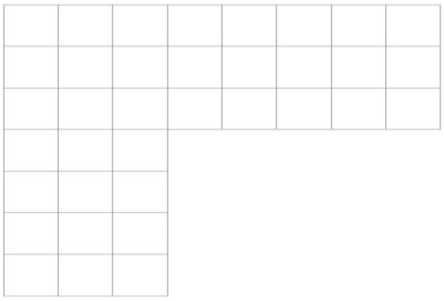


Fig. Grid of L type Building In Staad Pro.

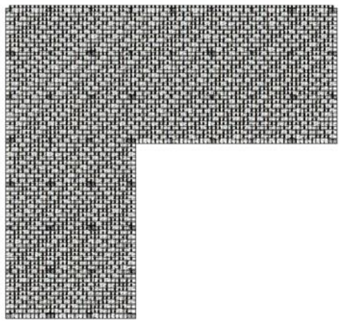


Fig Meshing For Raft In Staad Pr

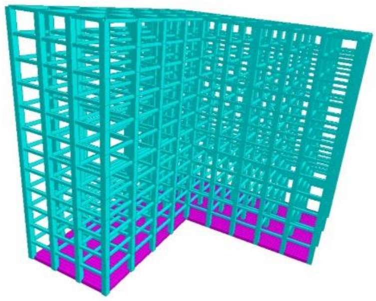


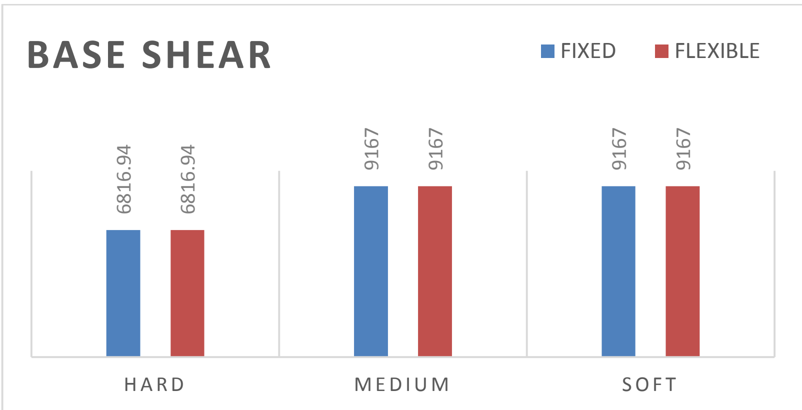
Fig. 3d View of Model In Staad Pro

V. REULT AND DISCUSSION

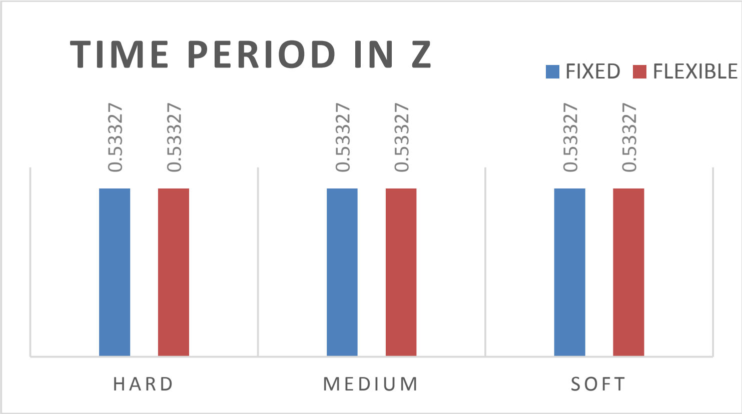
Seismic response has been studied with respect to base shear and Natural time period of the building with fixed base for Hard, Medium and Soft soils and building with raft foundation (flexible base and fixed base) And the results obtained are compared by using graphs.for both III zone .

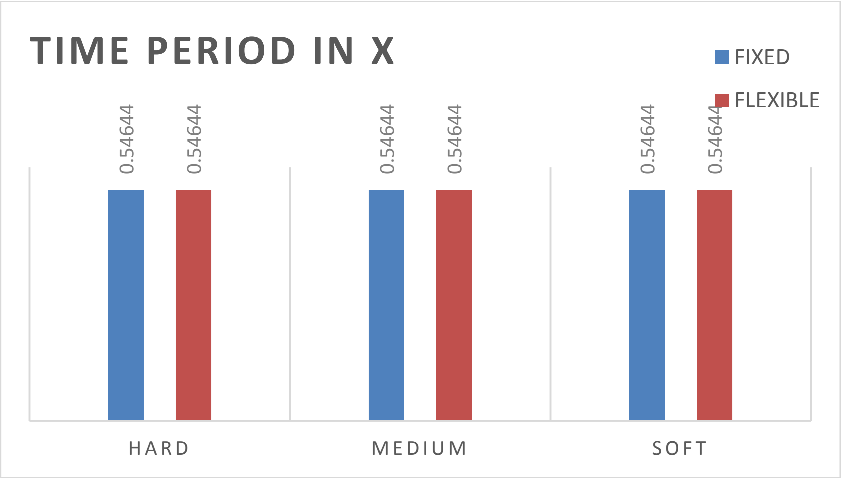
BASE SHEAR

BASE SHEAR (IN KN)			
		BASE	
		FIXED	FLEXIBLE
ZONE III	SOIL		
	HARD	6816.94	6816.94
	MEDIUM	9167.84	9167.84
	SOFT	9167.84	9167.84



TIME PERIOD

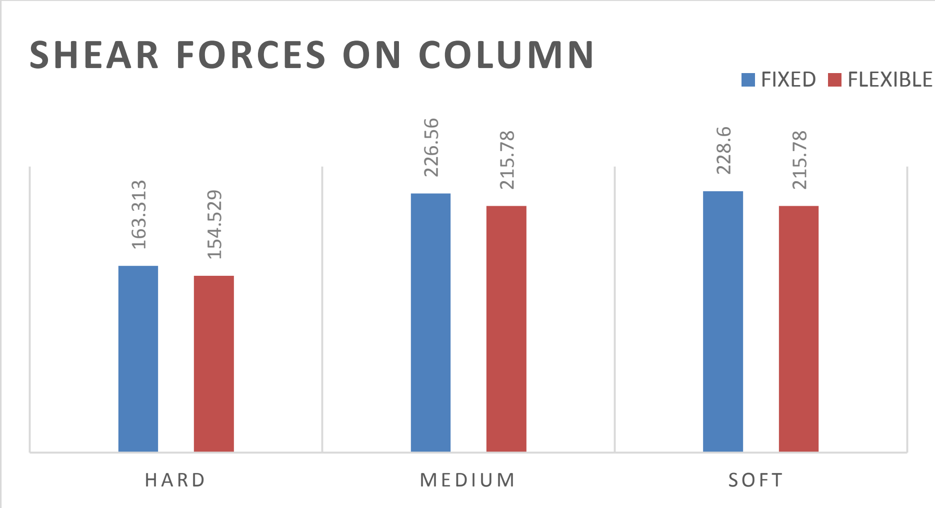


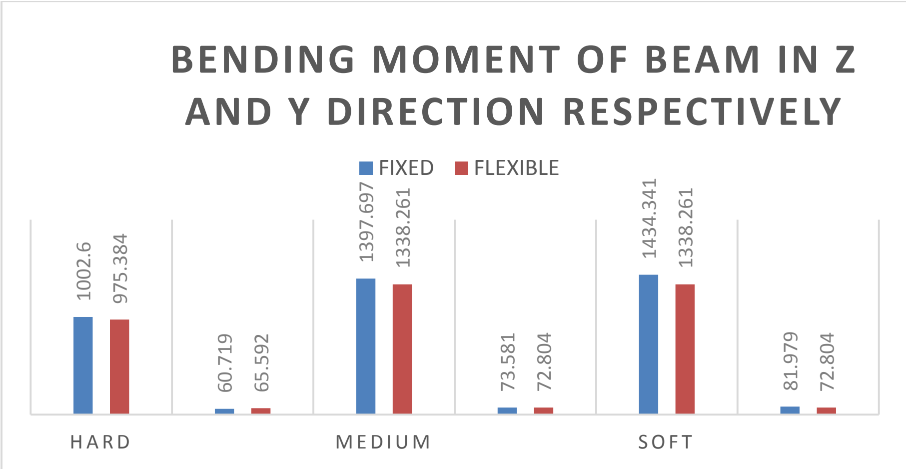


SHEAR FORCES AND BENDING MOMENT ON COLUMN

COLUMN RESULT						
SOIL TYPE	HARD		MEDIUM		SOFT	
BASE (ZONE III)	FIXED	FLEXIBLE	FIXED	FLEXIBLE	FIXED	FLEXIBLE
SHEAR FORCES (KN)	163.313	154.529	226.56	215.78	228.6	215.78

SOIL TYPE	HARD		MEDIUM		SOFT	
BASE (ZONE III)	FIXED	FLEXIBLE	FIXED	FLEXIBLE	FIXED	FLEXIBLE
BENDING MOMENT (KNM/M2	352.285	702.713	595.824	595.824	698.67	440.521
	299.732	744.917	442.834	442.834	460.300	462.591
	229.769	32.326	388.579	38.8579	447.327	21.265

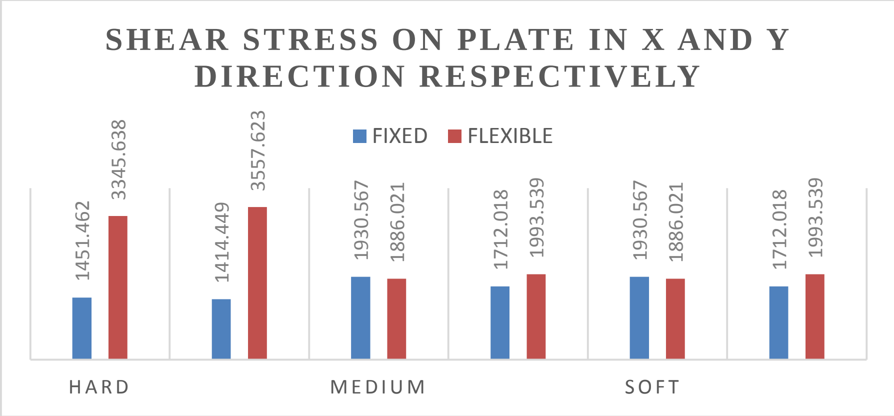


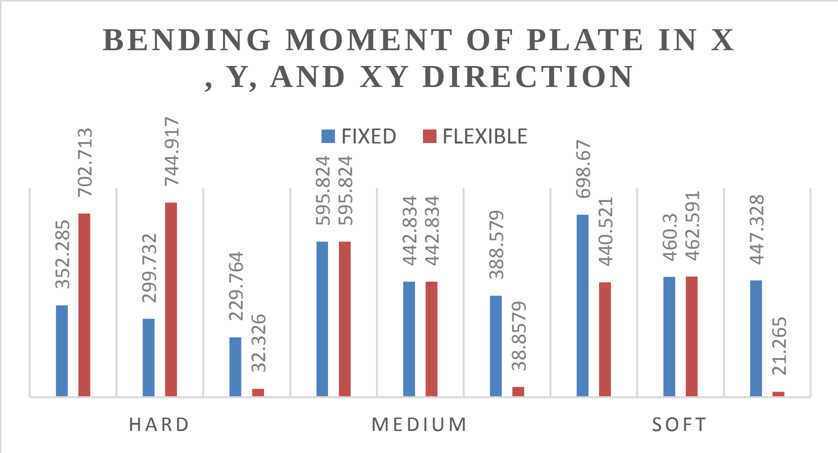


SHEAR STRESS AND BENDING MOMENT ON PLATE

PLATE RESULT						
SOIL TYPE	HARD		MEDIUM		SOFT	
BASE (ZONE III)	FIXED	FLEXIBLE	FIXED	FLEXIBLE	FIXED	FLEXIBLE
SHEAR STRESS (IN KNM-M)	1451.462	3345.638	1930.567	1886.021	1918.494	1886.021
	1414.449	3557.623	1712.018	1993.539	1535.20	1993.539

SOIL TYPE	HARD		MEDIUM		SOFT	
BASE (ZONE III)	FIXED	FLEXIBLE	FIXED	FLEXIBLE	FIXED	FLEXIBLE
BENDING MOMENT (KNM)	1002.60	975.384	1397.697	1338.261	1434.341	1338.261
	60.719	65.592	73.581	72.804	81.979	72.804





VI. CONCLUSION

In this work done to study the effect of soil structure interaction under seismic loading for ten storey RC building with raft foundation. With base fixed and flexible for different type of soil Also an attempt is made to study effect of the soil structure interaction on building with different seismic zones. This study has been mainly carried out to determine the change in various seismic response quantities due to consideration of flexibility of soil and the effect of seismic zones.

In the first parameter is time period , there is no changes occurs in both zones with different soil.

Base shear for fixed and flexible base is same but changes gradually with respect to change in soil condition.

Base shear in fixed and flexible base is greater than medium and soft soil for zone zone IV.

Shear forces on column are less in flexible raft as compared to fixed raft in both zones for all types of soil.

Also bending moment in column are less in flexible raft than fixed raft in both zone for all types of soil.

There is gradually variation occurs in shear stresses and bending moment of plate but this is safe to use practically .

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