Response Spectrum Analysis of Multiutility Building

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***Abstract*: when a structure is subjected to earthquake, it responds by vibrating. An earthquake force can be resolved into three mutually perpendicular directions-the two horizontal directions (x and y) and the vertical direction (z). This motion causes the structure to vibrate or shake in all three directions; the predominant direction of shaking is horizontal. The supporting soil influences the behavior of the structure due to its ability to deform. The response of the structure with fixed foundation has been done in this study. The objectives of the present work is to study the behavior of a multi storied R C building irregular in plan subjected to earth quake load at different Soil condition by adopting Response spectrum analysis. The present study is limited to reinforced concrete (RC) multiutility building with four different zones II, III, IV and V and three different soil I, II and III. The building model in the study has six storey's with constant storey height of 3m and foundation of 1.5m height. The analysis is carried out with the help of FEM software's ETABS.**

***Keywords*: Base Shear, Response Spectrum Analysis, Storey Displacement, Storey Stiffness.**

I. INTRODUCTION

Earthquake is the most critical phenomenon experienced on earth. It is triggered due to abrupt discharge of energy in the earth which produces seismic waves. When these waves reaches the footing level of the building, it experiences vertical and horizontal motion at ground surface level. Because of this ground motion, earthquake destroys and damages the structures. It also causes landslides, liquefaction, slope-instability and property loss and death of living beings. Intensity is a qualitative measure of the actual shaking at a location during an earthquake, and is assigned as Roman Capital Numerals. Intensity ranges from I (least) to XII (most severe). The intensity scales are based on shaking perception by people and animals, performance of buildings, and changes to natural surroundings. Magnitude is a quantitative measure of the actual size of the earthquake. Magnitude is measured by Richter Scale. Earthquake is classified into different groups based on magnitude. Earthquake having magnitude 3.0 and lesser is grouped as very minor to earthquake having magnitude 8.0 and higher is grouped as Great.

The process in which the area is segmented into various zones depending on the predictable ground motion, expressed in terms of PGA or PGV (peak ground acceleration and velocity) is termed as Seismic Zoning. In this process, the regions with seismicity varies from force or motion of ground for design of earthquake resistance structures are plotted in the map. This map provides the areas of varies seismicity and features of earthquake. The revised map in the year 2002 has four seismic zones i.e., Zone I, II, III, IV. The new zone had Latur earthquake in Zone III. The area coming in zone I are less affected during earthquake whereas in Zone IV are most affected under earthquake. The areas which fall under various seismic zones are listed in IS-1893-2002.

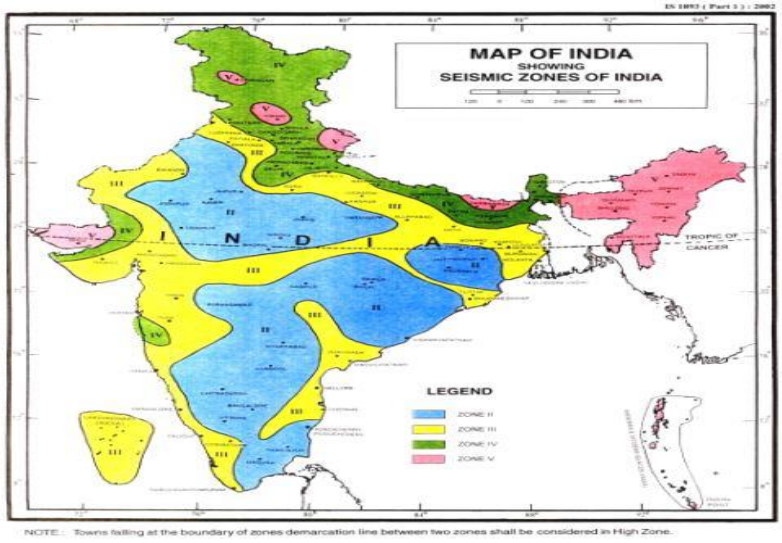

Fig 1.Seismic Zones of India

A. the main objectives of present work are as follows:

1) Modelling and analysis of multiutility building for different Zones and Soil condition using Response Spectrum Analysis.
2) Development and Comparison of Graphs for different Zones and Soil condition.

II. STRUCTURAL DATA

A. Structural Configure Ration

Structure Type: Reinforced Concrete Frame

Number of stories : Ground + 5
Typical storey height: 3.0m
Total height of structure: 19.5
Length along X-axis: 14.0m
Length along Y-axis:21.0m
Grade of concrete: M20 for Slab and Beam, M25 for Column
Grade of steel: Fe500

B. Member properties
Thickness of slab: Residential - 150mm , Office - 170mm
Beam size: 0.23 x 0.45m
Column size: 0.45 x0.23m
Wall thickness: 0.23m

C. Loads
Live load on floor: Residential - 3KN/ m2 , Office - 4KN/ m2
Floor finish: 1KN/ m2
Wall load : 11.5KN/ m2

D. Seismic Load Patternas per the IS1893-2002 Part-1
Seismic Zone Factor, Z: 0.10, 0.16, 0.24, 0.36
Soil type: I, II, III
Response Reduction, R: 5
Importance Factor, I: 1.5
Time Period along X-axis: 0.4690
Time Period along Y-axis: 0.3829

TABLE 1. Types Of Models

MODELS	PARAMETERS
M1	Zone II , Soil I
M2	Zone II , Soil II
M3	Zone II , Soil III
M4	Zone III , Soil I
M5	Zone III , Soil II
M6	Zone III , Soil III
M7	Zone IV , Soil I
M8	Zone IV , Soil II
M9	Zone IV , Soil III
M10	Zone V , Soil I
M11	Zone V , Soil II
M12	Zone V, Soil III

III. ANALYSIS

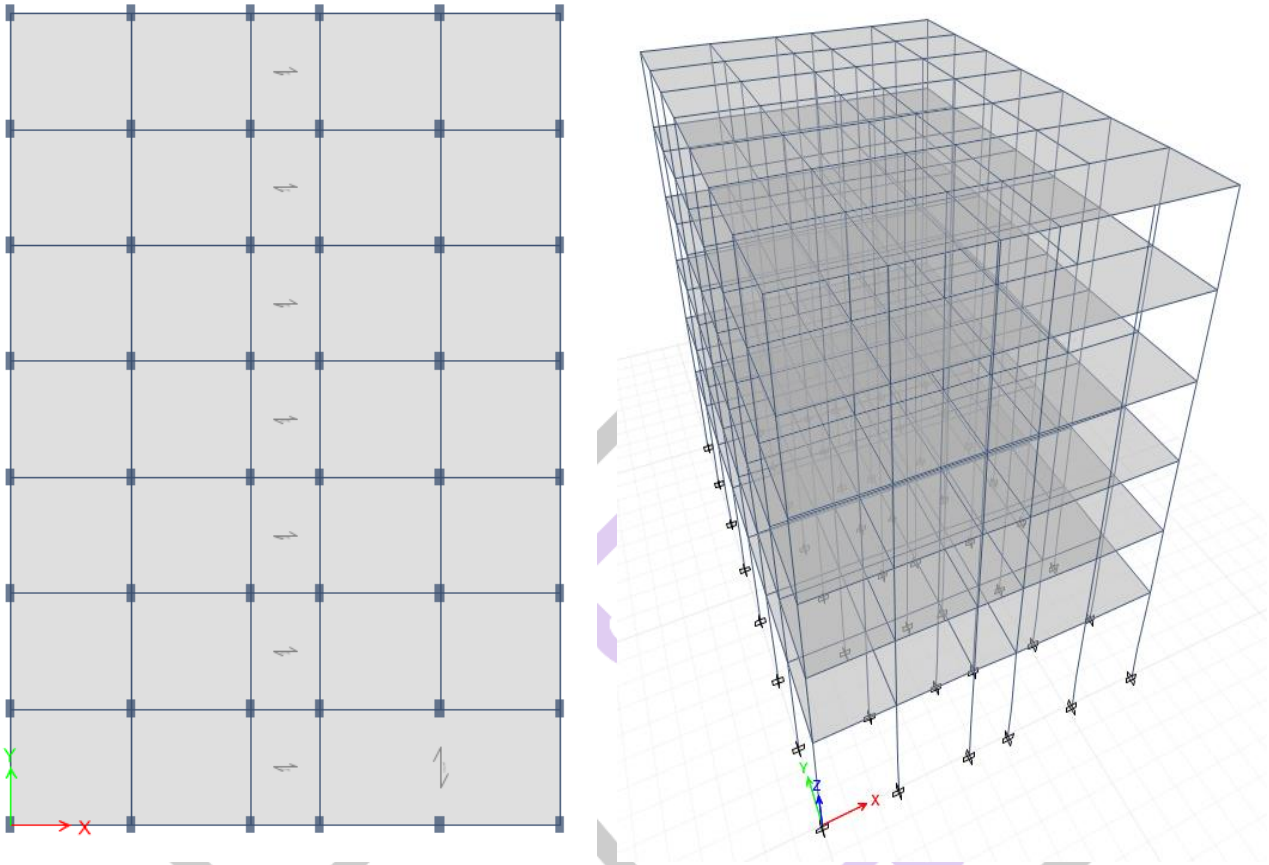

Fig 2. Beam Column Layout

Table 2. Result at Plinth level (1.5m)

Model	Shear Force (kN)		Story Displacement (mm)		Story Stiffness (kN m)	
	X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis
M1	1020.5659	1198.3185	0	0	67.0732	200.9315
M2	1198.1866	1198.3199	0	0	67.3504	201.554
M3	1198.5269	1198.2672	0	0	67.4963	200.5285
M4	1632.9054	1917.4823	0	0	67.4491	201.6296
M5	1917.2004	1917.3757	0	0	67.4133	202.3219
M6	1917.4762	1917.4891	0	0	67.6019	202.7813
M7	2449.358	2876.2235	0	0	67.7726	202.2455
M8	2876.0555	2876.2239	0	0	67.4349	202.1565
M9	2876.2144	2876.1029	0	0	67.9009	205.2172
M10	3674.037	4314.1193	0	0	67.3924	201.8602
M11	4314.0832	4314.0155	0	0	67.4352	202.5987
M12	4314.1133	4314.0234	0	0	67.6818	203.0824

Table 3. Result at Storey 1 (4.5m)

Model	Shear Force (kN)		Story Displacement (mm)		Story Stiffness (kN m)	
	X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis
M1	1020.5659	1198.3185	16	6.1	63.677	196.1738
M2	1198.1866	1198.3199	18.7	6.1	63.668	196.2034
M3	1198.5269	1198.2672	18.8	6.1	63.6514	196.2068
M4	1632.9054	1917.4823	25.5	9.7	63.9271	197.4051
M5	1917.2004	1917.3757	30	9.7	63.8002	197.4236
M6	1917.4762	1917.4891	30	9.7	63.8156	197.4473
M7	2449.358	2876.2235	38.3	14.5	63.8437	198.0858
M8	2876.0555	2876.2239	45	14.6	63.8058	196.7585
M9	2876.2144	2876.1029	45	14.6	63.8156	196.7622
M10	3674.037	4314.1193	57.5	21.8	63.7882	197.6215
M11	4314.0832	4314.0155	67.5	21.8	63.8058	197.6464
M12	4314.1133	4314.0234	67.5	21.8	63.8125	197.6588

Table 4. Result at Storey 2 (7.5m)

Model	Shear Force (kN)		Story Displacement (mm)		Story Stiffness (kN m)	
	X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis
M1	1020.5659	1198.3185	21.2	8.9	42.1134	120.8332
M2	1198.1866	1198.3199	24.9	9	42.6635	120.3701
M3	1198.5269	1198.2672	25	9	42.6521	120.7232
M4	1632.9054	1917.4823	34	14.3	42.6088	120.337
M5	1917.2004	1917.3757	39.9	14.3	42.6016	121.2159
M6	1917.4762	1917.4891	40	14.4	42.6484	120.7397
M7	2449.358	2876.2235	50.9	21.4	42.6926	120.6182
M8	2876.0555	2876.2239	59.8	21.5	42.6409	120.9408
M9	2876.2144	2876.1029	59.9	21.5	42.7196	121.2957
M10	3674.037	4314.1193	76.4	32.1	42.6646	120.6122
M11	4314.0832	4314.0155	89.7	32.3	42.641	120.7446
M12	4314.1133	4314.0234	89.9	32.3	42.694	121.1043

Table 5. Result at Storey 3 (10.5m)

Model	Shear Force (kN)		Story Displacement (mm)		Story Stiffness (kN m)	
	X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis
M1	1020.5659	1198.3185	25.5	11.3	30.8004	82.7961
M2	1198.1866	1198.3199	30	11.3	30.6659	82.8922
M3	1198.5269	1198.2672	30.1	11.4	30.4702	82.2056
M4	1632.9054	1917.4823	40.9	18	30.7251	83.1716
M5	1917.2004	1917.3757	48	18.2	30.6675	82.3484
M6	1917.4762	1917.4891	48.2	18.2	30.4422	82.3975
M7	2449.358	2876.2235	61.3	27	30.7501	83.1716
M8	2876.0555	2876.2239	72	27.2	30.6702	82.6558
M9	2876.2144	2876.1029	72.3	27.3	30.4422	82.3938
M10	3674.037	4314.1193	91.9	40.6	30.7669	82.9626
M11	4314.0832	4314.0155	108	40.9	30.6703	82.4476
M12	4314.1133	4314.0234	108.4	41	30.4548	82.2908

Table 6. Result at Storey 4 (13.5m)

Model	Shear Force (kN)		Story Displacement (mm)		Story Stiffness (kN m)	
	X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis
M1	1020.5659	1198.3185	29	13.2	22.4275	58.8841
M2	1198.1866	1198.3199	34.1	13.3	22.3542	57.2394
M3	1198.5269	1198.2672	34.2	13.3	21.8464	55.7478
M4	1632.9054	1917.4823	46.4	21.1	22.4275	58.9452
M5	1917.2004	1917.3757	54.5	21.2	22.3801	57.4573
M6	1917.4762	1917.4891	54.7	21.3	21.8525	56.7022
M7	2449.358	2876.2235	69.6	31.6	22.4275	59.0385
M8	2876.0555	2876.2239	81.8	31.8	22.3684	57.4605
M9	2876.2144	2876.1029	82.1	31.9	21.8391	56.1885
M10	3674.037	4314.1193	104.4	47.4	22.4276	59.0355
M11	4314.0832	4314.0155	122.6	47.8	22.3866	57.336
M12	4314.1133	4314.0234	123.1	47.9	21.847	56.7275

Table 7. Result at Storey 5 (16.5m)

Model	Shear Force (kN)		Story Displacement (mm)		Story Stiffness (kN m)	
	X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis
M1	1020.5659	1198.3185	31.5	14.5	15.3595	39.9936
M2	1198.1866	1198.3199	37	14.6	15.2574	37.6747
M3	1198.5269	1198.2672	37.1	14.7	14.5991	36.5654
M4	1632.9054	1917.4823	50.4	23.2	15.3595	39.9972
M5	1917.2004	1917.3757	59.2	23.4	15.2579	37.6116
M6	1917.4762	1917.4891	59.4	23.5	14.5881	36.6015
M7	2449.358	2876.2235	75.6	34.9	15.3595	39.8826
M8	2876.0555	2876.2239	88.8	35.1	15.2593	37.6137
M9	2876.2144	2876.1029	89.1	35.2	14.5881	36.6518
M10	3674.037	4314.1193	113.4	52.3	15.3595	39.9187
M11	4314.0832	4314.0155	133.2	52.7	15.2593	37.5752
M12	4314.1133	4314.0234	133.6	52.9	14.5928	36.5814

Table 8. Result at Storey 6 (19.5m)

Model	Shear Force (kN)		Story Displacement (mm)		Story Stiffness (kN m)	
	X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis
M1	1020.5659	1198.3185	32.9	15.3	8.0749	20.7357
M2	1198.1866	1198.3199	38.6	15.4	7.9142	18.9545
M3	1198.5269	1198.2672	38.7	15.5	7.4324	18.1282
M4	1632.9054	1917.4823	52.6	24.5	8.081	20.7206
M5	1917.2004	1917.3757	61.8	24.7	7.9094	18.9091
M6	1917.4762	1917.4891	62	24.7	7.4221	18.2041
M7	2449.358	2876.2235	78.9	36.8	8.081	20.6925
M8	2876.0555	2876.2239	92.7	37	7.9102	18.9357
M9	2876.2144	2876.1029	93	37.1	7.4222	18.1788
M10	3674.037	4314.1193	118.3	55.1	8.0847	20.729
M11	4314.0832	4314.0155	139	55.5	7.913	18.9343
M12	4314.1133	4314.0234	139.4	55.7	7.2471	18.1619

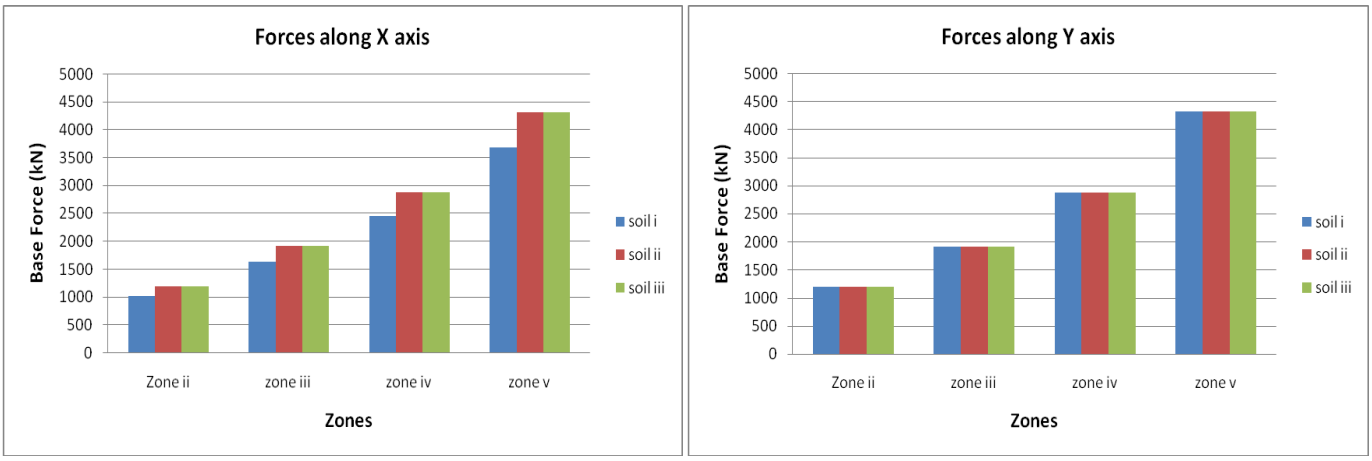

FIG 2. Comparison of Base Shear with respect to Different Zones along X-axis and Y-axis

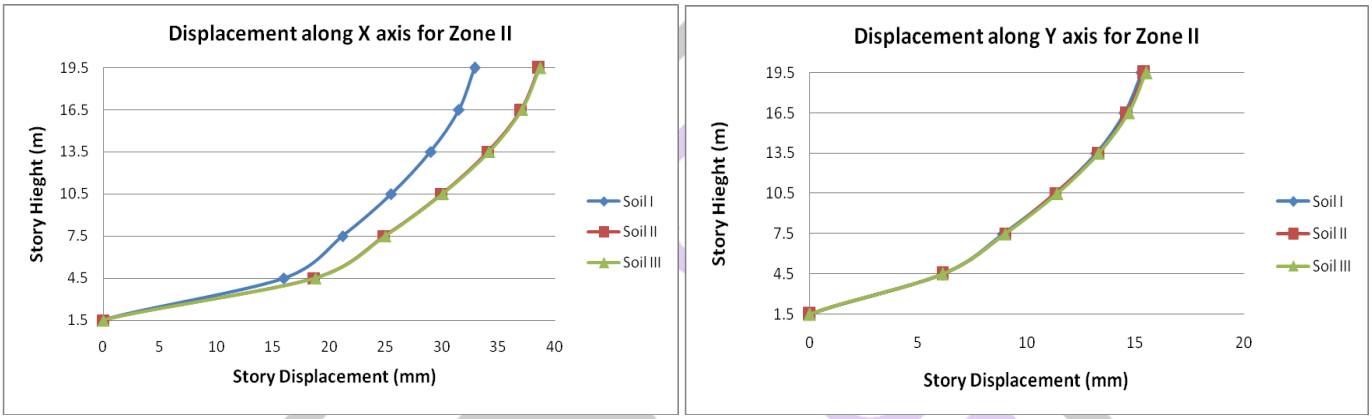

FIG 3. Comparison of Story Displacement with respect to Story height along X-Axis and Y-axis for Zone II

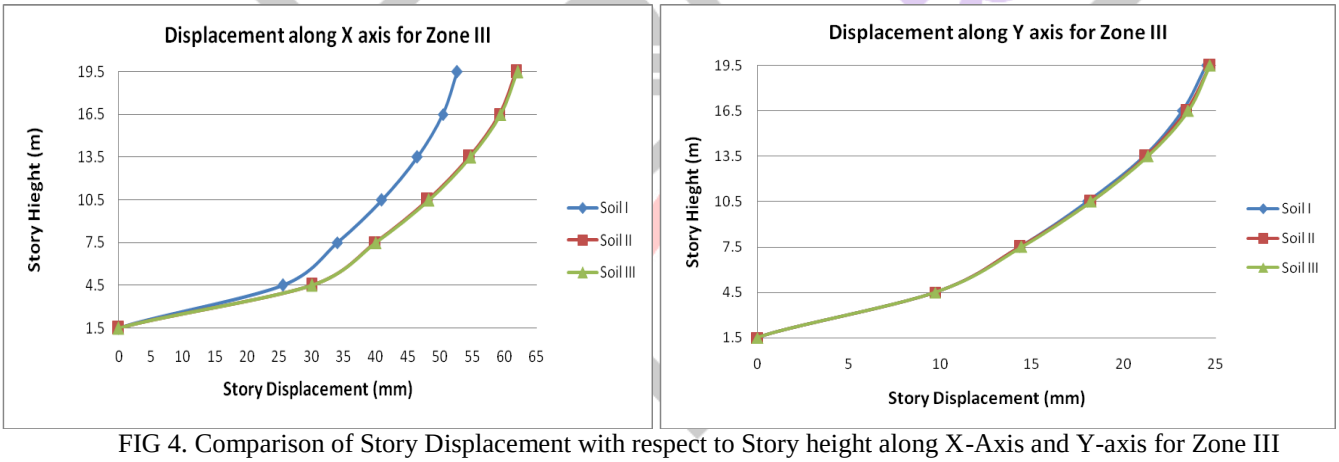

FIG 4. Comparison of Story Displacement with respect to Story height along X-Axis and Y-axis for Zone III

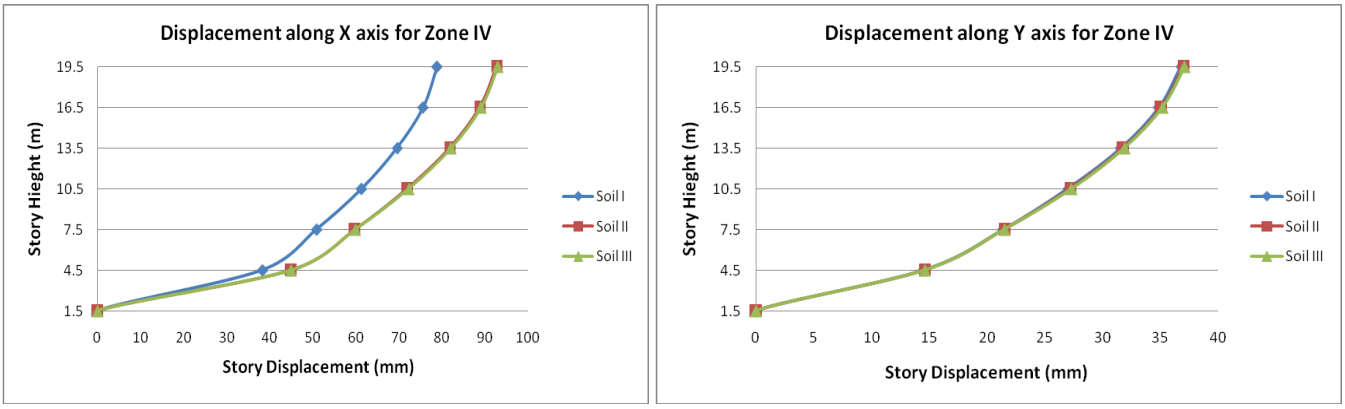

FIG 5. Comparison of Story Displacement with respect to Story height along X-Axis and Y-axis for Zone IV

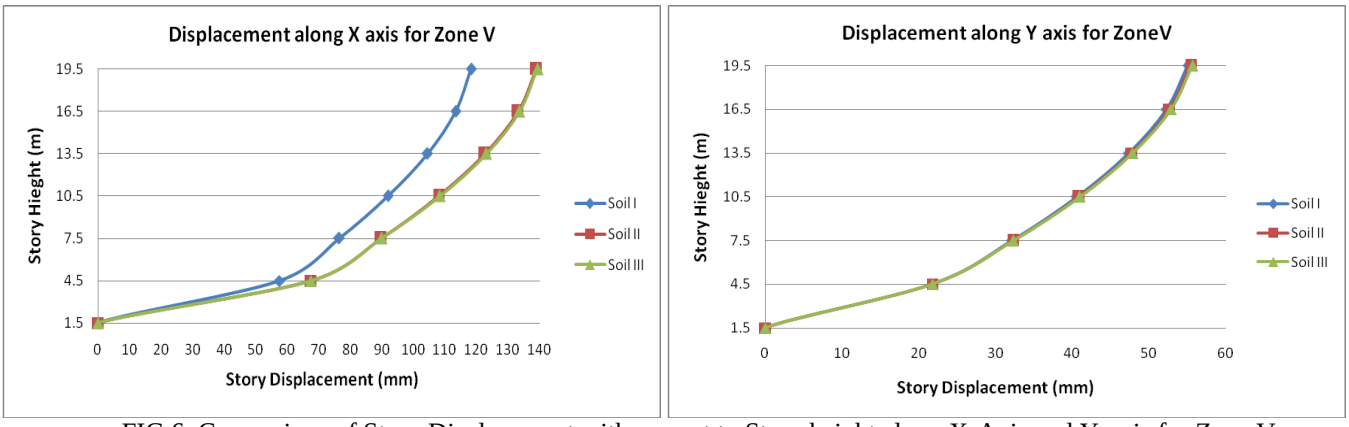

FIG 6. Comparison of Story Displacement with respect to Story height along X-Axis and Y-axis for Zone V

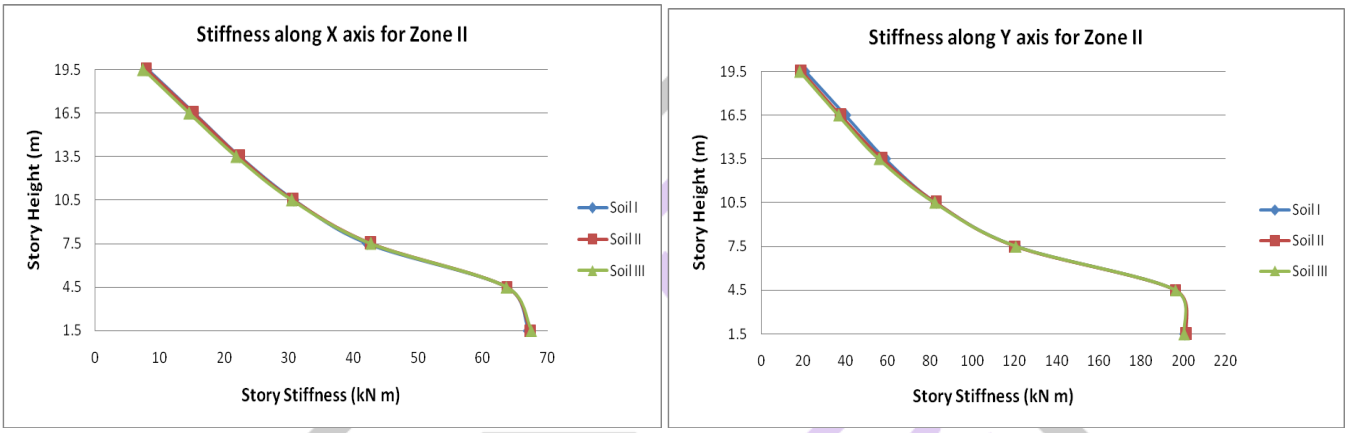

FIG 7. Comparison of Story Stiffness with respect to Story height along X-Axis and Y-axis for Zone II

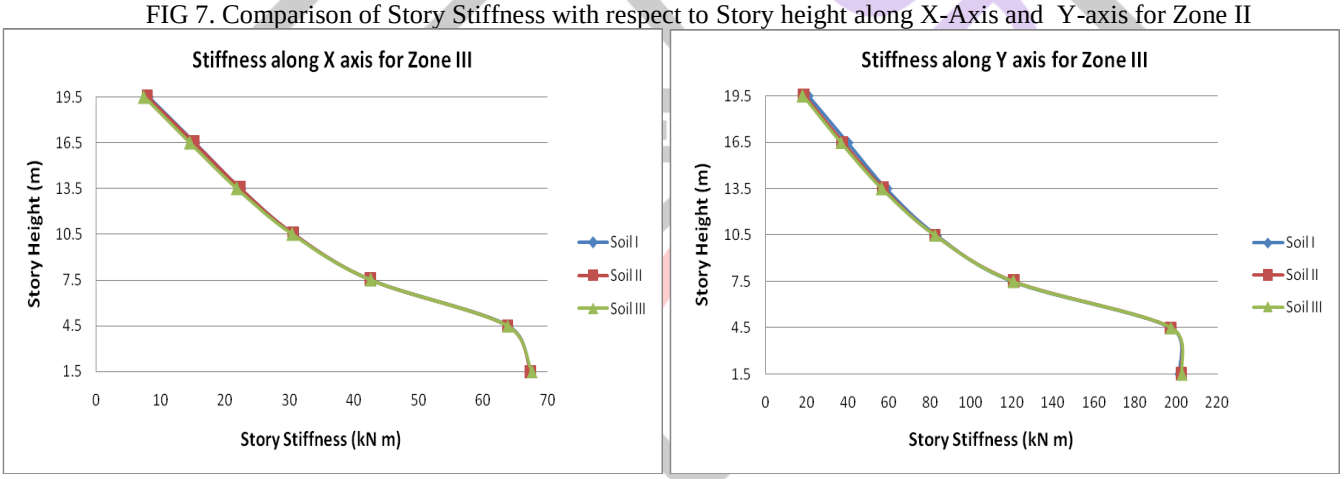

FIG 8. Comparison of Story Stiffness with respect to Story height along X-Axis and Y-axis for Zone III

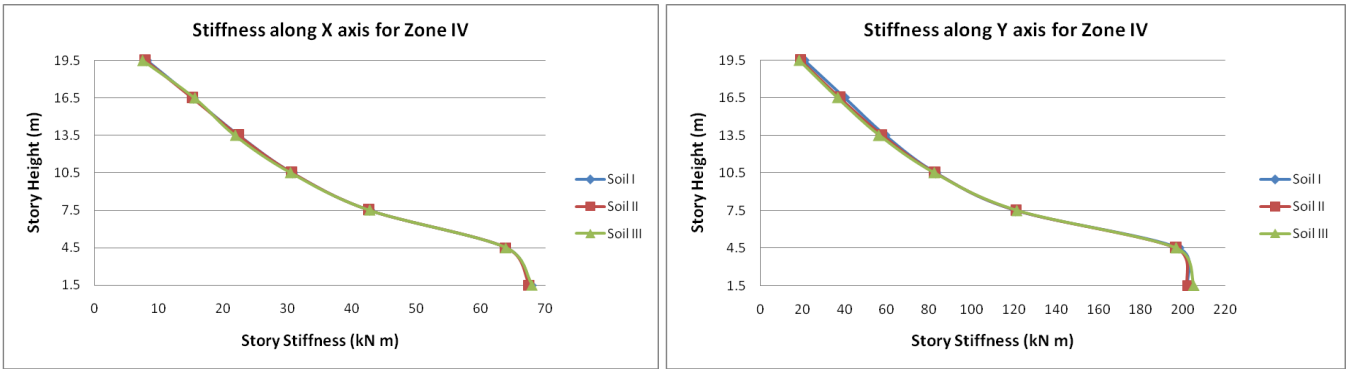

FIG 9. Comparison of Story Stiffness with respect to Story height along X-Axis and Y-axis for Zone IV

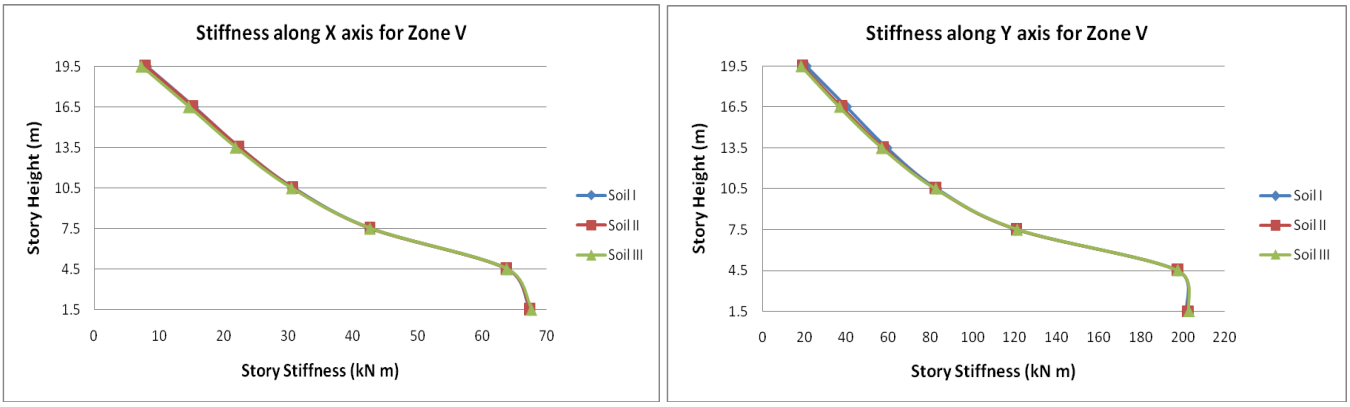

FIG 10. Comparison of Story Stiffness with respect to Story height along X-Axis and Y-axis for Zone V

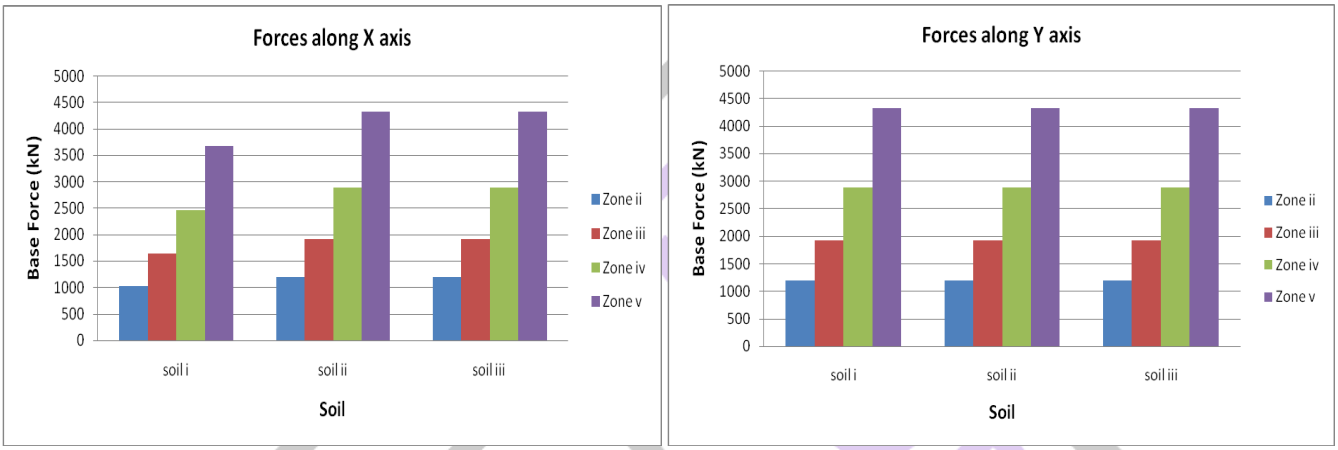

FIG 11. Comparison of Base Shear with respect to Different Soil along X-axis and Y-axis

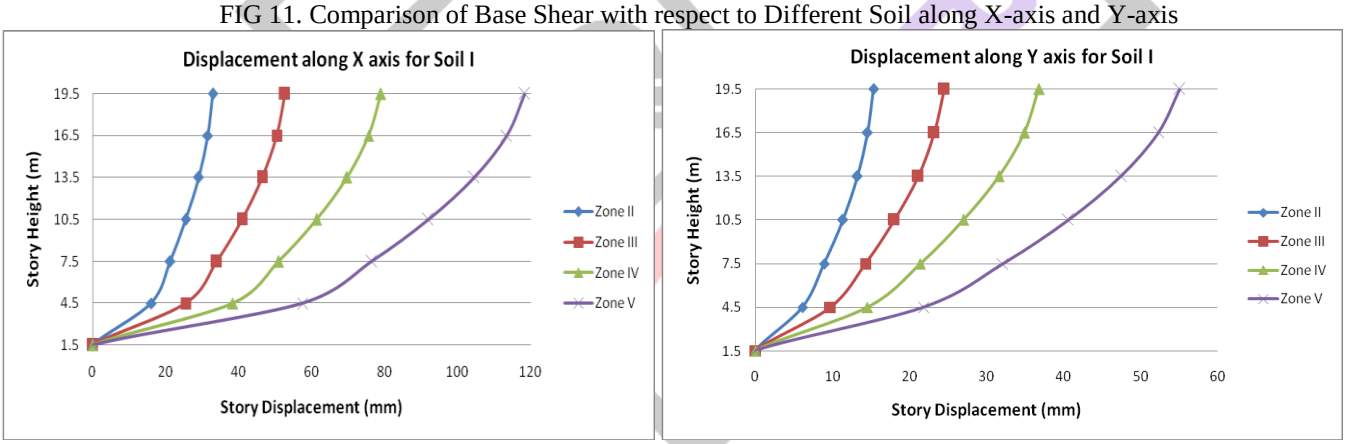

FIG 12. Comparison of Story Displacement with respect to Story height along X-Axis and Y-axis for Soil I

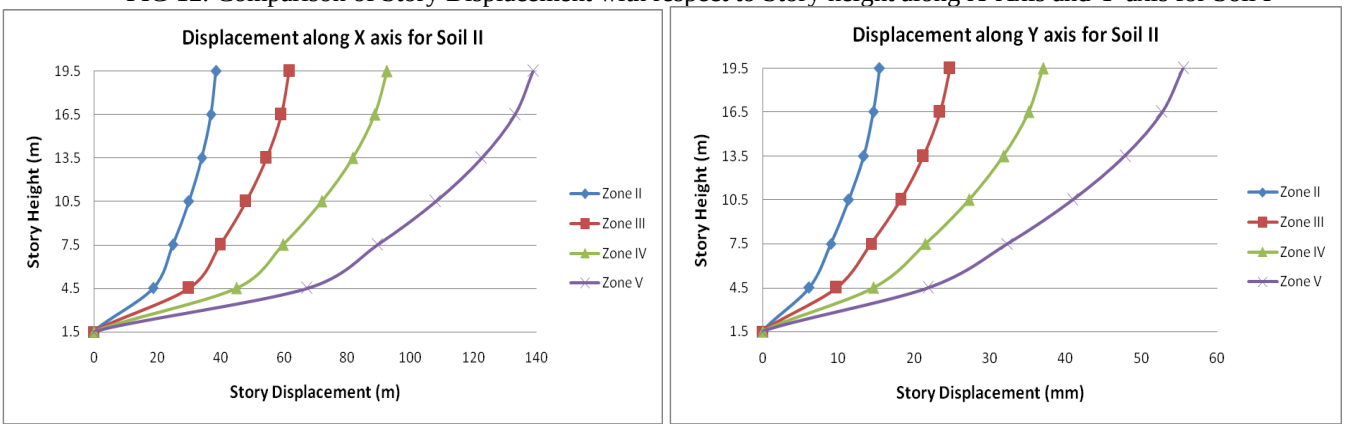

FIG 13. Comparison of Story Displacement with respect to Story height along X-Axis and Y-axis for Soil II

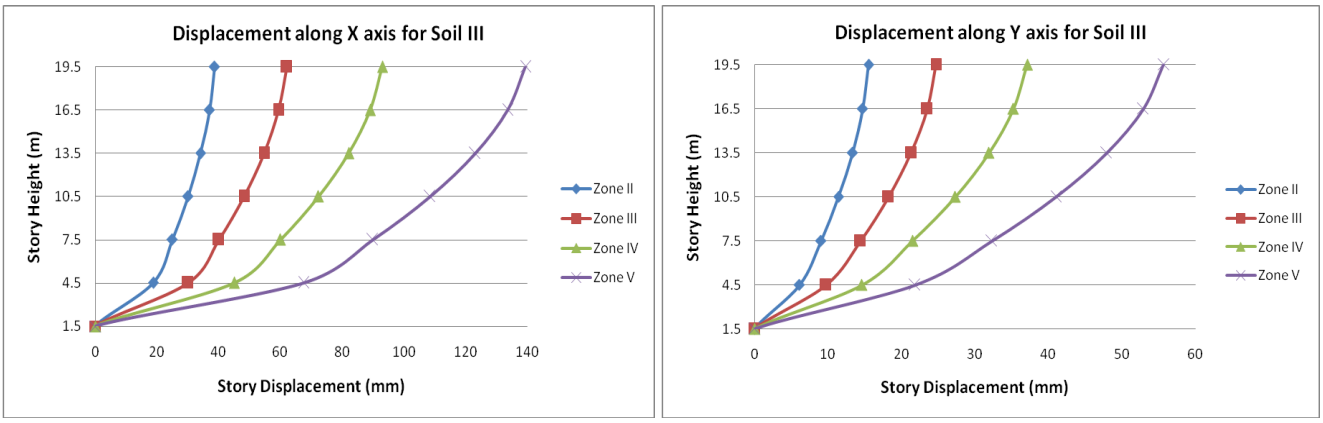

FIG 14. Comparison of Story Displacement with respect to Story height along X-Axis and Y-axis for Soil III

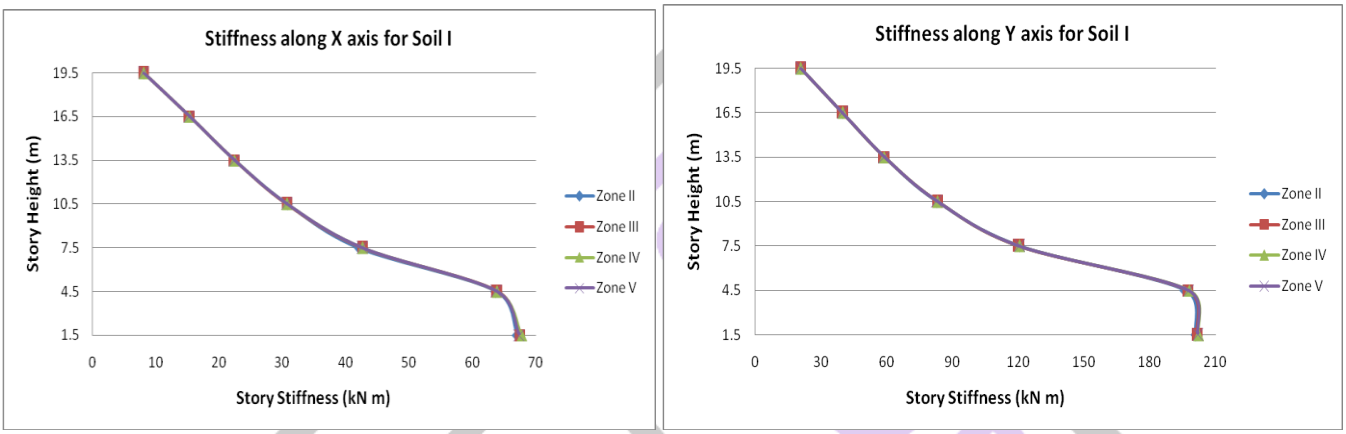

FIG 15. Comparison of Story Stiffness with respect to Story height along X-Axis and Y-axis for Soil I

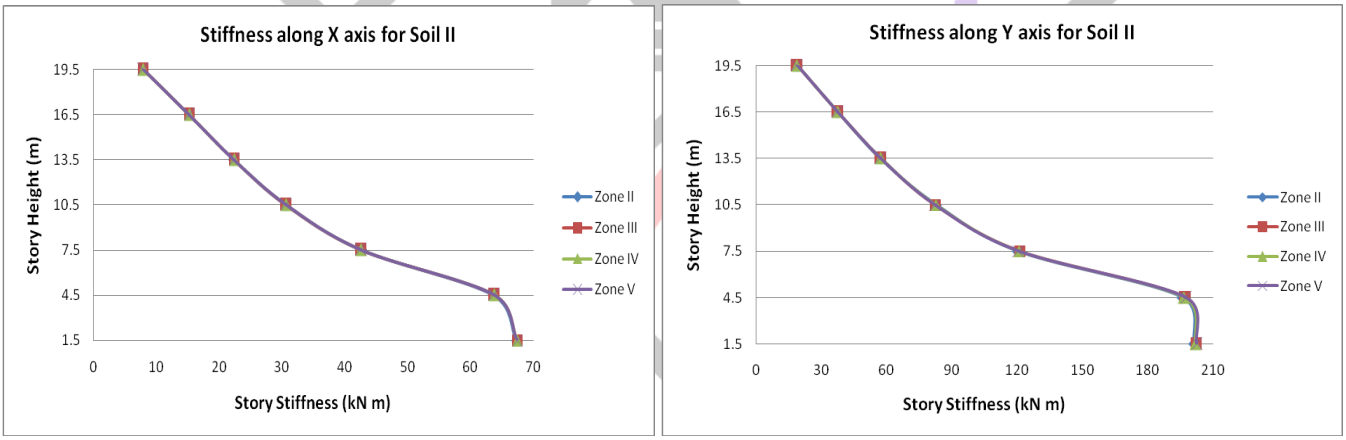

FIG 15. Comparison of Story Stiffness with respect to Story height along X-Axis and Y-axis for Soil II

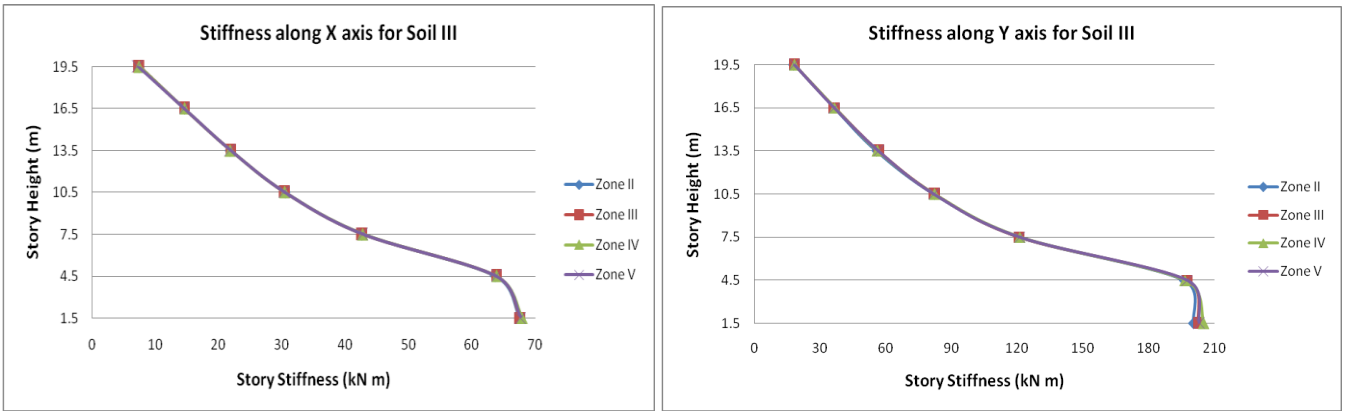

FIG 15. Comparison of Story Stiffness with respect to Story height along X-Axis and Y-axis for Soil III

IV. CONCLUSIONS

Following are the conclusions inferred from the study:

A. M1 has highest Story Stiffness, Lowest Shear Force and Story displacement

B. M12 had highest Shear Force and Story Displacement, Lowest Story Stiffness

C. Base Shear increases as Zone increases. Zone V has 3.6 times more base shear in both X and Y directions compared Zone II. Soil III has 3.6 times more base shear in both X and Y directions compared to Soil I.

D. Story displacement in each story gets increased as the story height increases. Story displacement is 15.00% less in Soil I compared to Soil III along X axis and 0.96% less along Y axis. Story displacement is 2.5 times more in X-axis compared to Y-axis.

E. Story displacement is 72.22% less in Zone II compared to Zone V along X axis and it is 72.21% less in Zone II compared to Zone V along Y axis. Story displacement is 2.38 times more in X-axis compared to Y-axis.

F. Story stiffness in each story gets deceased as the story height increases. Story stiffness is 9.40% more in Soil I compared to Soil III along X axis. And 13.93% along Y axis. Story stiffness is 2.45 times more in Y axis compared to X axis.

G. Story stiffness is 0.14% more in Zone II compared to Zone V along X axis and it is 0.10% more in Zone II compared to Zone V along Y axis. Story stiffness is 2.56 times more in Y axis compared to X axis.

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