

Seismic Analysis of Multi-Storey Building with E Shape RC Shear Wall at the Centre under Different Type of Soil

Mahdi Hosseini¹, Prof.N.V.Ramana Rao²

Ph.D. scholar student in Structural Engineering, Dept. of Civil Engineering, Jawaharlal Nehru Technological University Hyderabad (JNTUH), Hyderabad, Telangana, India¹

Professor, Dept. of Civil Engineering, Jawaharlal Nehru Technological University Hyderabad (JNTUH), Hyderabad, & Director of National Institute of Technology Warangal, Telangana, India²

ABSTRACT: The usefulness of shear walls in the structural planning of multistory buildings has long been recognized. When walls are situated in advantageous positions in a building, they can be very efficient in resisting lateral loads originating from wind or earthquakes. Incorporation of shear wall has become inevitable in multi-storey building to resist lateral forces. The seismic motion that reaches a structure on the surface of the earth is influenced by local soil conditions. The subsurface soil layers underlying the building foundation may amplify the response of the building to earthquake motions originating in the bedrock. Three types soil are considered here: Hard soil, Medium soil, soft soil. In present work, Thirtystorey buildings with E shape shear walls at the centre have been modeled using software package ETABS for earthquake zone V in India. This paper aims to study the behaviour of reinforced concrete building by conducting dynamic analysis for most suited positions and location of shear wall under different type of soil. Estimation of structural response such as; storey displacements, storey moment, storey shear, storey drift, Pier Forces, column forces is carried out. Dynamic responses under zone V earthquake as per IS 1893 (part 1) : 2002 have been carried out. In dynamic analysis; Response Spectrum method is used.

KEYWORDS: Soft, Medium & Hard Soil, E shape Shear Wall, Structural Response, Dynamic Analysis

I. INTRODUCTION

Background

Reinforced concrete (RC) buildings often have vertical plate-like RC walls called Shear Walls in addition to slabs, beams and columns. These walls generally start at foundation level and are continuous throughout the building height. Their thickness can be as low as 150mm, or as high as 400mm in high rise buildings. Shear walls are usually provided along both length and width of buildings. Shear walls are like vertically-oriented wide beams that carry earthquake loads downwards to the foundation.

Properly designed and detailed buildings with shear walls have shown very good performance in past earthquakes. The overwhelming success of buildings with shear walls in resisting strong earthquakes is summarised in the quote:

“We cannot afford to build concrete buildings meant to resist severe earthquakes without shear walls.” Mark Fintel, a noted consulting engineer in USA.

Shear walls in high seismic regions require special detailing. However, in past earthquakes, even buildings with sufficient amount of walls that were not specially detailed for seismic performance (but had enough well-distributed reinforcement) were saved from collapse. Shear wall buildings are a popular choice in many earthquake prone countries, like Chile, New Zealand and USA. Shear walls are easy to construct, because reinforcement detailing of walls is relatively straight-forward and therefore easily implemented at site. Shear walls are efficient, both in terms of

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construction cost and effectiveness in minimizing earthquake damage in structural and nonstructural elements (like glass windows and building contents).

Most RC buildings with shear walls also have columns; these columns primarily carry gravity loads (i.e., those due to self-weight and contents of building). Shear walls provide large strength and stiffness to buildings in the direction of their orientation, which significantly reduces lateral sway of the building and thereby reduces damage to structure and its contents. Shear walls should be provided along preferably both length and width. Special design checks are required to ensure that the net cross sectional area of a wall at an opening is sufficient to carry the horizontal earthquake force. Shear walls in buildings must be symmetrically located in plan to reduce ill-effects of twist in buildings. They could be placed symmetrically along one or both directions in plan. Buildings are designed primarily to serve the needs of an intended occupancy. One of the dominant design requirements is therefore the provision of an appropriate internal layout of buildings. Once the functional layout is established, one must develop a structural system that will satisfy the established design criteria as efficiently and economically as possible, while fitting into the architectural layout. The vital structural criteria are an adequate reserve of strength against failure, adequate lateral stiffness and an efficient performance during the service life of the buildings. In modern tall buildings, shear walls are commonly used as a vertical structural element for resisting the lateral loads that may be induced by the effect of wind and earthquakes. Shear walls of varying cross sections i.e. rectangular shapes to more irregular cores such as channel, T, L, barbell shape, E shape, box etc. can be used. Provision of walls helps to divide an enclosed space, whereas of cores to contain and convey services such as elevator.

Geo-Technical Consideration

Site selection:

The seismic motion that reaches a structure on the surface of the earth is influenced by local soil conditions. The subsurface soil layers underlying the building foundation may amplify the response of the building to earthquake motions originating in the bedrock.

For soft soils the earthquake vibrations can be significantly amplified and hence the shaking of structures sited on soft soils can be much greater than for structures sited on hard soils. Hence the appropriate soil investigation should be carried out to establish the allowable bearing capacity and nature of soil. The choice of a site for a building from the failure prevention point of view is mainly concerned with the stability of the ground. The very loose sands or sensitive clays are liable to be destroyed by the earthquake, so much as to lose their original structure and thereby undergo compaction. This would result in large unequal settlements and damage the building. If the loose cohesion less soils are saturated with water they are likely to lose their shear resistance altogether during ground shaking. This leads to liquefaction. Although such soils can be compacted, for small buildings the operation may be too costly and the sites having these soils are better avoided.

For large building complexes, such as housing developments, new colonies, etc. this factor should be thoroughly investigated and the site has to be selected appropriately. Therefore a site with sufficient bearing capacity and free from the above defects should be chosen and its drainage condition improved so that no water accumulates and saturates the ground especially close to the footing level.

Bearing capacity of foundation soil

Three soil types are considered here:

- I. **Hard**- Those soils, which have an allowable bearing capacity of more than 10t/m².
- II. **Medium** - Those soils, which have an allowable bearing capacity less than or equal to 10t/m²
- III. **Soft** - Those soils, which are liable to large differential settlement or liquefaction during an earthquake.

Soils must be avoided or compacted to improve them so as to qualify them either as firm or stiff. The allowable bearing pressure shall be determined in accordance with IS: 1888-1982 load test (Revision 1992). It is a common practice to increase the allowable bearing pressure by one-third, i.e. 33%, while performing seismic analysis of the materials like massive crystalline bedrock sedimentary rock, dense to very dense soil and heavily over consolidated cohesive soils, such as a stiff to hard clays. For the structure to react to the motion, it needs to overcome its own inertia, which results in an interaction between the structure and the soil. The extent to which the structural response may alter the characteristics of earthquake motions observed at the foundation level depends on the relative mass and stiffness

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properties of the soil and the structure. Thus the physical property of the foundation medium is an important factor in the earthquake response of structures supported on it. There are two aspects of building foundation interaction during earthquakes, which are of primary importance to earthquake engineering. First, the response to earthquake motion of a structure founded on a deformable soil can be significantly different from that would occur if the structure is supported on a rigid foundation. Second, the motion recorded at the base of a structure or in the immediate vicinity can be different from that which would have been recorded had there been no building. Observations of the response of the buildings during earthquakes have shown that the response of typical structures can be markedly influenced by the soil properties if the soils are sufficiently soft. Furthermore, for relatively rigid structures such as nuclear reactor containment structures, interaction effects can be important, even for relatively firm soils because the important parameter apparently is not the stiffness of the soil, but the relative stiffness of the building and its foundation. In terms of the dynamic properties of the building foundation system, past studies have shown that the interaction will, in general, reduce the fundamental frequency of the system from that of the structure on a rigid base, dissipate part of the vibrational energy of the building by wave radiation into the foundation medium and modify the base motion of the structure in comparison to the free- field motion. Although all these effects may be present in some degree for every structure, the important point is to establish under what conditions the effects are of practical significance.

II. LITERATURE REVIEW

Generally, the building configuration which is conceived by architects and then accepted by developer or owner may provide a narrow range of options for lateral-load resistant systems that can be utilized by structural engineers. By observing the following fundamental principles relevant to seismic responses, more suitable structural systems may be adopted (Paulay and Priestley, 1992):

1. To perform well in an earthquake, a building should possess simple and regular configurations. Buildings with articulated plans such as T and L shapes should be avoided.
2. Symmetry in plans should be provided, wherever possible. Lack of symmetry in plan may lead to significant torsional response, the reliable prediction of which is often difficult.
3. An integrated foundation system should tie together all vertical structural elements in both principal directions. Foundation resting on different soil condition should preferably be avoided.
4. Lateral force resisting systems with significantly different stiffness such as shear walls and frames within one building should be arranged in such a way that at every level of the building, symmetry in lateral stiffness is not grossly violated. Thus, undesirable torsional effects will be minimized.
5. Regularity in elevation should prevail in both the geometry and the variation of story stiffness.

III. METHODOLOGY

Essentials of Structural Systems For Seismic Resistance

The primary purpose of all structural members used in buildings is to support gravity loads. However, buildings may also be subjected to lateral forces due to wind and earthquakes. The effects of lateral forces in buildings will be more significant as the building height increases. All structural systems will not behave equally under seismic excitation. Aspects of structural configuration, symmetry, mass distribution and vertical regularity must be considered. In addition to that, the importance of strength, stiffness and ductility in relation to acceptable response must be evaluated in structural system (Paulay and Priestley, 1992).

The first task of the structural designer is to select the appropriate structural system for the satisfactory seismic performance of the building within the constraints dictated by architectural requirements. It is better where possible to discuss architect and structural engineer for alternative structural configuration at the earliest stage of concept development. Thus, undesirable geometry is not locked into the system before structural design is started.

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Irregularities in buildings contribute to complexity of structural behavior. When not recognized, they may result in unexpected damage and even collapse of the structures. There are many possible sources of structural irregularities. Drastic changes in geometry, interruptions in load path, discontinuities in both strength and stiffness, disruption in critical region by openings and unusual proportion of members are few of the possibilities. The recognition of many of these irregularities and of conceptions for remedial measures for the mitigation of their undesired effects relies on sound understanding of structural behavior.

Response Spectrum Method

In order to perform the seismic analysis and design of a structure to be built at a particular location, the actual time history record is required. However, it is not possible to have such records at each and every location. Further, the seismic analysis of structures cannot be carried out simply based on the peak value of the ground acceleration as the response of the structure depend upon the frequency content of ground motion and its own dynamic properties. To overcome the above difficulties, earthquake response spectrum is the most popular tool in the seismic analysis of structures. There are computational advantages in using the response spectrum method of seismic analysis for prediction of displacements and member forces in structural systems. The method involves the calculation of only the maximum values of the displacements and member forces in each mode of vibration using smooth design spectra that are the average of several earthquake motions.

This chapter deals with response spectrum method and its application to various types of the structures. The codal provisions as per IS 1893 (Part 1) : 2002 code for response spectrum analysis of multi-story building is also summarized.

Response Spectra

Response spectra are curves plotted between maximum response of SDOF system subjected to specified earthquake ground motion and its time period (or frequency). Response spectrum can be interpreted as the locus of maximum response of a SDOF system for given damping ratio. Response spectra thus helps in obtaining the peak structural responses under linear range, which can be used for obtaining lateral forces developed in structure due to earthquake thus facilitates in earthquake-resistant design of structures.

Usually response of a SDOF system is determined by time domain or frequency domain analysis, and for a given time period of system, maximum response is picked. This process is continued for all range of possible time periods of SDOF system. Final plot with system time period on x-axis and response quantity on y-axis is the required response spectra

pertaining to specified damping ratio and input ground motion. Same process is carried out with different damping ratios to obtain overall response spectra.

Design Of Earthquake Resistant Structure Based On Codal Provisions

General principles and design philosophy for design of earthquake-resistant structure are as follows:

- a) The characteristics of seismic ground vibrations at any location depends upon the magnitude of earth quake, its depth of focus, distance from epicenter, characteristic of the path through which the waves travel, and the soil strata on which the structure stands. Ground motions are predominant in horizontal direction.
- b) Earthquake generated vertical forces, if significant, as in large spans where differential settlement is not allowed, must be considered.
- c) The response of a structure to the ground motions is a function of the nature of foundation soil, materials size and mode of construction of structures, and the duration and characteristic of ground motion.
- d) The design approach is to ensure that structures possess at least a minimum strength to withstand minor earthquake (DBE), which occur frequently, without damage; resist moderate earthquake without significant damage though some nonstructural damage may occur, and aims that structures withstand major earthquake (MCE) without collapse. Actual forces that appeared on structures are much greater then the design forces specified here, but ductility, arising due to inelastic material behavior and detailing, and over strength, arising from the additional reserve strength in structures over and above the design strength are relied upon to account for this difference in actual and design lateral forces.
- e) Reinforced and pre-stressed members shall be suitably designed to ensure that premature failure due to shear

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or bond does not occur, as per IS:456 and IS:1343.

- f) In steel structures, members and their connections should be so proportioned that high ductility is obtained.
- g) The soil structure interaction refers to the effect of the supporting foundation medium on the motion of structure. The structure interaction may not be considered in the seismic analysis for structures supporting on the rocks.
- h) The design lateral forces shall be considered in two orthogonal horizontal directions of the structures. For structures, which have lateral force resisting elements in two orthogonal directions only, design lateral force must be considered in one direction at a time. Structures having lateral resisting elements in two directions other than orthogonal shall be analyzed according to clause 2.3.2 IS 1893 (part 1) : 2002. Where both horizontal and vertical forces are taken into account, load combinations must be according to clause 2.3.3 IS 1893 (part 1) : 2002.
- i) When a change in occupancy results in a structure being re-classified to a higher importance factor (I), the structure shall be confirm to the seismic requirements of the new structure with high importance factor.

Response Spectrum Method (Dynamic Analysis)

General Codal Provisions

Dynamic analysis should be performed to obtain the design seismic force, and its distribution to different levels along the height of the building and to various lateral load resisting elements, for the following buildings:

- Regular buildings- Those are greater than 40 m in height in zone IV, V and those are greater than 90 m height in zones II, III, and
- Irregular buildings-All framed buildings higher than 12 m in zone IV and V, and those are greater than 40 m in height in zone II and III.

Dynamic analysis may be performed either by time history method or by the response spectrum method. However in either method, the design base shear V_B shall be compared with a base shear V_B calculated using a fundamental period T_a . When V_B is less than V_B all the response quantities shall be multiplied by V_B / V_b

The values of damping for a building may be taken as 2 and 5 percent of the critical, for the purpose of dynamic analysis of steel and reinforced concrete buildings, respectively.

Modes To Be Considered

The number of modes to be considered in the analysis should be such that the sum of the total modal masses of all modes considered is at least 90% of the total seismic mass and the missing mass correction beyond 33%. If modes with natural frequency beyond 33 Hz are to be considered, modal combination shall be carried out only for modes up to 33 Hz.

Computation of Dynamic Quantities

Buildings with regular, or nominally irregular plan configuration may be modeled as a system of masses lumped at the floor levels with each mass having one degree of freedom, that of lateral displacement in the direction of consideration.

IV. MODELING OF BUILDING

Details of The Building

A symmetrical building of plan 38.5m X 35.5m located with location in zone V, India is considered. Four bays of length 7.5m & one bays of length 8.5m along X - direction and Four bays of length 7.5m & one bays of length 5.5m along Y - direction are provided. Shear Wall is provided at the center core of building model.

Load Combinations

As per IS 1893 (Part 1): 2002 Clause no. 6.3.1.2, the following load cases have to be considered for analysis:

- 1.5 (DL + IL)
- 1.2 (DL + IL ± EL)

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1.5 (DL ± EL)

0.9 DL ± 1.5 EL

Earthquake load must be considered for +X, -X, +Y and -Y directions.

Table 1 : Details of The Building

Building Parameters	Details
Type of frame	Special RC moment resisting frame fixed at the base
Building plan	38.5m X 35.5m
Number of storeys	30
Floor height	3.5 m
Depth of Slab	225 mm
Size of beam	(300 × 600) mm
Size of column (exterior)	(1250×1250) mm up to story five
Size of column (exterior)	(900×900) mm Above story five
Size of column (interior)	(1250×1250) mm up to story ten
Size of column (interior)	(900×900) mm Above story ten
Spacing between frames	7.5-8.5 m along x - direction 7.5-5.5 m along y - direction
Live load on floor	4 KN/m ²
Floor finish	2.5 KN/m ²
Wall load	25 KN/m
Grade of Concrete	M 50 concrete
Grade of Steel	Fe 500
Thickness of shear wall	450 mm
Seismic zone	V

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Density of concrete	25 KN/m ³
Type of soil	Soft,Medium,Hard Soil Type I=Soft Soil Soil Type II=Medium Soil Soil Type III= Hard Soil
Response spectra	As per IS 1893(Part-1):2002
Damping of structure	5 percent

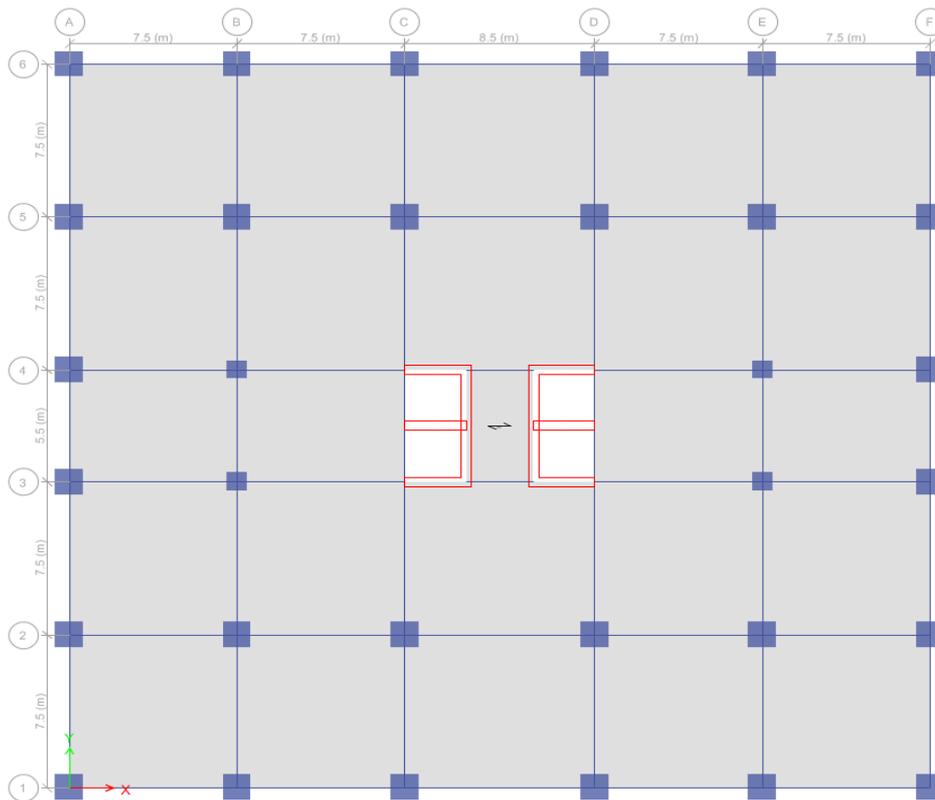


Figure 1. Plan of the building

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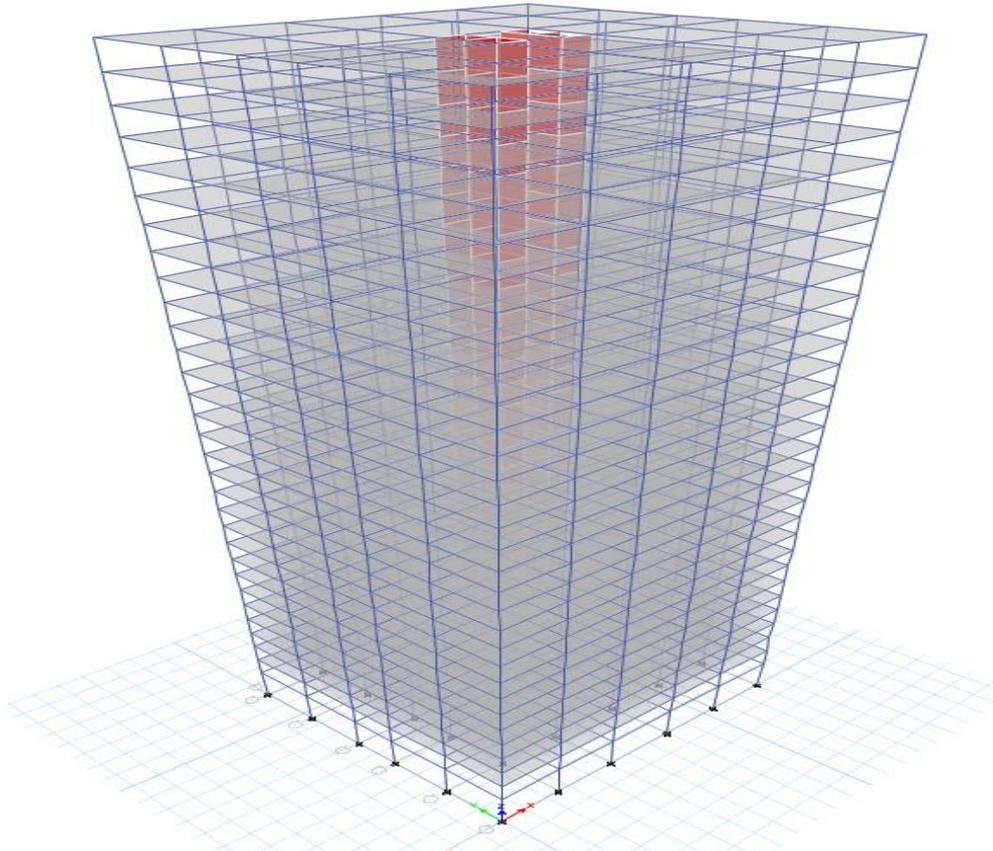


Figure 2.3D view showing shear wall location

V. RESULTS AND DISCUSSIONS

Table 2: Lateral Loads of Structure in Soft Soil, Medium Soil and Hard Soil in X-Direction for load cases EQXP

Story	Elevation m	Location	SOIL TYPE I	SOIL TYPE II	SOIL TYPE III
			X-Dir kN	X-Dir kN	X-Dir kN
30TH	111	Top	734.6607	1065.8278	1308.7739
29TH	107.5	Top	748.8055	1080.7416	1327.0871
28TH	104	Top	700.8398	1011.5134	1242.0789
27TH	100.5	Top	654.4617	944.5763	1159.8842
26TH	97	Top	609.671	879.9306	1080.503
25TH	93.5	Top	566.4679	817.5761	1003.9353
24TH	90	Top	524.8523	757.5128	930.1811
23RD	86.5	Top	484.8242	699.7407	859.2405
22ND	83	Top	446.3836	644.2599	791.1133

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21ST	79.5	Top	409.5306	591.0704	725.7997
20TH	76	Top	374.265	540.1721	663.2995
19TH	72.5	Top	340.587	491.565	603.6129
18TH	69	Top	308.4965	445.2492	546.7398
17TH	65.5	Top	277.9935	401.2246	492.6802
16TH	62	Top	249.0781	359.4912	441.4341
15TH	58.5	Top	221.7501	320.0491	393.0015
14TH	55	Top	196.0097	282.8983	347.3825
13TH	51.5	Top	171.8567	248.0387	304.5769
12TH	48	Top	149.2913	215.4703	264.5849
11TH	44.5	Top	128.3134	185.1932	227.4063
10TH	41	Top	110.1585	158.8837	195.0998
9TH	37.5	Top	93.2966	134.4658	165.1161
8TH	34	Top	76.6939	110.5369	135.7328
7TH	30.5	Top	61.7167	88.9506	109.2262
6TH	27	Top	48.3649	69.7071	85.5962
5TH	23.5	Top	37.6855	54.2268	66.5873
4TH	20	Top	28.1087	40.3798	49.584
3RD	16.5	Top	19.1315	27.4835	33.7481
2ND	13	Top	11.8759	17.0604	20.9492
1ST	9.5	Top	6.342	9.1107	11.1874
PLINTH	6	Top	1.3978	1.8992	2.3321
Base	0	Top	0	0	0

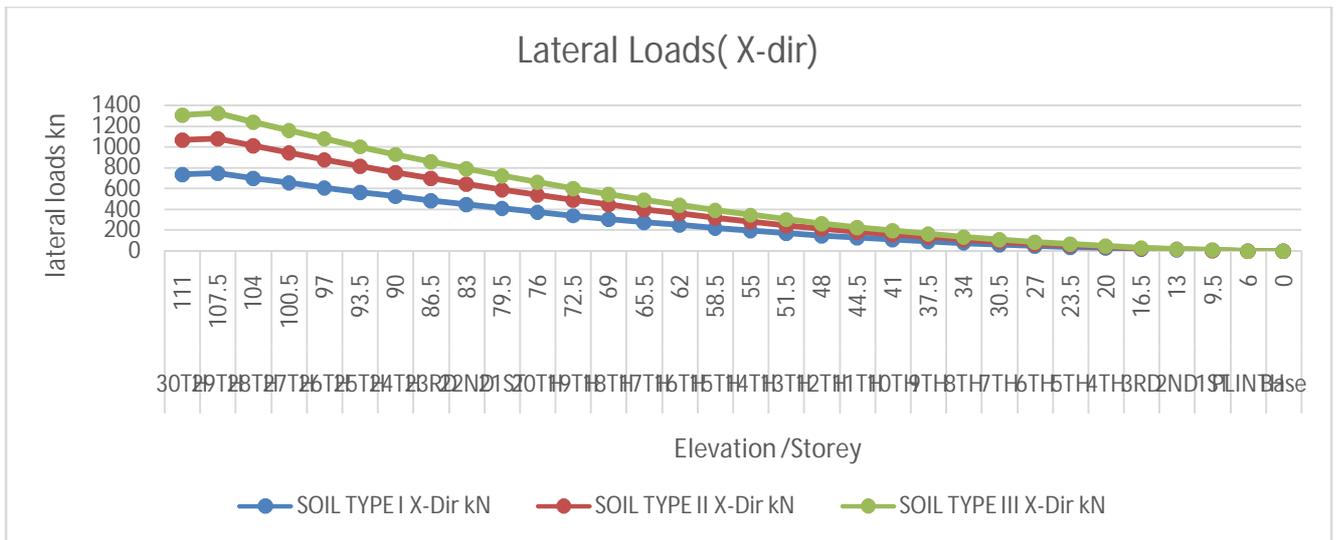
A plot for Lateral Loads of Structure in Soft Soil , Medium Soil and Hard Soil in X –Direction for load cases EQXP has been shown here

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Graph 1: Lateral Loads of Structure in Soft Soil, Medium Soil and Hard Soil in X-Direction

Table 3: Stiffness of Structure in Soft Soil, Medium Soil and Hard Soil in X-Direction for load cases EQXP

Story	Elevation m	Location	SOIL TYPE I	SOIL TYPE II	SOIL TYPE III
			X-Dir kN/m	X-Dir kN/m	X-Dir kN/m
30TH	111	Top	172953.339	173639.107	173639.107
29TH	107.5	Top	327254.392	327711.095	327711.095
28TH	104	Top	444924.118	445211.158	445211.158
27TH	100.5	Top	530105.692	530277.174	530277.174
26TH	97	Top	590667.978	590764.639	590764.639
25TH	93.5	Top	633562.623	633611.951	633611.951
24TH	90	Top	664160.849	664180.566	664180.566
23RD	86.5	Top	686302.445	686303.777	686303.777
22ND	83	Top	702657.154	702647.2	702647.2
21ST	79.5	Top	715067.826	715051.103	715051.103
20TH	76	Top	724816.109	724795.53	724795.53
19TH	72.5	Top	732811.079	732788.555	732788.555
18TH	69	Top	739719.634	739696.455	739696.455
17TH	65.5	Top	746057.058	746034.134	746034.134
16TH	62	Top	752252.191	752230.209	752230.209
15TH	58.5	Top	758697.633	758677.166	758677.166
14TH	55	Top	765794.668	765776.264	765776.264
13TH	51.5	Top	773989.455	773973.712	773973.712

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12TH	48	Top	783882.482	783870.122	783870.122
11TH	44.5	Top	795870.555	795862.623	795862.623
10TH	41	Top	813399.858	813390.213	813390.213
9TH	37.5	Top	832552.458	832535.911	832535.911
8TH	34	Top	857870.998	857850.356	857850.356
7TH	30.5	Top	891839.923	891817.354	891817.354
6TH	27	Top	939154.717	939132.284	939132.284
5TH	23.5	Top	1007354.759	1007326.596	1007326.596
4TH	20	Top	1089305.176	1089266.604	1089266.604
3RD	16.5	Top	1217443.451	1217396.932	1217396.932
2ND	13	Top	1432837.445	1432783.259	1432783.259
1ST	9.5	Top	1866169.209	1866102.995	1866102.995
PLINTH	6	Top	2409798.589	2409707.467	2409707.467
Base	0	Top	0	0	0

Table 4: Stiffness of Structure in Soft Soil , Medium Soil and Hard Soil in Y -Direction for load cases EQYP

Story	Elevation m	Location	SOIL TYPE I	SOIL TYPE II	SOIL TYPE III
			Y-Dir kN/m	Y-Dir kN/m	Y-Dir kN/m
30TH	111	Top	116081.044	116577.808	116577.808
29TH	107.5	Top	227134.567	227515.505	227515.505
28TH	104	Top	325289.284	325574.238	325574.238
27TH	100.5	Top	409057.523	409262.479	409262.479
26TH	97	Top	479661.571	479802.208	479802.208
25TH	93.5	Top	538628.011	538718.202	538718.202
24TH	90	Top	587701.998	587753.394	587753.394
23RD	86.5	Top	628596.387	628618.427	628618.427
22ND	83	Top	662891.088	662891.242	662891.242
21ST	79.5	Top	691990.14	691974.226	691974.226
20TH	76	Top	717119.319	717091.823	717091.823
19TH	72.5	Top	739344.806	739309.172	739309.172
18TH	69	Top	759602.203	759561.067	759561.067
17TH	65.5	Top	778730.008	778685.395	778685.395
16TH	62	Top	797505.172	797458.651	797458.651
15TH	58.5	Top	816680.403	816633.205	816633.205
14TH	55	Top	837026.241	836979.36	836979.36
13TH	51.5	Top	859371.155	859325.433	859325.433

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12TH	48	Top	884720.614	884676.795	884676.795
11TH	44.5	Top	913640.643	913599.703	913599.703
10TH	41	Top	951607.325	951561.757	951561.757
9TH	37.5	Top	992308.273	992251.544	992251.544
8TH	34	Top	1044407.058	1044341.611	1044341.611
7TH	30.5	Top	1110394.829	1110322.308	1110322.308
6TH	27	Top	1198282.023	1198203.898	1198203.898
5TH	23.5	Top	1321932.941	1321840.31	1321840.31
4TH	20	Top	1468099.344	1467985.226	1467985.226
3RD	16.5	Top	1692303.93	1692168.422	1692168.422
2ND	13	Top	2048530.453	2048369.731	2048369.731
1ST	9.5	Top	2698550.737	2698353.921	2698353.921
PLINTH	6	Top	3496978.337	3496729.493	3496729.493
Base	0	Top	0	0	0

Table 5: Storey Displacement of Structure in Soft Soil, Medium Soil and Hard Soil in X-Direction with load combination (DL+LL+EQXP)

Story	Load Case/Combination	Direction	SOIL TYPE I	SOIL TYPE II	SOIL TYPE III
			Maximum Storey Displacement mm	Maximum Storey Displacement mm	Maximum Storey Displacement mm
30TH	DLLLEQXP	X	274.19	395.964	486.221
29TH	DLLLEQXP	X	269.728	389.515	478.302
28TH	DLLLEQXP	X	264.919	382.567	469.769
27TH	DLLLEQXP	X	259.657	374.964	460.434
26TH	DLLLEQXP	X	253.868	366.6	450.163
25TH	DLLLEQXP	X	247.513	357.419	438.89
24TH	DLLLEQXP	X	240.58	347.404	426.592
23RD	DLLLEQXP	X	233.074	336.561	413.277
22ND	DLLLEQXP	X	225.011	324.916	398.977
21ST	DLLLEQXP	X	216.418	312.505	383.737
20TH	DLLLEQXP	X	207.328	299.376	367.616
19TH	DLLLEQXP	X	197.776	285.582	350.677
18TH	DLLLEQXP	X	187.804	271.18	332.994
17TH	DLLLEQXP	X	177.454	256.233	314.639
16TH	DLLLEQXP	X	166.77	240.804	295.694
15TH	DLLLEQXP	X	155.798	224.96	276.237

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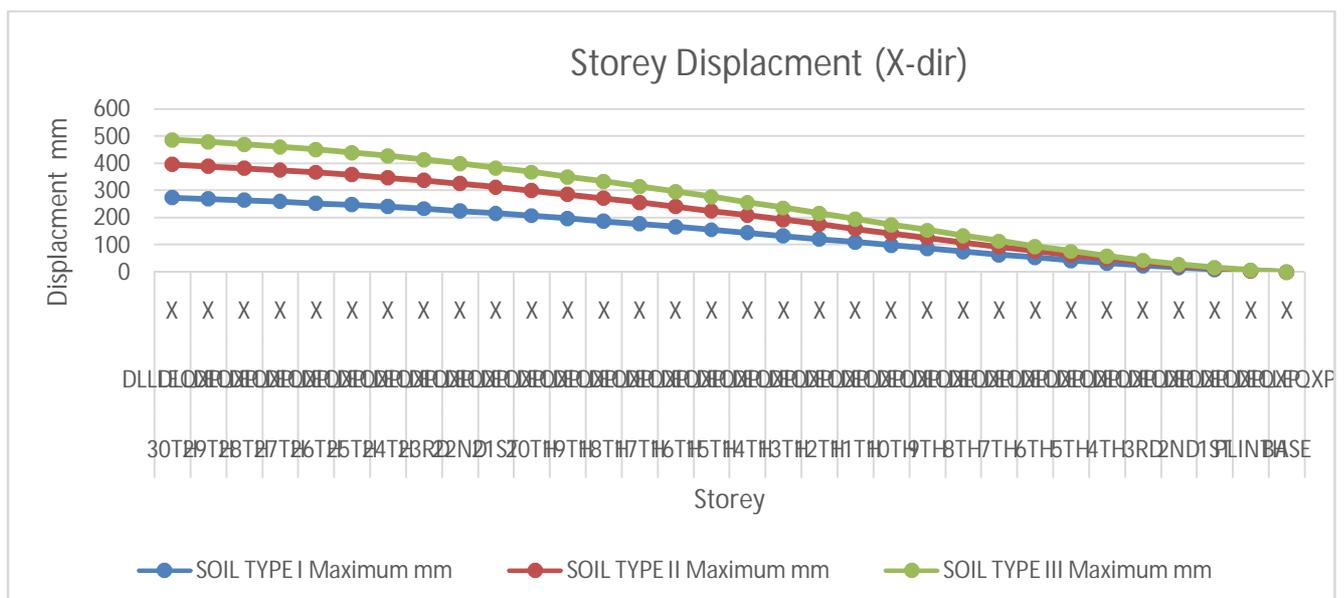
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14TH	DLLLEQXP	X	144.586	208.769	256.356
13TH	DLLLEQXP	X	133.184	192.305	236.14
12TH	DLLLEQXP	X	121.647	175.646	215.683
11TH	DLLLEQXP	X	110.036	158.879	195.094
10TH	DLLLEQXP	X	98.413	142.096	174.485
9TH	DLLLEQXP	X	86.888	125.455	154.051
8TH	DLLLEQXP	X	75.495	109.005	133.851
7TH	DLLLEQXP	X	64.327	92.879	114.05
6TH	DLLLEQXP	X	53.499	77.244	94.851
5TH	DLLLEQXP	X	43.16	62.316	76.52
4TH	DLLLEQXP	X	33.492	48.357	59.379
3RD	DLLLEQXP	X	24.501	35.376	43.439
2ND	DLLLEQXP	X	16.413	23.697	29.099
1ST	DLLLEQXP	X	9.503	13.72	16.847
PLINT H	DLLLEQXP	X	3.583	5.173	6.352
BASE	DLLLEQXP	X	0	0	0

A plot for StoreyDisplacment of Structure in Soft Soil , Medium Soil and Hard Soil in X -Direction with load combination (DL+LL+EQXP) has been shown here



Graph 2: Storey Displacment of Structure in Soft Soil , Medium Soil and Hard Soil in X -Direction

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Table 6: Storey Displacement of Structure in Soft Soil, Medium Soil and Hard Soil in Y-Direction with load combination (DL+LL+EQYP)

Story	Load Case/Comb o	Directi on	SOIL TYPE I	SOIL TYPE II	SOIL TYPE III
			Maximum Storey Displacement mm	Maximum Storey Displacement mm	Maximum Storey Displacement mm
30TH	DLLLEQYP	Y	265.397	383.274	470.638
29TH	DLLLEQYP	Y	258.816	373.766	458.962
28TH	DLLLEQYP	Y	251.96	363.862	446.801
27TH	DLLLEQYP	Y	244.831	353.563	434.155
26TH	DLLLEQYP	Y	237.381	342.801	420.939
25TH	DLLLEQYP	Y	229.584	331.538	407.11
24TH	DLLLEQYP	Y	221.429	319.759	392.645
23RD	DLLLEQYP	Y	212.915	307.462	377.545
22ND	DLLLEQYP	Y	204.049	294.657	361.821
21ST	DLLLEQYP	Y	194.847	281.366	345.501
20TH	DLLLEQYP	Y	185.33	267.62	328.622
19TH	DLLLEQYP	Y	175.523	253.458	311.231
18TH	DLLLEQYP	Y	165.46	238.924	293.385
17TH	DLLLEQYP	Y	155.175	224.071	275.146
16TH	DLLLEQYP	Y	144.708	208.956	256.585
15TH	DLLLEQYP	Y	134.104	193.642	237.781
14TH	DLLLEQYP	Y	123.409	178.199	218.818
13TH	DLLLEQYP	Y	112.677	162.701	199.787
12TH	DLLLEQYP	Y	101.963	147.229	180.789
11TH	DLLLEQYP	Y	91.33	131.874	161.934
10TH	DLLLEQYP	Y	80.84	116.727	143.334
9TH	DLLLEQYP	Y	70.608	101.952	125.191
8TH	DLLLEQYP	Y	60.651	87.574	107.536
7TH	DLLLEQYP	Y	51.063	73.73	90.536
6TH	DLLLEQYP	Y	41.94	60.557	74.361
5TH	DLLLEQYP	Y	33.411	48.241	59.237
4TH	DLLLEQYP	Y	25.627	37.002	45.436
3RD	DLLLEQYP	Y	18.541	26.771	32.874
2ND	DLLLEQYP	Y	12.32	17.788	21.843
1ST	DLLLEQYP	Y	7.115	10.273	12.615
PLINT	DLLLEQYP	Y	2.572	3.713	4.56

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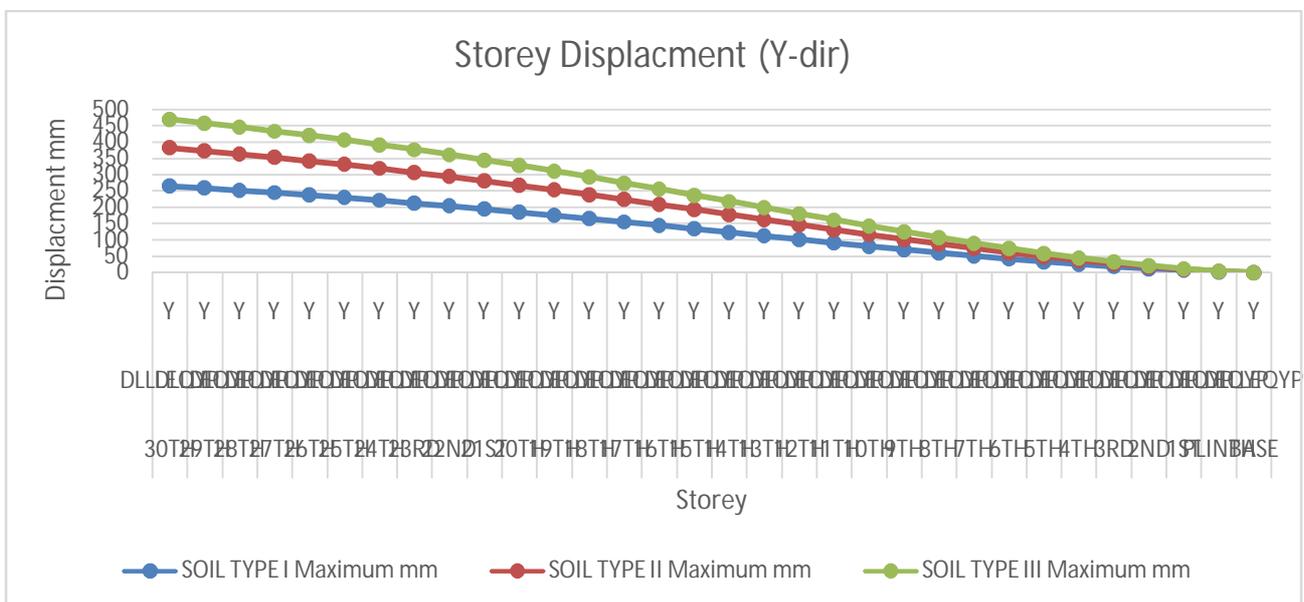
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H					
BASE	DLLLEQYP	Y	0	0	0

A plot for Storey Displacement of Structure in Soft Soil, Medium Soil and Hard Soil in Y-Direction with load combination (DL+LL+EQYP) has been shown here



Graph 3: Storey Displacement of Structure in Soft Soil, Medium Soil and Hard Soil in Y-Direction

For both X and Y directions, the behaviour of the graph is similar for model in Soft Soil, Medium Soil and Hard Soil as shown. The order of maximum storey displacement in both the directions for the models is same.

Table 7: Storey Drifts of Structure in Soft Soil, Medium Soil and Hard Soil in X-Direction with load combination (DL+LL+EQXP)

Story	Elevation m	Location	SOIL TYPE I X-Dir	SOIL TYPE II X-Dir	SOIL TYPE III X-Dir
30TH	111	Top	0.001275	0.001843	0.002263
29TH	107.5	Top	0.001374	0.001985	0.002438
28TH	104	Top	0.001503	0.002172	0.002667
27TH	100.5	Top	0.001654	0.00239	0.002935
26TH	97	Top	0.001816	0.002623	0.003221
25TH	93.5	Top	0.001981	0.002861	0.003514
24TH	90	Top	0.002145	0.003098	0.003804
23RD	86.5	Top	0.002304	0.003327	0.004086
22ND	83	Top	0.002455	0.003546	0.004354

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21ST	79.5	Top	0.002597	0.003751	0.004606
20TH	76	Top	0.002729	0.003941	0.00484
19TH	72.5	Top	0.002849	0.004115	0.005053
18TH	69	Top	0.002957	0.004271	0.005244
17TH	65.5	Top	0.003053	0.004408	0.005413
16TH	62	Top	0.003135	0.004527	0.005559
15TH	58.5	Top	0.003203	0.004626	0.00568
14TH	55	Top	0.003258	0.004704	0.005776
13TH	51.5	Top	0.003296	0.00476	0.005845
12TH	48	Top	0.003318	0.004791	0.005883
11TH	44.5	Top	0.003321	0.004795	0.005888
10TH	41	Top	0.003293	0.004755	0.005838
9TH	37.5	Top	0.003255	0.0047	0.005771
8TH	34	Top	0.003191	0.004607	0.005657
7TH	30.5	Top	0.003094	0.004467	0.005485
6TH	27	Top	0.002954	0.004265	0.005237
5TH	23.5	Top	0.002762	0.003988	0.004897
4TH	20	Top	0.002569	0.003709	0.004554
3RD	16.5	Top	0.002311	0.003337	0.004097
2ND	13	Top	0.001974	0.002851	0.0035
1ST	9.5	Top	0.001539	0.002218	0.002721
PLINTH	6	Top	0.000698	0.001006	0.001235
Base	0	Top	0	0	0

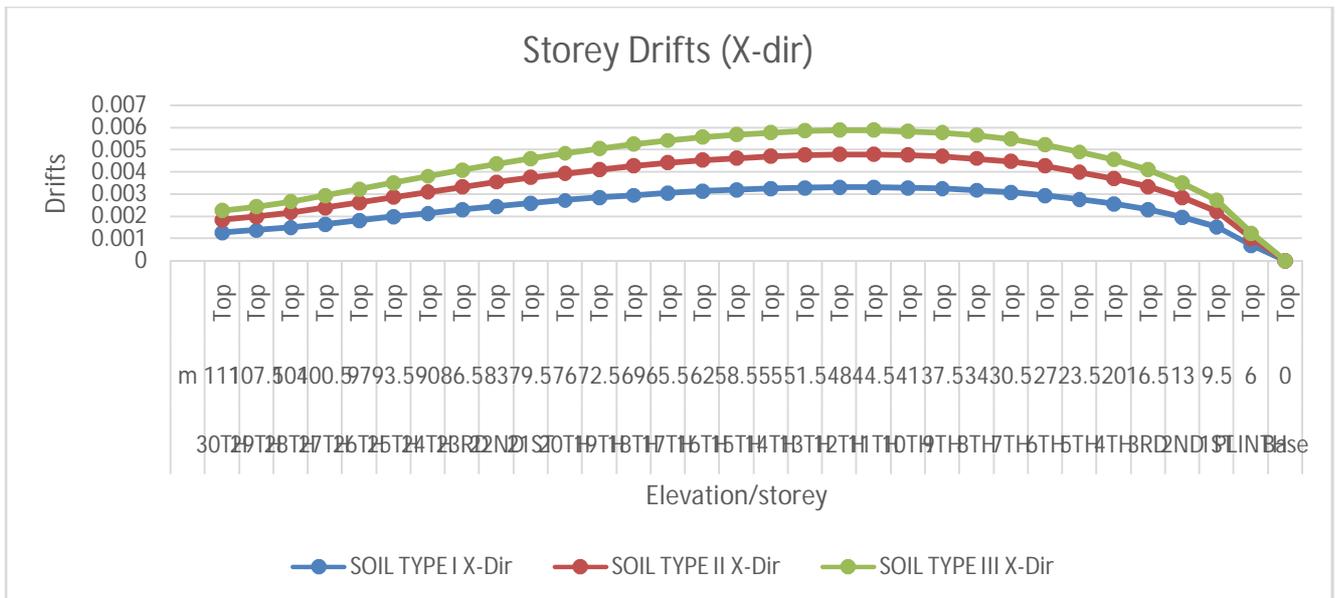
A plot for Storey Drifts of Structure in Soft Soil, Medium Soil and Hard Soil in X-Direction with load combination (DL+LL+EQXP) has been shown here

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Graph 4: Storey Drifts of Structure in Soft Soil, Medium Soil and Hard Soil in X-Direction

Table 8: Storey Drifts of Structure in Soft Soil, Medium Soil and Hard Soil in Y-Direction with load combination (DL+LL+EQYP)

Story	Elevation m	Location	SOIL TYPE I Y-Dir	SOIL TYPE II Y-Dir	SOIL TYPE III Y-Dir
30TH	111	Top	0.00188	0.002717	0.003336
29TH	107.5	Top	0.001959	0.00283	0.003475
28TH	104	Top	0.002037	0.002942	0.003613
27TH	100.5	Top	0.002129	0.003075	0.003776
26TH	97	Top	0.002228	0.003218	0.003951
25TH	93.5	Top	0.00233	0.003365	0.004133
24TH	90	Top	0.002433	0.003514	0.004314
23RD	86.5	Top	0.002533	0.003659	0.004492
22ND	83	Top	0.002629	0.003797	0.004663
21ST	79.5	Top	0.002719	0.003927	0.004823
20TH	76	Top	0.002802	0.004046	0.004969
19TH	72.5	Top	0.002875	0.004153	0.005099
18TH	69	Top	0.002939	0.004244	0.005211
17TH	65.5	Top	0.00299	0.004319	0.005303
16TH	62	Top	0.00303	0.004375	0.005373

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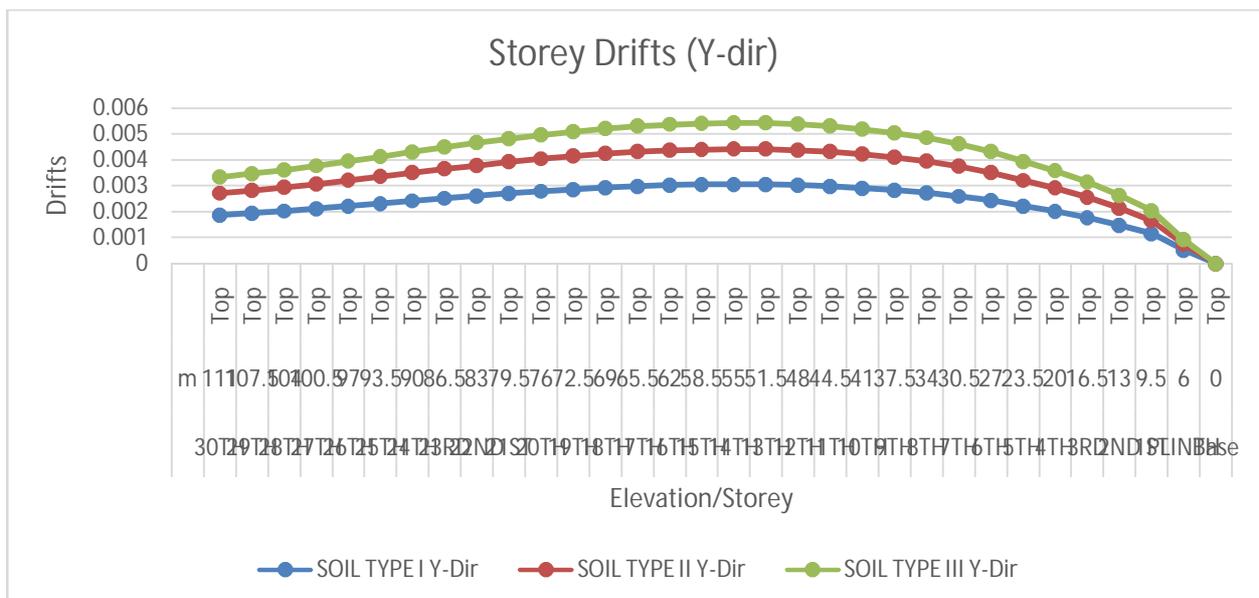
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15TH	58.5	Top	0.003055	0.004412	0.005418
14TH	55	Top	0.003066	0.004428	0.005437
13TH	51.5	Top	0.003061	0.00442	0.005428
12TH	48	Top	0.003038	0.004387	0.005387
11TH	44.5	Top	0.002997	0.004328	0.005314
10TH	41	Top	0.002924	0.004222	0.005184
9TH	37.5	Top	0.002845	0.004108	0.005044
8TH	34	Top	0.002739	0.003955	0.004857
7TH	30.5	Top	0.002606	0.003764	0.004621
6TH	27	Top	0.002437	0.003519	0.004321
5TH	23.5	Top	0.002224	0.003211	0.003943
4TH	20	Top	0.002024	0.002923	0.003589
3RD	16.5	Top	0.001778	0.002567	0.003152
2ND	13	Top	0.001487	0.002147	0.002637
1ST	9.5	Top	0.001155	0.001663	0.00204
PLINTH	6	Top	0.000523	0.000754	0.000926
Base	0	Top	0	0	0

A plot for Storey Drifts of Structure in Soft Soil, Medium Soil and Hard Soil in Y-Direction with load combination (DL+LL+EQYP) has been shown here



Graph 5: Storey Drifts of Structure in Soft Soil, Medium Soil and Hard Soil in Y-Direction

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As per Indian standard, Criteria for earthquake resistant design of structures, IS 1893 (Part 1) : 2002, the story drift in any story due to service load shall not exceed 0.004 times the story height. The height of the each storey is 3.5 m. So, the drift limitation as per IS 1893 (part 1) : 2002 is $0.004 \times 3.5 \text{ m} = 14 \text{ mm}$. The model show a similar behaviour for storey drifts as shown in graph.

Table 9: StoreyMoment of Structure in Soft Soil , Medium Soil and Hard Soil in X -Direction with load combination 1.2(DL+LL+EQXP)

Story	Elevation m	Location	SOIL TYPE I	SOIL TYPE II	SOIL TYPE III
			X-Dir kN-m	X-Dir kN-m	X-Dir kN-m
30TH	111	Top	461302.62	461302.62	461302.62
29TH	107.5	Top	993977.5463	993977.5463	993977.5463
28TH	104	Top	1526652	1526652	1526652
27TH	100.5	Top	2059327	2059327	2059327
26TH	97	Top	2592002	2592002	2592002
25TH	93.5	Top	3124677	3124677	3124677
24TH	90	Top	3657352	3657352	3657352
23RD	86.5	Top	4190027	4190027	4190027
22ND	83	Top	4722702	4722702	4722702
21ST	79.5	Top	5255377	5255377	5255377
20TH	76	Top	5788052	5788052	5788052
19TH	72.5	Top	6320727	6320727	6320727
18TH	69	Top	6853402	6853402	6853402
17TH	65.5	Top	7386077	7386077	7386077
16TH	62	Top	7918752	7918752	7918752
15TH	58.5	Top	8451427	8451427	8451427
14TH	55	Top	8984101	8984101	8984101
13TH	51.5	Top	9516776	9516776	9516776
12TH	48	Top	10049451	10049451	10049451
11TH	44.5	Top	10582126	10582126	10582126
10TH	41	Top	11114264	11114264	11114264
9TH	37.5	Top	11657622	11657622	11657622
8TH	34	Top	12200980	12200980	12200980
7TH	30.5	Top	12744338	12744338	12744338
6TH	27	Top	13287696	13287696	13287696
5TH	23.5	Top	13830115	13830115	13830115
4TH	20	Top	14400583	14400583	14400583
3RD	16.5	Top	14971051	14971051	14971051
2ND	13	Top	15541519	15541519	15541519

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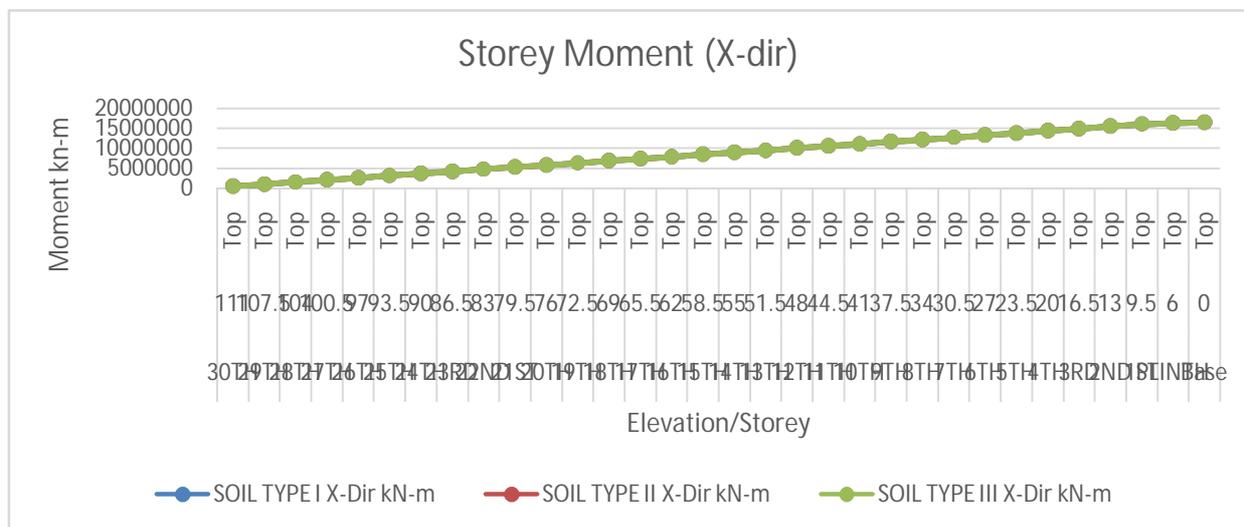
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1ST	9.5	Top	16111987	16111987	16111987
PLINTH	6	Top	16341549	16341549	16341549
Base	0	Top	16531220	16531220	16531220

A plot for StoreyMoment of Structure in Soft Soil , Medium Soil and Hard Soil in X -Direction with load combination 1.2(DL+LL+EXP)has been shown here



Graph 6: StoreyMoment of Structure in Soft Soil , Medium Soil and Hard Soil in X -Direction

Table 10: StoreyMoment of Structure in Soft Soil , Medium Soil and Hard Soil in Y -Direction with load combination 1.2(DL+LL+EQYP)

Story	Elevation m	Location	SOIL TYPE I	SOIL TYPE II	SOIL TYPE III
			Y-Dir kN-m	Y-Dir kN-m	Y-Dir kN-m
30TH	111	Top	-500286	-500286	-500286
29TH	107.5	Top	-1077976	-1077976	-1077976
28TH	104	Top	-1655665	-1655665	-1655665
27TH	100.5	Top	-2233355	-2233355	-2233355
26TH	97	Top	-2811045	-2811045	-2811045
25TH	93.5	Top	-3388734	-3388734	-3388734
24TH	90	Top	-3966424	-3966424	-3966424
23RD	86.5	Top	-4544114	-4544114	-4544114
22ND	83	Top	-5121804	-5121804	-5121804
21ST	79.5	Top	-5699493	-5699493	-5699493
20TH	76	Top	-6277183	-6277183	-6277183
19TH	72.5	Top	-6854873	-6854873	-6854873
18TH	69	Top	-7432562	-7432562	-7432562
17TH	65.5	Top	-8010252	-8010252	-8010252

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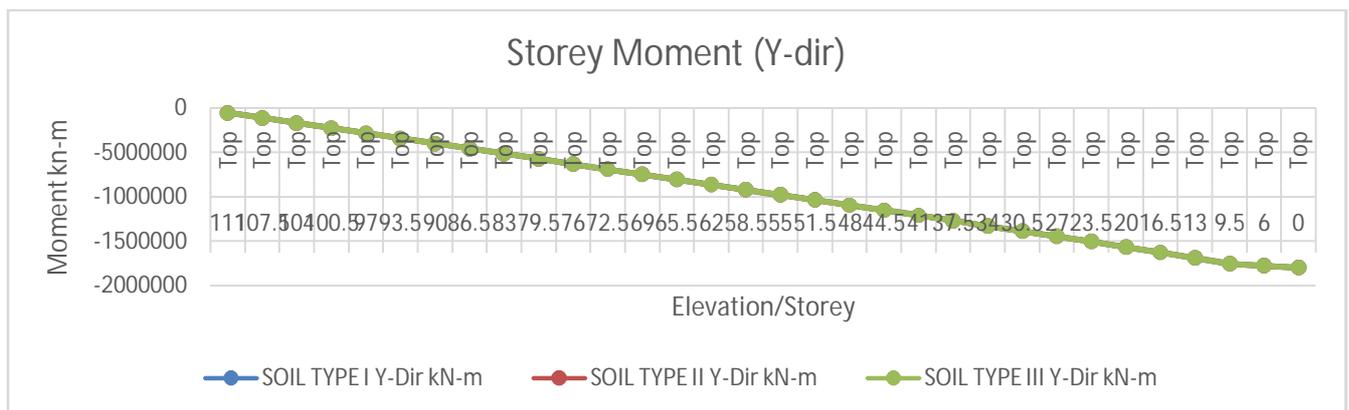
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16TH	62	Top	-8587942	-8587942	-8587942
15TH	58.5	Top	-9165632	-9165632	-9165632
14TH	55	Top	-9743321	-9743321	-9743321
13TH	51.5	Top	-10321011	-10321011	-10321011
12TH	48	Top	-10898701	-10898701	-10898701
11TH	44.5	Top	-11476390	-11476390	-11476390
10TH	41	Top	-12053498	-12053498	-12053498
9TH	37.5	Top	-12642774	-12642774	-12642774
8TH	34	Top	-13232049	-13232049	-13232049
7TH	30.5	Top	-13821325	-13821325	-13821325
6TH	27	Top	-14410600	-14410600	-14410600
5TH	23.5	Top	-14998857	-14998857	-14998857
4TH	20	Top	-15617533	-15617533	-15617533
3RD	16.5	Top	-16236210	-16236210	-16236210
2ND	13	Top	-16854887	-16854887	-16854887
1ST	9.5	Top	-17473563	-17473563	-17473563
PLINTH	6	Top	-17722524	-17722524	-17722524
Base	0	Top	-17928224	-17928224	-17928224

A plot for StoreyMoment of Structure in Soft Soil , Medium Soil and Hard Soil in Y -Direction with load combination 1.2(DL+LL+EYP)has been shown here



Graph 7: StoreyMoment of Structure in Soft Soil , Medium Soil and Hard Soil in Y -Direction

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Table 11: StoreyShear of Structure in Soft Soil , Medium Soil and Hard Soil in X -Direction with load combination1.2 (DL+LL+EQXP)

Story	Elevation m	Location	SOIL TYPE I	SOIL TYPE II	SOIL TYPE III
			X-Dir kN	X-Dir kN	X-Dir kN
30TH	111	Top	-881.5928	-1278.9934	-1570.5287
		Bottom	-881.5928	-1278.9934	-1570.5287
29TH	107.5	Top	-1780.1594	-2575.8833	-3163.0332
		Bottom	-1780.1594	-2575.8833	-3163.0332
28TH	104	Top	-2621.1672	-3789.6994	-4653.5279
		Bottom	-2621.1672	-3789.6994	-4653.5279
27TH	100.5	Top	-3406.5212	-4923.191	-6045.3889
		Bottom	-3406.5212	-4923.191	-6045.3889
26TH	97	Top	-4138.1264	-5979.1077	-7341.9925
		Bottom	-4138.1264	-5979.1077	-7341.9925
25TH	93.5	Top	-4817.8879	-6960.199	-8546.7149
		Bottom	-4817.8879	-6960.199	-8546.7149
24TH	90	Top	-5447.7107	-7869.2143	-9662.9322
		Bottom	-5447.7107	-7869.2143	-9662.9322
23RD	86.5	Top	-6029.4997	-8708.9032	-10694.0208
		Bottom	-6029.4997	-8708.9032	-10694.0208
22ND	83	Top	-6565.1601	-9482.0151	-11643.3568
		Bottom	-6565.1601	-9482.0151	-11643.3568
21ST	79.5	Top	-7056.5968	-10191.2996	-12514.3164
		Bottom	-7056.5968	-10191.2996	-12514.3164
20TH	76	Top	-7505.7148	-10839.5061	-13310.2758
		Bottom	-7505.7148	-10839.5061	-13310.2758
19TH	72.5	Top	-7914.4193	-11429.3841	-14034.6113
		Bottom	-7914.4193	-11429.3841	-14034.6113
18TH	69	Top	-8284.6151	-11963.6831	-14690.6991
		Bottom	-8284.6151	-11963.6831	-14690.6991
17TH	65.5	Top	-8618.2073	-12445.1526	-15281.9153
		Bottom	-8618.2073	-12445.1526	-15281.9153
16TH	62	Top	-8917.101	-12876.5421	-15811.6362
		Bottom	-8917.101	-12876.5421	-15811.6362
15TH	58.5	Top	-9183.2011	-13260.6011	-16283.2381
		Bottom	-9183.2011	-13260.6011	-16283.2381
14TH	55	Top	-9418.4127	-13600.079	-16700.097
		Bottom	-9418.4127	-13600.079	-16700.097

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13TH	51.5	Top	-9624.6408	-13897.7254	-17065.5893
		Bottom	-9624.6408	-13897.7254	-17065.5893
12TH	48	Top	-9803.7903	-14156.2898	-17383.0911
		Bottom	-9803.7903	-14156.2898	-17383.0911
11TH	44.5	Top	-9957.7665	-14378.5216	-17655.9787
		Bottom	-9957.7665	-14378.5216	-17655.9787
10TH	41	Top	-10089.9567	-14569.182	-17890.0985
		Bottom	-10089.9567	-14569.182	-17890.0985
9TH	37.5	Top	-10201.9125	-14730.541	-18088.2378
		Bottom	-10201.9125	-14730.541	-18088.2378
8TH	34	Top	-10293.9453	-14863.1853	-18251.1172
		Bottom	-10293.9453	-14863.1853	-18251.1172
7TH	30.5	Top	-10368.0053	-14969.926	-18382.1886
		Bottom	-10368.0053	-14969.926	-18382.1886
6TH	27	Top	-10426.0433	-15053.5745	-18484.904
		Bottom	-10426.0433	-15053.5745	-18484.904
5TH	23.5	Top	-10471.2659	-15118.6467	-18564.8088
		Bottom	-10471.2659	-15118.6467	-18564.8088
4TH	20	Top	-10504.9963	-15167.1024	-18624.3095
		Bottom	-10504.9963	-15167.1024	-18624.3095
3RD	16.5	Top	-10527.954	-15200.0825	-18664.8072
		Bottom	-10527.954	-15200.0825	-18664.8072
2ND	13	Top	-10542.2051	-15220.5551	-18689.9463
		Bottom	-10542.2051	-15220.5551	-18689.9463
1ST	9.5	Top	-10549.8156	-15231.4879	-18703.3712
		Bottom	-10549.8156	-15231.4879	-18703.3712
PLINTH	6	Top	-10551.4929	-15233.767	-18706.1697
		Bottom	-10551.4929	-15233.767	-18706.1697
Base	0	Top	0	0	0
		Bottom	0	0	0

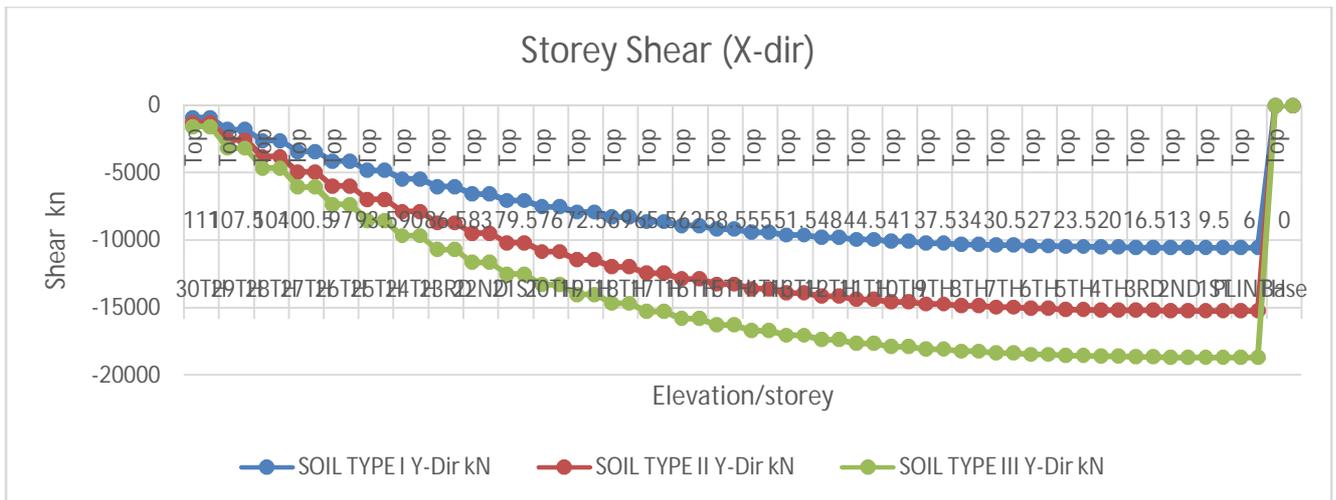
A plot for StoreyShear of Structure in Soft Soil , Medium Soil and Hard Soil in X -Direction with load combination 1.2(DL+LL+EXP) has been shown here

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Graph 8: Storey Shear of Structure in Soft Soil, Medium Soil and Hard Soil in X-Direction

Column Forces

Table 12: column axial force, P for structure with the load combination 1.2 (DL+LL+EQXP) & 1.2 (DL+LL+EQYP) in soft, medium & hard soil

TABLE: Column Forces					SOIL TYPE I	SOIL TYPE II	SOIL TYPE III
Story	Column	Unique Name	Load Case/Combo	Station m	P kN	P kN	P kN
1ST	C34	67	12DLRLLQXP	0	-24381.5444	-25446.3503	-26235.5482
1ST	C34	67	12DLRLLQXP	1.45	-24313.5757	-25378.3816	-26167.5794
1ST	C34	67	12DLRLLQXP	2.9	-24245.6069	-25310.4128	-26099.6107
1ST	C34	67	12DLRLLQYP	0	-23345.1752	-23949.6572	-24397.697
1ST	C34	67	12DLRLLQYP	1.45	-23277.2065	-23881.6884	-24329.7283
1ST	C34	67	12DLRLLQYP	2.9	-23209.2377	-23813.7197	-24261.7595

Table 13: column Moment, M for structure with the load combination 1.2 (DL+LL+EQXP) & 1.2 (DL+LL+EQYP) in soft, medium & hard soil

TABLE: Column Forces				SOIL TYPE I	SOIL TYPE I	SOIL TYPE II	SOIL TYPE II	SOIL TYPE III	SOIL TYPE III	
Story	Column	Unique Name	Load Case/Combo	Station m	M2 kN-m	M3 kN-m	M2 kN-m	M3 kN-m	M2 kN-m	M3 kN-m
1ST	C34	67	12DLRLLQXP	0	-239.9922	1271.7973	-325.927	1862.7469	-389.6526	2300.9465
1ST	C34	67	12DLRLLQXP	1.45	-142.186	1095.4925	-206.7527	1610.877	-254.632	1993.0377
1ST	C34	67	12DLRLLQXP	2.9	-44.3799	919.1878	-87.5785	1359.0072	-119.6113	1685.1289
1ST	C34	67	12DLRLLQYP	0	1153.6344	-157.4043	1686.2828	-200.7817	2081.2226	-232.9453
1ST	C34	67	12DLRLLQYP	1.45	974.8851	-107.0072	1406.1652	-125.3418	1725.9364	-138.9369
1ST	C34	67	12DLRLLQYP	2.9	796.1358	-56.6101	1126.0477	-49.9019	1370.6502	-44.9285

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Table 13:columnShear, V for structure with the load combination 1.2 (DL+LL+EQXP)&1.2 (DL+LL+EQYP) in soft ,medium &hard soil

TABLE: Column Forces				SOIL TYPE I	SOIL TYPE I	SOIL TYPE II	SOIL TYPE II	SOIL TYPE III	SOIL TYPE III	
Story	Column	Unique Name	Load Case/Combo	Station m	V2 kN	V3 kN	V2 kN	V3 kN	V2 kN	V3 kN
1ST	C34	67	12DLRLLQXP	0	121.5895	-67.4525	173.7034	-82.1892	212.3509	-93.1177
1ST	C34	67	12DLRLLQXP	1.45	121.5895	-67.4525	173.7034	-82.1892	212.3509	-93.1177
1ST	C34	67	12DLRLLQXP	2.9	121.5895	-67.4525	173.7034	-82.1892	212.3509	-93.1177
1ST	C34	67	12DLRLLQYP	0	-34.7566	123.2754	-52.0275	193.1845	-64.8334	245.025
1ST	C34	67	12DLRLLQYP	1.45	-34.7566	123.2754	-52.0275	193.1845	-64.8334	245.025
1ST	C34	67	12DLRLLQYP	2.9	-34.7566	123.2754	-52.0275	193.1845	-64.8334	245.025

Table 13:columnTorsion, T for structure with the load combination 1.2 (DL+LL+EQXP)&1.2 (DL+LL+EQYP) in soft ,medium &hard soil

TABLE: Column Forces					SOIL TYPE I	SOIL TYPE II	SOIL TYPE III
Story	Column	Unique Name	Load Case/Combo	Station m	T kN-m	T kN-m	T kN-m
1ST	C34	67	12DLRLLQXP	0	-42.3525	-61.1008	-75.004
1ST	C34	67	12DLRLLQXP	1.45	-42.3525	-61.1008	-75.004
1ST	C34	67	12DLRLLQXP	2.9	-42.3525	-61.1008	-75.004
1ST	C34	67	12DLRLLQYP	0	46.1375	66.66	81.8788
1ST	C34	67	12DLRLLQYP	1.45	46.1375	66.66	81.8788
1ST	C34	67	12DLRLLQYP	2.9	46.1375	66.66	81.8788

Pier Forces

Table 14: Pier Axial Force, P for structure with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP) in soft ,medium&hard soil

TABLE: Pier Forces				SOIL TYPE I	SOIL TYPE II	SOIL TYPE III
Story	Pier	Load Case/Combo	Location	P kN	P kN	P kN
1ST	P3	12DLRLLQXP	Top	-6497.8574	-3330.9739	-983.1011
1ST	P3	12DLRLLQXP	Bottom	-6627.7949	-3460.9114	-1113.0386
1ST	P3	12DLRLLQYP	Top	-13631.3189	-13631.3189	-13631.3189
1ST	P3	12DLRLLQYP	Bottom	-13761.2564	-13761.2564	-13761.2564

Table 15: Pier Moment, M for structure with the load combination 1.2 (DL+LL+EQXP)&1.2 (DL+LL+EQYP) in soft ,medium &hard soil

TABLE: Pier Forces				SOIL TYPE I	SOIL TYPE I	SOIL TYPE II	SOIL TYPE II	SOIL TYPE III	SOIL TYPE III
Story	Pier	Load Case/Combo	Location	M2 kN-m	M3 kN-m	M2 kN-m	M3 kN-m	M2 kN-m	M3 kN-m
1ST	P3	12DLRLLQXP	Top	-17.4689	1861.0597	-25.2213	3005.3081	-30.9703	3853.6925
1ST	P3	12DLRLLQXP	Bottom	21.225	6530.9935	30.6443	8971.8027	37.6294	10781.7386
1ST	P3	12DLRLLQYP	Top	21.4569	-716.6361	30.9946	-716.6361	38.0596	-716.6361
1ST	P3	12DLRLLQYP	Bottom	138.7803	1031.4388	200.3734	1031.4388	246.0468	1031.4388

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Table 16: Pier Shear Force, V for structure with the load combination 1.2 (DL+LL+EQXP)&1.2 (DL+LL+EQYP) in soft ,medium&hard soil

TABLE: Pier Forces				SOIL TYPE I	SOIL TYPE I	SOIL TYPE II	SOIL TYPE II	SOIL TYPE III	SOIL TYPE III
Story	Pier	Load Case/Combo	Location	V2 kN	V3 kN	V2 kN	V3 kN	V2 kN	V3 kN
1ST	P3	12DLRLLQXP	Top	1334.2668	11.0554	1704.7127	15.9616	1979.4418	19.5999
1ST	P3	12DLRLLQXP	Bottom	1334.2668	11.0554	1704.7127	15.9616	1979.4418	19.5999
1ST	P3	12DLRLLQYP	Top	499.45	33.521	499.45	48.3939	499.45	59.4249
1ST	P3	12DLRLLQYP	Bottom	499.45	33.521	499.45	48.3939	499.45	59.4249

Table 17: Pier Torsion, T for structure with the load combination 1.2 (DL+LL+EQXP)&1.2 (DL+LL+EQYP) in soft ,medium&hard soil

TABLE: Pier Forces				SOIL TYPE I	SOIL TYPE II	SOIL TYPE III
Story	Pier	Load Case/Combo	Location	T kN-m	T kN-m	T kN-m
1ST	P3	12DLRLLQXP	Top	-17.3115	-24.9942	-30.6914
1ST	P3	12DLRLLQXP	Bottom	-17.3115	-24.9942	-30.6914
1ST	P3	12DLRLLQYP	Top	35.9013	51.8336	63.6486
1ST	P3	12DLRLLQYP	Bottom	35.9013	51.8336	63.6486

TABLE18: Modal Load Participation Ratios

Case	Item Type	Item	Static %	Dynamic %
Modal	Acceleration	UX	99.99	94.54
Modal	Acceleration	UY	99.97	91.83
Modal	Acceleration	UZ	0	0

According to IS-1893:2002 the number of modes to be used in the analysis should be such that the total sum of modal masses of all modes considered is at least 90 percent of the total seismic mass. Here the minimum modal mass is 91.83 percent.

Table 19: Modal Participating Mass Ratios

Case	Mode	Period sec	UX	UY	UZ	RX	RY	RZ
Modal	1	6.375	0	0	0	0	0	0.7717
Modal	2	6.21	0.7557	0	0	0	0.2514	0
Modal	3	5.792	0	0.7165	0	0.2936	0	0
Modal	4	2.102	0	0	0	0	0	0.1043
Modal	5	1.901	0.1165	0	0	0	0.4355	0
Modal	6	1.575	0	0.1415	0	0.3632	0	0
Modal	7	1.212	0	0	0	0	0	0.0421
Modal	8	0.983	0.0469	0	0	0	0.0811	0
Modal	9	0.815	0	0	0	0	0	0.0227
Modal	10	0.714	0	0.0603	0	0.116	0	0
Modal	11	0.604	0.0263	0	0	0	0.078	0
Modal	12	0.589	0	0	0	0	0	0.0141

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Here the minimum modal mass for accelerations U_x and U_y is 94.54 % and 91.38 % respectively.

Table 20: Modal Periods and Frequencies

TABLE: Modal Periods and Frequencies SOIL TYPE I				SOIL TYPE II	SOIL TYPE II	SOIL TYPE III	SOIL TYPE III
Case	Mode	Period	Frequency	Period	Frequency	Period	Frequency
		sec	cyc/sec	sec	cyc/sec	sec	cyc/sec
Modal	1	6.375	0.157	6.375	0.157	6.375	0.157
Modal	2	6.21	0.161	6.21	0.161	6.21	0.161
Modal	3	5.792	0.173	5.792	0.173	5.792	0.173
Modal	4	2.102	0.476	2.102	0.476	2.102	0.476
Modal	5	1.901	0.526	1.901	0.526	1.901	0.526
Modal	6	1.575	0.635	1.575	0.635	1.575	0.635
Modal	7	1.212	0.825	1.212	0.825	1.212	0.825
Modal	8	0.983	1.017	0.983	1.017	0.983	1.017
Modal	9	0.815	1.226	0.815	1.226	0.815	1.226
Modal	10	0.714	1.401	0.714	1.401	0.714	1.401
Modal	11	0.604	1.656	0.604	1.656	0.604	1.656
Modal	12	0.589	1.697	0.589	1.697	0.589	1.697

Mode 1 is having maximum time period of 6.375 sec and 0.157 cyc/sec Frequency which is same for all three type of soils.

Mode shapes of shear wall

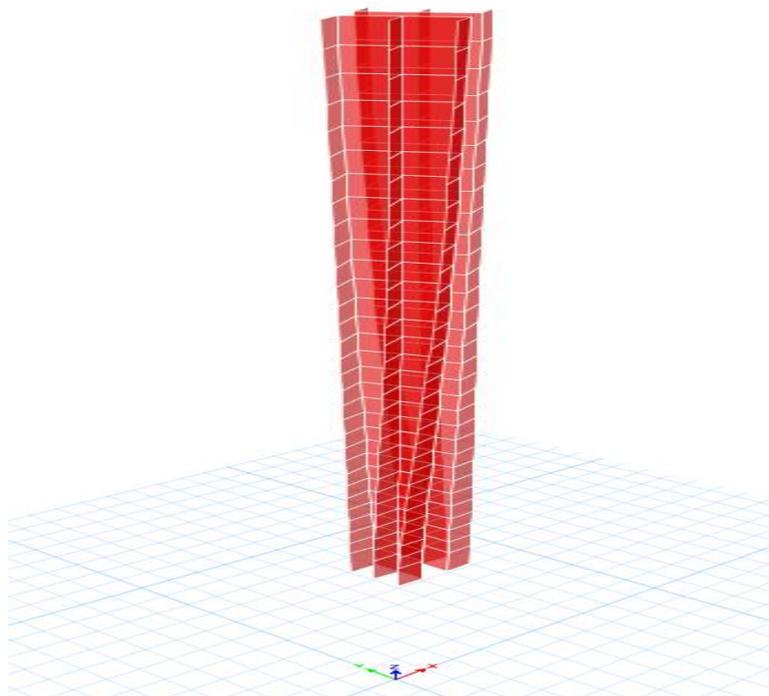


Figure 3: Mode shape 1 for shear wall

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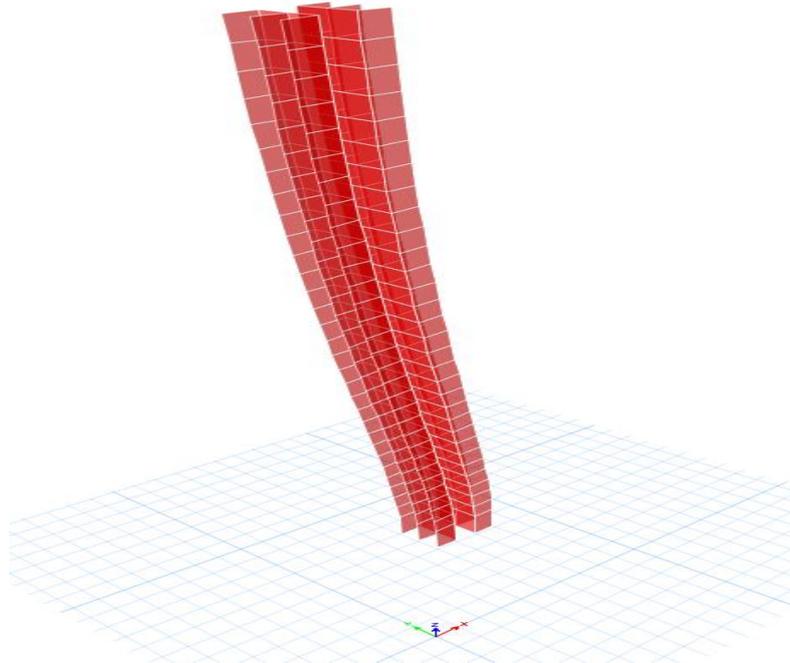


Figure 4: Mode shape 2 for shear wall

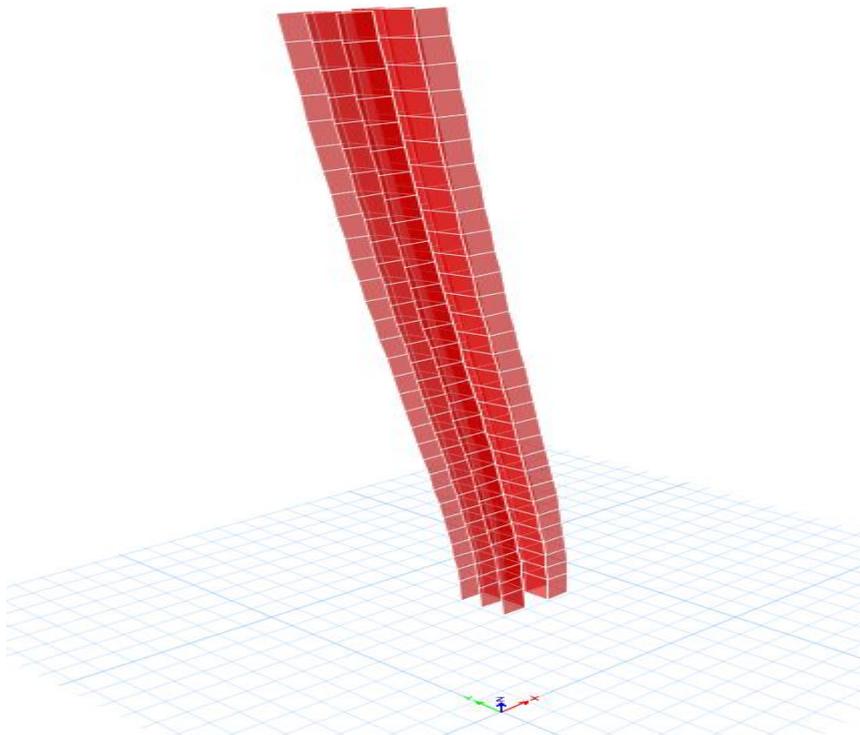


Figure 5: Mode shape 3 for shear wall

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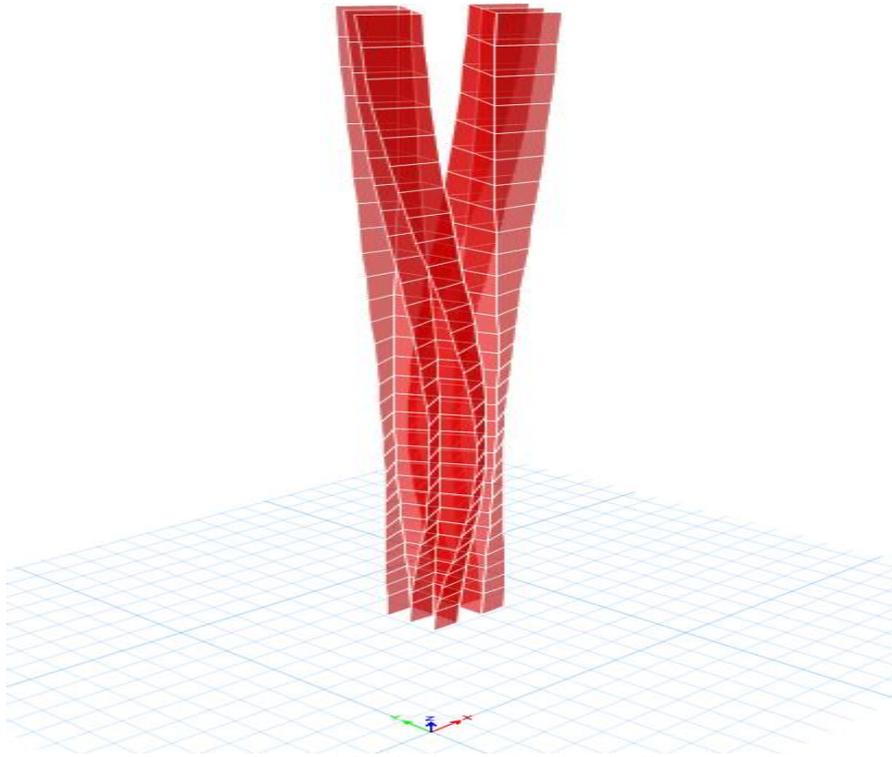


Figure 6: Mode shape 4 for shear wall

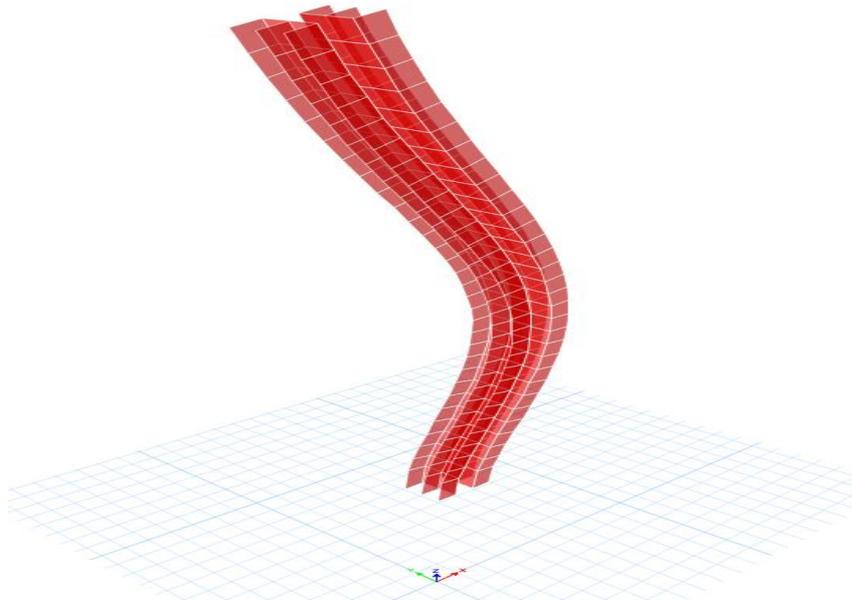


Figure 7: Mode shape 5 for shear wall

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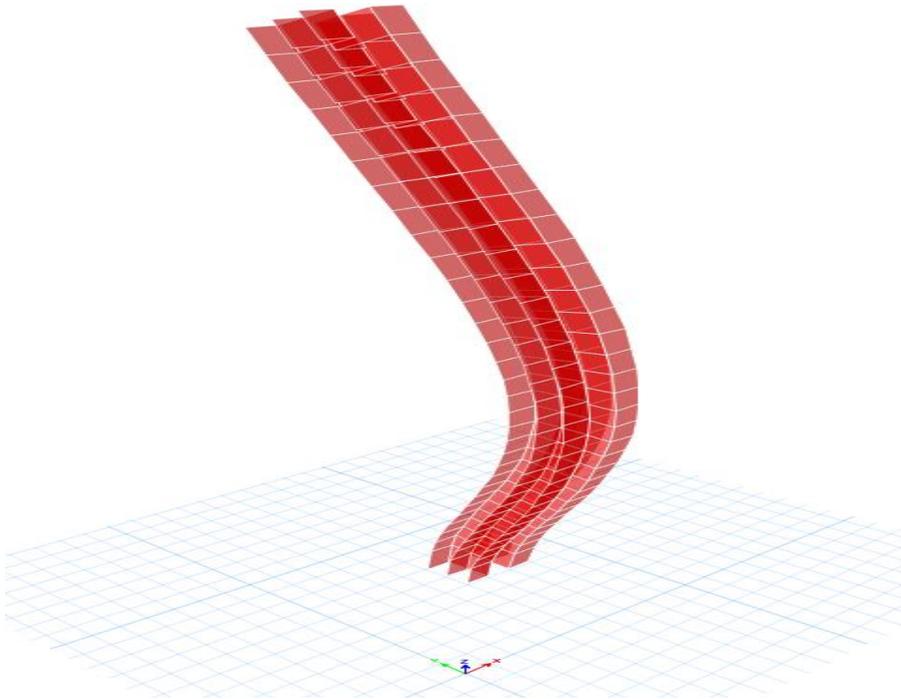


Figure 8: Mode shape 6 for shear wall

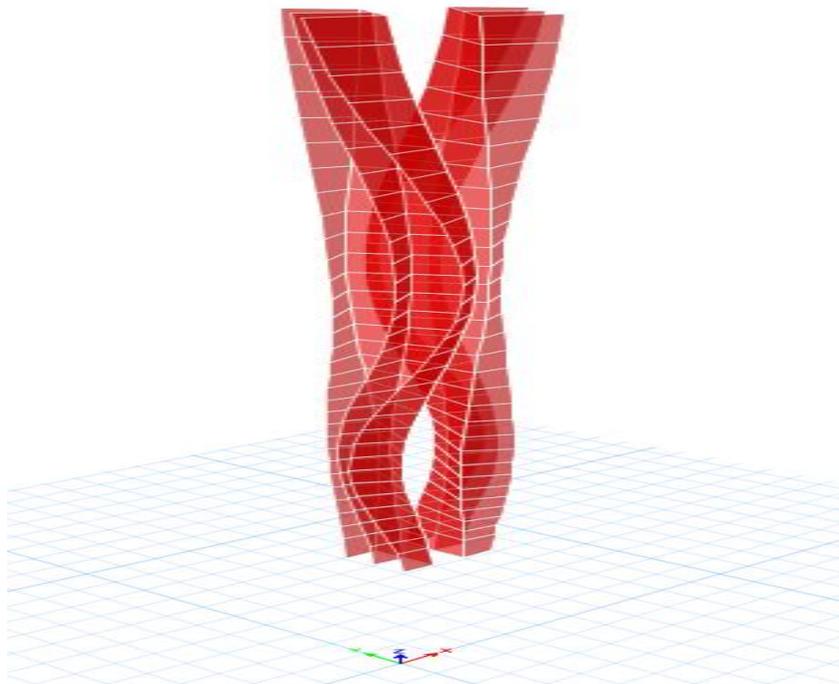


Figure 9: Mode shape 7 for shear wall

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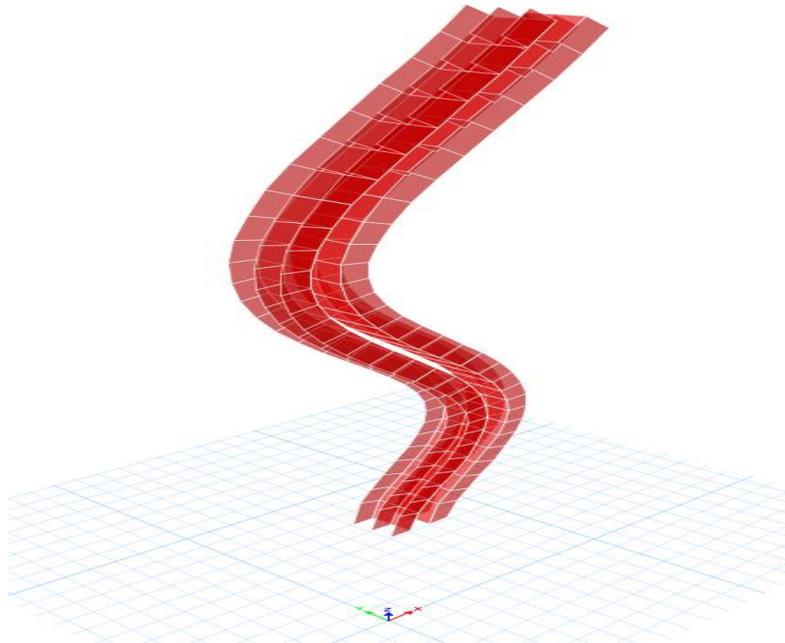


Figure 10: Mode shape 8 for shear wall

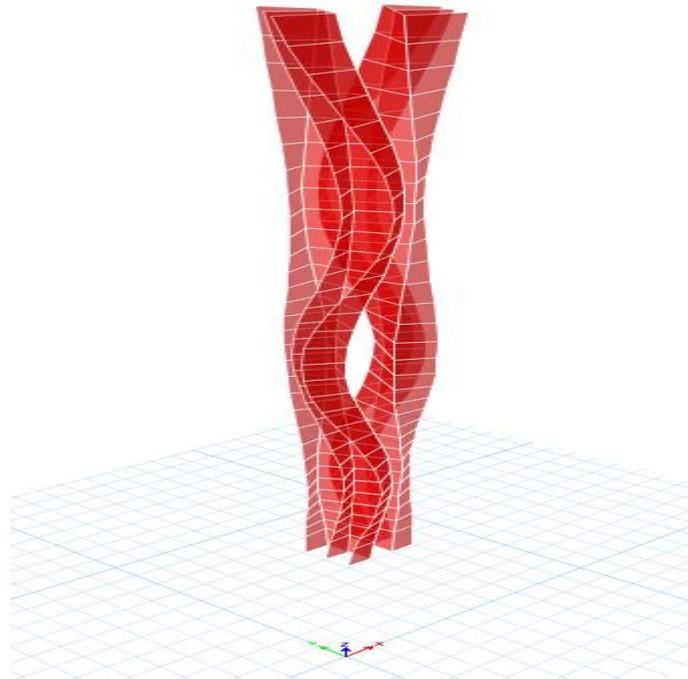


Figure 11: Mode shape 9 for shear wall

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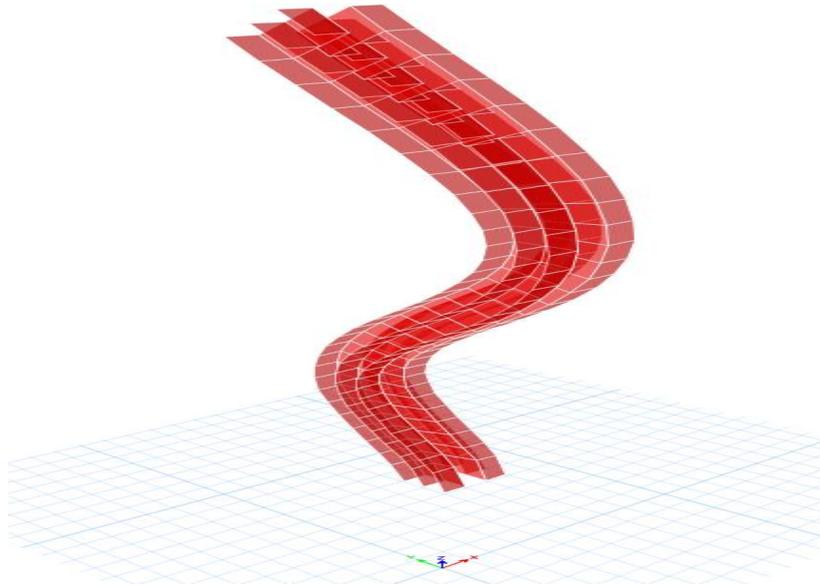


Figure 12: Mode shape 10 for shear wall

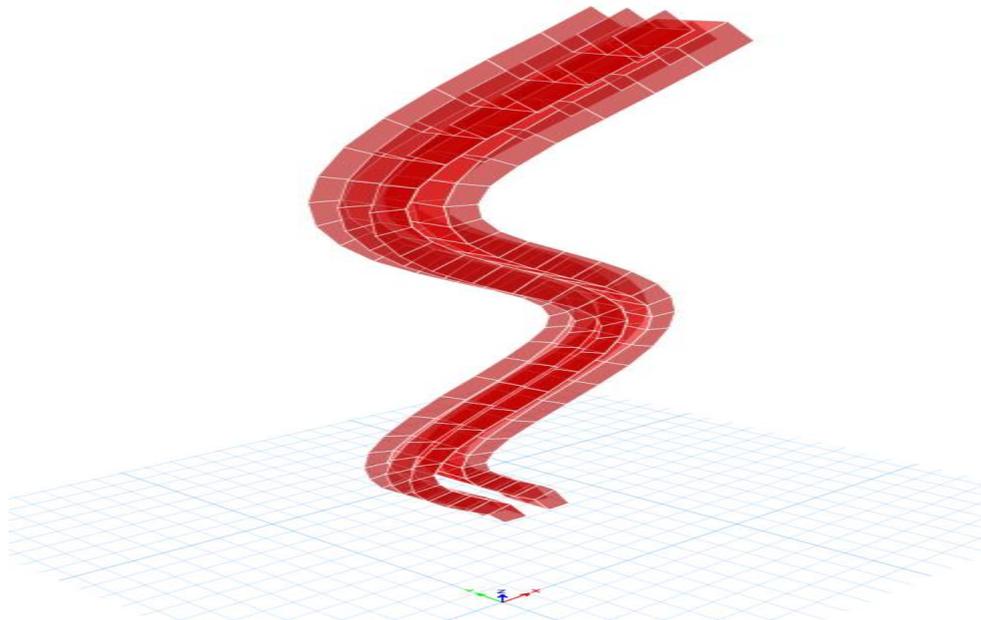


Figure 13: Mode shape 11 for shear wall

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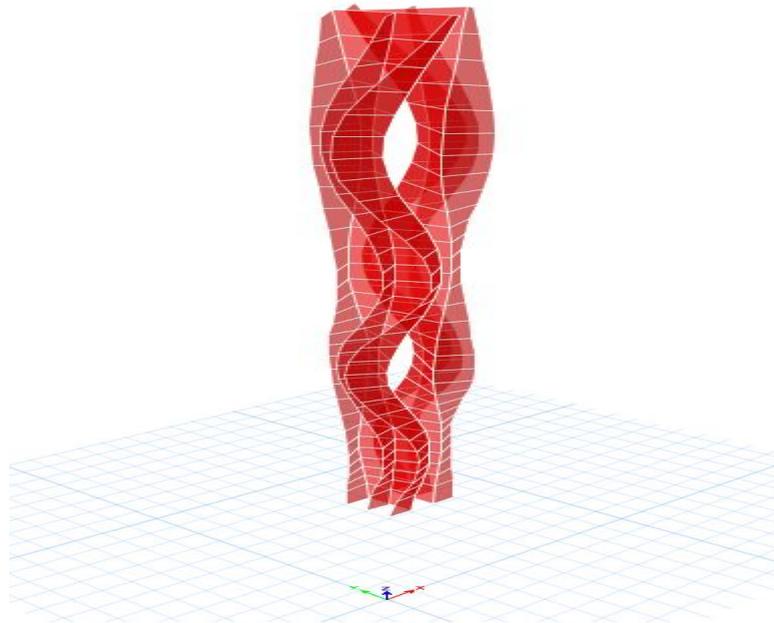


Figure 14: Mode shape 12 for shear wall

DISCUSSION ON RESULTS

The result obtained from the analysis models will be discussed and compared as follows:

It is observed that

- The time period is 6.375Sec for structure and it is same for different type of soil.
- The Frequency is 0.157 cyc/sec and it is same for different type of soil.

It is observed that

- The percentage of displacement in X& Y direction is more by 44.5 % of the model in medium soil and 77.5 % of model in hard soil compared with model in soft soil.

It is observed that

- The maximum storey drift in X-direction occurred at storey 11th for the model in hard ,medium and soft soil.
- The percentage of storey drift in X- direction is decreased by placing shear wall as shown below :-
- 44.5 % of model in medium soil compared with model in soft soil.
- 77.4 % of model in hard soil compared with model in soft soil.

It is observed that

- The column axial force is various with type of soil and placing of the shear wall.column axial force in soft soil>medium soil>hard soil.

It is observed that

- The column moment in Y-direction is influenced by the type of soil and placing of shear wall.
- The column moment M2 in X-direction for soft Soil >Medium soil > Hard soil.
- The column moment M3 in X-direction for soft Soil <Medium soil < Hard soil.
- The column moment M2 in Y-direction for soft Soil <Medium soil < Hard soil.
- The column moment M3in Y-direction for soft Soil >Medium soil > Hard soil.

It is observed that

- The column Shear V2 in X-direction for soft Soil <Medium soil < Hard soil.
- The column Shear V3 in X-direction for soft Soil >Medium soil > Hard soil.
- The column Shear V2 in Y-direction for soft Soil >Medium soil > Hard soil.

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- The column Shear V3 in Y-direction for soft Soil <Medium soil <Hard soil.

It is observed that

- The column Torsion T, in X-direction for soft Soil >Medium soil > Hard soil.
- The column Torsion T, in Y-direction for soft Soil <Medium soil < Hard soil.

It is observed that

Shear Wall forces (Pier Forces)

- Pier axial forces in X direction for soft Soil <Medium soil < Hard soil
- Pier Moment M2 in X direction for soft soil >medium soil > hard soil .
- Pier Moment M3 in X direction for soft soil <medium soil < hard soil .
- Pier Moment M2 in Y direction for soft soil <Medium soil < hard soil .
- Pier Moment M3 in Y direction for soft soil >Medium soil > hard soil .
- Pier Shear Forces V2 in X direction for soft soil <Medium soil < hard soil.
- Pier Shear Forces V3 in X direction for soft soil >Medium soil > hard soil.
- Pier Torsion in X direction for soft soil >Medium soil > hard soil.
- Pier Torsion in Y direction for soft soil <Medium soil < hard soil.

It is observed that

- There is considerable difference in storey shear force in x-direction with a type of soils and structures.
- The value of the storey shear force in x-direction decreases with increase in storey level.
- The value of the storey shear force in x-direction for the structure in soft soil is more compared with the structure in hard and medium soil.

It is observed that

- The value of the lateral loads in x-direction decreases with increase in storey level.
- The value of the lateral loads in x-direction for the structure in soft soil is less compared with the structure in medium soil and hard soil.
- lateral loads in X-direction for the structure in soft soil <Medium soil < hard soil.

It is observed that

- There is not difference in a storey moment in x-direction with different type of soils.
- There is not difference in a storey moment in y-direction with different type of soils.

It is observed that

- The value of the Stiffness of Structure in Soft Soil , Medium Soil and Hard Soil in X –Dir for load cases EQXP is same .
- The value of the Stiffness of Structure in Soft Soil , Medium Soil and Hard Soil in Y –Dir for load cases EQYP is same .

VI. CONCLUSIONS

The following conclusions are made from the present study:-

- ❖ The shear wall and its position has a significant influence on the time period. The time period is not influenced by the type of soil.
- ❖ Shear is affected marginally by placing of the shear wall, grouping of shear wall and type of soil. The shear is increased by adding shear wall due to increase the seismic weight of the building.
- ❖ Provision of the shear wall, generally results in reducing the displacement because the shear wall increases the stiffness of the building. The displacement is influenced by type and location of the shear wall and also by changing soil condition. The better performance for model with soft soil because it has low displacement.
- ❖ As per code, the actual drift is less than permissible drift. The parallel arrangement of shear wall in the center core and outer periphery is giving very good result in controlling drift in both the direction. The better performance for model with soft soil because it has low storey drift.

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- ❖ The shear force resisted by the column frame is decreasing by placing the shear wall and the shear force resisted by the shear wall is increasing. This can be concluded indirectly by observing the maximum column shear force and moment in both directions.
- ❖ The moment resisting frame with shear walls are very good in lateral force such as earthquake and wind force. The shear walls provide lateral load distribution by transferring the wind and earthquake loads to the foundation. And also impact on the lateral stiffness of the system and also carries gravity loads.
- ❖ It is evident that shear walls which are provided from the foundation to the rooftop, are one of the excellent mean for providing earthquake resistant to multistory reinforced building with different type of soil.
- ❖ For the columns located away from the shear wall the Bending Moment is high and shear force is less when compared with the columns connected to the shear wall.
- ❖ It is observed that the column axial force is various with type of soil and placing of the shear wall.
- ❖ It is observed that the column shear force in x-direction is influenced by the type of soil and placing of the shear wall.
- ❖ It is observed that the column torsion is influenced by the type of soil and placing shear wall.
- ❖ It is observed that the column moment in y-direction is influenced by the type of soil and placing of shear wall.
- ❖ It is observed that the Pier shear force in x& y-direction is influenced with a different type of soil and placing shear wall.
- ❖ It is observed that the pier Torsion in x& y-direction influenced with a different type of soil and placing shear wall.
- ❖ It is observed that the value of storey moment in x& y-direction is same for the model with a different type of soil and placing shear wall.
- ❖ It is observed that the pier Moment in x& y-direction is influenced with a different type of soil and placing shear wall.
- ❖ It is observed that the Pier Axial Force is various with type of soil and placing of the shear wall.
- ❖ It is observed that the value of stiffness in x& y-direction is same for the model with a different type of soil and placing shear wall.

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