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Study theImpact ofEarthquake load on Behavior of I Shape RC Shear Wallsat the Centerof Structure

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ABSTRACT
The usefulness of shear walls in the structural planning of multistory buildings has long been recognized .Shear walls are located on each level of the structure, to form an effective box structure, equal length shear walls are placed symmetrically on opposite sides of exterior walls of the building. Shear walls are added to the building interior to provide extra strength and stiffness to the building when the exterior walls cannot provide sufficient strength and stiffness or when the allowable span-width ratio for the floor or roof diaphragm is exceeded. Shear walls are analyzed to resist two types of forces: shear forces and uplift forces. Shear forces are created throughout the height of the wall between the top and bottom shear wall connections. Uplift forces exist on shear walls because the horizontal forces are applied to the top of the wall. These uplift forces try to lift up one end of the wall and push the other end down. In some cases, the uplift force is large enough to tip the wall over. Shear walls are analyzed to the provide necessary lateral strength to resist horizontal forces. Shear walls are strong enough, to transfer these horizontal forces to the next element in the load path below them. 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 this paper 30 story building with I Shape RC Shear wall at the center in Concrete Frame Structure with fixed support conditionsunder different type of soil for earthquake zone V as per IS 1893 (part 1) : 2002 in India are analyzed using software ETABS by Dynamic analysis(Response Spectrum method). All the analyses has been carried out as per the Indian Standard code books.This paper aims to Study the behaviour of high rise structure with dual system withI ShapeRC Shear Walls under different type of soil conditionwith seismic loading . Estimation of structural response such as; storey shear, storey drift,storey displacements, storey moment,Pier Forces, column forces ,Time period and frequency,Stiffness, Mode shape of shear walls is carried out.

***Keywords*_**I Shape RC Shear Wall, Response Spectrum Method,Soft ,Medium &Hard Soil, Structural Response

I.INTRODUCTION

Background

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. 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.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, I shape,box etc. can be used. Provision of walls helps to divide an enclose space, whereas of cores to contain and convey services such as elevator.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 construction cost and effectiveness in minimizing earthquake damage in structural and nonstructural elements (like glass windows and building contents).

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:

1. **Hard**- Those soils, which have an allowable bearing capacity of more than 10t/m2.
2. **Medium** - Those soils, which have an allowable bearing capacity less than or equal to 10t/m2
3. **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 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.

Based on the literature review, the salient objective of the present study have been identified as follows:

- ❖ behaviour of high rise structure with dual system withI shape RC Shear Wallswith seismic loading.
- ❖ To examine the effect of different types of soil (Hard, medium and Soft) on the overall interactive behaviour of the shear wall foundation soil system.
- ❖ The variation of maximum storey shear, storey moment of the models has been studied.
- ❖ The variation of storey drifts of the models has been studied
- ❖ The variation of displacement of the models has been studied
- ❖ The variation of Time period and frequency has been studied.
- ❖ The variation of maximum column axial force, maximum column shear force, maximum column moment and maximum column torsion of the model have been studied.
- ❖ The variation of Pier axial force, Pier shear force, Pier moment and Pier torsion of the models have been studied.

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.

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 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 Ta. When V_B is less than V_B all the response quantities shall be multiplied by V_B /VbThe 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)
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/m2

Floor finish	2.5 KN/m2
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
Density of concrete	25 KN/m3
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

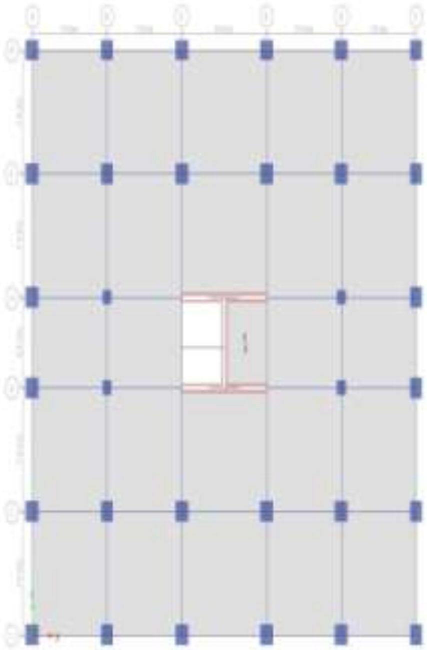


Figure 1.Plan of the building

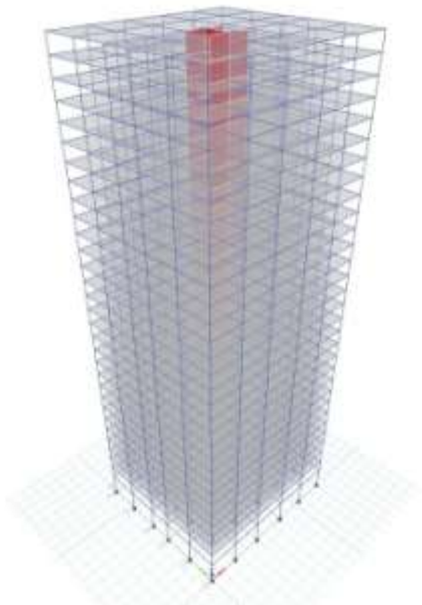


Figure 2.3D view showing shear wall location

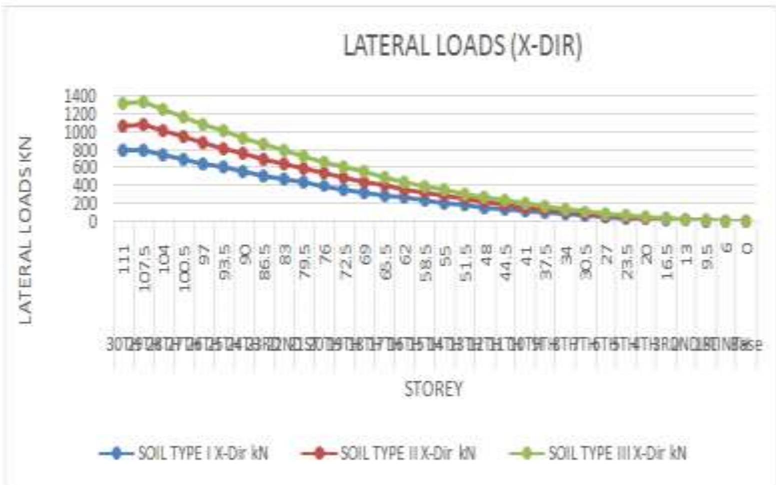
V. RESULTS AND DISCUSSIONS

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

			SOIL TYPE I	SOIL TYPE II	SOIL TYPE III
Story	Elevation	Location	X-Dir	X-Dir	X-Dir
	m		kN	kN	kN
30TH	111	Top	787.3047	1070.7344	1314.7989
29TH	107.5	Top	794.5243	1080.5531	1326.8556
28TH	104	Top	743.6301	1011.3369	1241.8623
27TH	100.5	Top	694.4203	944.4116	1159.6819
26TH	97	Top	646.8949	879.7771	1080.3145
25TH	93.5	Top	601.054	817.4335	1003.7602
24TH	90	Top	556.8975	757.3806	930.0189
23RD	86.5	Top	514.4255	699.6187	859.0906
22ND	83	Top	473.6379	644.1476	790.9753
21ST	79.5	Top	434.5348	590.9673	725.6731

20TH	76	Top	397.1161	540.0779	663.1838
19TH	72.5	Top	361.3818	491.4793	603.5076
18TH	69	Top	327.332	445.1715	546.6444
17TH	65.5	Top	294.9666	401.1546	492.5943
16TH	62	Top	264.2857	359.4285	441.3571
15TH	58.5	Top	235.2892	319.9933	392.933
14TH	55	Top	207.9772	282.8489	347.3219
13TH	51.5	Top	182.3496	247.9954	304.5238
12TH	48	Top	158.4064	215.4327	264.5387
11TH	44.5	Top	136.1477	185.1609	227.3667
10TH	41	Top	116.8056	158.8557	195.0654
9TH	37.5	Top	98.8543	134.4418	165.0867
8TH	34	Top	81.2626	110.5172	135.7086
7TH	30.5	Top	65.3932	88.9348	109.2067
6TH	27	Top	51.2461	69.6946	85.5809
5TH	23.5	Top	39.8653	54.2168	66.5751
4TH	20	Top	29.6854	40.3722	49.5746
3RD	16.5	Top	20.2046	27.4783	33.7417
2ND	13	Top	12.5421	17.0572	20.9453
1ST	9.5	Top	6.6978	9.109	11.1853
PLINTH	6	Top	1.3887	1.8886	2.3191
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



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

			SOIL TYPE I	SOIL TYPE II	SOIL TYPE III
Story	Elevation	Location	X-Dir	X-Dir	X-Dir
	m		kN/m	kN/m	kN/m
30TH	111	Top	127169.993	127169.993	127169.993
29TH	107.5	Top	248172.464	248172.464	248172.464
28TH	104	Top	354071.082	354071.082	354071.082
27TH	100.5	Top	443372.828	443372.828	443372.828
26TH	97	Top	517614.83	517614.83	517614.83
25TH	93.5	Top	578646.371	578646.371	578646.371

24TH	90	Top	628581.824	628581.824	628581.824
23RD	86.5	Top	669461.512	669461.512	669461.512
22ND	83	Top	703133.112	703133.112	703133.112
21ST	79.5	Top	731206.128	731206.128	731206.128
20TH	76	Top	755057.429	755057.429	755057.429
19TH	72.5	Top	775860.721	775860.721	775860.721
18TH	69	Top	794626.165	794626.165	794626.165
17TH	65.5	Top	812242.984	812242.984	812242.984
16TH	62	Top	829522.4	829522.4	829522.4
15TH	58.5	Top	847240.753	847240.753	847240.753
14TH	55	Top	866186.754	866186.754	866186.754
13TH	51.5	Top	887202.279	887202.279	887202.279
12TH	48	Top	911331.37	911331.37	911331.37
11TH	44.5	Top	939235.164	939235.164	939235.164
10TH	41	Top	975316.477	975316.477	975316.477
9TH	37.5	Top	1015663.136	1015663.136	1015663.136
8TH	34	Top	1067325.405	1067325.405	1067325.405
7TH	30.5	Top	1133147.012	1133147.012	1133147.012
6TH	27	Top	1220632.072	1220632.072	1220632.072
5TH	23.5	Top	1343308.893	1343308.893	1343308.893
4TH	20	Top	1494603.693	1494603.693	1494603.693
3RD	16.5	Top	1727466.79	1727466.79	1727466.79
2ND	13	Top	2105070.037	2105070.037	2105070.037
1ST	9.5	Top	2813604.443	2813604.443	2813604.443
PLINTH	6	Top	3716538.982	3716538.982	3716538.982
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

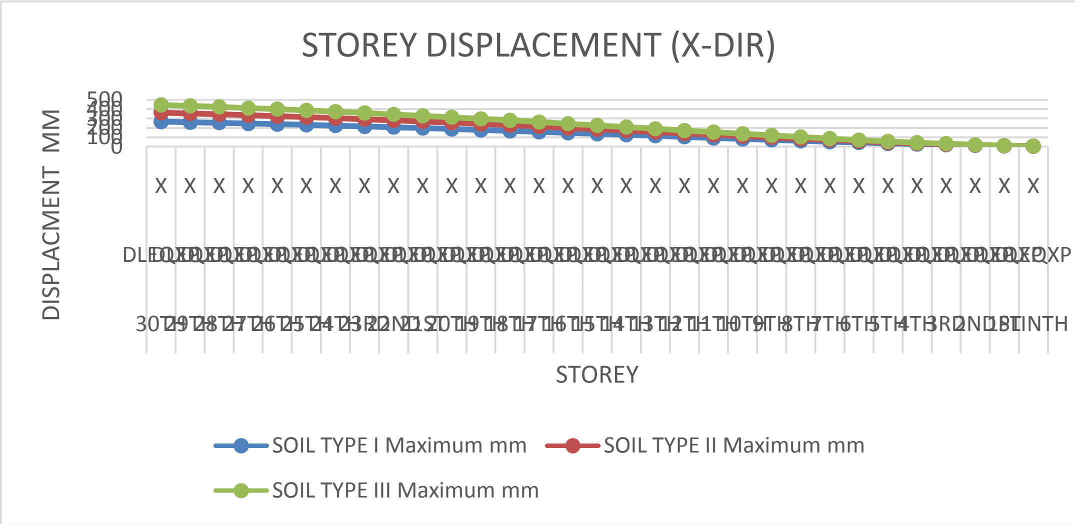
			SOIL TYPE I	SOIL TYPE II	SOIL TYPE III
Story	Elevation	Location	Y-Dir	Y-Dir	Y-Dir
	m		kN/m	kN/m	kN/m
30TH	111	Top	119164.119	119164.119	119164.119
29TH	107.5	Top	229810.931	229810.931	229810.931
28TH	104	Top	328402.199	328402.199	328402.199
27TH	100.5	Top	413473.499	413473.499	413473.499
26TH	97	Top	486134.555	486134.555	486134.555
25TH	93.5	Top	547831.972	547831.972	547831.972
24TH	90	Top	600146.012	600146.012	600146.012
23RD	86.5	Top	644624.109	644624.109	644624.109
22ND	83	Top	682702.979	682702.979	682702.979
21ST	79.5	Top	715677.877	715677.877	715677.877
20TH	76	Top	744700.513	744700.513	744700.513
19TH	72.5	Top	770793.357	770793.357	770793.357
18TH	69	Top	794872.745	794872.745	794872.745
17TH	65.5	Top	817776.659	817776.659	817776.659
16TH	62	Top	840295.4	840295.4	840295.4
15TH	58.5	Top	863205.201	863205.201	863205.201
14TH	55	Top	887306.209	887306.209	887306.209
13TH	51.5	Top	913466.212	913466.212	913466.212
12TH	48	Top	942691.624	942691.624	942691.624
11TH	44.5	Top	975623.28	975623.28	975623.28
10TH	41	Top	1019626.35	1019626.35	1019626.35
9TH	37.5	Top	1064004.896	1064004.896	1064004.896
8TH	34	Top	1120733.923	1120733.923	1120733.923
7TH	30.5	Top	1192207.735	1192207.735	1192207.735

6TH	27	Top	1287976.983	1287976.983	1287976.983
5TH	23.5	Top	1422330.025	1422330.025	1422330.025
4TH	20	Top	1570334.519	1570334.519	1570334.519
3RD	16.5	Top	1794350.918	1794350.918	1794350.918
2ND	13	Top	2138462.884	2138462.884	2138462.884
1ST	9.5	Top	2728249.129	2728249.129	2728249.129
PLINTH	6	Top	3423591.625	3423591.625	3423591.625
Base	0	Top	0	0	0

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

			SOIL TYPE I	SOIL TYPE II	SOIL TYPE III
Story	Load Case/Combo	Direction	Story Maximum Displacements	Story Maximum Displacements	Story Maximum Displacements
			mm	mm	mm
30TH	DLEQXP	X	268.025	363.899	446.457
29TH	DLEQXP	X	261.499	355.052	435.612
28TH	DLEQXP	X	254.729	345.873	424.358
27TH	DLEQXP	X	247.688	336.326	412.653
26TH	DLEQXP	X	240.323	326.336	400.404
25TH	DLEQXP	X	232.6	315.862	387.559
24TH	DLEQXP	X	224.505	304.88	374.091
23RD	DLEQXP	X	216.031	293.383	359.992
22ND	DLEQXP	X	207.184	281.378	345.268
21ST	DLEQXP	X	197.977	268.883	329.942
20TH	DLEQXP	X	188.429	255.925	314.047
19TH	DLEQXP	X	178.568	242.54	297.627
18TH	DLEQXP	X	168.424	228.77	280.735
17TH	DLEQXP	X	158.034	214.665	263.431
16TH	DLEQXP	X	147.438	200.281	245.783
15TH	DLEQXP	X	136.683	185.678	227.868
14TH	DLEQXP	X	125.818	170.925	209.767
13TH	DLEQXP	X	114.896	156.094	191.57
12TH	DLEQXP	X	103.977	141.266	173.376
11TH	DLEQXP	X	93.125	126.528	155.293
10TH	DLEQXP	X	82.407	111.973	137.432
9TH	DLEQXP	X	71.932	97.745	119.973
8TH	DLEQXP	X	61.735	83.895	102.977
7TH	DLEQXP	X	51.913	70.553	86.604
6TH	DLEQXP	X	42.567	57.856	71.021
5TH	DLEQXP	X	33.823	45.976	56.442
4TH	DLEQXP	X	25.836	35.124	43.121
3RD	DLEQXP	X	18.592	25.278	31.037
2ND	DLEQXP	X	12.262	16.675	20.474
1ST	DLEQXP	X	7.014	9.539	11.713
PLINTH	DLEQXP	X	2.591	3.499	4.281
Base	DLEQXP	X	0	0	0

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



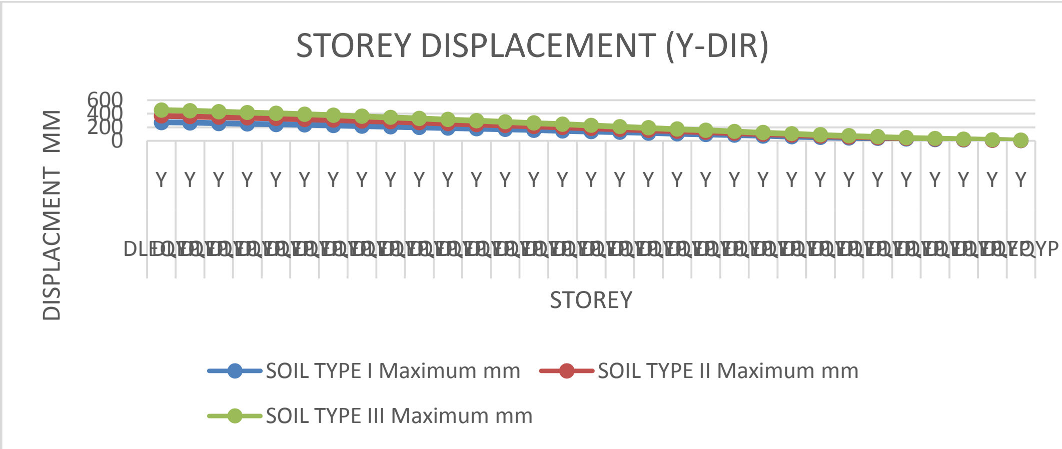
Graph 2: StoreyDisplacement of Structure in Soft Soil , Medium Soil and Hard Soil in X - Direction

Table 6: StoreyDisplacement of Structure in Soft Soil , Medium Soil and Hard Soil in Y – Direction with load combination (DL +EQYP)

			SOIL TYPE I	SOIL TYPE II	SOIL TYPE III
Story	Load Case/Combo	Direction	Story Maximum Displacements	Story Maximum Displacements	Story Maximum Displacements
			mm	mm	mm
30TH	DLEQYP	Y	271.202	368.981	453.18
29TH	DLEQYP	Y	264.307	359.599	441.655
28TH	DLEQYP	Y	257.064	349.742	429.548
27TH	DLEQYP	Y	249.533	339.493	416.959
26TH	DLEQYP	Y	241.681	328.809	403.835
25TH	DLEQYP	Y	233.491	317.664	390.146
24TH	DLEQYP	Y	224.956	306.05	375.881
23RD	DLEQYP	Y	216.078	293.97	361.044
22ND	DLEQYP	Y	206.869	281.44	345.654
21ST	DLEQYP	Y	197.346	268.483	329.74
20TH	DLEQYP	Y	187.532	255.13	313.339
19TH	DLEQYP	Y	177.455	241.419	296.5
18TH	DLEQYP	Y	167.147	227.395	279.275
17TH	DLEQYP	Y	156.645	213.106	261.726
16TH	DLEQYP	Y	145.988	198.608	243.919
15TH	DLEQYP	Y	135.222	183.96	225.929
14TH	DLEQYP	Y	124.392	169.226	207.833
13TH	DLEQYP	Y	113.549	154.475	189.716
12TH	DLEQYP	Y	102.749	139.782	171.671
11TH	DLEQYP	Y	92.051	125.228	153.796
10TH	DLEQYP	Y	81.517	110.895	136.194
9TH	DLEQYP	Y	71.269	96.954	119.072
8TH	DLEQYP	Y	61.302	83.395	102.42
7TH	DLEQYP	Y	51.711	70.347	86.395
6TH	DLEQYP	Y	42.589	57.937	71.153
5TH	DLEQYP	Y	34.066	46.342	56.913
4TH	DLEQYP	Y	26.295	35.77	43.93
3RD	DLEQYP	Y	19.184	26.097	32.049
2ND	DLEQYP	Y	12.893	17.539	21.539

1ST	DLEQYP	Y	7.562	10.287	12.633
PLINTH	DLEQYP	Y	2.858	3.888	4.774
Base	DLEQYP	Y	0	0	0

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



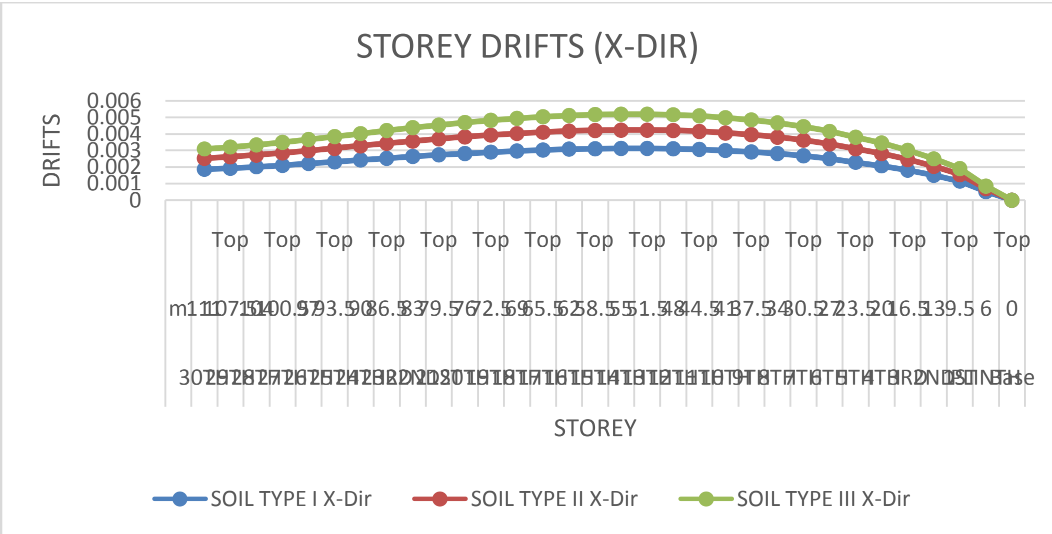
Graph 3: StoreyDisplacement of Structure in Soft Soil , Medium Soil and Hard Soil in Y - Direction
For both X and Y directions, the behaviour of the graph is similar for model in Soft Soil , Medium Soil and Hard Soil as shown. The order of maximum storey displacement in both the directions for the models is same.

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

			SOIL TYPE I	SOIL TYPE II	SOIL TYPE III
Story	Elevation m	Location	X-Dir	X-Dir	X-Dir
30TH	111	Top	0.001864	0.002528	0.003099
29TH	107.5	Top	0.001934	0.002623	0.003216
28TH	104	Top	0.002012	0.002728	0.003344
27TH	100.5	Top	0.002105	0.002854	0.0035
26TH	97	Top	0.002206	0.002993	0.00367
25TH	93.5	Top	0.002313	0.003138	0.003848
24TH	90	Top	0.002421	0.003285	0.004029
23RD	86.5	Top	0.002528	0.00343	0.004207
22ND	83	Top	0.002631	0.00357	0.004379
21ST	79.5	Top	0.002728	0.003702	0.004541
20TH	76	Top	0.002818	0.003824	0.004691
19TH	72.5	Top	0.002898	0.003934	0.004826
18TH	69	Top	0.002969	0.00403	0.004944
17TH	65.5	Top	0.003027	0.00411	0.005042
16TH	62	Top	0.003073	0.004172	0.005119
15TH	58.5	Top	0.003104	0.004215	0.005172
14TH	55	Top	0.003121	0.004237	0.005199
13TH	51.5	Top	0.00312	0.004237	0.005198
12TH	48	Top	0.003101	0.004211	0.005167
11TH	44.5	Top	0.003062	0.004159	0.005103
10TH	41	Top	0.002993	0.004065	0.004988

9TH	37.5	Top	0.002913	0.003957	0.004856
8TH	34	Top	0.002806	0.003812	0.004678
7TH	30.5	Top	0.00267	0.003628	0.004452
6TH	27	Top	0.002498	0.003394	0.004166
5TH	23.5	Top	0.002282	0.003101	0.003806
4TH	20	Top	0.00207	0.002813	0.003453
3RD	16.5	Top	0.001808	0.002458	0.003018
2ND	13	Top	0.0015	0.002039	0.002503
1ST	9.5	Top	0.001146	0.001555	0.001908
PLINTH	6	Top	0.000511	0.000693	0.00085
Base	0	Top	0	0	0

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



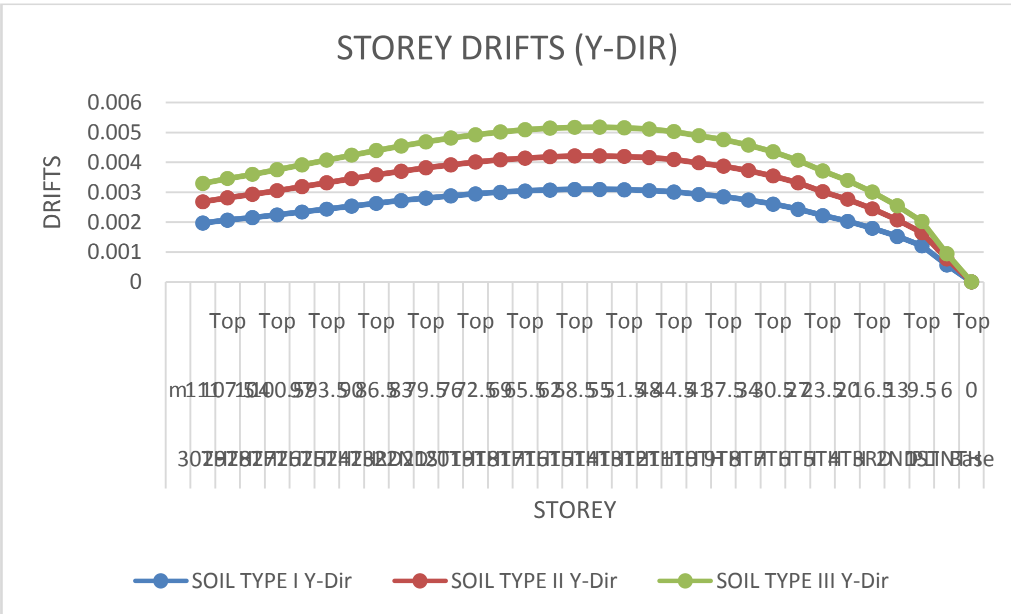
Graph 4: StoreyDrifts of Structure in Soft Soil , Medium Soil and Hard Soil in X - Direction

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

			SOIL TYPE I	SOIL TYPE II	SOIL TYPE III
Story	Elevation m	Location	Y-Dir	Y-Dir	Y-Dir
30TH	111	Top	0.00197	0.002681	0.003293
29TH	107.5	Top	0.002069	0.002816	0.003459
28TH	104	Top	0.002152	0.002928	0.003597
27TH	100.5	Top	0.002243	0.003053	0.00375
26TH	97	Top	0.00234	0.003184	0.003911
25TH	93.5	Top	0.002439	0.003318	0.004076
24TH	90	Top	0.002536	0.003451	0.004239
23RD	86.5	Top	0.002631	0.00358	0.004397
22ND	83	Top	0.002721	0.003702	0.004547
21ST	79.5	Top	0.002804	0.003815	0.004686
20TH	76	Top	0.002879	0.003917	0.004811

19TH	72.5	Top	0.002945	0.004007	0.004921
18TH	69	Top	0.003001	0.004082	0.005014
17TH	65.5	Top	0.003045	0.004142	0.005088
16TH	62	Top	0.003076	0.004185	0.00514
15TH	58.5	Top	0.003094	0.00421	0.00517
14TH	55	Top	0.003098	0.004215	0.005176
13TH	51.5	Top	0.003086	0.004198	0.005156
12TH	48	Top	0.003057	0.004158	0.005107
11TH	44.5	Top	0.00301	0.004095	0.005029
10TH	41	Top	0.002928	0.003983	0.004892
9TH	37.5	Top	0.002848	0.003874	0.004758
8TH	34	Top	0.00274	0.003728	0.004578
7TH	30.5	Top	0.002606	0.003546	0.004355
6TH	27	Top	0.002435	0.003313	0.004069
5TH	23.5	Top	0.00222	0.003021	0.00371
4TH	20	Top	0.002032	0.002764	0.003394
3RD	16.5	Top	0.001797	0.002445	0.003003
2ND	13	Top	0.001523	0.002072	0.002545
1ST	9.5	Top	0.001212	0.001646	0.002019
PLINTH	6	Top	0.000563	0.000766	0.00094
Base	0	Top	0	0	0

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



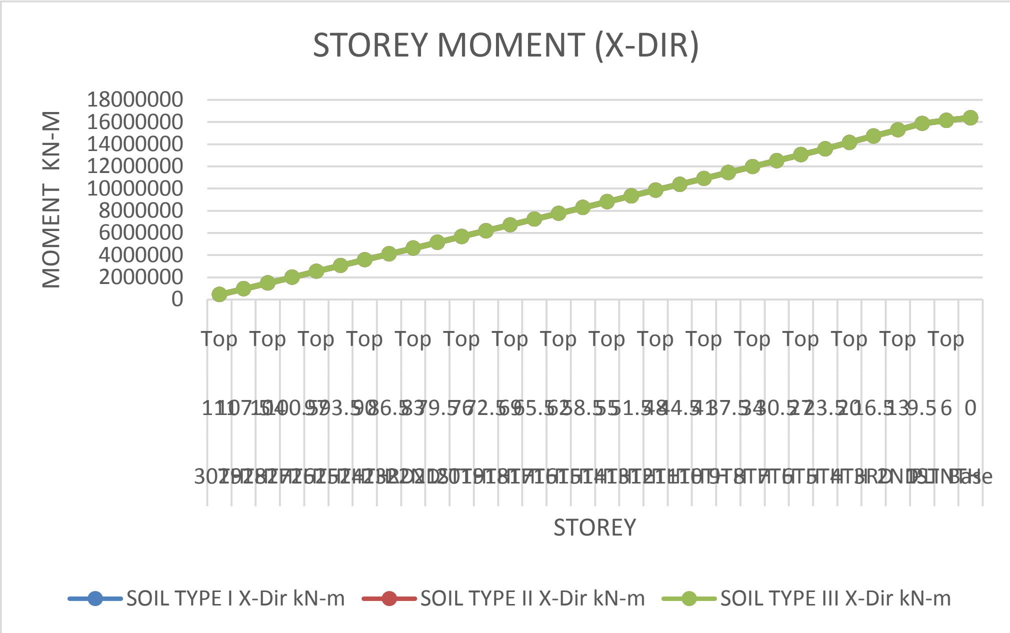
Graph 5: StoreyDrifts of Structure in Soft Soil , Medium Soil and Hard Soil in Y - Direction

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 X 3.5 m = 14 mm. The model show a similar behaviour for storey drifts as shown in graph.

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

			SOIL TYPE I	SOIL TYPE II	SOIL TYPE III
Story	Elevation	Location	X-Dir	X-Dir	X-Dir
	m		kN-m	kN-m	kN-m
30TH	111	Top	439229.5406	439229.5406	439229.5406
29TH	107.5	Top	962432.6672	962432.6672	962432.6672
28TH	104	Top	1485636	1485636	1485636
27TH	100.5	Top	2008839	2008839	2008839
26TH	97	Top	2532042	2532042	2532042
25TH	93.5	Top	3055245	3055245	3055245
24TH	90	Top	3578448	3578448	3578448
23RD	86.5	Top	4101651	4101651	4101651
22ND	83	Top	4624855	4624855	4624855
21ST	79.5	Top	5148058	5148058	5148058
20TH	76	Top	5671261	5671261	5671261
19TH	72.5	Top	6194464	6194464	6194464
18TH	69	Top	6717667	6717667	6717667
17TH	65.5	Top	7240870	7240870	7240870
16TH	62	Top	7764073	7764073	7764073
15TH	58.5	Top	8287276	8287276	8287276
14TH	55	Top	8810480	8810480	8810480
13TH	51.5	Top	9333683	9333683	9333683
12TH	48	Top	9856886	9856886	9856886
11TH	44.5	Top	10380089	10380089	10380089
10TH	41	Top	10902621	10902621	10902621
9TH	37.5	Top	11439178	11439178	11439178
8TH	34	Top	11975735	11975735	11975735
7TH	30.5	Top	12512292	12512292	12512292
6TH	27	Top	13048849	13048849	13048849
5TH	23.5	Top	13584231	13584231	13584231
4TH	20	Top	14154676	14154676	14154676
3RD	16.5	Top	14725120	14725120	14725120
2ND	13	Top	15295565	15295565	15295565
1ST	9.5	Top	15866010	15866010	15866010
PLINTH	6	Top	16150901	16150901	16150901
Base	0	Top	16379004	16379004	16379004

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



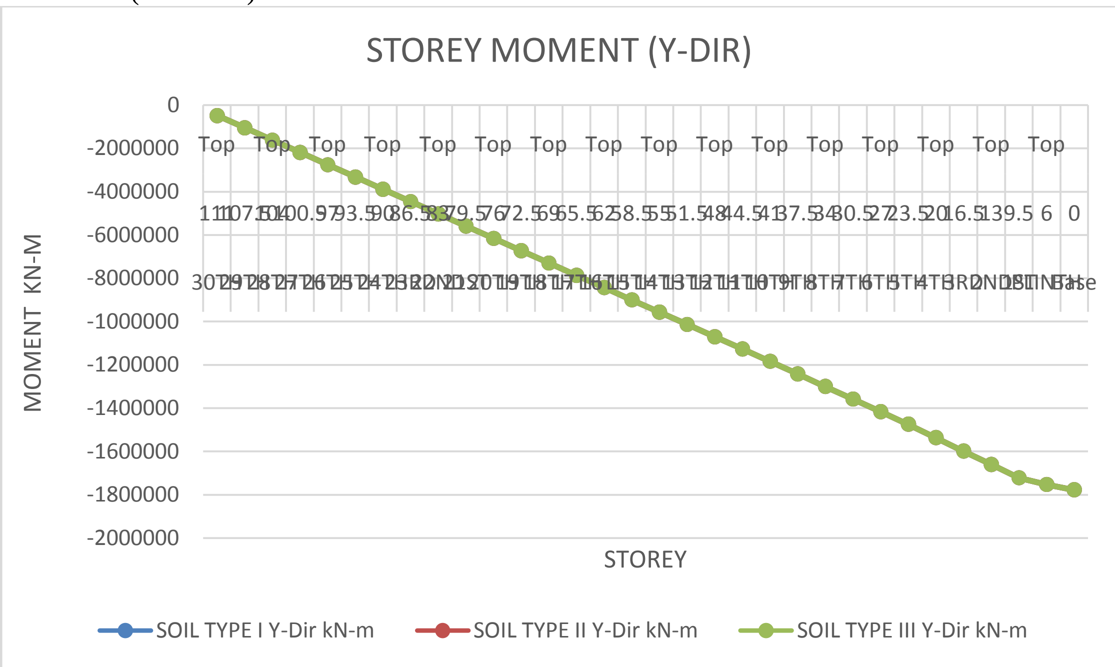
Graph 6: StoreyMoment of Structure in Soft Soil , Medium Soil and Hard Soil in X - Direction

Table 10: StoreyMoment of Structure in Soft Soil , Medium Soil and Hard Soil in Y – Directionwith load combination 1.2(DL +EQYP)

			SOIL TYPE I	SOIL TYPE II	SOIL TYPE III
Story	Elevation	Location	Y-Dir	Y-Dir	Y-Dir
	m		kN-m	kN-m	kN-m
30TH	111	Top	-476669	-476669	-476669
29TH	107.5	Top	-1044409	-1044409	-1044409
28TH	104	Top	-1612148	-1612148	-1612148
27TH	100.5	Top	-2179888	-2179888	-2179888
26TH	97	Top	-2747627	-2747627	-2747627
25TH	93.5	Top	-3315366	-3315366	-3315366
24TH	90	Top	-3883106	-3883106	-3883106
23RD	86.5	Top	-4450845	-4450845	-4450845
22ND	83	Top	-5018585	-5018585	-5018585
21ST	79.5	Top	-5586324	-5586324	-5586324
20TH	76	Top	-6154063	-6154063	-6154063
19TH	72.5	Top	-6721803	-6721803	-6721803
18TH	69	Top	-7289542	-7289542	-7289542
17TH	65.5	Top	-7857282	-7857282	-7857282
16TH	62	Top	-8425021	-8425021	-8425021
15TH	58.5	Top	-8992760	-8992760	-8992760
14TH	55	Top	-9560500	-9560500	-9560500
13TH	51.5	Top	-10128239	-10128239	-10128239
12TH	48	Top	-10695979	-10695979	-10695979
11TH	44.5	Top	-11263718	-11263718	-11263718
10TH	41	Top	-11830730	-11830730	-11830730
9TH	37.5	Top	-12412951	-12412951	-12412951
8TH	34	Top	-12995173	-12995173	-12995173
7TH	30.5	Top	-13577395	-13577395	-13577395
6TH	27	Top	-14159616	-14159616	-14159616

5TH	23.5	Top	-14740565	-14740565	-14740565
4TH	20	Top	-15359538	-15359538	-15359538
3RD	16.5	Top	-15978511	-15978511	-15978511
2ND	13	Top	-16597484	-16597484	-16597484
1ST	9.5	Top	-17216457	-17216457	-17216457
PLINTH	6	Top	-17525746	-17525746	-17525746
Base	0	Top	-17773125	-17773125	-17773125

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



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

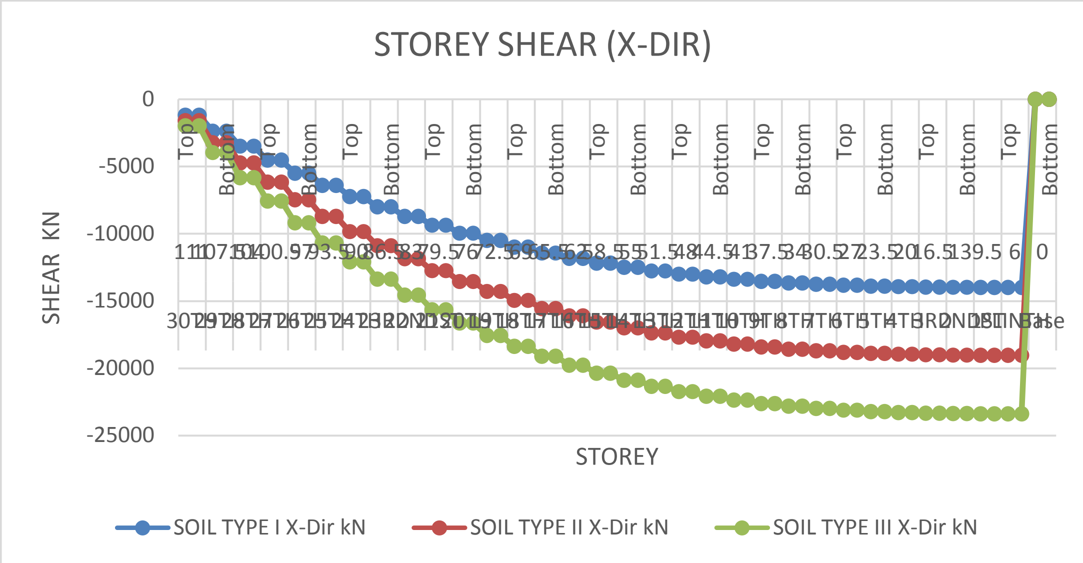
Table 11: StoreyShear of Structure in Soft Soil , Medium Soil and Hard Soil in X – Direction with load combination1.2 (DL +EQXP)

			SOIL TYPE I	SOIL TYPE II	SOIL TYPE III
Story	Elevation	Location	X-Dir	X-Dir	X-Dir
	m		kN	kN	kN
30TH	111	Top	-1180.9571	-1606.1016	-1972.1983
		Bottom	-1180.9571	-1606.1016	-1972.1983
29TH	107.5	Top	-2372.7436	-3226.9312	-3962.4818
		Bottom	-2372.7436	-3226.9312	-3962.4818
28TH	104	Top	-3488.1887	-4743.9366	-5825.2751
		Bottom	-3488.1887	-4743.9366	-5825.2751
27TH	100.5	Top	-4529.8191	-6160.554	-7564.798
		Bottom	-4529.8191	-6160.554	-7564.798
26TH	97	Top	-5500.1615	-7480.2197	-9185.2697
		Bottom	-5500.1615	-7480.2197	-9185.2697
25TH	93.5	Top	-6401.7425	-8706.3699	-10690.91
		Bottom	-6401.7425	-8706.3699	-10690.91
24TH	90	Top	-7237.0888	-9842.4408	-12085.9384
		Bottom	-7237.0888	-9842.4408	-12085.9384
23RD	86.5	Top	-8008.7271	-10891.8689	-13374.5743
		Bottom	-8008.7271	-10891.8689	-13374.5743
22ND	83	Top	-8719.184	-11858.0902	-14561.0372

		Bottom	-8719.184	-11858.0902	-14561.0372
21ST	79.5	Top	-9370.9861	-12744.5411	-15649.5468
		Bottom	-9370.9861	-12744.5411	-15649.5468
20TH	76	Top	-9966.6602	-13554.6579	-16644.3226
		Bottom	-9966.6602	-13554.6579	-16644.3226
19TH	72.5	Top	-10508.733	-14291.8768	-17549.584
		Bottom	-10508.733	-14291.8768	-17549.584
18TH	69	Top	-10999.731	-14959.6341	-18369.5507
		Bottom	-10999.731	-14959.6341	-18369.5507
17TH	65.5	Top	-11442.1809	-15561.366	-19108.4421
		Bottom	-11442.1809	-15561.366	-19108.4421
16TH	62	Top	-11838.6094	-16100.5088	-19770.4777
		Bottom	-11838.6094	-16100.5088	-19770.4777
15TH	58.5	Top	-12191.5432	-16580.4988	-20359.8772
		Bottom	-12191.5432	-16580.4988	-20359.8772
14TH	55	Top	-12503.509	-17004.7722	-20880.86
		Bottom	-12503.509	-17004.7722	-20880.86
13TH	51.5	Top	-12777.0333	-17376.7653	-21337.6457
		Bottom	-12777.0333	-17376.7653	-21337.6457
12TH	48	Top	-13014.643	-17699.9144	-21734.4537
		Bottom	-13014.643	-17699.9144	-21734.4537
11TH	44.5	Top	-13218.8645	-17977.6557	-22075.5037
		Bottom	-13218.8645	-17977.6557	-22075.5037
10TH	41	Top	-13394.073	-18215.9392	-22368.1018
		Bottom	-13394.073	-18215.9392	-22368.1018
9TH	37.5	Top	-13542.3544	-18417.602	-22615.7318
		Bottom	-13542.3544	-18417.602	-22615.7318
8TH	34	Top	-13664.2483	-18583.3777	-22819.2947
		Bottom	-13664.2483	-18583.3777	-22819.2947
7TH	30.5	Top	-13762.3381	-18716.7798	-22983.1047
		Bottom	-13762.3381	-18716.7798	-22983.1047
6TH	27	Top	-13839.2072	-18821.3218	-23111.476
		Bottom	-13839.2072	-18821.3218	-23111.476
5TH	23.5	Top	-13899.0052	-18902.6471	-23211.3387
		Bottom	-13899.0052	-18902.6471	-23211.3387
4TH	20	Top	-13943.5333	-18963.2053	-23285.7006
		Bottom	-13943.5333	-18963.2053	-23285.7006
3RD	16.5	Top	-13973.8403	-19004.4228	-23336.3133
		Bottom	-13973.8403	-19004.4228	-23336.3133
2ND	13	Top	-13992.6534	-19030.0086	-23367.7312
		Bottom	-13992.6534	-19030.0086	-23367.7312
1ST	9.5	Top	-14002.7001	-19043.6721	-23384.5091
		Bottom	-14002.7001	-19043.6721	-23384.5091
PLINTH	6	Top	-14004.7831	-19046.505	-23387.9877
		Bottom	-14004.7831	-19046.505	-23387.9877

Base	0	Top	0	0	0
		Bottom	0	0	0

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



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 +EQXP) &1.2 (DL +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	P	P	P
				m	kN	kN	kN
1ST	C34	67	1.5(DL+EQXP)	0	-25450.8356	-26503.928	-27410.7578
1ST	C34	67	1.5(DL+EQXP)	1.45	-25365.8747	-26418.967	-27325.7969
1ST	C34	67	1.5(DL+EQXP)	2.9	-25280.9137	-26334.006	-27240.836
1ST	C34	67	1.5(DL+EQYP)	0	-24254.57	-24877.007	-25412.9943
1ST	C34	67	1.5(DL+EQYP)	1.45	-24169.6091	-24792.046	-25328.0334
1ST	C34	67	1.5(DL+EQYP)	2.9	-24084.6481	-24707.085	-25243.0724

Table 13:column Moment, M for structure with the load combination 1.2 (DL +EQXP) &1.2 (DL +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	M2	M3	M2	M3	M2	M3
				m	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
1ST	C34	67	1.5(DL+EQXP)	0	-311.2144	1219.4677	-402.207	1665.7503	-480.5617	2050.0492
1ST	C34	67	1.5(DL+EQXP)	1.45	-194.3203	1051.1982	-263.2013	1446.0951	-322.5155	1786.1453
1ST	C34	67	1.5(DL+EQXP)	2.9	-77.4263	882.9288	-124.1957	1226.44	-164.4693	1522.2413
1ST	C34	67	1.5(DL+EQYP)	0	1469.7135	-88.758	2019.8549	-113.4367	2493.5878	-134.6877
1ST	C34	67	1.5(DL+EQYP)	1.45	1187.7076	-84.3004	1616.3567	-98.183	1985.4712	-110.1375
1ST	C34	67	1.5(DL+EQYP)	2.9	905.7018	-79.8429	1212.8586	-82.9294	1477.3547	-85.5873

Table 14:columnShear, V for structure with the load combination 1.2 (DL +EQXP) &1.2 (DL +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	V2	V3	V2	V3	V2	V3
				m	kN	kN	kN	kN	kN	kN
1ST	C34	67	1.5(DL+EQXP)	0	116.0479	-80.6166	151.4863	-95.866	182.0027	-108.9974
1ST	C34	67	1.5(DL+EQXP)	1.45	116.0479	-80.6166	151.4863	-95.866	182.0027	-108.9974
1ST	C34	67	1.5(DL+EQXP)	2.9	116.0479	-80.6166	151.4863	-95.866	182.0027	-108.9974
1ST	C34	67	1.5(DL+EQYP)	0	-3.0742	194.4868	-10.5197	278.2746	-16.9312	350.4252
1ST	C34	67	1.5(DL+EQYP)	1.45	-3.0742	194.4868	-10.5197	278.2746	-16.9312	350.4252
1ST	C34	67	1.5(DL+EQYP)	2.9	-3.0742	194.4868	-10.5197	278.2746	-16.9312	350.4252

Table 15:columnTorsion, T for structure with the load combination 1.2 (DL +EQXP) &1.2 (DL +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	T	T	T
				m	kN-m	kN-m	kN-m
1ST	C34	67	1.5(DL+EQXP)	0	-54.7871	-74.4626	-91.4055
1ST	C34	67	1.5(DL+EQXP)	1.45	-54.7871	-74.4626	-91.4055
1ST	C34	67	1.5(DL+EQXP)	2.9	-54.7871	-74.4626	-91.4055
1ST	C34	67	1.5(DL+EQYP)	0	60.7221	82.6299	101.4949
1ST	C34	67	1.5(DL+EQYP)	1.45	60.7221	82.6299	101.4949
1ST	C34	67	1.5(DL+EQYP)	2.9	60.7221	82.6299	101.4949

Pier Forces

Table 16: Pier Axial Force, P for structure with the load combination 1.2 (DL +EQXP) &1.2 (DL +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	P	P
				kN	kN	kN
1ST	P3	1.5(DL+EQXP)	Top	-32394.3369	-32193.1202	-32019.8502
1ST	P3	1.5(DL+EQXP)	Bottom	-32719.1806	-32517.9639	-32344.694
1ST	P3	1.5(DL+EQYP)	Top	-32953.4102	-32953.4598	-32953.5026
1ST	P3	1.5(DL+EQYP)	Bottom	-33278.2539	-33278.3036	-33278.3463

Table 17: Pier Moment, M for structure with the load combination 1.2 (DL +EQXP) &1.2 (DL +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	M3	M2	M3	M2	M3
				kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
1ST	P3	1.5(DL+EQXP)	Top	-63.8605	-76.9109	-67.1221	-89.0173	-69.9307	-99.4423
1ST	P3	1.5(DL+EQXP)	Bottom	-380.7271	-21.7227	-540.3743	-20.8092	-677.8482	-20.0225
1ST	P3	1.5(DL+EQYP)	Top	-54.7972	13884.4054	-54.796	18898.3728	-54.795	23215.9559
1ST	P3	1.5(DL+EQYP)	Bottom	62.739	43569.6278	62.7395	59263.4276	62.74	72777.5329

Table 18: Pier Shear, V for structure with the load combination 1.2 (DL +EQXP) &1.2 (DL +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	V3	V2	V3	V2	V3
				kN	kN	kN	kN	kN	kN
1ST	P3	1.5(DL+EQXP)	Top	15.768	-90.5333	19.488	-135.2149	22.6914	-173.6907
1ST	P3	1.5(DL+EQXP)	Bottom	15.768	-90.5333	19.488	-135.2149	22.6914	-173.6907
1ST	P3	1.5(DL+EQYP)	Top	8481.4921	33.5818	11532.8728	33.5816	14160.4506	33.5814
1ST	P3	1.5(DL+EQYP)	Bottom	8481.4921	33.5818	11532.8728	33.5816	14160.4506	33.5814

Table 19: Pier Torsion, T for structure with the load combination 1.2 (DL +EQXP) &1.2 (DL +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	T	T
				kN-m	kN-m	kN-m
1ST	P3	1.5(DL+EQXP)	Top	-42.4392	-57.7158	-70.8707
1ST	P3	1.5(DL+EQXP)	Bottom	-42.4392	-57.7158	-70.8707
1ST	P3	1.5(DL+EQYP)	Top	106.4507	144.7745	177.7754
1ST	P3	1.5(DL+EQYP)	Bottom	106.4507	144.7745	177.7754

Table 20: Modal Load Participation Ratios

TABLE: Modal Load Participation Ratios				
Case	Item Type	Item	Static	Dynamic
			%	%
Modal	Acceleration	UX	99.97	91.54
Modal	Acceleration	UY	99.97	92.51
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 91.54 percent.

Table 21: Modal Participating Mass Ratios

Case	Mode	Period sec	UX	UY	UZ	RX	RY	RZ
Modal	1	6.382	0	1.69E-05	0	6.15E-06	0	0.7689
Modal	2	5.694	0.7199	0	0	0	0.2895	0
Modal	3	5.642	0	0.7146	0	0.2952	0	1.69E-05
Modal	4	2.088	0	5.47E-07	0	2.02E-06	0	0.1054
Modal	5	1.565	0.1363	0	0	0	0.3653	0
Modal	6	1.524	0	0.1494	0	0.3701	0	0
Modal	7	1.19	0	0	0	0	0	0.0432
Modal	8	0.791	0	0	0	0	0	0.0235
Modal	9	0.711	0.0592	0	0	0	0.1115	0
Modal	10	0.703	0	0.0611	0	0.1219	0	0
Modal	11	0.565	0	0	0	0	0	0.0146
Modal	12	0.423	0	9.14E-07	0	2.6E-06	0	0.0104

Here the minimum modal mass for accelerations Ux and Uy is. 91.54 % and 92.51% respectively.

Table 22: Modal Periods and Frequencies

TABLE: Modal Periods And Frequencies SOIL TYPE I				SOIL TYPE II	SOIL TYPEII	SOIL TYPEIII	SOIL TYPEIII
Case	Mode	Period	Frequency	Period	Frequency	Period	Frequency
		Sec	Cyc/Sec	Sec	Cyc/Sec	Sec	Cyc/Sec
Modal	1	6.382	0.157	6.382	0.157	6.382	0.157
Modal	2	5.694	0.176	5.694	0.176	5.694	0.176
Modal	3	5.642	0.177	5.642	0.177	5.642	0.177
Modal	4	2.088	0.479	2.088	0.479	2.088	0.479
Modal	5	1.565	0.639	1.565	0.639	1.565	0.639
Modal	6	1.524	0.656	1.524	0.656	1.524	0.656
Modal	7	1.19	0.84	1.19	0.84	1.19	0.84
Modal	8	0.791	1.264	0.791	1.264	0.791	1.264
Modal	9	0.711	1.406	0.711	1.406	0.711	1.406
Modal	10	0.703	1.423	0.703	1.423	0.703	1.423
Modal	11	0.565	1.769	0.565	1.769	0.565	1.769
Modal	12	0.423	2.363	0.423	2.363	0.423	2.363

Mode 1 is having maximum time period of 6.382 sec and 0.157cyc/sec Frequency which is same for all three type of soils.

Mode shapes of shear wall

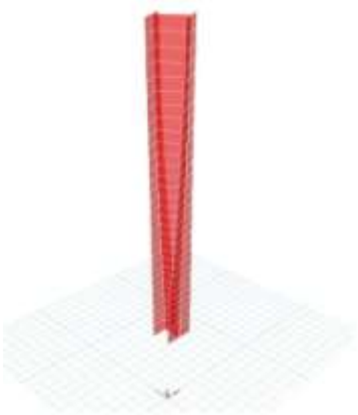


Figure 3: Mode shape 1 for shear wall

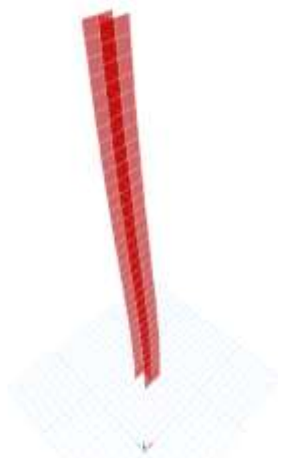


Figure 4: Mode shape 2 for shear wall

Figure 5: Mode shape 3 for shear wall

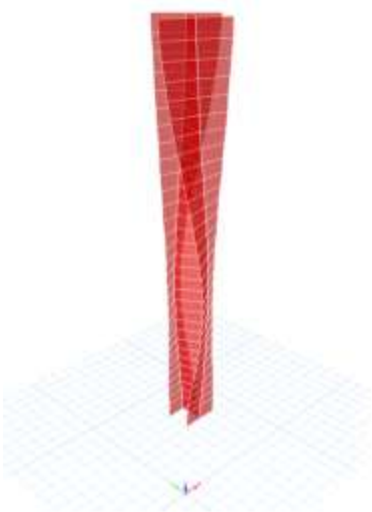


Figure 6: Mode shape 4 for shear wall

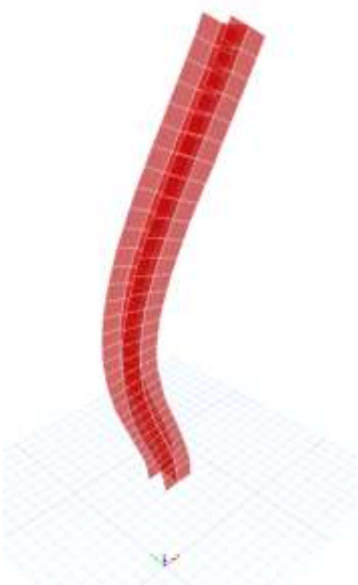


Figure 7: Mode shape 5 for shear wall

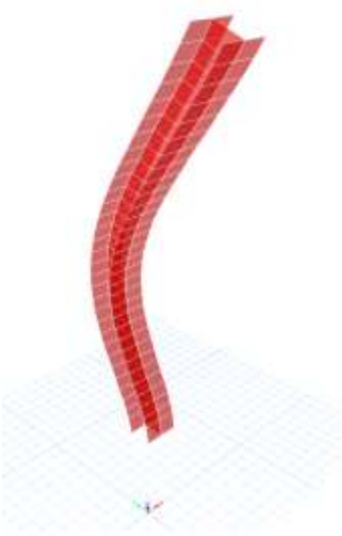


Figure 8: Mode shape 6 for shear wall

Figure 9: Mode shape 7 for shear wall

Figure 10: Mode shape 8 for shear wall

Figure 11: Mode shape 9 for shear wall

Figure 12: Mode shape 10 for shear wall

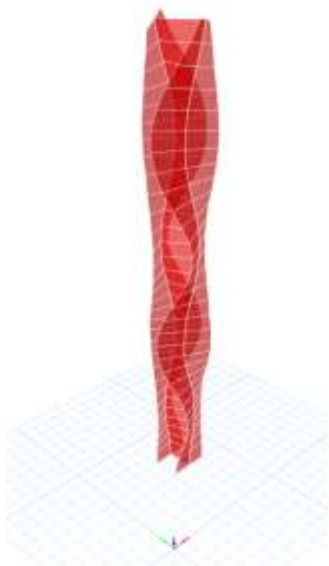


Figure 13: Mode shape 11 for shear wall

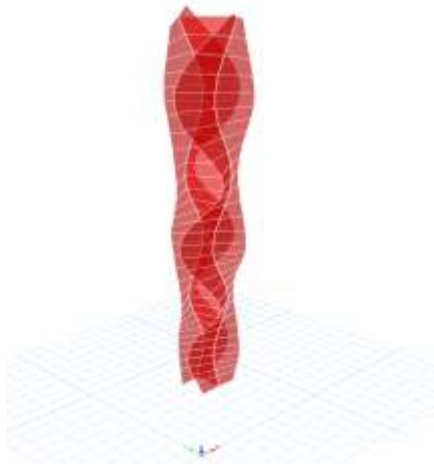


Figure 14: Mode shape 12 for shear wall

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 6.382Sec for structure and it is same for different type of soil.
- ❖ The Frequency is 0.157cyc/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 35.77 % of the model in medium soil and 66.5 % of model in hard soil compared with model in soft soil.

It is observed that

- ❖ The maximum storey drift in X-direction occurred at storey14th 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 :-
- ❖ 35.62 % of model in medium soil compared with model in soft soil.
- ❖ 66.25% of model in hard soil compared with model in soft soil.

It is observed that

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

- The maximum column moment M3 in X-direction for soft Soil <Medium soil < Hard soil.
- The maximum column moment M2 in Y-direction for soft Soil <Medium soil < Hard soil.
- The maximum column moment M3in Y-direction for soft Soil >Medium soil > Hard soil.

It is observed that

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

It is observed that

- The maximum column Torsion , T in X-direction for soft Soil >Medium soil > Hard soil.
- The maximum 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.
- 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 a different type of soils.
- There is not difference in a storey moment in y-direction with a 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 –direction for load cases EQXP is same .
- The value of the Stiffness of Structure in Soft Soil , Medium Soil and Hard Soil in Y –direction for load cases EQYP is same .

VI. Conclusions

In this paper, reinforced concrete shear wall buildings were analyzed with the procedures laid out in IS codes. Seismic performance of building model is evaluated.

From the above results and discussions, following conclusions can be drawn:

- Shear Walls must be coinciding with the centroid of the building for better performance. It follows that a centre core Shear wall should be provided.
- The shear wall and it is position has a significant influenced on the time period. The time period is not influenced by the type of soil..
- shear is effected 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.
- 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.

- 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.

- 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.
- Based on the analysis and discussion ,shear wall are very much suitable for resisting earthquake induced lateral forces in multistoried structural systems when compared to multistoried structural systems whit out shear walls. They can be made to behave in a ductile manner by adopting proper detailing techniques.

- The vertical reinforcement that is uniformly distributed in the shear wall shall not be less than the horizontal reinforcement .This provision is particularly for squat walls (i.e. Height-to-width ratio is about 1.0).However ,for walls whit height-to-width ratio less than 1.0, a major part of the shear force is resisted by the vertical reinforcement. Hence ,adequate vertical reinforcement should be provided for such walls.

- 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 shear force in y-direction is same for the column with a different type of soil and placing 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 is influenced by the type of soil and placing of shear wall.

- It is observed that the Pier shear force is various with type of soil and placing of the shear wall.
- It is observed that the pier Torsion is various with type of soil and placing of the shear wall.

- It is observed that the There is not difference in a storey moment with a different type of soils.
- It is observed that the pier Moment is various with type of soil and placing of the 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.

REFERENCES

[1]. Duggal, S.K., “Earthquake Resistant Design of Structures” Oxford University Press, New Delhi 2010
[2]. Chopra, A.K., “Dynamics of Structures: Theory and Application to Earthquake Engineering”, Pearson Education, 4th edition, 2012.
[3]. Bureau of Indian Standars, IS 456 : 2000, “Plain and Reinforced Concrete-Code of practice”, New Delhi, India.
[4]. Bureau of Indian Standards: IS 13920 : 1993, “Ductile detailing of reinforced concrete structures subjected to seismic forces— Code of Practice”, New Delhi, India.
[5]. Bureau of Indian Standards: IS 875(part 1) : 1987, “Dead loads on buildings and Structures”, New Delhi, India.

[6]. Bureau of Indian Standards: IS 875(part 2) : 1987, “Live loads on buildings and Structures”,New Delhi, India.
[7]. Bureau of Indian Standards: IS 1893 (part 1) : 2002, “Criteria for earthquake resistant design of structures: Part 1 General provisions and buildings”, New Delhi, India.
[8]. Berkeley “ETABS Integrated Building Design Software”, Computers and Structure, Inc., California, USA, February 2003
[9]. Gary R.scarer and Sigmund A.Freeman " Design drifts requirement for long period structures " , 1 3 ' World conference on earth quake engineering Vancouver,B.C, Canada ,Aug 2004 paper no-3292 .
[10]. J.L.Humar and S.Yavari "Design of concrete shear wall buildings for earthquake induced torsion". 4'1" structural conference of the Canadian society for civil engineering June-2002.
[11]. Mo and Jost,**“**the seismic response of multistory reinforced concrete framed shear walls using a nonlinear model**”** , Volume 15, Structure Engineering , Issue 3, 1993, Pages 155–166 .
[12]. Paulay,T., and Priestley, M.J.N., ‘Seismic design of reinforced concrete and masonry buildings’, 1992.
[13]. Anand, N. ,Mightraj, C. and Prince Arulraj, G. “Seismic behaviour of RCC shear wall under different soil conditions” Indian geotechnical conference, Dec – 2010, pp 119-120.
[14]. Anshuman, S., DipenduBhunia, BhavinRamjiyani,“Solution of shear wall location in multistory building”, International journal of civil and structural engineering, Vol. 4, Issue 5, pp. 22-32 ,2011.
[15]. Chandiwala, A., “Earthquake Analysis of Building Configuration withDifferent Position of Shear Wall”, International Journal of Emerging Technology and Advanced Engineering ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 2, Issue 12, December 2012
[16]. Chandurkar, P.P., Dr. Pajgade, P.S., “Seismic analysis of RCC building with and without shear wall”, International Journal of Modern Engineering Research. Vol. 3, Issue 3, pp. 1805-1810, 2013.
[17]. Rahangdale, H., Satone, S.R., “Design and analysis of multi-storied building with effect of shear wall”, International journal of engineering research and application", Vol. 3, Issue 3, pp. 223-232, 2013.

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