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Impact of Seismic Load on Pier Forces in Different Type of RC Shear Walls in Concrete Frame Structures with Different Type of Soil Condition

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Strictly as per the compliance and regulations of:

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Mahdi Hosseini [α] & N. V. Ramana Rao [σ]

Abstract- Shear walls are a type of structural system that provides lateral resistance to a building or structure. They resist in-plane loads that are applied along its height. The applied load is generally transferred to the wall by a diaphragm or collector or drag member. 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 the present work thirty story building with C Shape, Box shape, E Shape, I shape and Plus shape RC Shear wall at the center in Concrete Frame Structure with fixed support conditions under 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. All the analyses has been carried out as per the Indian Standard code books. This paper aims to Study the effect of Seismic load on Pier Forces in Different Type of RC Shear Walls in Concrete Frame Structures under Different Type of Soil Condition. Estimation of Pier Forces such as; Pier Axial Force , Pier moment, Pier shear Force, Pier Torsion, Time period and frequency and Modal Load Participation Ratios is carried out. In dynamic analysis; Response Spectrum method is used.

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I. Introduction

a) Shear wall structure

The usefulness of shear walls in framing of buildings has long been recognized. Walls situated in advantageous positions in a building can form an efficient lateral-force-resisting system, simultaneously fulfilling other functional requirements. When a permanent and similar subdivision of floor areas in all stories is required as in the case of hotels or apartment buildings, numerous shear walls can be utilized not only for lateral force resistance but also to carry gravity loads. In such case, the floor by floor repetitive planning allows the walls to be vertically continuous which may serve simultaneously as excellent acoustic and fire insulators between the apartments. Shear walls may be planar but are often of L-, T-, I-, or E, C, Box shaped section to better suit the planning and to increase their flexural stiffness.

The positions of shear walls within a building are usually dictated by functional requirements. These may or may not suit structural planning. The purpose of a building and consequent allocation of floor space may dictate required arrangements of walls that can often be readily utilized for lateral force resistance. Building sites, architectural interests or client's desire may lead the positions of walls that are undesirable from a structural point of view. However, structural designers are often in the position to advice as to the most desirable locations for shear walls in order to optimize seismic resistance. The major structural considerations for individual shear walls will be aspects of symmetry in stiffness, torsional stability and available overturning capacity of the foundations (Paulay and Priestley, 1992).

b) Earthquake Load

The seismic weight of building is the sum of seismic weight of all the floors. The seismic weight of each floor is its full dead load plus appropriate amount of imposed load, the latter being that part of the imposed loads that may reasonably be expected to be attached to the structure at the time of earthquake shaking. It includes the weight of permanent and

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movable partitions, permanent equipment, a part of the live load, etc. While computing the seismic weight of columns and walls in any storey shall be equally distributed to the floors above and below the storey. Earthquake forces experienced by a building result from ground motions (accelerations) which are also fluctuating or dynamic in nature, in fact they reverse direction somewhat chaotically. The magnitude of an earthquake force depends on the magnitude of an earthquake, distance from the earthquake source(epicenter), local ground conditions that may amplify ground shaking (or dampen it), the weight(or mass) of the structure, and the type of structural system and its ability to with stand abusive cyclic loading. In theory and practice, the lateral force that a building experiences from an earthquake increases in direct proportion with the acceleration of ground motion at the building site and the mass of the building (i.e., a doubling in ground motion acceleration or building mass will double the load).This theory rests on the simplicity and validity of Newton's law of physics: F = m x a, where 'F' represents force, 'm' represents mass or weight, and 'a' represents acceleration. For example, as a car accelerates forward, a force is imparted to the driver through the seat to push him forward with the car(this force is equivalent to the weight of the driver multiplied by the acceleration or rate of change in speed of the car). As the brake is applied, the car is decelerated and a force is imparted to the driver by the seat-belt to push him back toward the seat. Similarly, as the ground accelerates back and forth during an earthquake it imparts back-and-forth(cyclic) forces to a building through its foundation which is forced to move with the ground. One can imagine a very light structure such as fabric tent that will be undamaged in almost any earthquake but it will not survive high wind. The reason is the low mass (weight) of the tent. Therefore, residential buildings generally perform reasonably well in earthquakes but are more vulnerable in high-wind load prone areas. Regardless, the proper amount of bracing is required in both cases.

c) Importance of Seismic Design Codes

Ground vibration during earthquake cause forces and deformations in structures. Structures need to be designed withstand such forces and deformations. Seismic codes help to improve the behavior of structures so that may withstand the earthquake effect without significant loss of life and property. Countries around the world have procedures outlined in seismic code to help design engineers in the planning, designing, detailing and constructing of structures.

i. *An earthquake resistant has four virtues in it, namely*

a. *Good Structural Configuration*

Its size, shape and structural system carrying loads are such that they ensure a direct and smooth flow of inertia forces to the ground.

b. *Lateral Strength*

The maximum lateral (horizontal) force that it can resist is such that the damage induced in it does not result in collapse.

c. *Adequate Stiffness*

Its lateral load resisting system is such that the earthquake – indeed deformations in it do not damage its contents under low-to- moderate shaking.

d. *Good Ductility*

Its capacity to undergo large deformations under severe earthquake shaking even after yielding is improved by favorable design and detailing strategies.

ii. *Indian Seismic Codes*

Seismic codes are unique to a particular region or country. They take into account the local seismology, accepted level of seismic risk, buildings typologies, and materials and methods used in construction.

The Bureau of Indian Standards (BIS) the following Seismic Codes:

IS 1893 (PART 1) 2002, *Indian Standard Criteria* for Earthquakes Resistant of Design Structures (5^{th} revision).

IS 4326, 1993, Indian Standard Code of practice for Earthquake Resistant Design and Construction of Buildings. (2^{nd} revision).

IS 13827, 1993, Indian Standard Guidelines for improving Earthquake Resistant of Earthen buildings.

IS 13828, 1993 Indian Standard Guidelines for improving Earthquake Resistant of Low Strength Masonry Buildings.

IS 13920, 1993, Indian Standard Code for practice for Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces.

The regulations in these standards do not ensure that structures suffer no damage during earthquake of all magnitude. But, to the extent possible, they ensure that structures are able to respond to earthquake shaking of moderate intensities without structural damage and of heavy intensities wit out total collapse.

d) 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.

e) Bearing capacity of foundation soil

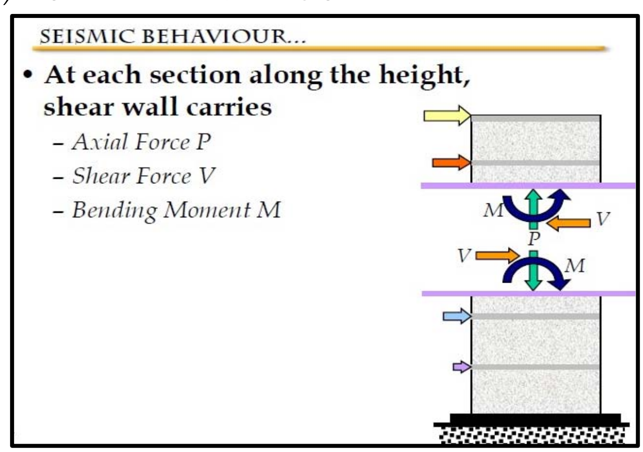
Three soil types are considered here:

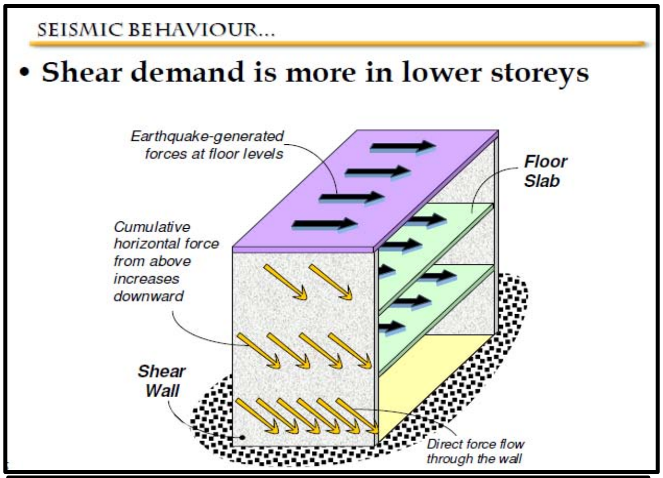
i. *Hard*- Those soils, which have an allowable bearing capacity of more than 10t/m2.
ii. *Medium*- Those soils, which have an allowable bearing capacity less than or equal to 10t/m2.
iii. *Soft*- Those soils, which are liable to large differential settlement or liquefaction during an earthquake.

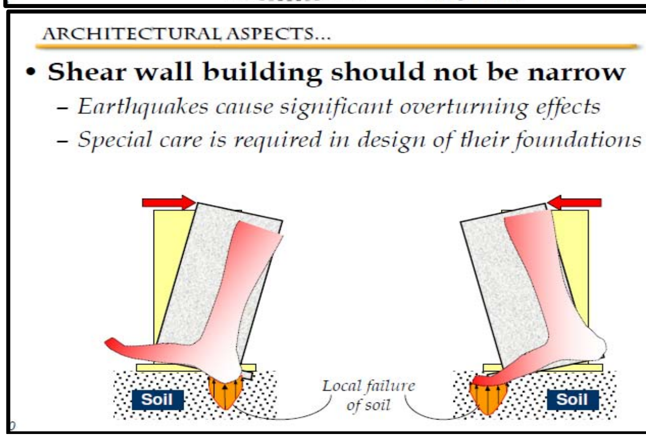
Soils must be avoided or compacted to improve them so as to qualify them either as firm or stiff. The allowable bearing pressure shall be determined in accordance with IS: 1888-1982 load test (Revision 1992). It is a common practice to increase the allowable bearing pressure by one-third, i.e. 33%, while 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 properties of the soil and the structure.

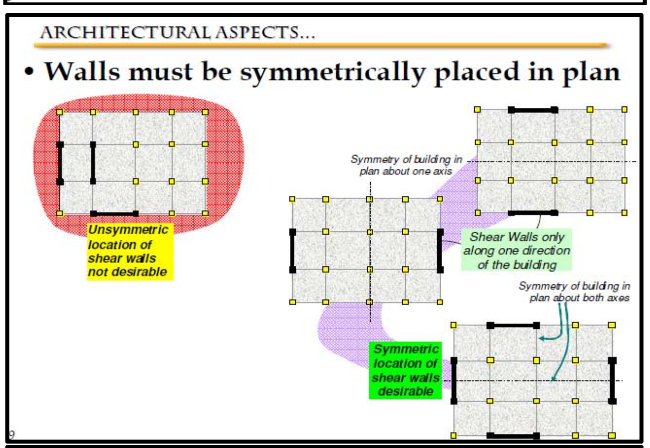
Thus the physical property of the foundation medium is an important factor in the earthquake response of structures supported on it. There are two aspects of building foundation interaction during earthquakes, which are of primary importance to earthquake engineering. First, the response to earthquake 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.

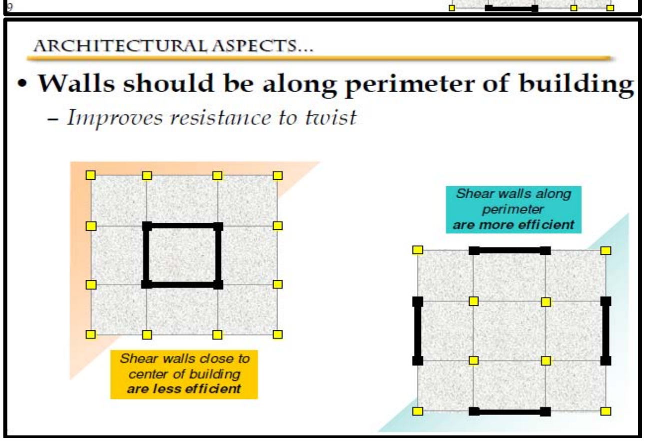
f) Seismic Behavior of RC Shear Wall

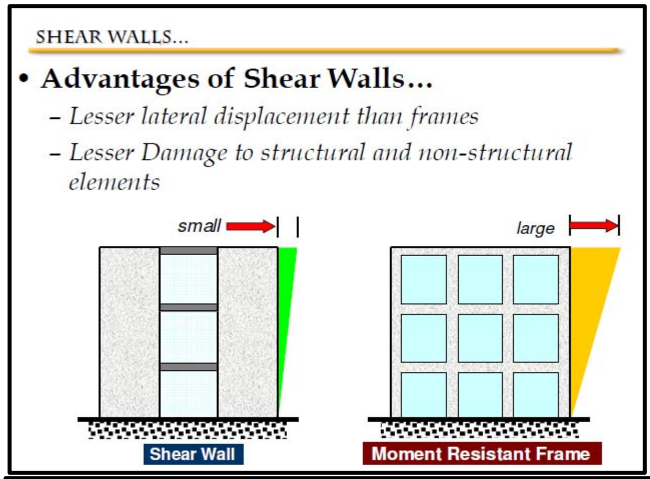


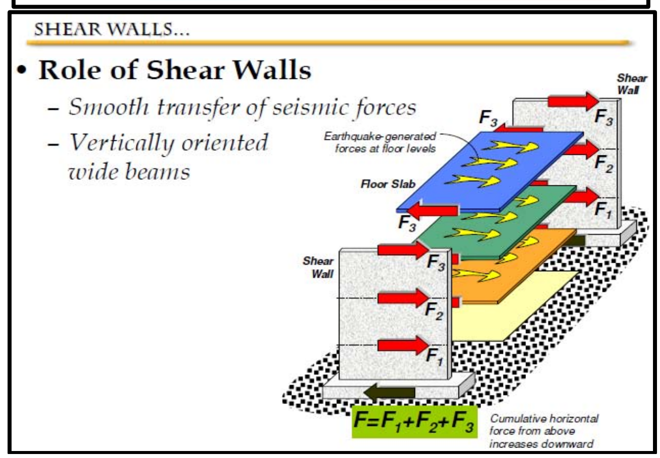


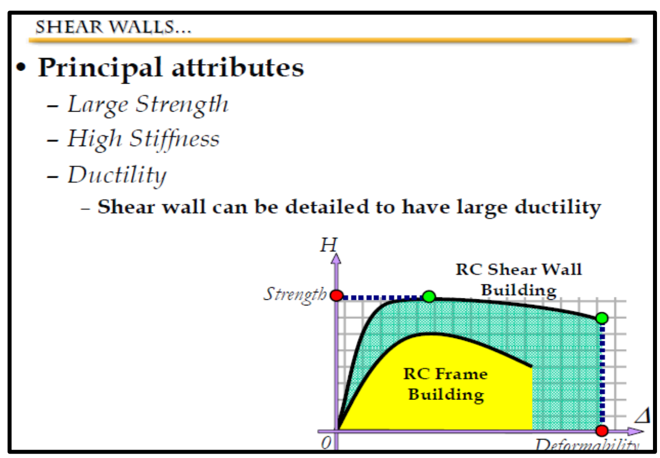












II. Methodology

Earthquake motion causes vibration of the structure leading to inertia forces. Thus a structure must be able to safely transmit the horizontal and the vertical inertia forces generated in the super structure through the foundation to the ground. Hence, for most of the ordinary structures, earthquake-resistant design requires ensuring that the structure has adequate lateral load carrying capacity. Seismic codes will guide a designer to safely design the structure for its intended purpose.

Quite a few methods are available for the earthquake analysis of buildings; two of them are presented here:

1. Equivalent Static Lateral Force Method (pseudo static method).
2. Dynamic Analysis.
   i. Response spectrum method.
   ii. Time history method.

a) Equivalent lateral Force (Seismic Coefficient) Method

This method of finding lateral forces is also known as the static method or the equivalent static method or the seismic coefficient method. The static method is the simplest one and it requires less computational effort and is based on formulae given in the code of practice.

In all the methods of analyzing a multi storey buildings recommended in the code, the structure is treated as discrete system having concentrated masses at floor levels which include the weight of columns and walls in any storey should be equally distributed to the floors above and below the storey. In addition, the appropriate amount of imposed load at this floor is also lumped with it. It is also assumed that the structure flexible and will deflect with respect to the position of foundation the lumped mass system reduces to the solution of a system of second order differential equations. These equations are formed by distribution, of mass and stiffness in a structure, together with its damping characteristics of the ground motion.

b) Dynamic Analysis

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

Regular buildings: Those greater than 40m in height in zones IV and V, those greater than 90m in height in zone II and III.

Irregular buildings: All framed buildings higher than 12m in zones IV and V, and those greater than 40m in height in zones II and III.

The analysis of model for dynamic analysis of buildings with unusual configuration should be such that it adequately models the types of irregularities present in the building configuration. Buildings with plan irregularities, as defined in Table 4 of IS code: 1893-2002 cannot be modeled for dynamic analysis.

Dynamic analysis may be performed either by the TIME HISTORY METHOD or by the RESPONSE SPECTRUM METHOD

c) Time History Method

The usage of this method shall be on an appropriate ground motion and shall be performed using accepted principles of dynamics. In this method, the mathematical model of the building is subjected to accelerations from earthquake records that represent the expected earthquake at the base of the structure.

d) Response Spectrum Method

The word spectrum in engineering conveys the idea that the response of buildings having a broad range of periods is summarized in a single graph. This method shall be performed using the design spectrum specified in code or by a site-specific design spectrum for a structure prepared at a project site. The values of damping for building may be taken as 2 and 5 percent of the critical, for the purposes of dynamic of steel and reinforce concrete buildings, respectively. For most buildings, inelastic response can be expected to occur during a major earthquake, implying that an inelastic analysis is more proper for design. However, in spite of the availability of nonlinear inelastic programs, they are not used in typical design practice because:

1. Their proper use requires knowledge of their inner workings and theories. design criteria, and
2. Result produced are difficult to interpret and apply to traditional design criteria , and
3. The necessary computations are expensive.

Therefore, analysis in practice typically use linear elastic procedures based on the response spectrum method. The response spectrum analysis is the preferred method because it is easier to use.

III. 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.

Prajapati R.J. et al., (2013) carried out study on deflection in high rise buildings for different position of shear walls. It was observed that deflection for building with shear walls provided at the corners in both the directions was drastically less when compared with other models.

Chandurkar P.P. et al., (2013) conducted a study on seismic analysis of RCC building with and without shear walls. They have selected a ten storied building located in zone II, zone III, zone IV and zone V. Parameters like Lateral displacement, story drift and total cost required for ground floor were calculated in both the cases.

Bhat S.M. et al., (2013) carried out study on Eathquakebehaviour of buildings with and without shear walls. Parameters like Lateral displacement, story drift etc were found and compared with the bare frame model.

Sardar S.J. et al., (2013) studied lateral displacement and inter-story drift on a square symmetric structure with walls at the centre and at the edges, and found that the presence of shear wall can affect the seismic behaviour of frame structure to large extent, and the shear wall increases the strength and stiffness of the structure.

Sagar K.et al., (2012) carried out linear dynamic analysis on two sixteen storey high buildings. It was concluded that shear walls are one of the most effective building elements in resisting lateral forces during earthquake. Providing shear walls in proper position minimizes effect and damages due to earthquake and winds.

Kumbhare P.S. et al., (2012) carried out a study on shear wall frame interaction systems and member forces. It was found that shear wall frame interaction systems are very effective in resisting lateral forces induced by earthquake. Placing shear wall away from center of gravity resulted in increase in the most of the members forces. It follows that shear walls should be coinciding with the centroid of the building.

Rahman A. et al., (2012) studied on drift analysis due to earthquake load on tall structures. In this study regular shaped structures have been considered. Estimation of drift was carried out for rigid frame structure, coupled shear wall structure and wall frame structure.

Anshuman et al., (2011) conducted a research on solution of shear wall location in multi storey building. An earthquake load was calculated and applied to a fifteen storied building located in zone IV. It was observed that the top deflection was reduced and reached within the permissible deflection after providing the shear wall.

Kameshwari B. et al., (2011) analyzed the effect of various configurations of shear walls on high-rise structure. The drift and inter-storey drift of the structure in the following configurations of shear wall panels was studied and was compared with that of bare frame. Diagonal shear wall configuration was found to be effective for structures in the earthquake prone areas.

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 with Different Type of RC Shear Walls (C, E,I, Box and Plus shapes) with 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 Pier Axial Force, Pier moment, Pier shear Force and Pier Torsion of the models has been studied.
- The variation of Time period and frequency has been studied.
- The variation of Modal Load Participation Ratios has been studied.

IV. Modeling of Building

a) 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.

Structure 1: In this model building with 30 storey is modeled as a (Dual frame system with shear wall (Plus Shape) at the center of building, The shear wall acts as vertical cantilever.

Structure 2: In this model building with 30 storey is modeled as (Dual frame system with shear wall (Box Shape) at the center of building ,The shear wall acts as vertical cantilever.

Structure 3: In this model building with 30 storey is modeled as (Dual frame system with shear wall (C- Shape) at the center of building, The shear wall acts as vertical cantilever.

Structure 4: In this model building with 30 storey is modeled as (Dual frame system with shear wall (E- Shape) at the center of building ,The shear wall acts as vertical cantilever.

Structure 5: In this model building with 30 storey is modeled as (Dual frame system with shear wall (I-Shape) at the center of building, The shear wall acts as vertical cantilever.

b) 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
Important Factor	1.5
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

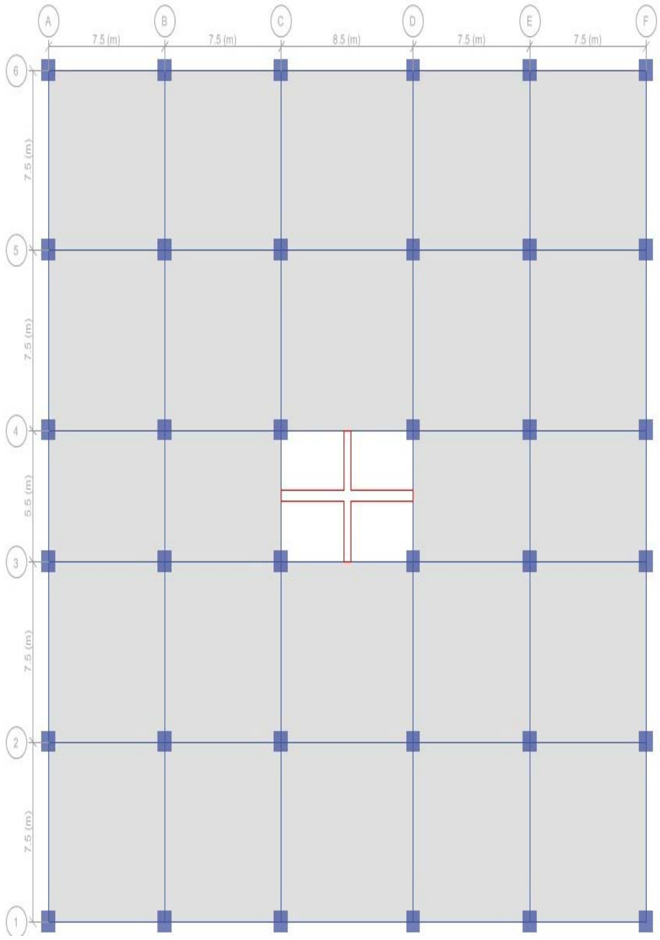


Fig. 1: Plan of the Structure 1

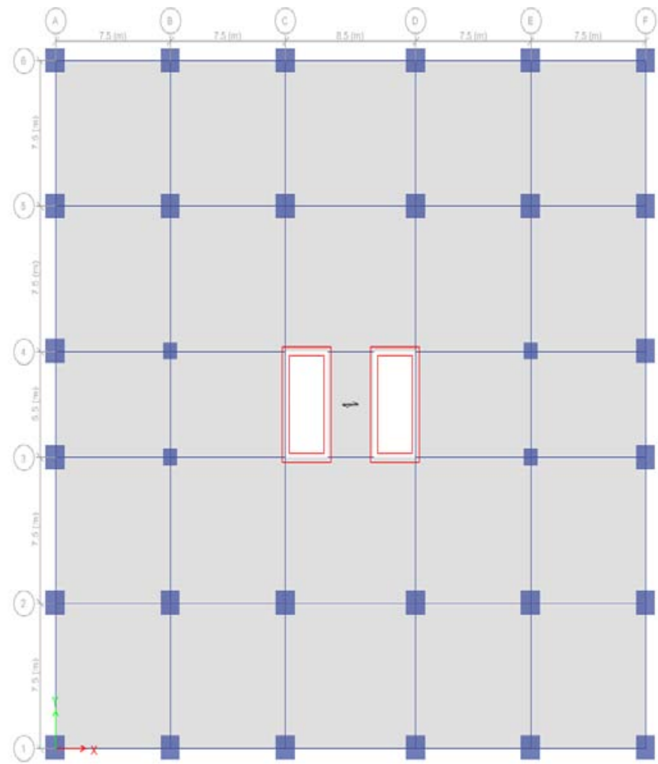


Fig. 3: Plan of the Structure 2

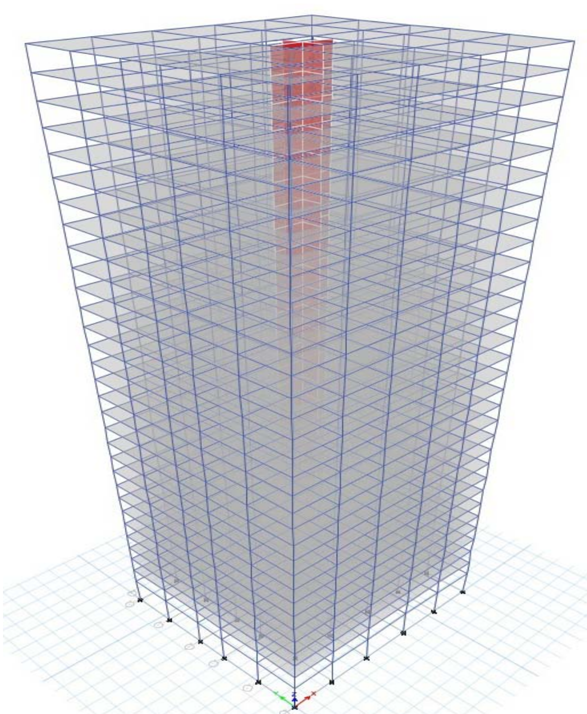


Fig. 2: 3D view showing shear wall location for Structure 1

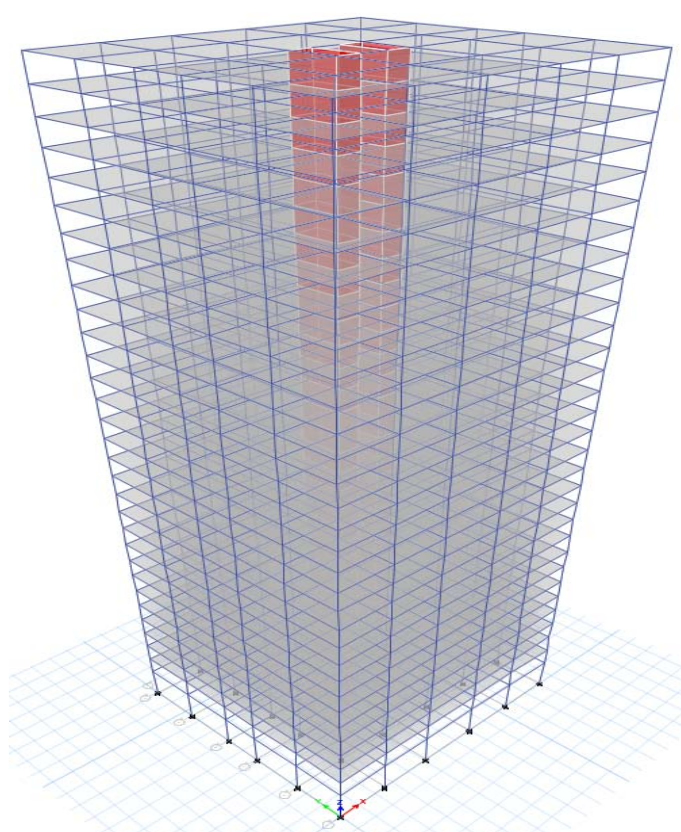


Fig. 4: 3D view showing shear wall location for Structure 2

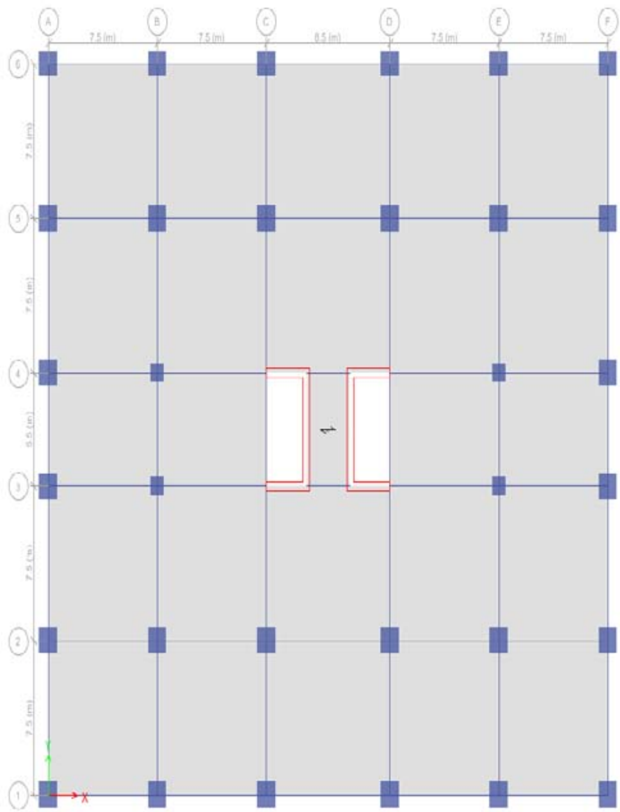


Fig. 5: Plan of the Structure 3

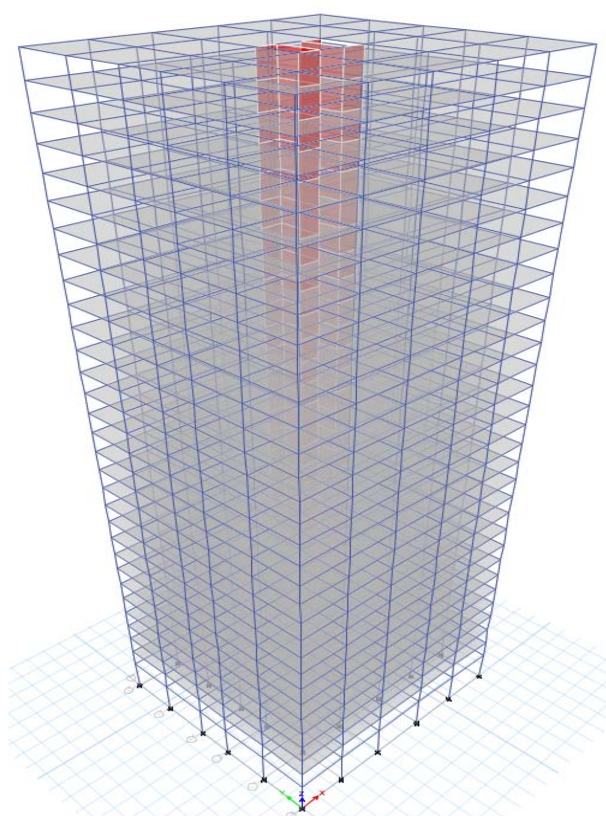


Fig. 6: 3D view showing shear wall location for Structure 3

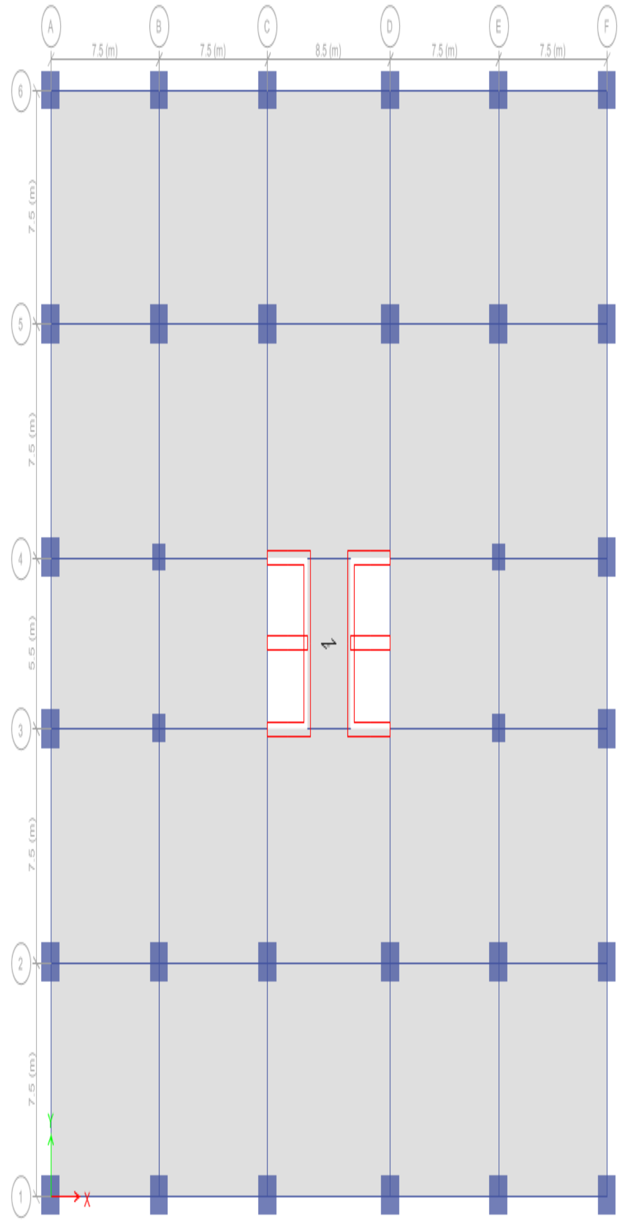


Fig. 7: Plan of the Structure 4

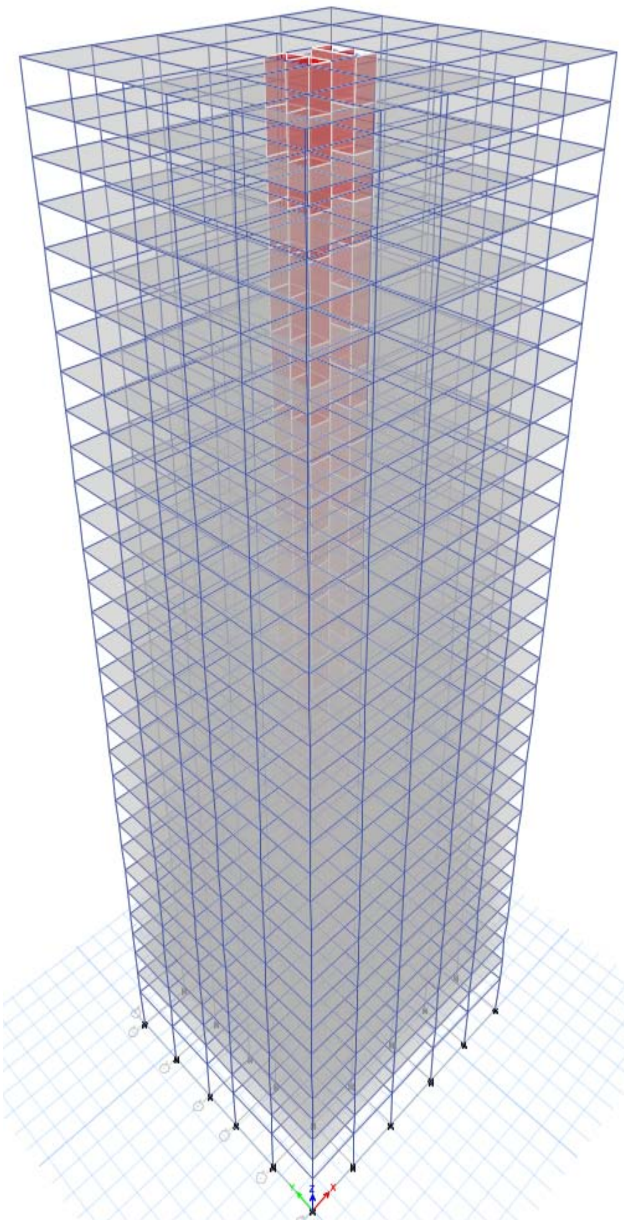


Fig. 8: 3D view showing shear wall location for Structure 4

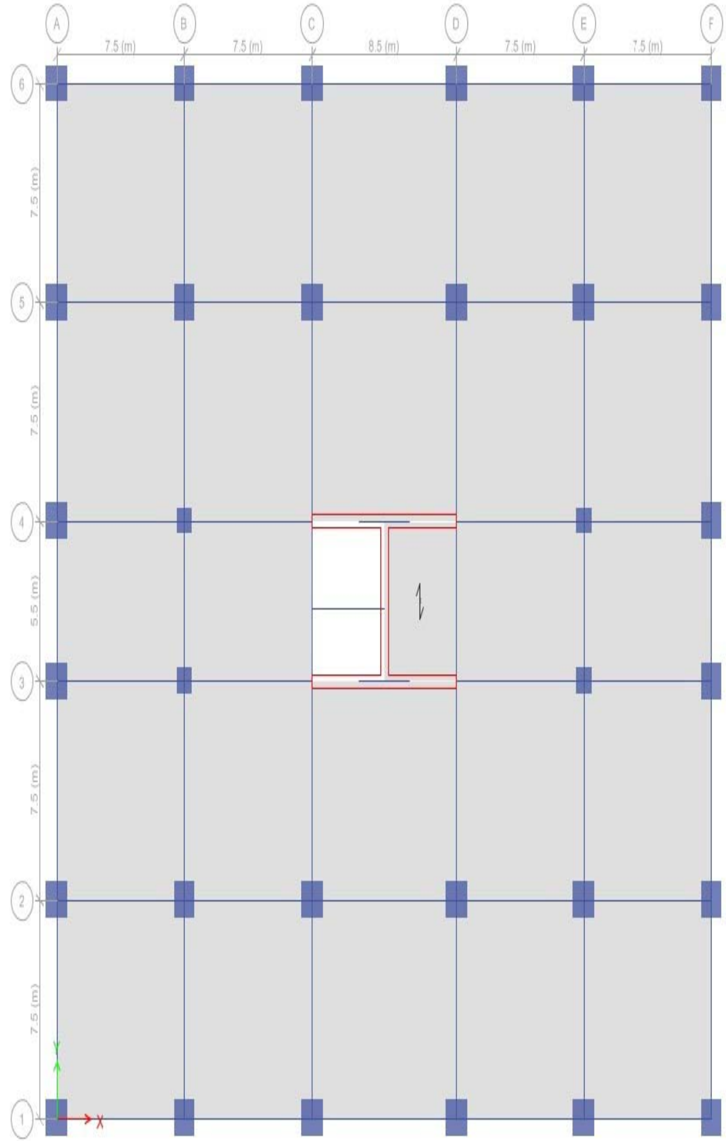


Fig. 9: Plan of the Structure 5

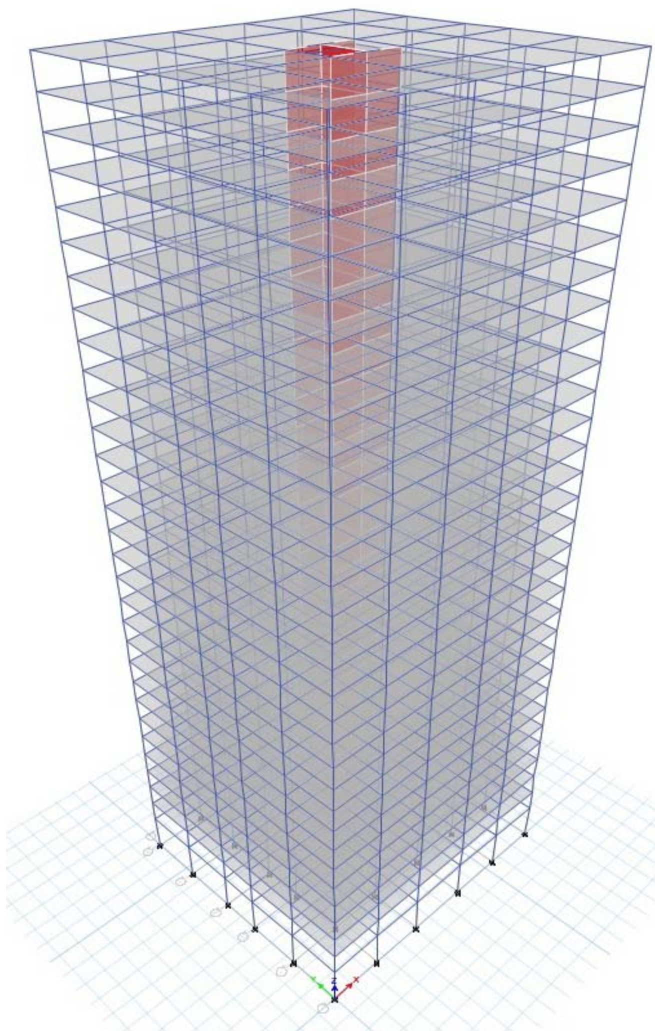


Fig. 10: 3D view showing shear wall location for Structure 5

V. Results and Discussions

Table 2: Pier Axial Force, P for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP) in soft soil

Table: Pier Forces				Structure -1	Structure -2	Structure -3	Structure -4	Structure -5
Story	Pier	Load Case/Combo	Location	P	P	P	P	P
				kN	kN	kN	kN	kN
1ST	P3	12DLRLLEQXP	Top	-31716.3887	-33051.4245	-34550.8106	-6497.8574	-33427.2625
1ST	P3	12DLRLLEQXP	Bottom	-31976.2637	-33311.2995	-34810.6856	-6627.7949	-33687.1375
1ST	P3	12DLRLLEQYP	Top	-31716.3887	-25170.9557	-32781.7792	-13631.3189	-33874.5211
1ST	P3	12DLRLLEQYP	Bottom	-31976.2637	-25430.8307	-33041.6542	-13761.2564	-34134.3961

Table 3: Pier Axial Force, P for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP) in medium soil

Table: Pier Forces				Structure -1	Structure -2	Structure -3	Structure -4	Structure -5
Story	Pier	Load Case/Combo	Location	P	P	P	P	P
				kN	kN	kN	kN	kN
1ST	P3	12DLRLLEQXP	Top	-31716.3887	-35888.3932	-35187.6619	-3330.9739	-33266.2891
1ST	P3	12DLRLLEQXP	Bottom	-31976.2637	-36148.2682	-35447.5369	-3460.9114	-33526.1641
1ST	P3	12DLRLLEQYP	Top	-31716.3887	-25170.9557	-32781.7792	-13631.3189	-33874.5608
1ST	P3	12DLRLLEQYP	Bottom	-31976.2637	-25430.8307	-33041.6542	-13761.2564	-34134.4358

Table 4: Pier Axial Force, P for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP) in hard soil

Table: Pier Forces				Structure -1	Structure -2	Structure -3	Structure -4	Structure -5
Story	Pier	Load Case/Combo	Location	P	P	P	P	P
				kN	kN	kN	kN	kN
1ST	P3	12DLRLLEQXP	Top	-31716.3887	-38331.3385	-35736.0616	-983.1011	-33127.6731
1ST	P3	12DLRLLEQXP	Bottom	-31976.2637	-38591.2135	-35995.9366	-1113.0386	-33387.5481
1ST	P3	12DLRLLEQYP	Top	-31716.3887	-25170.9557	-32781.7792	-13631.3189	-33874.595
1ST	P3	12DLRLLEQYP	Bottom	-31976.2637	-25430.8307	-33041.6542	-13761.2564	-34134.47

Table 5: Pier Moment, M for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP)in soft soil

Table: Pier Forces				Structure- 1	Structure -1	Structure -2	Structure -2	Structure - 3	Structure - 3	Structure - 4	Structure - 4	Structure - 5	Structure - 5
Story	Pier	Load Case/Combo	Location	M2	M3	M2	M3	M2	M3	M2	M3	M2	M3
				kN-m	kN-m	kN-m	kN -m	kN -m	kN -m	kN - m	kN-m	kN -m	kN -m
1ST	P3	12DLRLLEQXP	Top	429.3134	-285.376	54.4708	1200.3755	1.9394	237.7991	-17.4689	1861.0597	-65.0181	-61.6944
1ST	P3	12DLRLLEQXP	Bottom	-796.6308	-244.1397	-444.1125	-365.0748	-496.6401	403.2212	21.225	6530.9935	-290.8369	-17.1098
1ST	P3	12DLRLLEQYP	Top	-10.3264	29494.5797	0.9942	19086.5309	0.9679	18817.9303	21.4569	-716.6361	-57.7674	11107.3586
1ST	P3	12DLRLLEQYP	Botbm	4.0607	41193.3422	-3.6328	27973.8752	-4.8413	31627.6809	138.7803	1031.4388	63.9359	34855.9706

Table 6: Pier Moment, M for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP) in medium soil

Table: Pier Forces				Structure -1	Structure -1	Structure -2	Structure -2	Structure -3	Structure -3	Structure - 4	Structure -4	Structure - 5	Structure - 5
Story	Pier	Load Case/Combo	Location	M2	M3	M2	M3	M2	M3	M2	M3	M2	M3
				kN-m	kN-m	kN-m	kN -m	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
1ST	P3	12DLRLLEQXP	Top	587.5838	-285.376	73.7223	1632.5107	2.2891	323.4068	-25.2213	3005.3081	-67.6274	-71.3796
1ST	P3	12DLRLLEQXP	Bottom	-1084.8797	-244.1397	-602.6852	-496.5017	-673.6876	548.3809	30.6443	8971.8027	-418.5547	-16.379
1ST	P3	12DLRLLEQYP	Top	-10.3264	40215.3638	0.9942	25957.6821	0.9679	25592.3853	30.9946	-716.6361	-57.7665	15118.5325
1ST	P3	12DLRLLEQYP	Bottom	4.0607	56110.8357	-3.6328	38044.4703	-4.8413	43013.646	200.3734	1031.4388	63.9363	47411.0104

Table 7: Pier Moment, M for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP) in hard soil

Table: Pier Forces				Structure -1	Structure -1	Structure -2	Structure - 2	Structure -3	Structure -3	Structure -4	Structure -4	Structure- 5	Structure -5
Story	Pier	Load Case/Combo	Location	M2	M3	M2	M3	M2	M3	M2	M3	M2	M3
				kN-m	kN-m	kN-m	kN-m	kNm	kN-m	kN- m	kN-m	kN-m	kN-m
1ST	P3	12DLRLLEQXP	Top	723.8721	-285.376	90.3001	2004.6271	2.5903	397.1246	-30.9703	3853.6925	-69.8743	-79.7196
1ST	P3	12DLRLLEQXP	Bottom	-1333.0941	-244.1397	-739.2339	-609.6748	-826.1452	673.3795	37.6294	10781.7386	-528.5339	-15.7496
1ST	P3	12DLRLLEQYP	Top	-10.3264	49447.15	0.9942	31874.5067	0.9679	31425.9437	38.0596	-716.6361	-57.7657	18572.599
1ST	P3	12DLRLLEQYP	Bottom	4.0607	68956.455	-3.6328	46716.3716	-4.8413	52818.2271	246.0468	1031.4388	63.9367	58222.2947

Table 8: Pier Shear Force, V for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP) in soft soil

Table: Pier Forces				Structure-1	Structure-1	Structure -2	Structure -2	Structure - 3	Structure - 3	Structure - 4	Structure - 4	Structure - 5	Structure - 5
Story	Pier	Load Case/Combo	Location	V2	V3	V2	V3	V2	V3	V2	V3	V2	V3
				kN	kN	kN	kN	kN	kN	kN	kN	kN	kN
1ST	P3	12DLRLLEQXP	Top	11.7818	-350.2698	-447.2715	-142.4524	47.2635	-142.4513	1334.2668	11.0554	12.7385	-64.5197
1ST	P3	12DLRLLEQXP	Bottom	11.7818	-350.2698	-447.2715	-142.4524	47.2635	-142.4513	1334.2668	11.0554	12.7385	-64.5197
1ST	P3	12DLRLLEQYP	Top	3342.5036	4.1106	2539.2412	-1.322	3659.9287	-1.6598	499.45	33.521	6785.3177	34.7724
1ST	P3	12DLRLLEQYP	Bottom	3342.5036	4.1106	2539.2412	-1.322	3659.9287	-1.6598	499.45	33.521	6785.3177	34.7724

Table 9: Pier Shear Force, V for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP) in medium soil

Table: Pier Forces				Structure-1	Structure-1	Structure -2	Structure -2	Structure - 3	Structure- 3	Structure - 4	Structure - 4	Structure-5	Structure - 5
St or y	Pier	Load Case/Combo	Location	V2	V3	V2	V3	V2	V3	V2	V3	V2	V3
				kN	kN	kN	kN	kN	kN	kN	kN	kN	kN
1 ST	P3	12D LRLLEQXP	Top	11.7818	- 477.8467	-608.2892	- 193.2593	64.2783	-193.1362	1704.7127	15.9616	15.7145	-100.2649
1 ST	P3	12D LRLLEQXP	Bottom	11.7818	- 477.8467	-608.2892	- 193.2593	64.2783	-193.1362	1704.7127	15.9616	15.7145	-100.2649
1 ST	P3	12D LRLLEQYP	Top	4541.5634	4.1106	3453.3681	-1.32 2		1.6598	499.45	48.3939	9226.4222	34.7722
1 ST	P3	12D LRLLEQYP	Bottom	4541.5634	4.1106	3453.3681	- 1.322	4977.5031	- 1.6598	499.45	48.3939	9226.4222	34.7722

Table 10: Pier Shear Force, V for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP) in hard soil

Table: Pier Forces				Structure-1	Structure-1	Structure -2	Structure -2	Structure - 3	Structure- 3	Structure - 4	Structure - 4	Structure-5	Structure - 5
Stor y	Pier	Load Case/Combo	Location	V2	V3	V2	V3	V2	V3	V2	V3	V2	V3
				kN	kN	kN	kN	kN	kN	kN	kN	kN	kN
1ST	P3	12D LR LLEQXP	Top	11.7818	-587. 7046	-746. 9434	-237. 0097	78. 93	-236. 7816	1979. 4418	19. 5999	18. 2771	-131. 0456
1ST	P3	12D LR LLEQXP	Bottom	11.7818	-587. 7046	-746. 9434	- 237. 0097	78. 93	-236. 7816	1979. 4418	19. 5999	18. 2771	-131.0456
1ST	P3	12D LR LLEQYP	Top	5574. 0871	4. 1106	4240. 5328	-1. 322	6112. 081	-1. 6598	499.45	59. 4249	11328. 4845	34. 7721
1ST	P3	12D LR LLEQYP	Bottom	5574. 0871	4. 1106	4240. 5328	-1. 322	6112. 081	-1. 6598	499.45	59. 4249	11328.4845	34. 7721

Table 11: Pier Torsion, T for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP) in soft soil

Table: Pier Forces				Structure - 1	Structure -2	Structure -3	Structure -4	Structure -5
Story	Pier	Load Case/Combo	Location	T	T	T	T	T
				kN-m	kN-m	kN-m	kN-m	kN-m
1ST	P3	12DLRLLEQXP	Top	-57.8883	-31.8229	-32.2595	-17.3115	-33.9525
1ST	P3	12DLRLLEQXP	Bottom	-57.8883	-31.8229	-32.2595	-17.3115	-33.9525
1ST	P3	12DLRLLEQYP	Top	46.5531	41.9152	92.9513	35.9013	85.1595
1ST	P3	12DLRLLEQYP	Bottom	46.5531	41.9152	92.9513	35.9013	85.1595

Table 12: Pier Torsion, T for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP) in medium soil

Table: Pier Forces				Structure -1	Structure -2	Structure -3	Structure -4	Structure -5
Story	Pier	Load Case/Combo	Location	T	T	T	T	T
				kN-m	kN-m	kN-m	kN-m	kN-m
1ST	P3	12DLRLLEQXP	Top	-75.9256	-43.2792	-43.873	-24.9942	-46.1738
1ST	P3	12DLRLLEQXP	Bottom	-75.9256	-43.2792	-43.873	-24.9942	-46.1738
1ST	P3	12DLRLLEQYP	Top	66.1147	57.0047	126.4138	51.8336	115.8184
1ST	P3	12DLRLLEQYP	Bottom	66.1147	57.0047	126.4138	51.8336	115.8184

Table 13: Pier Torsion, T for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP) in hard soil

Table: Pier Forces				Structure -1	Structure -2	Structure -3	Structure -4	Structure -5
Story	Pier	Load Case/Combo	Location	T	T	T	T	T
				kN-m	kN-m	kN-m	kN-m	kN-m
1ST	P3	12DLRLLEQXP	Top	-91.4578	-53.1443	-53.8734	-30.6914	-56.6977
1ST	P3	12DLRLLEQXP	Bottom	-91.4578	-53.1443	-53.8734	-30.6914	-56.6977
1ST	P3	12DLRLLEQYP	Top	82.9594	69.9984	155.2287	63.6486	142.2192
1ST	P3	12DLRLLEQYP	Bottom	82.9594	69.9984	155.2287	63.6486	142.2192

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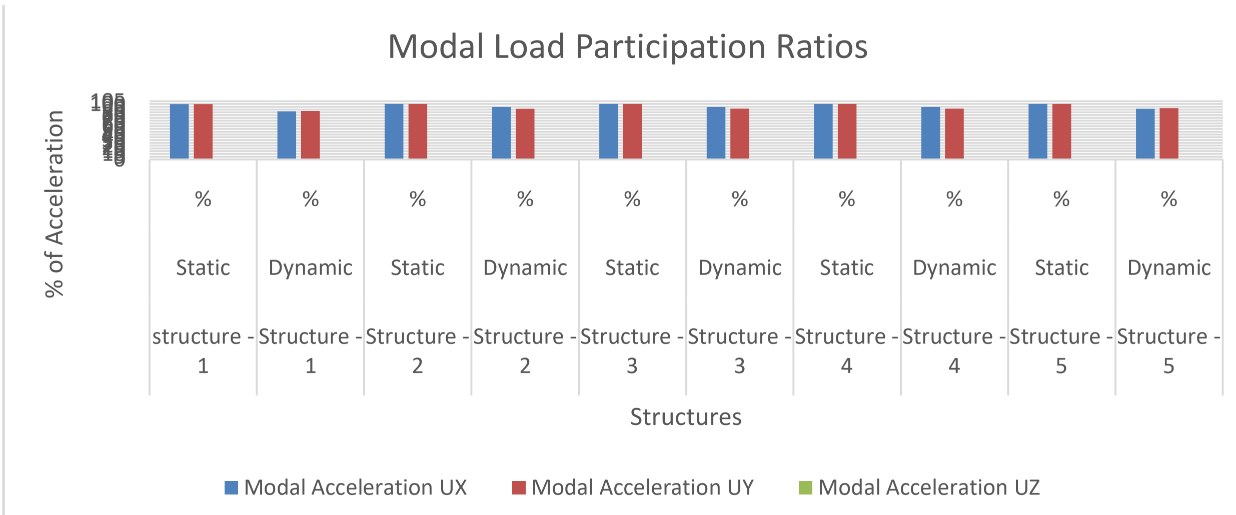
Table 14: Modal Load Participation Ratios

Table: Pier Forces			Structure-1	Structure-1	Structure-2	Structure-2	Structure-3	Structure-3	Structure-4	Structure-4	Structure-5	Structure-5
Case	Item Type	Item	Static	Dynamic	Static	Dynamic	Static	Dynamic	Static	Dynamic	Static	Dynamic
			%	%	%	%	%	%	%	%	%	%
Modal	Acceleration	UX	99.82	86.71	99.99	94.7	99.98	94.59	99.99	94.54	99.97	91.54
Modal	Acceleration	UY	99.79	87.46	99.98	91.46	99.97	91.85	99.97	91.83	99.97	92.51
Modal	Acceleration	UZ	0	0	0	0	0	0	0	0	0	0

A plot for Modal Load Participation Ratios of Structures in Soft Soil, Medium Soil and Hard Soil has been shown here



Graph 6: Modal Load Participation Ratios of Structures in Soft Soil, Medium Soil and Hard Soil

Table 15: Modal Periods and Frequencies

Structure - 1				Structure -2	Structure -2	Structure - 3	Structure - 3	Structure-4	Structure-4	Structure-5	Structure-5
Case	Mode	Period	Frequency	Period	Frequency	Period	Frequency	Period	Frequency	Period	Frequency
		sec	cyc/sec	sec	cyc/sec	sec	cyc/sec	sec	cyc/sec	sec	cyc/sec
Modal	1	6.298	0.159	5.785	0.173	6.415	0.156	6.375	0.157	6.382	0.157
Modal	2	6.248	0.16	5.606	0.178	6.32	0.158	6.21	0.161	5.694	0.176
Modal	3	5.545	0.18	4.684	0.213	5.767	0.173	5.792	0.173	5.642	0.177
Modal	4	2.062	0.485	1.701	0.588	2.114	0.473	2.102	0.476	2.088	0.479
Modal	5	1.952	0.512	1.547	0.646	1.958	0.511	1.901	0.526	1.565	0.639
Modal	6	1.603	0.624	1.475	0.678	1.568	0.638	1.575	0.635	1.524	0.656
Modal	7	1.191	0.84	0.9	1.112	1.219	0.82	1.212	0.825	1.19	0.84
Modal	8	1.027	0.974	0.838	1.193	1.028	0.972	0.983	1.017	0.791	1.264
Modal	9	0.803	1.245	0.645	1.551	0.82	1.22	0.815	1.226	0.711	1.406
Modal	10	0.782	1.279	0.613	1.632	0.711	1.406	0.714	1.401	0.703	1.423
Modal	11	0.645	1.55	0.5	2.002	0.641	1.56	0.604	1.656	0.565	1.769
Modal	12	0.581	1.72	0.45	2.222	0.592	1.689	0.589	1.697	0.423	2.363

VI. Discussion on Results

When a structure is subjected to earthquake, it responds by vibrating. An example force can be resolved into three mutually perpendicular directions-two horizontal directions (X and Y directions) and the vertical direction (Z). This motion causes the structure to vibrate or shake in all three directions; the predominant direction of shaking is horizontal. All the structures are primarily designed for gravity loads-force equal to mass time's gravity in the vertical direction. Because of the inherent factor used in the design specifications, most structures tend to be adequately protected against vertical shaking. Vertical acceleration should also be considered in structures with large spans those in which stability for design, or for overall stability analysis of structures. The basic intent of design theory for earthquake resistant structures is that buildings should be able to resist minor earthquakes without damage, resist moderate earthquakes without structural damage but with some non-structural damage. To avoid collapse during a major earthquake, Members must be ductile enough to absorb and dissipate energy by post elastic deformation. Redundancy in the structural system permits redistribution of internal forces in the event of the failure of key elements. When the primary element or system yields or fails, the lateral force can be redistributed to a secondary system to prevent progressive failure.

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

It is observed that

- ❖ The time period is 6.298 Sec for structure1 and it is same for different type of soil.
- ❖ The Frequency is 0.159 cyc/sec for structure1 and it is same for different type of soil.
- ❖ The time period is 5.785 Sec for structure2 and it is same for different type of soil.
- ❖ The Frequency is 0.173 cyc/sec for structure2 and it is same for different type of soil.
- ❖ The time period is 6.415 Sec for structure3 and it is same for different type of soil.
- ❖ The Frequency is 0.156 cyc/sec for structure3 and it is same for different type of soil.
- ❖ The time period is 6.375Sec for structure4 and it is same for different type of soil.
- ❖ The Frequency is 0.157 cyc/sec for structure4 and it is same for different type of soil.
- ❖ The time period is 6.382 Sec for structure5 and it is same for different type of soil.
- ❖ The Frequency is 0.157 cyc/sec for structure5 and it is same for different type of soil.

It is observed that

Shear Wall forces (Pier Forces) for structure 1

- ❖ For the Pier axial forces in X direction There is not considerable difference 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

Shear Wall forces (Pier Forces) for structure 2

- ❖ 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

Shear Wall forces (Pier Forces) for structure 3

- ❖ 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

Shear Wall forces (Pier Forces) for structure 4

- 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

Shear Wall forces (Pier Forces) for structure 5

- 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.

VII. 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:

- Building with box shape Shear Walls provided at the center core showed better performance in terms of Pier Forces.
- 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.
- There is considerable difference in Pier Moment with a Different type of soils and structures.
- There is considerable difference in Pier shear force with a Different type of soils and structures.
- There is not considerable difference in Pier axial forces with a Different type of soils and structures.
- It is evident that Pier Torsion in X direction for all structures in soft soil more than Medium soil and more than hard soil.
- It is evident that Pier Torsion in Y direction for soft soil less than Medium soil and less than hard 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.
- 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.
- 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.
- 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.
- 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 maximum mass for structure 2 is 94.7 percent and minimum mass for structure 1 is 86.71 percent.

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