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SEISMIC RESPONSE EVALUATION OF REINFORCED CONCRETE STRUCTURAL FRAMES WITH LATERAL LOAD RESISTING ELEMENTS

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Abstract : Performance of structures under frequently occurring earth quake ground motions resulting in structural damages as well as failures have repeatedly demonstrated the seismic vulnerability of existing buildings, due to their design based on gravity loads only or inadequate levels of lateral forces. This necessitates the need for design based on seismic responses by suitable methods to ensure strength and stability of structures. Shear wall systems are one of the most commonly used lateral load resisting systems in high rise buildings. This study aims at comparing various parameters such as storey drift, storey shear, deflection, etc. of a building under lateral loads based on strategic positioning of shear walls. In this project a parametric model of symmetric building configuration have been selected for study, 6 models of different structural configuration have been generated, combining frame and shear walls. Models started with first bare frame model, planar shear wall model with x and y orientation, corner L shaped shear walls and Central core wall with and without openings at each successive floor level. All mathematical models have been generated in E-tabs 2016.All earthquake parameters such as Lateral displacement; inter storey drift ratios, seismic base shear and dynamic parameters such as fundamental natural time periods, Modal mass participation factors, fundamental modes and modes shapes have been studied in detail. Results have compared with bare frames model with all other models and important conclusion has been drawn.

Keyword's: Structural Frames, Response spectrum method, Shear wall

INTRODUCTION

A Seismic is a sudden slip or displacement of a portion of the earth's crust or plates caused by an abrupt arrival of pressure. The inner core, the outer base, the mantle and the hull are four significant layers of the earth, the exterior and the tip of the mantle form a slight layer within the surface. Regardless, the earth has four substantial layers: the inner layer, the outer centre, the mantle, and the hull. On the outside, the exterior and the tip of the mantle form a slender layer of soil. This layer is unquestionably not a single spread in any case; there are multiple components involved, such as jigsaw covering the outside of the planet. They keep going slowly around each other, sliding past each other, and discovering each other. These interconnecting sections are called the basic Plates are known to the extent possible, and the boundary/edges of the plates. Quite far are included various imperfections and an enormous bit these problems emerge far and wide from the major earthquakes. Because the edges of the surfaces are disrupted, they slow down through the remainder of the layer keeps working. Finally, when the layer has rotated far sufficient, the boundary/edges detach on one of the defects, and there is a seismic tremor, unquestionably not a single spread, it involves several sections such as jigsaw that cover the outside of the earth. They move around each other slowly, wear away each other and explore each other. The basic plates are called these interconnecting parts, and the borders of the plates are known to the extent possible. Different imperfections are used as far as possible and on A significant part of the major earthquakes far and wide originate from these issues. Until the ends of the tectonic plates are disrupted, they slow down while the other of the tectonic plate keeps going. Finally, the boundary/edges detach on one of the defects when the surface has rotated far enough and there is a seismic tremor.

1.1 TYPES OF EARTHQUAKE

In the planet, most ground shaking/earthquake occur along the borders Tectonic plates they're addressed to as inter-plate earthquakes. Different tremors occur to the maximum practicable within the plate itself, called intra-plate earthquakes, in the same way. Shudders are marked by seismographs called tools. A seismogram is defined as the text that they recorded.

The seismogram consists of two parts to keep it immovable in the earth, a foundation and a weight. The seismograph base often shakes as a tremor causes the earth to shake, the body weight, however, doesn't. Or maybe the spring or string that it is dangling from ingests all the turn of events. Thus the differentiation between the moving and enthusiastic part is recorded. The size of a seismic tremor depends upon the size of the issue and the proportion of slip on the blemish; anyway this can't be assessed truly as issues are some place down in the earth. The seismogram accounts made on the seismographs at the outside of the earth are used to choose the power of tremor. A short line with fewer pieces of crisscross leads to a small quake and a lengthy line with a wide number of areas of crisscross indicate an immense quake. The duration of the line on the seismograph depends on the size of the deficiency and the line's wigginess depends on the deficiency's measure of oversight.

1.2: EARTHQUAKE ENVIRONMENT EFFECTS

Ecological impacts of tremor are the impacts of a quake on the common habitat, including surface blame, structural inspiration and subsidence, torrents, soil liquefactions, soil reverberation, avalanches and soil dissatisfaction, either legitimately related to the cause of the seismic tremor or incited by the shaking of the earth. These are customary features rendered in the vicinity of both regularly documented and diagrammed in progressive cases, recorded in chronicled accounts all the time and guaranteed in the static graphic record (pale earthquakes). Both surface distortion and blaming and shaking-related geographical impacts (e.g., soil liquefaction, avalanches) leave changeless engravings in the earth, yet additionally significantly influence human structures. Besides, submerged issue cracks and seismically-activated avalanches can produce damaging torrent waves. EEEs speak to a noteworthy well spring of peril, particularly (however not only) during huge quakes. This was watched for instance during pretty much calamitous seismic occasions as of late happened in altogether different pieces of the world.

1.3 FAILURE OF SOFT STOREY

In general, multi-celebrated structures in metropolitan urban areas require open taller first story for leaving of vehicles or for retail shopping, huge space for meeting room or a financial lobby attributable to absence of level space and significant expense. Because of this practical prerequisite, the primary story has lesser quality and solidness when contrasted with upper stories, which are hardened by stone work infill dividers. This trait of building development makes "feeble" or "delicate" story issues in multi-story structures. Expanded adaptability of first story results in quite a while, which thusly, prompts grouping of powers at second story associations joined by enormous plastic disfigurements. Moreover, a large portion of the vitality created during quake is disseminated by segments of the delicate stories. In this procedure the plastic pivots are shaped at the closures of sections, which change the delicate story into an instrument. In such case the breakdown is unavoidable. In this manner, the delicate stories merit an uncommon thought in investigation and plan. It has been seen from the overview that the harm is because of breakdown and clasping of segments particularly where stopping places are not secured appropriately. Despite what might be expected, the harm is decreased impressively where the parking spots are secured sufficiently. It is perceived that this sort of disappointment results from the blend of a few other negative reasons, for example, twist, over the top mass on upper floors, p-Δ impacts and absence of malleability in the base story.

Figure 1. Soft Storey Failure in Bhuj

1.4 SHEAR WALLS

Vertical components of concrete walls are of the resistive system for horizontal power. In order to overcome the impact of lateral forces on a structure, shear walls are built. Shear dividers are straight outer dividers in private construction that usually structure a crate that provides the entire sidelong support for the structure. At the point of structuring shear Dividers and properly made, and they will have the consistency and strength to oppose the flat forces.

In building advancement, an inflexible vertical stomach prepared for moving level forces from outside dividers, floors, and housetops to the ground foundation toward a way comparing to their planes. Models are the braced strong divider or vertical help. Flat powers achieved by wind, seismic tremor, and unbalanced settlement loads, despite the greatness of structure

2. LETIRATURE VIEW

For a long time, numerous research studies and experiments have been carried out around the world to explain or test the effects of seismic forces on existing RC buildings in high seismic zones.

An examination on "Seismic Performance Evaluation of Multi-celebrated RC confined structures with Shear divider" by SHAIK KAMAL MOHAMMED AZAM A correlation of auxiliary conduct as far as quality, solidness and damping attributes is finished by masterminding shear dividers at various areas/setups in the basic surrounding framework. The adaptable (response run assessment) similarly as in-adaptable (nonlinear static weakling examination) assessments are finished for the appraisal of seismic execution. The numerical models to be explicit, six praised, twelve commended, twenty four celebrated and thirty six commended second contradicting RC encompassed structures, having the plan estimations of 30m x 20m with gulf length of 5m in the two headings and floor height of 3m are considered in the assessment. The game plan of shear divider has vital impact on even quality in taller structures while it has less effect on equal robustness in taller structures. The course of action of shear divider has basic impact on sidelong strength in structures of shorter height while it has less effect on level quality. The effect of shear dividers is colossal to the extent the damping properties and period at the introduction point for tall buildings. The fundamental arrangement of model-8 has indicated dominating essential execution with respect to both the immovability and quality in the adaptable similarly as in the nonlinear range up to execution point. The model-7, in any case in like manner has closer helper execution to the model-7, with respect to both the robustness and quality in the adaptable similarly as in the nonlinear range up to execution point. Subsequently the helper game plans of models 7and 8 not simply gave the improvement in sidelong weight restriction limit yet also the extension in even strength. The packaging without the shear dividers but] with stone work infill showed shoddy helper execution to the extent both the immovability and quality. Course of action of shear dividers uniformly in the uttermost second contradicting edges and obviously interconnected regularly inverse way forming the middle will have better seismic execution to the extent quality and immovability.

3. METHODS OF ANALYSIS

3.1: EQUIVALENT STATIC ANALYSIS

This is a direct static examination. This strategy describes a way to deal with talk with the effect of shudder ground development when game plan of forces are follow up on a structure, through a seismic arrangement response extend. This strategy acknowledges that the structure responds in its key mode. The congruity of this procedure is connected in numerous development gauges by applying parts to speak to higher structures with some higher modes, and for low degrees of bending. Different codes apply modification factors that decline the arrangement powers to talk about impacts due to "yielding" the framework.

In the similar static technique, the equal force equivalent to the structure premise seismic tremor is applied statically. The tantamount flat powers at each story level The base element of the structure It is spoken to as d (in meters) at the plinth level along the bearing of horizontal forces and the tallness of the structure from the assistance is spoken to as h (in meters).

As per IS 1893-2002 this examination can be performed by utilizing the articulation

$$Q_S=\frac{VB\ X\ \sum WI\ HI2}{\sum WIHI}$$

Where Q_s= Lateral Load Distribution at Storey

Wi = Seismic Structural Mass

HI= The Framework Height

V_B=Design Base Shear, which can be determine by using, VB=A_h W

$$A_h = \frac{Zx\ Ix\ SA}{2x\ Rxg}$$

Z=Zone factor,

I=Importance factor,

R=Response reduction factor,

S_a / g =Average response acceleration coefficient

3.2 RESPONSE SPECTRUM:-

The real time history record is needed in order to determine the seismic analysis and schedule of a structure to be employed in a particular region. It's ridiculous, in any case, to presume to have such records in every single area. In addition, it is impossible to complete the seismic analysis of structures practically depending on the pinnacle estimate of the speeding up of the ground as the structure the response is based on the recurrence of the movement of the soil and its own specific properties. The range of quake reactions is the most common method in the seismic investigation of structures to solve the above challenges. The Indian standards configurations are: 1893 (Part 1)- 2002 code for response range study of multi-story construction is also summarized, according to Seems.The Approach Range Bend is given in accordance with IS 1893-2002 as

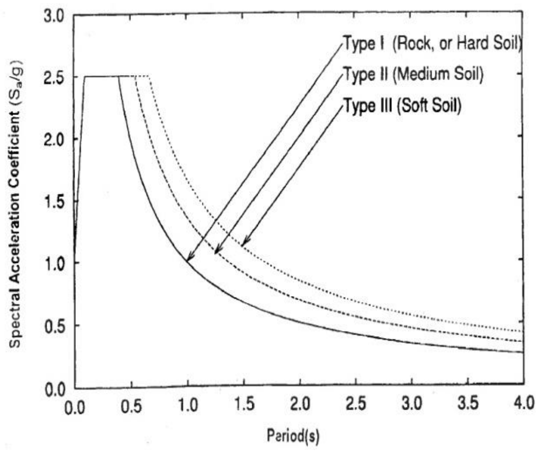

Chart 1. Response spectrum curve graph

3.2 RESPONSE SPECTRUM METHOD

Explanation spectra are curves that are graphed between the maximum response to the defined earthquake ground movement of the SDOF system and its time span (or frequency). For a given damping proportion, the response range can be deciphered as the locus of the most severe reaction of an SDOF system. In this way, interaction spectra helps to get the pinnacle auxiliary reactions under direct range, which can be used to acquire sidelong powers produced in structure due to the quake along these lines, enabling structures to prepare tremor securely.

Usually, an SDOF system response is regulated by time space or resection area examination, and most extreme reactions are chosen for a given period of time of the framework. For all possible time periods of the SDOF system, this procedure is carried out. Last plot with framework timeframe on x-pivot and reaction amount on y-hub is the necessary reaction spectra 103 relating to indicated damping proportion and information ground movement. Same procedure is completed with various damping proportions to acquire by and large reaction spectra.

3.3 STRUCTURAL MODELLING

To the FEM modelling software called ETABS2016 version have been used to complete the Seismic analysis process, after static and dynamic analysis, parameters like, modes shapes, lateral displacement, storey forces, inter storey drift have considered as the parameters for the current study ,
The models for analysis are as follows:
Model I- Model with bare frame (Including weight of Brick wall).

Model II – Model as same as **Model-I** but L-shaped shear walls are provided at the inner corners of the 3D building model.

Model III–Model as same as **Model-I** but Planar shear walls in X direction are provided at the inner corners of the 3D building model.

Model IV–Model as same as **Model-I** but Planar shear walls in Y direction are provided at the inner corners of the 3D building model.

Model V–Model as same as **Model-I** but a central core wall is provided.

Model VI–Model as same as **Model-V** shear wall openings are provided at each floor level to access lift.

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MODELLING DETAILS

1. Frame type: Special Moment Resisting Frame (SMRF)
2. Building: G+10
3. Typical Storey Height: 3.2m
4. Bottom storey Height: 4m
5. Plan Dimensions: 24.0m x 24.0m
6. Size of Columns: 350mm x 700mm
7. Size of Columns: 500mm diameter
8. Size of Beams: 350mm x 550mm
9. Slab thickness: 125mm
10. Unit weight of RCC: 25 KN/m^2
11. Unit weight of Masonry: 20 KN/m^2
12. Live Load Intensity on Floor: 3.5 KN/m^2
13. Weight of Floor finish: 1.0 KN/m^2
14. Thickness of Wall: 230mm
15. Height of Parapet: 1m
16. Seismic Zone: V, Z=0.36
17. Importance factor: 1.5
18. Response reduction factor: 5
19. Soil type: Medium
20. Shear wall thickness: 230mm

Following are the drawings which will indicate the detail explanation about mathematical models taken for study.

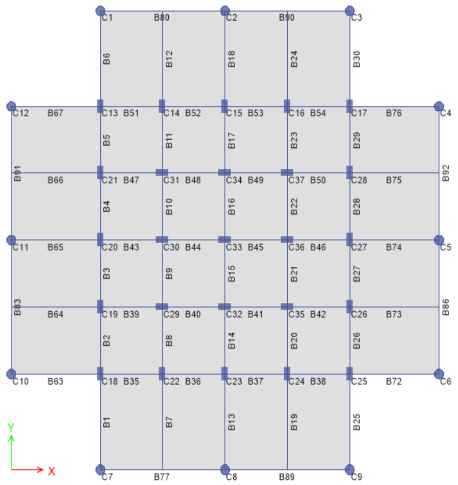

Figure 2.Plan of the Building at Bottom Storey Level

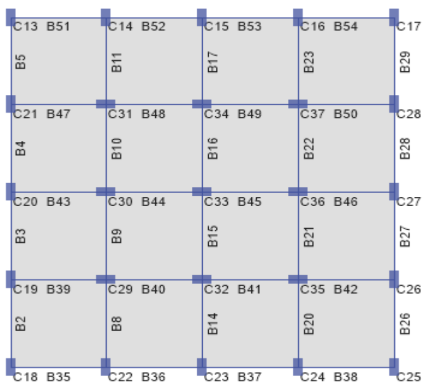

Figure 3. Plan of the Building at Typical Storey Level

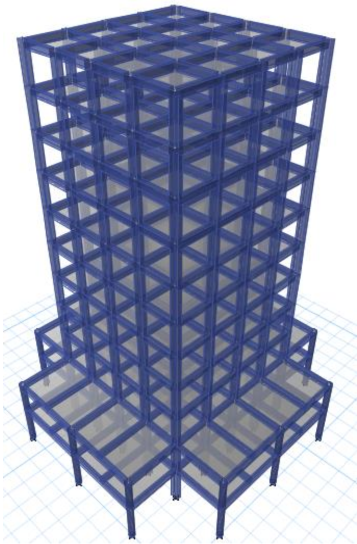

Figure 4. Plan View of Model II

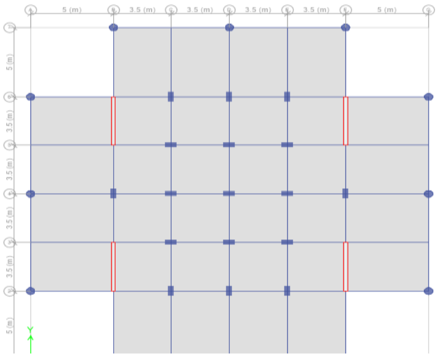

Figure 5 .Plan of the Building at Bottom Storey Level

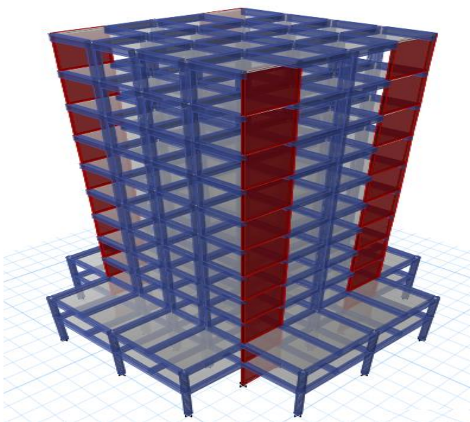

Figure 6. 3D View of Model III

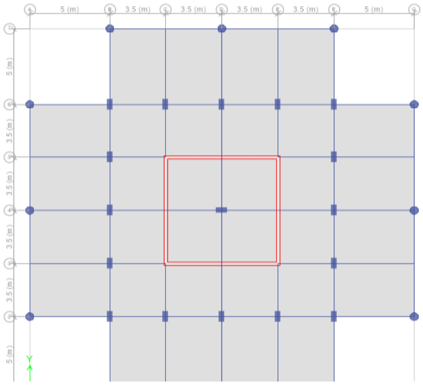

Figure 7 .Plan of the model III

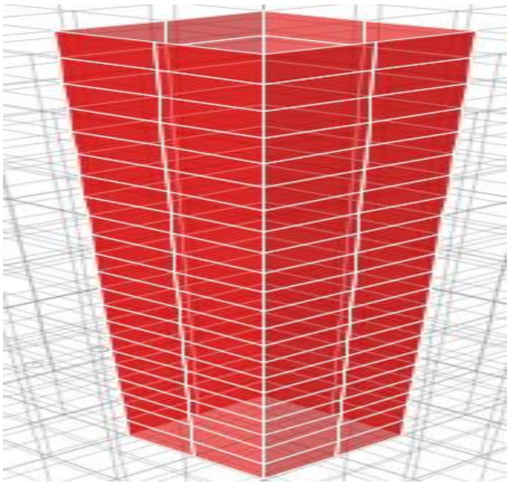

Figure 8. 3D View of Model III

4. RESULTS& DISCUSSIONS

4.1 GENERAL

For this section, after evaluating the models and effects, we will analyze the matter we obtained from ETABS in a tabular form and line chart for better comprehension.

The process measures have been analyzed and the effects of the software program have been extracted.

4.2 LATERAL STOREY DISPLACEMENT:-

Storey displacement is the lateral drift of the structure caused by lateral force. This parameter is one of the important parameters for lateral stability of the structures; no other parameter will give the better understanding that this one. As far as possible the displacement must be within the limits as specified by codal provision, otherwise leading to sever damage to buildings system.

Table 1: Displacement in longitudinal Direction

Roof Displacements in mm												
STOREY	MODEL 1		MODEL 2		MODEL 3		MODEL 4		MODEL 5		MODEL 6	
	UX	UY	UX	UY	UX	UY	UX	UY	UX	UY	UX	UY
11	32.6	32.0	22.1	22.1	25.2	32.9	31.8	25.7	16.4	15.5	17.2	16.4
10	31.6	30.9	20.4	20.4	23.5	32.1	31.0	23.9	14.8	14.1	15.6	14.9
9	30.1	29.3	18.5	18.5	21.6	30.7	29.7	22.0	13.1	12.5	13.9	13.3
8	28.0	27.1	16.4	16.4	19.5	28.6	27.7	19.7	11.4	10.9	12.2	11.6
7	25.4	24.4	14.2	14.2	17.0	26.1	25.3	17.2	9.7	9.2	10.3	9.9
6	22.4	21.4	11.8	11.8	14.3	23.1	22.5	14.4	7.9	7.6	8.5	8.2
5	19.2	18.1	9.3	9.3	11.4	19.8	19.3	11.5	6.2	5.9	6.7	6.4
4	15.6	14.4	6.9	6.9	8.5	16.1	15.7	8.5	4.6	4.4	5.0	4.8
3	11.8	10.6	4.6	4.6	5.7	12.1	12.0	5.6	3.1	3.0	3.4	3.3
2	8.0	7.0	2.5	2.5	3.1	8.2	8.1	3.1	1.8	1.7	2.0	1.9
1	4.4	3.7	1.0	1.0	1.2	4.6	4.5	1.2	0.8	0.8	0.9	0.9

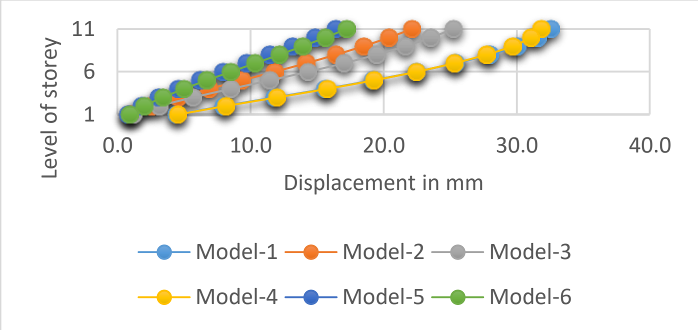

Chart 2. Displacement in Longitudinal Direction.

Table 2. Displacement in Transverse Direction.

Roof Displacements in mm												
STOREY	MODEL 1		MODEL 2		MODEL 3		MODEL 4		MODEL 5		MODEL 6	
	UX	UY	UX	UY	UX	UY	UX	UY	UX	UY	UX	UY
11	32.6	32.0	22.1	22.1	25.2	32.9	31.8	25.7	16.4	15.5	17.2	16.4
10	31.6	30.9	20.4	20.4	23.5	32.1	31.0	23.9	14.8	14.1	15.6	14.9
9	30.1	29.3	18.5	18.5	21.6	30.7	29.7	22.0	13.1	12.5	13.9	13.3
8	28.0	27.1	16.4	16.4	19.5	28.6	27.7	19.7	11.4	10.9	12.2	11.6
7	25.4	24.4	14.2	14.2	17.0	26.1	25.3	17.2	9.7	9.2	10.3	9.9
6	22.4	21.4	11.8	11.8	14.3	23.1	22.5	14.4	7.9	7.6	8.5	8.2
5	19.2	18.1	9.3	9.3	11.4	19.8	19.3	11.5	6.2	5.9	6.7	6.4
4	15.6	14.4	6.9	6.9	8.5	16.1	15.7	8.5	4.6	4.4	5.0	4.8
3	11.8	10.6	4.6	4.6	5.7	12.1	12.0	5.6	3.1	3.0	3.4	3.3
2	8.0	7.0	2.5	2.5	3.1	8.2	8.1	3.1	1.8	1.7	2.0	1.9
1	4.4	3.7	1.0	1.0	1.2	4.6	4.5	1.2	0.8	0.8	0.9	0.9

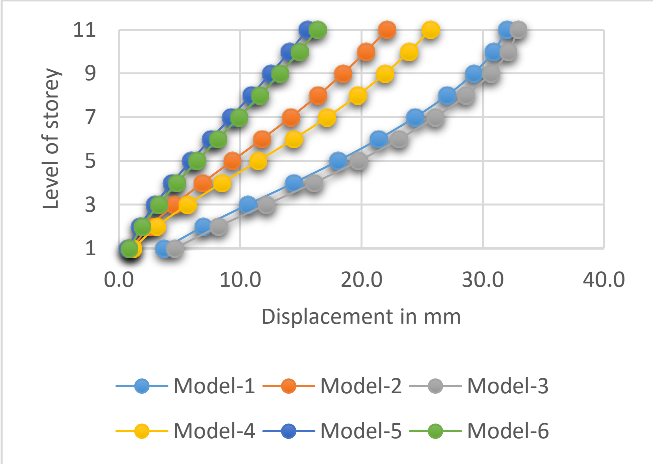

Chart 3. Displacement in Transverse Direction

it can be seen from above figures, the displacement of the stories of structures is reduced by developing MODEL-2,4,5,6.The displacement in Model-2 Has been reduced by 32.22 % in comparison of Model-1, Model-3 has been reduced to22.7%.Model-4 has been reduced by 2.45%, Model-5 has been reduced by 49.7%, Model-6 has been reduced by 47.24%.

In other words, the reaction of the structure such as velocity and acceleration can be reduced by constructing the MODEL-2, 3,4,5,6 and it is the cause of displacement reduction.
MODEL-2 and MODEL-3 reveals the same results when we compare with MODEL-1, therefore it can be stated that, orientation of shear walls will play a major rule in designing seismic resistant structures. Models with L-shapes shear walls shows better results than any other, therefore arranging shear wall away from the rigid centre will enhance the lateral stability of the structure and can considerably reduce the seismic hazardous.
Models with core walls and core walls openings are showing the same results, hence it can be stated that, opening in lift elevator, doesn't make much difference on overall performance of the building systems.
Comparison is made along longitudinal direction only. Transverse direction comparison can also be made and results can be compared, since the building is symmetrical along both orthogonal directions, only longitudinal direction's comparison has made.

4.3 STOREY DRIFT

The higher the drift, the greater the probability that harm will occur. Peak inter-story drift values greater than 0.06 indicate serious harm, whereas values greater than 0.025 indicate that the harm may be sufficiently serious to pose a serious threat to human safety. Values in excess of 0.10 indicate probable building collapse. According to I.S 1893 -2002 permissible storey drift is equals to 0.004 times height of storey.

Table 3. Storey Drift in Longitudinal Direction

STOREY DRIFT IN % OF STOREY HEIGHT						
	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6
STOREY	DRIFT X	DRIFT X	DRIFT X	DRIFT X	DRIFT X	DRIFT X
11	0.00034	0.00056	0.00056	0.00029	0.00050	0.00050
10	0.00058	0.00061	0.00063	0.00052	0.00052	0.00053

9	0.00079	0.00067	0.00071	0.00074	0.00054	0.00056
8	0.00094	0.00072	0.00080	0.00090	0.00055	0.00057
7	0.00106	0.00076	0.00087	0.00102	0.00056	0.00058
6	0.00114	0.00078	0.00091	0.00111	0.00054	0.00057
5	0.00121	0.00077	0.00093	0.00119	0.00051	0.00054
4	0.00126	0.00073	0.00090	0.00125	0.00047	0.00050
3	0.00124	0.00064	0.00079	0.00124	0.00040	0.00044
2	0.00111	0.00049	0.00061	0.00113	0.00032	0.00035
1	0.00111	0.00025	0.00030	0.00113	0.00019	0.00022

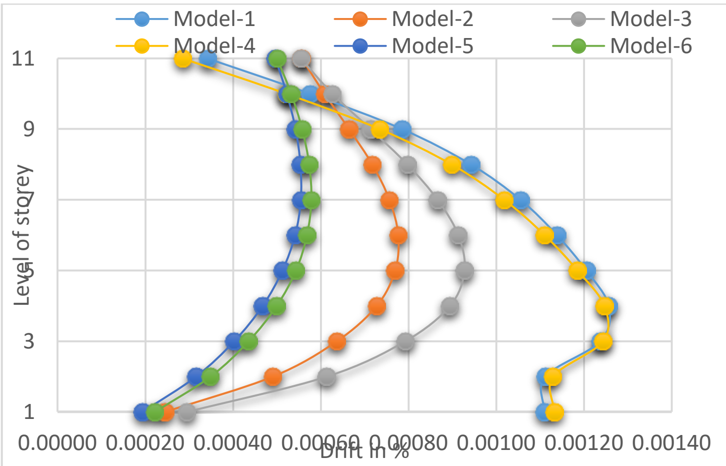

Chart 4. Drift in Longitudinal Direction

Table 4. Storey Drift in Transverse direction.

STOREY DRIFT IN % OF STOREY HEIGHT						
	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6
STOREY	DRIFT IN Y	DRIFT Y	DRIFT IN Y	DRIFT IN Y	DRIFT IN Y	DRIFT IN Y
11	0.00039	0.00056	0.00031	0.00058	0.00046	0.00047
10	0.00061	0.00061	0.00055	0.00065	0.00049	0.00050
9	0.00081	0.00066	0.00078	0.00074	0.00051	0.00053
8	0.00096	0.00072	0.00095	0.00082	0.00052	0.00054
7	0.00107	0.00076	0.00108	0.00089	0.00053	0.00055

6	0.00115	0.00078	0.00117	0.00093	0.00052	0.00054
5	0.00122	0.00077	0.00125	0.00094	0.00049	0.00052
4	0.00126	0.00073	0.00131	0.00090	0.00045	0.00048
3	0.00118	0.00064	0.00128	0.00079	0.00039	0.00042
2	0.00102	0.00049	0.00113	0.00061	0.00030	0.00034
1	0.00093	0.00025	0.00115	0.00029	0.00019	0.00022

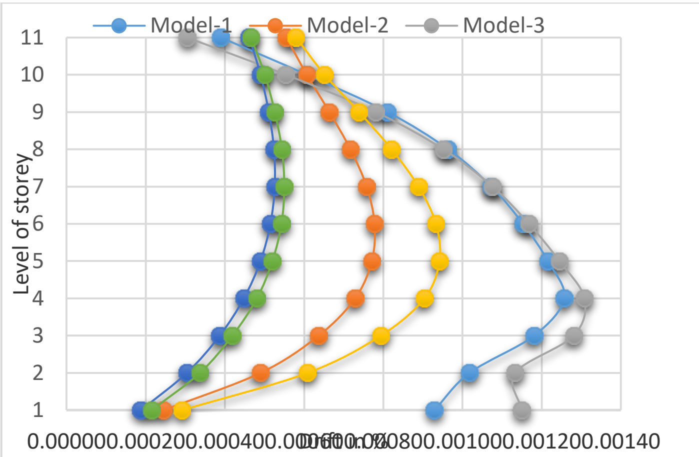

Chart 5. Drift in Transverse Direction

MODEL-1, MODEL-3and MODEL-4 are showing approximately same results as it can be seen from charts and tables, when we add lateral load resisting element like shear walls and central core walls, the storey drift considerably reduced, when we compare model 2, 5, and 6 with model 1 and 3, the percentage of reduction of inter storey drifts are, 32.17%, 57.85% and 55.37%.Therefore from charts reveals that, core wall and L-shapes shear wall will considerably enhance the performance.

From the storey drift analysis it can be seen that, higher base dimension can considerably reduce the drift % in turn make the structure more earthquake resistible and efficient enough in transferring the inertia forces induced due to Lateral loads.

All the drift values are within the permissible limits specified by IS1893-2002. Bare frame shows very flexible performance.

4.4 BASE SHEAR:

Base shear is the cumulative effect of lateral forces of each particular storey at the base level due to seismic activities. Base shear force various models have been tabulated fallows.

Table 5. Base shear in KN in Longitudinal Direction.

	BASE SHEAR IN X AND Y DIRECTION KN											
	MODEL 1		MODEL 2		MODEL 3		MODEL 4		MODEL 5		MODEL 6	
STOREY	Vx	Vy	Vx	Vy	Vx	Vy	Vx	Vy	Vx	Vy	Vx	Vy
11	237	249	353	353	323	229	231	324	456	460	448	447
10	654	677	901	902	816	632	638	812	1192	1206	1159	1168
9	983	1005	1310	1312	1177	950	963	1165	1801	1827	1738	1769
8	1226	1241	1628	1630	1452	1186	1208	1432	2295	2335	2208	2263
7	1405	1414	1899	1902	1687	1357	1391	1659	2699	2750	2596	2669
6	1547	1555	2143	2145	1900	1493	1536	1866	3036	3098	2926	3009
5	1675	1686	2355	2358	2087	1615	1666	2048	3325	3394	3209	3298
4	1802	1818	2533	2536	2248	1735	1791	2207	3572	3645	3447	3543
3	1926	1944	2679	2682	2385	1854	1912	2343	3772	3847	3638	3742
2	2205	2226	2942	2945	2635	2127	2186	2593	4087	4163	3961	4065
1	2448	2462	3100	3104	2776	2369	2425	2735	4268	4344	4172	4257

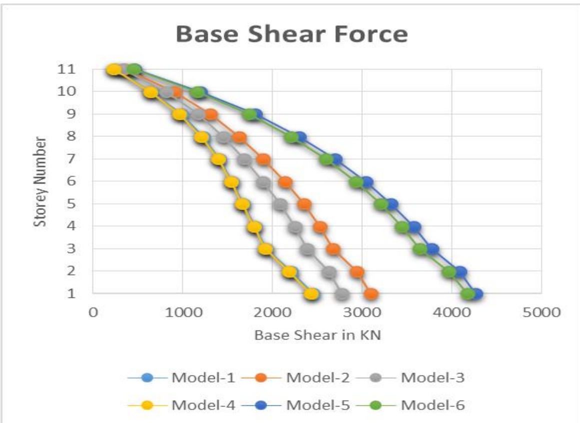

Chart 6. Base shear in Longitudinal Direction

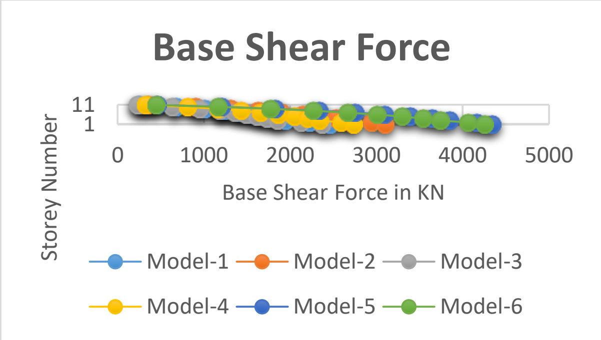

Chart 7. Base shear in Transverse Direction

As it can be seen from tables and charts that, MODEL-1, MODEL-3and MODEL-4 are showing nearly same base shear results, though it can be stated that, type, shape and orientation of shear walls in MODEL-3 and MODEL-4 are not showing much strength, these are as same as MODEL-1. When we compare MODEL-2 with MODEL-1, MODEL-3and MODEL-4, this model shows huge strength as well as stiffness.

MODEL-5 and MODEL-6 are considerably showing highest base shear values among all the models, therefore, core walls plays a vital rule to stiffen the building systems vertically or it may act as vertical stiffeners.

Successive openings in core walls at each floor, does not make any difference when seismic forces act on the structures.

4.5 Modal Analysis Results.

Modal analysis includes the fundamental natural time period of the structure, Modal Mass participations, and Mode shapes. These results will elaborate the vibration analysis of the building systems and its response to seismic loadings

Table 6. Modal analysis results.

Building Model No	Mode	Time period	% of Modal Mass participation		
		Sec	X-Translation	Y-Translation	Z -Torsion
Model-1	1	1.25	74.4	0	0
	2	1.223	0	72.2	0
	3	1.019	0	0	61
Model-2	1	0.793	63.9	0	0
	2	0.793	0	63.11	0
	3	0.48	0	0	50
Model-3	1	1.273	0	74.47	0
	2	0.918	64.26	0	0
	3	0.761	0	0	53.36
Model-4	1	1.235	75.05	0	0
	2	0.933	0	63.9	0

	3	0.783	0	0	52.87
Model-5	**1**	0.565	61.68	0	0
	2	0.546	0	61.87	0
	3	0.325	0	0	74.82
Model-6	**1**	0.589	62.5	0	0
	2	0.567	0	62.69	0
	3	0.361	0	0	73.9

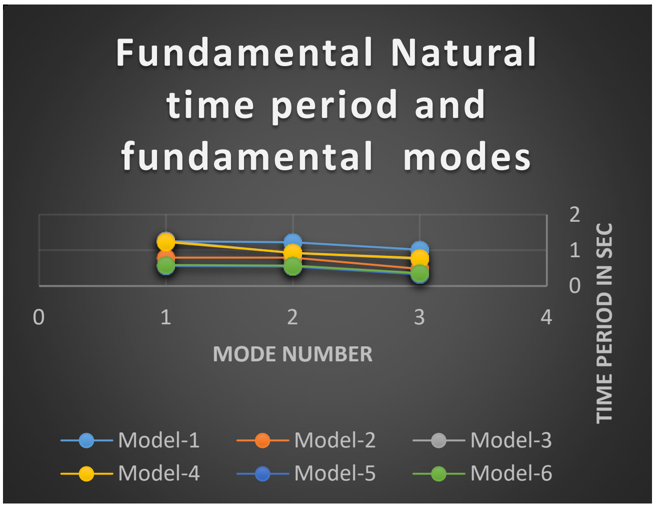

Chart 8. Fundamental natural time period according to no of modes.

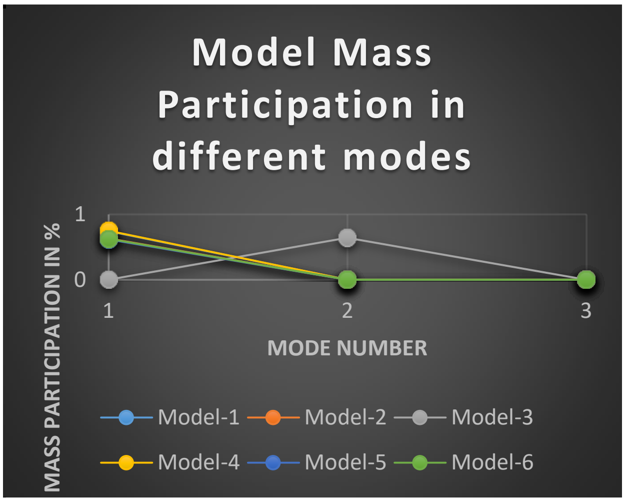

Chart 9. % of Modal Mass participation in X direction.

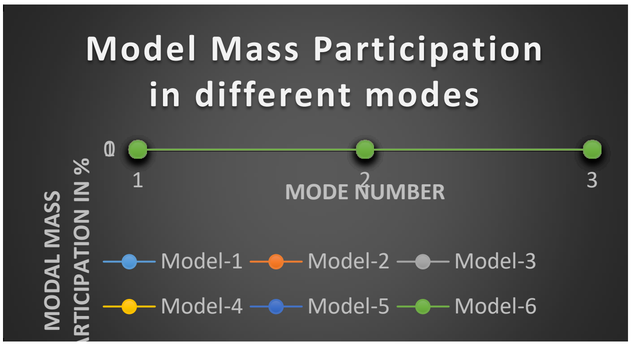

Chart 10. % of Modal Mass participation in Y direction.

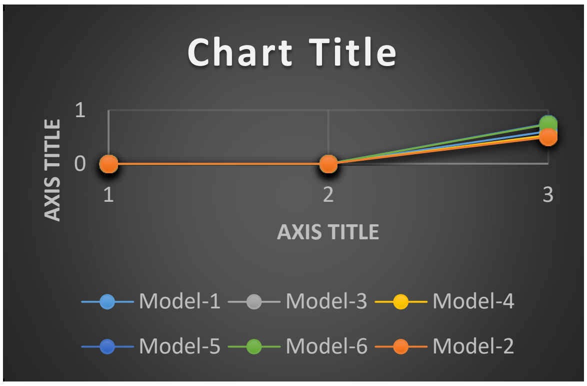

Chart 11. % of Modal Mass participation in Z direction (Torsion).

Above charts and tables reveals several things which be fallowed as.

The value of T depends on the building flexibility and mass; more the flexibility and mass, the longer is the period. The maximum time period is in MODEL-1 in first mode and minimum time period is inMODEL-5 and 6 in first mode. Therefore one can say that MODEL-5 and 6 have more flexibility when compared to other models.

When we add shear walls in different shapes and at different locations, they substantially decrease the fundamental time period of the structure and in turn increases the stiffness and thus overall lateral stability will be enhanced.

From the modal mass participation investigation it can be seen that, majority of the models are showing good mass participation in fundamental modes, and majority of models have got 1 mode shape as X translation, 2 mode shape as Y translation and 3 mode shape as Torsion which totally satisfying the requirements of IS-1893-2002.

Placing shear wall is very important, in correct location of shear walls may leads to extra torsional moments, which totally effect the overall performance of building systems, which can lead to disaster during seismic threatening.

4.6. MODE SHAPES:

Mode shapes are nothing but the sudden behaviour of the building systems due to lateral forces, for various models the modes shapes are tabulated as fallows.

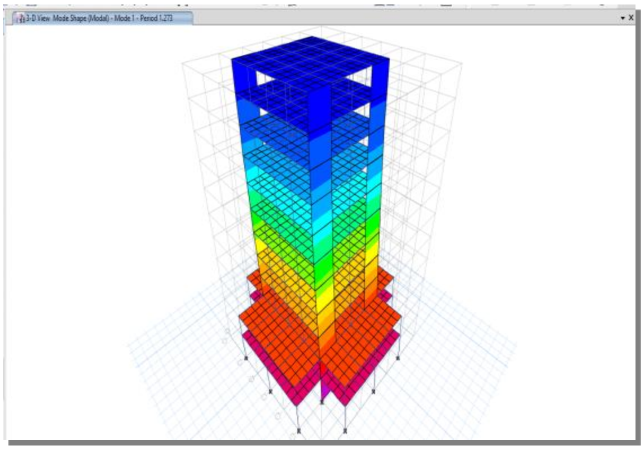

Figure 9. Model-1 X translations

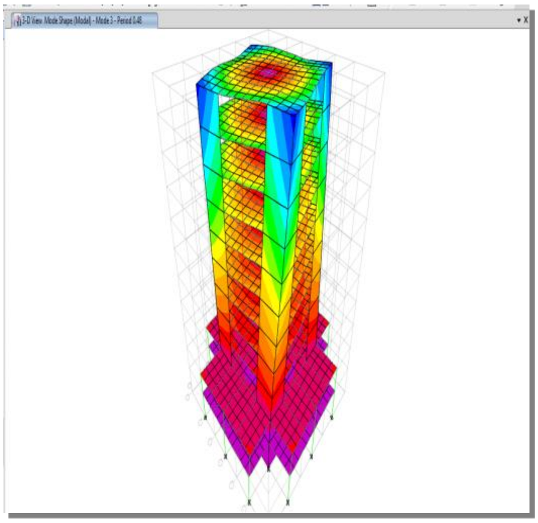

Figure 10. Model-1 Y translations

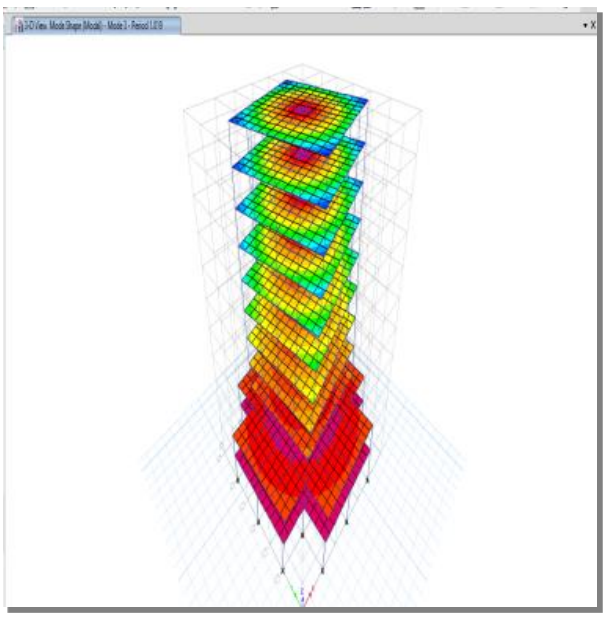

Figure 11. Model-1 Torsion

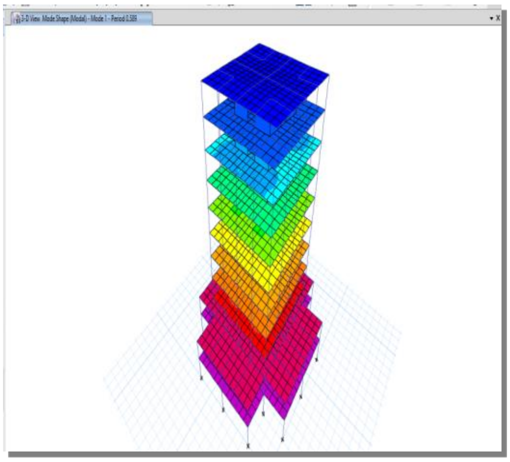

Figure 12. Model-2X translations.

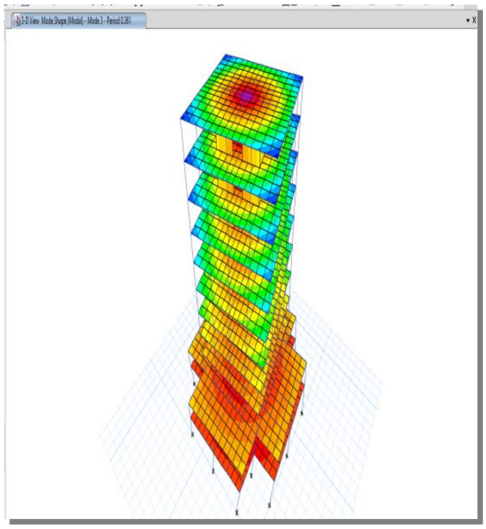

Figure 13. Model-2Y translations.

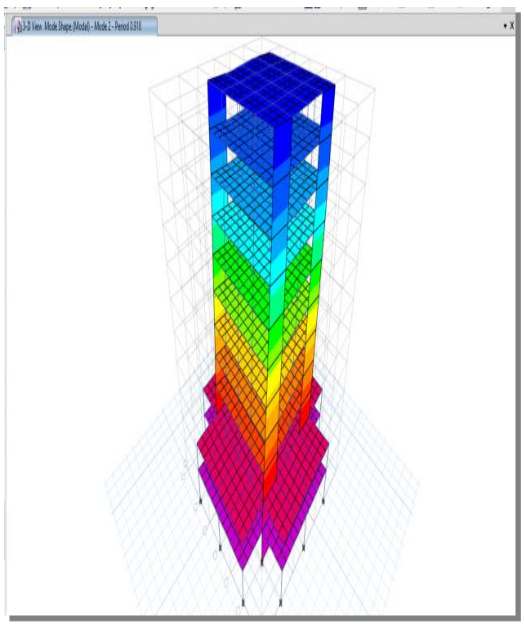

Figure 14. Model-2Torsion.

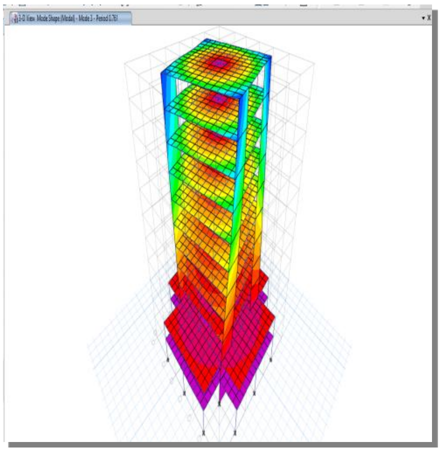

Figure 15. Model-3X translations.

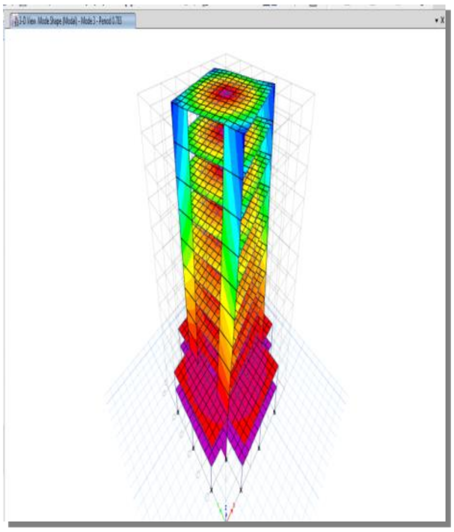

Figure 16. Model-3Y translations.

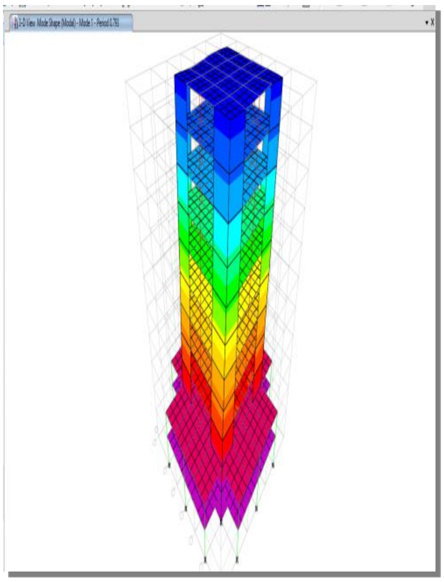

Figure 17. Model-3Torsion.

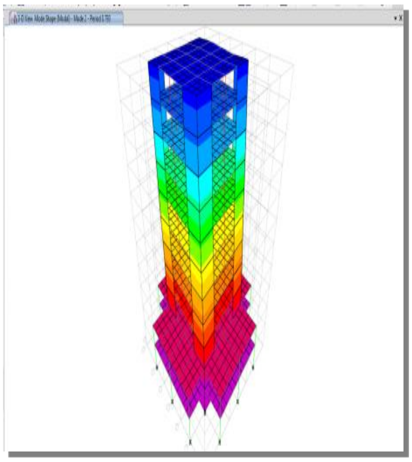

Figure 18. Model-4X translations.

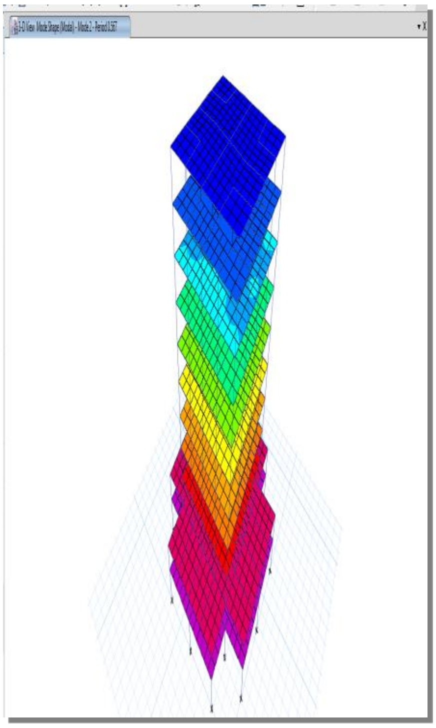

Figure 19. Model-4Torsion.

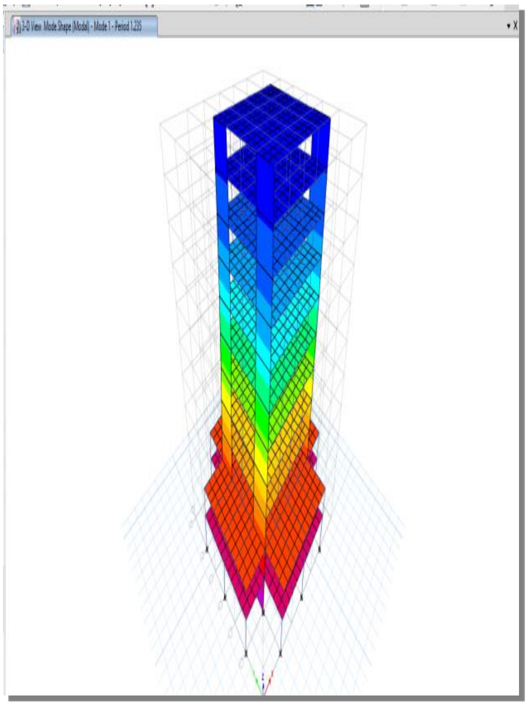

Figure 20. Model-5X translations.

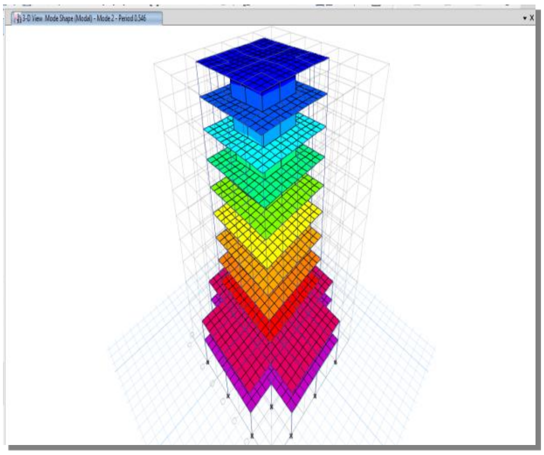

Figure 21. Model-5Y translations.

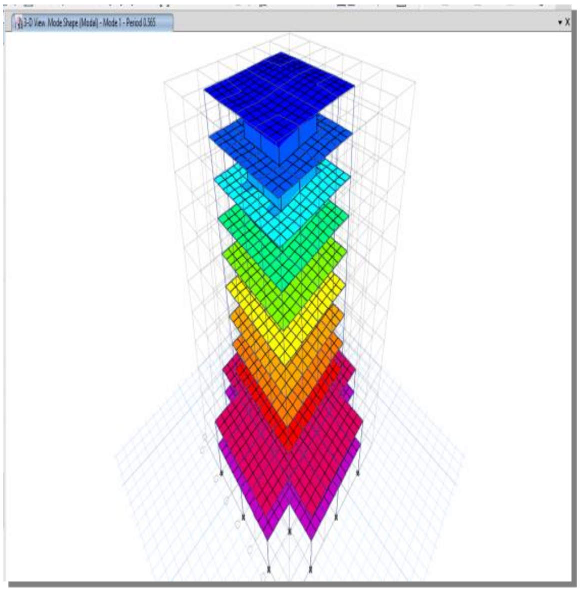

Figure 22. Model-5Torsion.

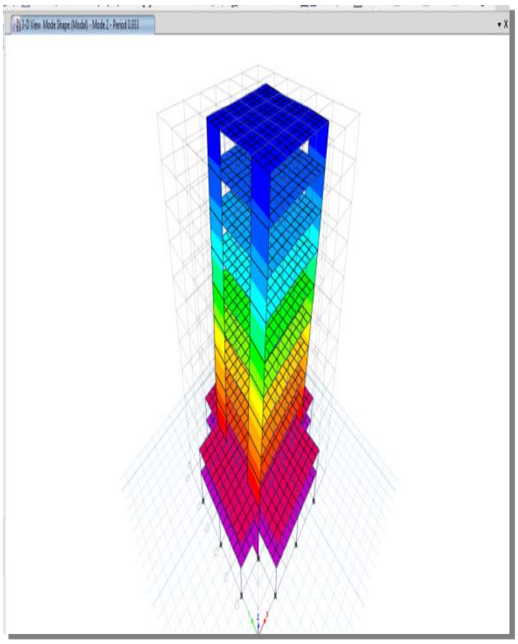

Figure 23. Model-5Torsion

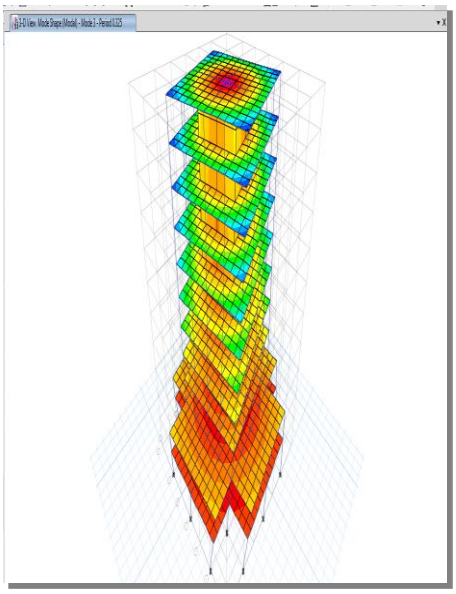

Figure 24. Model-6X Torsion

CONCLUSIONS

1. Model 1 exhibited the best amount of time and the lowest average shear, suggesting that it has the lowest resistance relative to the other five prototypes.
2. MODEL-2 and MODEL-3 reveals the same results when we compare with MODEL-1, therefore it can be stated that, orientation of shear walls will play a major rule in designing seismic resistant structures.
3. Models with L-shapes shear walls shows better results than any other, therefore arranging shear wall away from the rigid centre will enhance the lateral stability of the structure and can considerably reduce the seismic hazardous.
4. When we equate the bare frame model with several other models, when we add linear or L-shaped reinforced concrete wall it indicates the highest floor displacements at the top floor, thus reducing the shear wall supply substantially, reducing storey displacements and rendering the structure rigid. Models with core walls and core walls openings are showing the same results, hence it can be stated that, opening in lift elevator, doesn't make much difference on overall performance of the building systems.
5. From the storey drift analysis it can be seen that, higher base dimension can considerably reduce the drift % in turn make the structure more earthquake resistible and efficient enough in transferring the inertia forces induced due to Lateral loads.
6. All the drift values are within the permissible limits specified by IS1893-2002. Bare frame shows very flexible performance.
7. MODEL-5 and MODEL-6 are considerably showing highest base shear values among all the models, therefore, core walls plays a vital rule to stiffen the building systems vertically or it may act as vertical stiffeners.
8. Successive openings in core walls at each floor, does not make any difference when seismic forces act on the structures.
9. When we add shear walls in different shapes and at different locations, they substantially decrease the fundamental time period of the structure and in turn increases the stiffness and thus overall lateral stability will be enhanced.
10. From the modal mass participation investigation it can be seen that, majority of the models are showing good mass participation in fundamental modes, and majority of models have got 1 mode shape as X translation, 2 mode shape as Y translation and 3 mode shape as Torsion which totally satisfying the requirements of IS-1893-2002.
11. Placing shear wall is very important, in correct location of shear walls may leads to extra torsional moments, which totally effect the overall performance of building systems, which can lead to disaster during seismic threatening.

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- IS 875: 1987
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- IS 13920: 1993