SEISMIC BEHAVIOUR AND PUSHOVER ANALYSIS OF IRREGULAR FLAT SLAB BUILDING WITH DIFFERENT LATERAL RESISTING SYSTEMS

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Abstract - ***In*** *design and engineering practice, the selectively defined design of space, design of structure, speed and efficiency of realization represent an extraordinarily important factor for the Investor.*

This assertion is supported by the fact that the flat-slab RC system has lately been increasingly imposed as a more acceptable and more attractive structural system in the world and in Macedonia as well. What is rational and optimal for these flat-slab structures is that they enable simple design, pure and clear space with absence of beams (the role of the beams is transferred to the RC floor slab), faster construction and time saving. Flat-slab building structures possesses major advantages over traditional slab-beam-column structures because of the free design of space, shorter construction time, architectural –functional and economical aspects. Because of the absence of deep beams and shear walls, flat-slab structural system is significantly more flexible for lateral loads then traditional RC frame system and that make the system more vulnerable under seismic events.

1. INTRODUCTION

India at show is quickly developing nation in economy which gets requests expanding of foundation offices alongside the development of populace. The request of land in urban zones expanding step by step, keeping in mind the end goal to check this requests with urban zones vertical improvement is the main alternative. This sort of improvement brings difficulties to balance extra parallel loads because of wind and seismic tremor. Basic routine with regards to plan and development is to help the chunks by pillars and bolster the bars by segments. This might be called as shaft piece development.

A level piece is made thick shut to support sections to give satisfactory quality in shears and to lessen the measure of negative fortification.

In 1914 Eddy and Turner were first composed on level chunks, The level sections specifically lays on segments and dividers over different types of development and focal points are better lightning, bring down cost, more prominent tidiness of appearance, speed of development and expanded wellbeing is generally yielded as to render any dependable data with respect to the logical calculation of worries in level piece development of incredible intrigue.

Seismic tremors are a standout amongst the most destroying normal risks that reason incredible death toll and occupation. This is caused by sudden arrival of vitality from earths outside coming about because of activities of structural plates. This vitality, discharged as seismic waves can do high harm or in most pessimistic scenario devastate real structures. Structures with basic frameworks that have sporadic circulation of mass, firmness and qualities are inclined to genuine harm. Building design in this manner is a critical factor influencing the execution of the structures. Design can be comprehensively characterized as the sizes and state of the structures, the sizes and area of basic and no auxiliary components. Great setup brings about straightforward and prudent outline and better execution. Seismic codes recognize standard and unpredictable designs, sporadic setups happen when the building goes amiss from straightforward general, symmetrical shape in plan, area and rise which makes two sorts of issues in particular: torsion and stress focus.

Torsional issues are most regularly connected with design abnormality or geometries, where the sizes and regions of vertical segments make abnormality between the focal points of mass and protection. Torsion powers make incredible vulnerability in investigating the building's protection. Stress focus happens when extent of earth quake power is gathered at 1 or a couple of areas in structure. For sporadic structures molded as L shape in design the prevailing risky elements are torsion and stress focus.

1.1 OBJECTIVES

- To study the dynamic response of flat slab building using response spectrum analysis.
- To study the non-linear static behavior of flat slab structure with different lateral resisting system.
- To evaluate the most effect type of lateral resisting system.
- To compare buildings with different lateral resisting system with respect to their time period, base shear, storey drift and displacement.

2. LITERATURE REVIEW

K.S.Sable, Er.V.A.Ghodechor et al (2012) "Relative investigation of seismic conduct of multistory level section and ordinary fortified cement surrounded structures" Tall business structures are essentially a reaction to the request by business exercises to be as near each other, and to the downtown area as could reasonably be expected, in this way putting extreme weight on the accessible land space. Structures with a huge level of indeterminacy is better than one with less indeterminacy, as a result of more individuals are solidly associated with each other and if yielding happens in any of them, at that point a redistribution of powers happens. Accordingly it is important to break down seismic conduct of working for various statures to perceive what changes will happen if the tallness of regular building and level chunk building changes. Tremor stack following up on a structure relies upon epicenter separation and profundity of hypocenter underneath earth surface and the vitality discharged amid a seismic tremor. For less demanding comprehension, one might say that the line of activity joining hypocenter to the focal point of mass of structure shows bearing of load vector. The most determinant impact on a structure is by and large caused by sidelong part of earth tremor stack. When contrasted with gravity stack impact, quake stack consequences for structures are very factor and increment quickly as the stature of building increments. For gravity loads, structure is composed by considering territory bolstered by a section and traverses of shaft; though for seismic tremor loads, plan is a component of aggregate mass, tallness. It is likely that low and mid ascent structures, having great auxiliary shape can convey the greater part of seismic tremor loads. The quality prerequisite is a predominant factor in the plan of structure. As stature expands the unbending nature (i.e. the impervious to parallel redirection) and soundness (i.e. impervious to upsetting minutes) of structure gets influenced, and it ends up important to plan the structure ideally for sidelong powers, minutes, story float and aggregate flat diversion at highest story level. Unadulterated unbending edge framework or edge activity acquired by the association of pieces, shaft and section isn't sufficient. The edge alone neglects to give the required horizontal solidness to structures taller than 15 to 20 (50m to 60m) stories. It is a result of the shear taking segment of diversion created by the bowing of segments and section makes the building redirect unreasonably. There are two approaches to fulfill these prerequisites. In the first place is to build the measure of individuals past or more the quality necessities and second is to change the type of structure into more inflexible and stable to restrict misshaping. To start with approach has its own points of confinement, while second one is more exquisite which expands unbending nature and soundness of the structure and furthermore keep the twisting prerequisite. In seismic tremor building, the structure is intended for basic power condition among the heap mix. This paper explores the examination of ordinary strengthened solid building framework i.e. chunk, bar and section to the level piece building. These outcomes are looked at for changed statures of building.

Basavaraj H S and Rashmi B A (2015), with a specific end goal to be fruitful in moderation endeavors; the normal harm and the related misfortune in urban zones caused by serious seismic tremors ought to be legitimately evaluated. It is likewise fitting to think about the normal harm as a measure of seismic defenselessness. The assurance of such a powerlessness measure requires the evaluation of the seismic exhibitions of a wide range of building structures ordinarily built in a urban area when subjected to an assortment of potential quakes. In the present work the G+4 and G+8 storied building models are considered. The weakness of absolutely outline and simply level section models under horizontal loads and ground increasing speed were considered. Promote the level chunk models are reinforced by border shaft, infill dividers, shear dividers and expanding the cross sectional region of segments and the impact of situating of infill dividers and shear dividers on execution of level piece building models were investigated.

Gayathri.H1, Dr.H.Eramma2 et al, (2016) A basic framework called Moment Resisting Frame is outstanding for opposing gravity loads (Live Load and Dead Load. Be that as it may, other than these heaps, for example, wind burdens and horizontal burdens originating from the Earthquakes are opposed by a basic framework known as Dual frameworks. Our undertaking is worried on a Dual framework blend of SMRF and shear divider frameworks and Flat piece with shear divider framework. By utilizing these sidelong opposing frameworks the 3D models are created and broke down with ETABs programming. Equal static investigation and push over examination are done to discover regular period, horizontal removal, story float and base shear of the structure and henceforth to finish up the best sidelong load opposing framework design which is proficient to oppose the parallel burdens. Seismic tremors are major land wonders. Man has been frightened of these wonders for a very long time, as meager has been thought about the reasons for tremors, yet it deserts a trail of demolition. There are many little seismic tremors the world over consistently. Some of them are minor to the point that people can't feel them, yet seismographs and other delicate machines can record them. The investigation of Earthquake Engineering and Structural Design has enhanced colossally and subsequently today we can examine and outline safe structures which can securely withstand tremors of sensible greatness by presenting reasonable sidelong opposing frameworks.

3. MATERIALS

3.1 CONCRETE

Youngs's Modulus – steel, Es=2,10,000MPa

Young's Modulus – concrete, Ec=27,386MPa

Characterstic strength of Concrete,fck=30MPa

Yield stress of steel,fy=500Mpa

Ultimate strain in Bending=0.0035

Grade of concrete =M30

Grade of steel=Fe-500MPa

Density of RCC=25KN/m^3

Density of Brick = 20KN/m^3

3.2 FRAME SECTION PROPERTY

Member	Specification
Beam	230 X 600
Column	230 X 1050

3.3 LOAD DETAILING

Dead Load-Self weight –As calculated by software

Live Load –on floors – 3KN/m^2

Live Load – on Terrace – 3KN/m^2

Floor Finish – 1.5 KN/m^2

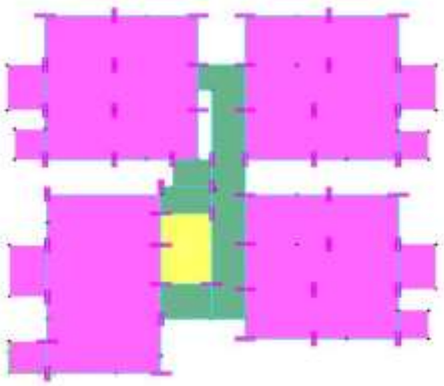
The heavy Load of Swimming pool and landscape is considered on the 5th and terrace floor with overall load of 20KN/m^2

4. MODEL GEOMETRY

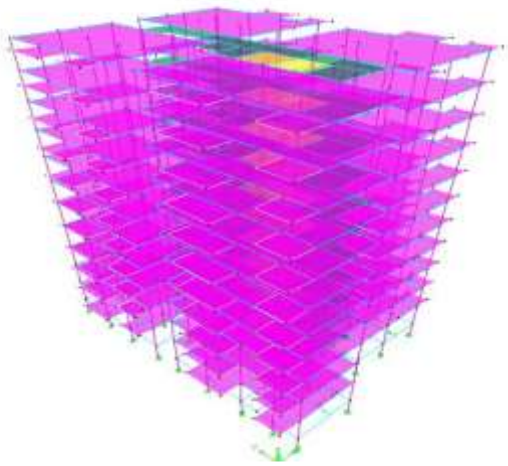
G+10 Building

Floor to Floor Height 3m

PLAN VIEW



BUILDING 3D VIEW G+10



5. BASE MODEL

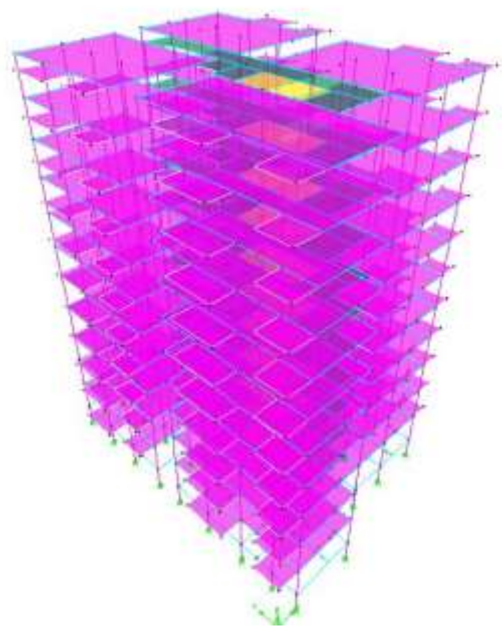
Model 1 - Irregular building with Flat slab

Model 2 – Irregular building with Flat slab and shear wall

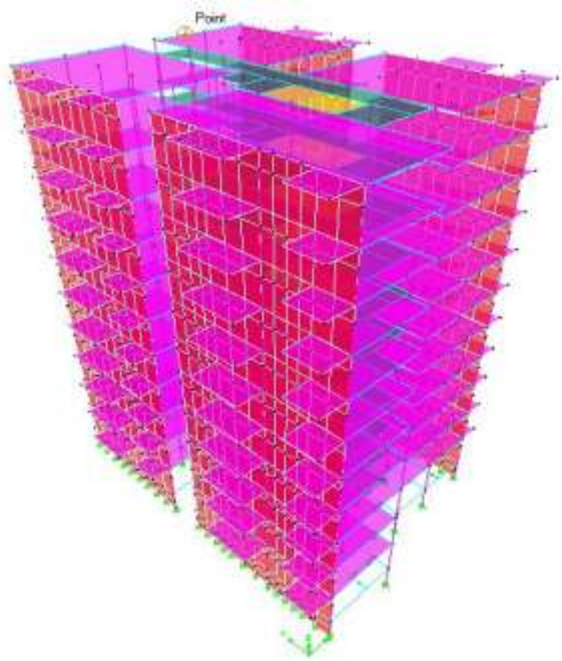
Model 3 – Irregular building with Flat slab and bracings, X bracing ISMB 100 is used with grade of Fe350

Model 4 – Irregular building with Flat slab and Infill wall

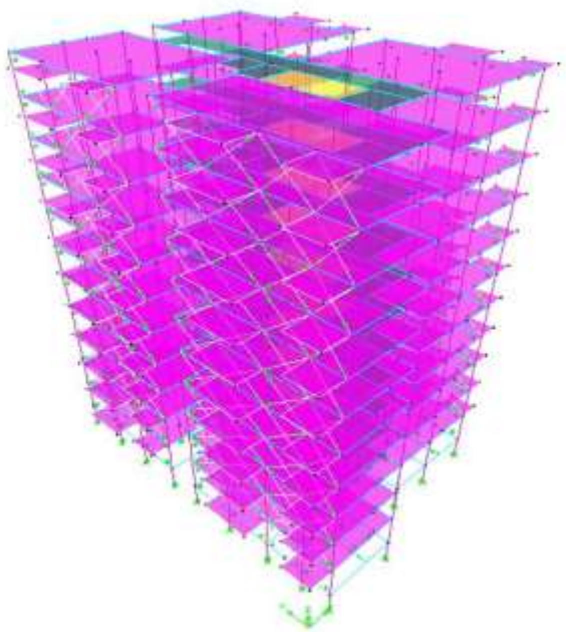
MODEL -1



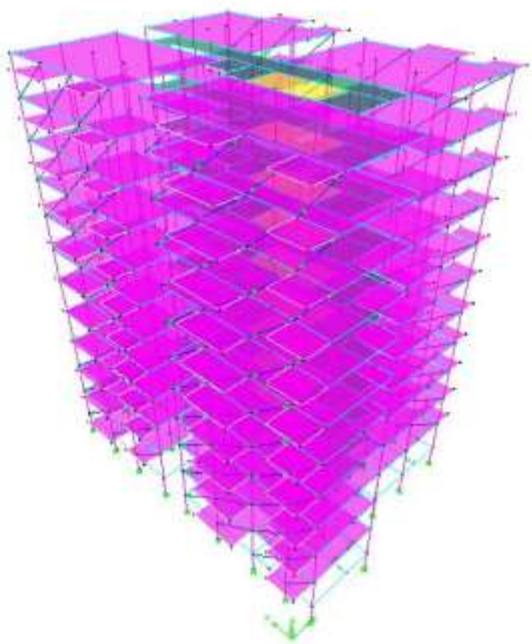
MODEL- 2



MODEL -3



MODEL- 4



4.1 EARTHQUAKE PARAMETERS

Zone Factor –Zone 3-0.16

Soil type – Medium – Type 2

Importance factor -1.5

Response reduction factor – 3

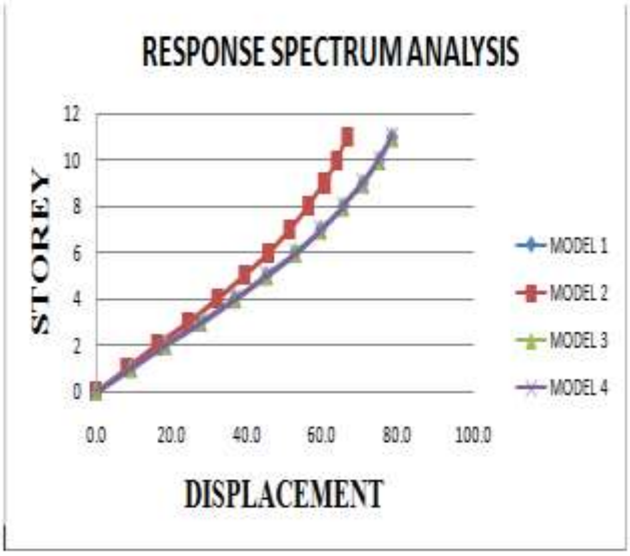
The time period calculated based on height of building

5. COMPARISON OF DIFFERENT MODELS OF BUILDING

5.1 RESPONSE SPECTRUM ANALYSIS RESULTS

DISPLACEMENTS - SPECX

STOREY	MODEL 1	MODEL 2	MODEL 3	MODEL 4
11	78.6	66.4	78.5	78.4
10	75.1	63.7	75.0	75.0
9	70.8	60.3	70.7	70.6
8	65.6	56.1	65.5	65.4
7	59.6	51.2	59.5	59.5
6	52.8	45.6	52.8	52.7
5	45.2	39.2	45.2	45.2
4	36.9	32.0	36.8	36.8
3	27.8	24.2	27.8	27.7
2	18.4	16.1	18.4	18.3
1	9.3	8.2	9.3	9.2
0	0.0	0.0	0.0	0.0

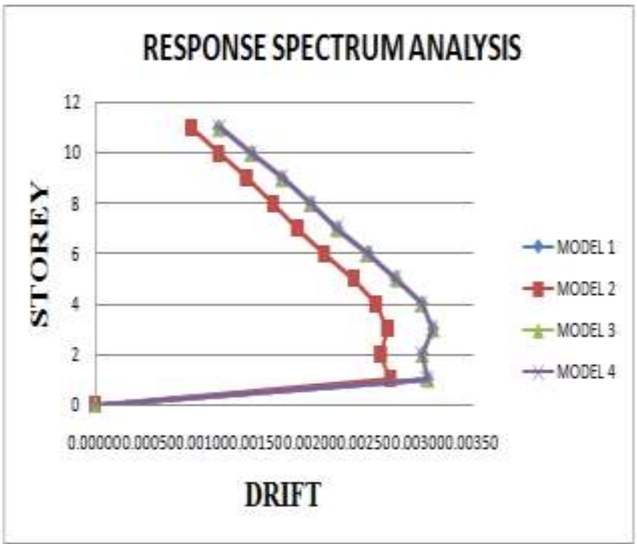


Comparison of displacements of different models in X direction

There is no significant variation in the displacement of the models with in regular model, and model with bracings and infill wall since the resisting members are considered parallel to Y axis .However, there is a reduction of 15.5% of deflection in model 2 since the stiffness is very high due to shear walls.

INTER STOREY DRIFT - X DIRECTION

STOREY	MODEL 1	MODEL 2	MODEL 3	MODEL 4
11	0.00114	0.00089	0.00115	0.00115
10	0.00145	0.00114	0.00145	0.00145
9	0.00173	0.00140	0.00173	0.00173
8	0.00200	0.00164	0.00199	0.00199
7	0.00225	0.00187	0.00224	0.00224
6	0.00253	0.00212	0.00252	0.00252
5	0.00279	0.00239	0.00280	0.00279
4	0.00303	0.00260	0.00303	0.00303
3	0.00313	0.00271	0.00313	0.00313
2	0.00304	0.00264	0.00304	0.00303
1	0.00309	0.00273	0.00308	0.00308
0	0.00000	0.00000	0.00000	0.00000

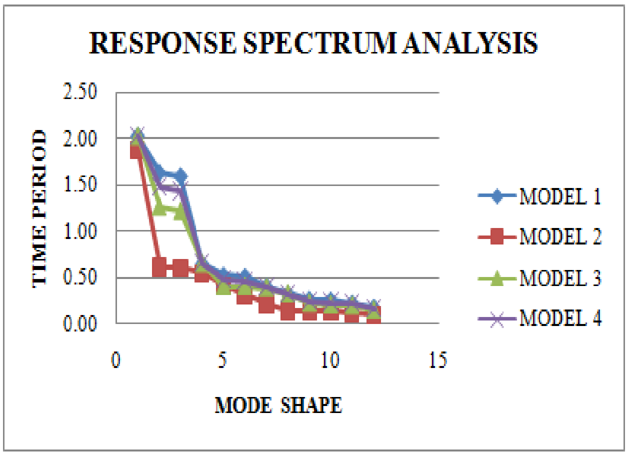


Comparison of storey drifts of different models in X direction

The inter Storey drift ratio is exhibiting similar variations in all different types of models. Model type with shear wall is exhibiting better performance compared to other mode.

TIME PERIOD

	TIME PERIOD			
MODE	MODEL 1	MODEL 2	MODEL 3	MODEL 4
1	2.03	1.87	2.03	2.03
2	1.63	0.61	1.26	1.48
3	1.60	0.60	1.22	1.43
4	0.65	0.54	0.65	0.65
5	0.52	0.40	0.41	0.48
6	0.51	0.31	0.40	0.46
7	0.40	0.21	0.39	0.40
8	0.33	0.14	0.33	0.33
9	0.26	0.14	0.22	0.24
10	0.26	0.13	0.20	0.23
11	0.22	0.11	0.20	0.22
12	0.18	0.09	0.15	0.17

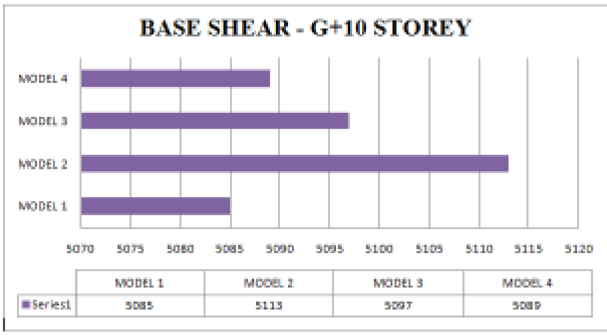


Comparison of mode numbers v/s time period

The fundamental time period of all the models are almost same except model 2. The Model 2 is exhibiting higher stiffness than other models. However, the successive modes show that, there is a higher flexibility in the model 1 compared to model 4 and model 3 respectively.

STUDY OF BASE SHEAR

G+10 STOREY (kN)			
MODEL 1	MODEL 2	MODEL 3	MODEL 4
5085	5113	5097	5089

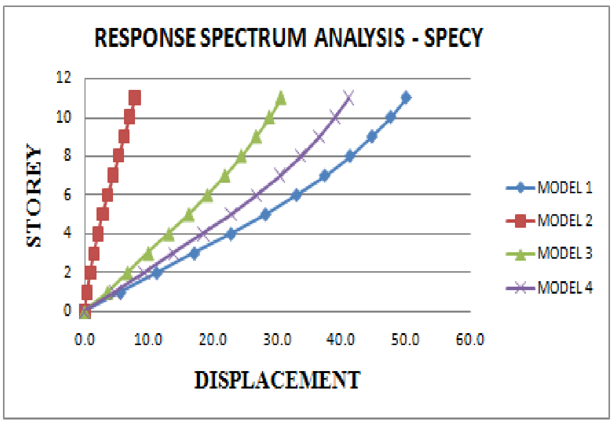


Comparison base shear v/s models

The base shear value mainly concentrates on the weight of the structure, since there is any higher load concentration due to shear wall, the load automatically turns the base shear on higher. Model 1 & 4 should be same due to same loads, however the strut action trying to increase the base shear

DISPLACMENTS – SPECY

STOREY	MODEL 1	MODEL 2	MODEL 3	MODEL 4
11	50.0	7.7	30.5	41.0
10	47.6	6.9	28.8	38.9
9	44.7	6.1	26.7	36.4
8	41.2	5.2	24.4	33.5
7	37.3	4.4	21.8	30.3
6	33.0	3.6	19.1	26.7
5	28.1	2.8	16.2	22.8
4	22.8	2.1	13.1	18.5
3	17.1	1.4	9.9	13.9
2	11.2	0.9	6.7	9.2
1	5.6	0.4	3.6	4.7
0	0.0	0.0	0.0	0.0

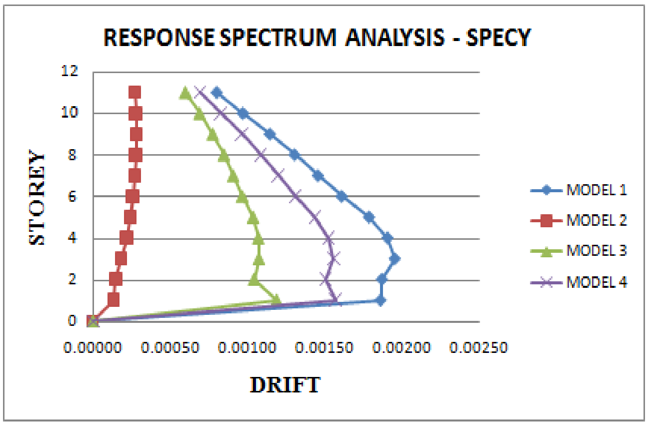


Comparison of storey v/s displacement

There is an huge difference in the displacement of the models compared to Response spectrum in X direction. Since all the resisting members are towards earthquake direction, there is reduction in displacement. The Model 2, shows greater reduction in the displacement due to very high stiffness compared to other models. There is a reduction of approximate 86% of displacement in the model 2 compared with model 1.

INTER STOREY DRIFT- Y DIRECTION

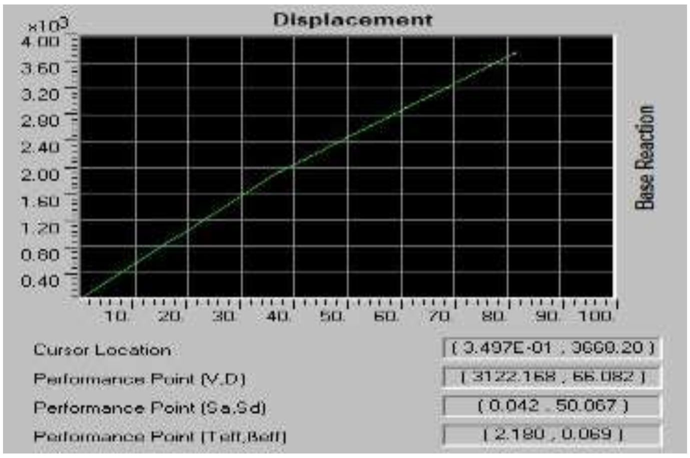
STOREY	MODEL 1	MODEL 2	MODEL 3	MODEL 4
11	0.00080	0.00028	0.00060	0.00069
10	0.00097	0.00028	0.00069	0.00083
9	0.00115	0.00028	0.00077	0.00096
8	0.00131	0.00028	0.00085	0.00109
7	0.00146	0.00027	0.00091	0.00120
6	0.00161	0.00026	0.00097	0.00131
5	0.00179	0.00024	0.00103	0.00144
4	0.00191	0.00022	0.00107	0.00152
3	0.00195	0.00019	0.00107	0.00156
2	0.00187	0.00015	0.00104	0.00150
1	0.00186	0.00014	0.00119	0.00157
0	0.00000	0.00000	0.00000	0.00000



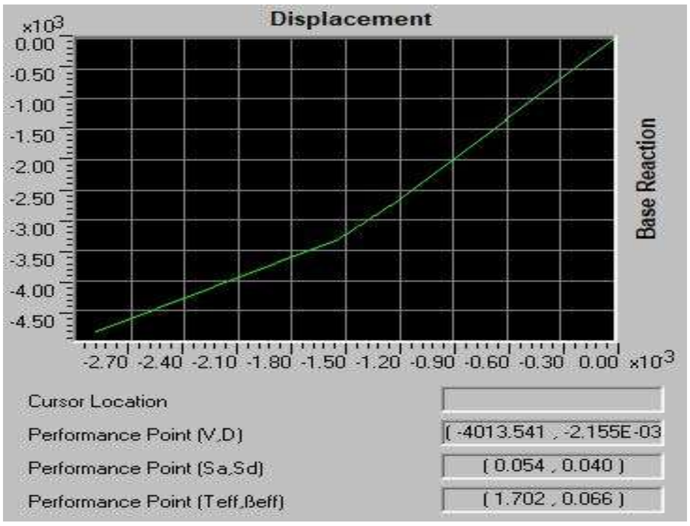
Comparison of storey drifts in Y-direction

The inter storey drift is reflecting the values of displacement. The model 2 shows considerable variation in the drift compared to other models.

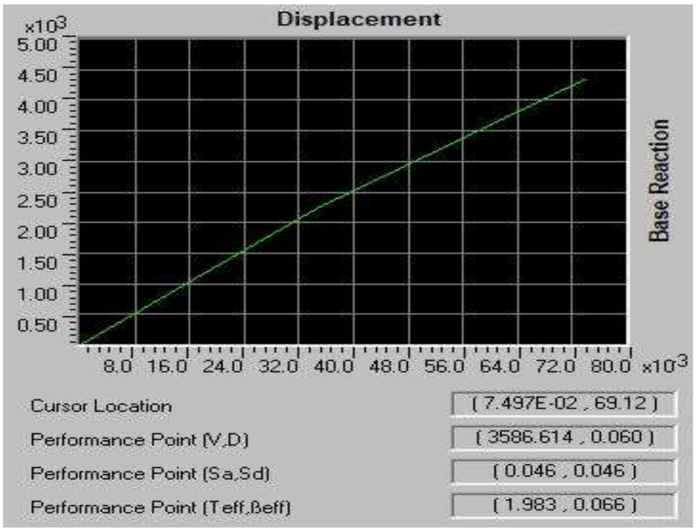
PUSHOVER ANALYSIS RESULTS



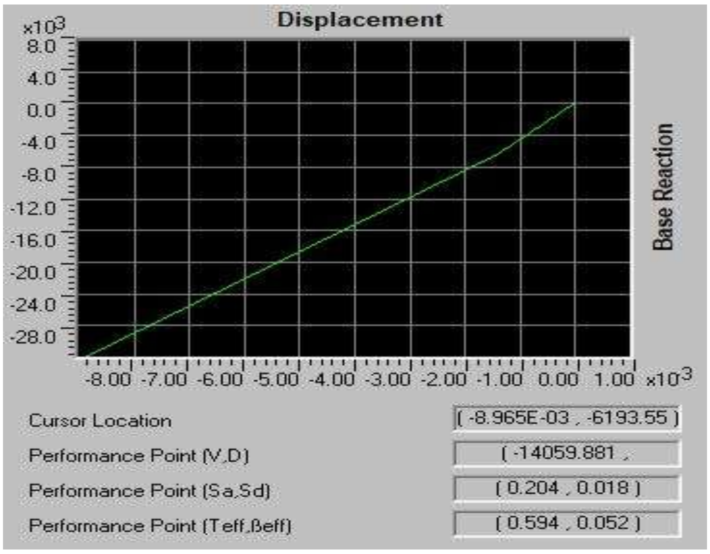
Base force v/s monitored displacement –Model 1-X Dir



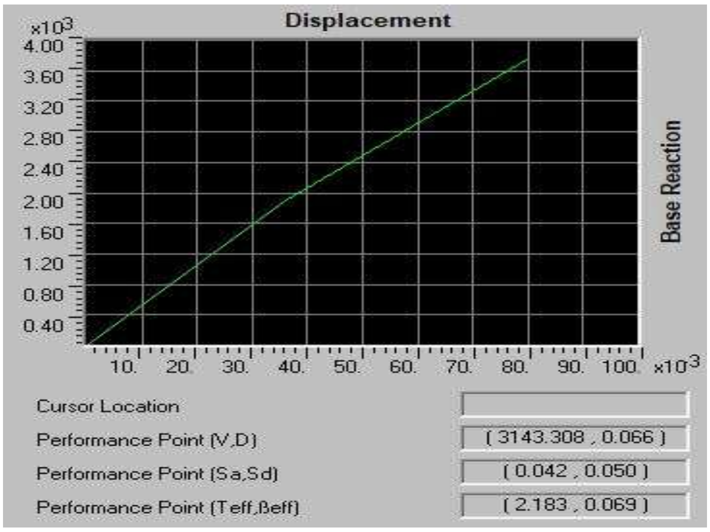
Base force v/s Monitored displacement –Model -1 –Y Dir



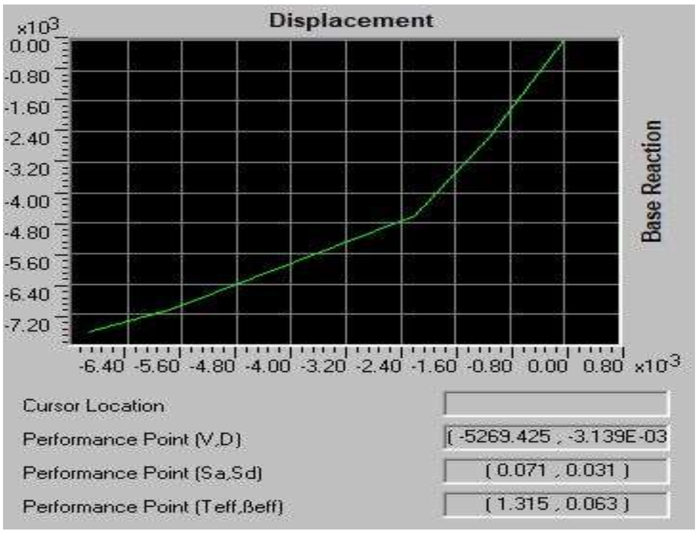
Base force v/s Monitored displacement – Model 2 –X Dir



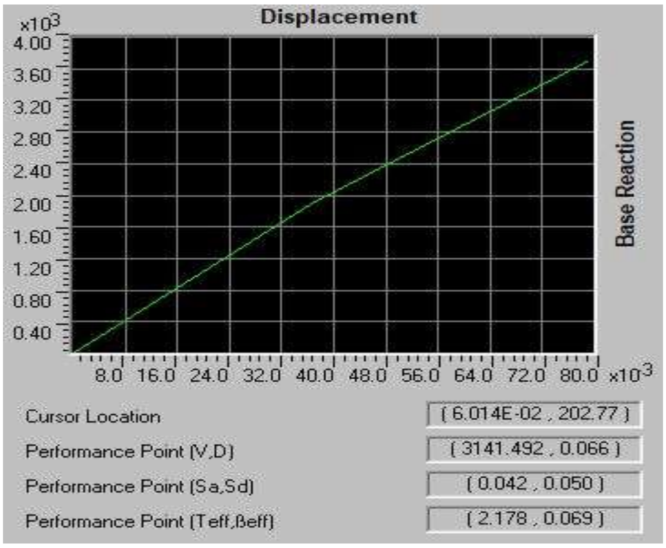
Base force v/s Monitored displacement – Model 2 –Y Dir



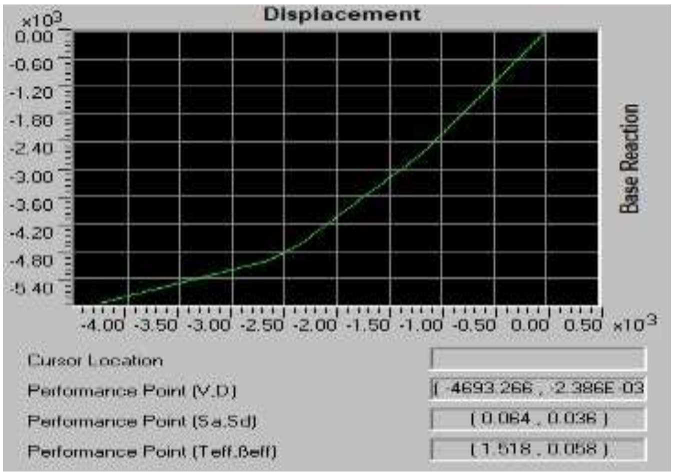
Base force v/s Monitored displacement – Model 3 –X Dir



Base force v/s Monitored displacement – Model 3 –Y Dir

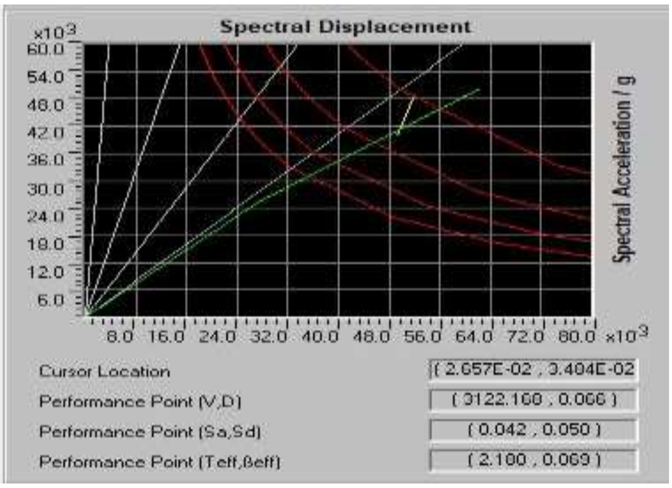


Base force v/s Monitored displacement – Model 4 –X Dir

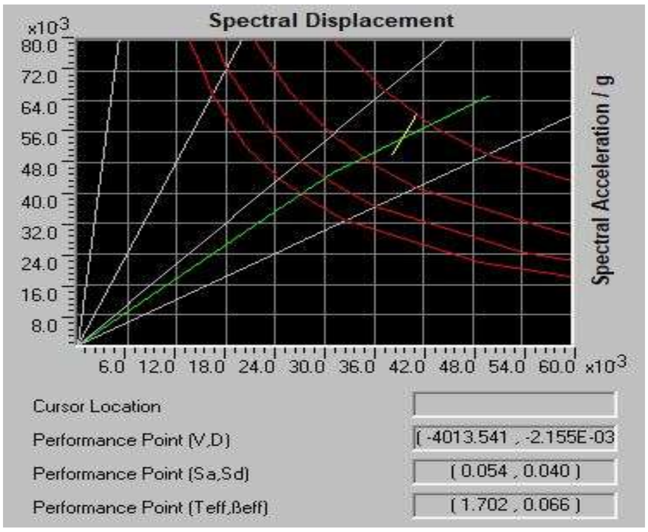


Base force v/s Monitored displacement –Model 4 –Y Dir

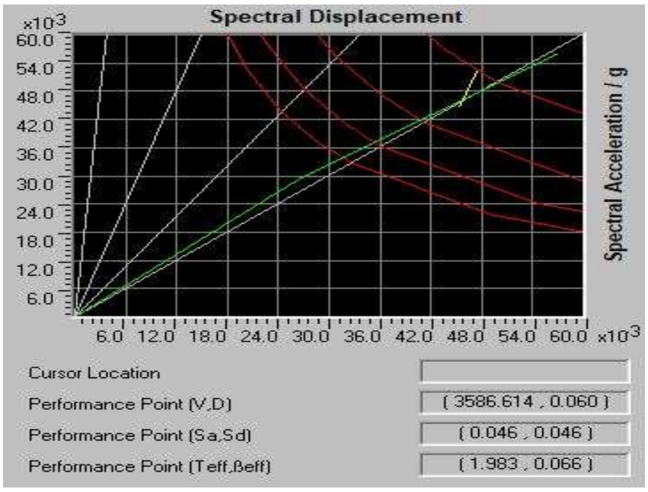
5.2 PERFORMANCE POINT



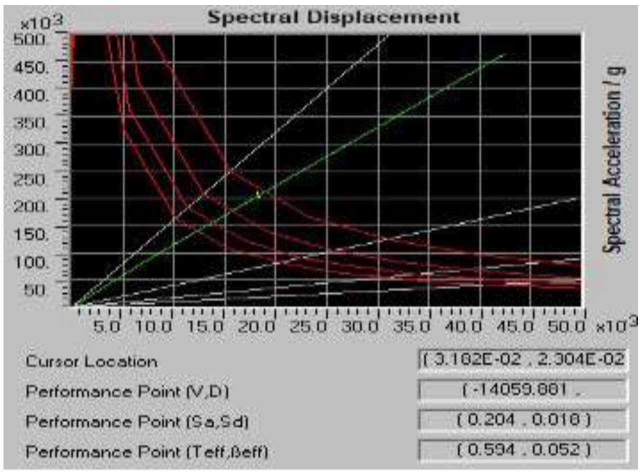
Performance Point – Model –X Dir



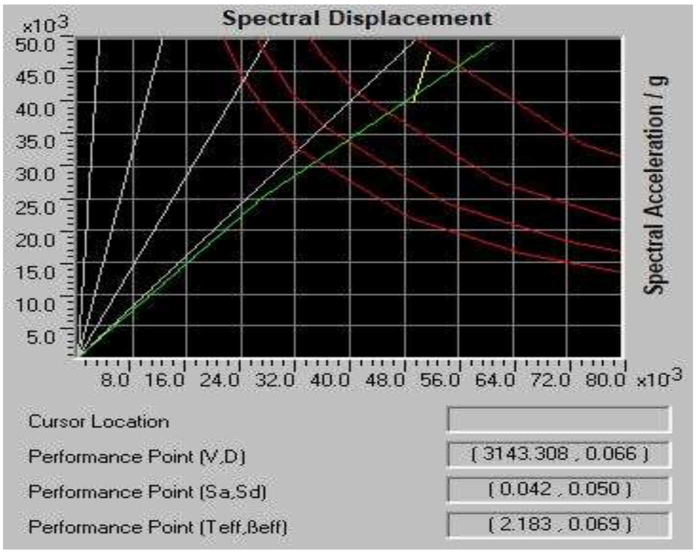
Performance Point –Model 1 – Y Dir



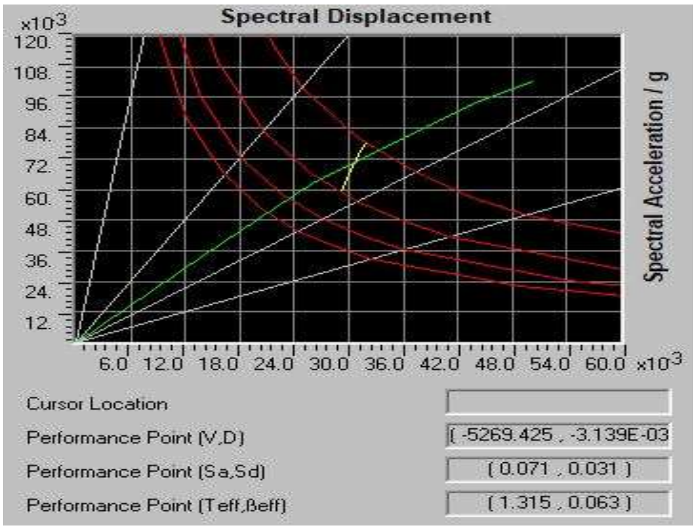
Performance Point – Model 2 – X Dir.



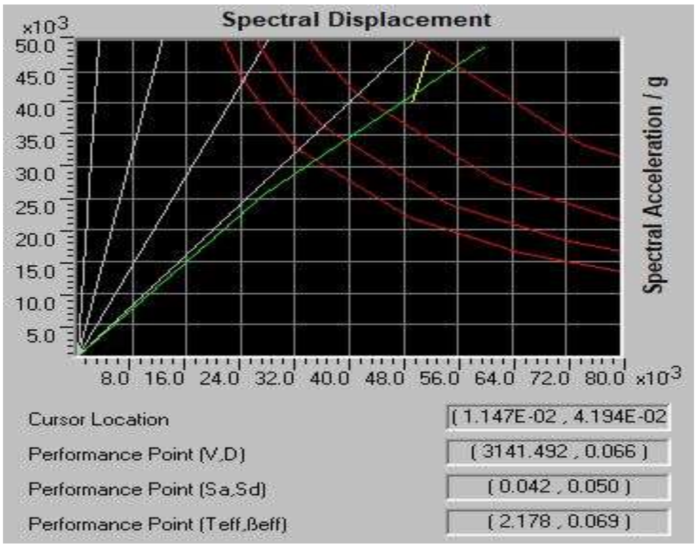
Performance Point – Model 2 – Y Dir



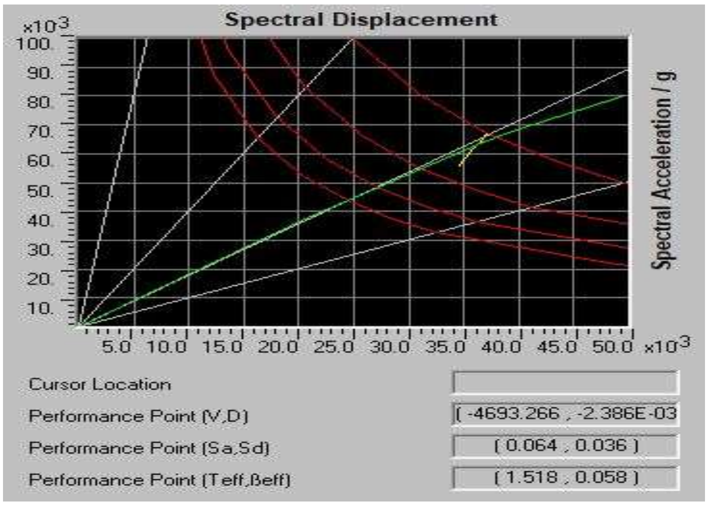
Performance Point - Model 3 – X Dir



Performance Point – Model 3 – Y –Dir



Performance Point – Model 4 – X Dir



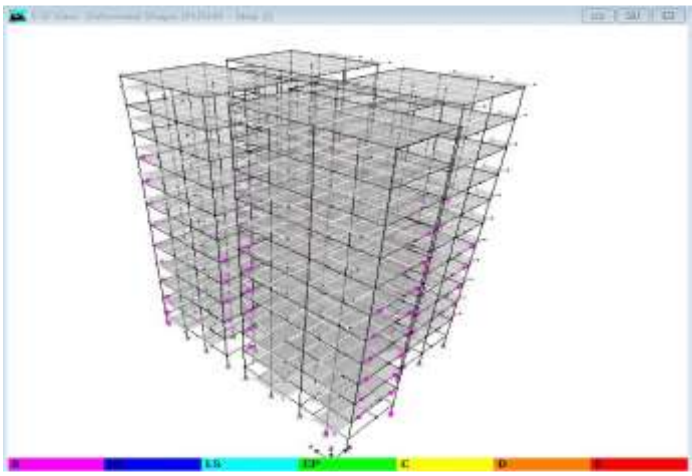
Performance Point - Model 4 – Y Dir

5.3 BASE SHEAR VALUES – PUSHOVER ANALYSIS

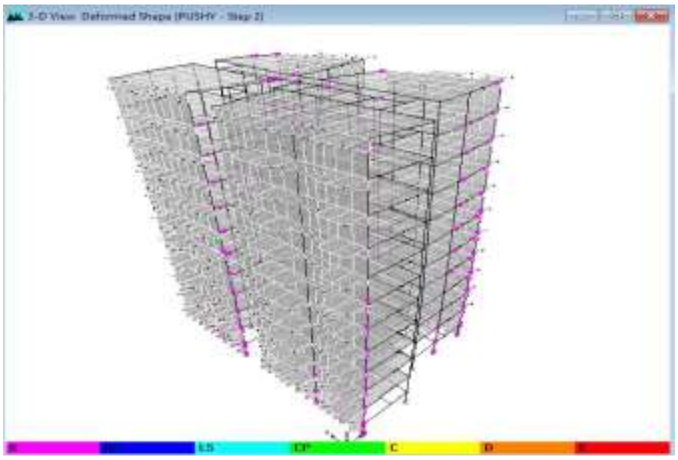
From the pushover summary results, it can be observed that, base force is found to almost same for all models in X axis, since there is no lateral load resisting systems support. However, base shear values in Y axis varies. There is a noticeable increase in the base shear value. This shows the stiffness of the shear wall structure attracts baser shear value.

Models	Base Force (KN)	
	X Dir.	Y Dir.
MODEL 1	3122	4013
MODEL 2	3586	14059
MODEL 3	3143	5269
MODEL 4	3141	4693

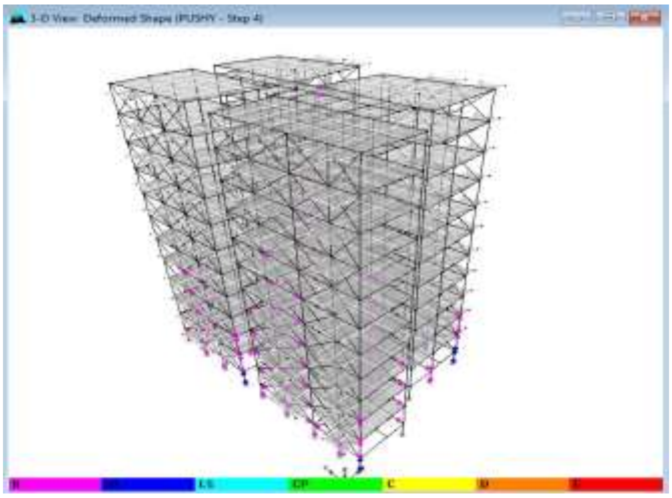
5.4 HINGES FORMATION



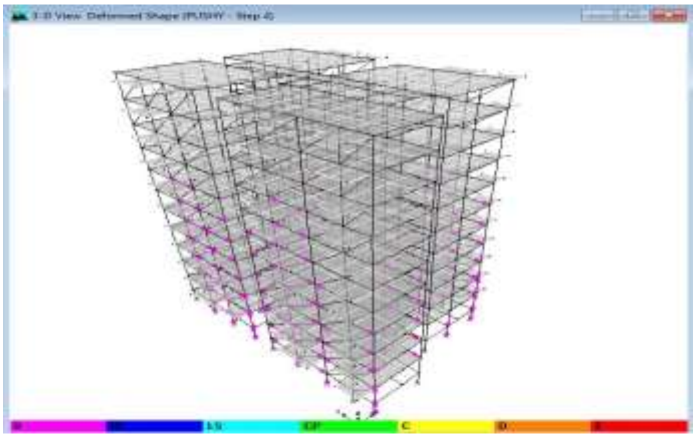
Hinge formation in Model 1



Hinges formation in Model 2



Hinges formation in Model 3



Hinges formation in Model 4

The range between A to B is being the elastic range, range between B to IO (Immediate occupancy) is the instant occupancy range, where only slight damage will occur in the structure. The range IO to LS (Life safety) is being the range of life safety of the occupants, where significant damage is observed in the structure. Range LS to CP is the collapse prevention range, where the structure will be heavily damaged but won't collapse. The point C in the force-displacement curve is the ultimate capacity of the structure, represents the maximum displacement and base shear, after which the hinges start to drop the load. Point D represents the residual strength of the structure and the point E represents the complete collapse of the structure.

6. CONCLUSION

The following are the conclusions drawn from the results obtained after the different analysis.

- The displacement due to response spectrum analysis in X direction is found to be same for model 1, 3 & 4. This is due stiffness of building is same in X direction. However, the stiffness in Model 2 is more compared to other models in X direction is high, there is a reduction in displacement of 15% is found.

  - Since the lateral resisting members are in parallel to Y direction, there is a considerable variations in the displacement value, compared with X direction. The Shear wall building is showing approximately 86% reduction in displacement compared to regular building.
  - Comparison with bracings and infill wall shows, the bracing the better performance in earthquake, since it shows reduction of around 26% in top Storey displacement.
  - The drift values in model 2 is almost linear, since the displacement variation is for Storey is less. The model of other Storey varies parabolic ally due to variations in the displacement is high.
  - The models 1, 3, 4 are showing same flexibility in the first mode of vibration. Whereas there is a reduction in the time period for other modes of vibration. The model 2 is stiffer than the other models due to the presence of shear wall thus showing lesser time period of vibration.
  - The base shear values depend on the weight of the structure, as the model 2 with shear wall having more weight shows max. Base shear out of other models.
  - The pushover analysis shows, the base force is found to almost same for all models in X axis, since there is no lateral load resisting systems support. However, base shear values in Y axis varies. There is a noticeable increase in the base shear value. This shows the stiffness of the shear wall structure attracts base shear value.

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