Seismic and Torsional Performance of Stiffness Irregular Buildings with Post Tensioned Flat Slabs

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Abstract - *The use of post-tensioned flat slab is increasing wide, due to its advantages over traditional concrete. These slabs are proven to be the most economical in comparison to the RCC slabs. As these slabs are quite simple to construct, Post-tensioned slabs are popular for industrial, commercial and residential floor slab construction. Irregular buildings represent and outsized portion of the modern urban infrastructure. The cluster of individuals concerned in constructing the building facilities, including owner, architect, structural engineer, contractor and native authorities, contribute to the overall planning, selection of structural system, and to its configuration. This might cause to building structures with irregular distributions in their mass, stiffness and strength along the height of building. When such buildings are located in a high seismic zone, the structural engineer's role becomes more challenging. This thesis is to investigate the seismic performance and torsional performance on stiffness irregularity building with improving lateral stiffness and shear wall configuration. Modeling G+14 building using ETABS and perform the response spectrum analysis using the said software.*

Key Words: **Post-tensioned slabs, irregular buildings, Seismic, E-tabs.**

1. INTRODUCTION

Due to the rapid increase in the shortage of land, necessity of high rise buildings are becoming an essential part. But this kind of construction creates challenges to counteract lateral load due to wind and earthquake. Behavior of a multistory building during strong earthquake motion depends on structural configuration. Irregular configurations either in plan or elevation is recognized as one of the major causes of failure during earthquakes. Irregular buildings represent an oversized portion of the present urban infrastructure. The cluster of individuals concerned in constructing the building facilities, together with owner, architect, structural engineer, contractor and native authorities, contribute to the general coming up with, selection of structural system, and to its configuration. This might cause to building structures with irregular distributions in their mass, stiffness and strength on the height of building. Torsional responses in structures arise from two important sources. Eccentricity in the mass and stiffness distributions, resulting a torsion response coupled with translation response.

1.1 Flat Slab

A Flat slab is a two-way reinforced concrete slab which directly supported by columns and doesn't have beams. So the loads are transferred directly to the supporting columns. In Flat slab structures, the absence of beams gives a plain ceiling and so an attractive appearance. The Flat slab is easier to construct and requires cheaper formwork. In Flat slab structures, partition walls can be placed anywhere and these structures are less vulnerable in the case of fire than the conventional slab-beam structures.

1.2 Post Tensioning

Post-tensioning is a method of reinforcing concrete or other materials with high-strength steel strands or bars, typically by tendons. Those zones of the member ultimately needed to carry tensile stresses in working load conditions are given an initial compressive stress before the application of serviceable loads so that the tensile stresses induced by these serviceable loads are balanced by induced compressive strength. In several cases, post-tensioning permits construction, which might rather be impossible due to either site constraints or architectural requirements. Designers commonly take advantage of this method to produce building and structure with large clear span allowing more architecture freedom. Reducing thickness of every structural member in building can reduce the total dead lead of the structure and decrease floor to floor height. The following are just a few of the many advantages of post-tensioned floor construction. Long spans reduce the number of columns and foundations, providing increased flexibility for internal planning, and maximizing the available letting space of a floor.

1.3 Scope of the Study

The main scope of this thesis is to study the seismic and torsional performance of stiffness irregular buildings with post-tensioned flat slab and thereby, to investigate the seismic performance of PT slab building with different stiffness irregularity configuration building. And, to investigate the seismic performance study on improving the lateral stiffness by shear wall configuration. Also to evaluate the improvement on lateral displacement, story shear, drift. To evaluate the torsional check limitations under irregularity condition.

1.4 Methodology

The structure is modelled using ETABS software. Plan dimension- 27.5mx27.5m, storey height- 3.6m, total number of stories- 15, M40 grade of concrete, Fe500 grade of steel, slab thickness- 200mm, column dimension: 1 to 5 storeys- 850mmx850mm, 6 to 10 storeys- 750mmx750mm, 11 to 15 storeys- 600mmx600mm, shear wall thickness- 250mm, seismic zone II, site type II, importance factor- 1. Live load on terrace floor- 1.5kN/m^2, live load on the floors- 3kN/m^2. Response spectrum analysis was performed in each of the models. Results are plotted graphically and compared.

2. ANALYTICAL STUDY

Several models were created in such a way that, some of it symmetrical to both vertical planes and others symmetrical to only one vertical plane. These models were analysed. The storey displacement, storey drift, time period got for each of these models were so high. So how to improve the stability became the matter of concern. The stability of high rise building can be well improved to a very greater extent by the introduction of shear walls. So 3 different cases of shear wall introduction were carefully studied for each of the models, that is,

- Case 1: Shear walls are provided at the corners.
- Case 2: Shear walls are provided at middle exterior.
- Case 3: Shear walls are provided at middle interior.

The storey displacement, storey drift, storey shear, time period for the above mentioned 3 cases along with no shear wall condition are compared and plotted graphically for better understanding. (S W represents shear wall)

2.1 Model 1

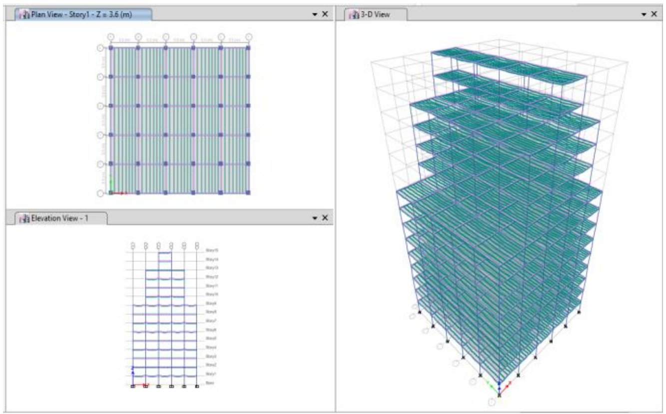

Fig -1: Model 1 considered for the study

In this model, the set backs are provided symmetrically from both sides. So this model is symmetrical to both vertical planes.

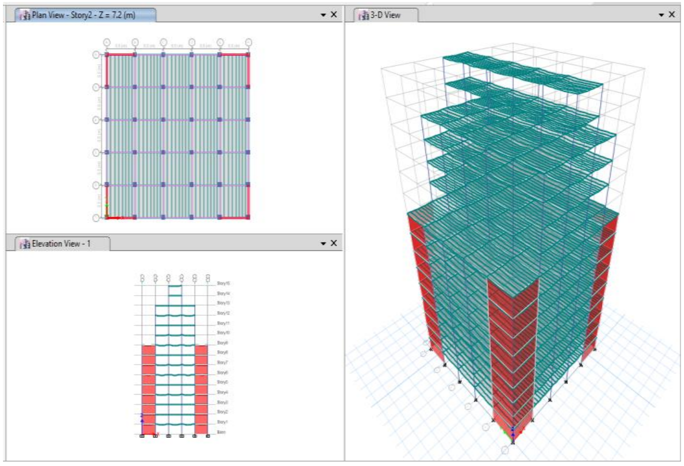

Fig -2: Model 1 with shear walls at corners

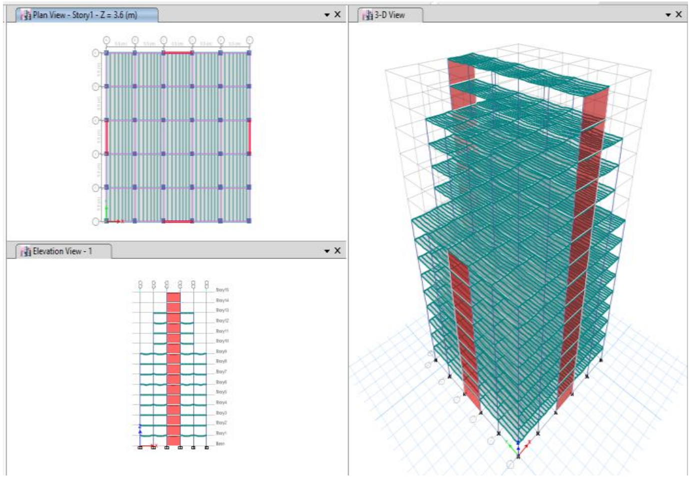

Fig -3: Model 1 with shear walls at middle exterior

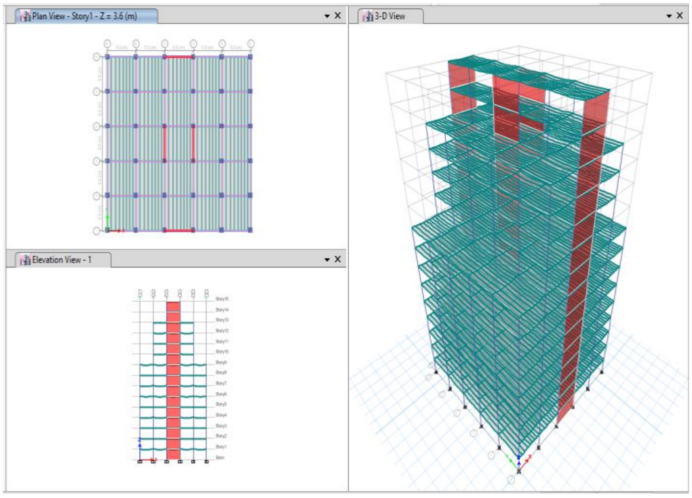

Fig -4: Model 1 with shear walls at middle interior

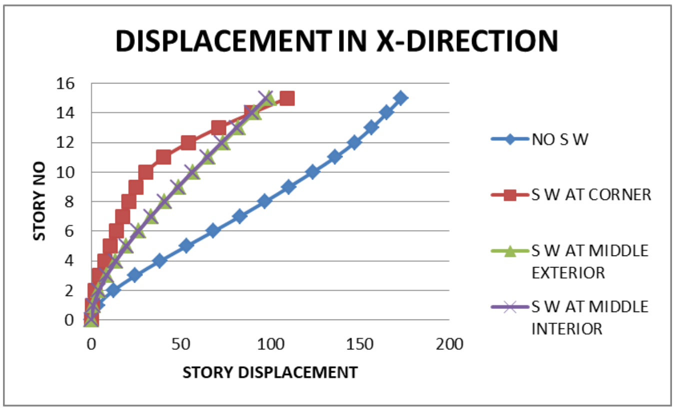

Chart -1: Storey displacement in X-direction

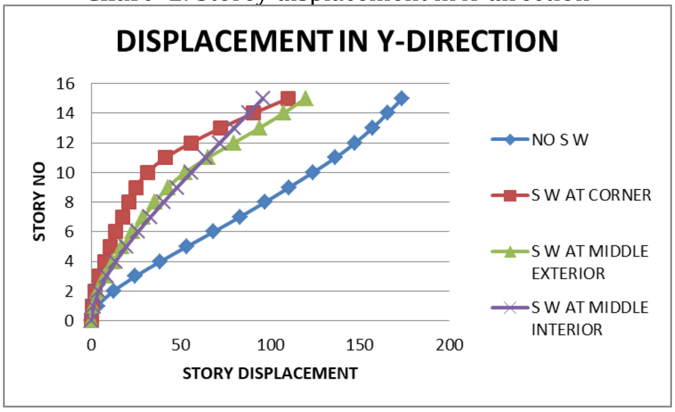

Chart -2: Storey displacement in Y-direction

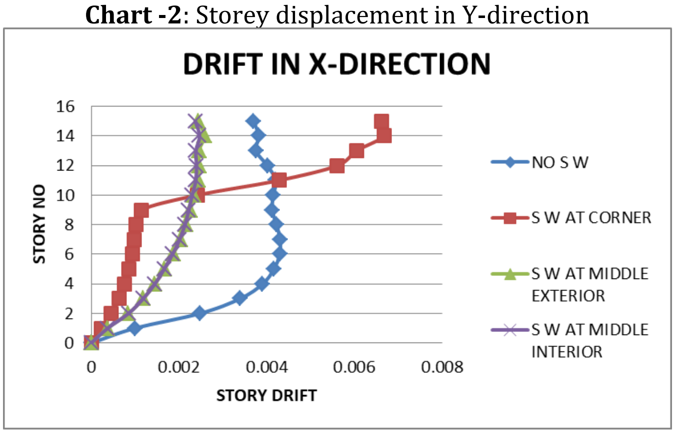

Chart -3: Storey drift in X-direction

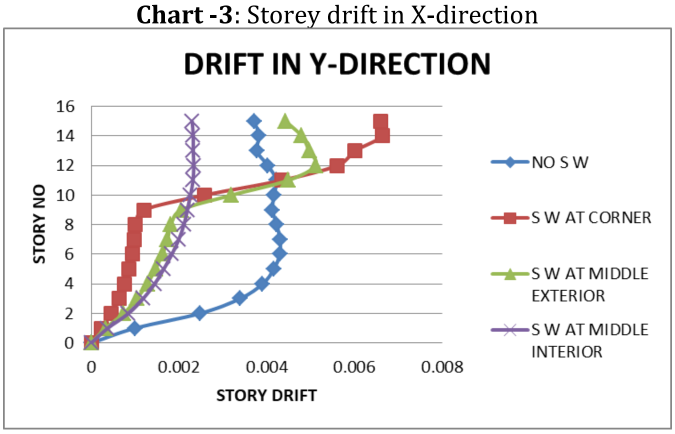

Chart -4: Storey drift in Y-direction

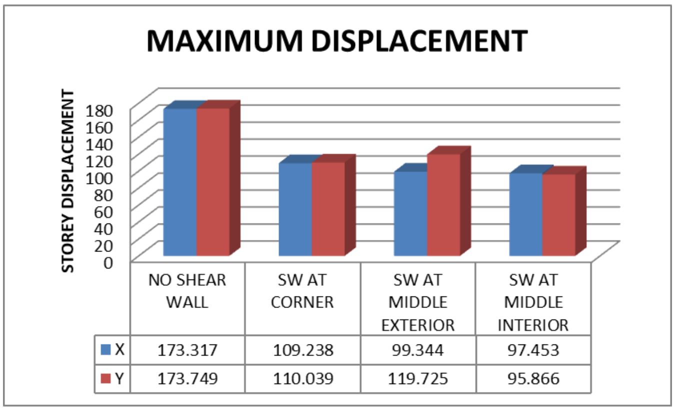

Chart -5: Maximum storey displacement

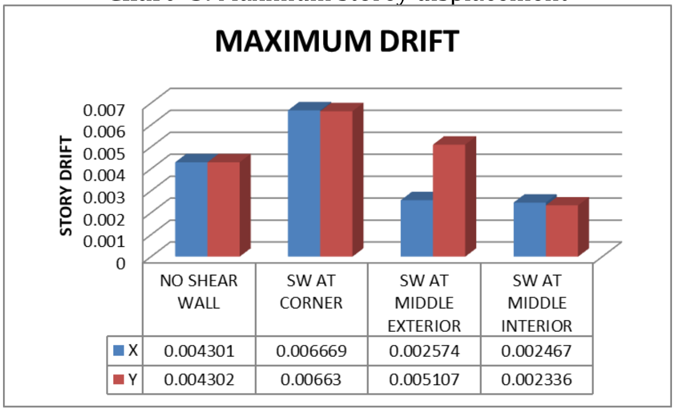

Chart -6: Maximum storey drift

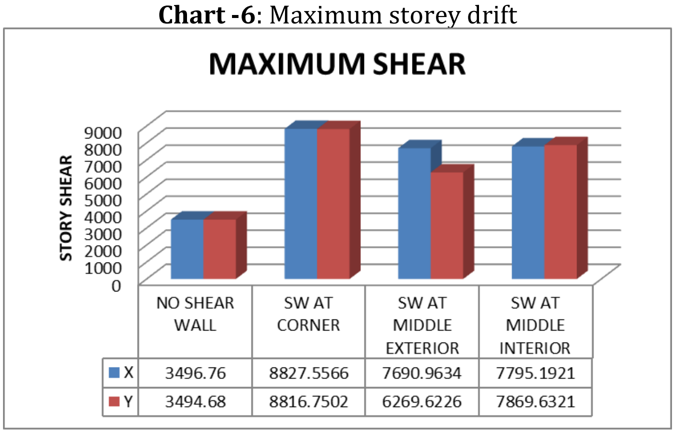

Chart -7: Maximum storey shear

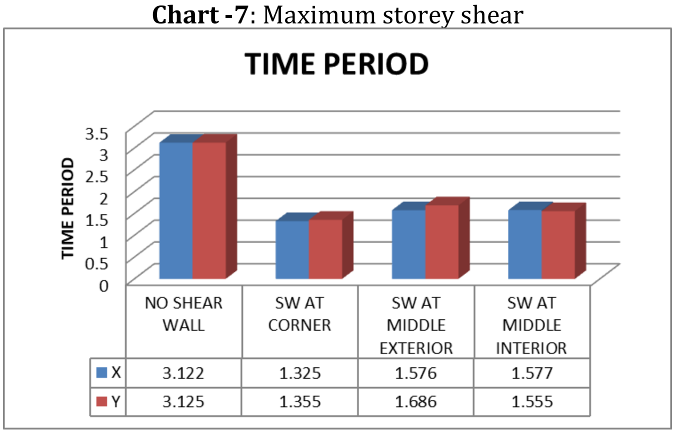

Chart -8: Time period

Table -1: Torsional calculation for Model 1

		No S W	Case 1	Case 2	Case 3
X	$U\ x$	173.318 173.318	109.238 109.238	99.179 99.179	97.453 97.453
	$\frac{U\ max}{U\ avg}$	1	1	1	1
	Torsional irregularity	NO	NO	NO	N0
Y	$U\ y$	173.75 173.75	110.039 110.039	119.715 119.715	95.821 95.821
	$\frac{U\ max}{U\ avg}$	1	1	1	1
	Torsional irregularity	NO	NO	NO	NO

If, $\frac{umax}{uavg} \leq 1.2$; then there is no torsional irregularity in the building. Otherwise, represents the presence of torsional irregularity .If $\frac{umax}{uavg}$ is greater than 1.4, then building contains severe torsional irregularity.

2.2. Results and Discussion- Model 1

From the charts it is clear that,

The model without shear wall, the displacement, drift, time period values are too much higher, thus the structure was found to fail under seismic loads.

The model with shear wall at the corner, the displacement and time period get reduced, but drift again increased..

The model with shear wall at middle exterior, the displacement, drift in X direction and the time period get reduced, but the drift in Y direction again increased.

The model with shear wall at middle interior, the displacement, drift, time period values get stably reduced. The structure became safe against seismic loads.

From the table it is clear that,

There is no torsional irregularity for the structure.

2.3 Model 2

In this model, the set backs is provided only in one side. So this model is symmetrical to only one vertical plane.

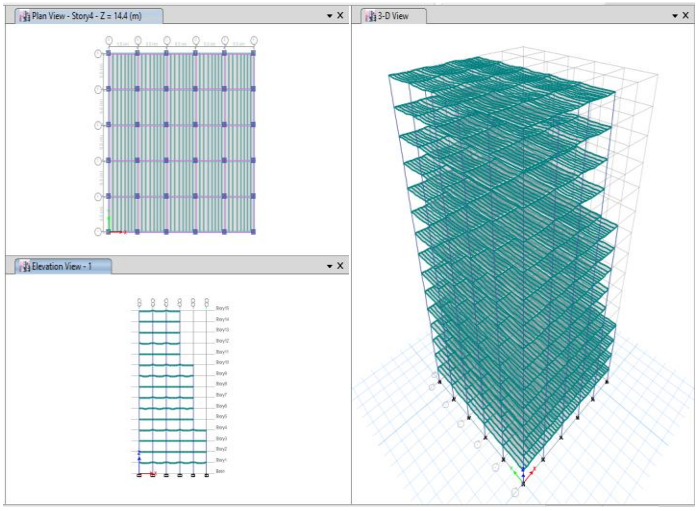

Fig -5: Model 2 considered for the study

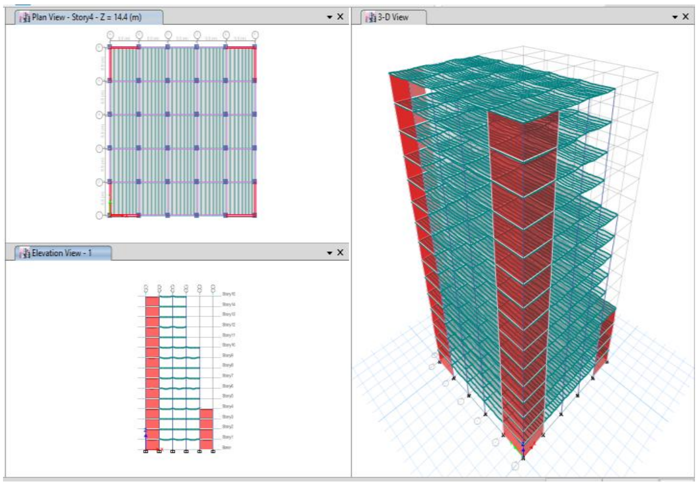

Fig -6: Model 2 with shear walls at corners

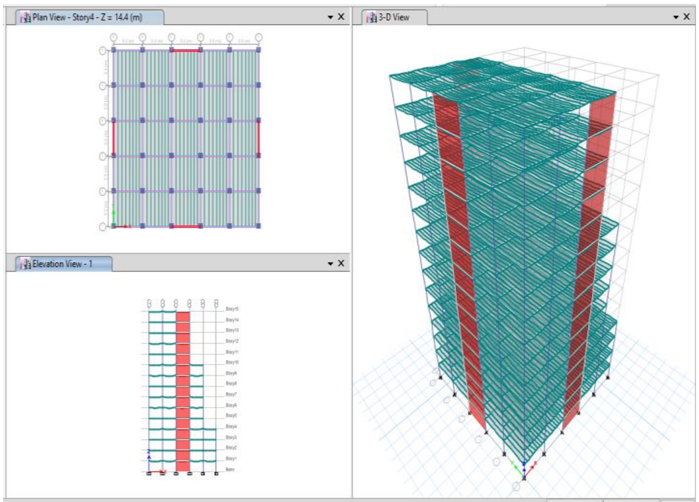

Fig -7: Model 2 with shear walls at middle exterior

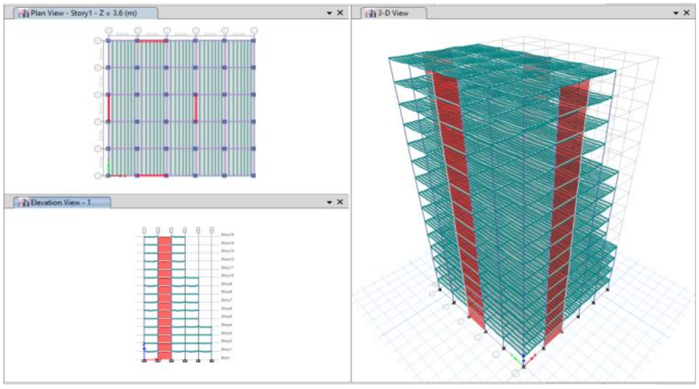

Fig -8: Model 2 with shear walls at middle interior

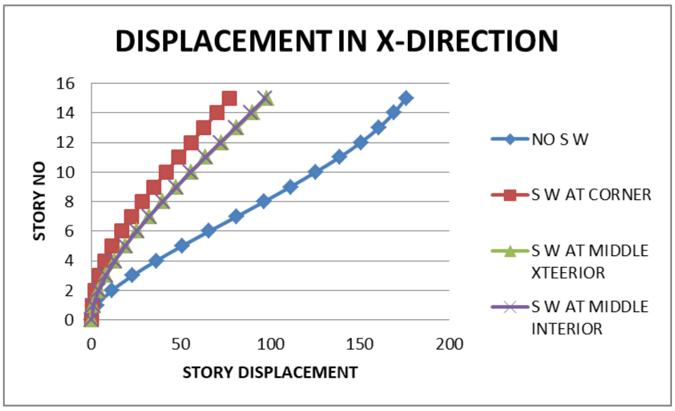

Chart -9: Storey displacement in X-direction

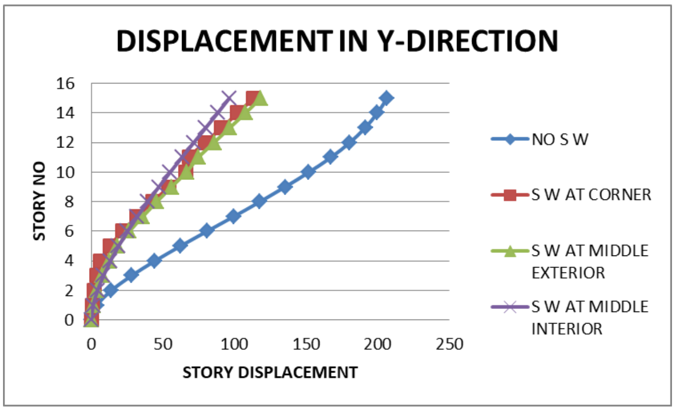

Chart -10: Storey displacement in Y-direction

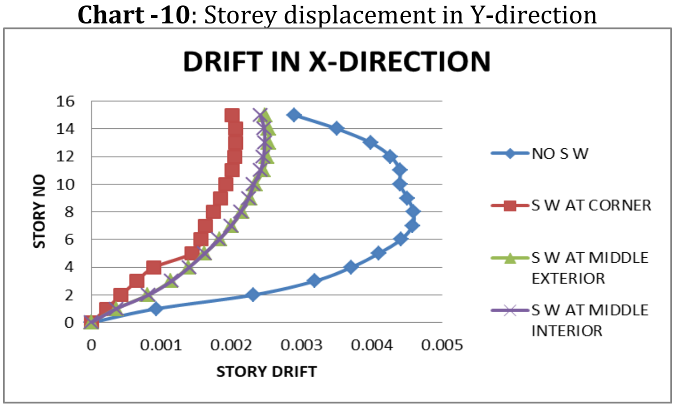

Chart -11: Storey drift in X-direction

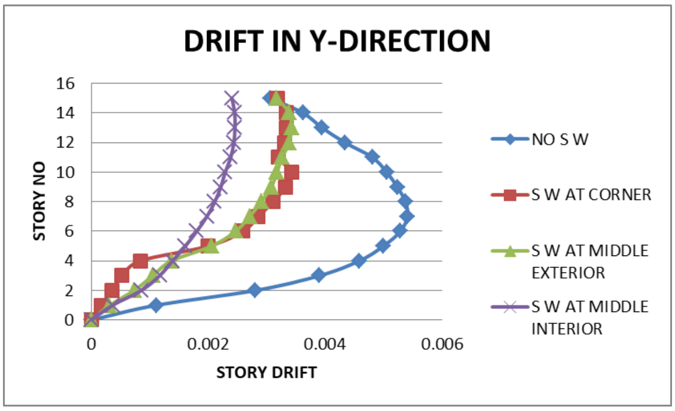

Chart -12: Storey drift in Y-direction

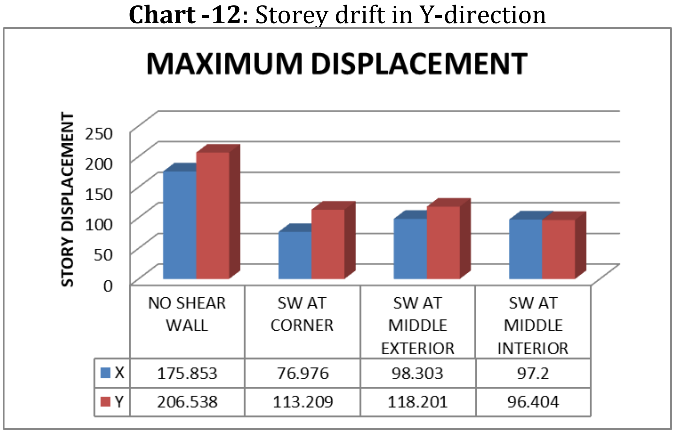

Chart -13: Maximum storey displacement

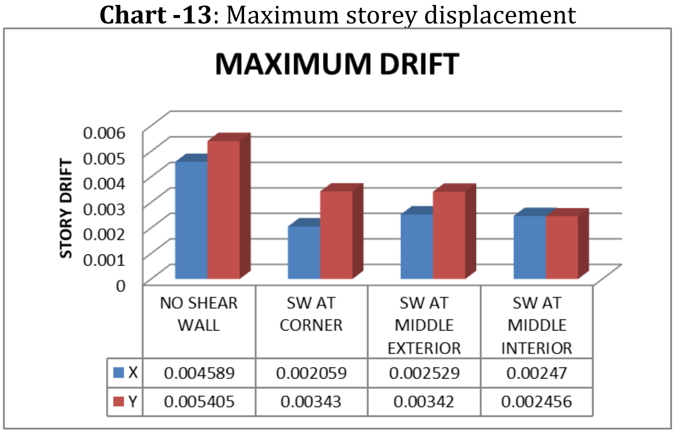

Chart -14: Maximum storey drift

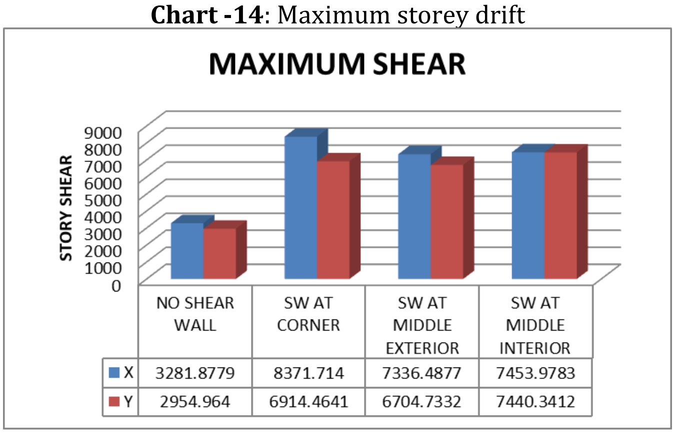

Chart -15: Maximum storey shear

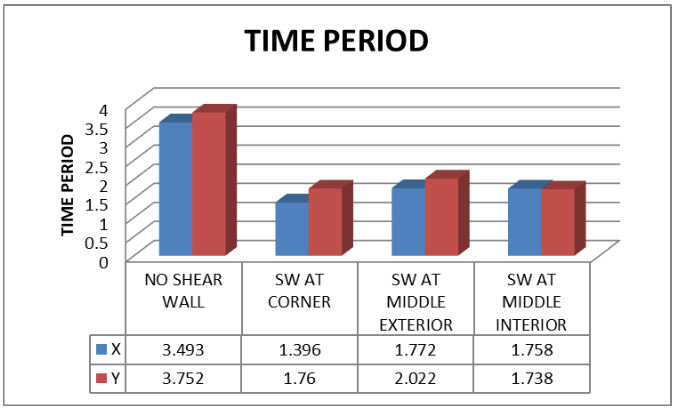

Chart -16: Time period

Table -2: Torsional calculation for Model 2

		No S W	Case 1	Case 2	Case 3
X	U x	175.853 175.853	76.927 76.927	98.221 98.221	97.155 97.155
	$\frac{U\ max}{U\ avg}$	1	1	1	1
	Torsional irregularity	NO	NO	NO	NO
Y	U y	206.538 135.711	64.362 113.209	102.872 118.201	96.357 95.955
	$\frac{U\ max}{U\ avg}$	1.2069	1.275	1.07	1.002
	Torsional irregularity	YES	YES	NO	NO

2.4. Results and Discussion- Model 2

From the charts it is clear that,

The model without shear wall, the displacement, drift, time period values are too much higher, thus the structure was found to fail under seismic loads.

The model with shear wall at the corner, the displacement, drift in X direction and time period get reduced, but drift in Y direction get increased.

The model with shear wall at middle exterior, the displacement, drift in X direction and the time period get reduced, but the drift in Y direction get increased.

The model with shear wall at middle interior, the displacement, drift, time period values get stably reduced. The structure became safe against seismic loads.

From the table it is clear that,

There is a slight torsional irregularity in no shear wall condition and shear wall at corner case.

3. CONCLUSIONS

From the above 2 models, we can conclude that, when shear walls are provided throughout the structure, that is from base to the top, the stability of structure gets improved and it becomes safe in seismic loads. And if we model a structure symmetrically (mass), then torsional irregularity can be avoided to a greater extend.

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