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Effect of Location of Shear wall on Torsional Performance of Symmetric and Asymmetric High Rise Building

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Abstract: Torsion force is a load that is a applied to a building through torque. The torque applied creates a shear stress. If a torsion force is large enough, it can cause a building to undergo a twisting action. The main aim of the project is to study the effect of location of shear wall on torsional performance of symmetric and asymmetric high-rise building ,post tensioned slabs are being used in the construction of building hence the thesis also analyze these post tensioned slab structures by changing shear wall configuration. Post tensioned slab structures have weak resistance to lateral loads. so to provide stiffness to structures against lateral forces shear walls are used. A study of 30 storey building in zone III, is considered and determine various parameters like base shear, storey drift, and storey displacement.post-tensioning is a mature technology as it provide efficient, economic and elegant structural solutions for a wide range of applications. Post-tensioned flat slab could be a better option compared to RCC flat slab, in respect of the cost of project and time of construction. ETABS 2017 software is used for the analysis.
Keywords: Torsional performance, Post tensioned slab, Reinforced cement concrete, Shear wall, Storey displacement.

I. INTRODUCTION

Torsion refers to the twisting of an object due to an applied torque, shear walls are structural members used to augment the strength of RCC structures. these shear walls are built in each level of the structure, to form an effective box structure. Shear walls are added to the building to provide extra strength and stiffness to the building when the exterior walls cannot provide sufficient strength and stiffness. It is necessary to provide these shear walls when the allowable span-width ratio for the floor or roof diaphragm is exceeded. The present work deals with a study on the effect of location of shear wall on torsional performance of symmetric and asymmetric high-rise building. The high-rise buildings is analyzed for its torsion, base shear, storey drift and storey displacement for different geometric building configurations. The results of the analysis on the storey displacement, storey drift, storey shear, torsional irregularity, time period is compared. The results are presented in tabular and graphical form. Post tensioned flats are being used in all building configurations.

A. Scope and Objectives

The main objective of the project is:

1) The performance of post tensioned flat slabs in torsion with various shear wall locations is analyzed regarding strength condition.
2) To investigate the seismic and torsional performance of post tensioned slab building with different shear wall configuration.
3) To investigate the resistance performance study on improving the lateral stiffness by shear wall configuration
4) To evaluate improvement on lateral displacement, story shear, drift.
5) To evaluate the torsional check limitation under irregularity condition.

II. MODELLING

A 30 storey building structure is modelled using ETABS. The different geometrical buildings such as symmetric like rectangle, C, T and I shaped and unsymmetrical buildings like L shaped buildings are modelled in ETABS 2019,the building is analysed in zone III. The results are tabulated and compared. Determines various parameters like base shear, storey drift, and displacement for different geometrical buildings and torsional performance of the posttensioned slab are computed, based on the comparisons most appropriate model is being selected also Dynamic analysis for post tensioned slab building was done by using response spectrum analysis for earthquake zone III as per Indian standard code The results are obtained from the analysis of building models are compared for the parameters like base shear, storey displacement, storey drift etc.

Structure Detailing

A. Details of Building

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1) Type of building: Symmetrical commercial building
2) Plan dimension: 30m x 30m
3) Total height of building: 108m
4) Height of each storey: 3.6m
5) Total no. of storeys: 30

B. Material Properties of the Building

1) Grade of concrete: M40
2) Grade of steel: Fe500

C. Post-Tension Strand Details

1) Ultimate strength: 1860 N/mm2
2) Nominal area of strands: 98.7mm2
3) Strand diameter: 12.7mm

D. Sectional Properties of Building

1) Beam dimensions for conventional structure: 300mm x 350mm
2) Thickness of slab for conventional structure: 150mm
3) Thickness of slab for RCC and Post-tensioned flat slab structures: 200mm
4) Thickness of shear wall: 250mm
5) Dimension of drop panel: 2000mm x 2000mm

E. Column Dimensions

1) 1 to 10 storeys: 850mm x 850mm
2) 11 to 20 storeys: 750mm x 750mm
3) 21 to 30 storeys: 600mm x 600mm

F. Loads on the Building

1) Seismic zone: Zone III
2) Site type: II
3) Importance factor: 1
4) Wind speed: 39m/s2
5) Terrain category: 4
6) Live load on terrace: 1.5kN/m2
7) Live load on floors: 3kN/m2

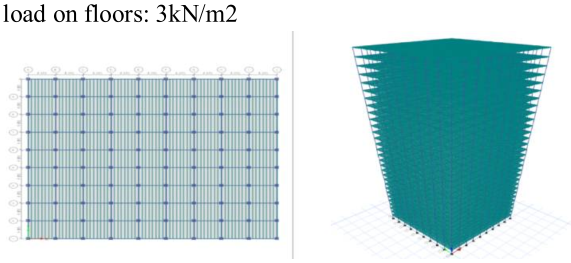

Fig:1 Plan of the Rectangle shaped structure.

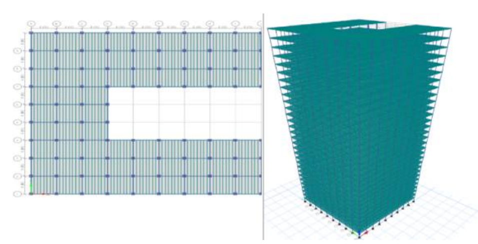

Fig:2 Plan of C shaped structure

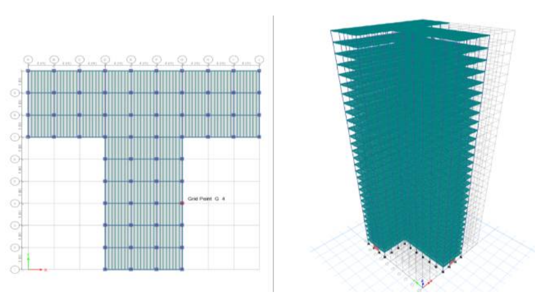

Fig:3Plan of I shaped structure.

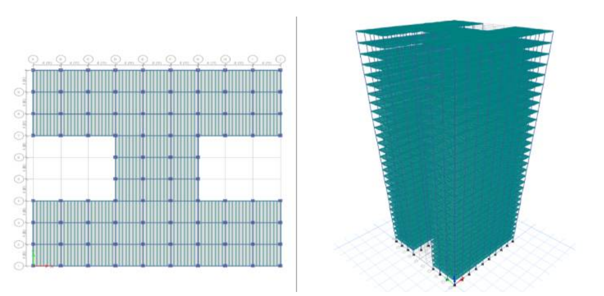

Fig:4 Plan of I shaped structure

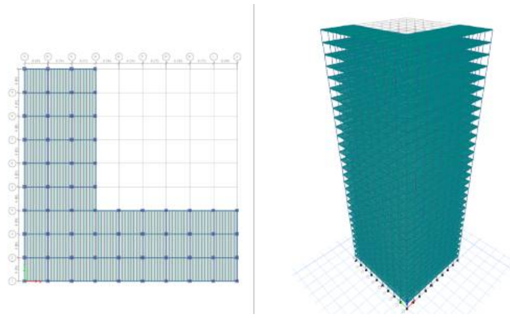

Fig:5 Plan of L shaped structure.

III. RESULT AND DISCUSSION

A. Storey Displacement

Storey displacement is the lateral displacement of the storey relative to the base Displacement of sotrey in X & Ydirection is collected for seismic loading from symmetric and asymmetric buildings direction.

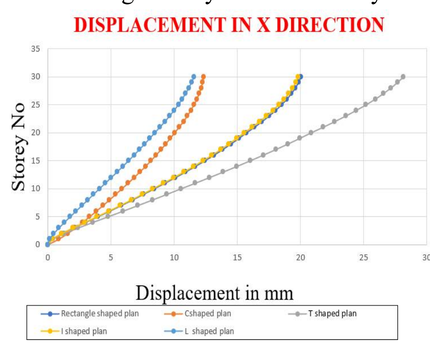

Fig 6 Storey displacement in X direction.

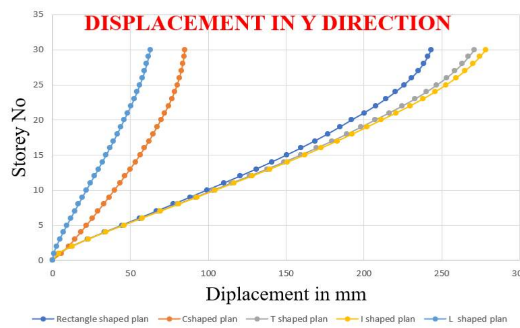

Fig:7 Storey displacement in Y

Graphs represents variation of displacement of storey in X and Y- directions .The displacement of T shaped plan building shows slightly greater than others in X-direction. All buildings shows slightly difference in displacements. I shaped plan building shows more displacement in Y-direction.

B. Storey Drift

Storey drift is defined as ratio of displacement of two consecutive floors to the height of that floor Total storey drift is absolute displacement of any point relative to the base. As per IS.1893-2002 cl.7.11.1 the storey drift in any storey due to the minimum specified design lateral force with partial load factor 1.00 shall not be exceeding 0.004 times the storey height

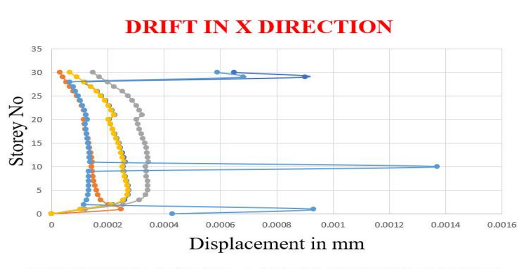

Fig:8 Storey Drift in X Direction,

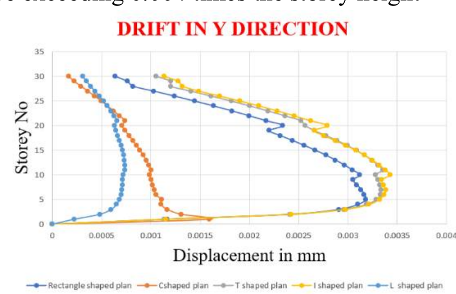

Fig:9Storey Drift in Y Direction.

As per IS code all buildings are not in the limit. All buildings fails under seismic loads. Comparing each buildings L shaped building shows more drift in X-direction.

C. Storey Shear

Storey shear is the lateral force acting on a storey due to forces such as seismic &wind force .Roughly storey shear can be seen as distribution of base shear along its storey based on its stiffness and mass.

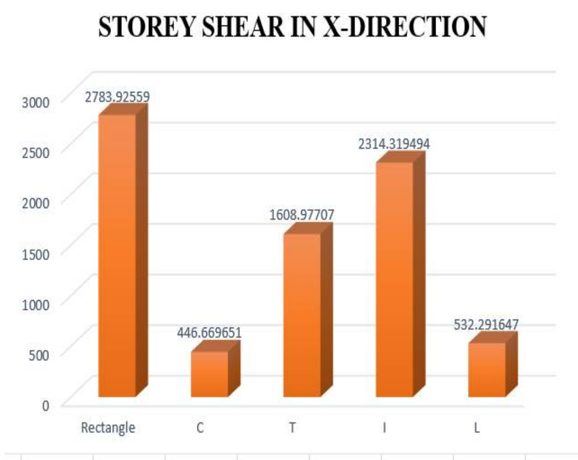

Fig:10 Storey shear in X Direction.

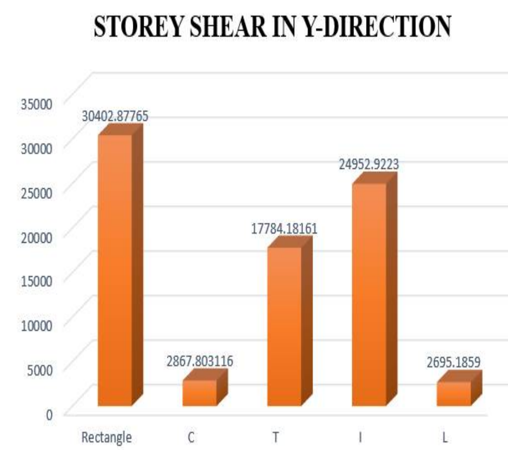

Fig:11 Storey shear Y Direction.

The storey shear is maximum at ground level and keeps on decreasing towards the top storey of the structure. The base shear of rectangle shaped structure is more than other structures both in X and Y directions. L shaped structure has lower base shear, which is lower than compared with rectangle shaped buildings both in X and Y directions

IV. COMPARISION ON BEHAVIOUR OF POST TENSIONED SLAB STRUCTURES WITH SHEAR WALL AT VARIOUS LOCATIONS

A. Storey Displacement

Fig:12 Storey Displacement of rectangle building.

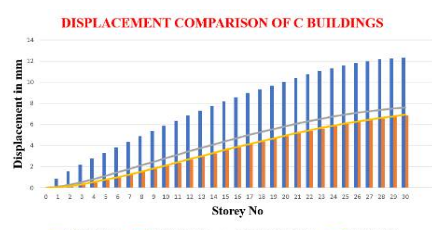

Fig:13 Storey Displacement of C shaped building.

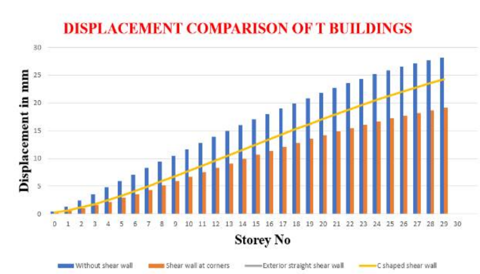

Fig:14 Storey Displacement of T shaped building.

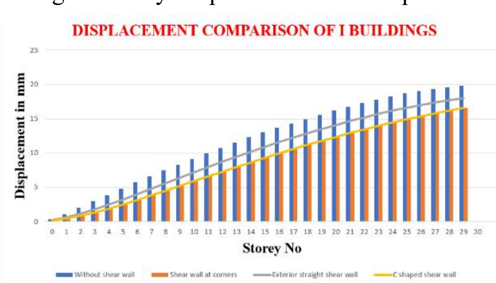

Fig:15 Storey Displacement of I shaped building.

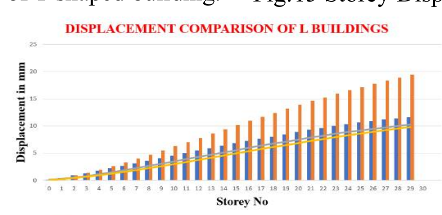

Fig:16 Storey Displacement of L shaped building.

Building without shear wall shows greater displacement. In case of I building, storey displacement in both X and Y direction is low when shear walls provided in both corner and c shape at middle.In rectangle buildings it is found that buildings having shear wall shows small displacement than Both C and T shaped buildings shows its symmetry in either X or Y axes. In both buildings storey displacement is low in case of shear wall are provided in corner. In T shaped buildings storey displacement comparatively low in X and Y when shear wall provided in both corner and c shaped shear wall. Also buildings with shear walls in middle shows poor performance .

B. *Storey Drift*

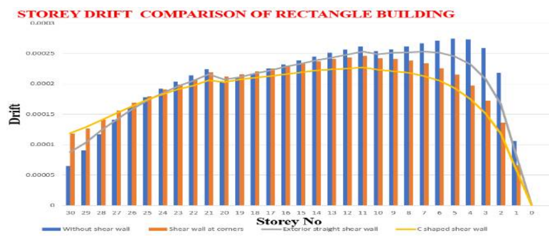

Fig:17 Storey Drift of Rectangle shaped building.

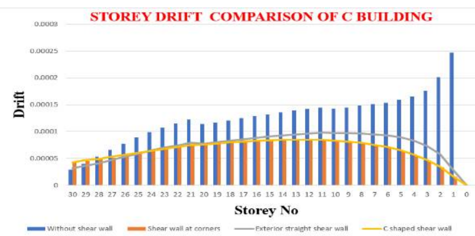

Fig:18 Storey Drift of C shaped building.

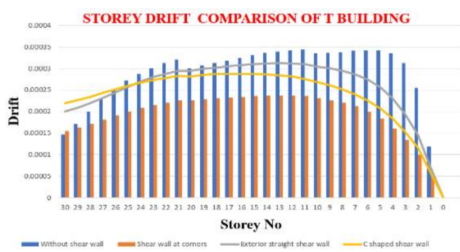

Fig:19 Storey Drift of T shaped building

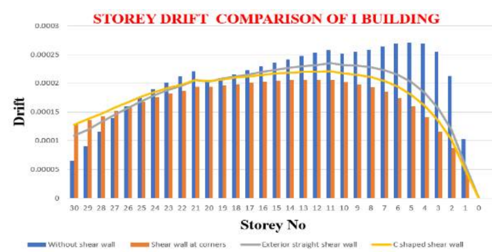

Fig:20GrStorey Drift of I shaped building

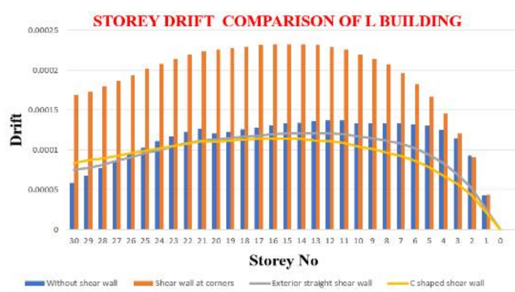

Fig:21 Storey Drift of L shaped building.

In both rectangle and I shaped buildings the story drift value is reduced to its permissible limit after providing shear walls. In both buildings the storey drift is lower in case of shear walls provided in both middle and corner. In rectangle shaped building the storey drift value is reduced from its permissible value as per Indian code. In case of I building drift value is reduced from its permissible value In case of C buildings the story drift is reduced when shear walls provided in both corner and middle It is also same in T shape and C shape buildings.Storey drift of L shaped Buildings having shear walls in corner and middle reduced in X & Y direction from its permissible limit.

C. *Time Period*

Time required for the undamped system to complete one cycle of free vibration is the natural time period of vibration of system in unit of second. Time period depends on mass of building and it indicates flexibility of building. The number of mode increases, the value of time period decreases. In case of symmetric building the time period along X and Y direction is same. But in asymmetric buildings it shows variation. From below chart itis observed that time period of C shaped building is more than other planned building. From below charts it is observed that symmetric building has lower time period than asymmetric buildings.

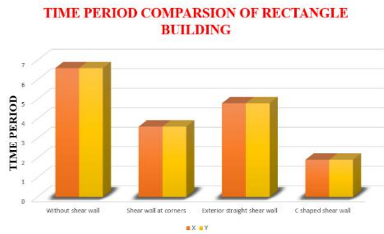

Fig:22 Time Period of Rectangle shaped building.

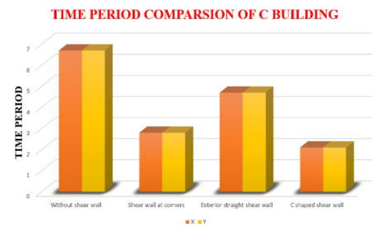

Fig:23 Time Period of C shaped building.

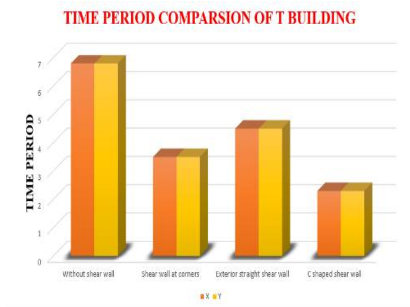

Fig:24 Time Period of T shaped building.

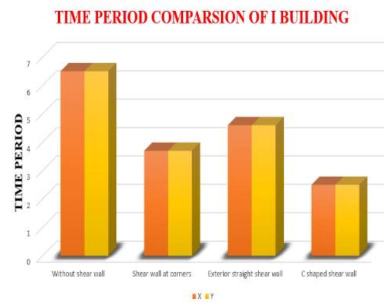

Fig:25 Time Period of I shaped building.

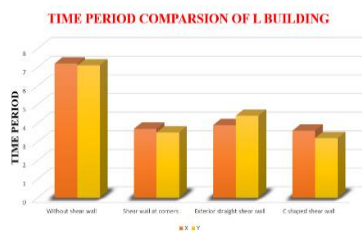

Fig:26 Time Period of L shaped building.

D. Torsional Irregularity

Torsion is created when the Centre of mass (CM) and the Centre of rigidity or resistance (CR) in the building do not coincide. The distance between these two points is referred to as torsion eccentricity. Torsional effects can develop only in buildings with rigid diaphragms. Torsion in buildings during earthquake is caused due to various reasons and the most common is unsymmetrical distribution of mass and stiffness along the height of building. A special care and attention must be taken, so that, torsional effects do not avert the ductile behaviour of the structure.

Table:1 Torsional Irregularity of Buildings.

		SHEAR WALL CONDITION			
SHAPE OF BUILDINGS		WITHOUT SHEAR WALL	SHEAR WALL AT CORNERS	EXTERIOR STRAIGHT SHEAR WALL	C SHAPED SHEAR WALL
RECTANGLE	X	1	1	1	1
	Y	1	1	1	1
C	X	1	1	1	1
	Y	1.03	1.04	1.02	1.004
T	X	1	1.03	1.16	1.05
	Y	1	1	1.06	1
I	X	1	1	1	1
	Y	1	1	1	1
L	X	1.008	1.06	1.26	1.06
	Y	1.007	1.06	1.04	1.08

As per code the value should not greater than 1.2. Here in some conditions such as in case of C shaped building along Y and l shaped buildings along X shows torsional irregularity greater than 1.2.

V. CONCLUSIONS

This is the summary of project work for post-tensioned slab buildings with different geometric plan irregularities in seismic zone III with type II medium soil. From the above charts following conclusions have been drawn:

A. Storey displacement value is high at top storey & decreases towards base of structure. L shaped plan building shows slightly greater storey displacement values as it is asymmetric structure but when shear wall provided, displacement of building reduced & shear walls provided at corner shows better performance in all cases.

B. Storey drift follows a parabolic path. Storey drift of each buildings higher than permissible value 0.004. After providing shear walls the drift value of each buildings gets reduced. In each buildings shear walls at corner and C shaped shear wall shows good performance in storey drift.

C. Storey shear is maximum at ground level and keeps on decreasing towards top storey Story shear is maximum in rectangular shaped building Cshaped structure has lower base shear, compared with rectangle shaped buildings X direction & L shaped has lower base shear compared with rectangle shaped buildings in Y direction. After providing shear walls stoery shear increased.

D. The time period is maximum in buildings with no shear wall condition . In case of symmetric building the time period along X and Y direction is same. But in asymmetric buildings it shows variation. Time period of C shaped building is more than other shaped building. Symmetric building has lower time period than asymmetric buildings. After providing shear wall its time period decreased. Buildings with shear walls at corner shows lower time period.

E. Torsion in buildings during earthquake is caused due to various reasons and most common is unsymmetrical distribution of mass and stiffness along the height of building. In some conditions such as in case of L shaped building along Y shows torsional irregularity greater than 1.2. Buildings with shear walls in corner perform well during earthquakes. Buildings with Shear wall at middle can’t perform well during earthquake. But shear walls at corner good in all condition.

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