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Seismic Analysis of Horizontal and Vertical Irregular RC Multi Storey Building With Effect of Opening in Shear Wall

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Abstract: *At present days building a structure with all the regular configurations is not feasible in most of the cases due to the irregular plot dimensions, aesthetic visual and functional requirements in the urban cities. The structure with more irregular configuration either horizontally or vertically are more vulnerable to earthquake which leads to collapses of structure, property loss and casualties. The shear walls are commonly used as a vertical element. Shear walls may have one or more openings for functional reasons such as windows, ventilation and other types of openings in shear wall. Frequently the shear wall is provided with openings thus necessary to study effect of irregular building. The present study was carried out the opening in shear wall with different shape of RC multi-Storey building and Study different building model with Combination of Horizontal & Vertical irregularities. The models were created using the ETABS software with Full Shear walls, Shear walls with a 25% opening. The location of the Shear wall was optimal. Prepared models of G+9 story and Analyze the model by Response Spectrum Analysis and Compare the Result with different buildings layout with parameters like storey Displacement, Storey Shear, Storey Drift, Storey Stiffness, Base shear, Torsion, Time Period and Mode Shape*

Keywords: Response Spectrum Analysis, Vertical & Horizontal Combination of Irregularity, Regular and Irregular building, Shear wall with Opening

I. INTRODUCTION

Seismic activity affects approximately 50-60% of India's total land area. Lateral forces caused by earthquake, and uneven settlement loads, in addition to the weight of structure and occupants; create powerful twisting (torsion) forces. As a result, the understanding of earthquake-resistant construction is must needed.

At present days building a structure with all the regular configurations is not feasible in most of the cases due to the irregular plot dimensions, aesthetic visual and functional requirements in the urban cities. The structure with more irregular configuration either horizontally or vertically are more vulnerable to earthquake which leads to collapses of structure, property loss and casualties.

Shear walls are vertical structural elements for resisting the lateral loads that may be induced by the effect of wind and earthquakes. Shear wall is a structure considered to be one, whose resistance to horizontal loading is provided entirely by them. Introduction of shear walls in a building is a structurally efficient solution to stiffen the building because they provide the necessary lateral strength and stiffness to resist horizontal forces.

Shear walls generally start at the foundation level and are continuous throughout the building height. They are generally provided along both length and width of the building and are located at the sides of the buildings or arranged in the form of core. The size and location of shear walls is extremely critical. They must be symmetrically located in plan to reduce the effect of twisting in buildings.

Shear walls may have one or more openings for functional reasons such as doors, windows, and other types of openings in shear wall. The size and location of openings may vary depending on purposes of the openings. The size and location of shear walls is extremely critical. Properly designed and detailed buildings with shear walls have shown good performance in past earthquakes.

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1.1 OBJECTIVE OF STUDY

To study the behavior of horizontal and vertical irregular RC multi-Storey building with a combination of irregularities. Study the effect of Opening in Shear wall with irregular building & also verify Torsion Ratio under seismic forces.

II. METHODOLGY

The present study was carried out the of opening in shear wall with L-Shape & C-Shape of G+9 RC multi-Storey building and Study different building model with Combination of Horizontal & Vertical irregularities. The Combination of irregularities [like Setback Case-1 irregularities with Re-entrant corner and setback Case-2 irregularities with Re-entrant corner] are Considered in models.

The models were created using the ETABS software having Without Shear wall, Full Shear walls and Shear walls with a 25% opening. The location of the Shear wall was optimal. Analyze the model by Response Spectrum Analysis and Compare the Result with different buildings layout with parameters like storey Displacement, Storey Shear, Storey Drift, Storey Stiffness, Base shear, Torsion, Time Period and Mode Shape.

Vertical Geometric Irregularity was modeled with a setback configuration Setback Case-1 (ground to 4^{th}floor, 5^{th} to 9^{th} floor) and Setback Case-2 (Stepped frame). As per IS 1893-2016 [11] (clause 7.1, Table 6, Fig. 4C) a building is said to be vertical geometric irregular building if the horizontal proportions of any storey which acts as a lateral force resisting system is over and above 125 percent.

Plan (Horizontal) Irregularity was modeled with a re-entrant corner configuration with a projection at any corner of the building along horizontal direction. As per IS 1893-2016 [11] (clause 7.1, Table 5, Fig. 3B) a structure is said to be Horizontal Irregular if the floor has a slab projection of measurement over and above 15 percent of floor proportions in the given direction.

III.MODELING DETAILS

Table 1. Model Parameters

MODEL PARAMETERS	
No of Storeys	G+9
Length of Bays in X direction	4m
Length of Bays in Y direction	4m
Plan Dimension	40m x 40m
Grade of steel	Fe500
Grade of concrete	M30
Slab thickness	125mm
Typical Storey height	3m
Bottom Storey height	3.5m
Size of Opening	As per analytical approach
Shear Wall Thickness	230mm
Floor Finish	1.5 kN/m^2
Live Load	4 kN/m^2 (Business & office Building)
Zone	III
Importance Factor	As per Specified clause
Type of Soil	Medium (II)
Response Reduction Factor	5 (SMRF)

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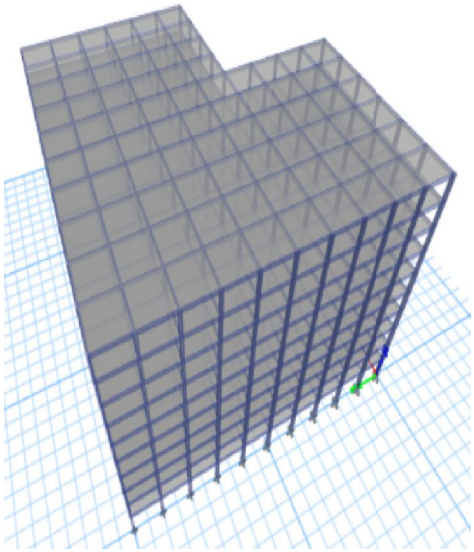

Figure 1.1 L-Shape Without Shear wall (WOTS)

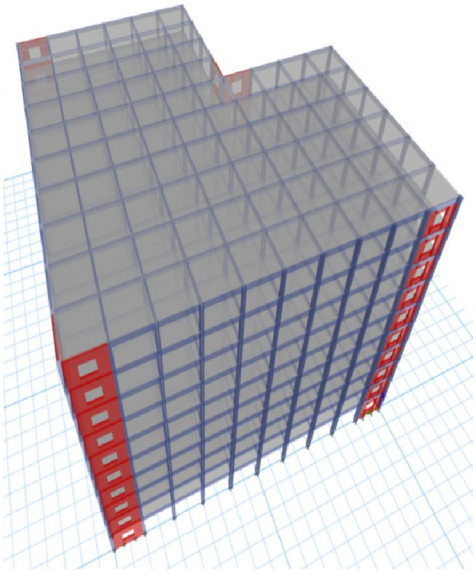

Figure 1.2 L-Shape Opening in Shear wall (Opening)

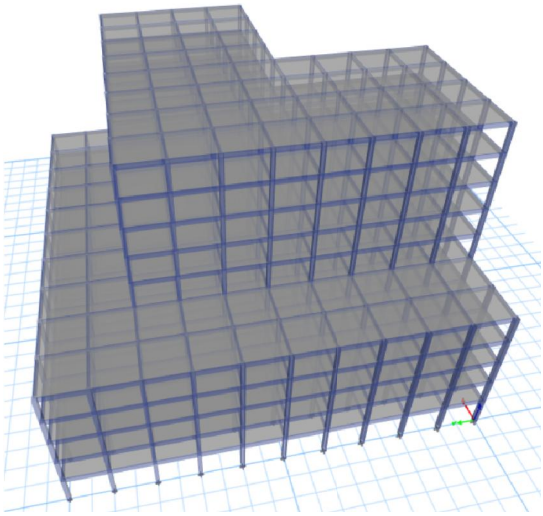

Figure 1.3 L-Shape Setback Case-1
Without Shear wall (WOTS)

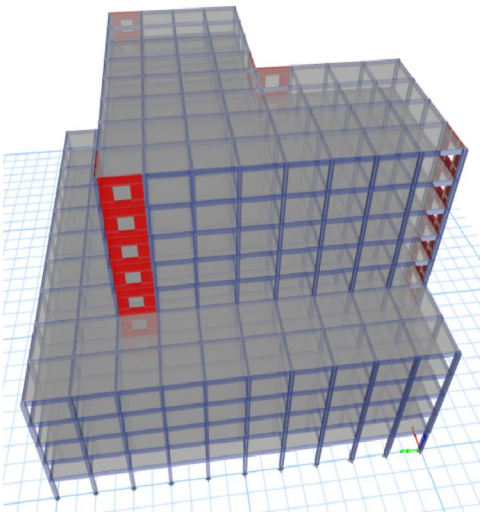

Figure 1.4 L-Shape Setback Case-1
Opening in Shear wall (Opening)

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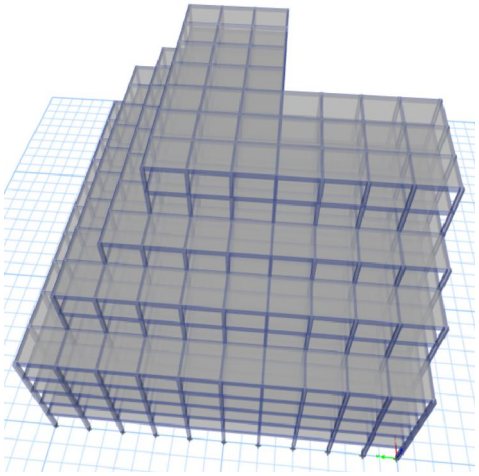

Figure 1.5 L-Shape Setback Case-2 Without Shear wall (WOTS)

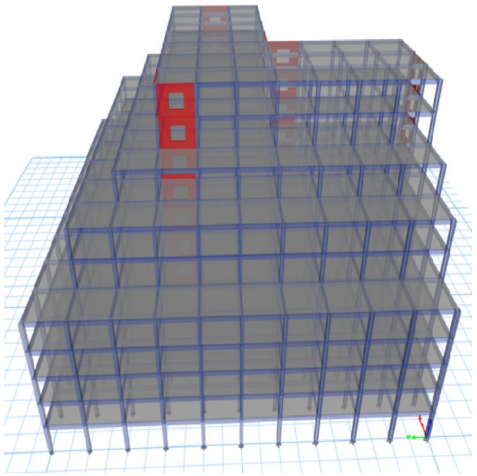

Figure 1.6 L-Shape Setback Case-2 Opening in Shear wall (Opening)

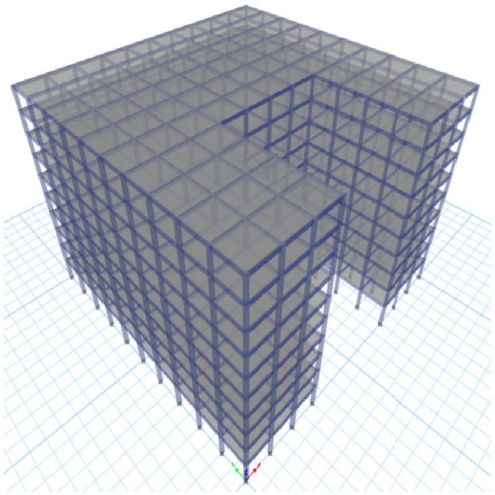

Figure 1.7 C-Shape Without Shear wall (WOTS)

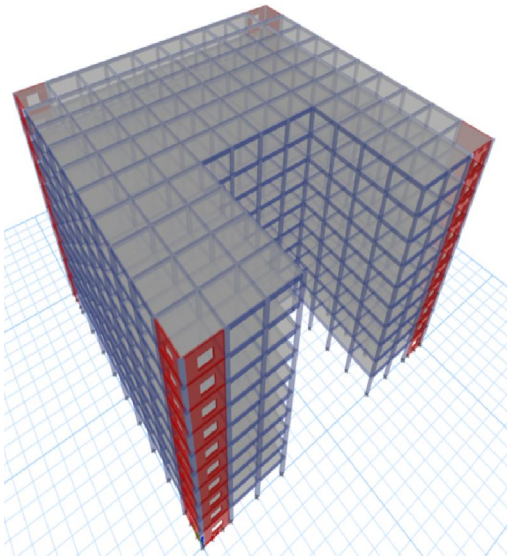

Figure 1.8 C-Shape Opening in Shear wall (Opening)

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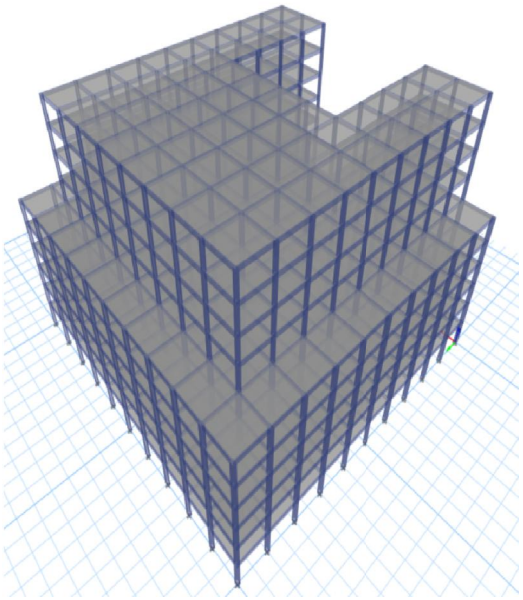

Figure 1.9 C-Shape Setback Case-1
Without Shear wall (WOTS)

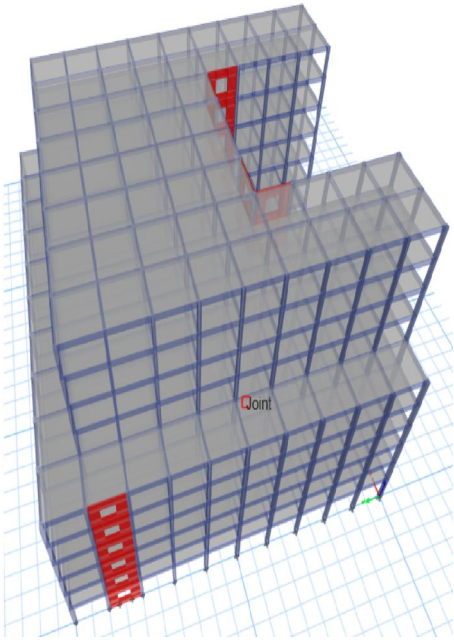

Figure 1.10 C-Shape Setback Case-1
Opening in Shear wall (Opening)

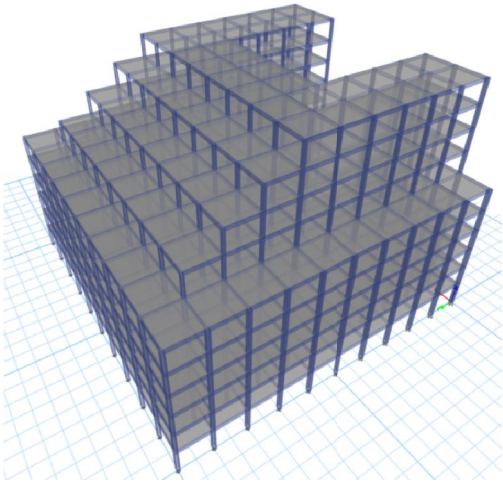

Figure 1.11 C-Shape Setback Case-2
Without Shear wall (WOTS)

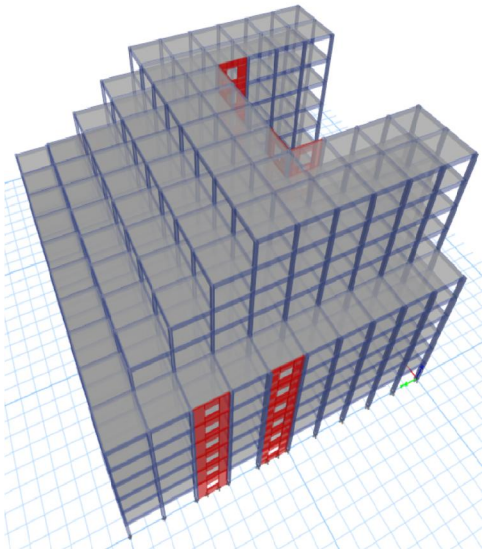

Figure 1.12 C-Shape Setback Case-2
Opening in Shear wall (Opening)

IV. RESULTS AND DISCUSSIONS

1. Maximum Displacement (mm)

According to IS: 1893:2016, the G+9 Storey without Shear Wall Models have the Maximum Storey displacement of Dynamic Load Combination. Displacement beyond the limit. According to IS: 1893:2016, the code limit is h/250. Storey model limit for earthquake code G+9 is 122mm.

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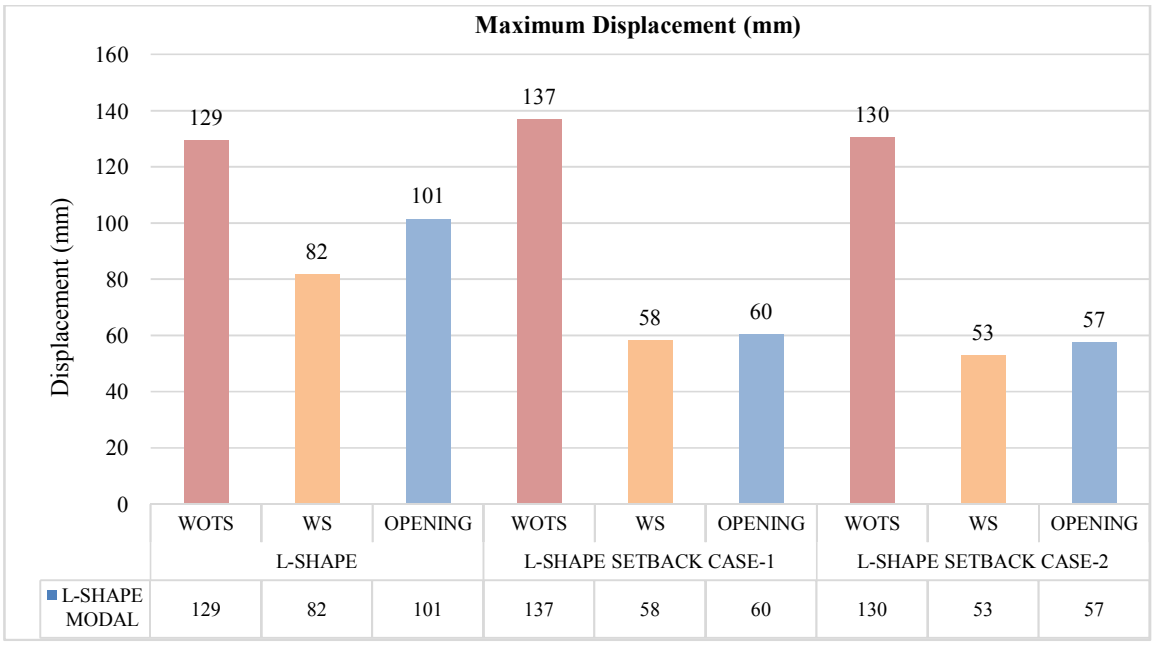

Figure1.1 Maximum Storey Displacement for L-Shape

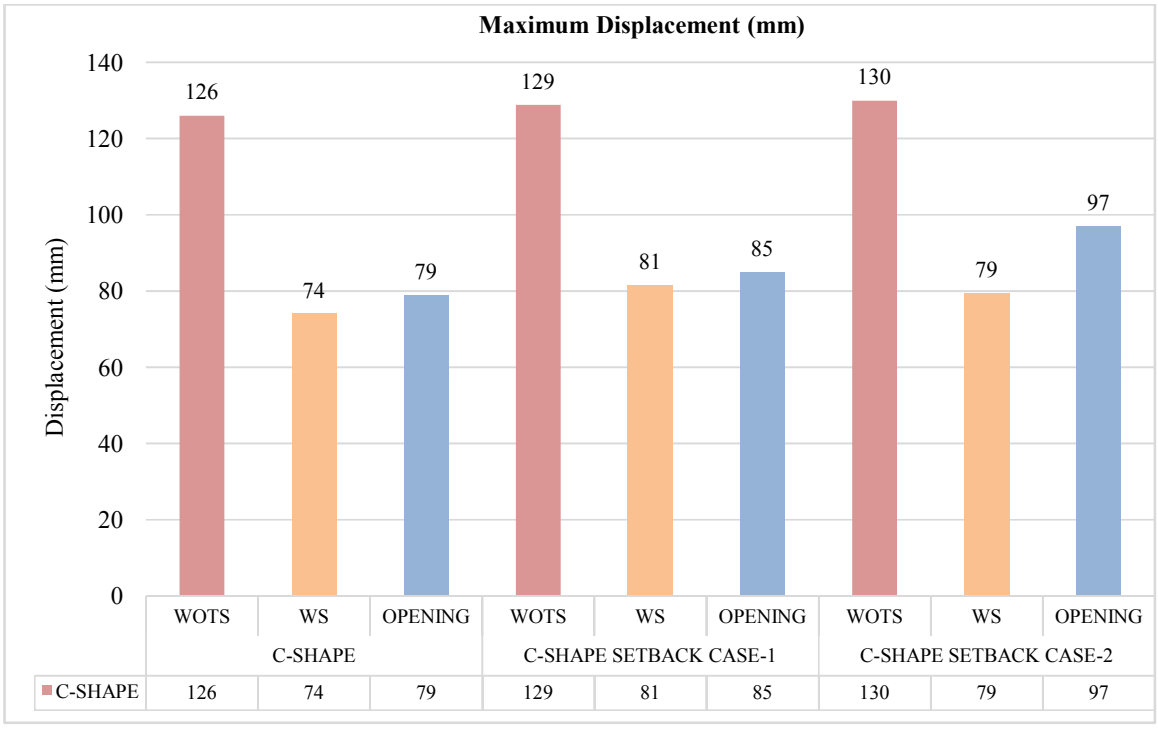

Figure1.2 Maximum Storey Displacement for C-Shape

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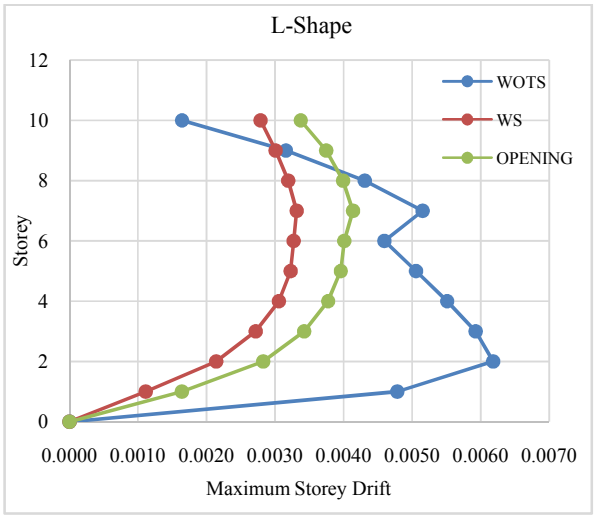
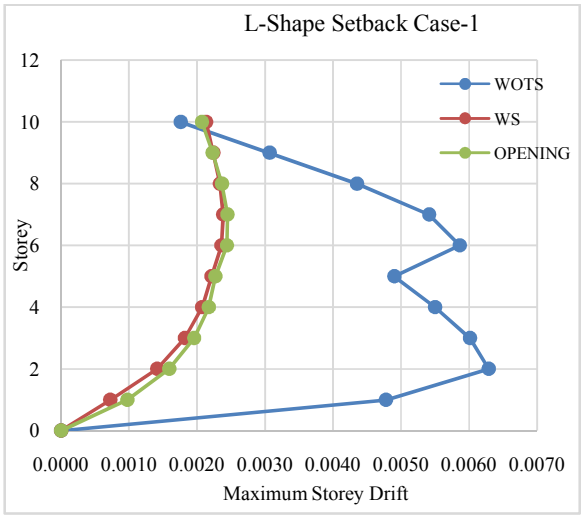
2. Storey Drift

As per Indian standard, Criteria for earthquake resistant design of structures, IS 1893(Part 1): 2016, the storey drift in any story shall not exceed 0.004 times storey height.





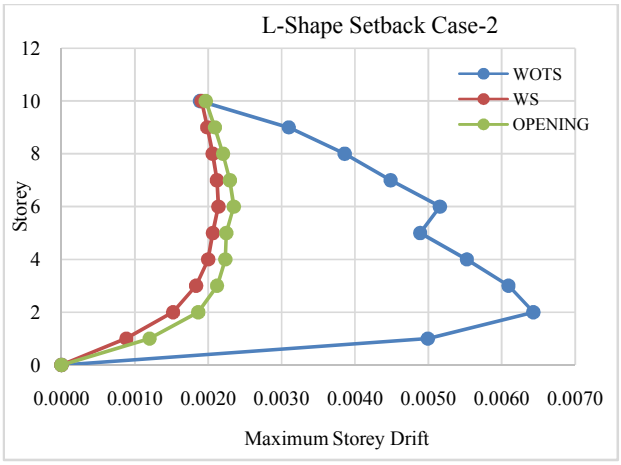
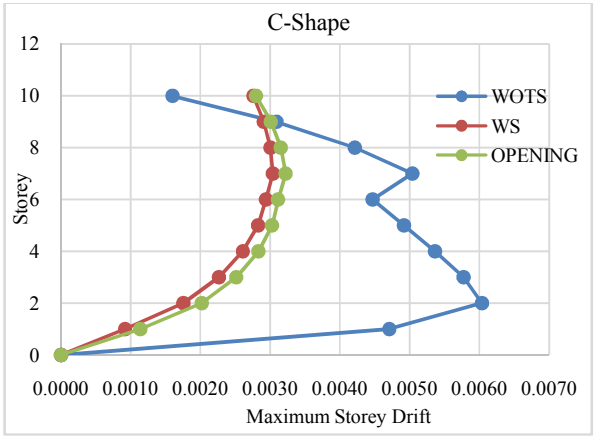
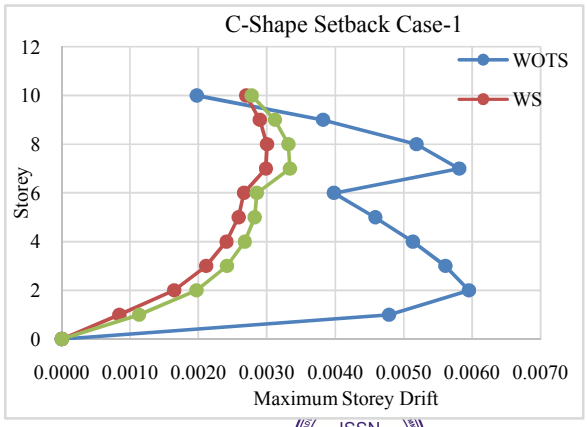


Figure1.3 Storey drift L-Shape





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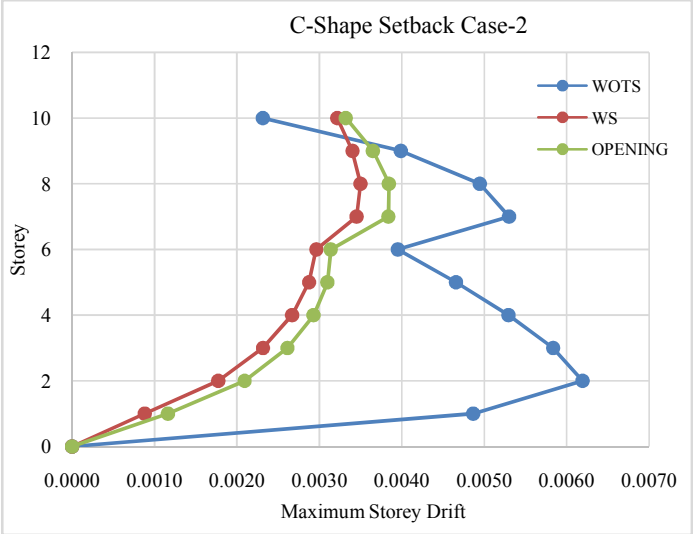

Figure1.4 Storey drift C-Shape

Torsion Ratio

The torsion irregularity As Per IS: 1893:2016 the maximum Displacement / minimum Displacement greater than 1.5 is building is Under Torsion Irregular.

Torsion Ratio									
Storey	L-SHAPE			L-SHAPE SETBACK CASE-1			L-SHAPE SETBACK CASE-2		
	WOTS	WS	OPENING	WOTS	WS	OPENING	WOTS	WS	OPENING
Storey9	1.022	1.021	1.207	1.46	1.092	1.115	1.476	1.005	1.043
Storey8	1.022	1.02	1.206	1.46	1.091	1.113	1.476	1.004	1.044
Storey7	1.022	1.019	1.205	1.458	1.09	1.111	1.481	1.003	1.051
Storey6	1.021	1.018	1.204	1.453	1.089	1.108	1.552	1.005	1.061
Storey5	1.021	1.017	1.204	1.444	1.087	1.105	1.549	1.008	1.067
Storey4	1.021	1.016	1.205	1.564	1.084	1.100	1.602	1.013	1.084
Storey3	1.02	1.015	1.207	1.557	1.077	1.088	1.600	1.022	1.101
Storey2	1.019	1.012	1.211	1.549	1.069	1.076	1.596	1.032	1.123
Storey1	1.017	1.009	1.218	1.539	1.060	1.061	1.589	1.049	1.151
G.F.	1.014	1.001	1.229	1.521	1.050	1.072	1.573	1.085	1.19

Table 3. Torsion Ratio L-Shape

Table 4. Torsion Ratio C-Shape

Torsion Ratio									
Storey	C-SHAPE			C-SHAPESETBACK CASE-1			C-SHAPE SETBACK CASE-2		
	WOTS	WS	OPENING	WOTS	WS	OPENING	WOTS	WS	OPENING
Storey9	1.008	1.001	1.035	2.001	1.049	1.037	1.995	1.001	1.168
Storey8	1.009	1.022	1.037	2.005	1.041	1.026	2.005	1.001	1.191
Storey7	1.01	1.013	1.039	2.010	1.036	1.019	2.010	1.001	1.202
Storey6	1.011	1.021	1.041	2.017	1.033	1.015	2.013	1.001	1.196
Storey5	1.011	1.015	1.043	2.019	1.034	1.016	2.009	1.001	1.177
Storey4	1.013	1.028	1.046	2.015	1.027	1.009	2.006	1.001	1.162

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Storey3	1.015	1.032	1.051	2.011	1.018	1.004	2.004	1.001	1.145
Storey2	1.018	1.041	1.057	2.008	1.009	1.01	2.002	1.001	1.125
Storey1	1.023	1.044	1.067	2.005	1.012	1.023	2.001	1.001	1.102
G.F.	1.034	1.032	1.085	2.003	1.041	1.043	1.999	1.001	1.074

Mode Shape & Time Period

As per IS: 1893:2016 The First Three modes together contribute at least 65 percent mass participation factor in each principal plan direction. And the fundamental tensional mode of oscillation shall be smaller than those of the first two translational modes along each of the principal plan direction.

Table 5. Mode Shape & Time Period L-Shape Setback Case-1

SETBACKCASE-1 (WOTS)						
Case	**Mode**	**Time Period (sec)**	**UX**	**UY**	**RZ**	**Ok/Not**
Modal	1	1.894	0.037	0.884	0.079	Ok
Modal	2	1.725	0.812	0.081	0.107	Ok
Modal	3	1.476	0.157	0.044	0.799	Ok
SETBACKCASE-1 (OPENING)						
Case	**Mode**	**Time Period (sec)**	**UX**	**UY**	**RZ**	**Ok/Not**
Modal	1	1.284	0.358	0.642	0.000	Ok
Modal	2	1.113	0.614	0.343	0.043	Ok
Modal	3	0.949	0.039	0.028	0.933	Ok

SETBACKCASE-2 (WOTS)						
Case	**Mode**	**Time Period (sec)**	**UX**	**UY**	**RZ**	**Ok/Not**
Modal	1	1.814	0.033	0.886	0.081	Ok
Modal	2	1.642	0.797	0.080	0.124	Ok
Modal	3	1.404	0.188	0.055	0.757	Ok
SETBACKCASE-2 (OPENING)						
Case	**Mode**	**Time Period (sec)**	**UX**	**UY**	**RZ**	**Ok/Not**
Modal	1	1.250	0.356	0.643	0.001	Ok
Modal	2	1.078	0.640	0.350	0.010	Ok
Modal	3	0.998	0.028	0.032	0.941	Ok

Table 7. Mode Shape & Time Period C-Shape Setback Case-1

SETBACKCASE-1 (WOTS)						
Case	**Mode**	**Time Period (sec)**	**UX**	**UY**	**RZ**	**Ok/Not**
Modal	1	1.932	0.000	1.000	0.000	Ok
Modal	2	1.779	0.841	0.000	0.159	Ok
Modal	3	1.628	0.161	0.000	0.839	Ok
SETBACKCASE-1 (OPENING)						
Case	**Mode**	**Time Period (sec)**	**UX**	**UY**	**RZ**	**Ok/Not**
Modal	1	1.334	0.994	0.000	0.006	Ok
Modal	2	1.262	0.000	1.000	0.000	Ok
Modal	3	1.247	0.008	0.000	0.991	Ok

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Table 8. Mode Shape & Time Period C-Shape Setback Case-2

SETBACKCASE-2 (WOTS)						
Case	**Mode**	**Time Period (sec)**	**UX**	**UY**	**RZ**	**Ok/Not**
Modal	1	1.790	0.000	1.000	0.000	Ok
Modal	2	1.683	0.704	0.000	0.296	Ok
Modal	3	1.428	0.331	0.000	0.669	Ok
SETBACKCASE-2 (OPENING)						
Case	**Mode**	**Time Period (sec)**	**UX**	**UY**	**RZ**	**Ok/Not**
Modal	1	1.246	0.949	0.000	0.051	Ok
Modal	2	1.071	0.000	1.000	0.000	Ok
Modal	3	0.997	0.1	0.000	0.900	Ok

V. CONCLUSION

L-Shape

- In L-Shape G+9 Storey Buildings, Irregularity Models were Increased Displacement Response by 6% to 22% Above the Allowed Limit; Therefore, By Providing Shear Wall with Opening Models, Displacement was Reduced by 12% to 39% Below the Allowed Limit.
- Torsion Ratio in an L-shaped building with a G+9 storey irregularity model were increased by 10% to 16%, which exceeds the limit, adding a Shear wall with Opening model cases can reduce the torsion ratio by up to 15% to 30% compared to case models without a shear wall.
- In L-Shape G+9 Storey model Cases Maximum drift was present 2nd and 7th Storey. Storey Drift decrees by L-Shape Shape Building by Providing a Shear wall with Opening 32% to 45% respectively.

C-Shape

- Irregularity Models in C-Shape G+9 Storey Buildings Increase Displacement Response by 9% to 25% Above the Allowed Limit; As a result, By Providing Shear Wall with Opening Models, Displacement was Reduced by 30% to 38% Below the Allowed Limit.
- Torsion ratio of the G+9 Storey C-Shape with Irregularity Cases were 20% to 25% above the limit and. And by including a Shear wall with Opening model, Torsion Ratio is 11% to 27%. Reduced when compared to models without shear walls.
- Maximum drift was present in the second, and eight storeys of the C-Shape G+9 Storey irregularity building Model Cases, Additionally, C-shaped buildings must provide a Shear wall with Opening 18% and 42% Decrees a Drift
- Shear walls play a crucial role in G+9 Storey models by increasing a building's storey stiffness and its ability to withstand lateral forces.
- In G+9Storey all model Case is L-Shape was Better Response as Compare to C-Shape and Square Shape Models.

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