Comparative Study of High-Speed Wind Effect on T-Shape Tall Building in Absence and Presence of Shear Wall

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Abstract – *As the globe progresses, urban development has led to construction of tall and super tall building across the world many high-density areas, where land is scarce and expensive, buildings of this sort are quite popular. Whenever land needs to be completely used, tall buildings are the solution. Due to the difficulty in resisting lateral pressures, such as wind forces, high-rise structures must be reinforced. Stabilizing a building in the face of multiple lateral forces is exceedingly challenging task. In this paper, by the means of comparative analysis the change in values of story drift and displacement in absence and presence of shear wall in the structure for the wind forces is shown using ETABS 19 software and IS 875 (Part 3)- 2015. Also with the help of graphical representation the entire study was done in global X and Y direction for particular stories of the building.*

Keywords: *Plan irregularity, shear wall, wind load, ETABS 19*

1. INTRODUCTION

Horizontal inertia forces are created within a structure whenever it is exposed to unstable excitation. These forces are believed to act through the structure's centre of mass (C.M). These forces are resisted by the structure's vertical elements, and the sum of these systems of forces acts through a location known as the centre of stiffness (C.S).When the centre of mass and the centre of stiffness do not coincide, eccentricities occur in the structures, causing torsion. Plan irregularity is further split into re-entrant corners, floor slabs with excessive cutouts or openings, vertical offsets out of plane, non-parallel lateral force system, and so on, are all examples of plan irregularity. Vertical irregularities, on the other hand, are further classified into Stiffness Irregularity, Mass Irregularity, Vertical Geometric Irregularity. It's crucial for structural engineers to analyse loads operating on a structure rationally and effectively, including wind load during design.

There are a variety of T-type buildings that have plan anomalies. In recent years, high-rise constructions have become an essential element of the construction industry. Construction technological advances have led to the transformation of classic rectangular sky scrapers into unusually shaped towers. High-rise buildings face the same vertical pressures as conventional structures, but the lateral loads caused by wind and earthquakes have a higher influence. Due to their high cost, wind tunnel studies are no longer widely utilised to predict wind loads on buildings. A more cost-effective alternative to wind analysis has been developed and is widely used in the building industry. High-rise structures are affected by both longitudinal and transverse wind forces.

Followings are the few types of plan irregularities:

Fig. -a : Plan Irregularity

Shear walls are structural panels that are capable of withstanding lateral pressures occurring on them Forces parallel to the wall's plane are known as lateral forces. Wind and other dynamic loadings are common examples. Side pressure might result in toppling of parallel structural panels, if perpendicular shear walls aren't holding them upright.

2. METHODOLOGY

In this method, the Tabular and graphical representation of the structures has been shown in which certain parameters has been consider. Parameters which are considered are Story displacement and Story Drift. These parameters are to be calculated using ETABS Software, and the data obtained by the execution of loadings in the software. The analysis is been done on the cladded structure.

Structure considered for graphical representation is T shape buildings having absence and presence of shear walls. It is called T shape since the shape of the building's plan is like alphabet "T". Wind is blowing in the X-direction in each case and it's velocity is considered as 50 m/sec. And the result to be shown in Global X and Global Y direction. Graph isplotted between Story Height and it's respective parameters. For eg. Story height vs Story displacement (or) Story drift. Here the comparison has been done by considering the maximum output of the particular condtion.

3. MODELLING :

3.1 Description of Stucture :

S. No	Structure Part	Dimension
1	Locality	East Coast of India
2	Kind of Building	Residential G+30
3	Kind of Structure	T Shape RC Tall Building
4	Span in X-Direction	40m
5	Span in Y – Direction	35m
6	No. of bays in X-Direction	8 Nos.@ 4m
7	No. of bays in Y-Direction	7 Nos. @ 4m
8	Story to Story Height	3m
9	Complete height of building	90m
10	Slab Thickness	140mm
11	Size of column	600*600mm
12	Beam	300*600mm

Table -1:

Table -2:

S. No	Material	Grade
1	Concrete	M 30
2	Steel Section (I-Shape)	Fe 250
3	Rebar	HYSD 500
4	Density of Steel	7850 kg/m cube
5	Youngs Modulus (E)	2.1 X 10^5 N/mm^2
6	Shear Modulus	80000 N/mm^2
7	Poisson's Ratio	0.3

S No.	Parameters	Value
1	Basic Wind speed	50 m/ sec
2	Risk Co-efficient (K1)	1.0 (Clause 6.3.1)
3	Terrain Category (K2)	1.2344 Category 2 (Clause 6.3.2)
4	Topography factor (K3)	1 (Clause 6.3.3)
5	Importance Factor (K4)	1.0
6	Wind directionality factor (Kd)	1
7	Area averaging factor (Ka)	0.8
8	Combination Factor (Kc)	0.9
9	Class of Building	Class-B
10	Windward Co-efficient	0.8
11	Leeward Co-efficient	0.5
12	External Pressure coefficient (Cpe)	0.8
13	Internal Pressure coefficient (Cpi)	0.5

Table -3:

3.2 Models:

In Fig.1 and Fig. 2 Building of T-shape in presence of Shear wall has been shown, here the shear wall is installed at each corner of the building. And the wind is blowing

towards X – Direction. Here total no of bays are 8 and total no of bays in Y direction are 7.

The height of building is taken to be 90 m and the length of projection is within 15 to 20% range as per codal provision of IS 4326 -1993 given in clause 4.4.4 in order to make the structure irregular.

Plan and 3-D view of building having shear wall:

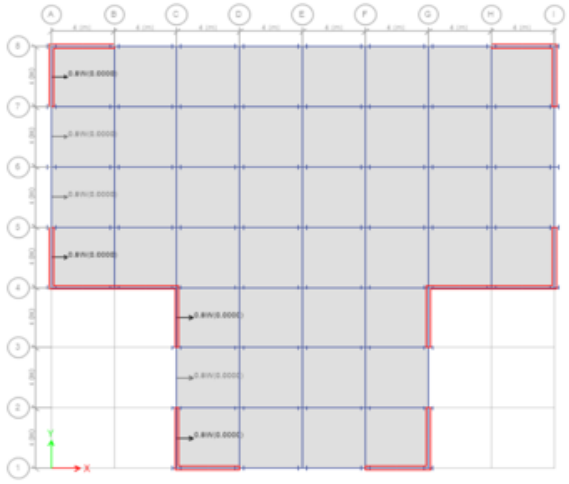

Fig.- 1 Plan view

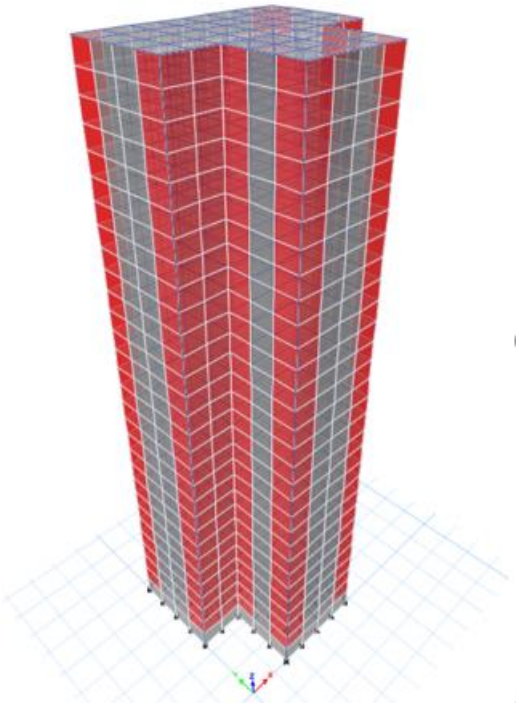

Fig.-2 Three dimensional View

In Fig. 3 and Fig. 4 Building of T-shape in absence of shear wall is shown, it is the simple type of irregular structure here as well the wind is blowing in X direction total no. of bays in X and Y direction is 8 and 7 respectively the height of building is 90m and the projection is within 15 to 20% range.

Plan and 3-D view of building not having shear wall:

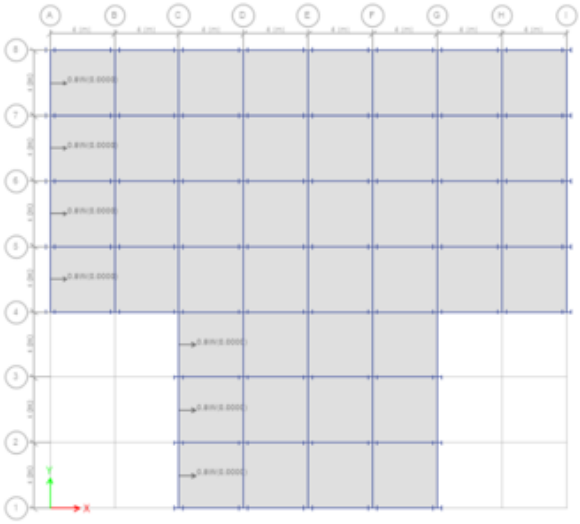

Fig.- 3 Plan view

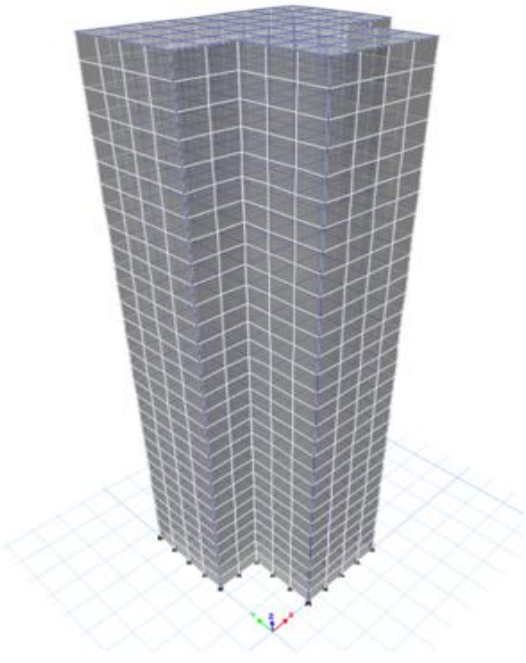

Fig. -4 Three dimensional view

4. ANALYSIS :

4.1 Drift in X-direction in absence and presence of shear wall :

In Chart 1 the value of maximum drift is occurring for the second and third load combination i.e Comb 2 and Comb 3 Whereas, in Chart 2 the value is comparatively less. And here the maximum value of drift comes for the second load combination. Hence, in the presence of shear wall, drifts comes out to be less. And the value is within permissible limits i.e. 0.012 .

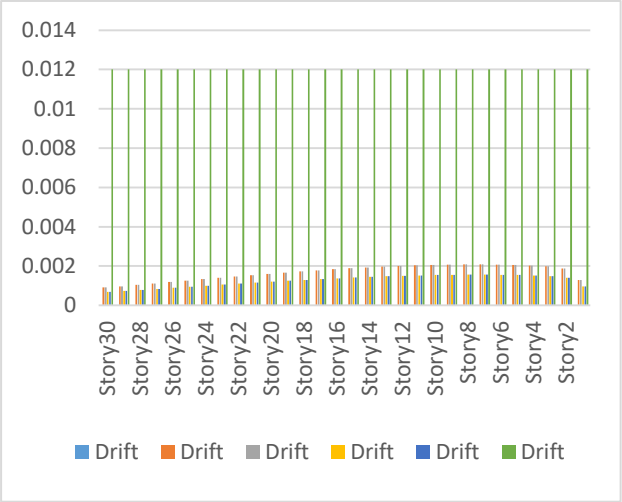

Chart – 1: Drift in X-direction in absence of shear wall

The maximum value of story drift comes out to be 0.002072 for the building not having shear wall and that is for Storey 30. Also it can be refer that, for the building having shear wall, the maximum value of story drift comes out to be 0.000714 and that is for Storey 30.

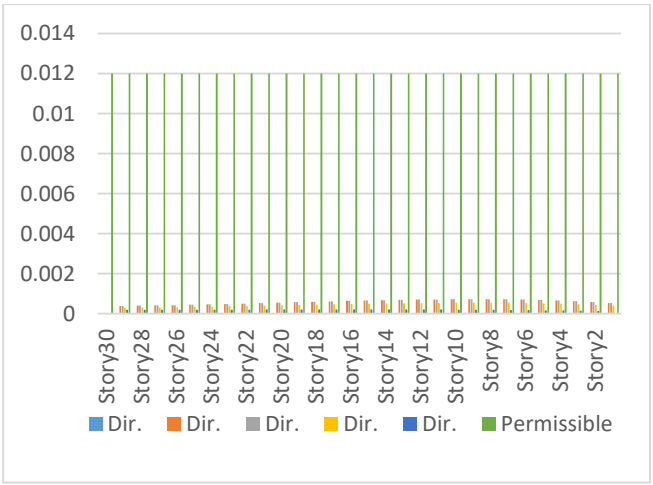

Chart – 2: Drift in X-direction in presence of shear wall

4.2 Displacement in X-direction for absence and presence of shear wall:

In Chart 3 it can be seen that, the value of maximum value of story displacement is occurring for the second and third load combination i.e Comb 2 and Comb 3 Whereas, in Chart 4 the value here also is comparatively less. And here the maximum value of displacement comes for load combination. Hence, in the presence of shear wall, displacements comes out to be less. And the value is within permissible limit i.e. 360 mm.

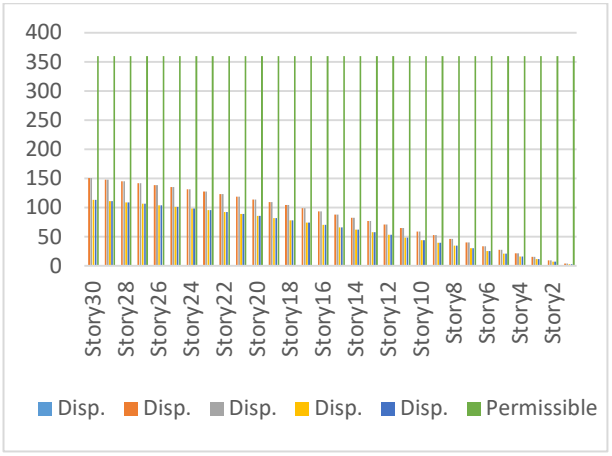

Chart – 3: Displacement in X-dir. In absence of shear wall

From graph it can be refer that, the maximum value of story displacement comes out to be 150.776 mm for the building not having shear wall and that is for Storey 30. Also from table it can be refer that, for the building having shear wall, the maximum value of story displacement comes out to be 97.477 mm and that is for Storey 30.

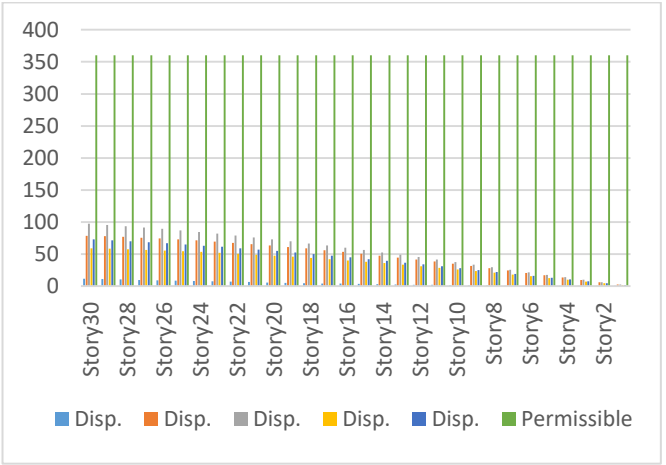

Chart -4: Displacement in X-dir. In presence of shear wall

4.3 Drift in Y direction for absence and presence of shear wall

In chart 5 the value of maximum drift is occurring for the second and third load combination i.e Comb 2 and Comb 3 But here the max value is coming for the presence of shear wall condition. Whereas, in chart 6 the value is comparatively more . And here the maximum value of drift comes for the second load combination and third load combination. Hence, in the case of wind effect in Y direction the absence of shear wall plays a key role, here drifts comes out to be less in absence of shear wall. And the value is within permissible limits for each conditions, i.e. 0.012 .

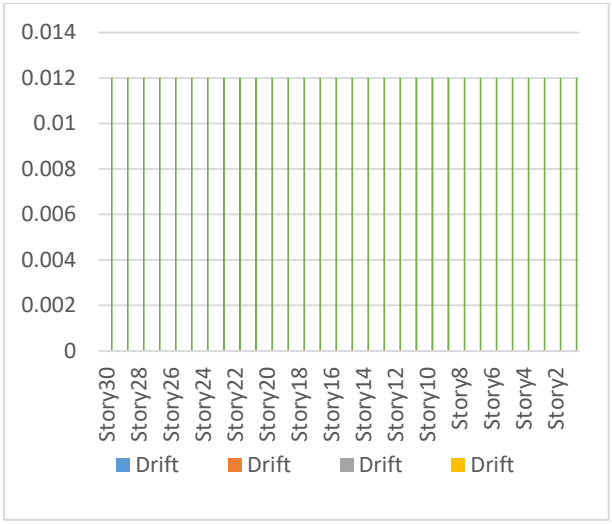

Chart -5: Drift in Y-direction in absence of shear wall

From graph it can be refer that, the maximum value of story drift comes out to be 0.00012 for the building not having shear wall and that is for Storey 30. Also from table it can be refer that, for the building having shear wall, the maximum value of story drift comes out to be 0.000275 and that is for Storey 17 and storey 16

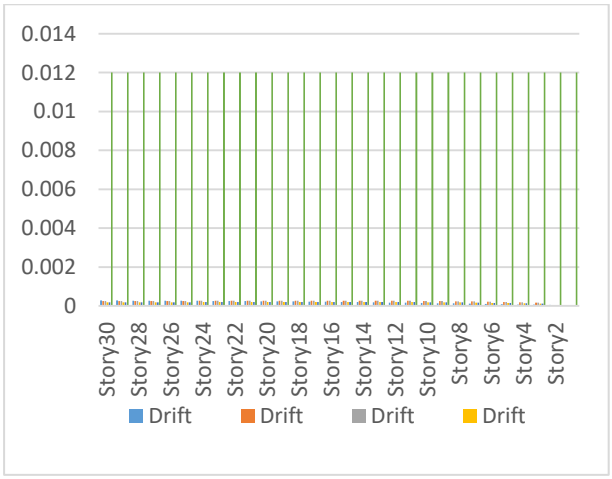

Chart -6: Drift in Y-direction in absence of shear wall

4.4 Displacement in Y direction for absence and presence of shear wall

In chart 7 it can be seen that, the value of maximum value of story displacement is occurring for the second and third load combination i.e Comb 2 and Comb 3 Whereas, in Chart 8 the value here also is comparatively less. And here the maximum value of displacement comes for First load combination. Hence, in the presence of shear wall, displacements comes out to be less. And the value is within permissible limits i.e. 360 mm.

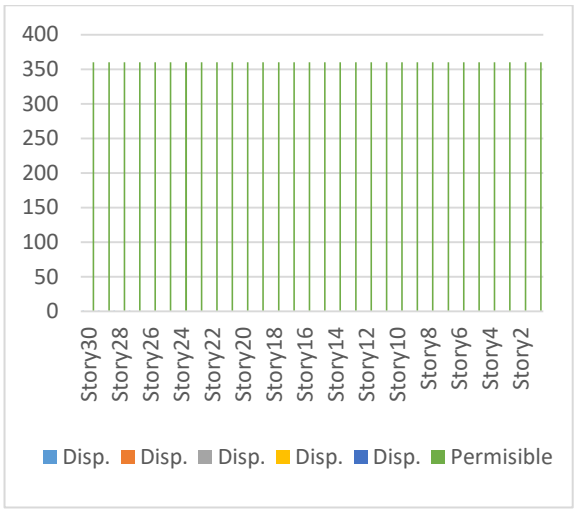

Chart – 7: Displacement in Y-dir. in absence of shear wall

From table it can be refer that, the maximum value of story displacement comes out to be 0.0661 mm for the building not having shear wall and that is for Storey 30. Also from table it can be refer that, for the building having shear wall, the maximum value of story displacement comes out to be 20.804 mm and that is for Storey 30.

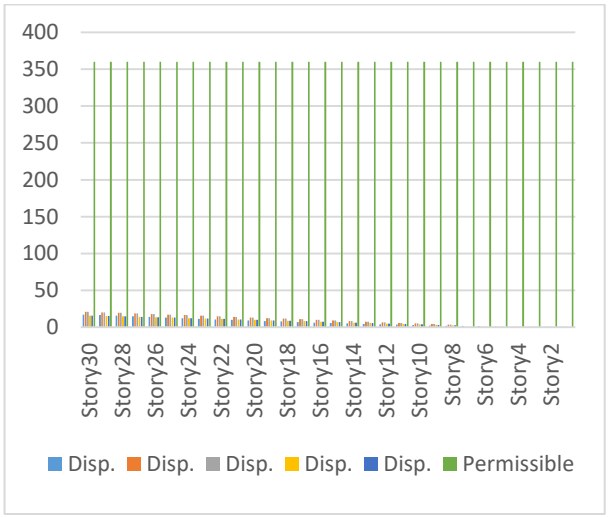

Chart – 8: Displacement in Y-dir. in absence of shear wal

5. RESULTS :

The results obtained after analysis work are depicted in tabular form are as follows

S no.	Parameters	Permissible Value	Wall Condition	Obtained Values
1 a)	Story Displacement	H/250 i.e. 360mm	Absence of Shear wall in X-direction	150.771mm
b)	Story Displacement	H/250 i.e. 360mm	Presence of Shear wall in X-direction	97.477mm
c)	Story Displacement	H/250 i.e. 360mm	Absence of Shear wall in Y-direction	0.0661 mm
d)	Story Displacement	H/250 i.e. 360mm	Presence of shear wall in Y-direction	20.804 mm
2 a)	Story drift	0.004xh i.e. 0.012	Absence of Shear wall in X-direction	0.002072
b)	Story drift	0.004xh i.e. 0.012	Presence of Shear wall in X-direction	0.000714
c)	Story drift	0.004xh i.e. 0.012	Absence of Shear wall in Y-direction	0.00012
d)	Story drift	0.004xh i.e. 0.012	Presence of shear wall in Y-direction	0.000275

Note :

Permissible value for **Story displacement** is **H/250** [where, H = Total Height of structure] as per **IS 1893 (part 1) 2016** and **Story drift** is **0.004h** [where, h = height of one storey] as per **IS 1893 (part 1) 2016** (Clause 7.11.1.1, Page no. 26 **)**

Maximum story displacement for the building having absence of shear wall in X-direction is 150.771 mm. Maximum story displacement for the building having presence of shear wall in X-direction is 97.477 mm. Maximum story displacement for the building having absence of shear wall in Y-direction is 0.0661 mm. Maximum story displacement for the building having presence of shear wall in Y-direction is 20.804 mm.

Maximum story drift for the building having absence of shear wall in X-direction is 0.002072.
Maximum story drift for the building having presence of shear wall in X-direction is 0.000714.
Maximum story drift for the building having absence of shear wall in Y-direction is 0.00012.
Maximum story drift for the building having absence of shear wall in Y-direction is 0.000275**.**

6. CONCLUSIONS :

In X direction the story drift and story displacement is maximum for absence of shear wall. And in Y direction the story drift and story displacement is maximum for presence of shear wall. Hence, Provision of shear wall in X direction of the building will reduce the wind effect and provision of shear wall in Y direction of the building will not reduce the wind effect.

Also, it has been observe that in X direction maximum story drift in absence of shear wall is 65.54% more than that in presence of shear wall. And Story displacement is 35.35% more than that in presence of shear wall.In case of Y direction maximum story drift in presence of shear wall is 56.36 % more than that in absence of shear wall. And Story displacement is 99.68 % more than that in presence of shear wall

By performing the study it has also been observed that shear wall is not necessary in every corner. So, provision of shear wall where the effect is more will obviously makes the structure durable, but on the other hand the removal of shear wall in unnecessary region will also be beneficial, plus it will be economically better as compare to the building having shear wall at every corner. Hence, it is beneficial to construct a building of T -type plan of this dimensions, having both absence in some region (Y-direction of plan) plus of course presence of shear wall i.e. X-direction in this case.

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