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### Impact of Vertical and Horizontal Shape Modification on Tall Structure Subjected to Dynamic Wind Load

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**ABSTRACT:** In modern scenario rapidly, increasing population resulted in scarcity of land. High-rise buildings are solution of this inevitable problem for providing accommodation to large amount of people in significantly less amount of land on affordable price. Skyscraper structures are more revered to twist powers at higher height focuses. At these points static analysis fails to give satisfactory results. To defeat these different nations incorporated the arrangement of Gust Effectiveness Method which considers the unique properties of construction, wind structure connection and afterward decides the breeze load as comparable to static burdens. In present work, research papers on dynamic behaviour of wind and Gust Effectiveness Method has been studied and conclusions are made. The effect of vertical and horizontal shape modification, plan ratio and aspect ratio with different terrain categories has also been studied.

**KEYWORDS:** Tall buildings, Gust load, Dynamic method, IS: 875 (part-3), Horizontal shape modification, Vertical shape modification, Max storey displacement, ETABS.

#### I. INTRODUCTION

Wind is a complicated peculiarity because of its stream circumstances coming about because of the connection of wind with structure. This rise concerns of structural engineers all around glob, because of dynamic properties of wind due to its changing effect with time. Techniques are evolved over the time for tall structures to accommodate wind forces. Wind load on tall structures has great significant as compared to other forces acting on tall structure. In a typical tall structure, oscillation due to wind has been observed in along wind & cross wind directions as well as in trosional mode. The tension variances on windward and leeward faces results in the along wind movements and by and large follows changes in the methodology stream. Most global codes and principles use the blast adequacy strategy in view of semi consistent hypothesis to anticipate the along wind reaction. The capabilities in isolating shear layers bringing about the cross-breeze movement of tall thin designs. The torsional movement is because of the lopsidedness in the immediate tension circulation of each face of the structure. The study presented here discuss the effect of wind on structure by using Gust Effectiveness Method by using different vertical(setback) and horizontal shape (square, octagon, dodecagon, hexadecagon) modifications. For this purpose, research paper of different authors has been studied and results are analyzed by considering the effect of shape, size, plan ratio and aspect ratio of tall building.



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#### **II. MODELING OF STRUCTURES**

#### **BUILDING PREMISE DIMNESIONS (G+59)**

S.No.	Particular	Square	Octagon	Dodecagon	Hexadecagon	
1.	No. of story			60		
2.	<b>Building Plan Area</b>		160	$00m^2$		
3.	No. of sides	4	8	12	16	
4.	Single Side Length	40m	18.20m	11.95m	8.92m	
5.	Building Height	210m				
6.	Projected Width	40m	43.90m	44.61m	44.84m	
7.	Setback at Storey		-	30		
8.	Setback at Height		105m (50% of	f overall height)		
9.	Setback Projection Width	28.28m	31.07m	31.54m	31.07m	
10.	Setback Plan Area	800m <sup>2</sup>				
11.	Stories Height		3.5n	n each		

#### **BUILDING PREMISE DIMNESIONS (G+39)**

S. No.	Particular	Square	Octagon	Dodecagon	Hexadecagon
1.	No. of story		4	40	
2.	Building Plan Area		160	$00m^2$	
3.	No. of sides	4	8	12	16
4.	Single Side Length	40m	18.20m	11.95m	8.92m
5.	Building Height	140m			
6.	Projected Width	40m	43.90m	44.61m	44.84m
7.	Setback at Storey		,	20	
8.	Setback at Height		70m (50% o	f total height)	
9.	Setback Projection Width	28.28m 31.07m 31.54m 31.07			31.07m
10.	Setback Plan Area	800m <sup>2</sup>			
11.	Stories Height		3.5n	n each	

#### STRUCTURAL PARAMETERS

S.No.	Particular	Square	Octagon	Dodecagon	Hexadecagon			
1.		Colu	mn Size (G+59)					
	G-G+14 (Dia.)	1100						
	G+15-G+29 (Dia.)		-	1000				
	G+30-G+44 (Dia.)			900				
	G+45-G+59 (Dia.)			800				
		Bea	m Size (G+59)					
	G-G+14, G+15-G+29		1200X60	0, 1000X600				
	G+30-G+44, G+45-G+59		900X50	0, 800X500				
2.	Length of beam	830.53	843.93	834.42	831.99			
3.		Colu	mn Size (G+39)					
	G-G+9 (Dia.)		-	1100				
	G+10-G+19 (Dia.)			1000				
	G+20-G+29 (Dia.)			900				
	G+30-G+39 (Dia.)			800				
		Bea	m Size (G+39)					
	G-G+9, G+10-G+19		1200X60	0, 1000X600				
	G+20-G+29, G+30-G+39		900X50	0, 800X500				
4.	Length of beam	459.57	478.97	474.37	465.56			
5.	Slab Thickness		150r	nm thick				
6.	Shear Wall Thickness		250r	nm thick				
7.	Shear Wall Length		33	3.12m				



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8.	Partition Wall Density	20 KN/cu.m.
9.	Column-Foundation Joint	Fixed At Base

MATERIAL PROPERTIES								
S.No.	Property	Unit	Concrete	Rebar				
1	Designation	-	M-40	HYSD-500				
2	Yield Strength	N/mm <sup>2</sup>	500	-				
3	Compressive Strength	N/mm <sup>2</sup>	-	40				
4	Unit Weight	KN/mm <sup>3</sup>	76.9729	25				
5	Modulus of Elasticity	Mpa	200000	31622.78				





SQUARE shaped Tall Building (G+39, G+59)

OCTAGON shaped Tall Building (G+39, G+59)





SQUARE SETBACK shaped Tall Building (G+39, G+59)



#### OCTAGON SETBACK shaped Tall Building (G+39, G+59)



DODECAGON shaped Tall Building (G+39, G+59) HEXADECAGON shaped Tall Building (G+39, G+59)



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#### DODECAGON SETBACK shaped Tall Building (G+39, G+59)



Hexadecagon Setback shaped Tall Building (G+39, G+59)

**III. PARAMETER'S EVALUATION** 

	Parameters		Exposure	Square	Octagon	Dodecagon	Hexadecagon
		Open	G+59	0.6222	0.6207	0.6205	0.6204
	BACKGROUN D RESPONSE	Open	G+59 (Setback)	0.6241	0.6231	0.6229	0.6228
	FACTOR	Rough	G+59	0.5756	0.5741	0.5738	0.5737
			G+59 (Setback)	0.5776	0.5765	0.5763	0.5762
	SECOND	Onen	G+59	0.0971	0.0969	0.0969	0.0969
+59	ORDER TURBULANC E INTENSITY FACTOR	open	G+59 (Setback)	0.0972	0.0971	0.0971	0.0971
		Rough	G+59	0.2906	0.2902	0.2901	0.2901
U		8	G+59 (Setback)	0.2911	0.2908	0.2907	0.2907
		Open	G+59	0.0883	0.0789	0.0775	0.077
	SIZE	open	G+59 (Setback)	0.1054	0.0951	0.0935	0.0929
	FACTOR	Dough	G+59	0.0487	0.0428	0.0419	0.0416
		Kough	G+59 (Setback)	0.0599	0.0531	0.052	0.0517
	EFFECTIVE	Open	G+59	1.1471	1.2024	1.2114	1.2145
F	FREQUENCY		G+59 (Setback)	1.0597	1.1108	1.1192	1.122

#### **GUST FORCE PARAMETERS (G+59)**



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		Rough	G+59	1.4421	1.5116	1.5229	1.5268
		nougn	G+59 (Setback)	1.3323	1.3965	1.407	1.4105
			G+59	0.0816	0.0791	0.0787	0.0786
	SPECTRUM OF	Open	G+59 (Setback)	0.0859	0.0833	0.0829	0.0828
	E	Dough	G+59	0.0703	0.0681	0.0678	0.0677
		Kough	G+59 (Setback)	0.074	0.0718	0.0714	0.0713
	PEAK FACTOR FOR	Open	G+59	3.7666	3.7791	3.7811	3.7818
			G+59 (Setback)	3.7456	3.7581	3.7601	3.7608
	RESONANT RESPONSE	Rough	G+59	3.7666	3.7791	3.7811	3.7818
			G+59 (Setback)	3.7456	3.7581	3.7601	3.7608
	GUST	Open	G+59	1.5949	1.5757	1.5728	1.5718
			G+59 (Setback)	1.6295	1.6086	1.6053	1.6042
	FACTOR	Rough	G+59	2.6423	2.6206	2.6173	2.6162
			G+59 (Setback)	2.6827	2.6581	2.6543	2.653

Ζ

#### **GUST FORCE PARAMETERS (G+39)**

	Parameters	Exposure		Square	Octagon	Dodecagon	Hexadecagon
			G+59	0.6828	0.68	0.6795	0.6793
	BACKGROU ND	Open	G+59 (Setback)	0.6866	0.6844	0.6841	0.684
	RESPONSE	Roug	G+59	0.6393	0.6364	0.6358	0.6357
	FACTOR	n	G+59 (Setback)	0.6433	0.6411	0.6407	0.6406
	SECOND ORDER	Open	G+59	0.1133	0.1131	0.1131	0.1131
6	TURBULAN	-	G+59 (Setback)	0.1137	0.1135	0.1135	0.1134
G+3	INTENSITY FACTOR	Roug	G+59	0.3445	0.3437	0.3435	0.3435
		n	G+59 (Setback)	0.3456	0.345	0.3449	0.3448
		Open	G+59	0.0671	0.059	0.0578	0.0574
	SIZE REDUCTIO	-	G+59 (Setback)	0.0822	0.073	0.0715	0.0711
	N FACTOR	Roug	G+59	0.0323	0.028	0.0273	0.0271
		n	G+59 (Setback)	0.0409	0.0356	0.0348	0.0346
	EFFECTIVE	Open	G+59	1.6113	1.689	1.7016	1.706



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REDUCED FREOUENC		G+59 (Setback)	1.4886	1.5604	1.5722	1.5761
Y	Roug	G+59	2.1411	2.2444	2.2612	2.267
	h	G+59 (Setback)	1.9781	2.0734	2.0891	2.0943
CDECEDIM	Open	G+59	0.0653	0.0633	0.063	0.0629
OF	Open	G+59 (Setback)	0.0688	0.0667	0.0664	0.0663
TURBULAN CE	Roug	G+59	0.0541	0.0525	0.0522	0.0521
	h	G+59 (Setback)	0.0571	0.0553	0.055	0.0549
PEAK	Open	G+59	3.8728	3.8849	3.8868	3.8875
FACTOR FOR	open	G+59 (Setback)	3.8523	3.8645	3.8664	3.8671
RESONANT	Roug	G+59	3.8728	3.8849	3.8868	3.8875
KESPUNSE	h	G+59 (Setback)	3.8523	3.8645	3.8664	3.8671
	Open	G+59	1.6267	1.61	1.6075	1.6066
GUST EFFECT	• <b>F</b> · · ·	G+59 (Setback)	1.6576	1.6388	1.6359	1.6349
FACTOR	Roug	G+59	2.9335	2.9159	2.9132	2.9123
	h	G+59 (Setback)	2.9654	2.9461	2.9431	2.9421

#### **IV. RESULTS & DISCUSSIONS**

#### MAXIMUM DYNAMIC WIND LOAD RESULTS:

#### MAXIMUM DYNAMIC GUST LOAD

	G+59		G+59	G+59		G+39		G+39	
			(SETBACK)				(SETBACK)		
	OPEN	ROUGH	OPEN	ROUGH	OPEN	ROUGH	OPEN	ROUGH	
SQUARE	427.49	304.351	385.964	218.466	405.968	281.581	363.872	201.243	
OCTAGON	397.757	284.28	358.833	203.844	378.41	263.598	338.803	188.278	
DODECAGON	235.076	168.108	212.027	120.574	223.706	155.93	200.248	111.412	
HEXADECAGON	208.234	148.945	187.808	106.779	198.178	138.171	177.387	98.6805	

In all categories maximum dynamic gust load is observed in square building while minimum dynamic gust load is observed in hexadecagon building.

#### MAXIMUM STOREY DISPLACEMENT (HORIZONTAL MODIFICATION):

MAXIMUM STOREY DISPLACEMENT (mm)							
STORY	TERRAIN	SQUARE	OCTAGON	DODECAGON	HEXADECAGON		
		_					
G+59	TC1	252	228.9	143.8	123.9		
	TC4	163.8	149.4	93.9	80.9		
G+59	TC1	238.6	214.7	136.1	118.6		
SETBACK	TC4	154.3	139.3	88.4	77		
G+39	TC1	85.7	76.7	48.9	41.9		
	TC4	54.8	49.3	31.4	26.9		
G+39	TC1	79.3	70.5	45.2	39.2		
SETBACK	TC4	49.1	43.9	28.2	24.4		



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**MAXIMUM STOREY DISPLACEMENT G+39 CATEGORY 1 & 4** 



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#### MAXIMUM STOREY DISPLACEMENT (VERTICAL MODIFICATION):.

#### PERCENTAGE OF REDUCTION IN STOREY DISPLACEMENT DUE TO SETBACK (TOP STORY)

STORY	TERRAIN	SQUARE	OCTAGON	DODECAGON	HEXADECAGON
	CATEGORY	( <b>mm</b> )	( <b>mm</b> )	( <b>mm</b> )	( <b>mm</b> )
G+59	TC1	5.62%	6.61%	5.66%	4.47%
	TC4	6.16%	7.25%	6.22%	5.06%
G+39 TC1		8.07%	8.79%	8.19%	6.89%
	TC4	11.61%	12.30%	11.35%	10.25%



#### PERCENTAGE OF REDUCTIONIN STOREY DISPLACEMENT DUE TO SETBACK IN TC-1 G+59



PERCENTAGE OF REDUCTIONIN STOREY DISPLACEMENT DUE TO SETBACK IN TC- 4 G+59



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#### PERCENTAGE OF REDUCTIONIN STOREY DISPLACEMENT DUE TO SETBACK IN TC-1 G+39



#### PERCENTAGE OF REDUCTIONIN STOREY DISPLACEMENT DUE TO SETBACK IN TC-4 G+39



#### PERCENTAGE OF REDUCTIONIN STOREY DISPLACEMENT

#### V. CONCLUSIONS

Based on structural performance under dynamic wind loading can be concluded as follows

#### CONCLUSION FOR HORIZONTAL MODIFICATIONS:

- Maximum dynamic gust load is observed at top story for structure without setback and for structure with setback maximum dynamic gust load observed at storey on which setback is assigned.
- Max. dynamic gust load is observed in square structure and minimum observed in hexadecagon structure in all categories.
- Max. dynamic gust load reduced by 6.80% to 7.60% when structure is upgraded from square to octagon.
- Max. dynamic gust load reduced by 68.90% to 69.30% when structure is upgraded from octagon to dodecagon.
- Max. dynamic gust load reduced by 12.80% to 13.00% when structure is upgraded from dodecagon to hexadecagon.
- Max. storey displacement is observed in square structure and minimum observed in hexadecagon structure in all catagories.



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- Max. story displacement reduction is observed when structure is upgraded from octagon to dodecagon while minimum story displacement is observed when structure is upgraded from square to octagon.
- Max. storey displacement of G+59story is reduced by 10.09% & 9.64% in terrain category 1 & terrain category 4 respectively when structure is upgraded from square to octagon.
- Max. storey displacement of G+59story with setback is reduced by 11.13% & 10.77% in terrain category 1 & terrain category 4 respectively when structure is upgraded from square to octagon.
- Max. storey displacement of G+39story is reduced by 11.73% & 11.16% in terrain category 1 & terrain category 4 respectively when structure is upgraded from square to octagon.
- Max. storey displacement of G+39story with setback is reduced by 12.48% & 11.85% in terrain category 1 & terrain category 4 respectively when structure is upgraded from square to octagon.
- Max. storey displacement of G+59story is reduced by 59.18% & 59.11% in terrain category 1 & terrain category 4 respectively when structure is upgraded from octagon to dodecagon.
- Max. storey displacement of G+59story with setback is reduced by 57.75% & 57.58% in terrain category 1 & terrain category 4 respectively when structure is upgraded from octagon to dodecagon.
- Max. storey displacement of G+39story is reduced by 56.85% \$57.01% in terrain category 1 & terrain category 4 respectively when structure is upgraded from octagon to dodecagon.
- Max. storey displacement of G+39story with setback is reduced by 55.97% 55.67% in terrain category 1 & terrain category 4 respectively when structure is upgraded from octagon to dodecagon.
- Max. storey displacement of G+59story is reduced by 16.06% & 16.07% in terrain category 1 & terrain category 4 respectively when structure is upgraded from dodecagon to hexadecagon.
- Maximum storey displacement of G+59story with setback is reduced by 14.76% & 14.81% in terrain category 1 & terrain category 4 respectively when structure is upgraded from dodecagon to hexadecagon.
- Maximum storey displacement of G+39story is reduced by 16.71% & 16.73% in terrain category 1 & terrain category 4 respectively when structure is upgraded from dodecagon to hexadecagon.
- Maximum storey displacement of G+39story with setback is reduced by 15.31% terrain category 1 & terrain category 4 respectively when structure is upgraded from dodecagon to hexadecagon.

#### CONCLUSION FOR HORIZONTAL MODIFICATIONS:

- Maximum story displacements reduce observed in octagon structure and minimum story displacement reduce observed in hexadecagon structure when setback is provided.
- Story displacement is reduced by 5.62%, 6.61%, 5.66%, and 4.47% when setback provided in square, octagon, dodecagon, hexadecagon respectively for G+59 structure in terrain category 1.
- Story displacement is reduced by 6.16%, 7.25%, 6.22%, and 5.06% when setback provided in square, octagon, dodecagon, hexadecagon respectively for G+59 structure in terrain category 4.
- Story displacement is reduced by 8.07%, 8.79%, 8.19%, and 6.89% when setback provided in square, octagon, dodecagon, hexadecagon respectively for G+39 structure in terrain category 1.
- Story displacement is reduced by 11.61%, 12.30%, 11.35%, and 10.25% when setback provided in square, octagon, dodecagon, hexadecagon respectively for G+39 structure in terrain category 4.

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