Scientific Journal of Impact Factor(SJIF): 3.134

e-ISSN(O): 2348-4470
p-ISSN(P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 2,Issue 5, May -2015

PARAMETRIC STUDY ON DIAGRID STRUCTURE SYSTEM FOR HIGH-RISE BUILDING

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Abstract — *The evolution of tall building structural systems based on new structural concepts with newly adopted high strength materials and construction methods have been towards "stiffness" and "lightness". Recently diagrid structural system is adopted in tall buildings due to its structural efficiency and flexibility in architectural planning. The use of diagrid structural systems for tall building design has continued to increase. This paper extends the previous studies on diagrids by further investigating more efficient diagrid configurations which require less amount of structural material to meet design requirements. Today, sustainable design to save our limited resources is one of the most important building design issues, especially for tall buildings constructed with an abundant amount of resources. Diagrid structures of various varying angle configurations are studied to determine more efficient geometric configurations of the system.*

Keywords-*Vertical angle variation, Diagrid structural system, Zone wise comparison, Displacement, Storey drift.*

I. INTRODUCTION

The rapid growths of urban population and consequent pressure on limited space have considerably influenced the residential development of city. The high cost of land, the desire to avoid a continuous urban sprawl, and the need to preserve important agricultural production have all contributed to drive residential buildings upward. As the height of building increase, the lateral load resisting system becomes more important than the structural system that resists the gravitational loads. The lateral load resisting systems that are widely used are: rigid frame, shear wall, wall-frame, braced tube system, outrigger system and tubular system.

In this paper analysis and design of 48 storey diagrid building with vertical angle variation is presented. A regular floor plan of 40 m × 40 m size is considered. ETABS software is used for modeling and analysis of structural members. Comparison of analysis results in terms of time period, top storey displacement and inter-storey drift is presented here.

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II.BUILDING CONFIGURATION

3.1 Geometry Data

Here, the general geometry data for all the models are as follows.

1. Plan dimension- 40m X 40m
2. Storey height- 3.5m
3. Number of floors- 48
4. Slab thickness- 0.120m.
5. Characteristic strength of concrete: 50N/mm^2
6. Characteristic strength of steel: 500N/mm^2

As the building is assumed as office building the live load is considered as 3 kN/m^2. The floor load is considered as 1.5 kN/m^2. This load is applied on all the slab panels for all floors. A member load of 8.4 kN/m^2 is considered on all the beams for the wall load considering the wall to be made of light weight bricks.

Here comparasion between Zone-3 & 5 is to be carried out. Data for both the zone is a s follows:

For zone-3: Assuming location – Vadodara, Wind speed-44 m/s, Terrain category-2, Structure class -B, Risk Coefficient-1, Topography factor-1, Design earthquake load is computed based on the zone factor -0.16, soil type-II, Importance factor-1, Response Reduction-5.

For zone-5: Assuming location – Bhuj, Wind speed-50 m/s, Terrain category-2, Structure class -B, Risk Coefficient-1, Topography factor-1, Design earthquake load is computed based on the zone factor -0.36, soil type-II, Importance factor-1, Response Reduction-5.

3.2 Notations of models:

Model-A & Model-D: Diagrid structure with uniform angle of 70degrees.

Model-B & Model-E: Diagrid structure with 2 different varying angles of 70 degrees and 76 degrees (from 0-24 storey 70 degree angle is taken and from 24-48 storey 76 degree angle is taken) and

Model-C & Model-F: Diagrid structure with 3 different varying angles of 70 degrees, 76 degrees and 79 degree(from 0-20 storey 70 degree angle, from 20-32 storey 76 degree angle and from 32-48 storey 79 degree angle is taken).
For zone-3 models A, B & C is taken and
For zone-5 models D, E &F is taken.
Figure below shows the Plan & Elevation of diagrid structure.

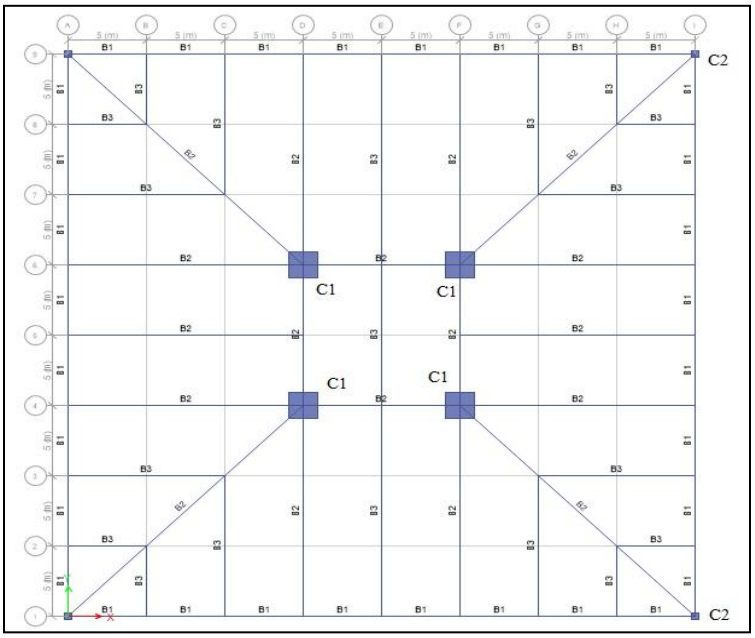
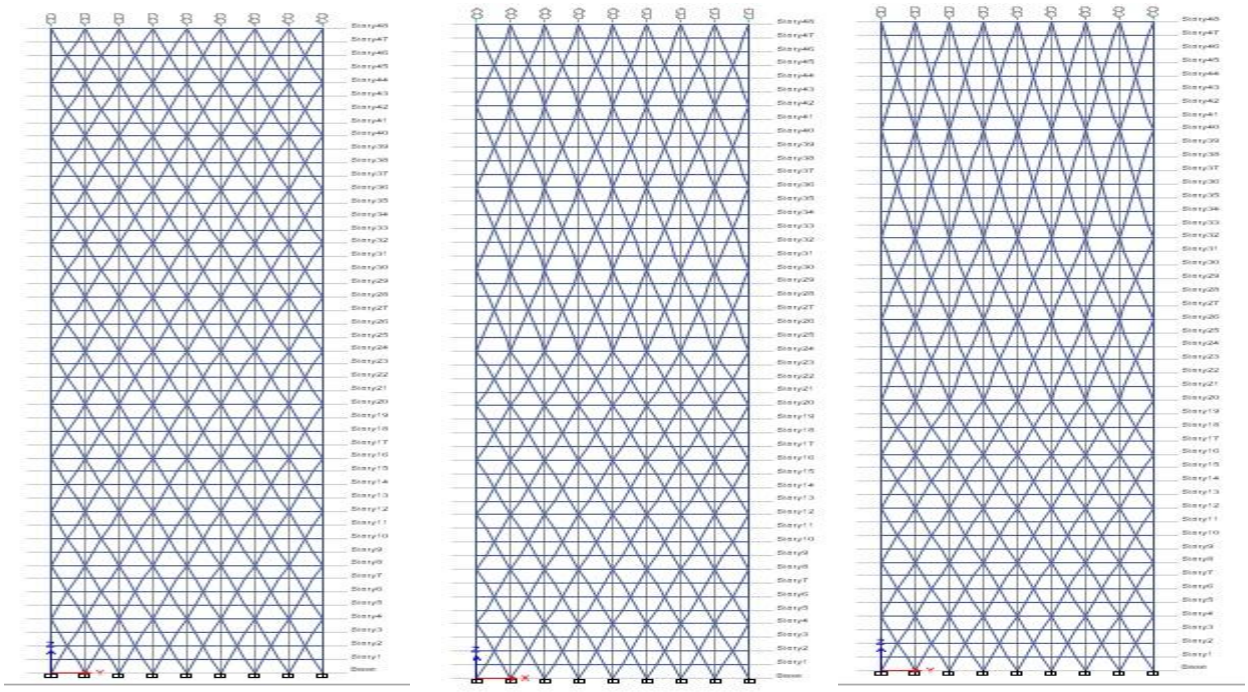


Fig1. Plan of Diagrid structure for all the cases



Model -A & D ***Model -B & E*** ***Model -C & F***

Fig2. Elevation of Diagrid structure for all models

The member sizes for both the models are preliminary decided but after analysis results and design results, the sizes are modified. Table 1 & 2 shows the member sizes for both the models.

TABLE 1 MEMBER SIZES FOR MODELS A, B & C

MEMBER	MEMBER NOS.	M-A	M-B	M-C
BEAM	B1	250 X 500	250 X 500	250 X 500
	B2	300 X 850	300 X 850	300 X 850
	B3	300 X 750	300 X 750	300 X 750
COLUMN	C1(INT.)	1900 X 1900	1900 X 1900	1900 X 1900
	C2 (EXT.)	500 X 500	500 X 500	500 X 500
DIAGRID	D1	700 X 700	700 X 700	700 X 700

TABLE 2 MEMBER SIZES FOR MODELS D, E & F

MEMBER	MEMBER NOS.	M-D	M-E	M-F
BEAM	B1	250 X 500	250 X 500	250 X 500
	B2	300 X 850	300 X 850	300 X 850
	B3	300 X 750	300 X 750	300 X 750
COLUMN	C1(INT.)	1900 X 1900	1900 X 1900	1900 X 1900
	C2 (EXT.)	500 X 500	500 X 500	500 X 500
DIAGRID	D1	700 X 700	750 X 750	750 X 750

III. ANALYSIS RESULTS

Here, static analysis results for all the models are presented here in terms of Reactions, Displacement, storey drift & Storey shear.

A. REACTION RESULTS

The summary of reactions results of gravity load and lateral loads due to earthquake and wind load for all the models is shown in table below,

TABLE 3 SUMMARIES OF REACTIONS

LOADING (KN)	TOTAL REACTION ON DIAGRID MODELS (KN)					
	M-A	M-B	M-C	M-D	M-E	M-F
GRAVITY LOAD	1053936	1072060	1050799	1053936	1072060	1071022
EQ LOAD IN X/Y DIR.	5783.09	5894	5763	13012	13262.5	13248
WL LOAD IN X/Y DIR.	13894	13894	13894	16508.1	17941.6	17941.63

B. DISPLACEMENT RESULTS

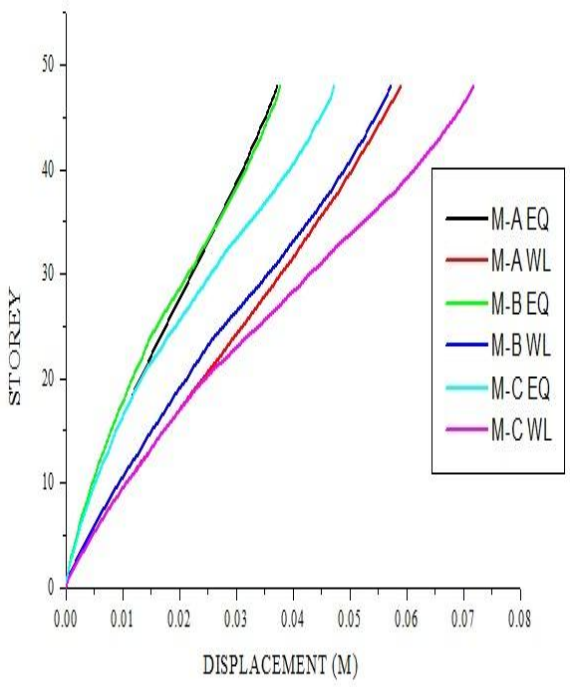
Here, displacement results for model A,B & C is shown in Table-4 & for model D,E & F is shown in table-5 for Earthquake and wind load cases. Figure shows graphical representation of displacement results for all models

TABLE 4 DISPLACEMENT RESULTS FOR MODEL A, B & C

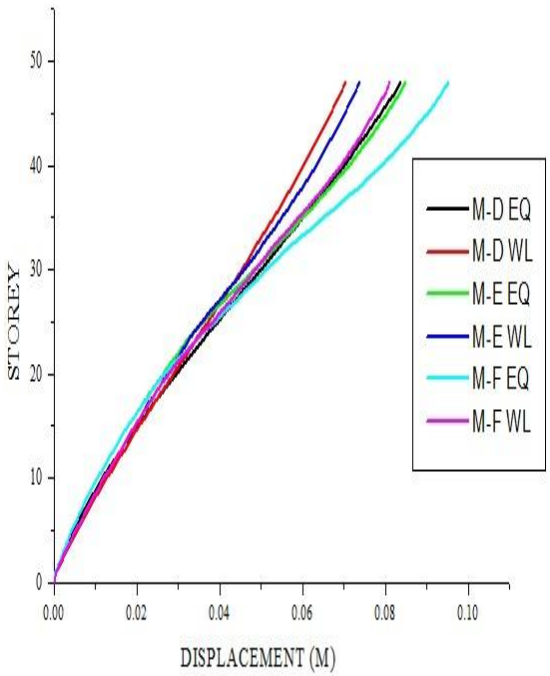
STOREY	DISPLACEMENT RESULTS FOR DIAGRID MODELS (MM)					
	M-A		M-B		M-C	
	EQ IN X/Y	WL IN X/Y	EQ IN X/Y	WL IN X/Y	EQ IN X/Y	WL IN X/Y
48	37.2	58.9	37.8	57.2	47.3	71.8
40	31.1	50.3	31.6	49	39.3	61.3
30	22.2	37.8	21.5	35.5	25.5	42.9
20	13.1	24.1	11.7	21.2	13.2	24.4
10	5.2	10.6	4.6	9.3	0.2	0.5
BASE	0	0	0	0	0	0

TABLE 5 DISPLACEMENT RESULTS FOR MODEL D, E &F

STOREY	DISPLACEMENT RESULTS FOR DIAGRID MODELS (MM)					
	M-D		M-E		M-F	
	EQ IN X/Y	WL IN X/Y	EQ IN X/Y	WL IN X/Y	EQ IN X/Y	WL IN X/Y
48	83.8	70.5	85	73.9	95.2	81.1
40	69.9	60.2	71.1	63.3	78.9	69.2
30	49.9	45.3	48.4	45.9	51.2	48.5
20	29.5	28.8	26.4	27.4	26.6	27.6
10	11.6	12.6	10.4	12	10.4	12
BASE	0	0	0	0	0	0



MODEL A, B & C



MODEL D, E & F

FIG. 3 & 4 GRAPHICAL REPRESENTATIONS OF DISPLACEMENT RESULTS FOR ALL MODELS

C. STOREY DRIFT RESULTS

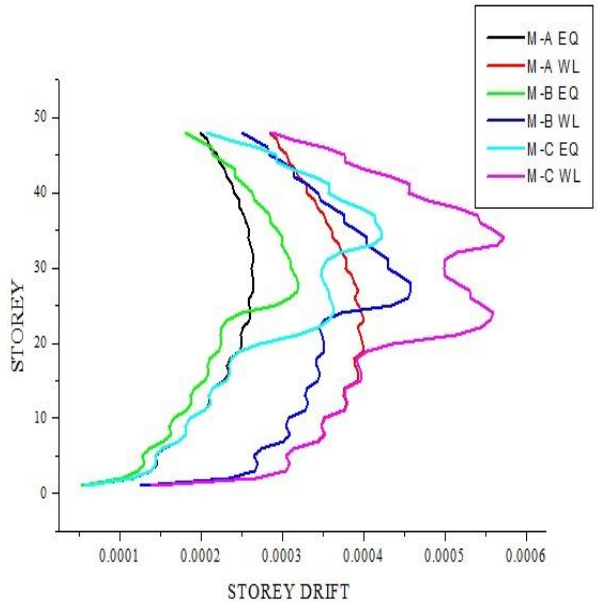
Here, storey drift results for model A,B & C is shown in Table-6 & for model D,E & F is shown in table-7 for Earthquake and wind load cases. Figure shows graphical representation of storey drift results for all models

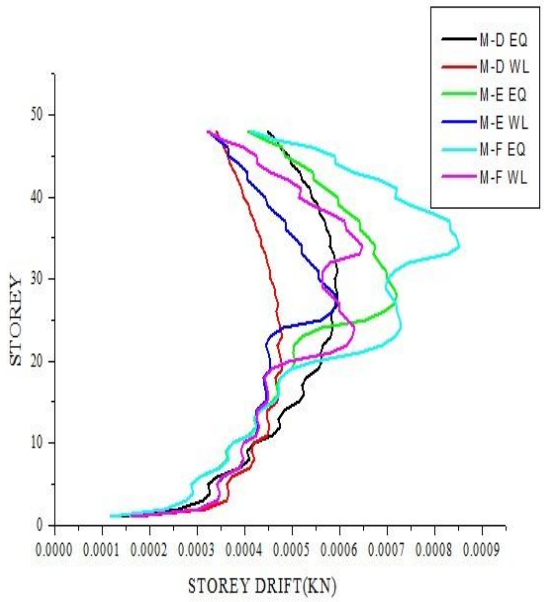
TABLE 6 STOREY DRIFT RESULTS FOR MODEL A, B & C

STOREY	STOREY DRIFT RESULTS FOR DIAGRID MODELS					
	M-A		M-B		M-C	
	EQ IN X/Y	WL IN X/Y	EQ IN X/Y	WL IN X/Y	EQ IN X/Y	WL IN X/Y
48	0.000199	0.000284	0.000181	0.00025	0.000207	0.000287
40	0.000241	0.000331	0.000264	0.000344	0.000357	0.000456
30	0.000262	0.000378	0.000311	0.000431	0.000349	0.000499
20	0.00025	0.000399	0.000225	0.000352	0.000272	0.000436
10	0.000187	0.000351	0.000167	0.000308	0.000187	0.000353
1	0.000057	0.000139	0.000053	0.000125	0.000057	0.000139

TABLE 7 STOREY DRIFT RESULTS FOR MODEL D, E & F

STOREY	STOREY DRIFT RESULTS FOR DIAGRID MODELS					
	M-A		M-B		M-C	
	EQ IN X/Y	WL IN X/Y	EQ IN X/Y	WL IN X/Y	EQ IN X/Y	WL IN X/Y
48	0.000449	0.000341	0.000407	0.000323	0.000412	0.000322
40	0.000542	0.000398	0.000595	0.000445	0.000717	0.000514
30	0.000589	0.000454	0.0007	0.000557	0.000702	0.000564
20	0.000563	0.000478	0.000507	0.000455	0.000545	0.000491
10	0.000421	0.00042	0.000376	0.000398	0.000376	0.000398
1	0.000129	0.000165	0.000118	0.000162	0.000118	0.000162





MODEL A, B & C MODEL D, E & F

FIG .5 & 6 GRAPHICAL REPRESENTATIONS OF STOREY DRIFT RESULTS FOR ALL MODELS

D. STOREY SHEAR RESULTS

Here, storey shear results for model A,B & C is shown in Table-8 & for model D,E & F is shown in table-8 for Earthquake and wind load cases. Figure shows graphical representation of storey shear results for all models

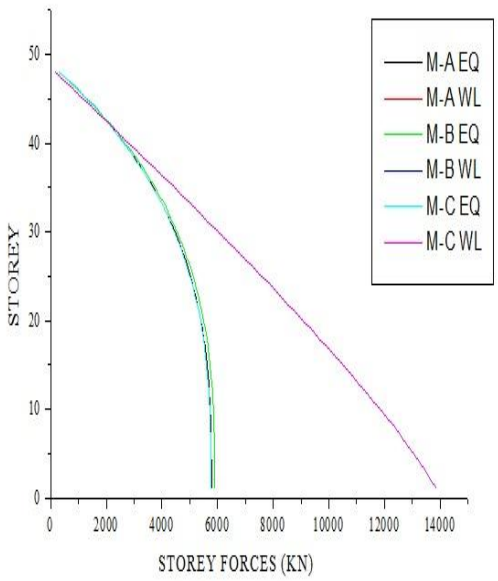
TABLE 8 STOREY SHEAR RESULTS FOR MODEL A, B & C

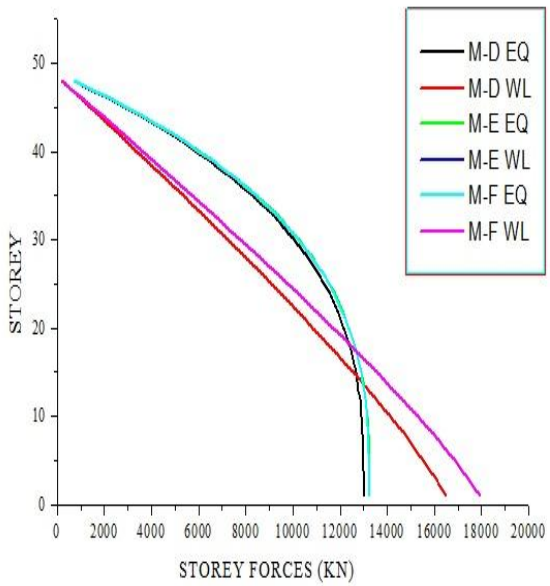
STOREY	STOREY DRIFT RESULTS FOR DIAGRID MODELS (KN)					
	M-A		M-B		M-C	
	EQ IN X/Y	WL IN X/Y	EQ IN X/Y	WL IN X/Y	EQ IN X/Y	WL IN X/Y

48	314.04	167.84	317.7	167.84	313.57	167.84
40	2638.24	2816.23	2686.01	2816.23	2627.62	2816.23
30	4473.25	6027.50	4555.84	6027.50	4455.25	6027.50
20	5404.91	9071.82	5507	9071.82	5384.6	9071.82
10	5739.46	11852.17	5894.73	11852.17	5719.9	11852.17
1	5783.1	13894	5894.44	13894	5763.6	13894

TABLE 9 STOREY SHEAR RESULTS FOR MODEL D, E & F

STOREY	STOREY DRIFT RESULTS FOR DIAGRID MODELS (KN)					
	M-D		M-E		M-F	
	EQ IN X/Y	WL IN X/Y	EQ IN X/Y	WL IN X/Y	EQ IN X/Y	WL IN X/Y
48	706.6	203.1996	714.83	216.7415	714.42	216.7415
40	5936.03	3405.372	6043.51	3636.669	6035.51	3636.669
30	10064.8	7249.446	10250.6	7783.457	10238.3	7783.457
20	12161.05	10860.1	12390.7	11714.65	12375.8	11714.65
10	12913.77	14132.47	13161.9	15304.97	13147.3	15304.97
1	13011.95	16508.11	13262.5	17941.63	13248	17941.63





MODEL A, B & C MODEL D, E & F

FIG. 7 & 8 GRAPHICAL REPRESENTATIONS OF STOREY SHEAR RESULTS FOR ALL MODELS

III. CONCLUSION

From the above analysis results considering two EQ zone it can be conclude that:

1. Considering displacement results, uniform angle is advisable for EQ & for WL 2-angle variation is advisable for Zone-3, while for Zone-5 uniform angle variation is advisable.
2. Considering storey drift results 2-angle variation is advisable for EQ & WL for Zone-3, while for Zone-5 for EQ 2- angle variation is advisable & for WL 2-angle & 3-angle variation is advisable.
3. Considering storey shear results 3-angle variation for EQ is advisable & for WL all structure is advisable for Zone-3, while for Zone-5 uniform angle variation for EQ and WL advisable Respectively.
4. Considering overall structural analysis uniform angle and 2-angle variation is advisable for Zone-3 and Zone-5.

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