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STUDY ON DIAGRID STRUCTURE OF MULTISTOREY BUILDING

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Abstract—*Construction of multi-storey building is rapidly increasing throughout the world. . Recently the diagrid structural system has been widely used for tall buildings due to the structural efficiency and aesthetic potential provided by the unique geometric configuration of the system.These days the latest trend of technology in diagrid structures is evolving. The diagrid structures are buildings with diagonal grids in the periphery at a particular angle and in modules across the height of the building. Diagrid structure uses triangulated grids which are in place of vertical columns in the periphery. Thus, systems that are more efficient in achieving stiffness against lateral loads are considered better options in designing tall buildings.*

This paper presents a stiffness-based design methodology for determining preliminary member sizes of r.c.c diagrid structures for tall buildings. A G+24, G+36,G+48,G+60 storey RCC building with plan size 18 m × 18 m located in surat wind and seismic is considered for analysis. STAAD.Pro software is used for modelling and analysis of structural members. All structural members are designed as per IS 456:2000 and load combinations of seismic forces are considered as per IS 1893(Part 1): 2002. Comparison of analysis results in terms of beam displacement, Storey Drift, Bending Moment. This cause economical design of diagrid structure compared to conventional structure.

Keywords-*Diagrid building, Diagrid Angel, STAAD.Pro, Displacement, Storey Drift, Bending Moment*

I. INTRODUCTION

The development and growth of tall buildings around the world in populated cities is increasing day by day. It is due to continuous urban sprawl, availability of more rental areas with less environmental damage, constructional cost efficiency and the need to preserve the agricultural land. Diagrid – Diagonalised grid structures is one of the emerging innovative concepts to design tall buildings. Diagrid not only gives more stiffness but also resist the lateral forces (Due to wind and seismic) and gravity load by axial action. It is a particular form of space truss consisting of perimeter grid made up of triangular structural system. Diagrid- a word formed by combination of "diagonal" and "grid" designated Diagrid as a totally new trend.

Diagrid is a particular form of space truss consisting of perimeter grid made up of series of triangular module. This module can also be of diamond shaped. The important point for a diagrid structure system is selection of material for the structure.

The materials available for the construction of diagrid are:-
1. Steel
2. Concrete
3. Timber

1.1 Diagrid System

A diagrid structure is a type of structural system consisting of diagonal grids connected through horizontal rings which create an elegant and redundant structure that is especially efficient for high-rise buildings. A diagrid structure is different from braced frame systems, since diagonals as main structural elements participate in carrying gravity load in addition to carrying lateral load due to their triangulated configuration, which eliminates the need for vertical columns. The column free structure of a diagrid system offers several advantages such as high architectural flexibility and elegancy, and enormous day lighting due to its large free surface.

1.2 Diagrid Angel

The structural design of diagrid structure is greatly influenced by the angle of diagonals. With the deviation of angle of diagonals from optimum condition, not only the required amount of steel increases significantly but also storey drift of structure, storey shear and top storey displacement changes. Therefore, it is very necessary for an Engineer to obtain the optimum angle of diagonals in diagrid structure in order to obtain a safe structural design of diagrid.

For maximum bending rigidity, the angle made by column should be 90^0 and for maximum shear rigidity, it is 35^0. It is expected that optimum angle of diagrid falls in this range. bending beams whereas short buildings with low aspect ratio behave like shear beams. Thus, it is expected that, increase in building height increases the optimal angle of diagonals.

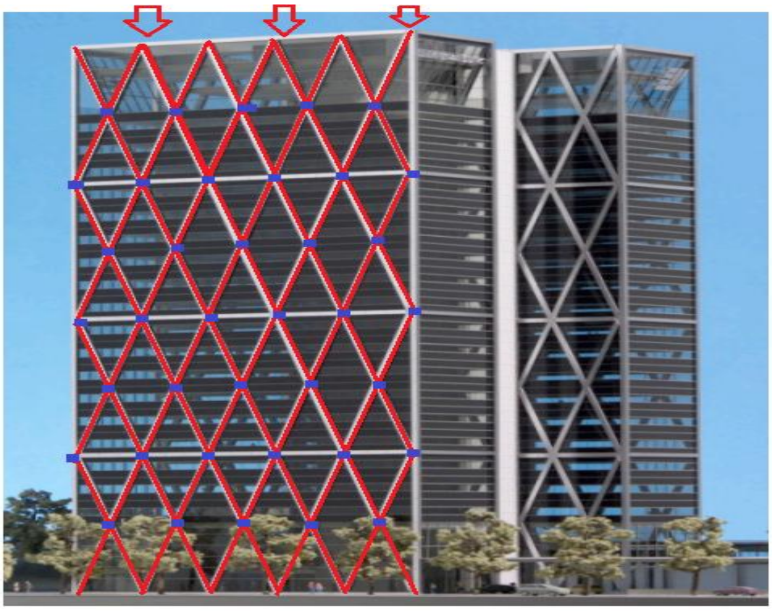


Figure 1 Show in Diagrid Structure

1.3 Objective Of Study

- The Main objective of this study is to understand the concept of diagrid structural system.
- The objective of this study is to understand the analysis and design methodology of diagrid structure using STAAD.Pro v8i ss5 software.
- To determine the various optimum angle and various storey for diagrid system.
- Analysis of building wind analysis.
- Analysis of building frames considering seismic analysis.
- Comparison between conventional building and diagrid building.

II METHODOLOGY AND DATA COLLECTION

The design methodology is applied to a set of diagrid structures G+24, G+36, G+48 and G+60 stories tall, The diagrid structure of each storey height is designed with diagonals of various uniform angles as well as diagonals of gradually changing angles over the building height in order to determine the optimal grid geometry of the structure within a certain height range. The building's typical plan dimensions are 18x 18 meters with typical storey heights of 3 meters. The structures are assumed to be in Surat.

2.1 Geometry And Structural Data

(1) Plan dimension-18x18 m
(2) Storey height-3 m
(3) Diagrid angel-57º,63º,69º,73º
(4) No. of storey- G+24, G+36, G+48 and G+60
(5) Diagrid storey module-2,3,4 and 6 storey
(6) The dead load taken -8.75 KN/m
Floor finish-2 KN/m²
(7) Live load-floor finish-2.5 KN/m²
(8) Slab thickness-200 mm
(9) Support- Pinned support
(10) Characteristic strength of concrete: 30 N/mm^2
(11) Characteristic strength of steel: 415 N/mm^2

2.2 Load Combination Of Wind And Seismic Load

(1) 1.5(DL+LL)
(2) 1.5(DL+WLX+VE) and 1.5(DL+ELX+VE)
(3) 1.5(DL-WLZ-VE) and 1.5(DL-ELZ-VE)
(4) 1.5(DL+LL+WLX+VE) and 1.5(DL+LL+ELX+VE)
(5) 1.5(DL+LL-WLZ-VE) and 1.5(DL+LL-ELZ-VE)
(6) 1.2(DL+LL-WLX-VE) and 1.2(DL+LL-ELX-VE)
(7) 1.2(DL+LL+WLZ+VE) and 1.2(DL+LL+ELZ+VE)
(8) 0.9(DL+LL+WLX+VE) and0.9(DL+LL+ELX+VE)
(9) 0.9(DL+LL-WLZ-VE)and 0.9(DL+LL-ELZ-VE)

2.3 Wind Design

Vz = vb kl k2 k3
Vz = design wind speed at any height z in m/s;
k1 = probability factor (risk coefficient)
k2 = terrain, height and structure size factor and
k3 = topography factor

2.4 Seismic Design

Ah= Z I Sa/2 R g

Z=zone factor
I= importance factor depending upon the functional use of the structures, characterized by hazardous consequences of its failure, post-earthquake functional needs, historical value, or economic importance
R= Response reduction factor, depending on the perceived seismic damage performance of the structure, characterised by ductile or brittle deformations. However, the ratio (I/R)shall not be greater than 1.0
Sa/g= Average response acceleration coefficient

Table 1 Seismic Parameters

NO	SEISMIC PARAMETERS	
1	Zone factor(zone-3)	0.16
2	Type of soil	Medium
3	Importance factor	1
4	Response reduction factor	5(SMRF)

2.5 Models Generation

There are four different story of building analyzed

(1) G+24 Storey
(2) G+36 Storey
(3) G+48 Storey
(4) G+60 Storey

And in each storey there are five types model generation

(1) 57° diagrid angel
(2) 63° diagrid angel
(3) 69° diagrid angel
(4) 73° diagrid angel
(5) Conventional building

And all these models are analyzed for wind analysis IS code 875(PART 3):1987 and seismic analysis IS 1893(part1):2002

Table 2 Storey module of diagrid angel

Storey module	Diagrid Angel	Storey			
2 Storey	57°	G+24	G+36	\ G+48	G+60
3 Storey	63°				
4 Storey	69°				
6 storey	73°				

Table 3 Preliminary sizes in mm for member G+24 Storey

Storey	Element size in mm		
G+24 Storey	Beams	Column	Diagrid
	450 X 800	750 X 750	650 X 650
	450 X 600	650 X 650	-
	300 X 600	600 X 600	-

Table 4 Preliminary sizes in mm for member G+36 Storey

Storey	Element size in mm		
G+36 Storey	Beam	Column	Diagrid
	450 X 450	800 X 800	650 X 650
	450 X 600	750 X 750	-
	300 X 600	700 X 700	-
	300 X 450	650 X 650	-
	300 X 400	600 X 600	-

Table 5 Preliminary sizes in mm for member G+48 Storey

Storey	Elements in mm		
G+48 Storey	Beam	Column	Diagrid
	450 X 800	900 X 900	650 X 650
	450 X 600	850 X 850	-
	300 X 600	800 X 800	-
	300 X 450	750 X 750	-
	300 X 400	700 X 700	-
	300 X 350	650 X 650	-

Table 6 Preliminary sizes in mm for member G+60 Storey

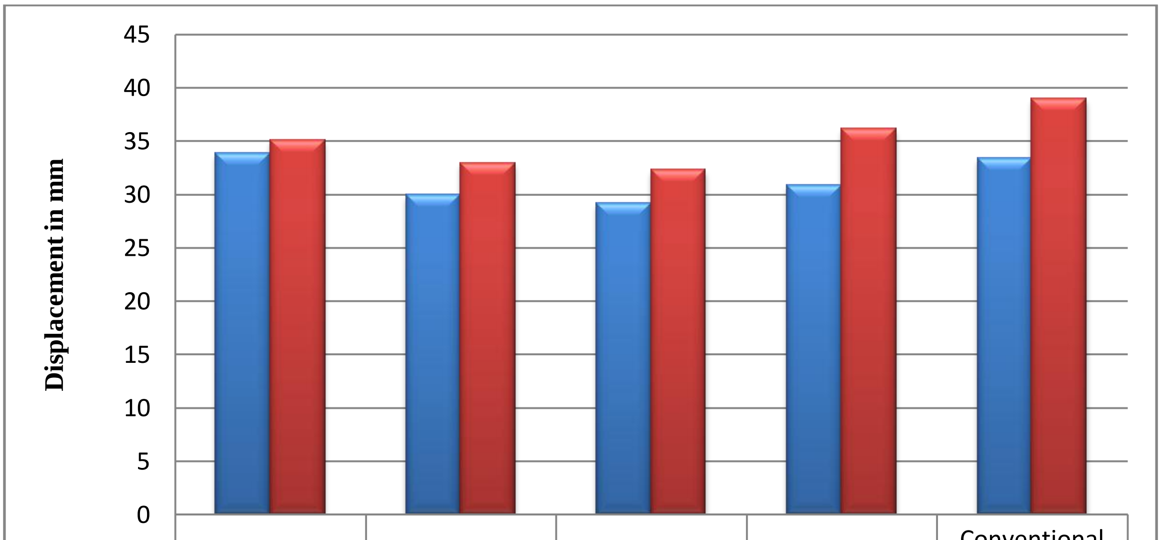
Storey	Elements in mm		
G+60 Storey	Beam	Column	Diagrid
	450 X 800	950 X 950	650 X 650
	450 X 600	900 X 900	-
	350 X 600	850 X 850	-
	300 X 600	800 X 800	-
	300 X 450	750 X 750	-
	300 X 400	700 X 700	-
	300 X 350	650 X 650	-

III RESULTS

3.1 Storey Displacement

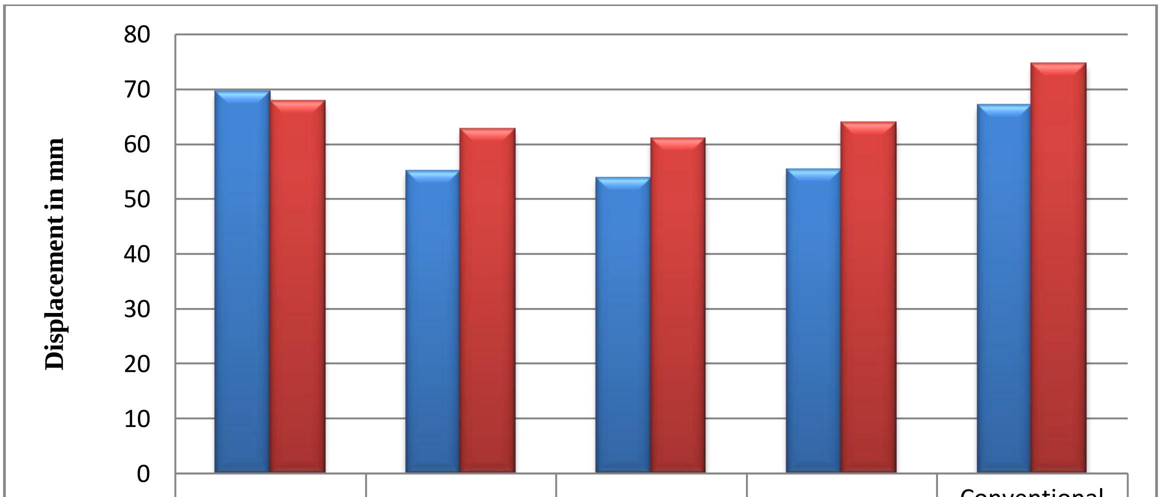
There are G+24,G+36,G+48,G+60 storey wind and seismic analysis max. displacement various diagrid angel and conventional buildingl. As per IS 456-2000 in clauses 23.2 page no. 37 permissible displacement should not exceed span/250.

A G+24 Storey



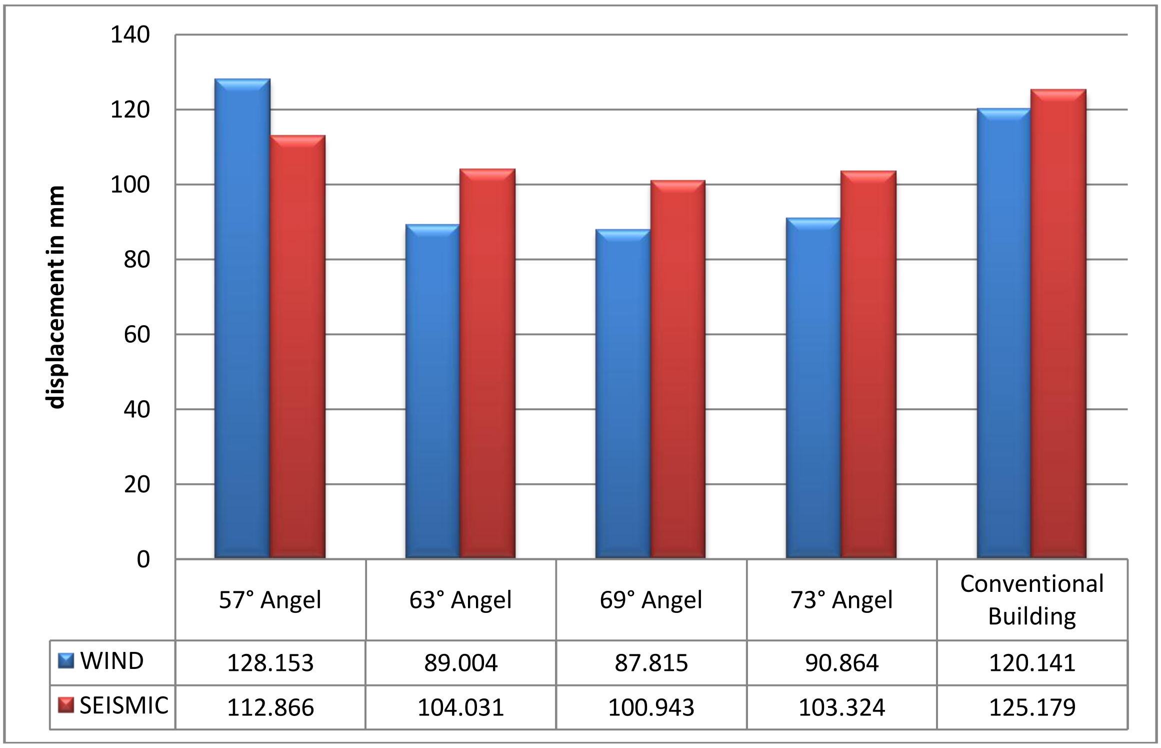
	57° Angel	63° Angel	69° Angel	73° Angel	Conventional building
WIND	33.835	29.953	29.199	30.891	33.43
SEISMIC	35.129	33.001	32.329	36.186	39.023

B G+36 Storey

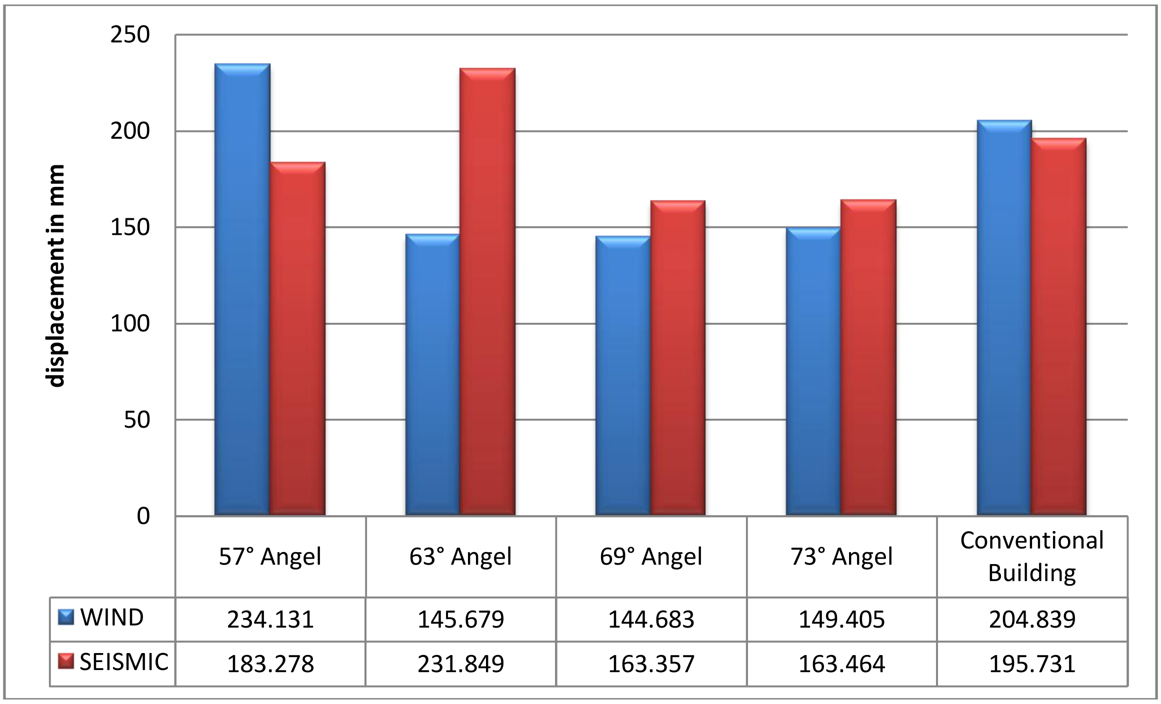


	57° Angel	63° Angel	69° Angel	73° Angel	Conventional building
WIND	69.507	55.037	53.829	55.334	67.061
SEISMIC	67.759	62.659	60.917	63.892	74.619

C G+48 Storey



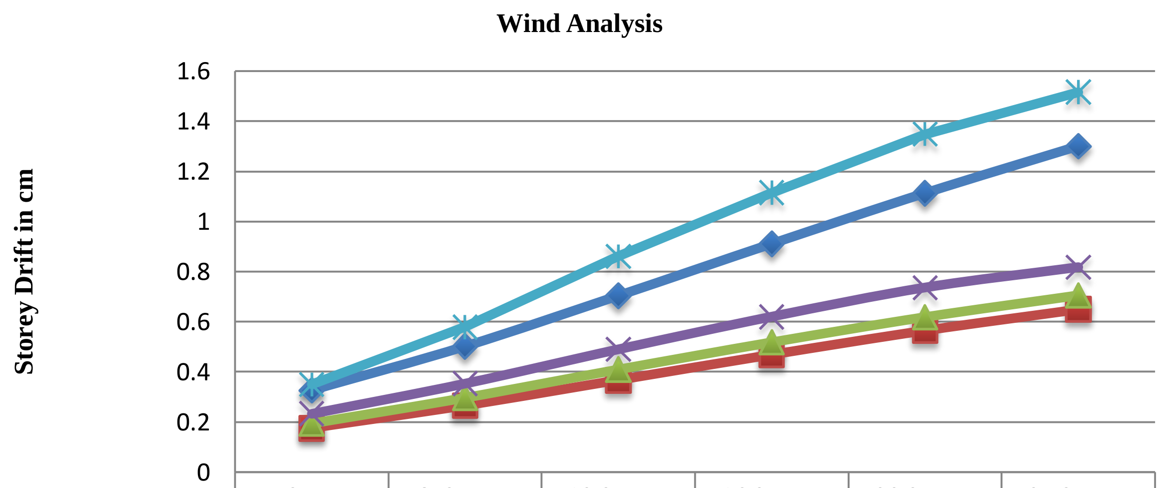
D G+60 Storey



3.2 Storey Drift

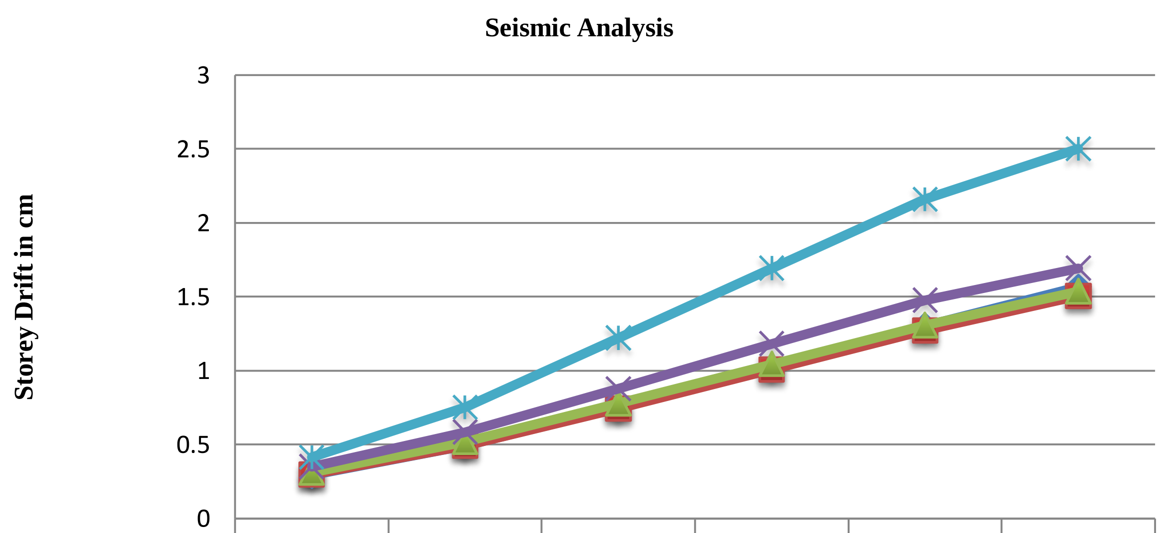
There are G+24,G+36,G+48,G+60 storey wind and seismic analysis max. displacement various diagrid angel and conventional buildingl. As per IS 1893(Part 1)-2002 in clauses 7.11.1 page no. 27 permissible Storey Drift should not exceeds 0.004 times the total height of the building.

A G+24 Storey Wind Analysis



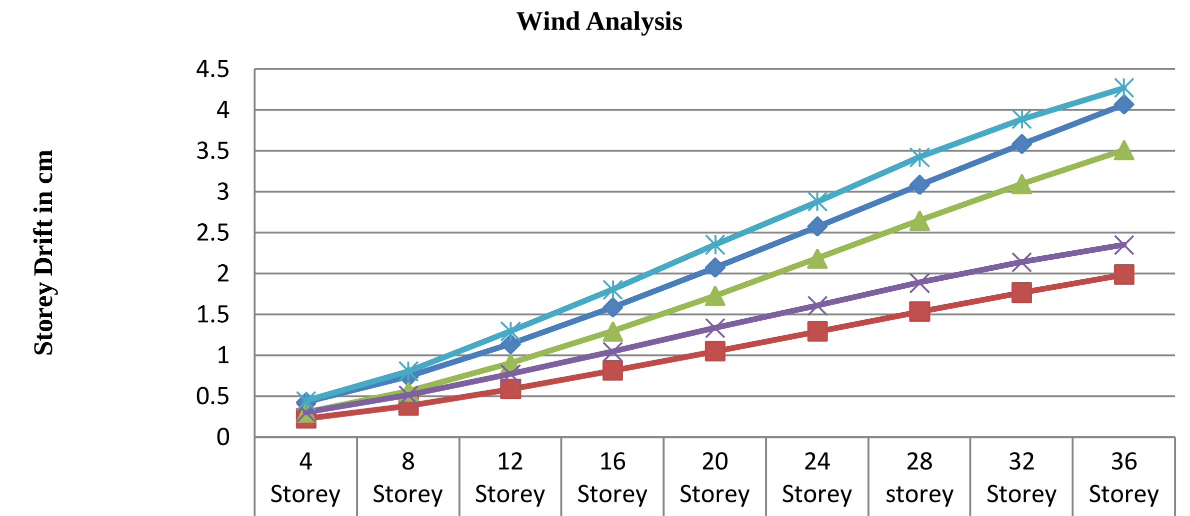
	4 Storey	8 Storey	12 Storey	16 Storey	20 Storey	24 Storey
57°	0.3278	0.5026	0.7045	0.9115	1.1134	1.3011
63°	0.1765	0.2663	0.3682	0.4698	0.5662	0.6508
69°	0.1966	0.2987	0.4112	0.5194	0.6197	0.7063
73°	0.2349	0.3552	0.4915	0.6213	0.7372	0.8182
Conventional	0.3509	0.5799	0.8618	1.1162	1.3496	1.5173

B G+24 Storey Seismic Analysis



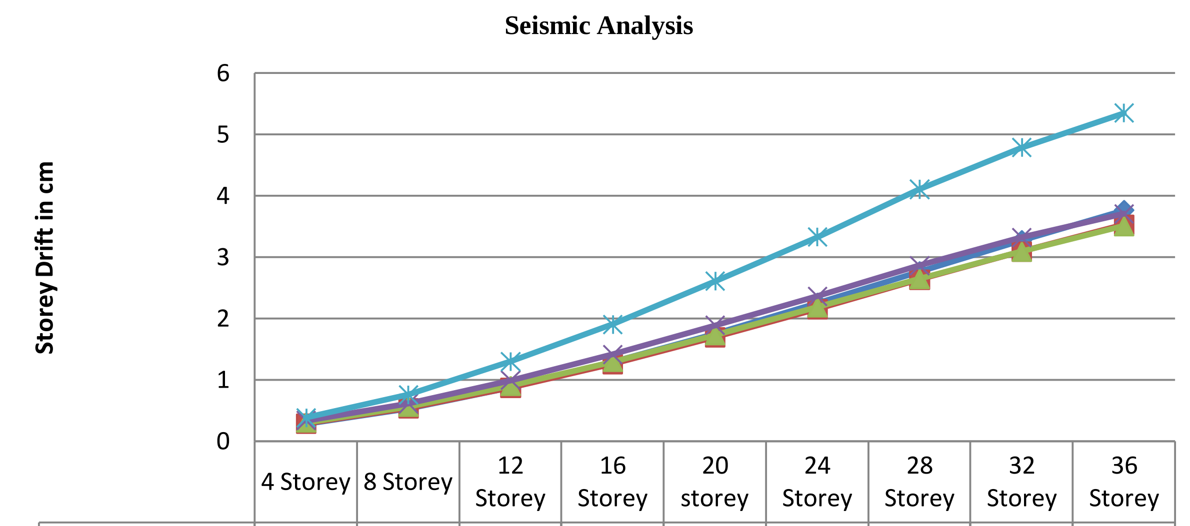
	4 Storey	8 Storey	12 Storey	16 Storey	20 Storey	24 Storey
57°	0.2921	0.4925	0.7462	1.0234	1.3045	1.5676
63°	0.2976	0.4948	0.7434	1.0074	1.2722	1.5071
69°	0.3125	0.5214	0.7783	1.0466	1.309	1.5382
73°	0.3518	0.5858	0.8789	1.1841	1.4779	1.6948
Conventional	0.4154	0.7519	1.2231	1.6942	2.1616	2.5033

C G+36 Storey Wind Analysis



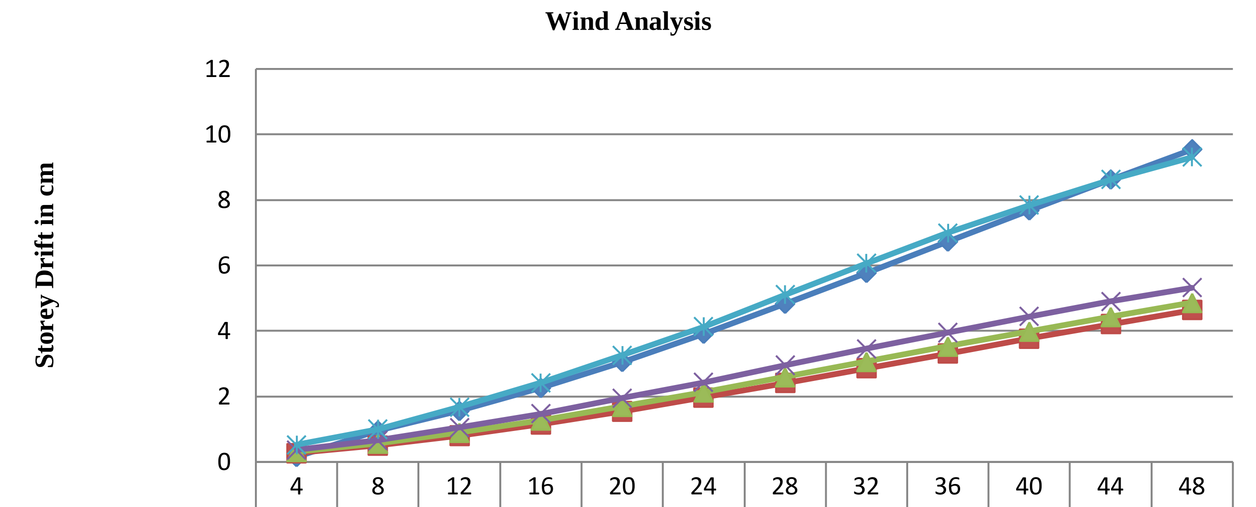
	4 Storey	8 Storey	12 Storey	16 Storey	20 Storey	24 Storey	28 storey	32 Storey	36 Storey
57°	0.4238	0.7363	1.1341	1.5835	2.0701	2.5733	3.0819	3.5814	4.0657
63°	0.2278	0.3878	0.59	0.8122	1.0489	1.2887	1.5309	1.7641	1.9856
69°	0.3004	0.5578	0.8994	1.2924	1.7284	2.1829	2.6461	3.0922	3.5088
73°	0.3025	0.5101	0.7726	1.0464	1.3344	1.6061	1.8854	2.1366	2.35
Conventional	0.4407	0.8041	1.2946	1.8027	2.3508	2.8791	3.4202	3.885	4.2689

D G+36 Storey Seismic Analysis



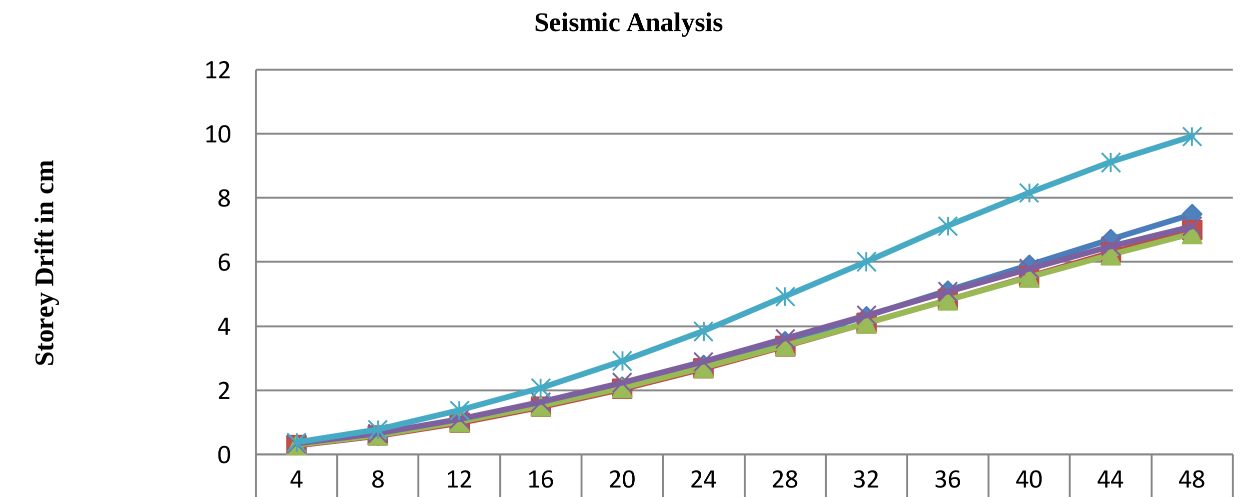
	4 Storey	8 Storey	12 Storey	16 Storey	20 storey	24 Storey	28 Storey	32 Storey	36 Storey
57°	0.2812	0.5343	0.8791	1.29	1.7542	2.2496	2.7622	3.2703	3.7619
63°	0.2863	0.533	0.8684	1.2579	1.6943	2.153	2.6266	3.0885	3.5261
69°	0.3004	0.5578	0.8994	1.2924	1.7284	2.1829	2.6461	3.0922	3.5088
73°	0.3324	0.6088	0.9911	1.4121	1.887	2.3627	2.8579	3.3173	3.7065
Conventional	0.3806	0.7513	1.2937	1.9032	2.6068	3.3257	4.1037	4.7881	5.3467

E G+48 Storey Wind Analysis



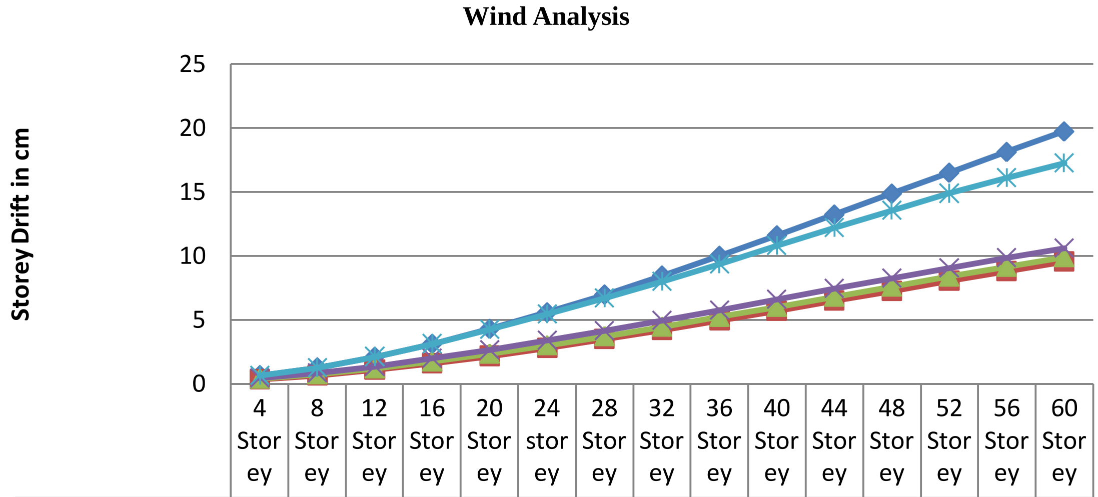
	4	8	12	16	20	24	28	32	36	40	44	48
57°	0.150	0.957	1.554	2.256	3.052	3.913	4.828	5.771	6.727	7.681	8.623	9.547
63°	0.274	0.504	0.809	1.159	1.551	1.969	2.413	2.864	3.318	3.770	4.212	4.641
69°	0.308	0.563	0.895	1.271	1.688	2.129	2.592	3.060	3.528	3.986	4.433	4.864
73°	0.364	0.654	1.044	1.470	1.944	2.428	2.946	3.453	3.945	4.434	4.897	5.317
Conventional	0.521	0.997	1.671	2.411	3.253	4.128	5.111	6.064	6.994	7.851	8.635	9.312

F G+48 Storey Seismic Analysis



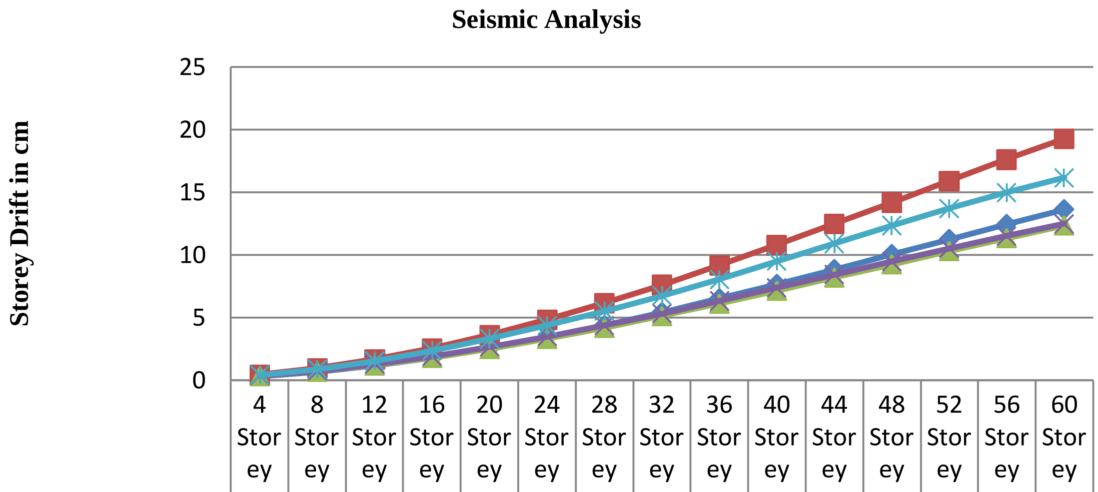
	4	8	12	16	20	24	28	32	36	40	44	48
57°	0.285	0.582	1.001	1.516	2.122	2.798	3.537	4.314	5.114	5.920	6.719	7.500
63°	0.291	0.581	0.988	1.48	2.053	2.687	3.377	4.095	4.832	5.570	6.297	6.999
69°	0.305	0.605	1.018	1.513	2.085	2.713	3.394	4.099	4.817	5.528	6.223	6.888
73°	0.337	0.653	1.107	1.628	2.240	2.896	3.615	4.343	5.074	5.797	6.493	7.116
Conventional	0.378	0.776	1.376	2.078	2.921	3.841	4.924	6.016	7.120	8.157	9.114	9.92

G G+60 Storey Wind Analysis



	4 Storey	8 Storey	12 Storey	16 Storey	20 Storey	24 storey	28 Storey	32 Storey	36 Storey	40 Storey	44 Storey	48 Storey	52 Storey	56 Storey	60 Storey
57°	0.6	1.2	2.0	3.1	4.2	5.5	6.9	8.4	10	11.	13.	14.	16.	18.	19.
63°	0.3	0.6	1.0	1.5	2.1	2.8	3.4	4.2	4.9	5.7	6.4	7.2	8.0	8.8	9.5
69°	0.3	0.7	1.1	1.7	2.3	3.0	3.7	4.4	5.2	6.0	6.8	7.6	8.3	9.1	9.9
73°	0.4	0.8	1.3	1.9	2.6	3.3	4.1	4.9	5.7	6.6	7.4	8.2	9.0	9.8	10.
Conventional	0.6	1.2	2.1	3.1	4.2	5.4	6.7	8.0	9.3	10.	12.	13.	14.	16.	17.

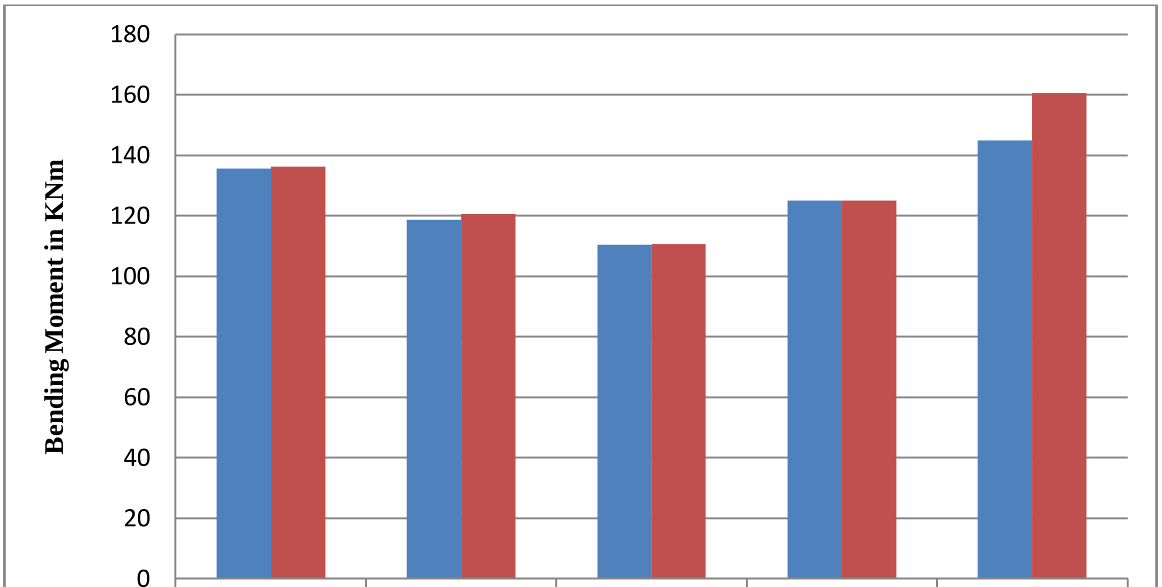
H G+60 Storey Seismic Analysis



	4 Storey	8 Storey	12 Storey	16 Storey	20 Storey	24 Storey	28 Storey	32 Storey	36 Storey	40 Storey	44 Storey	48 Storey	52 Storey	56 Storey	60 Storey
57°	0.3	0.6	1.1	1.8	2.5	3.4	4.3	5.4	6.5	7.6	8.8	10.	11.	12.	13.
63°	0.4	0.9	1.6	2.5	3.6	4.8	6.1	7.6	9.1	10.	12.	14.	15.	17.	19.
69°	0.3	0.6	1.1	1.8	2.5	3.3	4.1	5.1	6.1	7.1	8.2	9.2	10.	11.	12.
73°	0.3	0.7	1.2	1.9	2.6	3.4	4.3	5.3	6.3	7.3	8.4	9.4	10.	11.	12.
Conventional	0.4	0.8	1.5	2.3	3.3	4.3	5.5	6.7	8.0	9.4	10.	12.	13.	15	16.

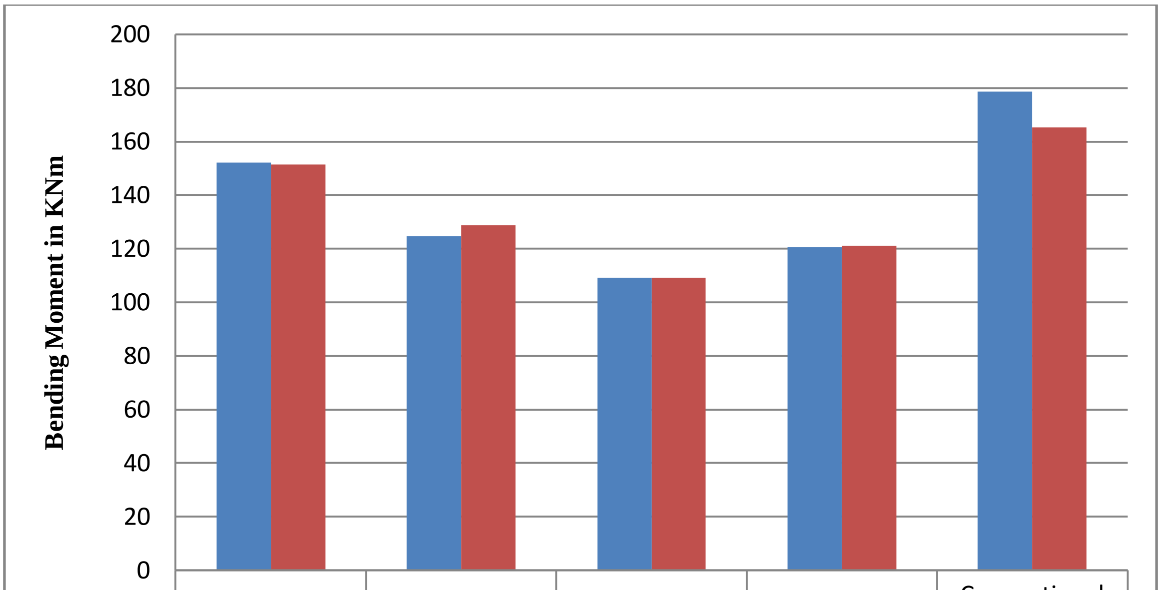
3.3 Bending Moment

A G+24 Storey



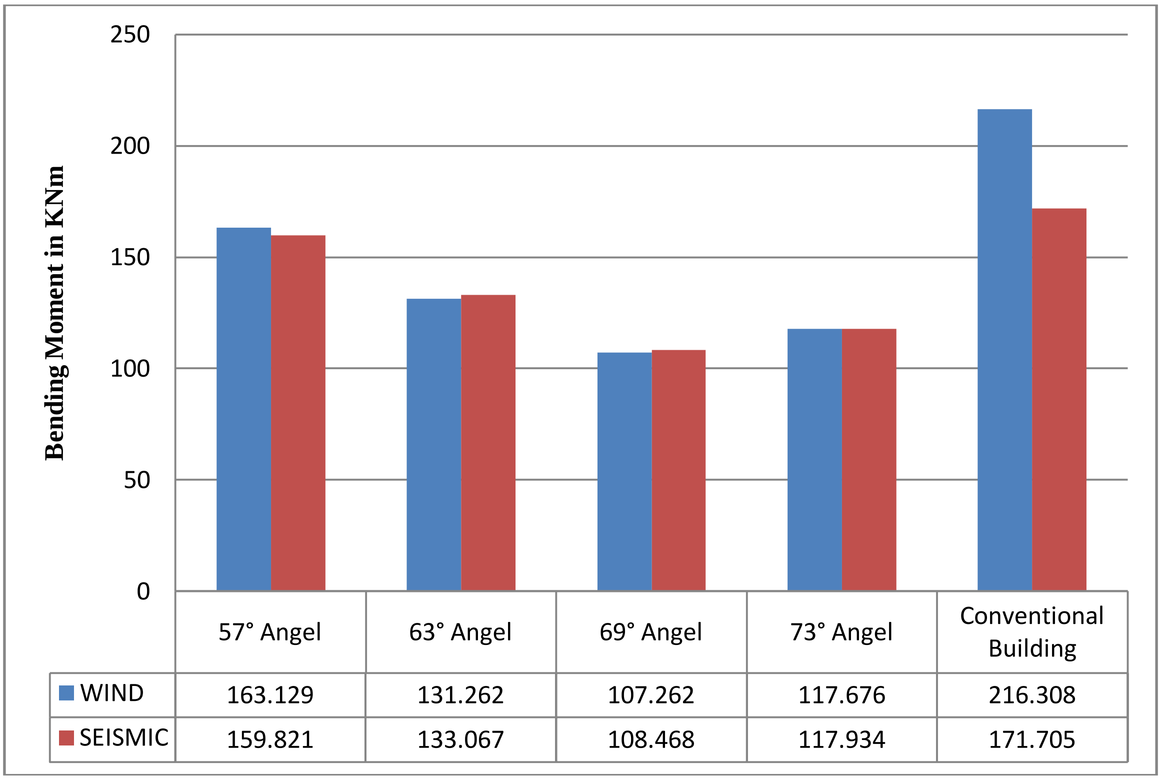
	57° Angel	63° Angel	69° Angel	73°Angel	Conventional Building
WIND	135.485	118.703	110.415	125.11	144.934
SEISMIC	136.265	120.52	110.521	125.014	160.611

B G+36 Storey



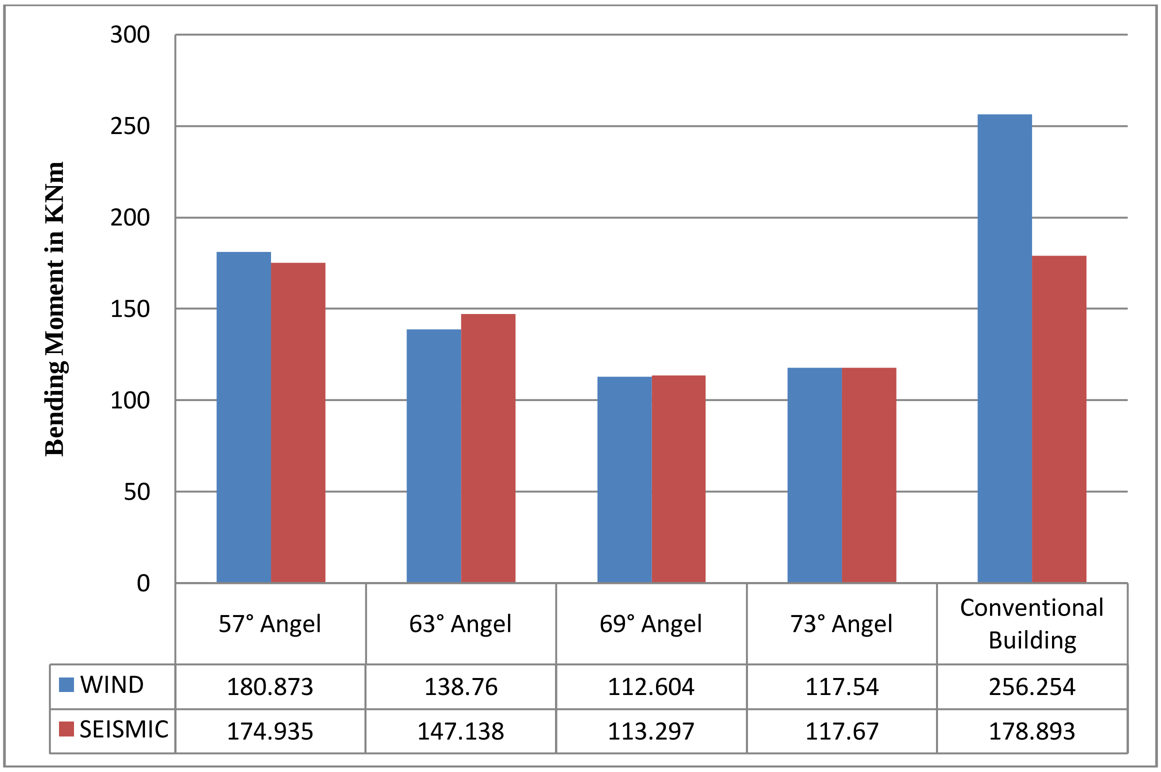
	57° Angel	63° Angel	69° Angel	73° Angel	Conventional Building
WIND	151.951	124.498	108.95	120.568	178.574
SEISMIC	151.263	128.649	109.081	121.002	165.118

C G+48 Storey



	57° Angel	63° Angel	69° Angel	73° Angel	Conventional Building
WIND	163.129	131.262	107.262	117.676	216.308
SEISMIC	159.821	133.067	108.468	117.934	171.705

D G+60 Storey



	57° Angel	63° Angel	69° Angel	73° Angel	Conventional Building
WIND	180.873	138.76	112.604	117.54	256.254
SEISMIC	174.935	147.138	113.297	117.67	178.893

CONCLUSIONS

The current study is carried out by considering the different angles of diagrid and also different storey module of the varying building height. The proposed plan of 18m x 18m is considered with four different types of angles of diagrid that is 57°, 63°, 69°,and 73° for 2 storey, 3 storey, 4 storey, 6 storey diagrid module for G+24, G+36, G+48 and G+60 storey building. also comparative study diagrid and conventional building is carried out.
We conclude from the study that

- For all the 40 models consider for the study storey displacement and storey drift values are within the permissible limit.
- Wind and seismic analysis are all storey diagrid angel 63° and 69° provides more stiffeness to the diagrid structural system which reflect the less storey displacement, less storey drift and less bending moment
- And comparison of diagrid building and conventional building they are shows that diagrid building are less displacement,less story drift and less bending moment in wind and seismic analysis.
- Diagrid structure comparison to conventional building provide more aesthetic look it becomes important for high rise structure
- So from result comparison with conventional building, one can adopt diagrid structure for better lateral and gravitational load resistance.

FUTURE SCOPE OF WORK

- Higher storey buildings can be studied in R.C.C symmetrical building for diagrid structure.
- Asymmetrical building with different angel study for diagrid structure.
- Study With and without outer column for diagrid structure.
- Steel building can also studies diagrid structures.
- Comparative study braced tube system and diagrid structures.

REFERENCES

[1] Sree Harsha and K Raghu “Analysis Of Tall Building For Desired Angel Of Diagrids IJRET Volume:04 Issue: 04 Apr-2015
[2] Khushbu Jani, Paresh V. Patel,”Analysis And Design Of Diagrid Structural System For High Rise Steel Building”, Procedia Engineering 51 (2013) 92 – 100
[3] Naga Subramanian and Augustine Maniraj Pandian “Evaluation of structural efficiency of steel diagrid system for multi-story buildings” ICEIS-2016
[4] Raghunath Deshpandey and Sadanand Patil “Analysis and Comparison Of Diagrid And Conventional Structural System” Volume: 02, Issue: 03, June-2015
[5] Sahana and Aswathy s Kumar “Comparative study of diagrid structures with and without corner columns” IJSR Volume 5, Issue 7, July-2016
[6] Harshita Tripathi and Dr. Sarita Singla “Diagrid structural system for R.C. framed multistoried building” International Journal of Scientific & Engineering Research Volume7, Issue 6, June-2016
[7] Kiran Kamath and Sachin Hirannaiah “An Analytical study on performance of a diagrid structure using nonlinear static pushover analysis” ScienceDirect April-2016
[8] Ravish Khan and Sangeeta Shinde “Analysis of diagrids using symmetric and asymmetric plan geometry” ISSN:2347-2812 Volume-4, Issue-3, 2016
[9] Nikesh Ganesh Rathod and P.Saha “Diagrid an innovative technique for high rise structure” ISSN:2349-8404 Volume 2, Issue 5, June-2015
[10] Amol Gorle and S.D. Gowardhan “Optimum performance of diagrid structure” IJER Volume 05,Issue 03 Feb-2016
[11] K Moon “Design and construction of steel diagrid structures” NSCC2009
[12] Pallavi Bhale and P.J. Salunke “Analytical study and design of diagrid building and comparison with conventional frame building” IJATES Volume 04, Issue 01, January 2016
[13] Saket Yadav and Vivek Garg “Advantage of steel diagrid building over conventional building” IJCSER Volume 03, Issue 01 Sep-2015
[14] Ravi Revankar and R.G. Talasadar “Pushover Analysis Of Diagrid Structure” IJEIT Volume 4 Issue 3 Sep-2014
[15] Raghunath Deshpande and Sadanand Patil “Analysis and comparison of diagrid and conventional structural system” IRJET Volume 02, Issue 03, June-2015
[16] IS456:2000 plain and reinforced concrete-code of practice
[17] IS 875(PART 3):1987 code for practice for design loads(other than earthquake) for buildings and structures
[18] IS 1893(part:1):2000 Proposed Draft Provisions and Commentary on Indian Seismic Code