PARAMETRIC STUDY OF DIAGRID STRUCTURES SUBJECTED TO SEISMIC FORCES

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Abstract: Parametric study of diagrid structure has been carried out by analyzing and designing 40 storey diagrid structure having variation in parameters like angle of diagrid, cross sectional shape of diagrid and column placed at different position. The plan area considered was 24m * 24m (aspect ratio equals to 5). The parameters nominated for evaluation are 3 different angle i.e. 45 degree, 63.43 degree and 78.69 degree. The second parameter considered was 4 different cross sectional shape i.e. I section, box section, tube section and composite section made up of tube section having concrete as an infill material. And the last parameter considered was the 3 different position of column i.e. no column placed on the periphery, column placed at the corner of the plan and column placed at the center of the external edge. Finally the results generated due to the variation of the above parameters were compared in terms of maximum top storey displacement, storey drift and base shear.

Index Terms – Parametric Study, I section, Box section, Tube section, Composite section, 45 degree, 63.43 degree, 78.69 degree, column position 1 N.A., column position 2 corner, column position 3 center.

I. INTRODUCTION

Scarcity of land restricted the horizontal development and resulted in evolution of vertical growth of the town which leads to the development of tall buildings. The concept of tall structures was introduced by Fazlur Khan in early 60's. The different structural systems provided start-up to the tall structures while advances in material and construction technology accelerated the development of tall structures. The Lateral load due to wind and earthquake is the major factor that governs the design of tall structures which are mainly resisted either by exterior or interior structural system.
The different type of lateral load resisting systems that are widely used are mainly

- Rigid frame
- Shear wall
- Braced tube system
- Exoskeleton
- Diagrid system
- Hexa-grid system
- Tube in tube system and
- Bundled tube system
- Core-and- outrigger
- Belt Truss
- Staggered Truss

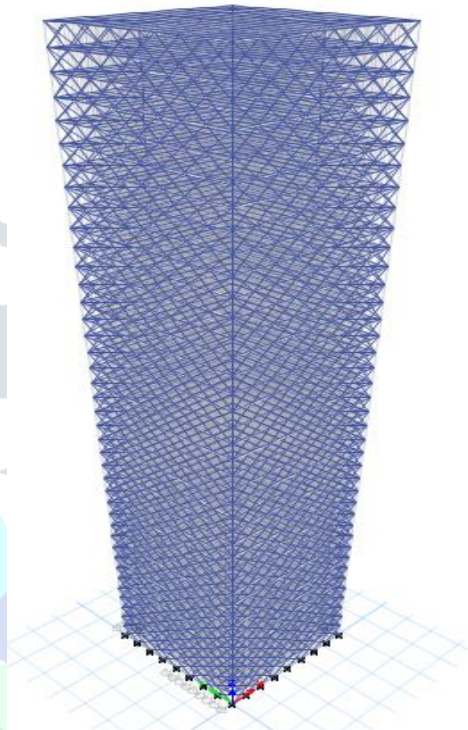
Diagrid is an exterior structural system in which almost all vertical columns can be eliminated and consists of only inclined columns on the facade of the building having triangular configuration. The major difference between a braced tube building and a diagrid building is that, there are no vertical columns present in the perimeter of a diagrid building. Diagrid structures do not need high shear rigidity cores because shear can be carried by the diagrid located on the perimeter. The diagonal members in diagrid structural system can carry both gravity as well as lateral load. The structural efficiency of diagrid system helps in avoiding interior and corner columns which allows architectural flexibility with the floor plan. The openings between the diagonal members can be filled either by glass or any aesthetically sound material. Now a days the concept of curtain wall is adopted to fill this large openings between diagonal members. Diagrid structural system saves approximately 20% structural steel weight when compared to a conventional moment frame structure. An early example of diagrid structure is the IBM building in Pittsburgh built in early 1960s, with its 13 storey building height. Some other well-known examples of diagrid structures are Hearst tower (New York), Capital Gate (Abu Dhabi), CCTV headquarters building (Beijing), West tower (Guangzhou), Mode Gakuen Spiral Tower (Aichi), The Swiss Re tower (London), Lotte super tower (Seoul), etc.

II. PROBLEM FORMULATION

For parametric study 40 storey building having base dimension 24m*24m was considered. Modelling Analysis and Design was carried out using Etabs. Software. IS 800 was consider for designing steel members. Building was analyzed and designed for dead load, live load, floor finish, wall load and earth quake load in both the direction. Zone 5 was considered for extreme conditions for both static as well as response spectrum analysis of earth quake. The parameters selected for comparison are base shear, storey drift and displacement.

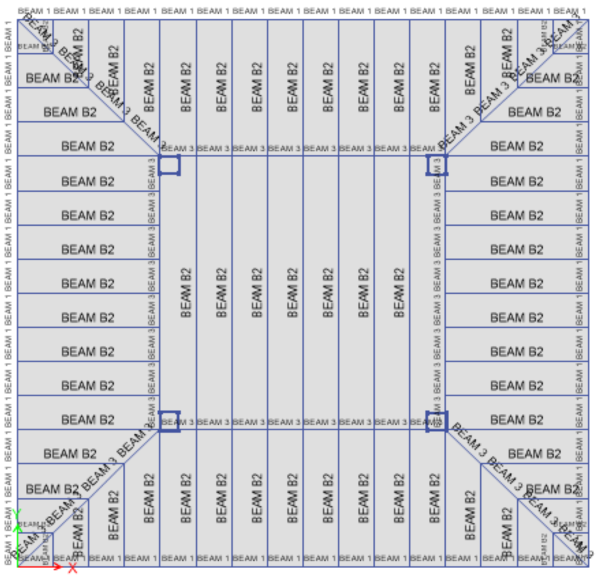
A. Building configuration

Plan Area	18 m × 18 m
Number of storey	30
Typical Storey Height	3 m
Steel Sections	Fe 250
Concrete (Slabs)	M30
Live Load	3 kN/m^2
Floor Finish	1 kN/m^2
Wall Load	12.42 kN/m
Slab Thickness	150 mm
Zone Factor	zone 5
Importance Factor	1.2
Response Reduction Factor	5
Analysis Method	Static and Response Spectrum



B. Beam

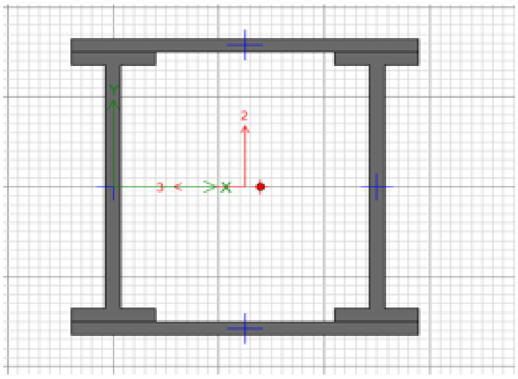
Details/Storey	Beam 1	Beam 2	Beam 3
Total depth (H)	ISMB500	550	600
Width of flange (B_f)		250	250
Thickness of flange (t_f)		25	25
Thickness of web (t_w)		15	15
Plate dimension		260*25	260*25



C. Column

Column is made up of 2 I section having cover plate at top and bottom as shown in figure below.

Details/Storey	0 to 10	11 to 20	21 to 30	31 to 40
Total depth (H)	1600	1250	1050	820
Width of flange (B_f)	415	315	275	210
Thickness of flange (t_f)	100	75	75	65
Thickness of web (t_w)	100	75	75	65
Plate dimension	1800*100	1400*75	1200*75	950*65
Center to center distance b/w I section	1385	1085	925	740



D. I section Diagrid

Details/Storey	0 to 10	11 to 20	21 to 30	31 to 40
Total depth (H)	810	700	660	550
Width of flange (B_f)	420	360	340	275
Thickness of flange (t_f)	50	60	50	50
Thickness of web (t_w)	30	30	30	30
Plate dimension	440*70	390*80	360*65	295*65

Details/Storey	0 to 10	11 to 20	21 to 30	31 to 40
Width of box	420	375	340	275
Depth of box	420	375	340	275
Thickness	45	45	40	40

E. Box section Diagrid

F. Tube section Diagrid

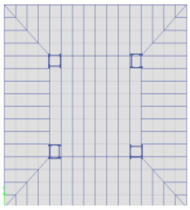
Details/Storey	0 to 10	11 to 20	21 to 30	31 to 40
Diameter	475	425	375	325
Thickness	45	45	40	30

G. Composite section Diagrid

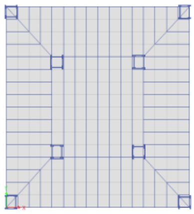
Details/Storey	0 to 10	11 to 20	21 to 30	31 to 40
Diameter	400	370	350	325
Thickness	35	30	30	30

Infill material: - M20 Grade Concrete

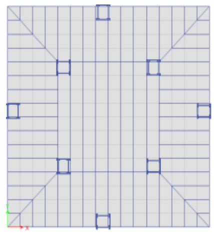
III. Types of Model



COLUMN POSITION 1 N.A.

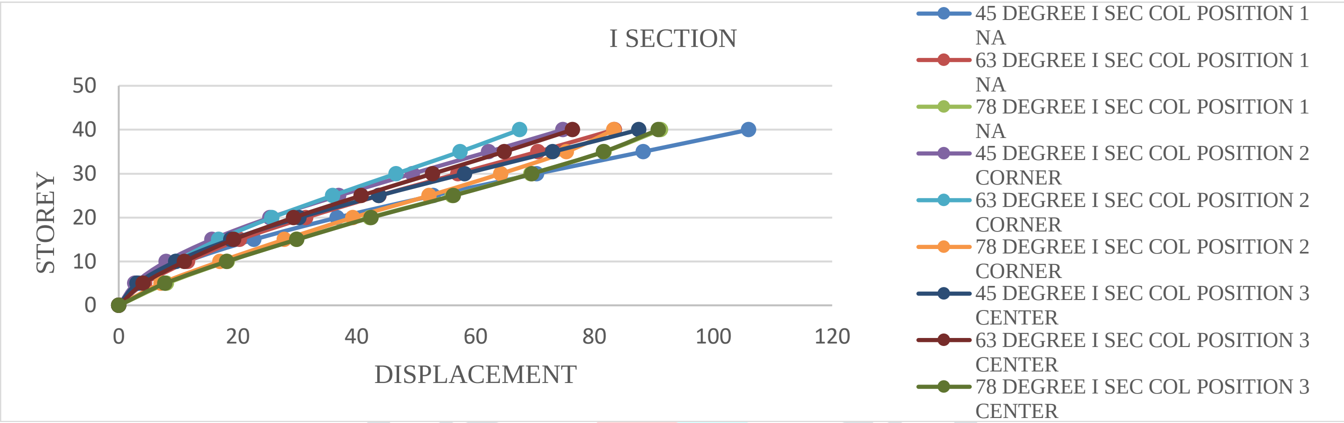


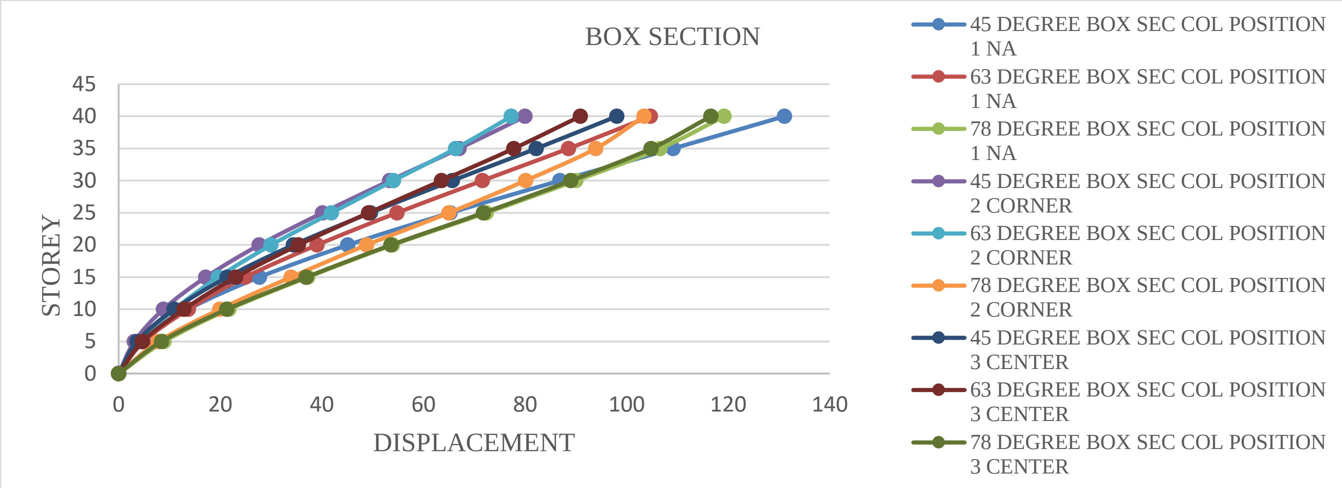
COLUMN POSITION 2 CORNER

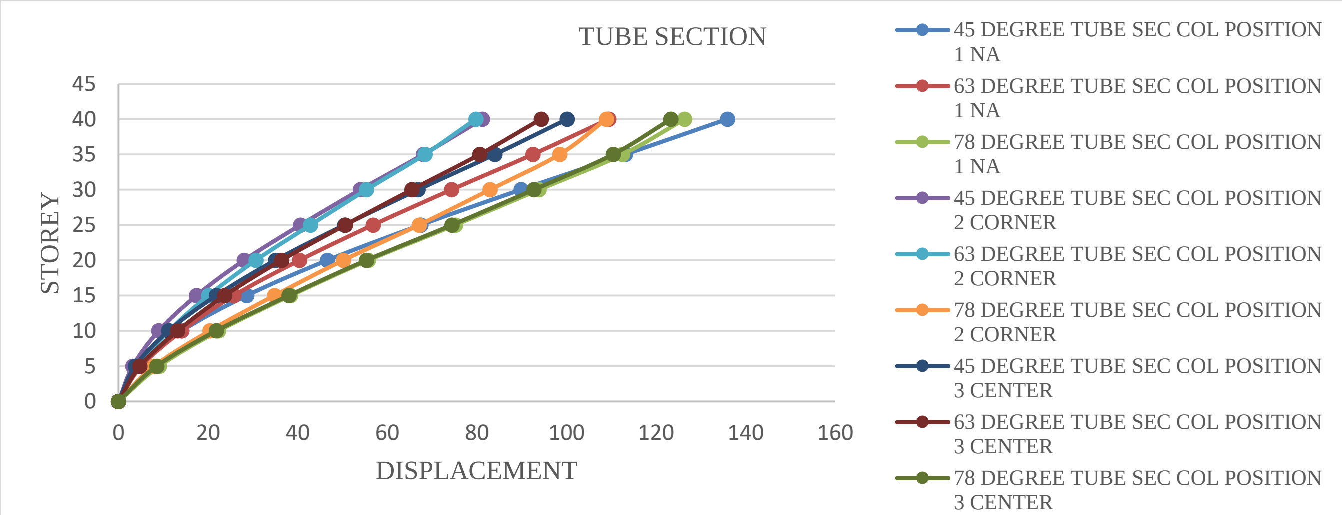


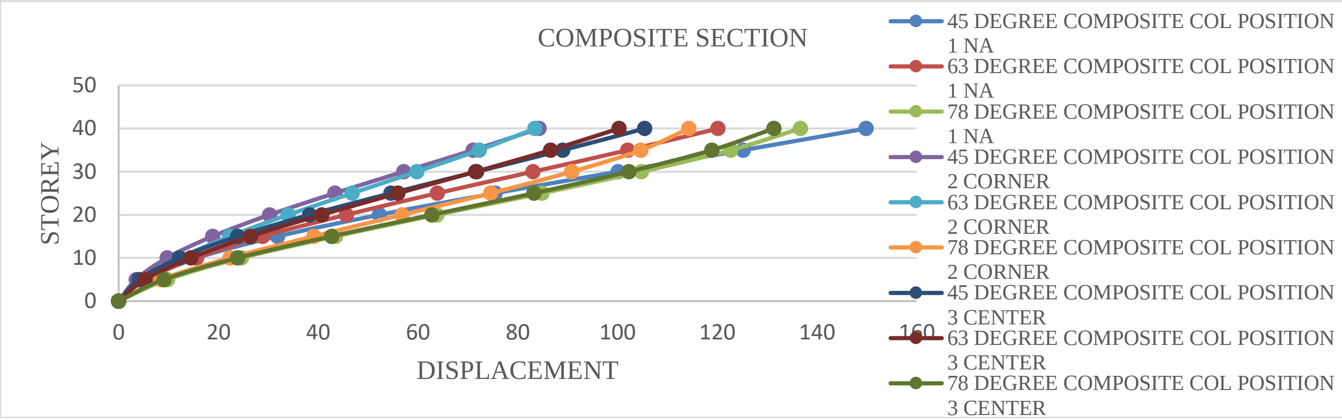
COLUMN POSITION 3 CENTER

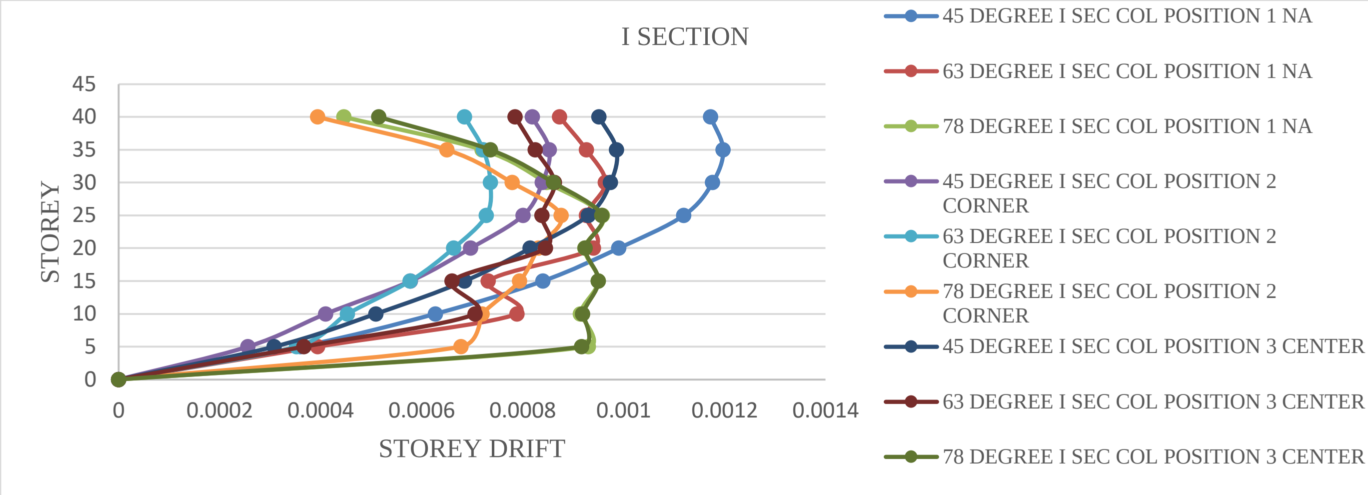
IV. Result and Comparison

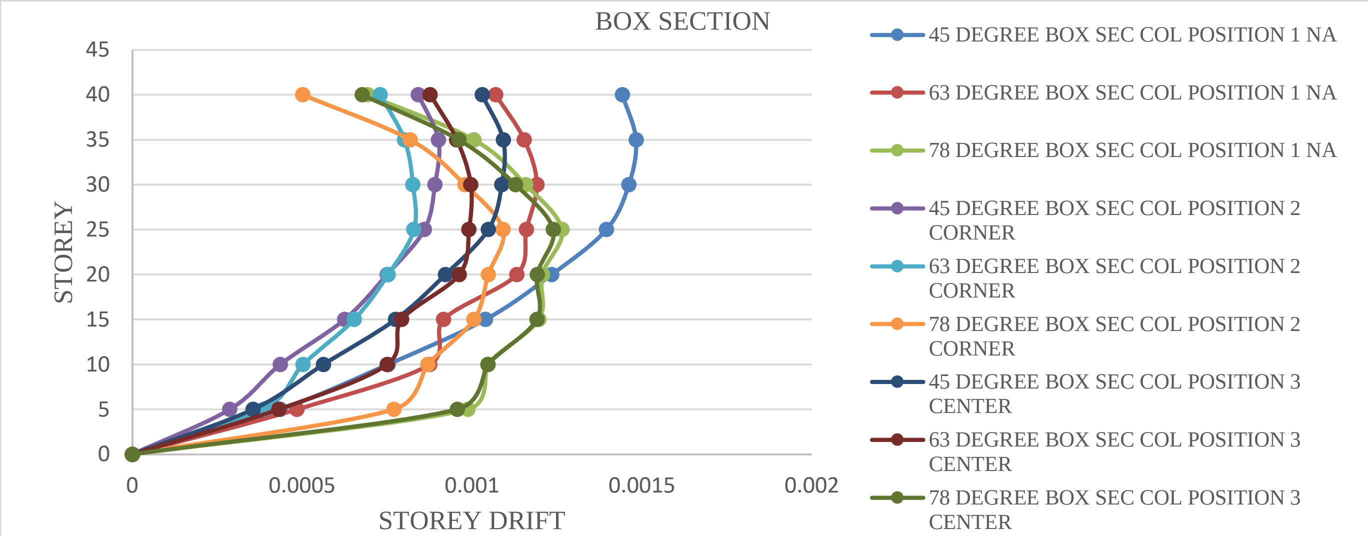


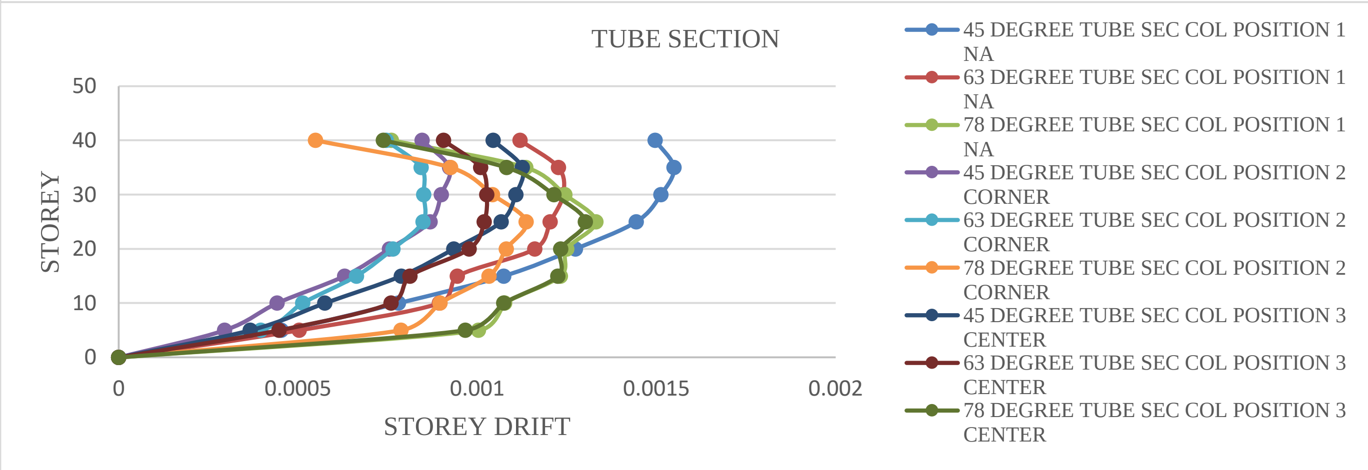

BOX SECTION
STOREY
DISPLACEMENT
0 5 10 15 20 25 30 35 40 45
0 20 40 60 80 100 120 140
45 DEGREE BOX SEC COL POSITION 1 NA
63 DEGREE BOX SEC COL POSITION 1 NA
78 DEGREE BOX SEC COL POSITION 1 NA
45 DEGREE BOX SEC COL POSITION 2 CORNER
63 DEGREE BOX SEC COL POSITION 2 CORNER
78 DEGREE BOX SEC COL POSITION 2 CORNER
45 DEGREE BOX SEC COL POSITION 3 CENTER
63 DEGREE BOX SEC COL POSITION 3 CENTER
78 DEGREE BOX SEC COL POSITION 3 CENTER

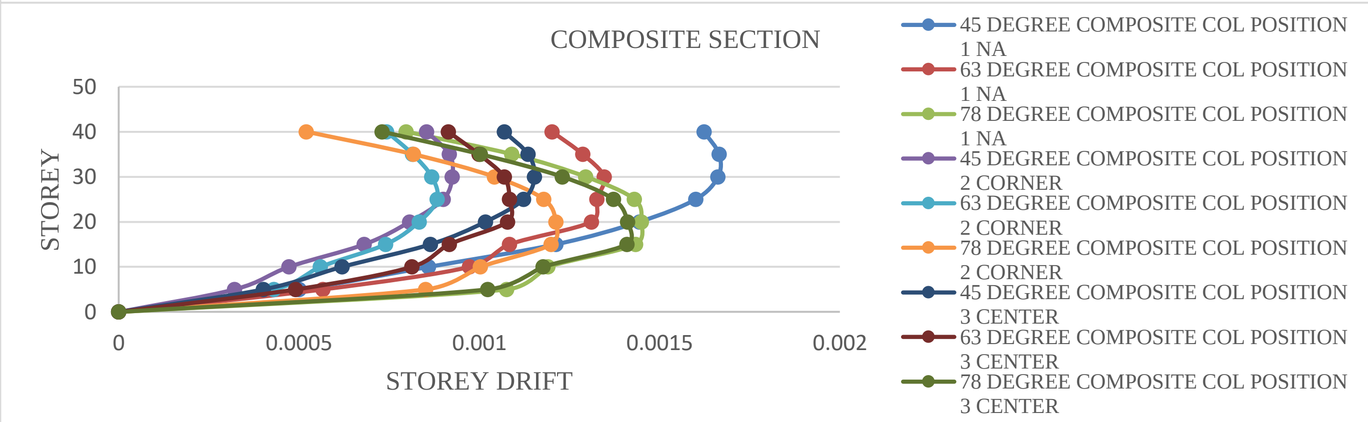

TUBE SECTION
STOREY
DISPLACEMENT
0 5 10 15 20 25 30 35 40 45
0 20 40 60 80 100 120 140 160
45 DEGREE TUBE SEC COL POSITION 1 NA
63 DEGREE TUBE SEC COL POSITION 1 NA
78 DEGREE TUBE SEC COL POSITION 1 NA
45 DEGREE TUBE SEC COL POSITION 2 CORNER
63 DEGREE TUBE SEC COL POSITION 2 CORNER
78 DEGREE TUBE SEC COL POSITION 2 CORNER
45 DEGREE TUBE SEC COL POSITION 3 CENTER
63 DEGREE TUBE SEC COL POSITION 3 CENTER
78 DEGREE TUBE SEC COL POSITION 3 CENTER

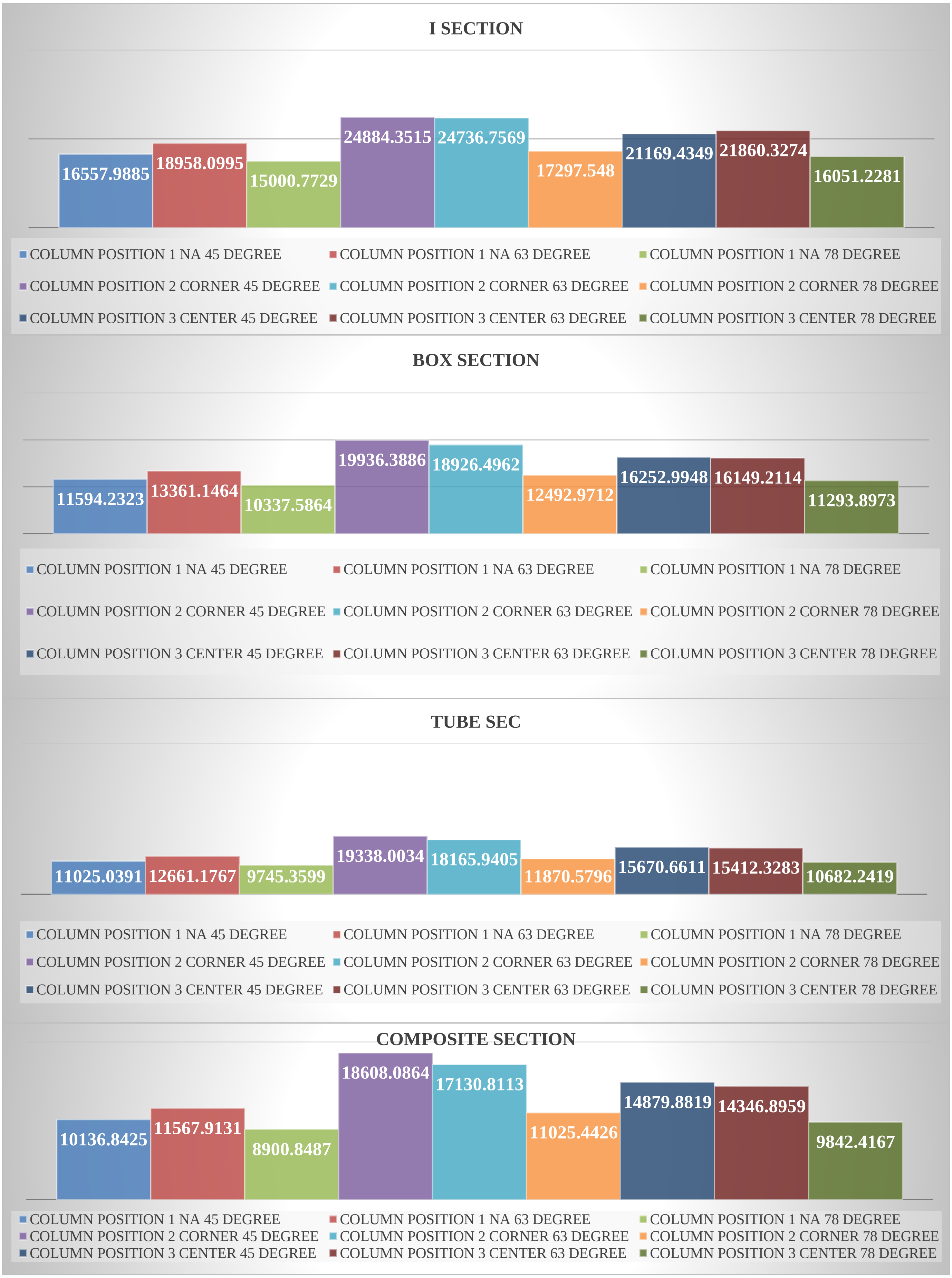

COMPOSITE SECTION
STOREY
DISPLACEMENT
0 10 20 30 40 50
0 20 40 60 80 100 120 140 160
45 DEGREE COMPOSITE COL POSITION 1 NA
63 DEGREE COMPOSITE COL POSITION 1 NA
78 DEGREE COMPOSITE COL POSITION 1 NA
45 DEGREE COMPOSITE COL POSITION 2 CORNER
63 DEGREE COMPOSITE COL POSITION 2 CORNER
78 DEGREE COMPOSITE COL POSITION 2 CORNER
45 DEGREE COMPOSITE COL POSITION 3 CENTER
63 DEGREE COMPOSITE COL POSITION 3 CENTER
78 DEGREE COMPOSITE COL POSITION 3 CENTER


I SECTION
STOREY
45
40
35
30
25
20
15
10
5
0
0
0.0002
0.0004
0.0006
0.0008
0.001
0.0012
0.0014
STOREY DRIFT
45 DEGREE I SEC COL POSITION 1 NA
63 DEGREE I SEC COL POSITION 1 NA
78 DEGREE I SEC COL POSITION 1 NA
45 DEGREE I SEC COL POSITION 2 CORNER
63 DEGREE I SEC COL POSITION 2 CORNER
78 DEGREE I SEC COL POSITION 2 CORNER
45 DEGREE I SEC COL POSITION 3 CENTER
63 DEGREE I SEC COL POSITION 3 CENTER
78 DEGREE I SEC COL POSITION 3 CENTER


BOX SECTION
STOREY
45
40
35
30
25
20
15
10
5
0
0
0.0005
0.001
0.0015
0.002
STOREY DRIFT
45 DEGREE BOX SEC COL POSITION 1 NA
63 DEGREE BOX SEC COL POSITION 1 NA
78 DEGREE BOX SEC COL POSITION 1 NA
45 DEGREE BOX SEC COL POSITION 2 CORNER
63 DEGREE BOX SEC COL POSITION 2 CORNER
78 DEGREE BOX SEC COL POSITION 2 CORNER
45 DEGREE BOX SEC COL POSITION 3 CENTER
63 DEGREE BOX SEC COL POSITION 3 CENTER
78 DEGREE BOX SEC COL POSITION 3 CENTER


TUBE SECTION
STOREY
50
40
30
20
10
0
0
0.0005
0.001
0.0015
0.002
STOREY DRIFT
45 DEGREE TUBE SEC COL POSITION 1 NA
63 DEGREE TUBE SEC COL POSITION 1 NA
78 DEGREE TUBE SEC COL POSITION 1 NA
45 DEGREE TUBE SEC COL POSITION 2 CORNER
63 DEGREE TUBE SEC COL POSITION 2 CORNER
78 DEGREE TUBE SEC COL POSITION 2 CORNER
45 DEGREE TUBE SEC COL POSITION 3 CENTER
63 DEGREE TUBE SEC COL POSITION 3 CENTER
78 DEGREE TUBE SEC COL POSITION 3 CENTER


COMPOSITE SECTION
STOREY
50
40
30
20
10
0
0
0.0005
0.001
0.0015
0.002
STOREY DRIFT
45 DEGREE COMPOSITE COL POSITION 1 NA
63 DEGREE COMPOSITE COL POSITION 1 NA
78 DEGREE COMPOSITE COL POSITION 1 NA
45 DEGREE COMPOSITE COL POSITION 2 CORNER
63 DEGREE COMPOSITE COL POSITION 2 CORNER
78 DEGREE COMPOSITE COL POSITION 2 CORNER
45 DEGREE COMPOSITE COL POSITION 3 CENTER
63 DEGREE COMPOSITE COL POSITION 3 CENTER
78 DEGREE COMPOSITE COL POSITION 3 CENTER


I SECTION
16557.9885
18958.0995
15000.7729
24884.3515
24736.7569
17297.548
21169.4349
21860.3274
16051.2281
COLUMN POSITION 1 NA 45 DEGREE
COLUMN POSITION 1 NA 63 DEGREE
COLUMN POSITION 1 NA 78 DEGREE
COLUMN POSITION 2 CORNER 45 DEGREE
COLUMN POSITION 2 CORNER 63 DEGREE
COLUMN POSITION 2 CORNER 78 DEGREE
COLUMN POSITION 3 CENTER 45 DEGREE
COLUMN POSITION 3 CENTER 63 DEGREE
COLUMN POSITION 3 CENTER 78 DEGREE
BOX SECTION
11594.2323
13361.1464
10337.5864
19936.3886
18926.4962
12492.9712
16252.9948
16149.2114
11293.8973
COLUMN POSITION 1 NA 45 DEGREE
COLUMN POSITION 1 NA 63 DEGREE
COLUMN POSITION 1 NA 78 DEGREE
COLUMN POSITION 2 CORNER 45 DEGREE
COLUMN POSITION 2 CORNER 63 DEGREE
COLUMN POSITION 2 CORNER 78 DEGREE
COLUMN POSITION 3 CENTER 45 DEGREE
COLUMN POSITION 3 CENTER 63 DEGREE
COLUMN POSITION 3 CENTER 78 DEGREE
TUBE SEC
11025.0391
12661.1767
9745.3599
19338.0034
18165.9405
11870.5796
15670.6611
15412.3283
10682.2419
COLUMN POSITION 1 NA 45 DEGREE
COLUMN POSITION 1 NA 63 DEGREE
COLUMN POSITION 1 NA 78 DEGREE
COLUMN POSITION 2 CORNER 45 DEGREE
COLUMN POSITION 2 CORNER 63 DEGREE
COLUMN POSITION 2 CORNER 78 DEGREE
COLUMN POSITION 3 CENTER 45 DEGREE
COLUMN POSITION 3 CENTER 63 DEGREE
COLUMN POSITION 3 CENTER 78 DEGREE
COMPOSITE SECTION
10136.8425
11567.9131
8900.8487
18608.0864
17130.8113
11025.4426
14879.8819
14346.8959
9842.4167
COLUMN POSITION 1 NA 45 DEGREE
COLUMN POSITION 1 NA 63 DEGREE
COLUMN POSITION 1 NA 78 DEGREE
COLUMN POSITION 2 CORNER 45 DEGREE
COLUMN POSITION 2 CORNER 63 DEGREE
COLUMN POSITION 2 CORNER 78 DEGREE
COLUMN POSITION 3 CENTER 45 DEGREE
COLUMN POSITION 3 CENTER 63 DEGREE
COLUMN POSITION 3 CENTER 78 DEGREE

V. Conclusion

- Most efficient section: - I section
- Optimum angle: - 63 degree
- Most efficient column position: - Corner
- Column placed at corner: - not much difference is observed in base shear due to variation of angle

VI. References

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