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DYNAMIC RESPONSE OF A TYPICAL RC FRAME WITH HYBRID BRACING SYSTEM

Desai Abhishek Annasaheb[1], Dr. Chethan K[2]

[1]P.G Student, Department of Civil Engineering, U.V.C.E, Bangalore University, Bengaluru
[2]Associate Professor, Department of Civil Engineering, U.V.C.E, Bangalore University, Bengaluru.

Abstract - *Steel bracing systems play a key role in ensuring the stability of high-rise buildings by effectively resisting lateral forces induced by wind, seismic activity and other dynamic loads. Various types of steel bracing systems are used in high-rise buildings focusing on their design considerations, performance under different loading conditions and the impact on overall building stability. The objective is to provide a comprehensive understanding of bracing systems, highlighting their importance in modern high-rise construction and offering insights into the selection of optimal bracing solutions to achieve a balance between safety, cost effectiveness and sustainability.*

In this study, RC Frame of G+15 stories is considered with different steel braces along with hybrid bracing system for the Finite Element Analysis. The performance of building is studied in terms of Modal, Equivalent Static and Response Spectrum analysis. Time Period, Base shear, Displacement and Storey Drift results are obtained, tabulated and conclusions are drawn.

***Key Words*: Cross-bracing, V-bracing, Inverted V-bracing, diagonal braces, Time Period, Base Shear, Storey Displacement and Storey Drift.**

1.INTRODUCTION

Steel bracings are a crucial component in the structural design of high-rise buildings, providing essential stability and resistance against lateral forces such as wind and earthquakes. These forces can cause significant displacement and deformation in a structure, and steel bracing systems are designed to minimize this by enhancing the building's rigidity and strength. The use of steel bracings in high-rise construction offers several advantages, including improved load-bearing capacity, cost-effectiveness, and ease of installation. Steel's high strength-to-weight ratio makes it an ideal material for supporting large loads while maintaining a relatively light structure. Furthermore, steel bracing systems can be tailored to meet the specific demands of different building designs, offering flexibility in layout and appearance. Bracing systems can take various forms, including diagonal braces, cross-bracing, and moment-resisting frames, each offering unique benefits in terms of performance and aesthetic integration. The choice of bracing type depends on factors such as the height of the building, its location, and the type of loads it is expected to encounter. Overall, incorporating steel bracings in high-rise buildings is vital for ensuring safety, stability, and structural integrity, making it a fundamental consideration for engineers and architects involved in the design and construction of tall structures.

1.1 Concentric Bracing System

The steel braces are usually placed in vertically aligned spans. This system allows to obtaining a great increase of stiffness with a minimal added weight. Concentric bracings increase the lateral stiffness of the frame thus increases the natural frequency and also usually decreases the lateral storey drift. Concentric bracing are designed to be in pure axial compression or tension when lateral loads are applied. When wind or seismic forces push or pull on the building, the braces either compress or stretch, transferring the load through the diagonal braces to the columns and beams, which in turn transfer the forces to the foundation. This system operates based on the concept of axial load transfer, which makes it effective in resisting lateral forces without inducing bending or significant deformation in the frame.

1.2 Eccentric Bracing System

The eccentricity in the bracing system introduces a combination of both shear and bending forces, allowing the braces to resist larger lateral loads more efficiently. The braces work to absorb lateral forces by "deforming" at the connection point, often through a plastic hinge mechanism where the braces or connections yield, dissipating energy from seismic forces. The eccentric nature of the bracing allows for a more flexible system, which can dissipate energy more effectively during seismic events, reducing the amount of force transmitted to the overall structure. The energy dissipation through the yielding of braces or joints makes the system especially useful in earthquake-resistant designs.

2. OBJECTIVES

1. To evaluate the Dynamic Response of a Typical RC Bare Frame with various bracing systems subjected to seismic loads. Bracing system used in this study are X, V, Inverted V and Diagonal Bracings.
2. To evaluate the Dynamic Response of a Typical RC Bare Frame with combination of the bracing systems called as "Hybrid Bracing System".

3. Finite Element Software is used for the analysis of FE models developed using details from literature.
4. FE Analysis involving Modal Analysis, Equivalent Static Analysis and Response Spectrum Analysis to be performed on all the models.
5. Results such as Base Shear, Time Period, Lateral Displacement and Storey Drift are obtained.
6. To identify the suitable Hybrid bracing system for resisting the seismic load efficiently.

3. METHODOLOGY

1. Detailed literature review is carried out on the seismic response of reinforced concrete structure with different types of bracing and combinations.
2. A typical RC Frame G+15 storey structure is considered for the study.
3. The types of bracing system considered are X,V,IV and D the combinations of the bracings called as "Hybrid Bracing System".
4. The Hybrid bracings system considered for the study are as follows X,XV,XIV,XD,V,VX,VIV,VD,IV,IVX,IVV,IVD,D,DX,DV and DIV.
5. Each bracing system are placed in alternate storey level in a typical RF structure.
6. FE Analysis involves Modal, Equivalent Static and Response Spectrum analysis are performed on a Typical RF G+15 Storey structure with bracing and the combinations of bracing system to obtain Time period, Base shear, Storey displacement and Storey drift.

4. PROBLEM FORMULATION AND ANALYSIS

A detailed summary of the various parameters defining the Regular frame (RF) with conventional bracing system and hybrid bracing system models are presented.

The methodology involved in computing some of these parameters is explained and important feature of the current provisions relating to earthquake resisting design of reinforced concrete lateral forces resisting system are presented.

5. PRESENT STUDY

The present study adopts structural 3D models with conventional bracing system and hybrid bracing system models. The seismic responses of these braced models have been compared with that of the Regular frame building model. The base plan size has been kept as 25m x 25m.

6. PROJECT DESCRIPTION

Table -1: Details for Modelling

Description	**Data**
Number of storeys	G+15
Seismic Zone	V
Seismic Zone Factor (Z)	0.36
Importance Factor (I)	1.5
Response Reduction Factor (R)	5.0
Type of Frame	Building With Ordinary Braced Frame (OBF) Having Concentric Braces
Damping Ratio	5%
Soil Type	Medium Soil (Type II)
Bay Width	5m
Column Size	600 x 600
Beam Size	300 x 450
Thickness of Slab	150mm
Floor Finish Load	1.5kN/m^2
Live Load	3kN/m^2
Floor to Floor Height	3.0m
Total Height of Structure	48m
Grade of Concrete (f_{ck})	M30
Grade of Structural Steel (f_{ys})	Fe250
Grade of Reinforcing Steel (f_{yr})	Fe500
Load Combination	1.5 (DL+LL) 1.2 (DL+LL$\pm$ EQ) 0.9DL $\pm$ 1.5EQ

Table -2: Nomenclature and description of the model G+15 storey.

Details	Nomenclature
Regular Frame	RF
RF + X-Bracing	X
RF + V-Bracing	V
RF + Inverted V-Bracing	IV
RF + Diagonal Bracing	D
RF + X-Bracing and V-Bracing	XV
RF + X-Bracing and IV-Bracing	XIV
RF + X-Bracing and D-Bracing	XD
RF + V-Bracing and X-Bracing	VX
RF + V-Bracing and IV-Bracing	VIV
RF + V-Bracing and D-Bracing	VD
RF + IV-Bracing and X-Bracing	IVX
RF + IV-Bracing and V-Bracing	IVV
RF + IV-Bracing and D-Bracing	IVD
RF + D-Bracing and X-Bracing	DX
RF + D-Bracing and V-Bracing	DV
RF + D-Bracing and IV-Bracing	DIV

Plan, 3D and Elevation of Regular Bare Frame Structure model created in software as shown in fig 1,2 and 3 below.

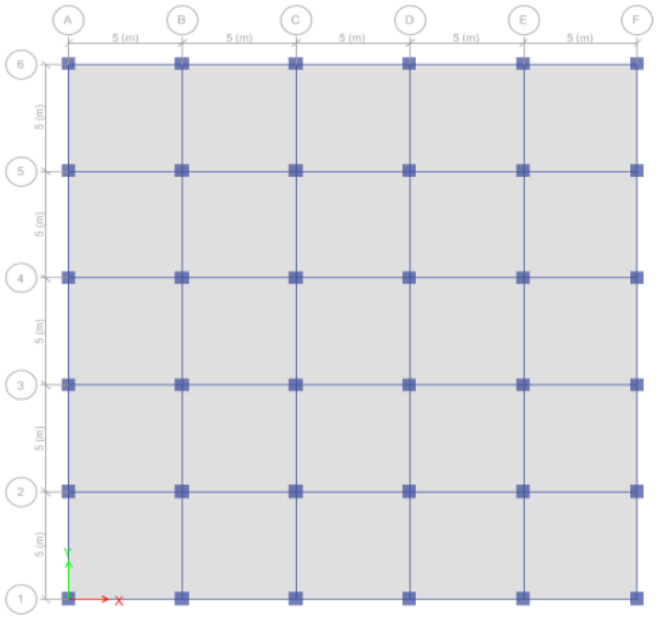


Fig 1: Plan of Regular Frame Structure (RF)

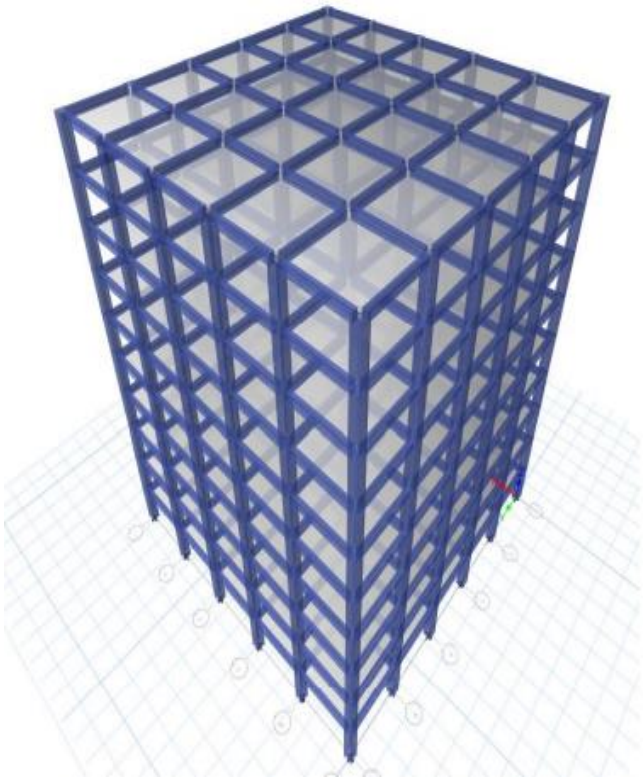


Fig 2: 3D View of Regular Frame (RF)

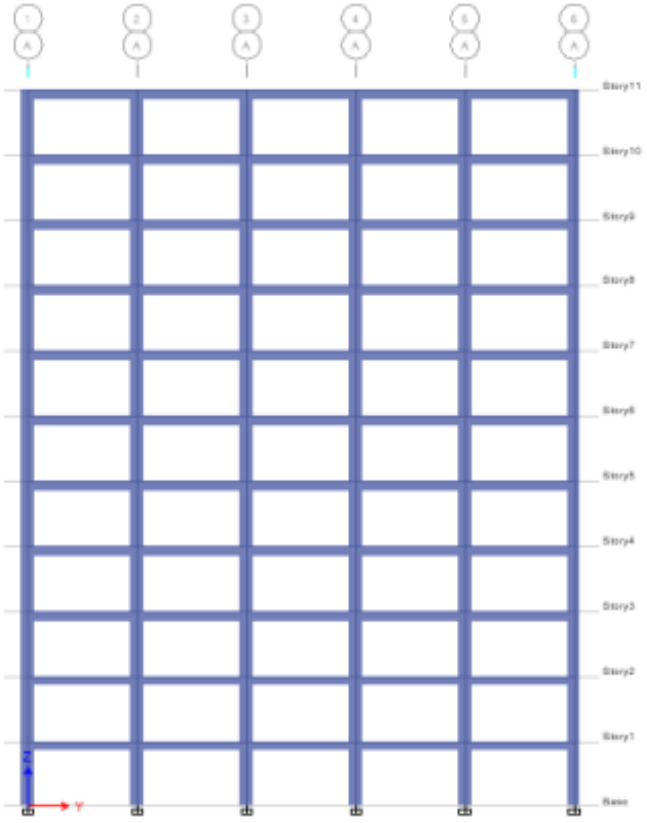
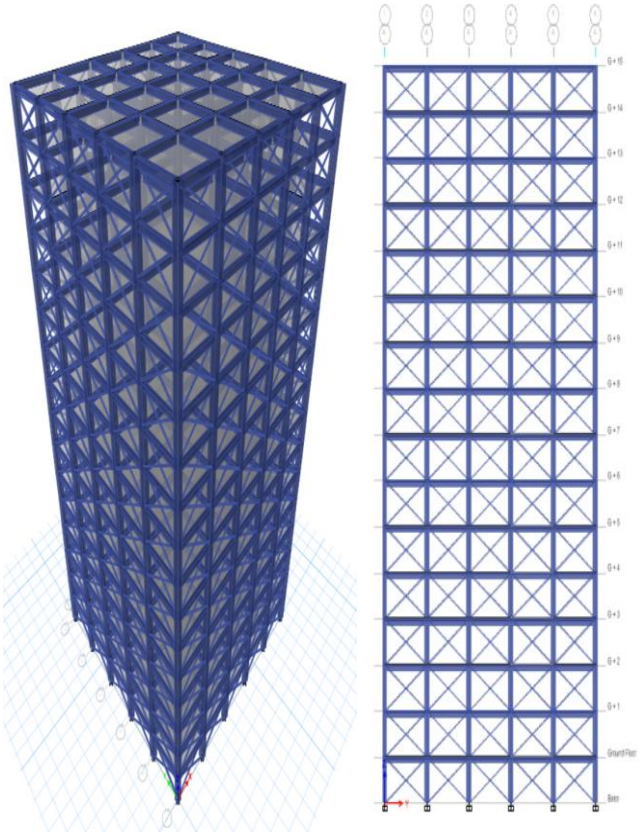
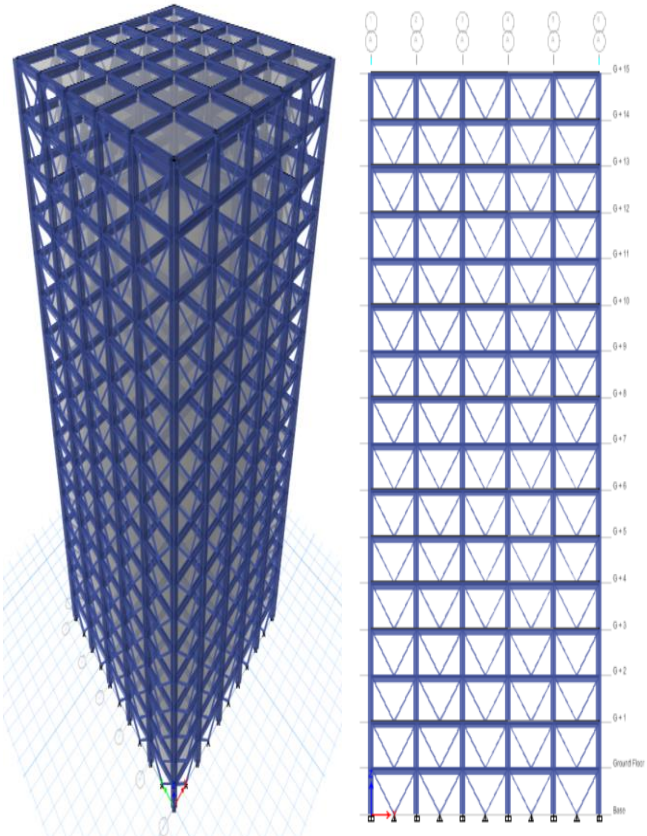


Fig 3: Elevation of Regular Frame (RF)

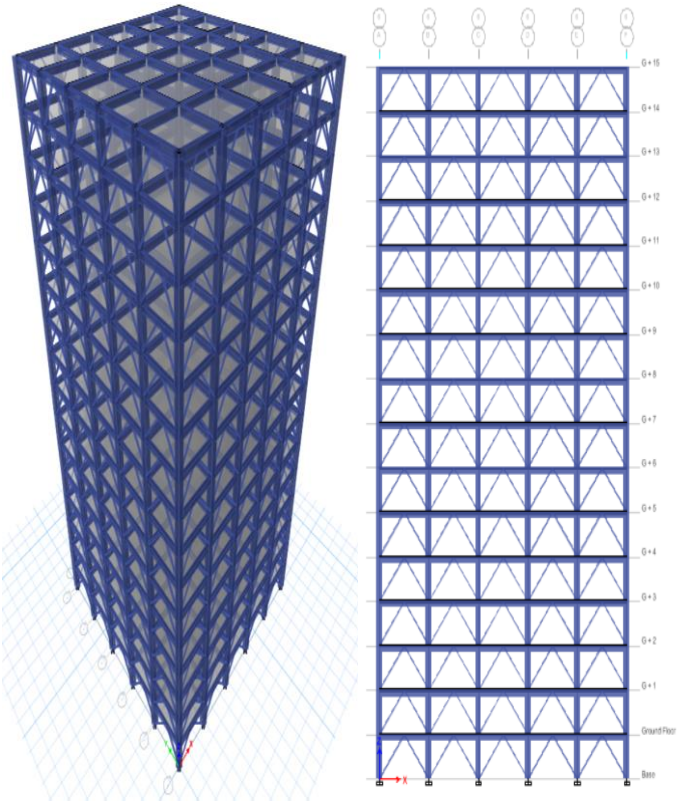
a) 3D & Elevation of RF with X Bracing



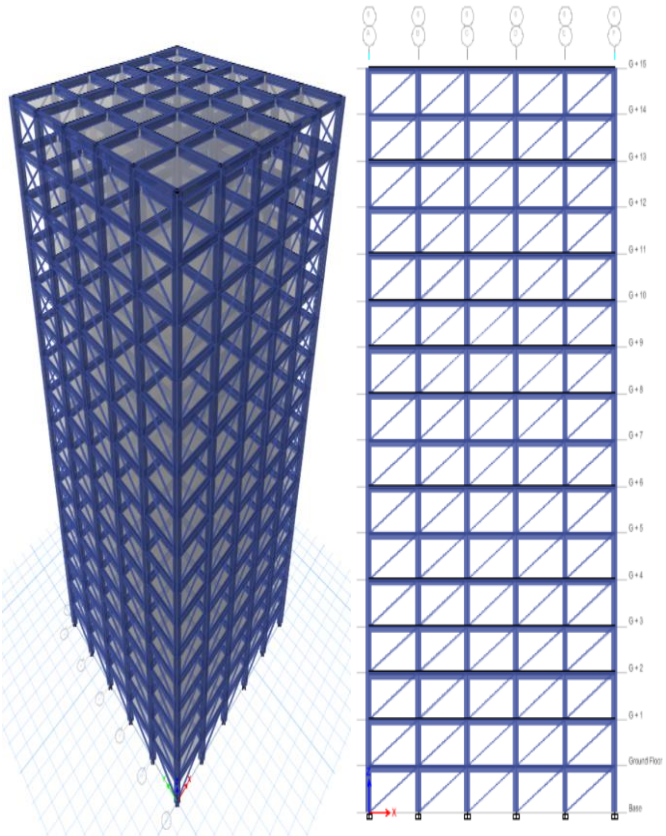
b) 3D & Elevation of RF with V Bracing



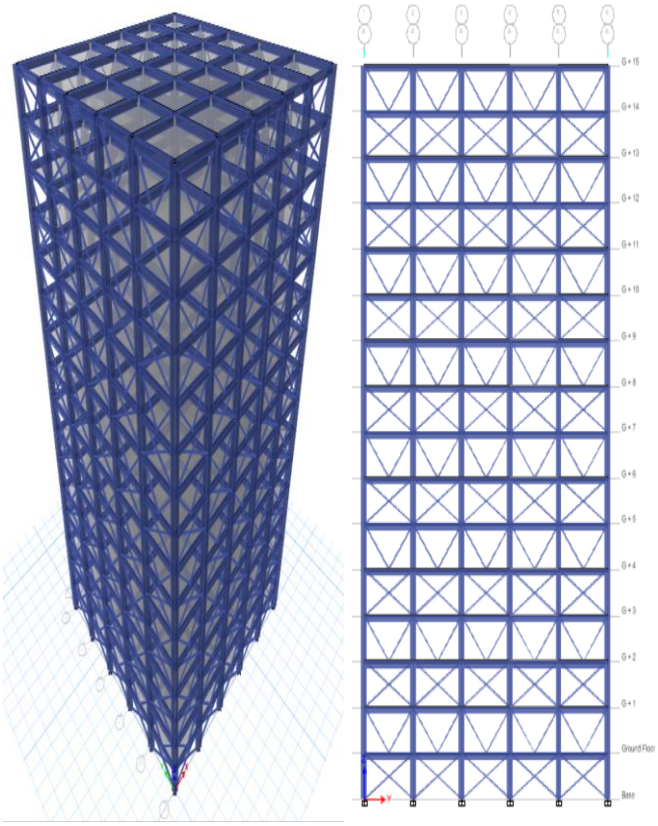
c) 3D & Elevation of RF with IV Bracing



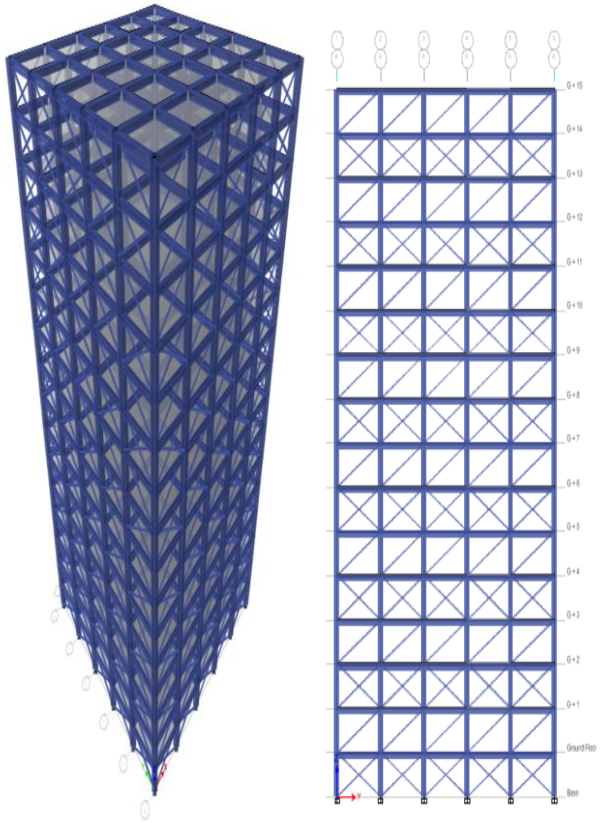
d) 3D & Elevation of RF with D Bracing



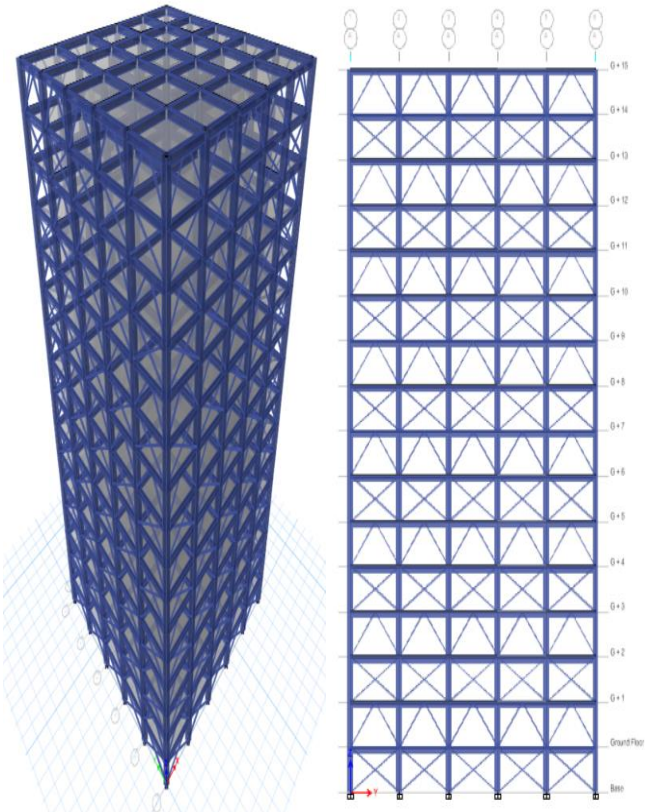
e) 3D & Elevation of RF with XV Bracing



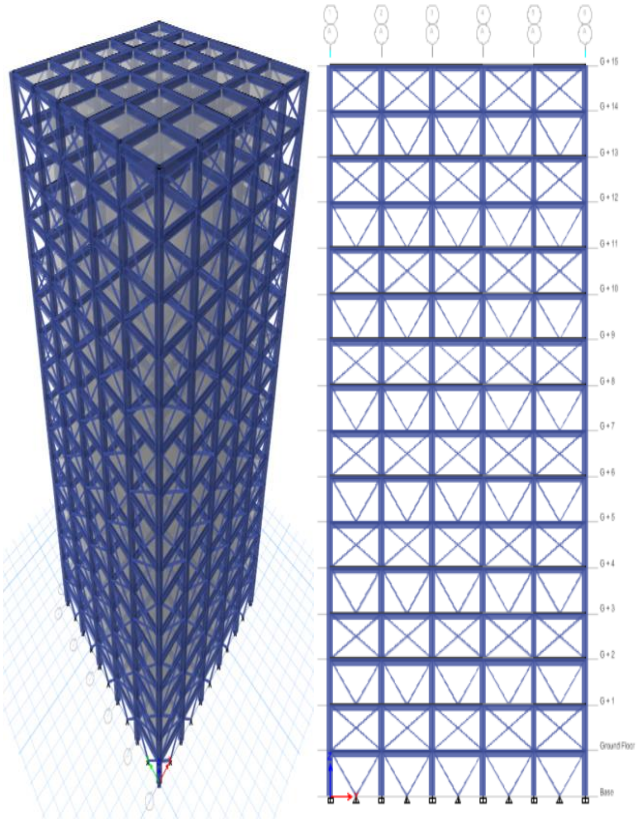
g) 3D & Elevation of RF with XD Bracing



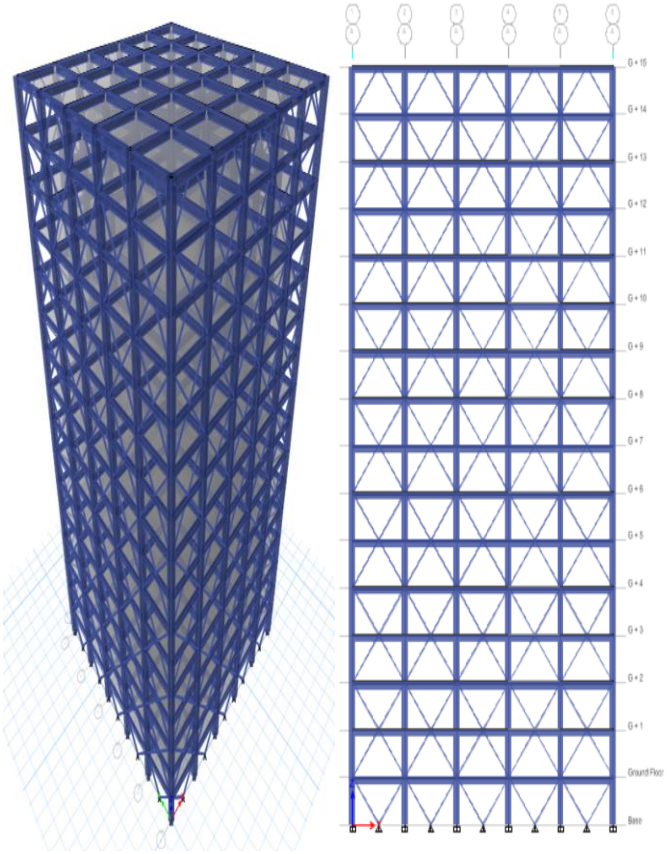
f) 3D & Elevation of RF with XIV Bracing



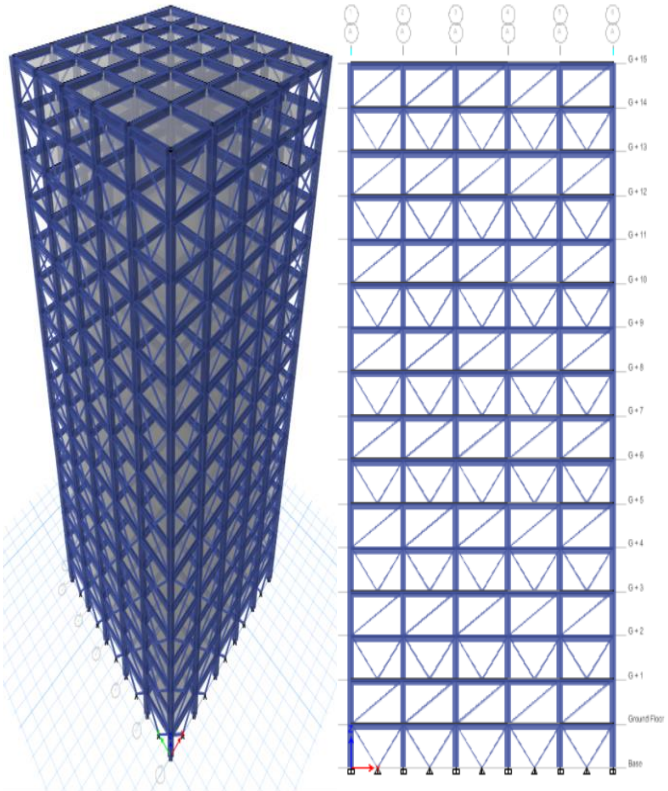
h) 3D & Elevation of RF with VX Bracing



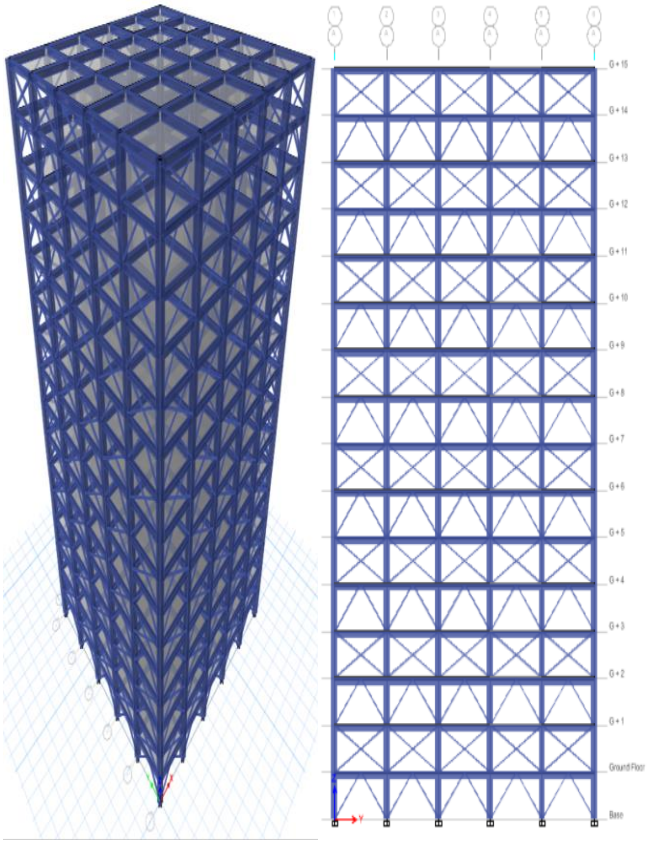
i) 3D & Elevation of RF with VIV Bracing



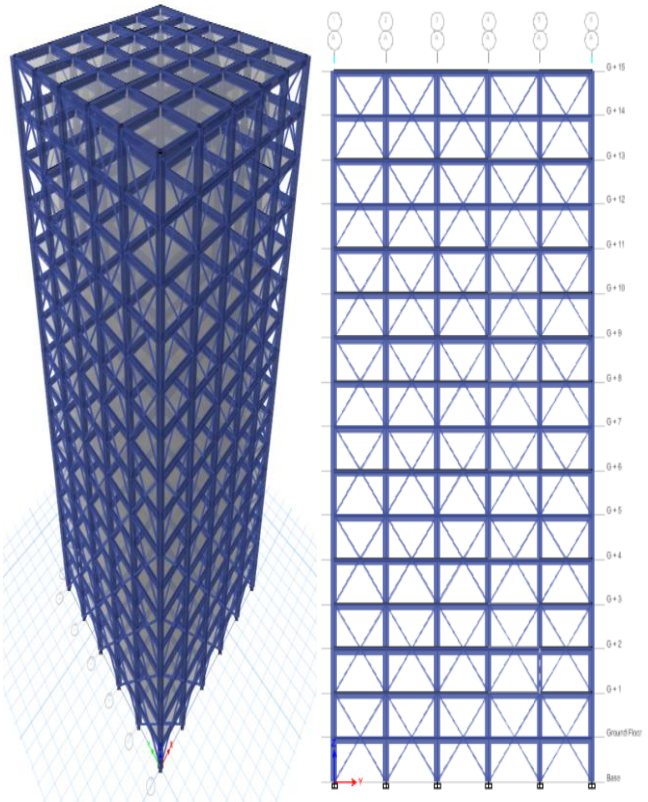
j) 3D & Elevation of RF with VD Bracing



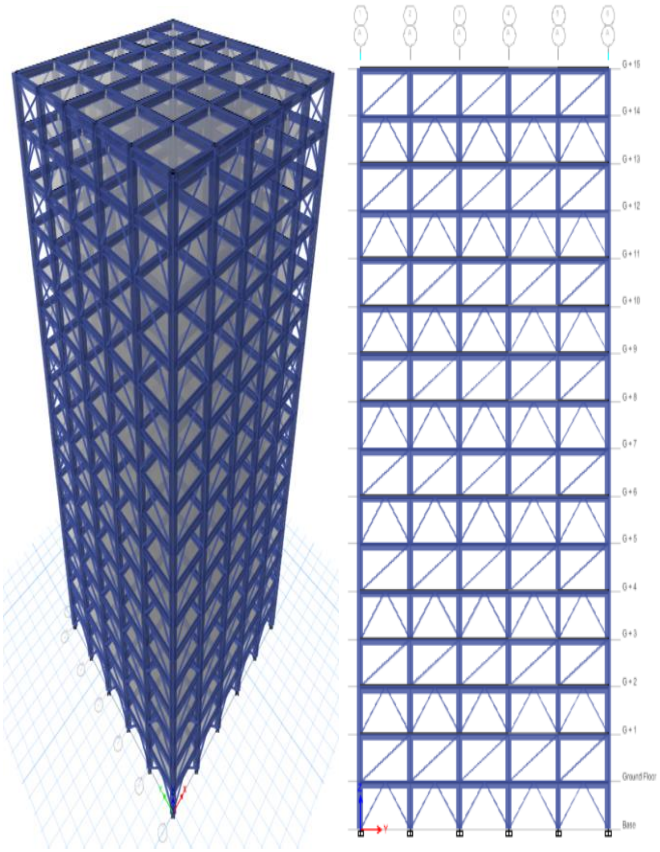
k) 3D & Elevation of RF with IVX Bracing



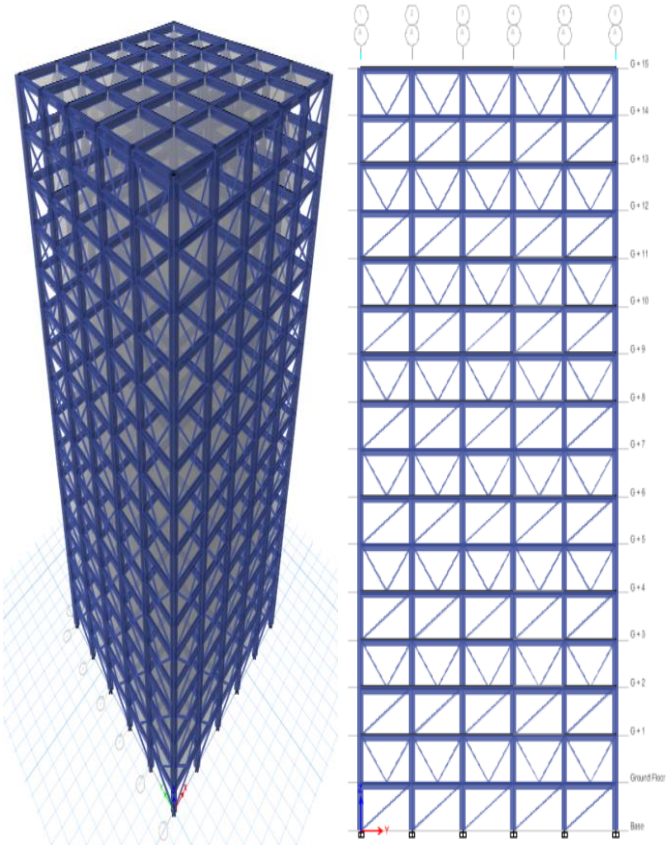
l) 3D & Elevation of RF with IVV Bracing



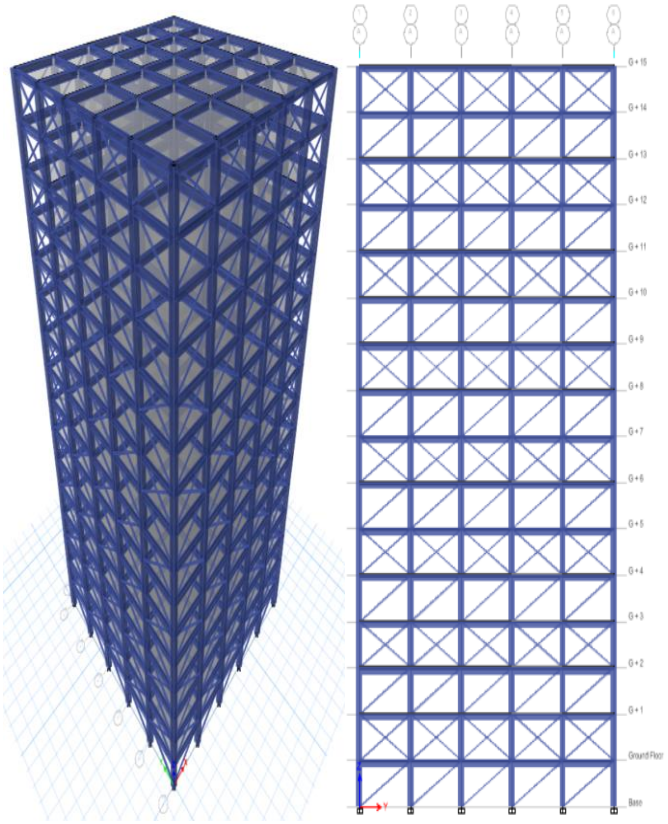
m) 3D & Elevation of RF with IVD Bracing



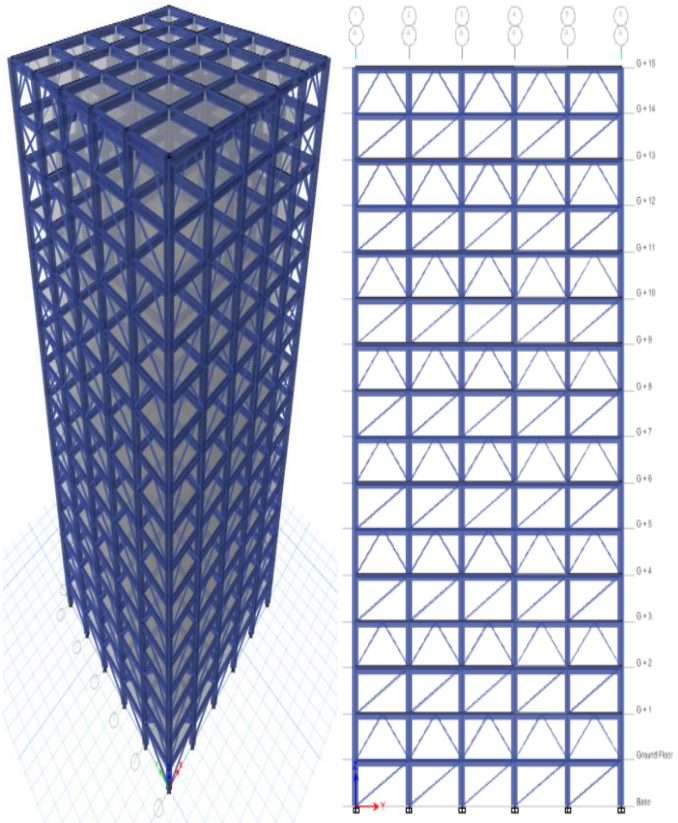
o) 3D & Elevation of RF with DV Bracing



n) 3D & Elevation of RF with DX Bracing



p) 3D & Elevation of RF with DIV Bracing



7. FINITE ELEMENT ANALYSIS

Finite Element Analysis (FEA) is a computerized method for predicting how structures will behave under different conditions. In the context of building design, FEA can be used to simulate the structural behavior of a building, and to optimize its design to ensure it is safe, stable, and cost-effective. FEA works by dividing a complex structure into smaller, simpler parts, called finite elements. By simulating the behavior of each element individually. The process of dividing a continuous domain (like a structure or object) into smaller subdomains, or "elements".

FEA can be particularly useful in identifying potential weaknesses or failure points in a building design before construction begins. By simulating different loads and stresses on the building, FEA can predict how the structure will behave under different conditions, and help engineers and architects make informed decisions about the design and materials used. FEA is a numerical method used to solve complex engineering problems, particularly those involving structures, mechanical components, or systems. It is widely used in fields like civil, mechanical, aerospace, and automotive engineering, as well as in material science.

8. RESPONSE SPECTRUM ANALYSIS

Response spectrum analysis of structure is carried out for the seismic zone V, as per IS 1893-2016, using the response spectrum generated. Base shear, Displacement, Inter-storey drift are obtained for all the models are discussed in this section.

A response spectrum is essentially a representation showing the peak or steady-state response (displacement, velocity, or acceleration) of a sequence of oscillators with varying natural frequencies that are all moved by the same base vibration or shock.

CROSS SECTIONAL PROPERTIES AND MATERIAL CONSTANTS

The cross-sectional properties and material constants considered for the study are shown in Table 3.

Table -3: Cross Sectional Properties and Material Constants

Characteristic strength of steel	250MPa
Modulus of elasticity of steel	21000MPa
Density of steel	77 kN/m^3
Poisson's ratio for steel	0.3
Characteristic strength of concrete	30MPa
Modulus of elasticity of concrete	27386.13MPa
Density of concrete	25 kN/m^3
Poisson's ratio for concrete	0.2

LOADS

Three types of loads are as follows.

1. Dead load
2. Live load / Imposed load
3. Earthquake load (in X and Y direction)

LINEAR DYNAMIC ANALYSIS:

Table -4: Seismic Coefficients

Zone	V
Zone Factor	0.36 (Table 3 of IS:1893:2016)
Importance Factor (I)	1.5 (Table 8 of IS:1893:2016)
Percentage of Live Load Reduction	25% (Table 8 of IS: 1893:2016)
Response Reduction Factor (R)	5.0 (Table 9 of IS:1893:2016)
Soil Type	Type II (Medium or Stiff soil)
Zone	V
Zone Factor	0.36 (Table 3 of IS:1893:2016)
Time period (T)	Program calculated

9. RESULTS AND DISCUSSIONS

9.1 MODAL ANALYSIS

The fundamental time period for all models is obtained from the modal analysis, which calculates the time period on the basis of mass and stiffness of the structure. IS 1893 (Part I): 2016 gives the empirical formula for calculating the natural time period without masonry infill. i.e,

$Ta = 0.075h^{0.75}$

Where h is the total height of the building.

Fundamental time period calculated by modal analysis results are tabulated in Table 5 and the graph showing time period versus models are shown in Fig 4.

Table 5: Time period (sec)

Models	IS 1893(PART 1)-2016	Time period (sec)
RF	1.367	2.881
X		1.423
XV		1.474
XIV		1.468
XD		1.595
V		1.528
VX		1.473
VIV		1.520
VD		1.659
IV		1.514
IVX		1.466
IVV		1.520
IVD		1.652
D		1.818
DX		1.375
DV		1.656
DIV		1.649

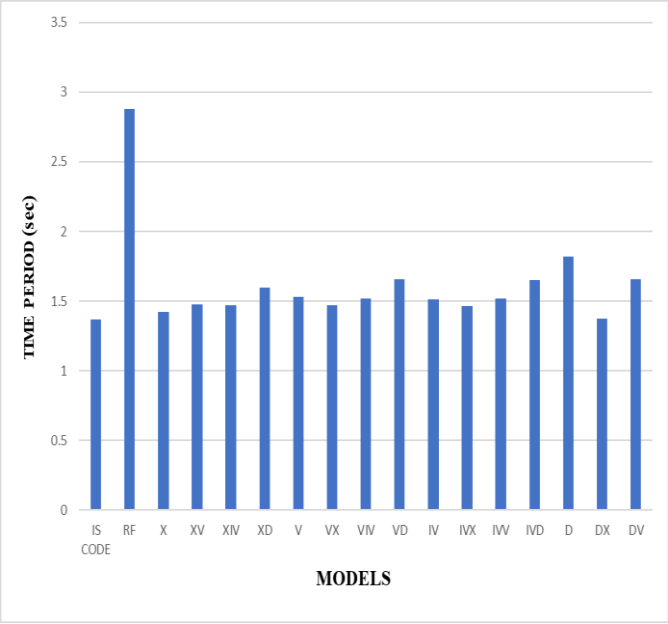


Fig 4. Time period (sec)

9.2 SCALE FACTOR

Scale factor is defined as the ratio of static base shear to dynamic base shear, the ratio this obtained is used in further part of dynamic analysis and shown in Table 6 and 7 and the graph showing corrected base shear versus models are shown in Fig 5.

Scale Factor = $\frac{I\ g}{2\ R}$

Were, g = Acceleration due to gravity (9810 mm/sec^2)

I = Importance factor (1.5)

R = Reduction factor (5)

Scale Factor = $\frac{Static\ base\ shear}{Dynamic\ base\ shear} = \frac{1720.64}{1521.64} = 1.14 > 1s$

Table -6: Scale Factor

Models	Static Base Shear	Dynamic Base Shear	Scale Factor
	EQX/EQY	RSX/RSY	X/Y
RF	1720.64	1521.64	1.14
X	4639.07	3972.73	1.17
XV	4473.78	3853.73	1.16
XIV	4493.67	3867.96	1.16
XD	4132.63	3580.39	1.15
V	4311.92	3729.63	1.16
VX	4477.15	3859.22	1.16
VIV	4333.49	3747.07	1.16
VD	3967.82	3462.10	1.15
IV	4350.82	3761.23	1.16
IVX	4497.52	3870.59	1.16
IVV	4334.87	3747.30	1.16
IVD	3985.92	3474.41	1.15
D	3619.78	3165.28	1.14
DX	3591.09	3058.18	1.17
DV	3976.13	3468.25	1.15
DIV	3993.72	3480.36	1.15

Table -7: Corrected Dynamic Base Shear (kN)

Models	Dynamic Base Shear
	RSX/RSY
RF	1720.64
X	4639.07
XV	4473.78

XIV	4493.67
XD	4132.63
V	4311.92
VX	4477.15
VIV	4333.49
VD	3967.82
IV	4350.82
IVX	4497.52
IVV	4334.87
IVD	3985.92
D	3619.78
DX	3591.09
DV	3976.13
DIV	3993.72

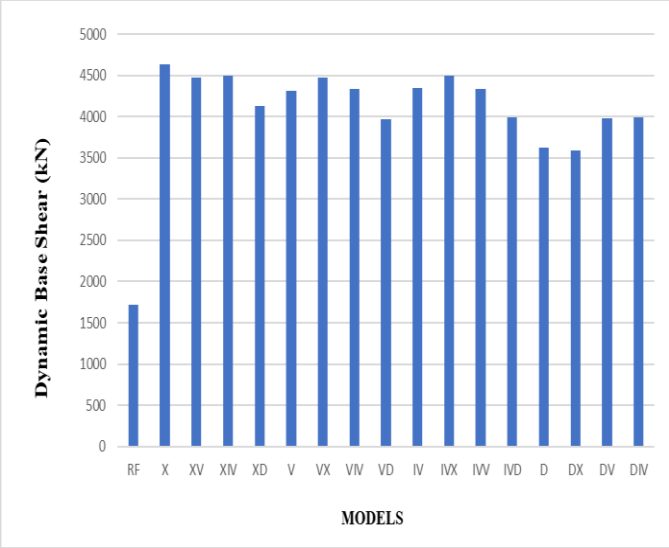


Fig 5. Corrected Dynamic Base Shear (kN)

9.3 STOREY DISPLACEMENT

The storey displacement results of G+15 models are shown in Table 8, 9, 10 and 11. The plot of displacement versus storey for RF and Conventional bracing system and Hybrid bracing system models are shown in Fig 6.

Table -8: Storey Displacement (mm) for Hybrid X Bracings

Storey	RF	X	XV	XIV	XD
G+15	102.51	49.59	51.04	51.31	55.44
G+14	100.18	48.34	49.76	50.00	54.02
G+13	97.00	46.63	48.05	48.27	52.26
G+12	92.83	44.46	45.80	46.01	49.78
G+11	87.70	41.88	43.20	43.39	47.09
G+10	81.71	38.95	40.15	40.32	43.69
G+9	74.96	35.75	36.91	37.07	40.32
G+8	67.59	32.31	33.31	33.46	36.28
G+7	59.71	28.70	29.66	29.79	32.47
G+6	51.43	24.96	25.73	25.85	28.04
G+5	42.87	21.14	21.86	21.97	24.00
G+4	34.15	17.28	17.80	17.89	19.38
G+3	25.42	13.42	13.88	13.95	15.27
G+2	16.92	9.58	9.84	9.89	10.64
G+1	9.10	5.81	6.01	6.04	6.62
Ground	2.84	2.22	2.23	2.23	2.28
Base	0	0	0	0	0

Table -9: Storey Displacement (mm) for Hybrid V Bracings

Storey	RF	V	VX	VIV	VD
G+15	102.51	53.11	51.25	52.77	57.61
G+14	100.18	51.79	50.00	51.49	56.18
G+13	97.00	50.00	48.22	49.72	54.34
G+12	92.83	47.69	46.02	47.44	51.82
G+11	87.70	44.95	43.32	44.72	48.98
G+10	81.71	41.83	40.36	41.63	45.51
G+9	74.96	38.41	36.99	38.22	41.94
G+8	67.59	34.73	33.50	34.57	37.81
G+7	59.71	30.86	29.69	30.72	33.77
G+6	51.43	26.85	25.90	26.73	29.23
G+5	42.87	22.74	21.88	22.64	24.93
G+4	34.15	18.59	17.94	18.50	20.20
G+3	25.42	14.41	13.85	14.34	15.82
G+2	16.92	10.26	9.94	10.22	11.07
G+1	9.10	6.17	5.93	6.14	6.77
Ground	2.84	2.32	2.31	2.32	2.37
Base	0	0	0	0	0

Table -10: Storey Displacement (mm) for Hybrid IV Bracings

Storey	RF	IV	IVX	IVV	IVD
G+15	102.51	52.56	50.99	52.76	57.31
G+14	100.18	51.29	49.76	51.48	55.91
G+13	97.00	49.53	48.00	49.71	54.09
G+12	92.83	47.27	45.82	47.43	51.58
G+11	87.70	44.56	43.14	44.71	48.77
G+10	81.71	41.47	40.18	41.62	45.31
G+9	74.96	38.08	36.83	38.21	41.76
G+8	67.59	34.43	33.35	34.56	37.64
G+7	59.71	30.59	29.56	30.71	33.62
G+6	51.43	26.60	25.77	26.71	29.09
G+5	42.87	22.53	21.76	22.63	24.81
G+4	34.15	18.4	17.84	18.49	20.10
G+3	25.42	14.26	13.77	14.34	15.73
G+2	16.92	10.15	9.87	10.20	11.00
G+1	9.10	6.10	5.89	6.14	6.73
Ground	2.84	2.29	2.28	2.30	2.35
Base	0	0	0	0	0

Table -11: Storey Displacement (mm) for Hybrid D Bracings

Storey	RF	D	DX	DIV	DV
G+15	102.51	63.06	47.81	57.49	57.19
G+14	100.18	61.61	46.74	56.18	55.90
G+13	97.00	59.60	45.10	54.23	53.98
G+12	92.83	56.97	43.16	51.87	51.64
G+11	87.70	53.78	40.59	48.82	48.61
G+10	81.71	50.12	37.94	45.58	45.39
G+9	74.96	46.07	34.68	41.74	41.56
G+8	67.59	41.69	31.55	37.90	37.74
G+7	59.71	37.06	27.84	33.53	33.38
G+6	51.43	32.24	24.41	29.32	29.20
G+5	42.87	27.28	20.47	24.66	24.54
G+4	34.15	22.24	16.91	20.28	20.19
G+3	25.42	17.16	12.88	15.52	15.44
G+2	16.92	12.09	9.32	11.14	11.09
G+1	9.10	7.11	5.36	6.46	6.42
Ground	2.84	2.56	2.14	2.49	2.49
Base	0	0	0	0	0

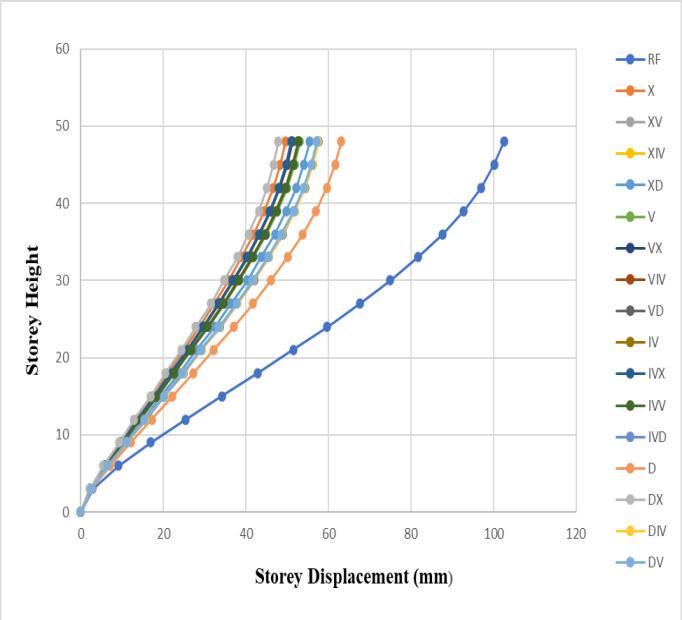


Fig 6. Maximum Storey Displacement (mm) for various Bracing Combinations

9.4 STOREY DRIFT

The storey drift results of G+15 models are shown in Table 12, 13, 14 and 15. The plot of drift versus storey for RF and Conventional bracing system and Hybrid bracing system models are shown in Fig 7.

Table -12: Storey Drift (10^{-4}) for Hybrid X Bracings

Storey	RF	X	XV	XIV	XD
G+15	7.75	4.17	4.35	4.27	4.71
G+14	10.61	5.68	5.76	5.69	5.87
G+13	13.90	7.24	7.56	7.50	8.27
G+12	17.09	8.60	8.72	8.66	8.96
G+11	19.98	9.75	10.22	10.17	11.35
G+10	22.48	10.70	10.86	10.81	11.23
G+9	24.57	11.45	12.04	11.99	13.47
G+8	26.27	12.04	12.23	12.19	12.70
G+7	27.60	12.46	13.13	13.07	14.77
G+6	28.54	12.73	12.94	12.91	13.49
G+5	29.08	12.87	13.59	13.52	15.37

G+4	29.10	12.88	13.12	13.08	13.72
G+3	28.32	12.79	13.56	13.47	15.42
G+2	26.07	12.58	12.81	12.78	13.42
G+1	20.87	11.95	12.70	12.59	14.46
Ground	9.46	7.40	7.44	7.43	7.59
Base	0	0	0	0	0

Table -13: Storey Drift (10^{-4}) for Hybrid V Bracings

Storey	RF	V	VX	VIV	VD
G+15	7.75	4.38	4.20	4.28	4.77
G+14	10.61	5.99	5.90	5.90	6.13
G+13	13.90	7.67	7.34	7.58	8.43
G+12	17.09	9.14	9.00	9.06	9.44
G+11	19.98	10.39	9.89	10.31	11.59
G+10	22.48	11.42	11.23	11.36	11.88
G+9	24.57	12.25	11.63	12.18	13.78
G+8	26.27	12.90	12.67	12.84	13.47
G+7	27.60	13.37	12.66	13.30	15.12
G+6	28.54	13.69	13.44	13.64	14.34
G+5	29.08	13.86	13.09	13.78	15.75
G+4	29.10	13.91	13.64	13.87	14.62
G+3	28.32	13.84	13.03	13.75	15.82
G+2	26.07	13.62	13.35	13.59	14.33
G+1	20.87	12.84	12.08	12.74	14.67
Ground	9.46	7.74	7.69	7.73	7.90
Base	0	0	0	0	0

Table -14: Storey Drift (10^{-4}) for Hybrid IV Bracings

Storey	RF	IV	IVX	IVV	IVD
G+15	7.75	4.23	4.13	4.28	4.69
G+14	10.61	5.86	5.84	5.90	6.06
G+13	13.90	7.55	7.28	7.58	8.36
G+12	17.09	9.03	8.95	9.06	9.38
G+11	19.98	10.29	9.84	10.32	11.54
G+10	22.48	11.33	11.19	11.35	11.82
G+9	24.57	12.16	11.60	12.19	13.73
G+8	26.27	12.81	12.62	12.83	13.41
G+7	27.60	13.28	12.63	13.32	15.08
G+6	28.54	13.59	13.38	13.61	14.27
G+5	29.08	13.76	13.07	13.82	15.72
G+4	29.10	13.80	13.56	13.82	14.54
G+3	28.32	13.72	13.00	13.8	15.78
G+2	26.07	13.49	13.26	13.53	14.23
G+1	20.87	12.70	12.04	12.81	14.62
Ground	9.46	7.64	7.60	7.65	7.82
Base	0	0	0	0	0

Table -15: Storey Drift (10^{-4}) for Hybrid D Bracings

Storey	RF	D	DX	DIV	DV
G+15	7.75	4.81	3.57	4.37	4.29
G+14	10.61	6.72	5.46	6.48	6.40
G+13	13.90	8.78	6.46	7.89	7.81
G+12	17.09	10.62	8.59	10.15	10.09
G+11	19.98	12.2	8.83	10.79	10.73
G+10	22.48	13.51	10.85	12.82	12.77
G+9	24.57	14.59	10.46	12.80	12.74
G+8	26.27	15.43	12.34	14.57	14.53
G+7	27.60	16.07	11.43	14.02	13.95
G+6	28.54	16.52	13.15	15.55	15.51
G+5	29.08	16.8	11.87	14.58	14.50
G+4	29.10	16.94	13.43	15.89	15.84
G+3	28.32	16.91	11.85	14.60	14.51
G+2	26.07	16.59	13.20	15.60	15.55
G+1	20.87	15.19	10.74	13.21	13.10
Ground	9.46	8.52	7.15	8.31	8.30
Base	0	0	0	0	0

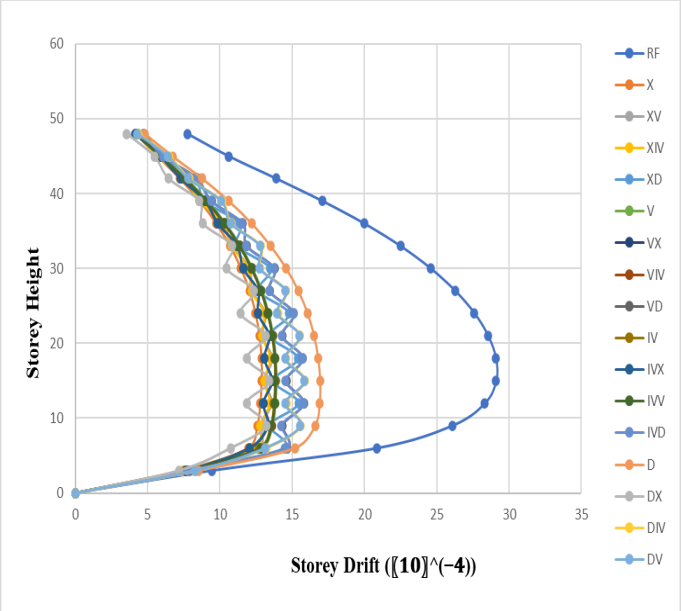


Fig 7. Storey Drift (10^{-4}) for various Bracing Combinations

10. CONCLUSIONS

1. According to IS 1893-2016, the Time Period is same for all models having same heights and the code does not take bracings into account.
2. The Time Period calculated according to IS 1893-2016 (Part I) does not match with the time period by modal analysis for bare frame models, where as to some extent it is highlighting the influence with Hybrid bracing system.
3. The Time Period in Hybrid bracing system is least of DX-Bracings followed by IVX-Bracings and XIV-Bracings for all the floor height due to the increase in stiffness by bracings.
4. The Time Period in Conventional bracing system is least of X-Bracings followed by IV-Bracings, V-Bracings and D-Bracings for all the floor height due to the increase in stiffness by bracings.
5. Form all the models Bare frame models are having the highest time period due to less stiffness compared to all other models.
6. The average Time Period in Conventional bracing system is 15% more than IS 1893 (Part 1)-2016 due to increase in stiffness.
7. The average Time Period in Hybrid bracing system is 13% more than IS 1893 (Part 1)-2016 due to increase in stiffness.
8. As the height of the structure increases there is decrease in Base Shear due to increase in Time Period.
9. The Base shear in Hybrid bracing system is highest of IVX-Bracings followed by XIV-Bracings and VX-Bracings for all the floor height.
10. The Base shear in Conventional bracing system is highest of X-Bracings followed by IV-Bracings, V-Bracings and D-Bracings for all the floor height.
11. For all the floor height Bare frame model is having the least Base Shear due to less self-weight the structure compared to all other braced models.
12. The average Base shear of Conventional bracing system is 60% more than Bare frame model due to increase in self-weight of the structure.
13. The average Base shear of Hybrid bracing system is 59% more than Bare frame model due to increase in self-weight of the structure.
14. The Comparing of various X bracings combinations, X-Bracing followed by XV, XIV and XD has a least storey displacement.
15. The Comparing of various V bracings combinations, VX-Bracing followed by VIV, V and VD has a least storey displacement.
16. The Comparing of various IV bracings combinations, IVX-Bracing followed by IV, IVV and IVD has a least storey displacement.
17. The Comparing of various D bracings combinations, DX-Bracing followed by DV, DIV and D has a least storey displacement.
18. The Storey Displacements in Conventional bracing system is least of X-Bracing followed by IV-Bracing, V-Bracing and D-Bracing for all the floor height.
19. The Storey Displacements in Hybrid bracing system is least of DX-Bracing followed by IVX-Bracing and XV-Bracing for all the floor height.
20. For all the floor height Bare frame models is having the highest displacements due to less stiffness of the structure compared to all other braced models.
21. The average Storey Displacement of Conventional bracing system is 53% less than Bare frame model due to increase in stiffness of the structure.
22. The average Storey Displacement of Hybrid bracing system is 49% more than Bare frame model due to increase in stiffness of the structure.
23. The DX-Bracing has least Storey Displacement when compaired to all other models.
24. The Comparing of various X bracings combinations, X-Bracing followed by XIV, XV and XD has a least storey drift.
25. The Comparing various V bracings combinations, VX-Bracing followed by VIV, V and VD has a least storey drift.
26. The Comparing various IV bracings combinations, IVX-Bracing followed by IV, IVV and IVD has a least storey drift.
27. The Comparing various D bracings combinations, DX-Bracing followed by DV, DIV and D has a least storey drift.
28. The Storey Drift in Conventional bracing system is least of X-Bracing followed by IV-Bracing, IV-Bracing and D-Bracing for all the floor height.

29. The Storey Drift in Hybrid bracing system is least of DX-Bracing followed by IVX-Bracing and VX-Bracing for all the floor height.
30. For all the floor height Bare frame models is having the highest storey drift due to decrease in lateral stability to the structure compared to all other braced models.
31. The average Storey Drift of Conventional bracing system is 57% less than Bare frame model due to increase in lateral stability of the structure.
32. The average Storey Drift of Hybrid bracing system is 52% more than Bare frame model due to increase in lateral stability of the structure.
33. Storey Drift of all the models are within the permissible limit i.e 0.004 times the height of the storey as per IS 1893-2016.
34. In Hybrid bracing system there is irregular shape of graph in storey drift it is due to alternative bracing at each floor of the building.
35. The DX-Bracing has least Storey Drift when compaired to all other models.
36. DX-Hybrid Bracing System performs well in Storey Displacement and Storey Drift when compaired to all other Conventional braced models as well as Hybrid braced models.

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