DYNAMIC ANALYSIS OF STEEL TUBE STRUCTURE WITH BRACING SYSTEMS

Dhanapalagoud Patil[1], Naveena M P[2]

[1] Student, Structural Engineering, MVJ College of Engg, Karnataka, India
[2]Assistant Professor, Structural Engineering, MVJ College of Engg, Karnataka, India

Abstract

Nowadays, competition towards rise of tall steel structures made certain factors are compulsory like serviceability and comfort of human relating to lateral loads caused by wind or earthquake. Earthquake is dangerous to the living beings in terms of its effects on manmade structures. Structures like tall buildings are built to resist gravity loads. However many tall buildings are not so resistant in lateral loads due to earthquake so need an improvement in resisting lateral loads. So there are many structural systems which resist lateral loads by varying orientation, addition of different structural systems. Like steel tubular structural system is considered and compared for their results against lateral forces and also by providing mega bracing system and diagrid bracing system. In this dissertation work, four structural systems are considered in which one is framed structure and rest are tubular system with addition of different bracing systems as mega bracing and diagrid bracing system. For the purpose 45 storey steel structure with rectangular plan of dimension 44mx24m uniform throughout the height is considered and analyzed for gravity and lateral loads using ETABS software. Its intention is to obtain the functioning characteristics like displacements, storey shear, time period, frequency, peak displacement and peak acceleration in both x and y direction to get most economical structure in all ways. Results shows that the steel tubular structure with mega bracing system performance is much better than the framed structure, tubular and tubular structure with diagrid bracing system.

Keywords: *Steel Tube Structure, Mega Bracing, Diagrid Bracing, Dynamic Analysis, ETABS, Time and History Analysis.*

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1. INTRODUCTION

Structures are being used from the antiquated times, where as the change in human's life made tall structures more adoptable for their economic wellbeing, requirement for their most elevated eminence in the general public for their legendry. Now days the development of urban communities by relocation of individuals from their local to lovely urban areas made more thickness more than a territory as a result ascent of tall structures have been happened. However science, technology, architect have also influencing the ascent of tall buildings. In tall structures the tallness is comparative term. Exact definition of tall structures cannot be applied worldwide. From structural engineering point of view tall structures must resist gravity and also lateral loads. The competition towards rise of tall structures have made significant about the design of building to resist against lateral load. The geometry of the building also not the fundamental criteria to design the tall and slender building yet the drift of the building is responsible for stresses developed in the building. Various structural systems are raised for stabilization of tall building against lateral loads like shear frames, belt truss with out-rigged system, frames with bracings, super columns, shear wall, wall-frame, braced tube system, outrigger system, tubular system, mega bracing. Recently, the Diagrid – Diagonal Grid – structural system is widely used.

1.1 Scope and Objective.

- An attempt has been made to Analyze the fallowing tall structure using conventional software ETABS. 1) Frame structure, 2) Tube Structure, 3) Tube Structure with mega bracings, 4) Tube Structure with Diagrid bracings.
- Numbers of stories considered are 45 stories, each of height 4m for all models.
- To investigate and study by applying different available structural systems. For minimizing the deflection under lateral loading.
- Structures are analyzed using equivalent static analysis and dynamic analysis for particular soil and zone.
- Responses of different structural systems are studied in terms of displacements, story drifts.
- Conclusions are drawn based on the observations and better structural system is found out with this study.

1.2 Concept of Tubular System

- ✓ The main ideology of tubular structure is to resist horizontal load by arranging structural element efficiently.
- ✓ In this system many elements contribute to resist loads like slabs columns beams mainly spandrel beams and columns at the periphery of the building resist lateral load.

The interior core of the building is to resist gravity load.

- ✓ The distance between the interior and external frame is connected by beams and slab or only slab to resist gravity load.

1.3 Framed Tube Behavior

This type of structure has columns spaced closely at the perimeter and columns joined by beams which resist lateral loads. This creates tube as continues perforated chimney. Stiff moment resistant between beam and column provides lateral stiffness. This type of structure is constructed for 40 and 60 stories above up to 100 stories. The columns and beams frame along loading direction of loading acts as web frames and normal to the direction of loading acts as flange frames. Shear lag is suffered by flange frames which results in less stressed at internal tube and more stressed at external corner columns. This type of structure will have large floor openings and internal columns will resist vertical load only.

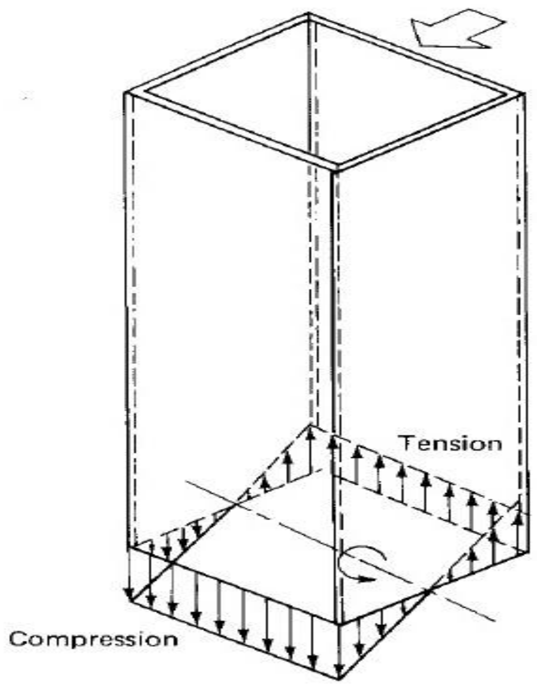

Fig - 1: Framed Tube Structure Behavior

1.4 Shears Lag in Tube Structure

The frames normal to the loading are called flange frames and perpendicular to the loading are web frames. The axial force distribution of the web and flange frames is shown in Fig - 2. The ideal tube behavior tells that uniform axial force in flange frame and varying in web frame. In framed tube structure the axial force will be maximum at the corner and reduces at the centre due to high rigidity of a spandrel beam. The axial strength in the inner column will lag behind corner column because of less sharing rigidity among the inner and outer frames. This is known as shear-lag. Negative shear-lag observed as the axial force allocation shown in Fig -2, will be reverse at the top of the building.

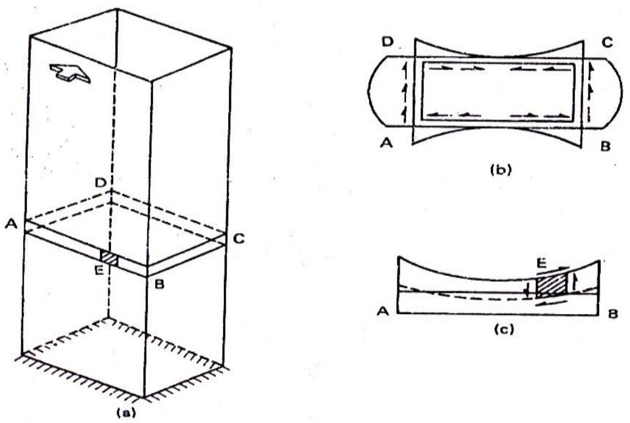

Fig - 2: Shear Lag Effect in Tube Structures.(a)Cantilever tube subjected to lateral loads; (b) Shear stress distribution; (c) distribution of flange element caused by shear stresses.

1.5 Tube Structure with Mega Bracings

With the increment in utilizing tall steel braced tube structures, the significance of different propping setups to have the best execution and the most reduced material was more considered. External larger scale bracing, stretching out over numerous stories, has been utilized to deliver exceptionally proficient structures, as well as attractively appealing structures. The diagonal components that keep running over a bay or face of the building fasten the entire structure together and convert the building into a vertical cantilever beam. In the braced tube structures the bracing contributes also enhanced execution of the tube in conveying gravity loading, differences between gravity load stresses in the columns are leveled out by the braces transferring axial loading from the more highly to the less highly stressed columns. In this dissertation work the diagonal bracing is provided for every 5stories.

1.6 Tube Structure with Diagrids Bracing System

Configuration and development of counterfeit foundation on the lines of biomimicking standards requires the improvement of much progressed structural frameworks which has the characteristics of aesthetic expression, basic productivity and in particular geometric flexibility. Diagrids, the most recent transformation of tubular structures, have an ideal blend of the above qualities. The Diagrids are perimeter structural setup characterized by a narrow grid of diagonal members which are implicated both in gravity and in lateral load resistance. Diagonalized applications of structural steel members for providing well organized solutions both in terms of strength and stiffness are not new, however nowadays a renewed interest in and a widespread application of Diagrid is registered with reference to large span and tall structures, predominantly when they are characterized by complex geometries and curved shapes, sometimes by completely free forms.

As in the Diagrids, diagonals convey both shear and moment. Therefore, the ideal point of diagonals is exceptionally needy upon the building height. Since the optimal point of the segments for most extreme bending rigidity is 90 degrees and that of the diagonals for greatest shear rigidity is about 35 degrees, it is expected that the optimal angle of diagonal members for Diagrid structures will fall between these angles and as the building height increases, the optimal angle also increases. Usually adopted range is 60º -70º degree. In this case 60º is provided.

2. METHODOLOGY

To achieve the above objective following step-by-step procedures are followed

- Carried out literature study to find out the objectives of the project work.
- Understand the Earthquake loading analysis of Steel Tube Structure with Bracing Systems is carried out as per Indian Standard IS 1893(part 1):2002.
- Analyse all the selected Steel Tube Structure models using ETABS Software.
- Evaluate the analysis results and verify the requirement of the geometrical limitations.

2.1 Dimensional Description of Steel Tube Structure with Bracing Systems.

In this study four types of models are chosen. The plan, height of floor, no of Stories, deck slab thickness remains the same for all the models. Plan dimension of all models is 44 m x 24 m and inner core of dimension 12 m x 8 m. The total height of the structure is 180 meter. Each floor height is 4 meter, floor of steel composite deck of thickness 175 mm and 200 mm , the built up column dimension is ISWB - 600, beam is ISMB - 600, and the live load is taken as $4kN/m^2$, SDL of $2kN/m^2$ and glazing of $6kN/m^2$ are considered. In mega bracing system the bracings ISWB-600 are provided for every 5stories interval and in Diagrid Bracing system the bracings ISWB - 600 are provided at an angle of 60^0.

2.2 Basic Data for Modeling

- Type of soil = medium soil
- Seismic zone = IV
- Importance factor = 1
- Response reduction factor = 5
- Height of Structure = 180m.

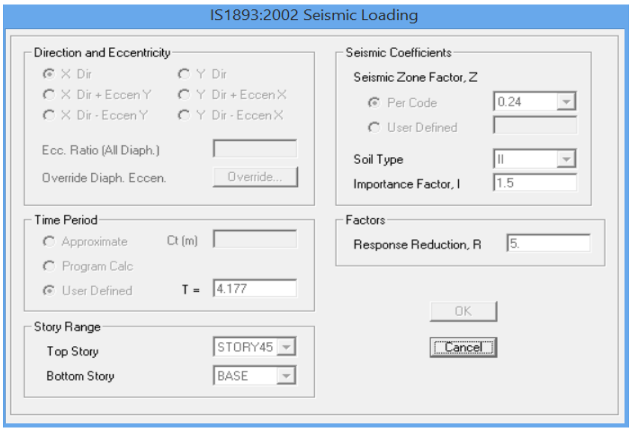

Table - 1: IS 1893:2002 Sesmic Loading.

$$T_a = 0.085(180)^{0.75} = 4.177$$

Combination	Limit State of Strength						Limit State of Serviceability		WL/EL
	DL	LL		WL/ EL	AL	DL	LL		
		Leading	Accompanying (CL, SL etc.)				Leading	Accompanying (CL, SL etc.)	
DL+LL+CL	1.5	1.5	1.05	-	-	1.0	1.0	1.0	-
DL+LL+CL+	1.2	1.2	1.05	0.6	-	1.0	0.8	0.8	0.8
WL/EL	1.2	1.2	0.53	1.2					
DL+WL/EL	1.5 (0.9)*	-	-	1.5	-	1.0	-	-	1.0
DL+ER	1.2 (0.9)	1.2	-	-	-	-	-	-	
DL+LL+AL	1.0 0.35	0.35	-	1.0	-	-	-		

*This value is to be considered when stability against overturning or stress reversal is critical. Abbreviations: DL = Dead Load, LL = Imposed Load (Live Loads), WL = Wind Load, SL = Snow Load, CL = Crane Load (Vertical / horizontal), AL = Accidental Load, ER = Erection Load, EL = Earthquake Load.

Note: The effects of actions (loads) in terms of stresses or stress resultants may be obtained from an appropriate method of analysis.

Table - 2: Load Combination for Analysis.

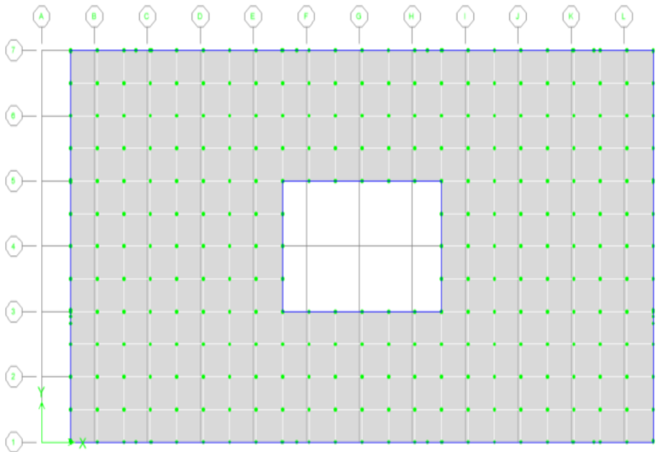

Fig - 3: Plan for All Model Analysis

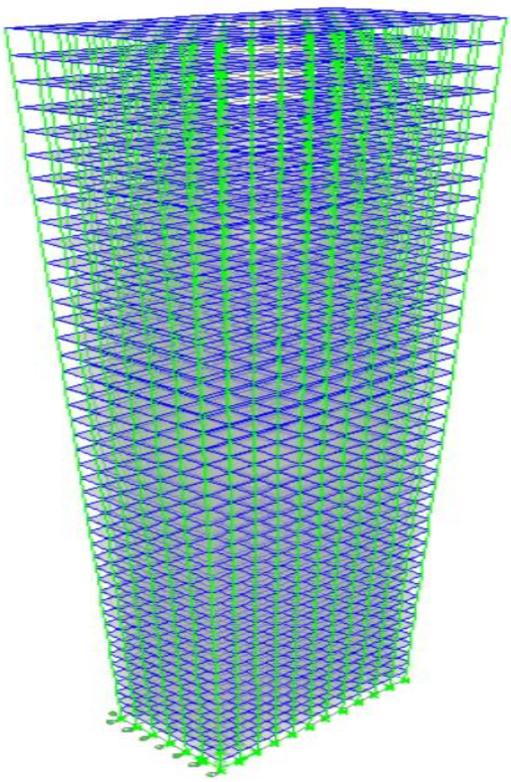

Fig - 4: Steel Frame Structure Model M1.

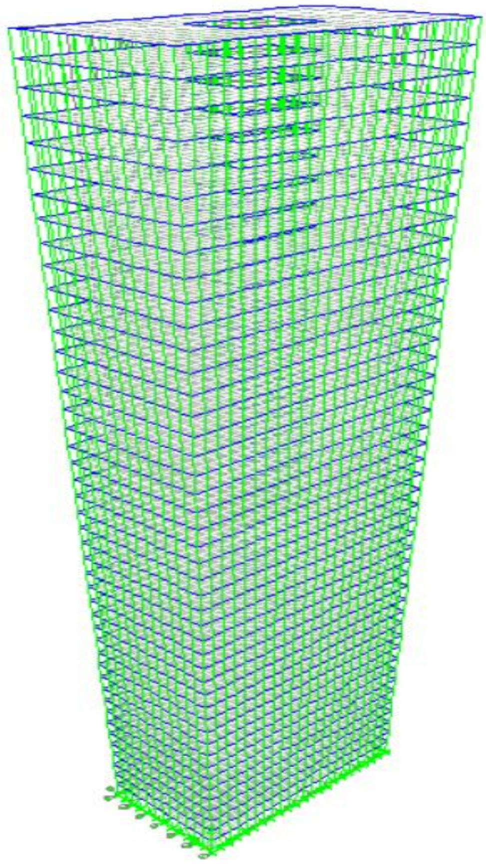

Fig - 5: Steel Tubular Structure Model M2

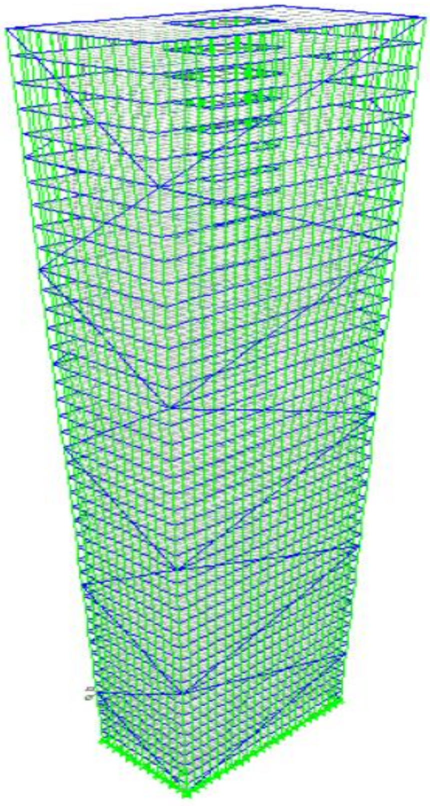

Fig - 6: Steel Tubular Structure with Mega Bracing System Model M3

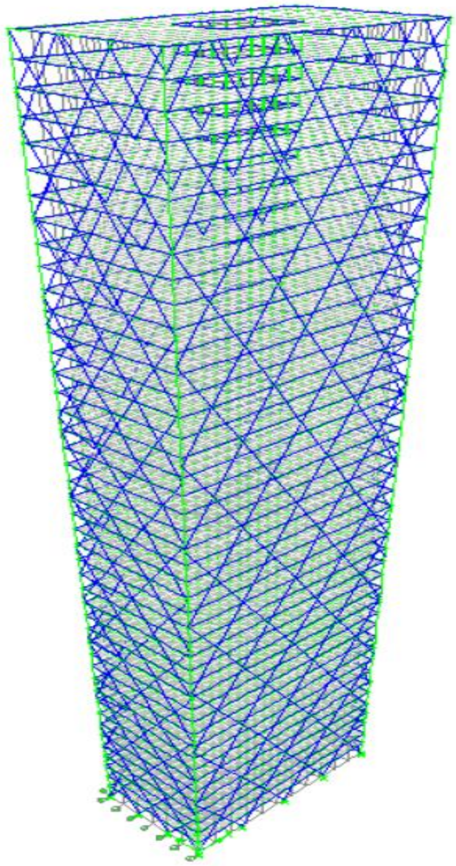

Fig - 7: Steel Tubular Structure with Diagrid Bracing System Model M4

3. RESULTS AND DISCUSSIONS

Here the results of frame structure and tubular structure with different bracing system are compared after their analysis in ETABS equivalent static and response spectrum methods. The results considered for the following parameters.

1. Point displacement
2. Storey drift
3. Modal analysis
4. Time history results

The models and their abbreviations are given below:

a) FRAME STRUCTURE - **M1**
b) TUBE STRUCTURE - **M2**
c) TUBE STRUCTURE WITH MEGA BRACINGS - **M3**
d) TUBE STRUCTURE WITH DIAGRID BRACINGS - **M4**

3.1 Lateral Displacements

The results for the maximum displacements for frame structure and tubular structural with different bracing systems (45 storey) obtained from seismic analysis along x and y direction are obtained and are compared between them in table further graphs for the same results are provided. Displacement values in mm.

Table - 3: Displacement for 45 storey seismic analysis in X - direction

Displacement for EQX mm				
Storey	**M1**	**M2**	**M3**	**M4**
STOREY45	200	142	123	221
STOREY44	198	140	121	216
STOREY43	196	138	119	210
STOREY42	193	136	117	205
STOREY41	190	133	115	200
STOREY40	187	130	112	194
STOREY39	183	128	110	187
STOREY38	180	125	107	181
STOREY37	176	122	105	175
STOREY36	172	119	102	169
STOREY35	168	116	99	162
STOREY34	164	113	96	155
STOREY33	159	109	93	149
STOREY32	155	106	90	143
STOREY31	150	102	87	137
STOREY30	145	99	84	130
STOREY29	140	95	81	124
STOREY28	136	92	78	118
STOREY27	131	88	75	112
STOREY26	125	85	72	106
STOREY25	120	81	69	100
STOREY24	115	77	65	94
STOREY23	110	73	62	88
STOREY22	105	70	59	83
STOREY21	99	66	56	77
STOREY20	94	62	52	72
STOREY19	89	59	49	66
STOREY18	84	55	46	62
STOREY17	78	51	43	58
STOREY16	73	48	40	53
STOREY15	68	44	37	49
STOREY14	63	41	34	45
STOREY13	58	37	31	41
STOREY12	52	34	28	38
STOREY11	47	30	25	34
STOREY10	42	27	22	31
STOREY9	38	24	20	27
STOREY8	33	21	17	24
STOREY7	28	18	15	21
STOREY6	23	15	12	18
STOREY5	19	12	10	15
STOREY4	14	9	8	11
STOREY3	10	7	5	8
STOREY2	6	4	3	5
STOREY1	2	2	2	2

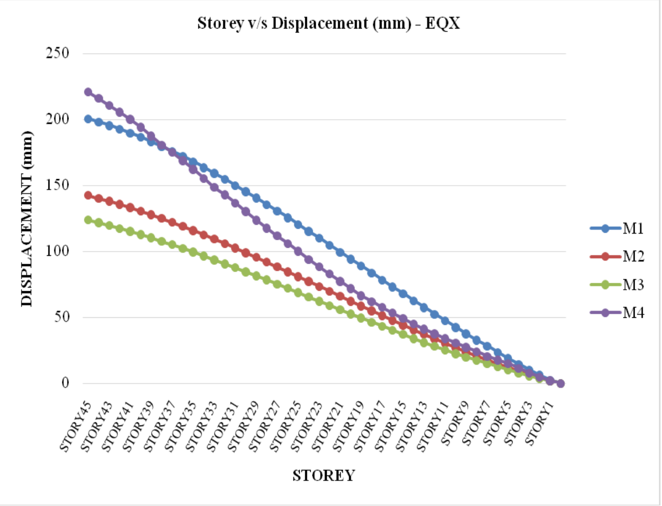

Fig - 8: Storey displacement in x direction for 45 storey seismic analysis

Observations and Discussions: From the above graph, it is observed that as the height of building increases, displacement stories also increases. The model M1 showing displacement of 200mm at the 45th storey and it has been considered as Datum line. The model M2, M3, and M4 correspondingly showing the displacement of 142mm, 123mm, and 221mm respectively. From the above statistics the model M3 shows reduction in displacement up to 38.5% of M1, 13.38% of M2, and 79.67% of M4. As per the economical view and codal provision the model M4 shows best suitable for practical application.

Table - 4: Displacement for 45 storey seismic analysis in Y -direction

Displacement for EQY mm				
Storey	**M1**	**M2**	**M3**	**M4**
STOREY45	363	322	270	524
STOREY44	357	316	265	510
STOREY43	351	310	260	495
STOREY42	344	304	254	480
STOREY41	337	298	248	465
STOREY40	330	291	243	450
STOREY39	323	284	237	435
STOREY38	315	277	231	420
STOREY37	307	270	224	405
STOREY36	299	263	218	389
STOREY35	291	255	211	374
STOREY34	282	248	204	359
STOREY33	274	240	197	344
STOREY32	265	232	191	329
STOREY31	256	224	184	314
STOREY30	247	216	177	298
STOREY29	237	207	170	283
STOREY28	228	199	163	269
STOREY27	219	191	156	254
STOREY26	209	182	149	240
STOREY25	200	174	141	226
STOREY24	191	165	134	211
STOREY23	181	157	127	197
STOREY22	172	148	120	184

STOREY21	162	140	113	171
STOREY20	153	131	106	158
STOREY19	143	123	99	145
STOREY18	134	115	92	133
STOREY17	125	107	86	121
STOREY16	116	98	79	109
STOREY15	107	91	72	99
STOREY14	98	83	65	88
STOREY13	90	75	59	78
STOREY12	81	68	53	68
STOREY11	73	60	47	59
STOREY10	65	53	42	51
STOREY9	57	46	36	42
STOREY8	49	40	31	35
STOREY7	42	34	26	28
STOREY6	35	28	22	21
STOREY5	28	22	17	15
STOREY4	21	16	12	11
STOREY3	15	11	8	7
STOREY2	9	7	5	3
STOREY1	3	3	2	1
BASE	0	0	0	0

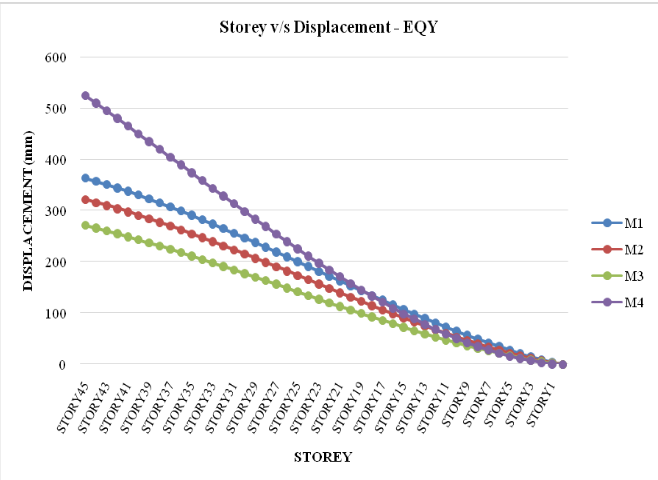

Fig - 9: Storey displacement in x direction for 45 storey seismic analysis

Observations and Discussions: From the above graph, it is observed that as the height of building increases, displacement stories also increases. The model M1 showing displacement of 363mm at the 45th storey and it has been considered as Datum line. The model M2, M3, and M4 correspondingly showing the displacement of 322mm, 270mm, and 524mm respectively. From the above statistics the model M3 shows reduction in displacement up to 25.61% of M1, 16.14% of M2, and 48.47% of M4. As per the economical view and codal provision the model

3.2 Storey Drift

The results for the Storey Drift for frame structure and tubular structural with different bracing systems (45 storey) obtained from seismic analysis along x and y direction are obtained and are compared between them in table further graphs for the same results are provided. Storey Drift values are in mm.

Table - 5: Storey Drift for 45 storey static analysis in X – direction

Storey Drift for EQX mm				
Storey	**M1**	**M2**	**M3**	**M4**
STOREY45	0.00059	0.00054	0.00051	0.00122
STOREY44	0.00064	0.00057	0.00053	0.00135
STOREY43	0.00069	0.0006	0.00055	0.00128
STOREY42	0.00075	0.00063	0.00058	0.00138
STOREY41	0.0008	0.00066	0.00062	0.0015
STOREY40	0.00085	0.00069	0.00064	0.00162
STOREY39	0.0009	0.00071	0.00065	0.00171
STOREY38	0.00094	0.00074	0.00066	0.00147
STOREY37	0.00098	0.00076	0.00069	0.00154
STOREY36	0.00102	0.00078	0.00072	0.00163
STOREY35	0.00106	0.00081	0.00074	0.00173
STOREY34	0.0011	0.00082	0.00074	0.00169
STOREY33	0.00113	0.00084	0.00074	0.00148
STOREY32	0.00116	0.00086	0.00076	0.00155
STOREY31	0.00118	0.00087	0.00079	0.0016
STOREY30	0.00121	0.00089	0.00081	0.00166
STOREY29	0.00123	0.0009	0.0008	0.00153
STOREY28	0.00125	0.00091	0.00079	0.00144
STOREY27	0.00127	0.00092	0.0008	0.00147
STOREY26	0.00128	0.00092	0.00083	0.00149
STOREY25	0.00129	0.00093	0.00084	0.00154
STOREY24	0.0013	0.00093	0.00082	0.00142
STOREY23	0.00131	0.00093	0.0008	0.00136
STOREY22	0.00132	0.00093	0.0008	0.00139
STOREY21	0.00132	0.00093	0.00083	0.00137
STOREY20	0.00132	0.00093	0.00084	0.00136
STOREY19	0.00132	0.00092	0.0008	0.00114
STOREY18	0.00132	0.00091	0.00078	0.00111
STOREY17	0.00131	0.00091	0.00077	0.00108
STOREY16	0.00131	0.0009	0.00079	0.00105
STOREY15	0.0013	0.00088	0.0008	0.00106
STOREY14	0.00129	0.00087	0.00076	0.00096
STOREY13	0.00127	0.00086	0.00072	0.00091
STOREY12	0.00126	0.00084	0.0007	0.00088
STOREY11	0.00124	0.00082	0.00072	0.00084
STOREY10	0.00122	0.0008	0.00072	0.00088
STOREY9	0.0012	0.00078	0.00067	0.00085
STOREY8	0.00118	0.00076	0.00063	0.00083
STOREY7	0.00116	0.00073	0.0006	0.00076
STOREY6	0.00113	0.00071	0.0006	0.0007
STOREY5	0.0011	0.00068	0.0006	0.00093
STOREY4	0.00107	0.00065	0.00055	0.00086
STOREY3	0.00103	0.00061	0.00051	0.00079
STOREY2	0.00094	0.00058	0.00047	0.00069
STOREY1	0.00059	0.00046	0.00039	0.00051
BASE	0	0	0	0

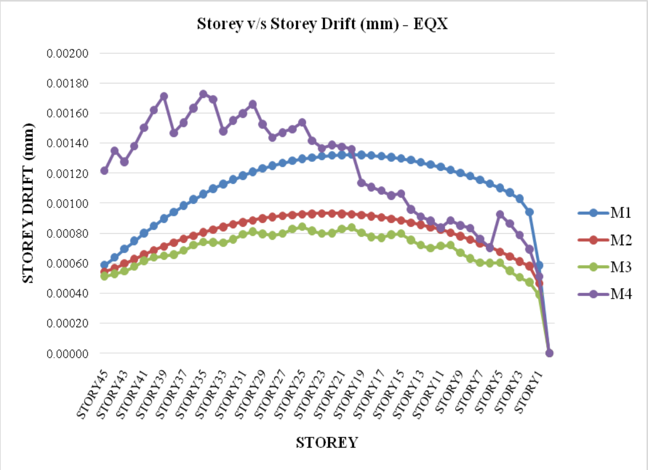

Fig - 10: Storey drift in x - direction for 45 storey static analysis

Observations and Discussions: From the above graph, it is observed that as the height of building increases, drift stories increases up to 18th and after that it is decreasing. The model M1 showing drift of 0.00132mm at the 18th storey and it has been considered as Datum line. The model M2, M3, and M4 correspondingly showing the displacement of 0.00091mm, 0.00078mm, and 0.00111mm respectively. From the above statistics the model M3 shows reduction in displacement up to 31.06% of M1, 14.28% of M2, and 29.72% of M4. Due to the absence of vertical column in M4 model, the inter storey relative displacement is occurring in increasing and decreasing manner.

Table - 6: Storey Drift for 45 storey static analysis in Y – direction

Storey Drift for EQY mm				
Storey	**M1**	**M2**	**M3**	**M4**
STOREY45	0.00150	0.00149	0.00137	0.00369
STOREY44	0.00157	0.00150	0.00137	0.00371
STOREY43	0.00165	0.00154	0.00140	0.00373
STOREY42	0.00172	0.00160	0.00146	0.00376
STOREY41	0.00179	0.00165	0.00153	0.00377
STOREY40	0.00185	0.00170	0.00156	0.00376
STOREY39	0.00192	0.00175	0.00157	0.00380
STOREY38	0.00197	0.00179	0.00157	0.00382
STOREY37	0.00203	0.00184	0.00163	0.00380
STOREY36	0.00208	0.00188	0.00171	0.00380
STOREY35	0.00213	0.00192	0.00174	0.00384
STOREY34	0.00217	0.00196	0.00171	0.00381
STOREY33	0.00221	0.00199	0.00170	0.00379
STOREY32	0.00224	0.00202	0.00175	0.00379
STOREY31	0.00227	0.00204	0.00183	0.00381
STOREY30	0.00230	0.00207	0.00185	0.00372
STOREY29	0.00232	0.00208	0.00180	0.00367
STOREY28	0.00234	0.00210	0.00177	0.00371
STOREY27	0.00235	0.00211	0.00180	0.00365
STOREY26	0.00236	0.00212	0.00187	0.00351
STOREY25	0.00237	0.00212	0.00189	0.00353
STOREY24	0.00237	0.00212	0.00181	0.00354
STOREY23	0.00237	0.00212	0.00176	0.00339
STOREY22	0.00236	0.00211	0.00177	0.00327
STOREY21	0.00235	0.00210	0.00183	0.00333
STOREY20	0.00233	0.00209	0.00185	0.00321
STOREY19	0.00232	0.00207	0.00174	0.00311
STOREY18	0.00229	0.00205	0.00167	0.00301
STOREY17	0.00227	0.00202	0.00166	0.00300
STOREY16	0.00224	0.00199	0.00171	0.00274
STOREY15	0.00220	0.00195	0.00172	0.00257
STOREY14	0.00216	0.00191	0.00159	0.00271
STOREY13	0.00212	0.00187	0.00149	0.00248
STOREY12	0.00208	0.00182	0.00146	0.00222
STOREY11	0.00203	0.00177	0.00149	0.00221
STOREY10	0.00197	0.00171	0.00150	0.00218
STOREY9	0.00191	0.00165	0.00134	0.00193
STOREY8	0.00185	0.00158	0.00123	0.00166
STOREY7	0.00179	0.00151	0.00117	0.00180
STOREY6	0.00172	0.00143	0.00116	0.00149
STOREY5	0.00165	0.00134	0.00117	0.00120
STOREY4	0.00157	0.00125	0.00099	0.00111
STOREY3	0.00148	0.00114	0.00086	0.00106
STOREY2	0.00135	0.00104	0.00075	0.00057
STOREY1	0.00087	0.00072	0.00053	0.00020
BASE	0	0	0	0

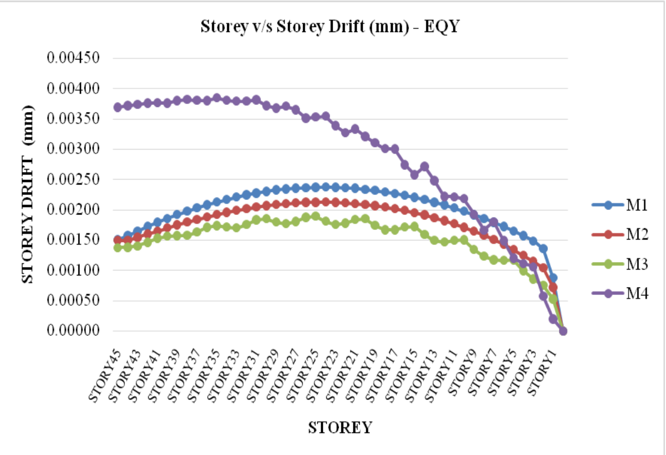

Fig - 11: Storey drift in Y - direction for 45 storey static analysis

Observations and Discussions: From the above graph, it is observed that as the height of building increases, drift stories increases up to 23rd storey and after that it is decreasing. The model M1 showing drift of 0.00237mm at the 23rd storey and it has been considered as Datum line. The model M2, M3, and M4 correspondingly showing the drift of 0.00212mm, 0.00176mm, and 0.00339mm respectively. From the above statistics the model M3 shows reduction in displacement up to 25.73% of M1, 16.98% of M2, and 48.08% of M4. Due to the absence of vertical column in M4 model, the inter storey relative displacement is occurring in increasing and decreasing manner.

3.3modal Analysis

The results for Modal Analysis are obtained in the form of Modes against Period and Modes against Frequency. The results for Modes against Period are given in Table - 7 and plotted in the form of graph given in Fig -12. Similarly the results for Modes against Frequency are given in the Table - 8 and plotted in a graph given in Fig - 13.

Table - 7: Modal Analysis with respect to Period

	Period (Seconds)			
Mode	**M1**	**M2**	**M3**	**M4**
1	7.37	6.88	6.24	8.26
2	5.64	4.66	4.3	5.45
3	5.26	3.15	2.69	2.18
4	2.24	2.04	1.8	2.18
5	1.8	1.44	1.32	2.01
6	1.74	1.06	0.92	1.86
7	1.18	1.05	0.89	1.84
8	1.02	0.77	0.7	1.71
9	1	0.72	0.62	1.42
10	0.82	0.62	0.53	1.42
11	0.72	0.54	0.48	1.3
12	0.7	0.54	0.47	1.08

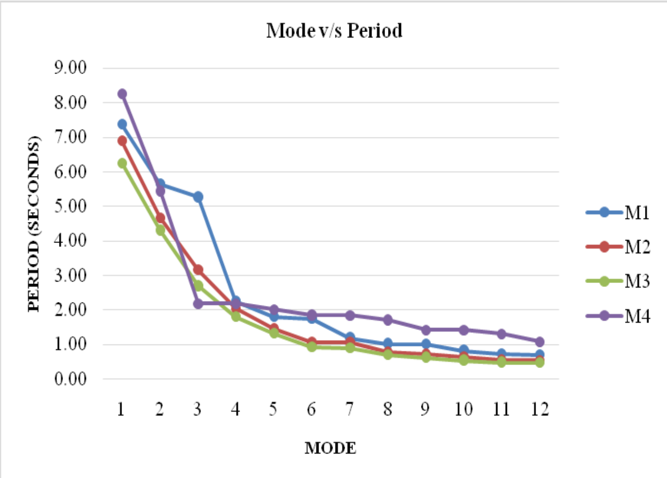

Fig - 12: Graphical Representation of Modal Analysis in terms of Period

Table - 8: Modal Analysis with respect to Frequency

	Frequency (Hz)			
Mode	**M1**	**M2**	**M3**	**M4**
1	0.14	0.15	0.16	0.12
2	0.18	0.21	0.23	0.18
3	0.19	0.32	0.37	0.46
4	0.45	0.49	0.56	0.46
5	0.55	0.69	0.76	0.5
6	0.58	0.95	1.09	0.54
7	0.84	0.95	1.12	0.54
8	0.98	1.29	1.43	0.58
9	1	1.39	1.61	0.7
10	1.22	1.6	1.89	0.7
11	1.39	1.85	2.07	0.77
12	1.43	1.87	2.13	0.93

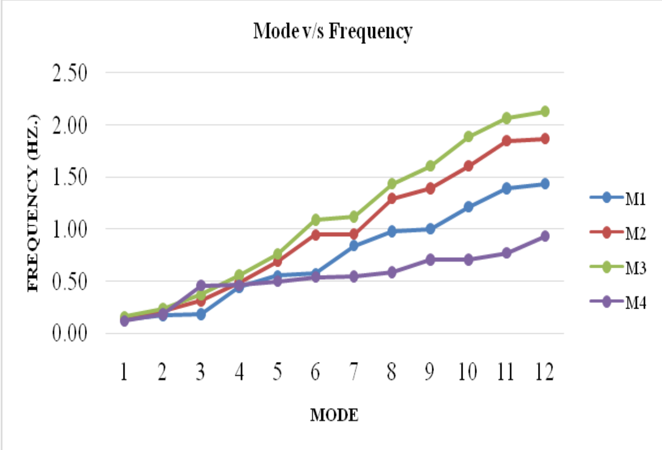

Fig - 13: Graphical Representation of Modal Analysis in terms of Frequency

Observations And Discussions: From Fig -12 and 13, the graph showing mode v/s period and mode v/s frequency for all types of models such as M1, M2, M3, and M4. We can notice that model M4 is with least frequency and higher period. For mode 1, the frequency of Diagrid tube structure has lowest of all compared to other models that is 0.12Hz and maximum period of 8.26 seconds.

3.4 Time History Results

The results of Time History Analysis are given below for different models M1, M2, M3 and M4 in both X and Y directions.

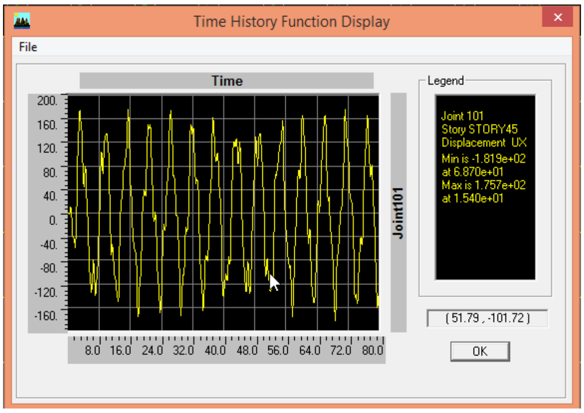

Fig - 14: Peak Displacement in X – direction in M1

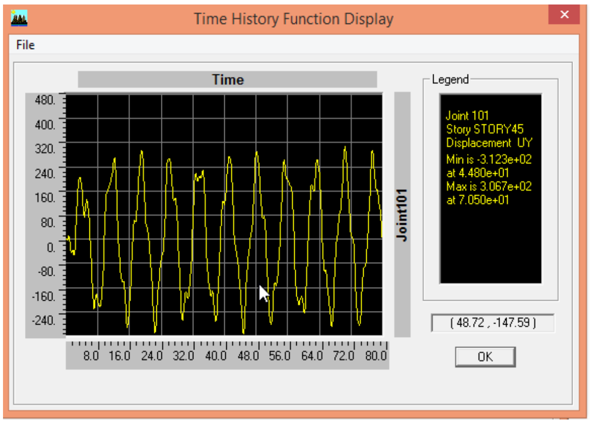

Fig - 15: Peak Displacement in Y – direction in M1

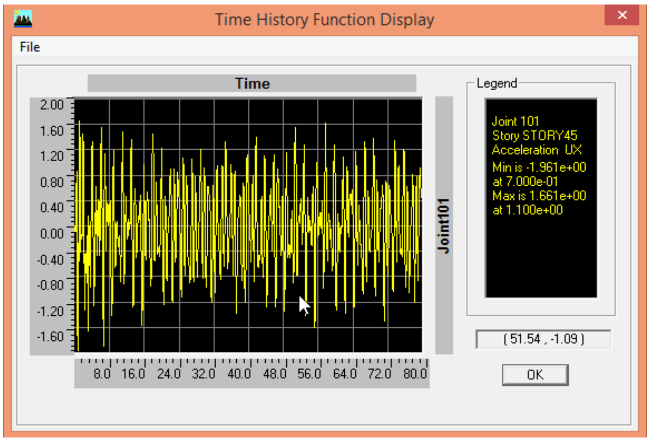

Fig - 16: Peak Acceleration in X – direction in M1

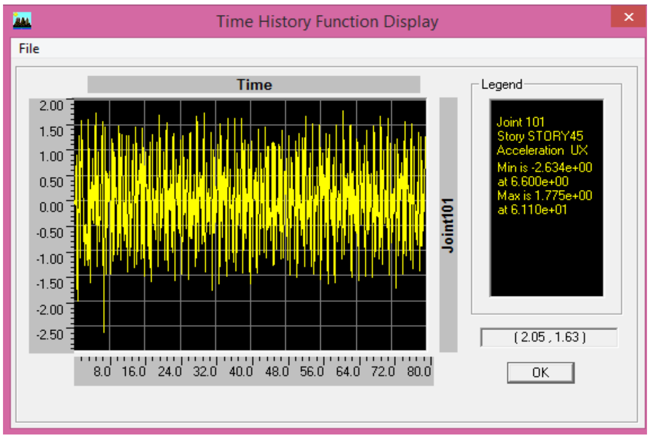

Fig - 20: Peak Acceleration in X – direction in M2

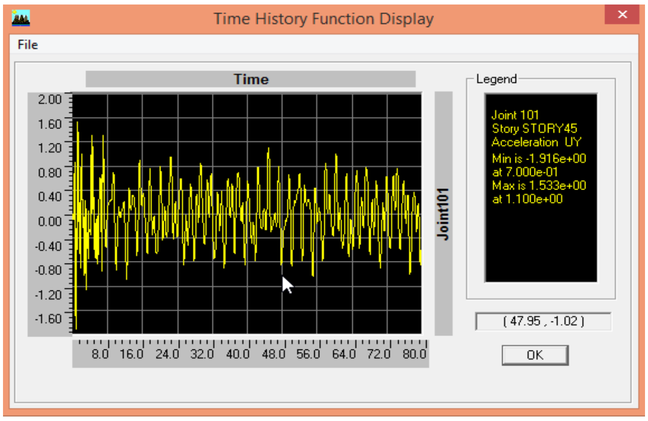

Fig - 17: Peak Acceleration in Y – direction in M1

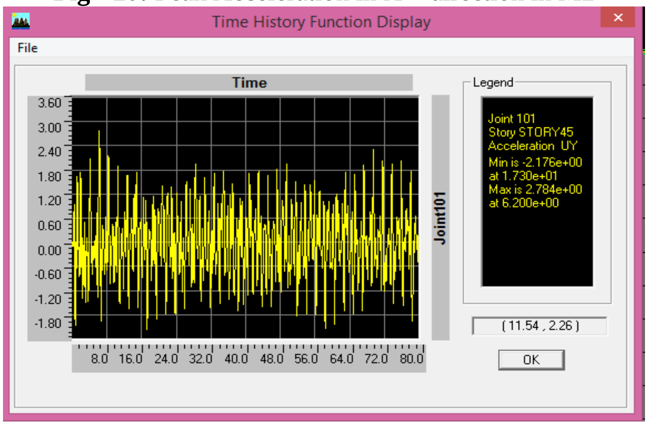

Fig - 21: Peak Acceleration in Y – direction in M2

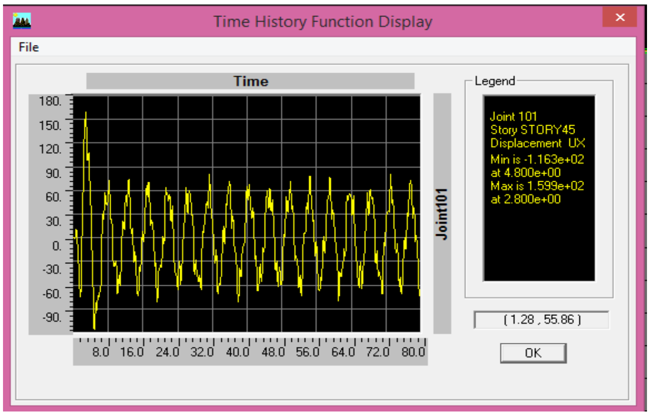

Fig - 18: Peak Displacement in X – direction in M2

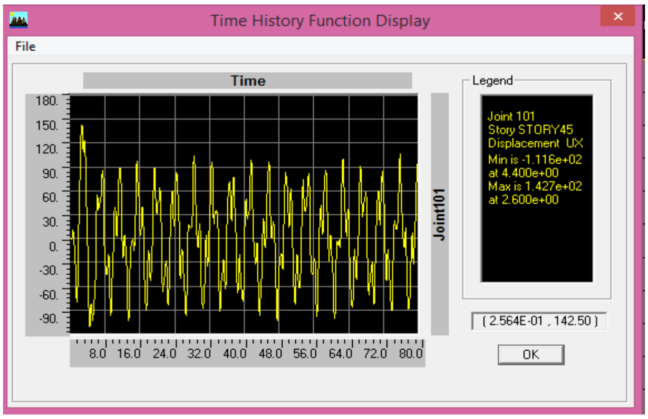

Fig - 22: Peak Displacement in X – direction in M3

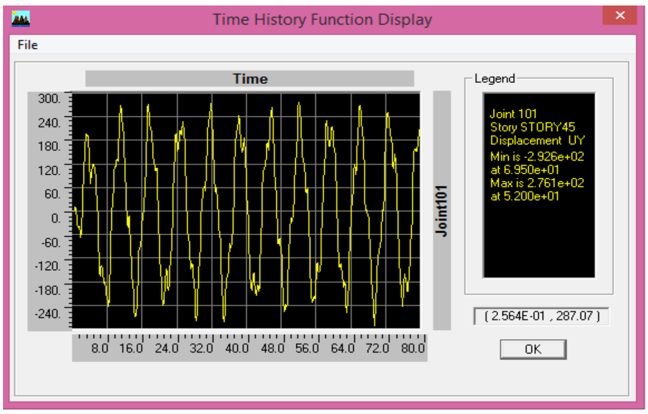

Fig - 19: Peak Displacement in Y – direction in M2

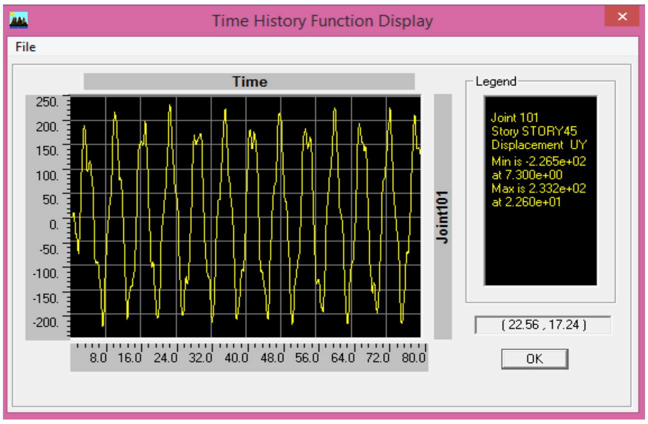

Fig - 23: Peak Displacement in Y – direction in M3

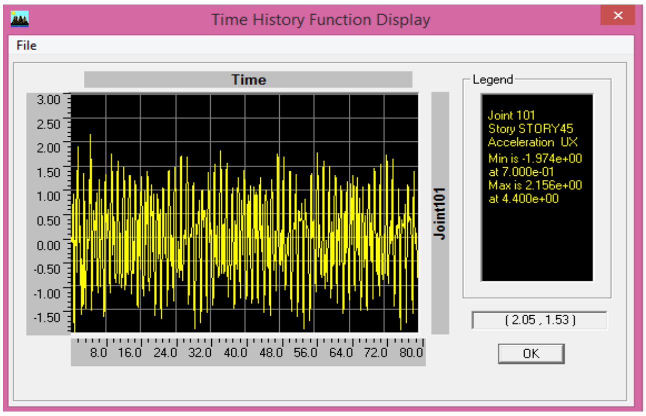

Fig - 24: Peak Acceleration in X – direction in M3

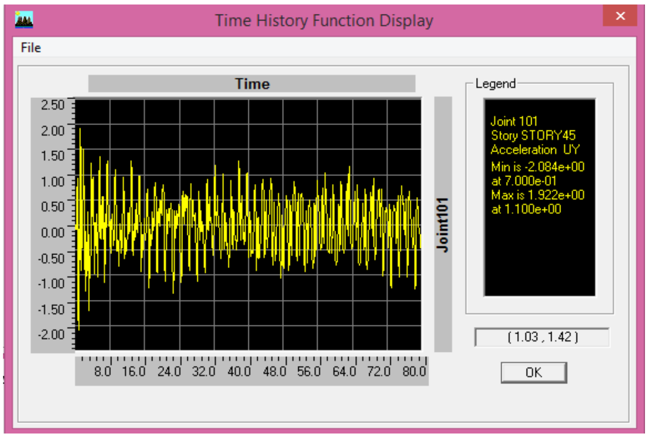

Fig - 25: Peak Acceleration in Y – direction in M3

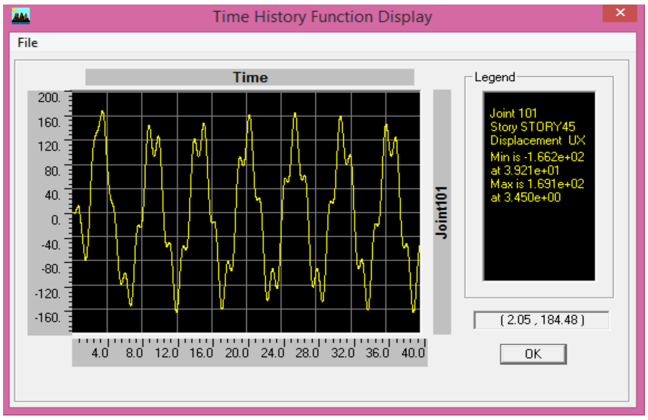

Fig - 26: Peak Displacement in X - direction in M4

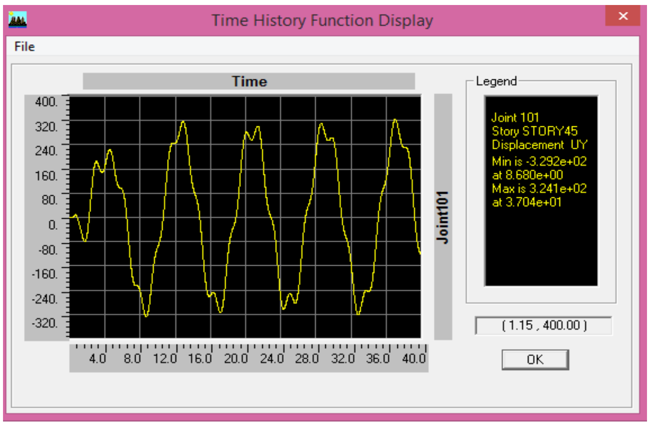

Fig - 27: Peak Displacement in Y – direction in M4

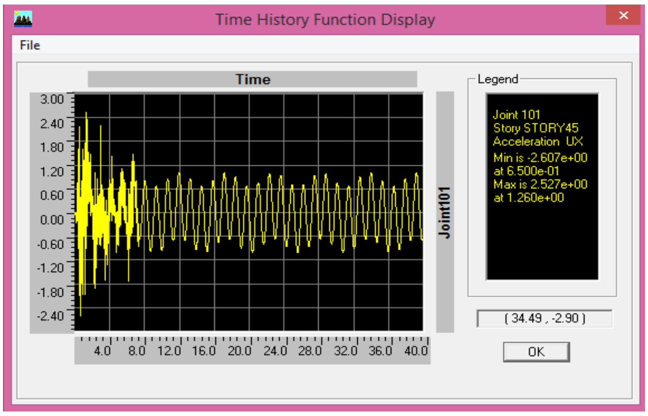

Fig - 28: Peak Acceleration in X – direction in M4

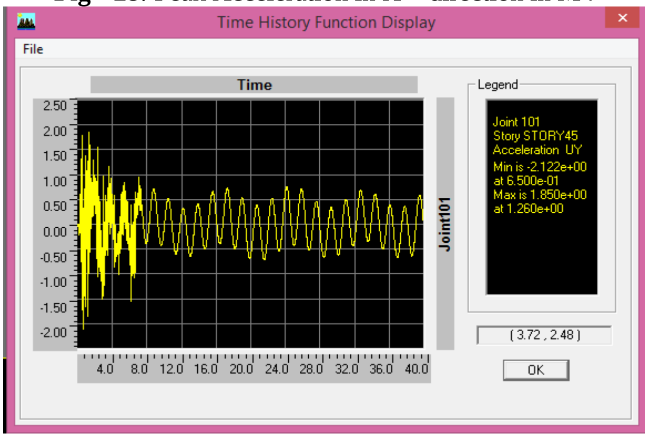

Fig - 29: Peak Acceleration in Y – direction in M4

Summary of the Time History Analysis Results are tabulated below for Peak Displacement and Peak Acceleration in both X and Y directions. Also comparison graphs are plotted.

Table - 9: Time History Results with respect to Peak Displacement

Peak Displacement (mm)		
Model	**X - Direction**	**Y - Direction**
M1	189	312
M2	160	293
M3	143	233
M4	169	324

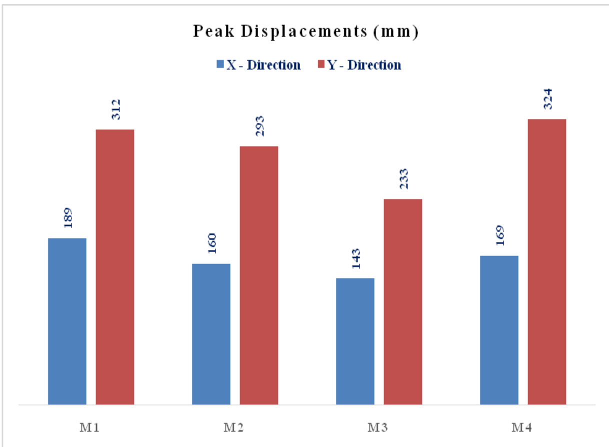

Fig - 30: Showing Peak displacement Bar Chart

Observations and Discussions: From the plotted bar chart the peak displacement is observed that model M3 exhibits least displacement in both the direction x and y, of 24.33%of M1 x-direction and 25.32% of M1y-diretion, 10.62% of M2 in x-direction and 20.47% in y-direction, 15.38% of M4 in x-direction and 28.08% of M4 in y-direction.

Table - 10: Time History Results with respect to Peak Acceleration

Peak Acceleration (N/m^2)		
Model	**X - Direction**	**Y - Direction**
M1	1.96	1.91
M2	2.63	2.78
M3	2.15	2.08
M4	2.6	2.1

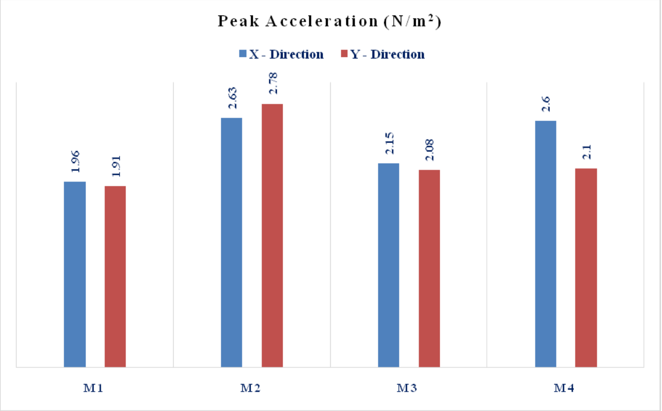

Fig - 31: Showing Peak Acceleration Bar Chart

Observations and Discussions: From the plotted bar chart it is observed that the model M1 showing least peak acceleration in both 1.96N/m^2 in x direction and 1.91N/m^2 in y direction respectively. And it is taken as datum line. The model M2 it is showing maximum peak acceleration 34.18% increase of M1 model in x direction and 45.54% of M1 in y direction. M3 and M4 showing increase in peak acceleration 9.69% and 32.65% in x direction, 8.9% and 9.94% in y direction respectively as compared with model M1.

CONCLUSIONS

- Steel tubular structure system is stiffer than frame structure in terms of displacement, Showing 29% and 11.29% decrease in displacement in x and y direction of frame structure respectively. And the drift showing 31.06% and 10.55% decrease in x and y direction respectively compared with frame model.
- The steel tubular structure with Mega Bracing System is most efficient in lateral displacement and drift in both the directions x and y respectively, It shows reduction in displacement up to 38.5% of frame structure, 13.38% of tubular structure, and 79.67% of tubular structure with Diagrid Bracing System.
- From the modal analysis result it is observed that Diagrid bracing system showing satisfactory performance by the parametric observation on period and frequency. The frequency of Diagrid tube structure has lowest of all compared to other models that is 0.12Hz and maximum period of 8.26 seconds.
- The steel tubular structure with Mega bracing system exhibits least displacement in both the direction x and y, of 24.33% of frame structure in x-direction and 25.32% of frame structure in y-direction, 10.62% of tubular structure in x-direction and 20.47% of tubular structure in y-direction, 15.38% of tubular structure with Diagrid bracing system in x-direction and 28.08% in y-direction.

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BIOGRAPHIES

Dhanapalagoud Patil. Student, Structural Engineering, MVJ College of Engineering, Bangalore.

Naveena M P. Assistant Professor, Structural Engineering, MVJ College of Engineering Bangalore.