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"DYNAMIC ANAYSIS OF BUNDLED TUBE STEEL STRUCTURE WITH BELT-TRUSS AND MEGA BRACINGS"

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Abstract - *These days, Competition towards ascent of tall steel structures made certain elements are necessary like serviceability and comfort of people with lateral forces brought on by quake. Seismic tremor is unsafe to the living creatures as far as its consequences for artificial structures. Structures like tall structures are worked to oppose gravity loads. However many tall structures are not that safe in lateral forces because of seismic tremor so require an improvement in resisting lateral forces. So there are numerous structural frameworks which oppose lateral forces by varying orientation, addition of various basic frameworks. Like steel bundled tube framework is considered and compared for their outcomes against lateral forces and also by providing super belt-truss and mega bracings. In this work, five structural frameworks are considered in which are 1) Regular steel structure, 2) Tube structure, 3) Bundled tube structure, 4) Bundled tube structure with belt-truss, 5) Bundled tube structure with belt-truss and mega bracings. For the reason 110 story steel structure with rectangular arrangement of measurement 60mx60m is considered and analyzed for gravity and lateral forces utilizing ETABS programming. Functioning characteristics like displacement, story shear, time period, story drift are extracted from ETABS. Results shows that the steel bundled tube structure with belt-truss and mega bracings framework is much stable than the other four structural frameworks.*

Key Words: Dynamic Analysis, bundled tube, belt-truss, mega bracings, seismic tremor, ETABS.

1. INTRODUCTION

Steel is a typical building material utilized all through the construction business. Its main role is to shape a skeleton for the building or structure basically the part of the structure that holds everything up and together. Steel has numerous advantages when contrasted with other basic materials, for example, solid, timber, plastics and more current composite materials. Steel is one of the friendliest natural building material-steel is 100% recyclable. In India we are utilizing steel as a part of modern building. Utilizing steel as a part of Tall building construction is presently in beginning stage.

Advancement in the basic frameworks of tall structures has been a persistently developing procedure since the development in tall structures started in 1880s. From structure specialist's perspective tall structures might be characterized as one that, in light of its stature, it is influenced by the lateral forces because of wind or earthquake to a degree that they assume a vital part in the design of structures. The factors responsible for tall structure improvement are accessibility of urban area, progresses in development innovation and high quality materials, effective basic frameworks and computational strategies and so forth.

If there should be a tall structure, stiffness is more critical than its quality. It is important to guarantee that the top story displacement, sidelong float and human solace level in tall structure are inside as far as possible. To fulfill these configuration prerequisites distinctive basic frameworks are created for tall structure as appeared. It is likewise essential to guarantee that in the chose framework basic individuals can be used up to the full design capacity limit with design necessities.

1.1 Demands for high rise frameworks

- Scarcity of land in urban areas.
- More demand for residential and commercial place.
- Economical development.
- Advancements in technology.
- Innovative works in structural systems.
- For architectural and aesthetic view in urban area.
- For reputation and cultural importance.
- To build in different way.

1.2 Braced bundled tube

A tubular framework goes about as a simple tube opposing more torsion and overturning moment. A framed tube proved unable be utilized for super tall structures since section plans are controlled by bending activity, bringing about huge size. Also, the cantilever conduct of the structure is undermined and shear lag is expanded in the sections (axial strengths in the corner segments are more prominent than the center ones and the appropriation is nonlinear). Braced tube framework can in part tackle the issue by hardening the broadly spaced columns by slanting supports to make wall like attributes. A bundled tube is a bunch of individual tubes associated together to go about as solitary tube extraordinarily utilized for super-tall structures (e.g.

Sear Tower, Chicago). All together to build the tallness of the tower fundamentally bundled with tubes and helping its cantilever activity, inclining individuals could be included accordingly acquiring the auxiliary framework the so called braced bundled tube.

The bundled tube framework offers extraordinary flexibility in the architectural planning by making an assortment of existing building frames. It implies that a bundled tube framework can have an arrangement including numerous particular tubes at its base and only one at its peak level. The numbers of bundled tubes could be diminished as the tallness increments without loss of auxiliary integrity. This idea has constructive outcome on the reaction of the tower against wind and earthquake. In fundamental tubular framework, the firmly spaced sections lead architect to make a auxiliary perspective exterior however expansive windows couldn't be utilized. In bundled tube framework, the edge sections could be set with more extensive space not withstanding when utilizing moment resisting frame with inflexible connection (basic tubes) and inner planning is dispensed with by moderately bigger section space.

2. RESULTS AND DISCUSSIONS:

In this Chapter we discuss about the results obtained from the analysis of bundled tube model which are obtained from the ETABS model. Analysis Results obtained from the software ETABS, from the analysis results like, story shear, displacement story drift and time period are extracted for five proposed models and are compared with each other to obtain a stable structural system.

2.1 Analysis results

Table-1: Preliminary data.

Type of Structure	**Steel**
Grid data	**Plane regular-rectangular geometric shape**
Grid Spacing	To be decided based on the structural system
Total dimension	60x60m
Grid Height	Uniform-3m
No. of Storey's	110
Material Properties	
Grade of structural steel	Fe350
Grade of concrete deck	M30
Poisson's ratio	0.2
Frame Section Properties	
column	Built-up section
Beam/Braces/Belt truss	ISMB
Slab section Properties	
Deck slab	200mm
Static loads	
Self weight	Considered
Super dead load (SDL)	1.5kN/m^2
Live load	4 kN/m^2
Wall load	Glazing load considered (1 kN/m)
Earthquake load-ESA	**Mass source considered**

2.2 Models for analysis

- Model 1: Normal steel structure.
- Model 2: Tube structure.
- Model 3: Bundle Tube structure.
- Model 4: Bundle Tube structure with belt truss.
- Model 5: Bundle Tube structure with mega bracings.

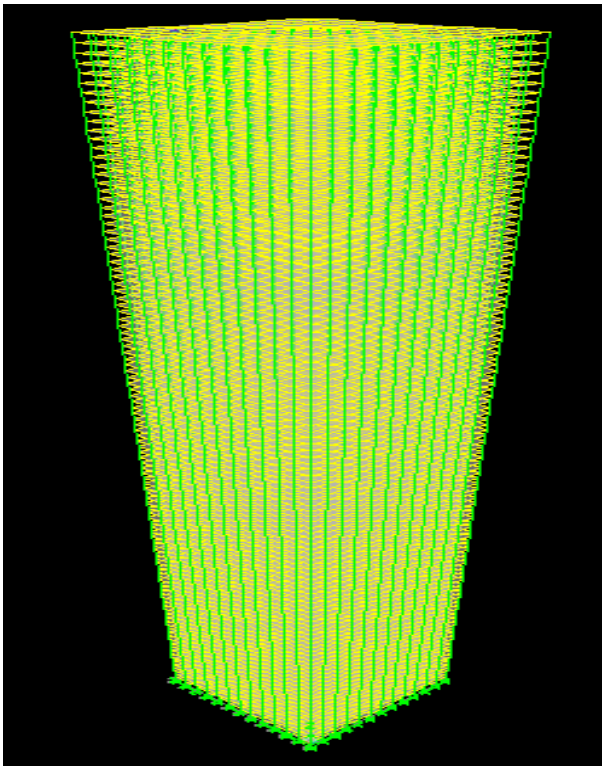

Fig-1: 3-D view of regular steel structure.

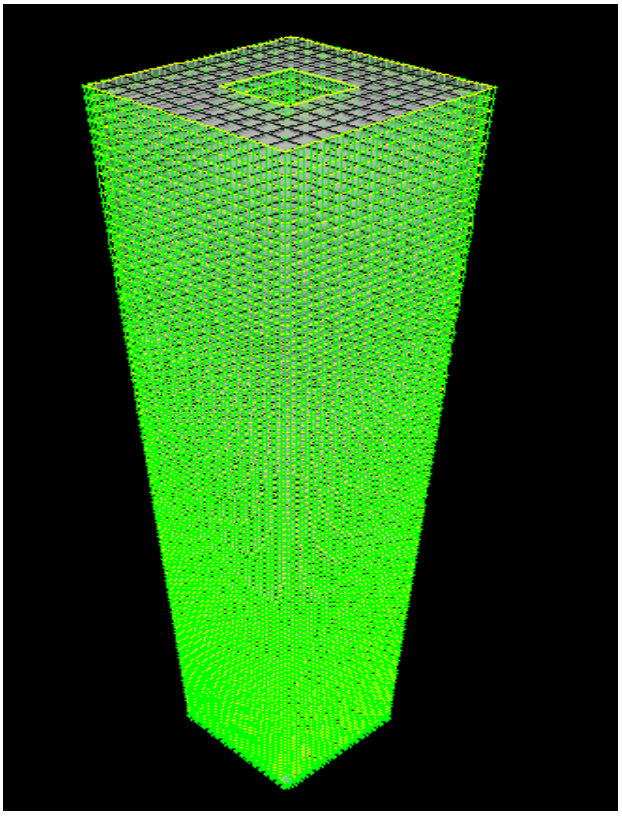

Fig-2: 3-D view of steel Tube structure.

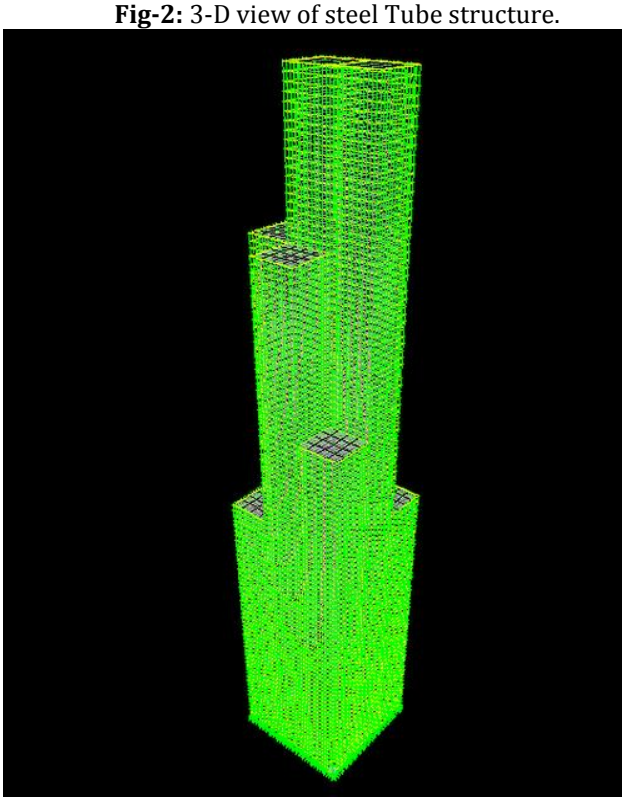

Fig-3: 3-D view of steel Bundled Tube structure.

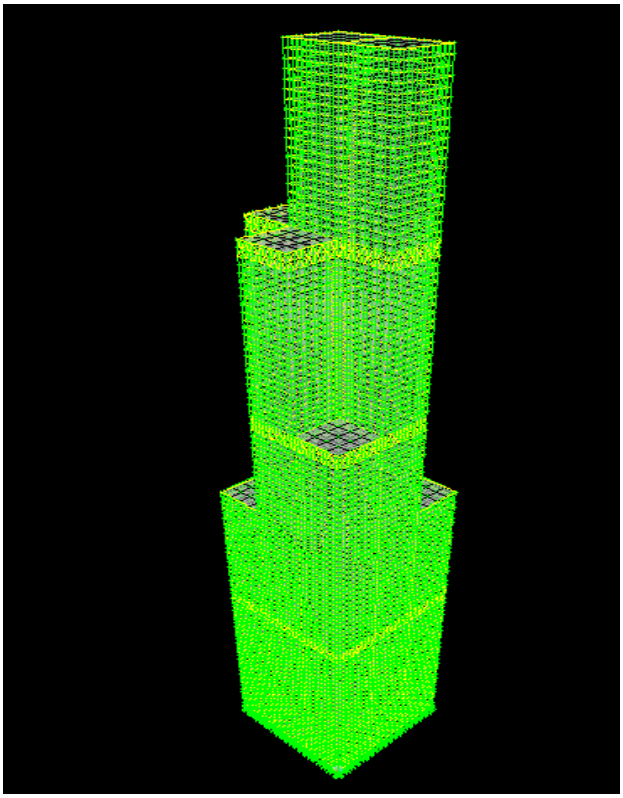

Fig-4: 3-D view of steel bundled tube structure with belt truss.

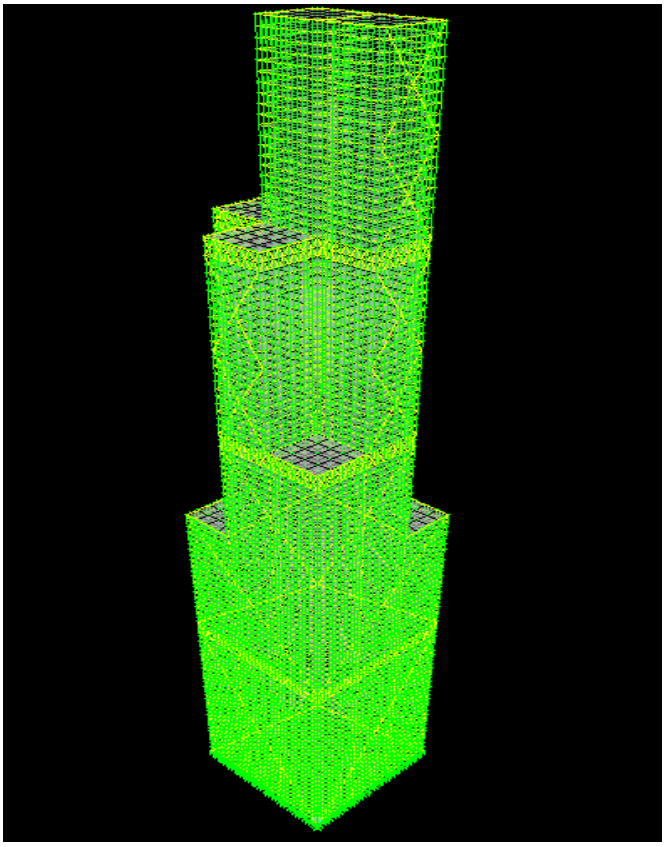

Fig-5:3-D view of steel bundled tube structure with belt truss and mega bracing.

2.3 Displacement results.

Table-2: Displacement of different formworks.

Story	M1	M2	M3	M4	M5
STORY110	604.4274	589.9499	316.0905	207.3469	192.2024
STORY109	600.4688	586.7638	313.9722	206.5519	191.4026
STORY108	596.4371	583.5015	311.7753	205.7569	190.5996
STORY107	592.322	580.1471	309.4821	204.9617	189.7935
STORY106	588.1221	576.6965	307.0878	204.1663	188.9851
STORY105	583.8375	573.1489	304.5917	203.3706	188.175
STORY104	579.4693	569.5046	301.9948	202.5746	187.364
STORY103	575.0185	565.7646	299.2992	201.7781	186.5531
STORY102	570.4863	561.9299	296.5072	200.9811	185.7431
STORY101	565.874	558.0016	293.6215	200.1835	184.9349
STORY100	561.1828	553.981	290.6452	199.3852	184.129
STORY99	556.4141	549.8696	287.5816	198.586	183.324
STORY98	551.5694	545.6686	284.4346	197.786	182.5156
STORY97	546.6499	541.3797	281.2083	196.9849	181.7026
STORY96	541.6573	537.0044	277.9076	196.1824	180.8852
STORY95	536.593	532.5441	274.5384	195.3785	180.0641
STORY94	531.4584	528.0006	271.1091	194.5724	179.2398
STORY93	526.2553	523.3754	267.634	193.7629	178.4123
STORY92	520.9852	518.6704	264.1429	192.9469	177.5804
STORY91	515.6497	513.887	260.71	192.1154	176.739
STORY90	510.2505	509.0272	249.8914	191.3266	175.986
STORY89	504.7892	504.0927	247.2183	190.364	175.0478
STORY88	499.2676	499.0851	244.7967	189.374	174.0842
STORY87	493.6874	494.0065	242.3339	188.3305	173.0707
STORY86	488.0503	488.8584	239.8171	187.2156	171.9883
STORY85	482.358	483.6429	237.243	186.0243	170.8334
STORY84	476.6124	478.3617	234.6115	184.7561	169.6075
STORY83	470.8152	473.0167	231.9237	183.4119	168.3129
STORY82	464.9682	467.6097	229.181	181.9933	166.9517
STORY81	459.0733	462.1427	226.3852	180.502	165.525
STORY80	453.1322	456.6176	223.5379	178.9399	164.033
STORY79	447.1469	451.0362	220.6411	177.3087	162.475
STORY78	441.1191	445.4004	217.6967	175.6106	160.8499
STORY77	435.0508	439.7122	214.7066	173.8475	159.1589
STORY76	428.9438	433.9735	211.6728	172.0215	157.4147
STORY75	422.7999	428.1862	208.5976	170.1347	155.6254
STORY74	416.6211	422.3523	205.4831	168.1894	153.792
STORY73	410.4093	416.4736	202.3316	166.1879	151.9144
STORY72	404.1663	410.5522	199.1457	164.1326	149.9929
STORY71	397.8941	404.5898	195.928	162.0264	148.0283
STORY70	391.5946	398.5886	192.682	159.8728	146.0218
STORY69	385.2696	392.5505	189.4127	157.6777	143.9757
STORY68	378.9211	386.4772	186.1298	155.4536	141.8969
STORY67	372.551	380.3709	182.8578	153.2345	139.809
STORY66	366.1613	374.2335	179.6672	151.1226	137.7942
STORY65	359.7538	368.0669	176.6751	149.3007	136.011
STORY64	353.3304	361.873	173.6969	147.4577	134.211
STORY63	346.8932	355.6537	170.7039	145.382	132.2386
STORY62	340.444	349.4111	167.6896	143.1812	130.1858
STORY61	333.9848	343.1471	164.6526	140.9142	128.0981
STORY60	327.5174	336.8634	161.5935	138.6007	125.9881
STORY59	321.0439	330.5622	158.5139	136.2484	123.8572
STORY58	314.5661	324.2454	155.4153	133.861	121.7058
STORY57	308.0859	317.9147	152.2996	131.4414	119.5339
STORY56	301.6053	311.5723	149.169	128.9918	117.3386
STORY55	295.1263	305.2199	146.0256	126.5148	115.1172
STORY54	288.6506	298.8595	142.8726	124.0133	112.8705
STORY53	282.1803	292.493	139.7144	121.4913	110.6004
STORY52	275.7173	286.1223	136.5605	118.9567	108.3087
STORY51	269.2634	279.7493	133.435	116.4282	106.0086
STORY50	262.8207	273.3759	130.409	113.961	103.7437
STORY49	256.391	267.004	127.5994	111.6452	101.5934
STORY48	249.9762	260.6354	124.821	109.3407	99.4596
STORY47	243.5782	254.2721	122.0437	107.0247	97.332
STORY46	237.199	247.916	119.26	104.692	95.2079
STORY45	230.8404	241.5688	116.4681	102.3417	93.0854
STORY44	224.5044	235.2326	113.668	99.9744	90.9605
STORY43	218.1928	228.9091	110.8605	97.5911	88.8237
STORY42	211.9077	222.6002	108.0465	95.193	86.6701
STORY41	205.6508	216.3078	105.2271	92.7815	84.5031

STORY40	199.424	210.0337	102.4034	90.3579	82.3278
STORY39	193.2294	203.7799	99.5764	87.9235	80.1474
STORY38	187.0688	197.5482	96.7474	85.4798	77.9637
STORY37	180.944	191.3404	93.9174	83.028	75.7779
STORY36	174.857	185.1583	91.0876	80.5698	73.5879
STORY35	168.8098	179.004	88.2591	78.1066	71.3899
STORY34	162.8042	172.8792	85.433	75.6408	69.1799
STORY33	156.8421	166.7857	82.6105	73.1763	66.9562
STORY32	150.9255	160.7256	79.7926	70.7226	64.7221
STORY31	145.0562	154.7005	76.9804	68.3071	62.4936
STORY30	139.2363	148.7125	74.1749	66.0151	60.3334
STORY29	133.4676	142.7634	71.3774	64.006	58.372
STORY28	127.752	136.8552	68.5888	62.0012	56.4047
STORY27	122.0917	130.9897	65.8102	59.7165	54.2062
STORY26	116.4884	125.1688	63.0426	57.3124	51.9241
STORY25	110.9443	119.3945	60.2871	54.8748	49.6322
STORY24	105.4612	113.6688	57.5446	52.4313	47.3525
STORY23	100.0412	107.9937	54.8162	49.9911	45.0917
STORY22	94.6863	102.3711	52.1029	47.5583	42.85
STORY21	89.3986	96.8032	49.4057	45.1346	40.6266
STORY20	84.1801	91.2919	46.7256	42.7216	38.4218
STORY19	79.0328	85.8394	44.0635	40.3205	36.2361
STORY18	73.959	80.4478	41.4205	37.9324	34.0688
STORY17	68.9608	75.1195	38.7976	35.5584	31.9187
STORY16	64.0403	69.8566	36.1956	33.1996	29.7866
STORY15	59.1998	64.6615	33.6157	30.857	27.6724
STORY14	54.4415	59.5366	31.0587	28.5317	25.576
STORY13	49.7677	54.4845	28.5258	26.2248	23.4993
STORY12	45.1808	49.508	26.018	23.9373	21.4438
STORY11	40.6832	44.6097	23.5362	21.6703	19.4096
STORY10	36.2773	39.7928	21.0818	19.4249	17.3967
STORY9	31.9658	35.0605	18.6557	17.2023	15.4071
STORY8	27.7511	30.4164	16.2593	15.0038	13.4405
STORY7	23.6361	25.8648	13.8942	12.8309	11.4971
STORY6	19.6238	21.411	11.5622	10.6853	9.5796
STORY5	15.718	17.0631	9.2666	8.5701	7.6913
STORY4	11.9253	12.8362	7.0143	6.4919	5.8365
STORY3	8.2634	8.7668	4.8237	4.4677	4.028
STORY2	4.7926	4.9573	2.7492	2.5481	2.3087
STORY1	1.741	1.7145	0.9601	0.8905	0.8139

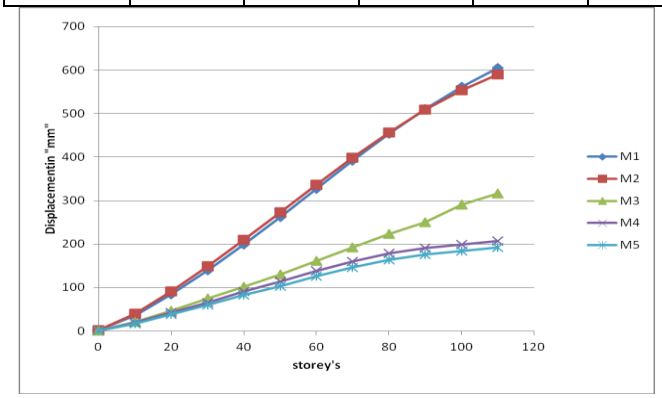

Chart-1: plotting displacement with storey's.

Discussion: From the above graph, it is observed that as the height of building increases, displacement stories also increases. The model M1 showing displacement of 604mm at the 110th storey and it has been considered as Datum line. The model M2, M3, M4 and M5 correspondingly showing the displacement of 589mm, 316mm, and 207mm, 192mm respectively. From the above statistics the models shows reduction in displacement up to 2.48% of M2, 47.6% of M3, and 65.7% of M4, 68.2% of M5. Hence the model M5 shows less displacement with 68.2% reduction compared to model M1.

2.4 Time Period results.

Table-3: Time period with respect to modes of structure.

	M1	M2	M3	M4	M5
Mode	Period	Period	Period	Period	Period
1	15.54506	16.06931	9.985084	9.895978	9.266902
2	14.18942	14.26582	8.718489	8.652051	8.28078
3	11.05231	8.515712	5.754338	5.678465	5.050256
4	4.833453	5.139302	3.960667	3.917658	3.70434
5	4.308444	4.463766	3.501182	3.456057	3.311345
6	3.661638	2.839108	2.538641	2.500179	2.243262
7	2.595246	2.835564	2.28177	2.259009	2.13093
8	2.274257	2.415756	2.024746	2.001707	1.896002
9	2.171279	1.985231	1.681953	1.646814	1.566042
10	1.802296	1.695562	1.556375	1.537271	1.426238
11	1.569908	1.674189	1.485491	1.46673	1.360454
12	1.537864	1.520746	1.310452	1.29744	1.220691

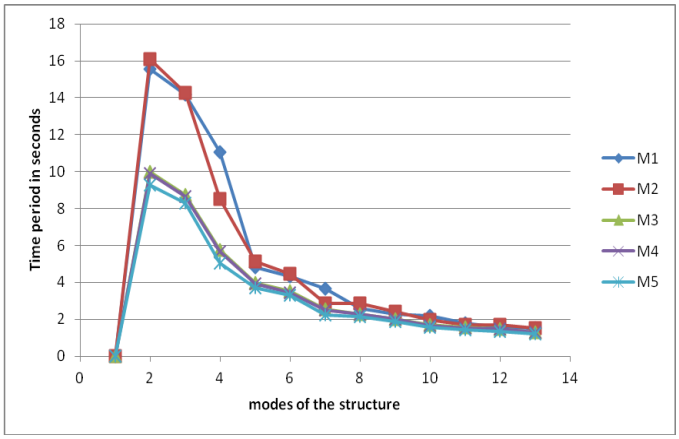

Chart-2: plotting modes with time period.

Discussion: From the above graph, it is observed that model M1 has a time period of 15.54secs, M2 16.06secs, M3 9.98secs, M4 9.89secs, M5 9.26secs, which is maximum among all the modes of structure. Hence the model M5 has got less time period of 9.26secs, which is much better than other models.

2.5 Story Shear results.

Table -4: Storey shears with respect to storey height.

Story	Loc	M1	M2	M	M4	M5
STORY110	Top	-395.39	-382.07	3	0	0
STORY110	Bottom	-395.39	-382.07	-147.76	0	0
STORY109	Top	-799.47	-770.17	-304.2	0	0
STORY109	Bottom	-799.47	-770.17	-304.2	0	0
STORY108	Top	-1196.17	-1151.17	-457.79	0	0
STORY108	Bottom	-1196.17	-1151.17	-457.79	0	0
STORY107	Top	-1585.56	-1525.15	-608.55	0	0
STORY107	Bottom	-1585.56	-1525.15	-608.55	0	0
STORY106	Top	-1967.71	-1892.18	-756.5	0	0
STORY106	Bottom	-1967.71	-1892.18	-756.5	0	0
STORY105	Top	-2342.67	-2252.31	-901.67	0	0
STORY105	Bottom	-2342.67	-2252.31	-901.67	0	0
STORY104	Top	-2710.53	-2605.62	-1044.09	0	0
STORY104	Bottom	-2710.53	-2605.62	-1044.09	0	0
STORY103	Top	-3071.35	-2952.16	-1183.79	0	0
STORY103	Bottom	-3071.35	-2952.16	-1183.79	0	0
STORY102	Top	-3425.2	-3292.01	-1320.79	0	0
STORY102	Bottom	-3425.2	-3292.01	-1320.79	0	0
STORY101	Top	-3772.14	-3625.23	-1455.11	0	0
STORY101	Bottom	-3772.14	-3625.23	-1455.11	0	0
STORY100	Top	-4112.25	-3951.88	-1586.79	0	0
STORY100	Bottom	-4112.25	-3951.88	-1586.79	0	0
STORY99	Top	-4445.59	-4272.03	-1715.84	0	0
STORY99	Bottom	-4445.59	-4272.03	-1715.84	0	0
STORY98	Top	-4772.23	-4585.75	-1842.31	0	0
STORY98	Bottom	-4772.23	-4585.75	-1842.31	0	0
STORY97	Top	-5092.23	-4893.09	-1966.2	0	0
STORY97	Bottom	-5092.23	-4893.09	-1966.2	0	0
STORY96	Top	-5405.67	-5194.13	-2087.55	0	0
STORY96	Bottom	-5405.67	-5194.13	-2087.55	0	0
STORY95	Top	-5712.62	-5488.94	-2206.39	0	0
STORY95	Bottom	-5712.62	-5488.94	-2206.39	0	0
STORY94	Top	-6013.14	-5777.57	-2322.74	0	0
STORY94	Bottom	-6013.14	-5777.57	-2322.74	0	0
STORY93	Top	-6307.3	-6060.09	-2436.63	0	0
STORY93	Bottom	-6307.3	-6060.09	-2436.63	0	0
STORY92	Top	-6595.16	-6336.56	-2548.08	0	0
STORY92	Bottom	-6595.16	-6336.56	-2548.08	0	0
STORY91	Top	-6876.81	-6607.06	-2657.12	0	0
STORY91	Bottom	-6876.81	-6607.06	-2657.12	0	0
STORY90	Top	-7152.29	-6871.65	-2910.36	0	0
STORY90	Bottom	-7152.29	-6871.65	-2910.36	0	0
STORY89	Top	-7421.69	-7130.39	-3167.09	0	0
STORY89	Bottom	-7421.69	-7130.39	-3167.09	0	0
STORY88	Top	-7685.07	-7383.35	-3418.07	-314.59	-314.73
STORY88	Bottom	-7685.07	-7383.35	-3418.07	-314.59	-314.73
STORY87	Top	-7942.5	-7630.59	-3663.38	-620.86	-621.36
STORY87	Bottom	-7942.5	-7630.59	-3663.38	-620.86	-621.36
STORY86	Top	-8194.04	-7872.18	-3903.09	-920.14	-920.96
STORY86	Bottom	-8194.04	-7872.18	-3903.09	-920.14	-920.96
STORY85	Top	-8439.77	-8108.19	-4137.25	-1212.49	-1213.63
STORY85	Bottom	-8439.77	-8108.19	-4137.25	-1212.49	-1213.63
STORY84	Top	-8679.75	-8338.67	-4365.94	-1498.01	-1499.46
STORY84	Bottom	-8679.75	-8338.67	-4365.94	-1498.01	-1499.46

STORY83	Top	-8914.04	-8563.7	-4589.21	-1776.76	-1778.52
STORY83	Bottom	-8914.04	-8563.7	-4589.21	-1776.76	-1778.52
STORY82	Top	-9142.73	-8783.34	-4807.14	-2048.85	-2050.9
STORY82	Bottom	-9142.73	-8783.34	-4807.14	-2048.85	-2050.9
STORY81	Top	-9365.88	-8997.66	-5019.78	-2314.33	-2316.67
STORY81	Bottom	-9365.88	-8997.66	-5019.78	-2314.33	-2316.67
STORY80	Top	-9583.55	-9206.72	-5227.21	-2573.3	-2575.92
STORY80	Bottom	-9583.55	-9206.72	-5227.21	-2573.3	-2575.92
STORY79	Top	-9795.81	-9410.58	-5429.48	-2825.84	-2828.73
STORY79	Bottom	-9795.81	-9410.58	-5429.48	-2825.84	-2828.73
STORY78	Top	-10002.7	-9609.31	-5626.66	-3072.03	-3075.2
STORY78	Bottom	-10002.7	-9609.31	-5626.66	-3072.03	-3075.2
STORY77	Top	-10204.4	-9802.99	-5818.82	-3311.94	-3315.38
STORY77	Bottom	-10204.4	-9802.99	-5818.82	-3311.94	-3315.38
STORY76	Top	-10400.8	-9991.66	-6006.02	-3545.66	-3549.37
STORY76	Bottom	-10400.8	-9991.66	-6006.02	-3545.66	-3549.37
STORY75	Top	-10592.1	-10175.4	-6188.33	-3773.27	-3777.23
STORY75	Bottom	-10592.1	-10175.4	-6188.33	-3773.27	-3777.23
STORY74	Top	-10778.4	-10354.3	-6365.81	-3994.86	-3999.05
STORY74	Bottom	-10778.4	-10354.3	-6365.81	-3994.86	-3999.05
STORY73	Top	-10959.6	-10528.4	-6538.52	-4210.49	-4214.92
STORY73	Bottom	-10959.6	-10528.4	-6538.52	-4210.49	-4214.92
STORY72	Top	-11135.9	-10697.7	-6706.54	-4420.26	-4424.91
STORY72	Bottom	-11135.9	-10697.7	-6706.54	-4420.26	-4424.91
STORY71	Top	-11307.4	-10862.4	-6869.92	-4624.24	-4629.12
STORY71	Bottom	-11307.4	-10862.4	-6869.92	-4624.24	-4629.12
STORY70	Top	-11474	-11022.4	-7028.73	-4822.51	-4827.61
STORY70	Bottom	-11474	-11022.4	-7028.73	-4822.51	-4827.61
STORY69	Top	-11636	-11177.9	-7183.03	-5015.16	-5020.47
STORY69	Bottom	-11636	-11177.9	-7183.03	-5015.16	-5020.47
STORY68	Top	-11793.2	-11329	-7332.9	-5202.27	-5207.77
STORY68	Bottom	-11793.2	-11329	-7332.9	-5202.27	-5207.77
STORY67	Top	-11945.9	-11475.6	-7478.39	-5383.92	-5389.63
STORY67	Bottom	-11945.9	-11475.6	-7478.39	-5383.92	-5389.63
STORY66	Top	-12094	-11617.9	-7670.94	-5624.99	-5630.78
STORY66	Bottom	-12094	-11617.9	-7670.94	-5624.99	-5630.78
STORY65	Top	-12237.7	-11755.9	-7859.38	-5861.56	-5867.31
STORY65	Bottom	-12237.7	-11755.9	-7859.38	-5861.56	-5867.31
STORY64	Top	-12377.1	-11889.7	-8042.06	-6090.28	-6096.11
STORY64	Bottom	-12377.1	-11889.7	-8042.06	-6090.28	-6096.11
STORY63	Top	-12512	-12019.4	-8219.08	-6311.29	-6317.32
STORY63	Bottom	-12512	-12019.4	-8219.08	-6311.29	-6317.32
STORY62	Top	-12642.8	-12144.9	-8390.52	-6525.33	-6531.56
STORY62	Bottom	-12642.8	-12144.9	-8390.52	-6525.33	-6531.56
STORY61	Top	-12769.3	-12266.5	-8556.48	-6732.53	-6738.95
STORY61	Bottom	-12769.3	-12266.5	-8556.48	-6732.53	-6738.95
STORY60	Top	-12891.8	-12384.1	-8717.04	-6932.99	-6939.6
STORY60	Bottom	-12891.8	-12384.1	-8717.04	-6932.99	-6939.6
STORY59	Top	-13010.2	-12497.8	-8872.29	-7126.83	-7133.61
STORY59	Bottom	-13010.2	-12497.8	-8872.29	-7126.83	-7133.61
STORY58	Top	-13124.6	-12607.7	-9022.32	-7314.14	-7321.1
STORY58	Bottom	-13124.6	-12607.7	-9022.32	-7314.14	-7321.1
STORY57	Top	-13235.1	-12713.8	-9167.23	-7495.06	-7502.18
STORY57	Bottom	-13235.1	-12713.8	-9167.23	-7495.06	-7502.18
STORY56	Top	-13341.7	-12816.2	-9307.1	-7669.68	-7676.96
STORY56	Bottom	-13341.7	-12816.2	-9307.1	-7669.68	-7676.96
STORY55	Top	-13444.6	-12915	-9442.01	-7838.13	-7845.56
STORY55	Bottom	-13444.6	-12915	-9442.01	-7838.13	-7845.56
STORY54	Top	-13543.8	-13010.3	-9572.06	-8000.5	-8008.08
STORY54	Bottom	-13543.8	-13010.3	-9572.06	-8000.5	-8008.08
STORY53	Top	-13639.3	-13102	-9697.35	-8156.91	-8164.64
STORY53	Bottom	-13639.3	-13102	-9697.35	-8156.91	-8164.64
STORY52	Top	-13731.3	-13190.4	-9817.94	-8307.48	-8315.34
STORY52	Bottom	-13731.3	-13190.4	-9817.94	-8307.48	-8315.34
STORY51	Top	-13819.7	-13275.3	-9933.95	-8452.31	-8460.31
STORY51	Bottom	-13819.7	-13275.3	-9933.95	-8452.31	-8460.31
STORY50	Top	-13904.8	-13357	-10074.9	-8628.35	-8636.46
STORY50	Bottom	-13904.8	-13357	-10074.9	-8628.35	-8636.46
STORY49	Top	-13986.4	-13435.4	-10211.3	-8798.62	-8806.86
STORY49	Bottom	-13986.4	-13435.4	-10211.3	-8798.62	-8806.86
STORY48	Top	-14064.8	-13510.7	-10342.2	-8962.02	-8970.37
STORY48	Bottom	-14064.8	-13510.7	-10342.2	-8962.02	-8970.37
STORY47	Top	-14139.9	-13582.8	-10467.7	-9118.68	-9127.14
STORY47	Bottom	-14139.9	-13582.8	-10467.7	-9118.68	-9127.14

STORY46	Top	-14211.9	-13652	-10587.9	-9268.75	-9277.31
STORY46	Bottom	-14211.9	-13652	-10587.9	-9268.75	-9277.31
STORY45	Top	-14280.8	-13718.1	-10702.9	-9412.36	-9421.03
STORY45	Bottom	-14280.8	-13718.1	-10702.9	-9412.36	-9421.03
STORY44	Top	-14346.6	-13781.3	-10812.9	-9549.66	-9558.42
STORY44	Bottom	-14346.6	-13781.3	-10812.9	-9549.66	-9558.42
STORY43	Top	-14409.5	-13841.7	-10917.9	-9680.79	-9689.64
STORY43	Bottom	-14409.5	-13841.7	-10917.9	-9680.79	-9689.64
STORY42	Top	-14469.5	-13899.4	-11018.1	-9805.89	-9814.83
STORY42	Bottom	-14469.5	-13899.4	-11018.1	-9805.89	-9814.83
STORY41	Top	-14526.7	-13954.3	-11113.6	-9925.11	-9934.13
STORY41	Bottom	-14526.7	-13954.3	-11113.6	-9925.11	-9934.13
STORY40	Top	-14581.1	-14006.5	-11204.5	-10038.6	-10047.7
STORY40	Bottom	-14581.1	-14006.5	-11204.5	-10038.6	-10047.7
STORY39	Top	-14632.8	-14056.2	-11290.9	-10146.5	-10155.6
STORY39	Bottom	-14632.8	-14056.2	-11290.9	-10146.5	-10155.6
STORY38	Top	-14681.9	-14103.4	-11372.9	-10248.9	-10258.1
STORY38	Bottom	-14681.9	-14103.4	-11372.9	-10248.9	-10258.1
STORY37	Top	-14728.5	-14148.1	-11450.7	-10345.9	-10355.3
STORY37	Bottom	-14728.5	-14148.1	-11450.7	-10345.9	-10355.3
STORY36	Top	-14772.6	-14190.4	-11524.3	-10437.9	-10447.2
STORY36	Bottom	-14772.6	-14190.4	-11524.3	-10437.9	-10447.2
STORY35	Top	-14814.2	-14230.5	-11593.9	-10524.7	-10534.2
STORY35	Bottom	-14814.2	-14230.5	-11593.9	-10524.7	-10534.2
STORY34	Top	-14853.5	-14268.2	-11659.5	-10606.7	-10616.2
STORY34	Bottom	-14853.5	-14268.2	-11659.5	-10606.7	-10616.2
STORY33	Top	-14890.6	-14303.8	-11721.4	-10684	-10693.5
STORY33	Bottom	-14890.6	-14303.8	-11721.4	-10684	-10693.5
STORY32	Top	-14925.4	-14337.2	-11779.6	-10756.6	-10766.2
STORY32	Bottom	-14925.4	-14337.2	-11779.6	-10756.6	-10766.2
STORY31	Top	-14958.1	-14368.6	-11834.2	-10824.7	-10834.4
STORY31	Bottom	-14958.1	-14368.6	-11834.2	-10824.7	-10834.4
STORY30	Top	-14988.7	-14398	-11885.3	-10888.7	-10898.4
STORY30	Bottom	-14988.7	-14398	-11885.3	-10888.7	-10898.4
STORY29	Top	-15017.3	-14425.5	-11933	-10948.6	-10958.3
STORY29	Bottom	-15017.3	-14425.5	-11933	-10948.6	-10958.3
STORY28	Top	-15044	-14451.1	-11977.6	-11004.3	-11014
STORY28	Bottom	-15044	-14451.1	-11977.6	-11004.3	-11014
STORY27	Top	-15068.8	-14474.9	-12019	-11056	-11065.7
STORY27	Bottom	-15068.8	-14474.9	-12019	-11056	-11065.7
STORY26	Top	-15091.7	-14497	-12057.4	-11104	-11113.7
STORY26	Bottom	-15091.7	-14497	-12057.4	-11104	-11113.7
STORY25	Top	-15113	-14517.4	-12092.9	-11148.3	-11158
STORY25	Bottom	-15113	-14517.4	-12092.9	-11148.3	-11158
STORY24	Top	-15132.6	-14536.2	-12125.6	-11189.1	-11198.9
STORY24	Bottom	-15132.6	-14536.2	-12125.6	-11189.1	-11198.9
STORY23	Top	-15150.6	-14553.5	-12155.7	-11226.7	-11236.5
STORY23	Bottom	-15150.6	-14553.5	-12155.7	-11226.7	-11236.5
STORY22	Top	-15167	-14569.3	-12183.2	-11261	-11270.8
STORY22	Bottom	-15167	-14569.3	-12183.2	-11261	-11270.8
STORY21	Top	-15182	-14583.7	-12208.2	-11292.3	-11302.1
STORY21	Bottom	-15182	-14583.7	-12208.2	-11292.3	-11302.1
STORY20	Top	-15195.7	-14596.8	-12230.9	-11320.6	-11330.5
STORY20	Bottom	-15195.7	-14596.8	-12230.9	-11320.6	-11330.5
STORY19	Top	-15207.9	-14608.6	-12251.4	-11346.2	-11356.1
STORY19	Bottom	-15207.9	-14608.6	-12251.4	-11346.2	-11356.1
STORY18	Top	-15218.9	-14619.2	-12269.8	-11369.2	-11379.1
STORY18	Bottom	-15218.9	-14619.2	-12269.8	-11369.2	-11379.1
STORY17	Top	-15228.8	-14628.6	-12286.3	-11389.7	-11399.6
STORY17	Bottom	-15228.8	-14628.6	-12286.3	-11389.7	-11399.6
STORY16	Top	-15237.5	-14637	-12300.8	-11407.9	-11417.8
STORY16	Bottom	-15237.5	-14637	-12300.8	-11407.9	-11417.8
STORY15	Top	-15245.1	-14644.3	-12313.6	-11423.8	-11433.7
STORY15	Bottom	-15245.1	-14644.3	-12313.6	-11423.8	-11433.7
STORY14	Top	-15251.8	-14650.7	-12324.7	-11437.7	-11447.6
STORY14	Bottom	-15251.8	-14650.7	-12324.7	-11437.7	-11447.6
STORY13	Top	-15257.6	-14656.2	-12334.3	-11449.7	-11459.6
STORY13	Bottom	-15257.6	-14656.2	-12334.3	-11449.7	-11459.6
STORY12	Top	-15262.4	-14660.9	-12342.5	-11459.9	-11469.8
STORY12	Bottom	-15262.4	-14660.9	-12342.5	-11459.9	-11469.8
STORY11	Top	-15266.6	-14664.9	-12349.4	-11468.5	-11478.4
STORY11	Bottom	-15266.6	-14664.9	-12349.4	-11468.5	-11478.4
STORY10	Top	-15270	-14668.2	-12355	-11475.6	-11485.5
STORY10	Bottom	-15270	-14668.2	-12355	-11475.6	-11485.5

STORY9	Top	-15272.7	-14670.8	-12359.6	-11481.3	-11491.3
STORY9	Bottom	-15272.7	-14670.8	-12359.6	-11481.3	-11491.3
STORY8	Top	-15274.9	-14672.9	-12363.3	-11485.9	-11495.8
STORY8	Bottom	-15274.9	-14672.9	-12363.3	-11485.9	-11495.8
STORY7	Top	-15276.6	-14674.5	-12366.1	-11489.3	-11499.3
STORY7	Bottom	-15276.6	-14674.5	-12366.1	-11489.3	-11499.3
STORY6	Top	-15277.8	-14675.7	-12368.1	-11491.9	-11501.9
STORY6	Bottom	-15277.8	-14675.7	-12368.1	-11491.9	-11501.9
STORY5	Top	-15278.6	-14676.5	-12369.5	-11493.7	-11503.6
STORY5	Bottom	-15278.6	-14676.5	-12369.5	-11493.7	-11503.6
STORY4	Top	-15279.2	-14677	-12370.4	-11494.8	-11504.8
STORY4	Bottom	-15279.2	-14677	-12370.4	-11494.8	-11504.8
STORY3	Top	-15279.5	-14677.3	-12370.9	-11495.4	-11505.4
STORY3	Bottom	-15279.5	-14677.3	-12370.9	-11495.4	-11505.4
STORY2	Top	-15279.6	-14677.4	-12371.2	-11495.7	-11505.7
STORY2	Bottom	-15279.6	-14677.4	-12371.2	-11495.7	-11505.7
STORY1	Top	-15279.7	-14677.5	-12371.2	-11495.8	-11505.8
STORY1	Bottom	-15279.7	-14677.5	-12371.2	-11495.8	-11505.8

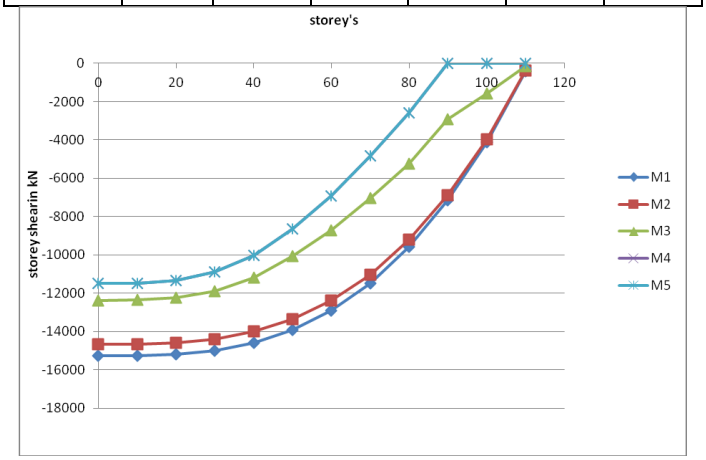

Chart-3: plotting storey shear with storey's.

Discussion: From the above graph, it is observed that model M1 has storey shear of -15279.7 kN, M2 -15279.7 kN, M3 -12371.2 kN, M4 -11495.8 kN, M5 -11505.8 kN at the base of structure. Hence the model M5 has got less time period of -11505.8 kN, which is much less than other models.

2.6 Story Drift results.

Table-5: plotting story drift with storey's.

Story	Item	M1	M2	M3	M4	M5
STORY110	Max Drift X	0.00132	0.001062	0.00075	0.000279	0.000273
STORY109	Max Drift X	0.001344	0.001087	0.000774	0.000278	0.000273
STORY108	Max Drift X	0.001372	0.001118	0.000806	0.000278	0.000274
STORY107	Max Drift X	0.0014	0.00115	0.00084	0.000279	0.000274
STORY106	Max Drift X	0.001428	0.001183	0.000874	0.000279	0.000274
STORY105	Max Drift X	0.001456	0.001215	0.000908	0.000279	0.000276
STORY104	Max Drift X	0.001484	0.001247	0.000942	0.000279	0.000276
STORY103	Max Drift X	0.001511	0.001278	0.000975	0.00028	0.000276
STORY102	Max Drift X	0.001537	0.001309	0.001007	0.00028	0.000277
STORY101	Max Drift X	0.001564	0.00134	0.001038	0.00028	0.000278
STORY100	Max Drift X	0.00159	0.00137	0.001068	0.000281	0.000279
STORY99	Max Drift X	0.001615	0.0014	0.001097	0.000281	0.00028
STORY98	Max Drift X	0.00164	0.00143	0.001124	0.000282	0.00028
STORY97	Max Drift X	0.001664	0.001458	0.001151	0.000283	0.000281
STORY96	Max Drift X	0.001688	0.001487	0.001175	0.000284	0.000282
STORY95	Max Drift X	0.001712	0.001515	0.001197	0.000285	0.000283
STORY94	Max Drift X	0.001734	0.001542	0.001215	0.000286	0.000284
STORY93	Max Drift X	0.001757	0.001568	0.001224	0.000289	0.000288
STORY92	Max Drift X	0.001778	0.001594	0.001212	0.000293	0.000291
STORY91	Max Drift X	0.0018	0.00162	0.001146	0.000301	0.0003
STORY90	Max Drift X	0.00182	0.001645	0.001001	0.000329	0.000322
STORY89	Max Drift X	0.001841	0.001669	0.000983	0.000336	0.000328
STORY88	Max Drift X	0.00186	0.001693	0.000993	0.000353	0.000345
STORY87	Max	0.00187	0.0017	0.00101	0.000377	0.000368

	Drift X	9	16			
STORY86	Max Drift X	0.001897	0.001739	0.001028	0.000402	0.000392
STORY85	Max Drift X	0.001915	0.00176	0.001047	0.000427	0.000416
STORY84	Max Drift X	0.001932	0.001782	0.001065	0.000452	0.000438
STORY83	Max Drift X	0.001949	0.001802	0.001082	0.000477	0.00046
STORY82	Max Drift X	0.001965	0.001822	0.001099	0.000501	0.000481
STORY81	Max Drift X	0.00198	0.001842	0.001116	0.000524	0.000502
STORY80	Max Drift X	0.001995	0.00186	0.001132	0.000547	0.000524
STORY79	Max Drift X	0.002009	0.001879	0.001147	0.000569	0.000546
STORY78	Max Drift X	0.002023	0.001896	0.001161	0.000591	0.000567
STORY77	Max Drift X	0.002036	0.001913	0.001175	0.000612	0.000585
STORY76	Max Drift X	0.002048	0.001929	0.001188	0.000632	0.0006
STORY75	Max Drift X	0.00206	0.001945	0.0012	0.000651	0.000615
STORY74	Max Drift X	0.002071	0.00196	0.001212	0.00067	0.00063
STORY73	Max Drift X	0.002081	0.001974	0.001222	0.000687	0.000644
STORY72	Max Drift X	0.002091	0.001987	0.001232	0.000704	0.000658
STORY71	Max Drift X	0.0021	0.002	0.00124	0.00072	0.000672
STORY70	Max Drift X	0.002108	0.002013	0.001247	0.000734	0.000685
STORY69	Max Drift X	0.002116	0.002024	0.001249	0.000743	0.000695
STORY68	Max Drift X	0.002123	0.002035	0.00124	0.000741	0.000698
STORY67	Max Drift X	0.00213	0.002046	0.001195	0.000705	0.000673
STORY66	Max Drift X	0.002136	0.002056	0.001086	0.000608	0.000595
STORY65	Max Drift X	0.002141	0.002065	0.001077	0.000615	0.000601
STORY64	Max Drift X	0.002146	0.002073	0.001081	0.000692	0.000658
STORY63	Max Drift X	0.00215	0.002081	0.001088	0.000734	0.000685
STORY62	Max Drift X	0.002153	0.002088	0.001095	0.000756	0.000697
STORY61	Max Drift X	0.002156	0.002095	0.001102	0.000772	0.000704
STORY60	Max Drift X	0.002158	0.0021	0.001109	0.000784	0.000711
STORY59	Max Drift X	0.002159	0.002106	0.001115	0.000796	0.000718
STORY58	Max Drift X	0.00216	0.00211	0.001121	0.000807	0.000724
STORY57	Max Drift X	0.00216	0.002114	0.001125	0.000817	0.000732
STORY56	Max Drift X	0.00216	0.002117	0.001129	0.000826	0.000741
STORY55	Max Drift X	0.002159	0.00212	0.001132	0.000834	0.000749
STORY54	Max Drift X	0.002157	0.002122	0.001134	0.000841	0.000757
STORY53	Max Drift X	0.002154	0.002124	0.001132	0.000845	0.000764
STORY52	Max Drift X	0.002151	0.002124	0.00112	0.000843	0.000767
STORY51	Max Drift X	0.002148	0.002124	0.001081	0.000823	0.000755
STORY50	Max Drift X	0.002143	0.002124	0.000992	0.000772	0.000717
STORY49	Max Drift X	0.002138	0.002123	0.00098	0.000768	0.000711
STORY48	Max Drift X	0.002133	0.002121	0.000979	0.000772	0.000709
STORY47	Max Drift X	0.002126	0.002119	0.000981	0.000778	0.000708
STORY46	Max Drift X	0.00212	0.002116	0.000984	0.000783	0.000708
STORY45	Max Drift X	0.002112	0.002112	0.000987	0.000789	0.000708
STORY44	Max Drift X	0.002104	0.002108	0.000989	0.000794	0.000712
STORY43	Max Drift X	0.002095	0.002103	0.000991	0.000799	0.000718
STORY42	Max Drift X	0.002086	0.002097	0.000993	0.000804	0.000722
STORY41	Max Drift X	0.002076	0.002091	0.000995	0.000808	0.000725
STORY40	Max Drift X	0.002065	0.002085	0.000996	0.000811	0.000727
STORY39	Max Drift X	0.002054	0.002077	0.000996	0.000815	0.000728
STORY38	Max Drift X	0.002042	0.002069	0.000997	0.000817	0.000729
STORY37	Max Drift X	0.002029	0.002061	0.000997	0.000819	0.00073
STORY36	Max Drift X	0.002016	0.002051	0.000996	0.000821	0.000733

STORY35	Max Drift X	0.002002	0.002042	0.000996	0.000822	0.000737
STORY34	Max Drift X	0.001987	0.002031	0.000994	0.000822	0.000741
STORY33	Max Drift X	0.001972	0.00202	0.000993	0.000818	0.000745
STORY32	Max Drift X	0.001956	0.002008	0.000991	0.000805	0.000743
STORY31	Max Drift X	0.00194	0.001996	0.000989	0.000764	0.00072
STORY30	Max Drift X	0.001923	0.001983	0.000986	0.00067	0.000654
STORY29	Max Drift X	0.001905	0.001969	0.000983	0.000668	0.000656
STORY28	Max Drift X	0.001887	0.001955	0.00098	0.000762	0.000733
STORY27	Max Drift X	0.001868	0.00194	0.000976	0.000801	0.000761
STORY26	Max Drift X	0.001848	0.001925	0.000972	0.000813	0.000764
STORY25	Max Drift X	0.001828	0.001909	0.000968	0.000815	0.00076
STORY24	Max Drift X	0.001807	0.001892	0.000963	0.000813	0.000754
STORY23	Max Drift X	0.001785	0.001874	0.000958	0.000811	0.000747
STORY22	Max Drift X	0.001763	0.001856	0.000953	0.000808	0.000741
STORY21	Max Drift X	0.00174	0.001837	0.000947	0.000804	0.000735
STORY20	Max Drift X	0.001716	0.001817	0.000941	0.0008	0.000729
STORY19	Max Drift X	0.001691	0.001797	0.000934	0.000796	0.000722
STORY18	Max Drift X	0.001666	0.001776	0.000928	0.000791	0.000717
STORY17	Max Drift X	0.00164	0.001754	0.000921	0.000786	0.000711
STORY16	Max Drift X	0.001614	0.001732	0.000913	0.000781	0.000705
STORY15	Max Drift X	0.001586	0.001708	0.000906	0.000775	0.000699
STORY14	Max Drift X	0.001558	0.001684	0.000898	0.000769	0.000692
STORY13	Max Drift X	0.001529	0.001659	0.000889	0.000763	0.000685
STORY12	Max Drift X	0.001499	0.001633	0.000881	0.000756	0.000678
STORY11	Max Drift X	0.001469	0.001606	0.000871	0.000748	0.000671
STORY10	Max Drift X	0.001437	0.001577	0.000862	0.000741	0.000663
STORY9	Max Drift X	0.001405	0.001548	0.000852	0.000733	0.000656
STORY8	Max Drift X	0.001372	0.001517	0.000842	0.000724	0.000648
STORY7	Max Drift X	0.001337	0.001485	0.00083	0.000715	0.000639
STORY6	Max Drift X	0.001302	0.001449	0.000818	0.000705	0.000629
STORY5	Max Drift X	0.001264	0.001409	0.000804	0.000693	0.000618
STORY4	Max Drift X	0.001221	0.001356	0.000783	0.000675	0.000603
STORY3	Max Drift X	0.001157	0.00127	0.000743	0.00064	0.000573
STORY2	Max Drift X	0.001017	0.001081	0.000644	0.000553	0.000498
STORY1	Max Drift X	0.00058	0.000571	0.000349	0.000297	0.000271

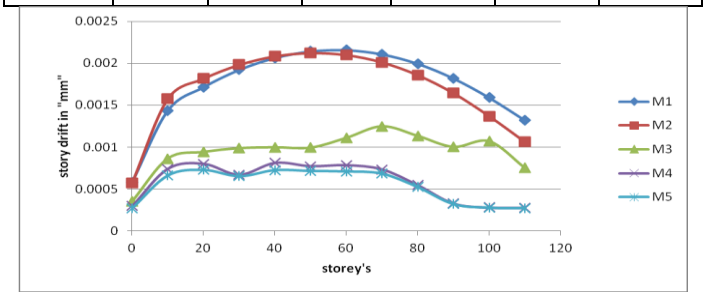

Chart-4: plotting storey drift with storeys.

Discussion: From the above graph, it is observed that model M1 has a story drift of 0.00132m at the top and of 0.001062m in M2, of 0.00075m in M3, of 0.000279m in M4, of 0.000273m in M5, in which it is much reduced in M5 compared to M1. Hence the model M5 has got 79.3% less story drift than M1.

3. CONCLUSIONS

The following conclusions have been drawn based on the results obtained from the analysis of five different structural formworks.

1) Bundled tube steel structure with belt-truss and mega bracings system is stiffer than other frame in terms of displacement, showing 68.2% reduction compared to regular steel model.
2) The inclusion of belt-truss and mega bracings in the bundled tube have efficiently made time period among all 12 modes of structure reducible i,e from 15.54506secs to 9.266902secs, which is reduced by 40.38%.
3) From the table of story shear it is observed that in last 2 models the story shear is zero up to 89th story which is due to the use of belt-truss and mega bracings, and the story

shear has been decreased by 24.69% compared to regular steel structure.

4) From the model analysis result it is observed that, the use of belt-truss and mega bracing has reduced the story drift by 79.31%, compared to regular steel structure.

5) From the model analysis result it is observed that, the belt-truss and mega bracings system showing satisfactory performance on all design outcomes as mentioned above i,e displacement, time period, story shear, story drift.

6) ETABS 9.7.3 have proved to be an efficient tool for carrying out dynamic analysis of complicate structure like bundled tube structures.

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