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COMPARATIVE STUDY ON SEISMIC PERFORMANC OF CFST BUILDINGS AND RCC BUILDINGS WITH AND WITHOUT BRACINGS USING ETABS SOFTWARE

Suresh Mahantappa Hunagund
PG Student, M.Tech, Dept of Civil Engineering, Ghousia College of Engineering, Ramanagaram

Mr. B R Narayana
Associate Professor,Dept of Civil Engineering,Ghousia College of Engineering , Ramanagaram

ABSTRACT

ETABS Software is used to analyse the G+25 Storied CFST and RCC Buildings with objective as. To determine the response of G+25 CFST Building under static and dynamic analysis. To determine the effect of story height on story displacement in G+25 CFST and RCC buildings. To determine the seismic performance of G+25 CFST building with steel bracings. Finally to compare the performance of G+25 CFST against equivalent RCC building in terms of time period, story displacement, drift and storey shear.

3D modelling for analysis of concrete filled steel tubes (CFST) column and reinforced concrete (RCC) frame multi-storey building having different storey height as well as "X" bracings are done using ETABS. There buildings is analysed by equivalent static analysis and response spectrum analysis. In india reinforced concrete structure are mostly used since this is the most convenient and economic system for low-rise buildings this type of structure is no longer economic because of increased dead load, less stiffness, span restriction and hazardous formwork. So the structural engineers are facing the challenge of striving for the most efficient and economical design solution.

KEYWORDS*: ETABS, concrete filled steel tube(CFST), Equivalent static analysis, Response spectrum analysis, Storey displacement, Storey drift and storey shear*

1. INTRODUCTION

Columns were hardly used from the Second World War till the initial 1970's; research had started a long time before, at the 20th century. Combining of these materials had a number of motivations; steel columns were frequent encased in concrete to give resistance against the fire, and the other hand concrete columns used with steel as a rebar providing. 'til the 1950s. It was common to use a wet mix of less strength concrete and neglect the role of the good class concrete to the strength of the column. In 1956 Faber and Steven proved that it had well in savings could be made by using good-class concrete and use these columns like a composite part. Method was discovered by stages from initially design ways for steel columns. Not centered on ultimate research on composite columns. In the era of 1980 many buildings were built by using of composite column.

2. LITERATURE REVIEW

Faizulla Z Shariff & Suma Devi et.al., (2015) [1]**:** In this journal, based on modern building extensive study is basically done for composite columns in which steel section is encased in concrete have been carried out by ETABS software using non-linear analysis is used for stimulation of steel concrete composite with steel reinforcement concrete structure of varying number of storeys such as G+14, G+19 and G+24 are considered for comparative study for the analysis. And structural parameters considered are axial force, base shear and bending moment is done and concluded that the composite structures are stronger for seismic analysis than RCC and finally composite structures shows better performance for these structural parameters.

Gayathri S et.al., (2017) [2] **:** In this research for the seismic analysis G+9 building is considered for the comparison of RCC and CFST structures in zoneIII using ETABS software. In seismic analysis only for equivalent static method the results are considered for structural parameters such as Story displacement, Base shear, Time period is used for the analysis and finally concluded that composite structure under ESA method shows better performance than RCC under seismic loading. It can be considered as an alternative to conventional structures in seismic prone regions.

3. OBJECTIVES

1. To determine the behavior of G+25 building under Equivalent static method with comparison of RCC and CFST structures.
2. To determine the effect of storey height on storey displacement in G+25 CFST and RCC buildings.
3. To determine the seismic performance of G+25 CFST building with steel bracings.
4. Finally to compare the performance of G+25 CFST against equivalent RCC building in terms of time period, story displacement, drift and storey shear.

4. METHODOLOGY

- 3D modeling for analysis of concrete filled steel tubes (CFST) columns and reinforced Concrete (RCC) frame multistory building having different storey height as well as x bracings are done using ETABS.
- These buildings are analyzed by Equivalent Static Analysis and Response Spectrum Analysis.

BRACINGS

A braced frame is a structural system commonly used in structures subject to lateral loads such as wind and seismic pressure. The members in a braced frame are generally made of structural steel, which can work effectively both in tension and compression The beams and columns that form the frame carry vertical loads, and the bracing system carries the lateral loads. The positioning of braces, however, can be problematic as they can interfere with the design of the façade and the position of openings.

Fig-1: Exoskeleton Structure with X-bracing in London

5. TYPES OF BRACINGS

5.1 Single diagonals

Trussing, or triangulation, is formed by inserting diagonal structural members into rectangular areas of a structural frame, helping to stabilize the frame. If a single brace is used, it must be sufficiently resistant to tension and compression.

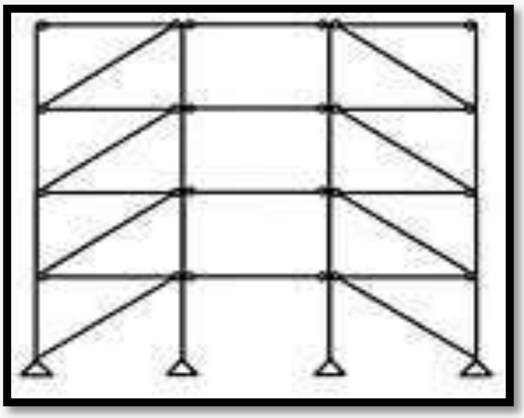

Fig-2: Single diagonal bracing

5.2. Cross bracings

Cross-bracing (or X-bracing) uses two diagonal members crossing each other. These only need to be resistant to tension, one brace at a time acting to resist sideways forces, depending on the direction of loading. As a result, steel cables can also be used for cross-bracing.

Fig-3: Cross- bracing

5.3 K- Bracing

K-braces connect to the columns at mid-height. This frame has more flexibility for the provision of openings in the facade and results in the least bending in floor beams. K-bracing is generally discouraged in seismic regions because of the potential for column failure if the compression brace buckles.

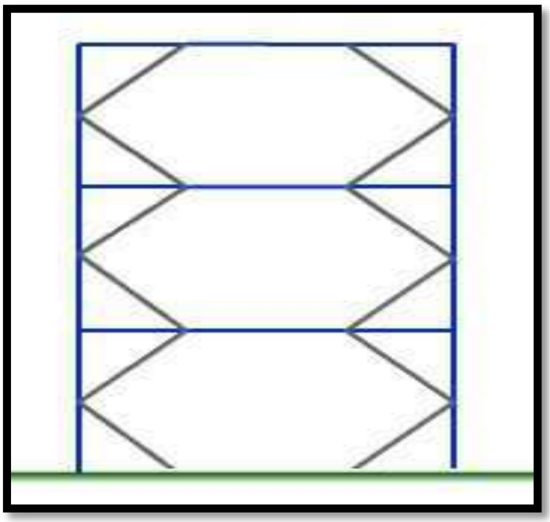

Fig-4: K- bracing

6. ANALYTICAL MODELLING

In this study the seismic analysis for a G+25 storey structure is performed for both R.C.C and composite structures using ETABS software. The structure is located in Coimbatore of seismic zone III. The plan dimensions of the structure are 42m X 25m of 25 storey building analyzed for Equivalent static method of analysis is performed as per IS 1893.After analysis the seismic performance of both the structures are compared from the obtained results using ETABS software.

6.1 Modelling in ETABS

A 3-D model of the structure analysed drawn in ETABS. The following table gives the details used in modelling of the R.C.C and Composite structures.

	RCC Building	CFT Building
MATERIAL PROPERTIES		
Grade of Concrete F_{ck}	M30	M30
Grade of Reinforcing Steel F_y	Fe 415	Fe 415,500
BUILDING PLAN		
No of Bays in X-direction	8	8
No of Bays in Y-direction	6	6
Width of bay in X-direction	6m	6m
Width of bay in Y-direction	5m	5m
Height of Storey	2.8,3 &3.2m	2.8,3 &3.2m
SECTIONAL PROPERTIES		
Column size	D=900mm	D=900mm, t=9mm
Beam size	550x250 mm	ISWB 600
Slab Thickness	150mm	150mm
Bracing size	200x300	ISMC 200
LOAD ASSIGNMENTS		
Live load on roof slab	1.5 k N /m	1.5 k N /m
Live load on floor slab	3 k N /m	3 k N /m
Floor Finishing	1 k N /m	1 k N /m
SEISMIC DATA		
Seismic Zone	3	3
Importance Factor	1	1
Zone factor	0.16	0.16
Soil type	Medium	Medium
Response Reduction Factor	3	3

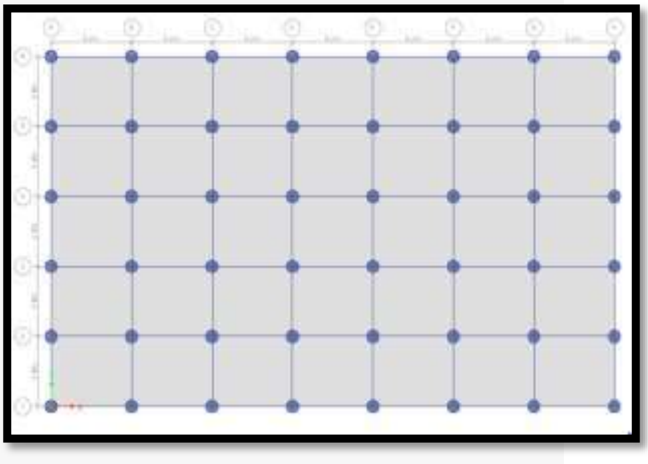

Fig. 5: Plan view of RCC Structure.

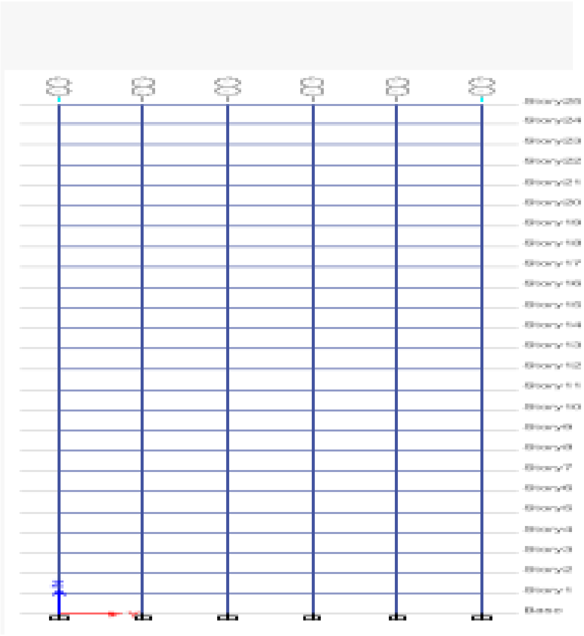

Fig.6: R.C.C and C.F.S.T structures without bracings for 3.0 meter

Fig. 7: R.C.C and C.F.S.T structures with bracings for 3.0 meter

7. RESULTS AND DISCUSSION

7.1 FUNDAMENTAL NATURAL PERIOD

Natural Time Period of a building is the time taken by it to undergo one complete cycle of oscillation. It is an inherent property of a building controlled by its mass and stiffness. Its units are seconds (s). Thus, buildings that are heavy with larger mass and flexible with smaller stiffness have larger natural period than light and stiff buildings.

7.2 Comparison of Time period of varying different storey height buildings with and without bracings.

Table-1: Time period for 3m storey height

MODES	RCC	CFST	XRCC	XCFST
1	3.074	2.088	2.626	1.58
2	2.967	2.07	2.386	1.415
3	2.685	1.859	1.896	1.038
4	0.997	0.68	0.792	0.508
5	0.96	0.671	0.712	0.463
6	0.873	0.607	0.56	0.343
7	0.567	0.389	0.419	0.284
8	0.542	0.379	0.374	0.266
9	0.499	0.349	0.291	0.202
10	0.38	0.265	0.278	0.197
11	0.366	0.258	0.249	0.186
12	0.337	0.238	0.204	0.148

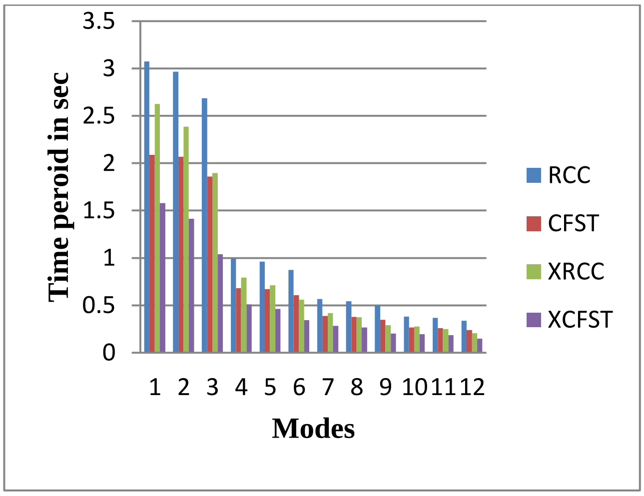

Fig-.8: Time period v/s mode for bare frame and X-bracing frame structure of 3.0m storey height

7.3 STOREY DISPLACEMENT

The maximum displacement at each floor level with respect to ground is examined in tables obtained from equivalent static analysis and response spectrum analysis. For better compatibility, the displacement for each model is taken along the longitudinal and transverse direction of ground motion which is plotted in charts below.

7.4 COMPARISION OF STOREY DISPLACEMENT RESULTS

Table 2: Storey displacement of bare frame models for ESA in X-direction.

Storey Displacement in X-direction (mm)						
ESA	**RCC Building**			**CFST Building**		
STOREYS	**2.8 m**	**3m**	**3.2m**	**2.8 m**	**3m**	**3.2m**
25	74.298	79.148	84.155	50.388	53.69	57.319
24	73.441	78.265	83.244	49.819	53.147	56.697
23	72.221	77.104	82.132	48.986	52.36	55.927
22	70.639	75.609	80.711	47.9	51.336	54.941
21	68.692	73.771	78.966	46.561	50.075	53.734
20	66.405	71.601	76.898	44.992	48.589	52.31
19	63.82	69.121	74.51	43.225	46.895	50.672
18	61.192	66.359	71.612	41.44	45.015	48.688
17	58.36	63.341	68.406	39.522	42.965	46.498
16	55.334	60.095	64.935	37.477	40.766	44.136
15	52.132	56.646	61.236	35.317	38.434	41.626
14	48.773	53.02	57.339	33.055	35.988	38.988
13	45.277	49.241	53.273	30.704	33.442	36.24
12	41.662	45.331	49.063	28.278	30.811	33.4
11	37.948	41.31	44.731	25.789	28.111	30.482
10	34.153	37.199	40.3	23.248	25.353	27.502
9	30.293	33.017	35.789	20.668	22.551	24.473
8	26.385	28.78	31.22	18.057	19.715	21.407
7	22.448	24.511	26.612	15.428	16.858	18.318
6	18.504	20.23	21.991	12.791	13.992	15.217
5	14.585	15.972	17.388	10.162	11.132	12.123
4	10.742	11.79	12.862	7.569	8.307	9.063
3	7.072	7.784	8.515	5.061	5.57	6.092
2	3.757	4.15	4.556	2.749	3.036	3.332
1	1.158	1.285	1.417	0.877	0.973	1.073
Base	0	0	0	0	0	0

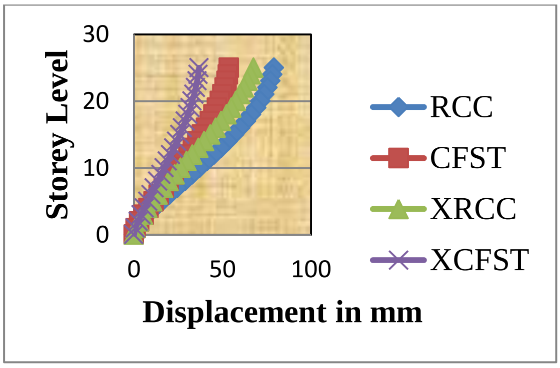

Fig. 9: Comparison of Storey displacement for bare frame and X bracing frame structure of 3m storey height for ESA in X-direction.

7.5 STOREY DRIFT

The total lateral displacement that occurs in a single story of a multi-story building is known as storey drift. Drift in building frames is a result of flexural and shear mode contributions due to the column axial deformations and to the diagonal and beams deformations respectively. The maximum storey drifts for various building models along longitudinal and transverse direction obtained from ETABS are shown in tables and figures below.

7.6 COMPARISION OF STOREY DRIFT RESULTS

Table 3: Storey drift for bare frame models for ESA in X-direction.

Storey Drift in X-direction						
ESA	**RCC Building**			**CFST Building**		
STOREYS	**2.8 m**	**3m**	**3.2m**	**2.8 m**	**3m**	**3.2m**
25	0.000309	0.000296	0.000286	0.000207	0.000197	0.000196
24	0.000407	0.000388	0.000371	0.000278	0.000263	0.000257
23	0.000527	0.000498	0.000474	0.000362	0.000341	0.000329
22	0.000649	0.000613	0.000582	0.000446	0.00042	0.000402
21	0.000763	0.000723	0.000689	0.000523	0.000495	0.000475
20	0.000862	0.000827	0.000796	0.000589	0.000565	0.000546
19	0.000938	0.000921	0.000906	0.000638	0.000627	0.00062
18	0.001011	0.001006	0.001002	0.000685	0.000683	0.000684
17	0.001081	0.001082	0.001085	0.00073	0.000733	0.000738
16	0.001144	0.00115	0.001156	0.000771	0.000777	0.000785
15	0.0012	0.001209	0.001218	0.000808	0.000816	0.000824
14	0.001249	0.00126	0.001271	0.00084	0.000849	0.000859
13	0.001291	0.001303	0.001316	0.000866	0.000877	0.000888
12	0.001326	0.00134	0.001354	0.000889	0.0009	0.000912
11	0.001356	0.00137	0.001385	0.000907	0.000919	0.000931
10	0.001379	0.001394	0.001409	0.000922	0.000934	0.000947
9	0.001396	0.001412	0.001428	0.000932	0.000945	0.000958
8	0.001406	0.001423	0.00144	0.000939	0.000952	0.000966
7	0.001409	0.001427	0.001444	0.000942	0.000956	0.000969
6	0.0014	0.001419	0.001438	0.000939	0.000953	0.000967
5	0.001372	0.001394	0.001415	0.000926	0.000942	0.000956
4	0.001311	0.001335	0.001358	0.000896	0.000912	0.000928
3	0.001184	0.001211	0.001237	0.000826	0.000844	0.000862
2	0.000928	0.000955	0.000981	0.000668	0.000688	0.000706
1	0.000414	0.000428	0.000443	0.000313	0.000324	0.000335
Base	0	0	0	0	0	0

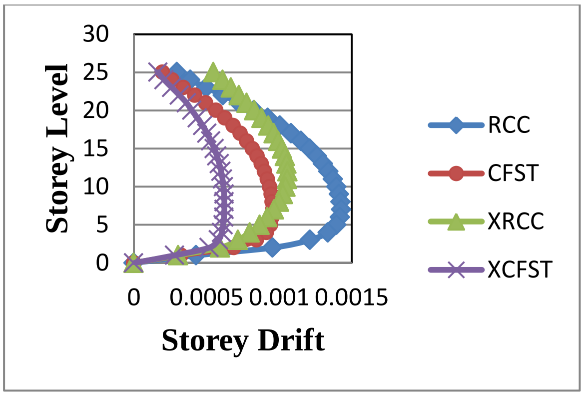

Fig. 10: Comparision of Storey drift for bare frame and X bracing frame structure of 3m storey height for ESA in X-direction.

7.7 STOREY SHEAR

The storey shear at each storey level for RCC and CFT buildings of 2.8m, 3mand 3.2m storey height are obtained for both X and Y directions presented in tables and charts, shown below.

7.8 COMPARISION OF STOREY SHEAR RESULTS

Table 4: Storey shear for bare frame models in X-direction.

Storey Shear in X-direction (k N)						
STOREY LEVELS	RCC Building			CFST Building		
	2.8 m	3m	3.2m	2.8 m	3m	3.2m
25	376.068	348.3298	324.4427	495.6867	452.7996	429.0883
24	781.2226	722.5661	672.1066	1045.257	956.917	901.6767
23	1155.061	1066.266	989.784	1553.159	1425.079	1332.828
22	1495.289	1380.728	1281.819	2015.398	1853.415	1729.177
21	1803.488	1667.253	1549.29	2434.123	2243.698	2092.188
20	2081.243	1927.139	1793.276	2811.484	2597.695	2423.326
19	2327.776	2161.687	2016.956	3145.893	2917.178	2727.38
18	2546.924	2372.195	2219.596	3442.67	3203.915	3003.257
17	2742.398	2559.962	2400.346	3707.388	3459.679	3249.333
16	2915.552	2726.29	2560.457	3941.878	3686.237	3467.309
15	3067.737	2872.476	2701.179	4147.974	3885.36	3658.891
14	3200.308	2999.82	2823.764	4327.505	4058.819	3825.779
13	3314.617	3109.622	2929.462	4482.306	4208.383	3969.678
12	3412.016	3203.181	3019.525	4614.207	4335.822	4092.29
11	3493.858	3281.797	3095.202	4725.04	4442.906	4195.318
10	3561.496	3346.768	3157.745	4816.638	4531.406	4280.465
9	3616.283	3399.395	3208.405	4890.832	4603.09	4349.434
8	3659.571	3440.977	3248.433	4949.455	4659.73	4403.929
7	3692.714	3472.813	3279.079	4994.338	4703.094	4445.651
6	3717.064	3496.203	3301.595	5027.313	4734.954	4476.304
5	3733.973	3512.446	3317.23	5050.212	4757.079	4497.59
4	3744.795	3522.841	3327.237	5064.868	4771.239	4511.214
3	3750.883	3528.689	3332.866	5073.112	4779.204	4518.877
2	3753.588	3531.288	3335.368	5076.776	4782.744	4522.283
1	3754.22	3531.895	3335.953	5077.625	4783.566	4523.076

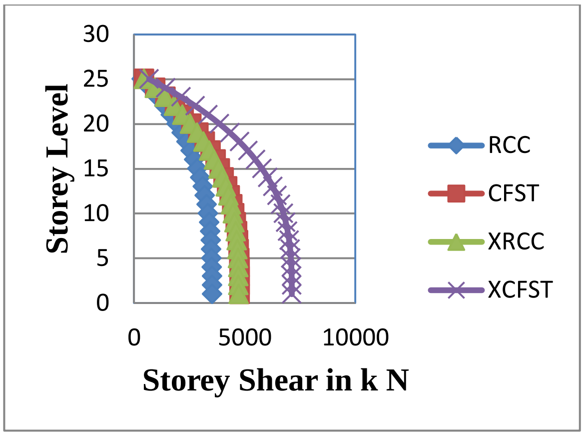

Fig. 11: Comparision of Storey shear for bare frame and X bracing frame structure of 3.0m storey height in X-direction

7.9 CONCLUSION

Fundamental Time Period:

- ➢ Fundamental time period decreased by providing bracings in the building frames.
- ➢ Time period for RCC buildings is greater than CFT buildings at different modes and can be reduced by using bracings, when compared with bare frame.
- ➢ Therefore bracings are considerably influence the overall performance of RCCand CFST framed structures.

Storey Displacement:

- ➢ Displacement reduces with introducing bracings for both RCC and CFT buildings, when compared with bare frame displacement.
- ➢ Increase in number of stories increases the lateral displacement along both thedirections.

Storey Drift:

- ➢ Storey drifts are found within the permissible limit as specified in clause 7.11.1of IS1893-2002.
- ➢ Storey drift for RCC buildings is greater than CFT buildings for ESAmethod, when

bracing is used for building drift action is less.

- Therefore using bracings storey drift can be minimized.

Storey Shear:

- Storey shear in case of bare frame is less compared to frames with bracings storey shear value in both X and Y direction.
- CFST buildings showed greater storey shear value when compared with RCC buildings.
- In case of both RCC and CFST buildings, the base shear value increases in braced framed compared to bare frame.

7.10 Scope of future study

- Further studies can be conducted on high rise steel buildings with base isolators. The study can also be conducted by modeling the structures by using different types of base isolators with various damping mechanisms.
- The study can be conducted by providing dual system at different positions of thebuilding where shear wall and bracing can resist lateral forces more effectively.
- The study can also be further extended for buildings with irregular plan and elevation, where torsional moment occurs.
- Also we can compare the performance of concrete filled steel tube with concrete encased steel section columns.

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