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A REVIEW PAPER ON COMPARETIVE STUDY OF REINFORCED CONCRETE FILLED STEEL TUBE STRUCTURE WITH TRADITIONAL REINFROCED CONCRETE AND STEEL STRUCTURE

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Abstract— *In India reinforced concrete structures are mostly used since this is the most convenient & economic system for low-rise buildings. However, for medium to high-rise buildings this type of structure is no longer economic because of increased dead load, less stiffness, span restriction and hazardous formwork. Structural engineers are facing the challenge of striving for the most efficient and economical design solution while ensuring that the final design of a building must be serviceable for its intended function, habitable for its occupants and safe over its design life-time. A concrete filled steel tubes (CFST) column is constructed by filling a hollow structural steel tube with concrete. As one of the structural element, CFST column has high load bearing capacity, excellent earthquake resistance, good ductility, high fire resistance and its higher stiffness delay the onset of buckling. Besides that, steel tube can function as a permanent formwork as well as reinforcement, thus proving more economical. Comparative study on CFST, RCC and Steel structure with different storey height of G+14, G+19 and B+G+20 stories with all structural systems as frame structure is carried out. E-Tabs software is carried out for analysis. Comparison of parameters like axial force, joint reaction, time period and story drift is done.*

Keywords- Composite CFST column, Shear wall, Story drift, Axial force and ETABS software.

I. INTRODUCTION

A Concrete filled steel tube (CFST) column is a structural system with excellent structural characteristics, which is the result of combining the advantages of a steel tube and those of concrete. A CFST column is constructed by filling a hollow rectangular or circular structural steel tube with concrete. As a structural system, a CFST column has a high load bearing capacity, excellent earthquake resistance, good ductility, high fire resistance and its higher stiffness which delays the onset of local buckling. Besides that, the steel tube can function as permanent formwork as well as reinforcement, thus more economical to be utilized. The increasing costs and project works delay in construction industries in our country require certain measures to be taken as to reduce the costs and increase the speed of construction. One of the solutions worth considering is by applying the Industrialized Building System (IBS), where concrete filled steel columns can be considered as one of the structural elements. The promising features of a CFST column as an excellent earthquake resistance might be of interest for structural engineers or designers in finding a solution to the increasing threat of earthquake in our country.

This study deals with the Comparison between the Steel-Concrete Composite structure and Traditional Concrete Structure. As Steel-Concrete Composite Structures are more popular in the western world and they had developed multifaceted design and construction technique. But it is still in a very nascent stage in India so its effectiveness and applicability must be propagated for structures where fast track construction is almost important. Looking to the present trend of the construction and design of building, it is found that the use of structural steel is very low in India. Very few structures are other than R.C.C structures. Earthquake has created awareness in the structural consultants for the alternative design methods. The Steel Concrete Composites have many advantages like more ductility & reliability, fast track construction, reduction in self-weight, more usable area, reduction in foundation cost and less inertia force due to earthquake. [1]

Elements of composite construction

1. Composite beam, slab & shear connectors a steel concrete composite beam consists of a steel beam, over which a reinforced concrete slab is cast with shear connectors. The composite action reduces the beam depth. Rolled steel sections themselves are found adequate frequently for buildings and built up girders are generally unnecessary. The composite beam can also be constructed with profiled sheeting with concrete topping or with cast in place or precast reinforced concrete slab.

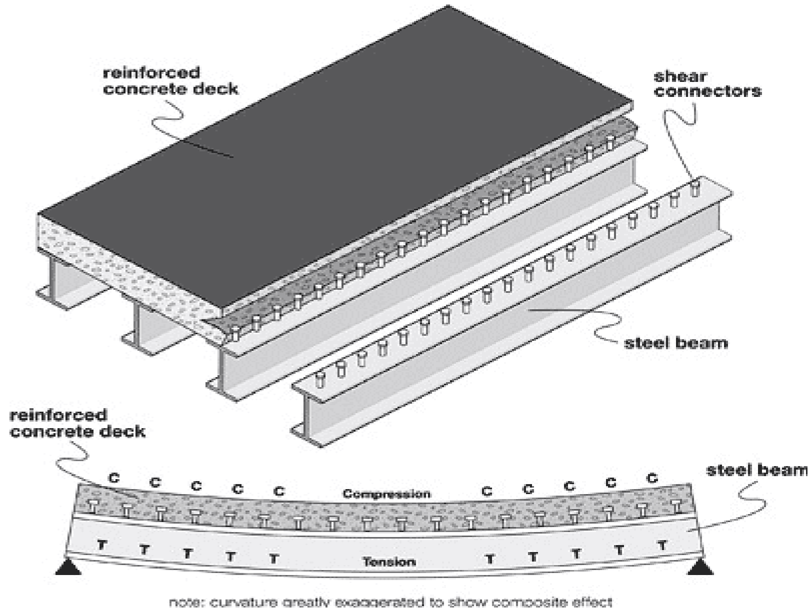

Fig. 1 Typical Composite Beam Slab Details with shear connectors

2. Concrete filled composite column different types of composite columns are principally in use which can be categorized as concrete encased steel and concrete-filled steel tube columns.
Concrete–encased composite columns have structural steel component that could be either one or more rolled steel sections. In addition to supporting a proportion of the load acting on the column, the concrete encasement enhances the behaviour of the structural core by stiffening it, and so making it more effective against both local and overall buckling. The concrete encasement can be either full encasement or partial encasement. [7, 11]

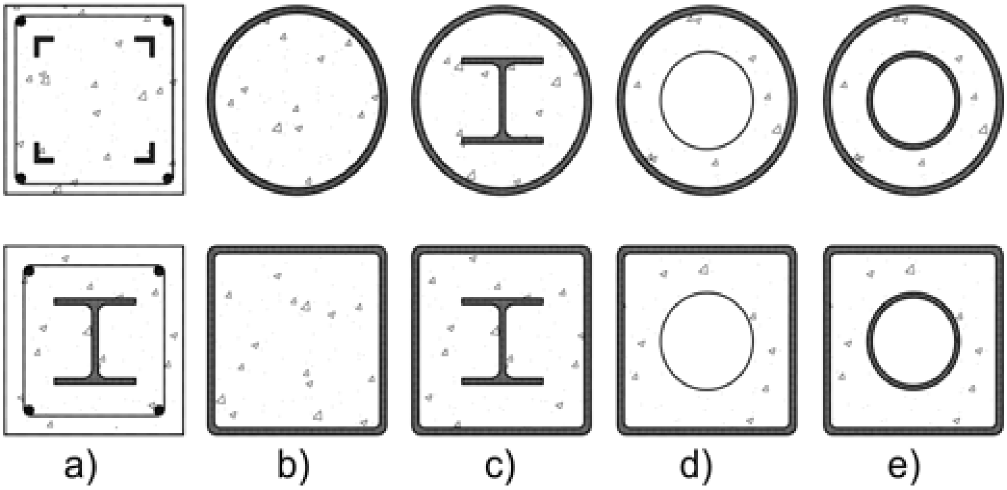

Fig 2. Various types of composite columns: concrete encased steel (CES) (a), CFST (b), combination of CES and CFST (c), hollow CFST sections (d) and double skin sections.

3. Concrete-filled Tube (CFT) columns consist of a steel tube filled with concrete. The concrete core adds compressive strength and stiffness to the tubular column which reduces possible for inward local buckling. The steel tube acts as longitudinal and lateral reinforcement for the concrete core helping it to resist bending moment, shear force and twisting moment which provides confinement for the concrete. Since the benefit of these composite action of two such materials, CFT columns provide better seismic resistant structural properties such as rise in ductility, increase in strength and enormous energy absorption capacity.

II. LITERATURE REVIEW

1. Faizulla Z Shariff, Suma Devi, "COMPARATIVE STUDY ON RCC AND CFT MULTI-STOREYED BUILDINGS" International Journal of Engineering and Technology Volume: 02, Issue: 03, June- 2015

Faizulla Z Shariff, Suma Devi, "Comparative Study on RCC and CFT Multi-Storeyed Buildings**"** This paper deal with the study of lateral load analysis as per the seismic code for the following type of structure such as bare frame, X bracing, V bracing, inverted V bracing, forward and backward diagonal bracings and also for shear wall had been carried out. All the above models were analyzed and results are compared to know the efficiency and strength of the structure by equivalent static method of analysis, response spectrum method of analysis and time history procedure. The analysis was carried out using ETABS software. They model the different height of the building for comparative study. Beams and column members have been defined as frame elements and the columns have been restrained in all six degrees of freedom at the base. Slabs were defined as area elements having the properties of membrane elements and have been modelled as rigid diaphragms. Also concentric bracings and shear walls were defined as frame elements and shell area elements respectively. In this study E-Tabs nonlinear software was used for simulation of steel concrete composite (CFT) with steel reinforced concrete structures (RCC) of G+14, G+19 and G+24 stories each were considered for comparative study. Comparison of parameters like base shear, axial force and bending moment was done.

Table 1: Details of material properties, structural configuration and seismic data.

	CFT building	**RCC building**
Material Properties		
Grade of Concrete [fck]	M-30	M-30
Grade of Reinforcing Steel [fy]	Fe-415	Fe-415
Grade of Structural Steel	340N/mm2	-
Unit wt. of Concrete	25 kN/m3	25 kN/m3
Sectional Properties		
Column size	D=800 & t=9mm	D = 750mm
Beam size	ISWB600	250x550
Bracing size	ISMC200	200x300
Shear wall thickness	200mm	200mm
Slab thickness	150mm	150mm
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	3m	3m

Load Assignment		
Live Load on roof slab	1.5kN/m2	1.5kN/m2
Live Load on floor slab	2kN/m2	2kN/m2
Weathering Course	1kN/m2	1kN/m2
Floor finishing	1kN/m2	1kN/m2
Seismic Data		
Seismic Zone	V	
Importance Factor, I	1	
Response Reduction Factor, R	5 (SMRF)	
Soil Type	Medium Soil	
Response Spectrum Function	IS 1893:2002 Spectrum	
Function Damping Ratio	0.05	
Time History Function	Elcentro	

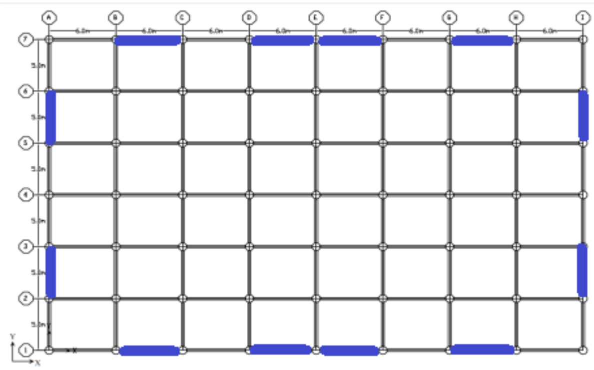

Fig -3: Plan Layout showing the location of different types of bracings and shear wall for RCC and CFT building.

Fig. 3 plan layout show the position of shear wall and different types of the bracing for concrete filled steel tube structure. Previous studies on different buildings such symmetrical and unsymmetrical have adopted idealized structural systems with different bracings. Although these systems were sufficient to understand the general behaviour and dynamic characteristics, it would be interesting to know how real building will respond to earthquake forces. The results of shear force, axial force and overall performance of different building models were presented and compared.

Axial Force: The resultant longitudinal component of force which acts perpendicular to the cross-section of a structural member and at its centroid producing uniform stress was termed as axial force. Axial force in columns for RCC and CFT buildings of 15 storeys were shown in figures below.

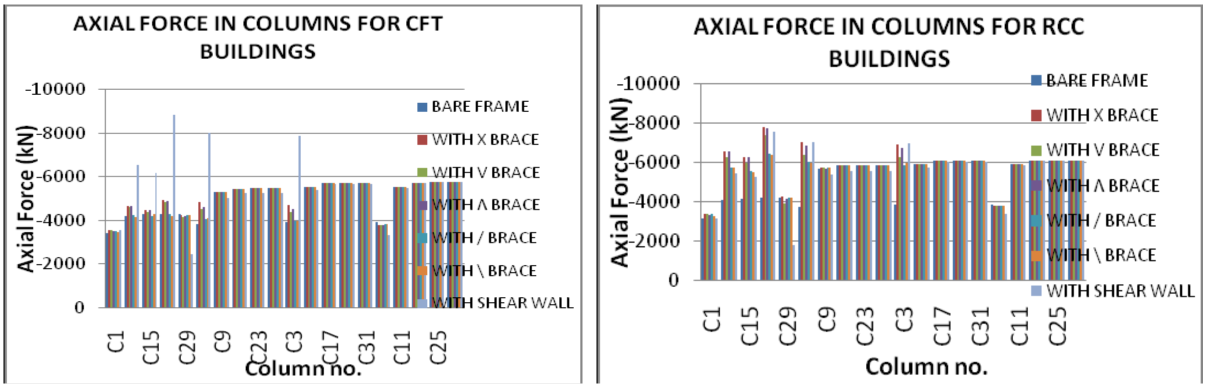

Fig. 4 Axial force in columns for RCC and CFT buildings

Shear Force: Force acting on a structure in a direction perpendicular to the extension of the structure was termed as shear force. Shear forces often result in shear strain. Shear force in columns for various building frame systems along longitudinal and transverse direction obtained from ETABS are shown in figures below.

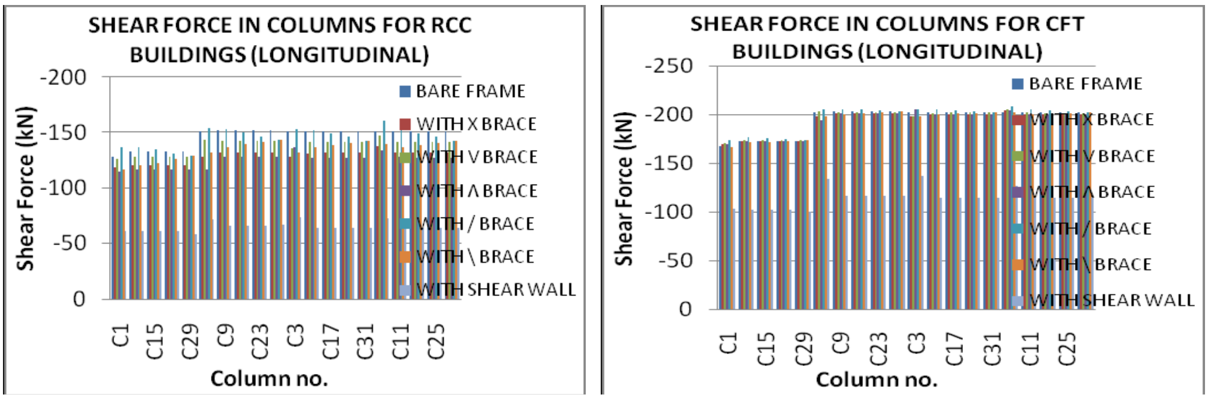

Fig. 5 Shear force in columns for RCC and CFT buildings (LONGITUDINAL)

Figure show the result of shear force in longitudinal direction for RCC and CFT building. It could be seen from figures that shear force in columns of RCC buildings had lesser values compared to CFT buildings in both longitudinal direction. In RCC buildings, bare frame value increases when compared to different types of bracings. Shear wall shows the least value of shear force in columns. While in CFT buildings, bare frame value decreases when compared to different types of bracings but shear wall shows the least value of shear force in columns in both longitudinal and transverse direction for 15 storeys.

Based on the comparative study of concrete filled steel tube structure with RCC and Steel structure, following conclusions were drawn:

1. Axial Force result, axial force in internal columns was greater than external columns in case of both RCC and CFT buildings.
2. Shear walls and bracings increases the axial force in columns. CFT buildings distribute loads more evenly than RCC.
3. Shear Force results, Shear force in columns of RCC buildings had lesser values compared to CFT buildings in both longitudinal and transverse direction. Shear wall shows the least value of shear force in columns.
4. In RCC buildings, bare frame shear force value increases when compared to RCC buildings with different types of bracings. While in CFT buildings, bare frame shear force value was less when compared to CFT structures with different types of bracings.
5. The base shear for bare frame was less compared to bracings and shear wall in both RCC and CFT buildings.

Response spectrum analysis shows lesser value of storey shear when compared with equivalent static analysis.

2. SATTAINATHAN.A, NAGARAJAN.N , "COMPARATIVE STUDY ON THE BEHAVIOR OF R.C.C, STEEL & COMPOSITE STRUCTURE", International Journal on Applications in Civil and Environmental Engineering Volume 1: Issue 3: March 2015

Sattainathan.A, Nagarajan.N, "Comparative Study On The Behavior Of R.C.C, Steel & Composite Structure**"** They presented the work on steel, concrete and CFST building which ware considered for comparative study of B+G+20 storey of commercial building which was situated in earthquake zone 4 and for earthquake load, the provisions of IS:1893(Part1)-2002 was considered. For modeling of composite, Steel and RCC structures, E-TABS software ware used. Comparison of parameters like time period, displacement, base shear and load carried capacity were done with steel and R.C.C structures.
The building considered a commercial building and total height of the building was 60m and each storey 3m. They also gave depth of the foundation 3m.The plan dimension was 30m x 24m study is carried out on the same building plan for both R.C.C, Steel and Composite construction.

Table 2: Data for Analysis of R.C.C, Steel and Composite Structure

S.I No	Particulars	Dimension/Value for (RCC)	Dimension/Value for (Steel)	Dimension/Value for (CFST)
1	**Plan Dimension**	30x24 m	30x24 m	30x24 m
2	**Total height of the building**	60 m	60 m	60 m
3	**Height of each storey**	3 m	3 m	3 m
4	**Height of parapet**	1 m	1 m	1 m
5	**Depth of foundation**	3 m	3 m	3 m
6	**Size of beams 6.0m span** **Size of beams 4.0m span** **Cold form deformation bars**	450x600 300x450	ISMB 450 ISMB 300	ISMB 450 ISMB 300 Based on req.
7	**Size of outer columns** **Size of internal columns** **Cold form deformation bars**	450x1000 450x850	ISMB 450	ISMB 450 Based on req.
8	**Thickness of slab** **Thickness of walls** **Thickness of profile deck**	140mm 230mm	140mm 230mm	140mm 230mm 75-100mm
9	**Seismic zone** **Wind speed** **Importance factor** **Zone factor** **Damping ratio**	IV 50 m/s 1.0 0.16 5%	IV 50 m/s 1.0 0.16 5%	IV 50 m/s 1.0 0.16 5%
10	**Floor finish** **Live load at all floors** **Density of concrete Density of brick**	4.0kN/m^2 1.0 kN/m^2 25 kN/m^3 20 kN/m^3	1.0kN/m^2 4.0 kN/m^2 7850 kg/m^3 20 kN/m^3	1.0kN/m^2 4.0 kN/m^2 7850 kg/m^3 20 kN/m^3
11	**Grade of concrete** **Grade of reinforcing steel** **Soil condition**	M30 Fe500 hard soil	M30 Fe415 hard soil	M30 Fe415 hard soil

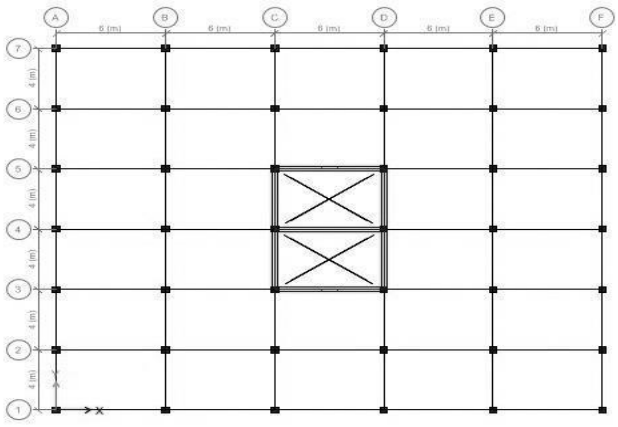

Fig.6 Plan showing typical floor and position Shear wall position

Applied all the necessary data for the analysis of building. When the analysis of all three types buildings was done and the results were as follows:

Table 3: Comparisons of Composite, R.C.C. And Steel Buildings

Factor	Composite Building	R.C.C Building	Steel Building
Time period	5.91 (sec)	3.48 (sec)	3.77 (sec)
Max. nodal displacement	0.129m (X-dir.) 0.131m (Z-dir.)	0.049m (X-dir.) 0.048m (Z-dir.)	0.061m (X-dir.) 0.046m (Z-dir.)
Max. support reaction (axial force)	6017.81	7987.02	688.43
Story drift	0.012m (X-dir.) 0.0109m (Z-dir.)	0.0045m (X-dir.) 0.003m (Z-dir.)	0.0053m (X-dir.) 0.0032m (Z-dir.)
Actual wt. of column and beam	8252.554kN	27873.627kN	9967.65kN

The maximum axial force, shear force, twisting moment and bending moment in columns in transverse and longitudinal direction were analysed and studied thoroughly and it is found that axial force in all composite columns were reduced by 18% to 30% than RCC columns. The shear force in exterior columns was observed to be more than interior columns in transverse direction and for composite columns it was reduced by 31% to 47%. Shear force in longitudinal direction is also more for exterior columns than interior columns and for composite columns it was also reduced by 30% to 45%. Twisting moment in columns of composite structure is reduced from 40% to 66% and about 39% to 65% in transverse and longitudinal directions respectively as compared to RCC structure. It could be seen that the bending moment in composite columns in transverse direction is reduced by 24% to 41% whereas in longitudinal direction it was reduced only by 25% to 42%.
The comparison of results of all three building gave conclude that:

1. As the results show the Steel option was better than R.C.C. But the Composite option for high rise building is best
2. The maximum nodal displacement in Steel and R.C.C. structures were nearly same but it is double in composite structure but within the limit. This was because; composite structure is more flexible as compared to RCC structure and steel structures.
3. The dead weight of composite structure was found to be 20% to 25% less than RCC structure and 16%- 18% and hence the seismic forces were reduced by 15% to 20%.
4. In all the options the values of story displacements were within the permissible limits as per code limits.
5. Presents work shows the use of concrete filled steel tube columns had been consistently applied in the design of tall buildings as they provided nsiderable economy in comparison with conventional steel building.
6. Also performance wise result good compared to RCC and Steel building.

3. K.KALINGARANI, B. SHANMUGAVALLI AND DR. M.C. SUNDARRAJA, "AXIAL COMPRESSIVE BEHAVIOUR OF SLENDER CFST MEMBER-ANALITICAL INVESTIGATION", International Journal of Innovative Research in Science, Engineering and Technology Volume 3, Special Issue 1, January 2014

K.Kalingarani, B. Shanmugavalli and Dr. M.C. Sundarraja, "Axial Compressive Behaviour of Slender CFST Member-Analitical Investigation" This paper summarized the research work on deriving an analytical solution for the behaviour of slender concrete-filled steel tubular sections with normal strength concrete. Analytical and comparative study were carried out on the bases of codes available for this study such as Eurocode 4, EC 4 uses limit state design concepts to achieve the aims of safety and serviceability by applying partial safety factor to load and material properties. ACI 318-1999: American Concrete Institute-Building code requirements for Structural Concrete and AISC-2005: American Institute of Steel Construction-Load and Resistance Factor Design Specification for Structural Steel Buildings. The ultimate capacity of different CFST sections based on their D/t ratio and L/D ratio were found according to Eurocode 4, ACI and AISC provisions. The theoretical capacity of CFST sections developed using all of the above codes denote that increase in D/t ratio enhances the capacity which was due to increased confinement pressure and decrease in L/D ratio also enhances the capacity of the section which was due to the slenderness effect. Slenderness ratio of the Column, The length to width or diameter ratio (L/D) represents the slenderness of the column. Columns with greater slenderness ratio fail by overall buckling. Hence it could be observed from the analytical results that the decrease in L/D ratio increases the capacity of the CFST section. D/ t ratio, the increase in D/t ratio may be either due to the increase in diameter or due to the decrease in thickness of the section. Hence it was analyzed by keeping the diameter.

Based on the analytical study for the calculation of theoretical capacity of CFST sections with reference to ACI, AISC and Eurocode for different D/t and L/D ratios, the following conclusions were made:

The theoretical capacity of CFST sections developed using all of the above codes denote that increase in D/t ratio enhances the capacity which was due to the increased confinement pressure when the diameter alone was increased. But increase in D/t ratio reduces the capacity of the section which was due to reduction in cross section when the thickness was reduced for a constant diameter.

The ultimate capacity of different CFST sections with varied L/D ratio denote that there exists enhancement in section capacity with reduced L/D ratio and the reason was attributed to the fact of slenderness effect.

All of the above codes agree with each other but EC 4 gives conservative results and it was concluded that EC 4 provisions may be used for further analytical study to develop an expression to predict the section capacity of strengthened CFST columns.

III. CONCLUSION

From the above literature I conclude that:

1. Composite structures are more economical than that of R.C.C. structure.
2. Weight of composite structure is quite low as compared to R.C.C. structure which helps in reducing the foundation cost. Speedy construction facilitates quicker return on the invested capital & benefit in terms of rent.
3. In condition of axial force, shear force and base shear CFST structure perform well compare to RCC and steel.
4. Base shear increases in CFT buildings compared to RCC buildings.
5. The confinement effect is very effective in round section because the effective radial tension develops effective hoop tension in the tube
6. The effect of confinement in CFST can be utilized in using thinner walls (large B/t ratio), which can reach the yielding strength
7. Calculation of theoretical capacity of CFST sections with reference to ACI, AISC and Eurocode for different D/t and L/D ratios we achieved the desired axial forces and other parameters within permissible limit.
8. Concrete-filled steel tubular columns possess excellent earth-quake resistant properties such as high strength and ductility and large energy absorption capacity.
9. For concrete-filled steel tubes (CFST), inward local buckling commonly observed in bare steel columns is effectively prevented, giving a higher capacity.
10. I could say that composite structures are the best solution for high rise structure.

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