"STUDY OF SEISMIC BEHAVIOUR OF CONCRETE FILLED STEEL COLUMN"

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Abstract: Concrete filled tubular column or CFT column consists of hallow steel tube filled by concrete. Concrete filled steel column is becoming popular for the earthquake resistant structures because of good ductility and high axial strength. It has been observed that structure with concrete filled steel column performs well during strong earthquake. Several codes, namely Eurocode- 4, FEMA-356, and Architectural Institute of Japan have their own specifications for concrete filled steel columns. In this paper various formulae stated in these codes are described in detail. Then load carrying capacity of concrete filled steel columns determined analytically using these codes specified formulae. Finally, the analytical results are compared with experimental data available from existing literature. Different shapes of columns are considered for the study.

Index Terms **- Composite Column, Design Codes-FEMA-356, EC-4, AIJ.**

I. INTRODUCTION

Composite steel and concrete structural members are formed by bonding steel component to a concrete component so that the two-component act as one. There are certain problems involved in construction either steel or concrete, as each of these materials has its own peculiarity. For example steel structural members are generally fabricated as components consisting of thin plate element they are prone to local and lateral buckling. Therefore, steel standards are concerned predominantly with the prevention of failure by instability or buckling.

Conversely, concrete structural members are generally thick and unlikely to buckle. However, concrete is weak in tension and is subjected to creep and shrink with time. In order to overcome the problem of weak tensile strength a more effort in the design is the placing the steel reinforcing bars as substitute for weak concrete.

II. ADVANTAGES OF CONCRETE FILLED STEEL COLUMN

The CFT column system has many advantages compared with ordinary steel or reinforced concrete systems. The main advantages are listed below

1) Interaction between steel tube and concrete: Local buckling of the steel tube is delayed, and the strength deterioration after the local buckling is moderated, both due to the restraining effect of the concrete. On the other hand, the strength of the concrete is increased due to the confining effect provided by the steel tube, and the strength deterioration is not very severe, because concrete spalling is prevented by the tube. Drying shrinkage and creep of the concrete are much smaller than in ordinary reinforced concrete.
2) Cross-sectional properties - The steel ratio in the CFT cross section is much larger than in reinforced concrete and concrete-encased steel cross sections. The steel of the CFT section is well plastified under bending because it is located most outside the section.
3) Construction efficiency - Labor for forms and reinforcing bars is omitted, and concrete casting is done by the pump-up method. This efficiency leads to a cleaner construction site and a reduction in manpower, construction cost, and project length.
4) Fire resistance - Concrete improves fire resistance so that fireproof material can be reduced or omitted.
5) Cost performance - Because of the merits listed above, better cost performance is obtained by replacing a steel structure with a CFT structure.
6) Ecology - The environmental burden can be reduced by omitting the formwork and by reusing steel tubes and using high-quality concrete with recycled aggregates.

III. STUDY OF DESIGN CODES

There is no Indian Standard specification available for the design of concrete filled steel column. So, for the design of concrete filled steel column Eurocode-4 and Architectural Institute of Japan specifications has been studied which are described.

Eurocode-4:
Eurocode-4 applies to the design of composite structures and members for building and civil engineering works for the ultimate limit state and it also checks for the serviceability limit state.

1. Local buckling of steel hollow section:

For concrete filled rectangular hollow sections (RHS) = $\frac{b}{t} \leq 52\varepsilon$ where, $\varepsilon = \sqrt{\frac{235}{f_y}}$

Where, t is the wall thickness of the steel hollow section in mm.
b is the larger outer dimension of the rectangular hollow section in mm
f_y is the yield strength of the steel section in N/mm².

2. Axial Load capacity of Concrete filled rectangular hollow section:

The plastic resistance of a concrete filled rectangular hollow section (i.e., the so-called "squash load") is given by the sum of the resistances of the components as follows:

$$P_p = A_a . f_y / \gamma_a + \alpha A_c f_{ck} / \gamma_c + A_s . f_{sk} / \gamma_s$$

Where, $\mathbf{A_a}$, $\mathbf{A_c}$ **and** $\mathbf{A_s}$ areas of the steel section, the concrete and the reinforcing steel respectively.
$\mathbf{f_y}$, $\mathbf{f_{ck}}$ **and** $\mathbf{f_{sk}}$ yield strength of the steel section, the characteristic compressive strength (cylinder) of the concrete, and the yield strength of the reinforcing steel respectively.
α Strength coefficient for concrete, which is *1.0* for concrete filled tubular sections, and *0.85* for fully or partially concrete encased steel sections.

3. Effective elastic Flexural Stiffness:

$$P_{cr} = \frac{\pi^2 (EI)_e}{\ell^2}$$

Where,
(EI)ₑ is the effective elastic flexural stiffness of the composite column (defined in earlier section).
L is the effective length of the column, which may be conservatively taken as system length L for an isolated non-sway composite column.

4. Short-Term Loading:

The effective flexural stiffness of the composite column $(EI)_e$ is obtained from adding up the flexural stiffness's of the individual components of the cross-section:

$$(EI)_{eff} = E_a I_a + E_s I_s + 0.8 E_{cd} I_c$$

Where,
Ia , Is and **Ic** are the second moment of area, about the appropriate axis of bending, for the steel section, the reinforcement and the concrete (assumed uncracked) respectively.

Ea and Es are the elastic modules for the structural steel and the reinforcement.

0.8EcdIc is the effective stiffness of the concrete the factor *0.8* is an empirical multiplier (determined by a calibration exercise to give good agreement with test results). Note Ic is the moment of inertia about the centroid of the uncracked column section.

$$E_{cd} = E_{cm} / \Upsilon_c$$

Ecm is the secant modulus of elasticity for structural concrete.

ϒc is reduced to 1.35 for the determination of the effective stiffness of concrete according to Eurocode *2.*

Yield Rotation (ϴ) for column is calculated by using equation (5-2) (5.5.2.2.2) given in FEMA – 356 as:

$$\theta = \frac{Zp \times fy \times lc}{6 \times Es \times Ic}\left(1 - \frac{P}{Pye}\right)$$

Architectural Institute of Japan:

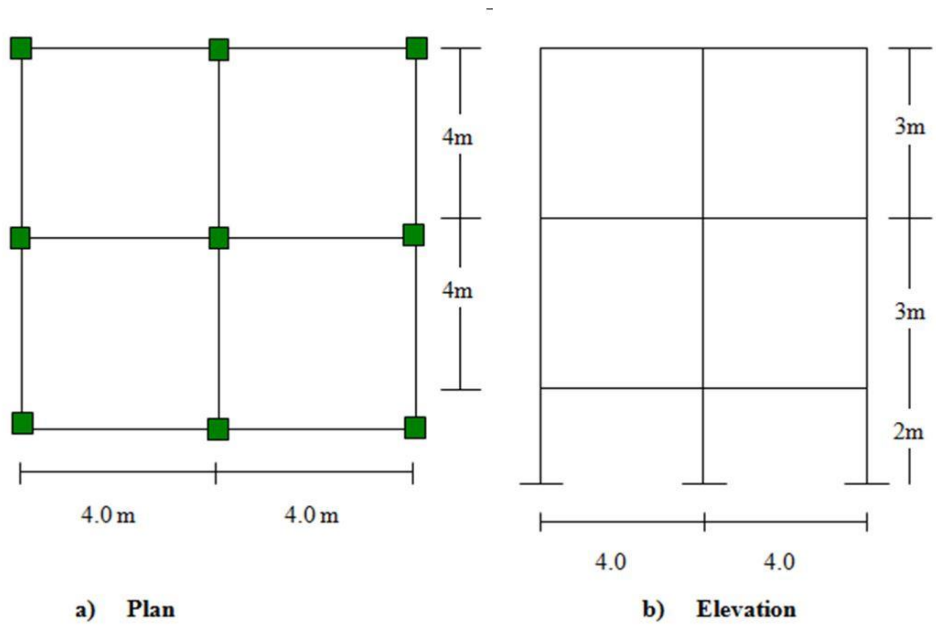
- The maximum effective length l_e of a CFT member is limited to:

For a compression member $le / D \leq 50$
For a Beam column $l_e / D \leq 30$

Where,

l_e effective buckling length of a member.
D minimum depth of a cross section.

IV Numerical Example



plan and elevation of a building

Load data:

Thickness of slab	=	150 m
Floor finish	=	1 kN / m^2
Imposed load	=	3 kN/m^2

Material Data:

Yield strength of steel	=	250 N/mm^2
Modulus of Elasticity of steel Es	=	200000 N/mm^2
Partial Safety factor for steel γ_s	=	1.10

Seismic Data:

Zone	=	V
Zone factor	=	0.36
Importance factor	=	1.50
Response Reduction Factor	=	5.0
Soil type	=	Medium soil.

Section Properties:

Beam

- ISMB 350 @ 52.4 Kg / meter

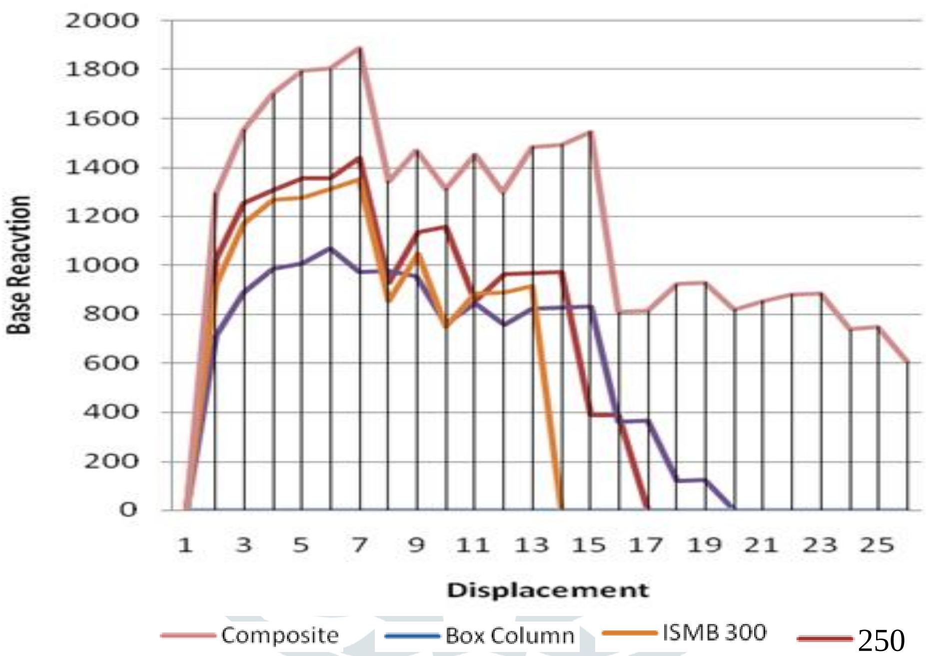
Area	=	6671 mm^2
Ixx	=	13630.3 x 10^4 mm^4
Zxx	=	778.9 x 10^{3}mm^3

- ISMB 500 @ 86.9 Kg / meter

Area	=	11074 mm^2
Ixx	=	45218.3 x 10^4 mm^4
Zxx	=	1808.7 x $10^3 mm^3$

V. RESULTS AND CONCLUSIONS:

Property / *Column type*	**AREA mm^2**	**Ic mm^4**	**Zp mm^3**	**Mp kN-m**	**Pye kN**
BOX	6975	63x10^6	608343	139	1585
ISMB250	4755	51.36x10^6	466000	106	1080
ISMB300	5626	86.03x10^6	683000	155	1278
COMPOSITE COLUMN	4706	255.09x10^6	3.25x10^6	139	2420
	55319	45.23x10^6	426.531x10^3		



Push over curves for a building with different column system

Conclusions:

From the present study following conclusions have been drawn.

1. Concrete filled steel column has more axial load capacity as compared to steel box column and rolled section column for the same moment capacity.
2. Concrete filling in steel box column delays the local buckling of steel tube / plate. So thin section can be used.
3. Concrete filled steel column shows more baser shear capacity as compared to that of steel box column and rolled steel section column.
4. The ultimate lateral displacement of building achieved from push over analysis is more in case of concrete filled steel columns as compared to that of steel box columns, rolled section columns.
5. The building with rolled section column shows the less ductile behaviour as well as less base shear capacity as compared to box column.
6. The quantity of steel required for the building with box columns and is almost 30-35 % more than that of building with concrete filled steel column.

Scope for Future Work:

In the present study the results from push over analysis are obtained by analyzing a building with concrete filled steel column by limiting the width thickness ratio of steel equal to 50 only because of non-availability of information about ultimate rotation for concrete filled steel columns with width thickness ratio less than 50. To evaluate ultimate rotation capacity of concrete filled steel column FEM analysis can be done with varying s parameters such as yield strength of steel, width thickness ration and concrete strength. Then the push over analysis can be extended for concrete filled steel column with various width thickness ratio of steel. The analysis is done by considering square columns only; the same can be done for circular column.

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