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EXPERIMENTAL INVESTIGATION AND NUMERICAL ANALYSIS OF TIE BARS IN CONCRETE FILLED STEEL TABULAR CIRCULAR COLUMN

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ABSTRACT –

Concrete Filled Steel Tubes (CFT) are preferred for high-rise construction owing to their exceptional strength, rigidity, reduced cross-sectional area, improved fire resistance, and additional seismic resistant characteristics, including ductility and energy absorption capacity. Alongside strength and ductility, an adequate bond between steel and concrete at the contact is essential in CFT columns to ensure composite action. The bond strength of a CFT column can be augmented by employing internal stiffeners (tie bars). This project does an experimental examination of the bond strength of a circular concrete-filled tube (CFT) column with tie stiffeners by assessing the axial capacity of CFT column specimens that are 114.3 mm in diameter and 2 mm in thickness, fitted with 6 mm diameter tie bars. The behavior and bond strength of CFT columns with slenderness ratios of 3, 6, and 9 (short columns) and 12, 15, and 18 (long columns) will be analyzed.

I. INTRODUCTION

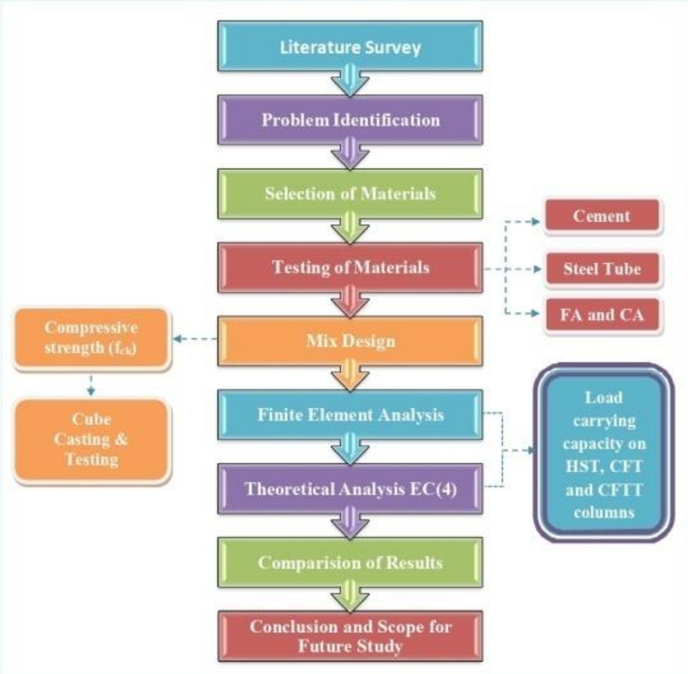
Concrete-Filled-Steel-Tube (CFT) columns are increasingly used in the construction of high-rise structures because to the synergistic interaction between steel and concrete. Numerous other economic benefits emerge from the application of CFT. The tube serves as formwork in building, minimizing labor and material costs. In moderate to high-rise construction, the building can ascend more swiftly than a comparable reinforced concrete structure, as the steel framework can be constructed several levels in advance of the concrete. CFTs are employed as bridge piers in applications throughout Japan and Europe [1]. CFT can be utilized for retrofitting reinforced concrete columns in seismic zones. The CFT structural member offers distinct advantages over comparable steel, reinforced concrete, or steel-reinforced concrete members. Therefore, utilizing CFT for columns subjected to substantial axial loading is quite advantageous. Numerous tests have shown the improvement of cyclic strength, ductility, and damping with the incorporation of concrete into hollow tubes. However, a notable disadvantage of employing CFT columns is the insufficient interface bonding between the concrete and steel tube during the initial elastic phase, as steel expands more than concrete. The insufficient bonding will reduce the confining pressure applied by the steel tube, thereby diminishing the initial stiffness and elastic strength of the columns. This work presents an innovative stiffening technique to enhance the performance of circular concrete-filled tube (CFT) columns in terms of composite action. The suggested reinforcement approach involves welding a series of steel bars, known as tie bars, along the tube's axis.

II. OBJECTIVES

- To study on behavior of composite action of circular CFT columns with andwithout tie bars under axial loading.
- To study the Non-linear behavior of concrete filled steel tubular circularcolumns with varying slenderness under axial loading
- To compare the Numerical analysis results of columns with the predictionsresult using Eurocode 4.
- To investigate the influence of parameters such as column slenderness andconcrete strength on axial compression.

III. METHODOLOGY

This chapter clearly outlines the methodologies utilized in the proposed experimental endeavor. The previous chapter has previously discussed the application and advantages of CFT columns with the main objective of this experimental endeavor. The following methodology has been utilized to achieve the stated objective. The methodology flowchart is displayed below:



IV. MATERIALS

Cement

Cement is an essential element of mortar, functioning as the binding agent employed in many facets of construction. The principal benefit is the expedited enhancement of strength. Ordinary Portland cement grade 53 is employed for its rapid hydration characteristics. The concrete demonstrates a markedly increased initial rate of heat of hydration, with the highest heat release observed in 53-grade concrete.

Fine aggregate

Fine aggregate sand comprises either rounded or angular particles and is commonly found in diverse gradations of fineness throughout various geographies. IS 383-1970 specifies the four zones and their corresponding fineness modulus. Fine aggregate is composed of locally sourced, debris-free, and almost riverbed sand. Among the several attributes, the most critical is the grading; coarse sand is favored since fine sand increases the water demand of concrete, while excessively fine sand is typically superfluous due to its elevated proportion of fine particles like to cement. Sand particles must be consolidated to attain a minimal void ratio, as elevated void content requires more mixing water.

Coarse Aggregate

Coarse aggregates are particles larger than 4.75 mm, generally ranging from 10 mm to 40 mm in size. Gravels are the primary component of coarse aggregate employed in concrete, while crushed stone represents the majority of the remainder. Coarse aggregates contribute strength, toughness, and hardness to concrete. The incorporation of coarse aggregate augments concrete's resilience to freeze-thaw cycles, guarantees chemical stability, and promotes abrasion resistance. The specific gravity was established to be 2.6.

Water

Water is an essential element of concrete, as it participates in a chemical reaction with cement. The volume and quality of water must be rigorously regulated to guarantee the production of the strength-enhancing cement gel. Drinking water is employed in the formulation of mortar. The pH value of water ranges from 6 to 8, signifying the absence of organic matter.

Steel Tie Bars

Mild steel bars with a diameter of 3 mm were utilized as tie bars along the longitudinal axis of the steel tube. The yield strength of steel is 250 megapascals (N/mm²).

Steel Pipe

All round tubes were produced with elevated yield strength in compliance with Indian Standard 1161. The tube's thickness was assessed at four points utilizing a screw gauge, and the mean value was computed. A conventional coupon test was conducted to determine the yield strength of the steel tube. Coupons for testing were removed from the steel tube section, and the testing methodology was executed in line with ASTM A370. The dimensions of the tensile coupon test specimen are depicted in Fig. 4.3. The yield strength of the steel tubes is 240 MPa, and the modulus of elasticity is anticipated to be 2 x 10^5 N/mm². All tie bars were cylindrical mild steel rods with a diameter of 3 mm and a yield strength of 250 MPa.

Cementitious substance

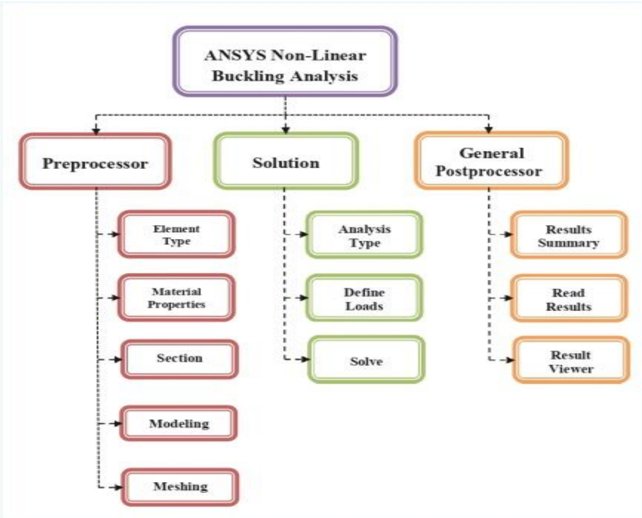
Concrete

Concrete strengths are determined by the standard average cube strengths (fck) evaluated at 28 days. The properties of different concrete grades were employed in line with IS 456-2000 and the corresponding EC(4) values. The concrete classification is M20.

V. MIX DESIGN FOR M20 CONCRETE (AS PER IS 10262:2009)

Cement	Fine aggregate	Coarse aggregate	Water
1	1.65	2.67	0.55
378.18 kg/m^3	625.24 kg/m^3	1001.47 kg/m^3	208 liters

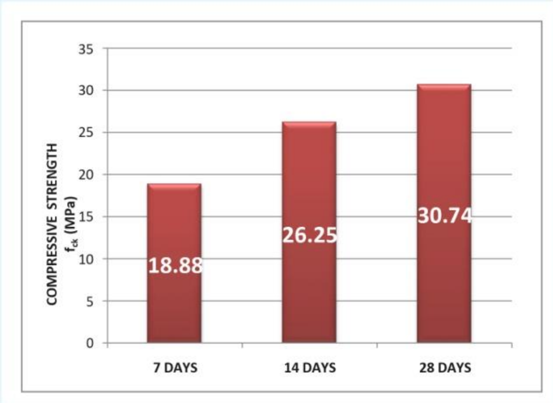
VI. STEPS IN FINITE ELEMENT METHOD



VII. RESULT

COMPRESSIVE STRENGTH

Compressive test is the most familiar test conducted on hardened concrete, partly because it is easy test to perform, and partly because most of the characteristic properties of concrete are qualitatively related to its compressive strength. The cube specimen of size 15 x 15 x 15 cm with the mix proportion ofcement, fine aggregate, coarse aggregate of 1:1.65:2.67 and a water cement ratio of 0.55 are used.



VIII. CONCLUSION

- ✓ From numerical results, CFTT columns show higher ductility after maximum load. Tie bars could increase the axial load carrying capacity (maximum,
- ✓ 3.98 %) than the CFT columns.
- ✓ The results states that decrease in column slenderness increase the column axial load carrying capacity and increase in column slenderness decrease the column load carrying capacity.
- ✓ Even though, there is no significant increase in load carrying capacity of the concentrically loaded CFTT columns, such columns offer more ductility thanthe CFT columns. Hence, structures with CFTT can be used in seismic areas for improved structural behaviour.
- ✓ Finite element model results are obtained from ANSYS and compared with the theoretical results are significantly same.
- ✓ Increase in tie bars will increase the load carrying capacity of the columns.

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