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ANALYTICAL STUDY ON FLEXURAL STRENGTH OF CFST UNDER THE PURE BENDING WITH ANSYS

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ABSTRACT

Concrete filled steel tubular (CFST) members utilize the advantages of both steel and concrete with hollow steel sections. They are widely used in high-rise buildings as columns and beam-columns and as beams in low-rise buildings where efficient structural system is required. Usually in concrete-filled steel tubular columns, the local buckling of the steel tube normally occurs after the ultimate strength of the composite member is reached. Several authors suggest using the plastic moment capacity of the steel tube as a lower bound for the strength of a CFT in pure bending. A limited number of tests have been performed. to study the ultimate strength of concrete filled steel tube beams. To compare the deflection of steel-concrete composite beams with conventional concrete. M20 Grade of concrete is used as infills in hollow steel tubes and the concrete mixing is done for one batch. To determine the ultimate moment carrying capacity and deflection of the section under pure bending done by flexural test of empty rectangular steel tubes, concrete filled steel tubes and concrete filled steel tubes with diagonal stiffener. The experiment test results are compared with analytical results, To develop finite element analysis model of the concrete filled steel tubes, ANSYS WORKBENCH software is used.

KEYWORDS: CFST, EHST, CIVIL, ANSYS Software.

Steel tubes or plates have high tensile strength. However, they are relatively week against local compression buckling. On the other hand, when steel tubes filled with concrete, the steel buckling resistance increases and heavy stiffeners are not required, which makes composite beams economical and alternative for concrete bridges applications1,2,3. Therefore, concrete materials added many advantages to steel tubes such as increasing the flexural ultimate strength, stiffness, and rigidity of steel tube, significant reducing or eliminating the local buckling of steel tube, and increasing the area under the load-deflection curve (energy absorption) and the overall ductility of the section.

Concrete filled steel tubular(CFST) members utilize the advantages of both steel and concrete with hollow steel sections .They are widely used in high-rise buildings as columns and beam-columns and as beams in low-rise buildings where efficient structural system is required .Usually in concrete-filled steel tubular columns , the local buckling of the steel tube normally occurs after the ultimate strength of the composite member is reached. Several authors suggest using the plastic moment capacity of the steel tube as a lower bound for the strength of a CFT in pure bending. A limited number of tests have been performed.

As shown the Fig 1.1 depicts three typical cross sections .A circular hollow section(CHS).A square hollow section (SHS).A rectangular hollow section(RHS).It is noted that the circular cross section provides the strongest confinement to the core concrete, and the local buckling is more likely to occur in square or rectangular cross sections.

OBJECTIVE:

To study the ultimate strength of concrete filled steel tube beams .To compare the deflection of steel-concrete composite beams with conventional concrete.M20 Grade of concrete is used as in fills in hollow steel tubes and the concrete mixing is done for one batch .To determine the ultimate moment carrying capacity and deflection of the section under pure bending done by flexural test of empty rectangular steel tubes, concrete filled steel tubes and concrete filled steel tubes with diagonal stiffener .The experiment test results are compared with analytical results .To develop finite element analysis model of the concrete filled steel tubes ,ANSYS WORKBENCH software is used.

SCOPE OF THE STUDY:

In this study, the flexural behavior of concrete filled steel tube (CFST) beams with different concrete compressive strengths have been investigated. To develop finite element analysis model of the concrete filled steel tubes, ANSYS WORKBENCH software is used.

SAMPLE CROSS SECTION:

Concrete filled steel tubular (CFST) members utilize the advantages of both steel and concrete with hollow steel sections. They are widely used in high-rise buildings as columns and beam-columns and as beams in low-rise buildings where efficient structural system is required usually in concrete-filled steel tubular columns , the local buckling of the steel tube normally occurs after the ultimate strength of the composite member is reached. Several authors suggest using the plastic moment capacity of the steel tube as a lower bound for the strength of a CFT in pure bending. A limited number of tests have been performed.

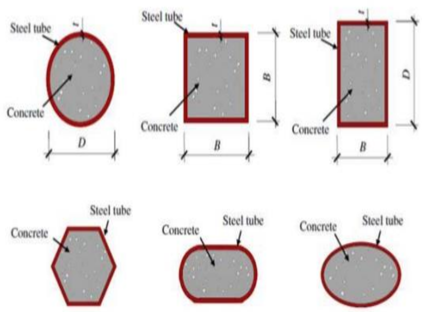


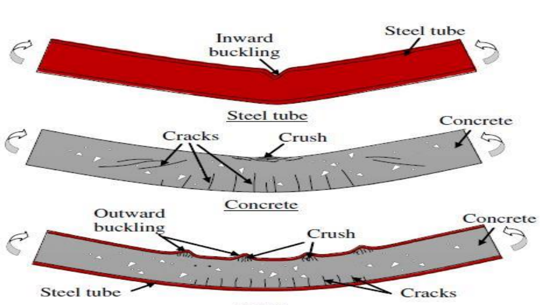
Fig 1.1 Typical CFST Cross sections

PURE BENDING(CFT BEAMS):
Concrete-filled steel tubes subjected to pure bending behave much like hollow tubes .In fact, several authors suggest using the plastic moment capacity of the steel tube as a lower bound for the strength of a CFT in pure bending.

STRENGTH Pure bending tests of CFTs by Lu and Kennedy (1994) indicated an increase in moment capacity due to concrete infill for the square and rectangular beams of between 10 and 35% as compared to hollow tubes.

STIFFNESS: The stiffness of a CFT beam depends to some degree on whether or not bond exists at the interface of the two materials. In the absence of bond, there will be no interaction between the materials, little or no concrete augmentation, and the composite stiffness will depend heavily on the stiffness of the steel tube.

CYCLIC LOADING: Concrete-filled steel tubes in bending dissipate a significant amount of energy with only a slight decrease in strength as the loading is cycled.



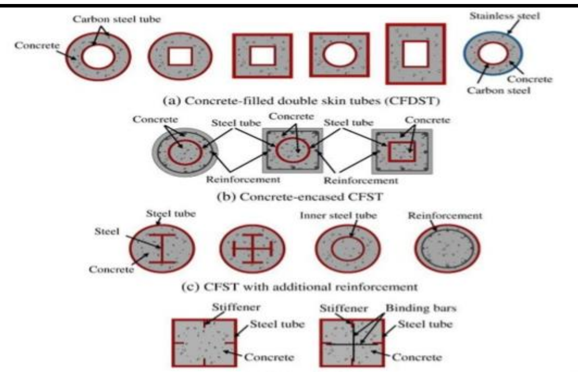


Fig 1.2 Bending of CFST

Stiffened CFST

ANSYS WORKBENCH: The pre- and post-processing work was performed by ANSYS which is a graphical user interface module that allows the user to execute a FE analysis process from start to finish.

OBJECTIVE OF THE STUDY : To study the ultimate strength of concrete filled steel tube beams .To compare the deflection of steel-concrete composite beams with conventional concrete.M20 Grade of concrete is used as in fills in hollow steel tubes and the concrete mixing is done for one batch .

SCOPE OF THE STUDY: In this study, the flexural behavior of concrete filled steel tube (CFST) beams with different concrete compressive strengths have been investigated. To develop finite element analysis model of the concrete filled steel tubes ,ANSYS WORKBENCH software is used

ADVANTAGES OF CFST: The steel tube provides formwork for the concrete ,The concrete prolongs local buckling of the steel tube wall ,The tube prohibits excessive concrete spalling, and Composite columns add significant stiffness to a frame compared to more traditional steel frame construction.Additionally, it has been shown that the steel tube confines the concrete core, which increases the compressive strength for circular

CFTs, and the ductility for rectangular CFTs.

DISADVANTAGES OF CFST: A primary deterrent to widespread use of CFTs is the limited knowledge regarding their behavior. A number of factors complicate the analysis and design of concrete-filled steel tubes. A CFT member contains two materials with different stress-strain curves and distinctly different behavior.

MATERIALS USED: Concrete is a composite material composed of fine and coarse aggregate bonded together with a fluid cement (cement paste) that hardens (cures) over time. In the past lime based cement binders were often used, such as lime putty, but sometimes with other hydraulic cements, such as a calcium aluminate cement or with Portland cement to form Portland cement concrete (named for its visual resemblance to Portland stone).

The following properties of the materials are used., Cement Ordinary Portland cement of 53grade, Fine aggregate, River sand, Coarse aggregate (8 to 10mm), angular, Hollow steel tubes 60 X 120 X 3.6mm

Apparatus Required

Cement, Kerosene, Specific Gravity Bottle capacity of 250 ml with stopper.Weighing balance with 0.1 gm accurate

In general, To calculate the specific gravity of material, we use water. But in cement, we use kerosene for finding specific gravity in it. The reason behind this, cement hydrates and forms calcium oxide when it reacts with water. Cement won't show any reaction when it mixed with kerosene.

1 Specific gravity of cement

S NO	Weight	Weight in gms
1	W1	680
2	W2	1300
3	W3	1770
4	W4	1400

Calculation: Specific gravity of cement =(W2-W1)/((W2-W1)-(W3-W4))

=(1300-680)/((1300-680)-(1770-1400))
=2.47(0.79)

=3.21 g/cc

2 Normal consistency

S.NO	% of water	Amount of water(ml)	Reading of pointer(mm)
1	10	50	41
2	15	75	35
3	20	100	36
4	25	120	35
5	30	140	34

Table 4.3 Initial setting time

S.NO	Time in minutes	Reading of pointer
1	5	0
2	10	5
3	15	14
4	20	25
5	25	25
6	30	30
7	35	34

Specific Gravity of Fine aggregates

S.NO	WEIGHT	WEIGHT in gms
1	W1	650
2	W2	950
3	W3	1700

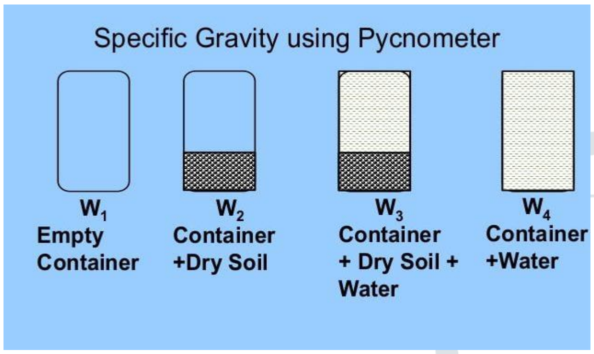
4	W4	1500

Calculation

Specific gravity of fine aggregates

=(W2-W1)/((W2-W1)-(W3-W4)) =(950-650)/((950-650)-(1700-1500))

=2.60



MIX PROPORTION

Material	Water content	Cement	FA	CA
Volume (Kg/m3)	197.4	384.48	790.3	1000

HOLLOW STEEL TUBES: Hollow sections are manufactured using only high quality pure steel HR coils. The structural hollow tubes conform to IS: 4923 and IS: 1161 manufacturing standards

IS 4923: Hollow steel sections for structural use – Specification

EXPERIMENTAL RESULTS AND DISCUSSION: The experimental study of concrete-filled steel tube columns subjected to axial compression was accomplished with several objectives, namely, the evaluation of the accuracy of several design codes to predict the resistance capacity, to determine the maximum load capacity of the concentric loading specimens, and to investigate the failure pattern before and after the ultimate load is reached. The specimens were tested; a summary of their properties is presented.

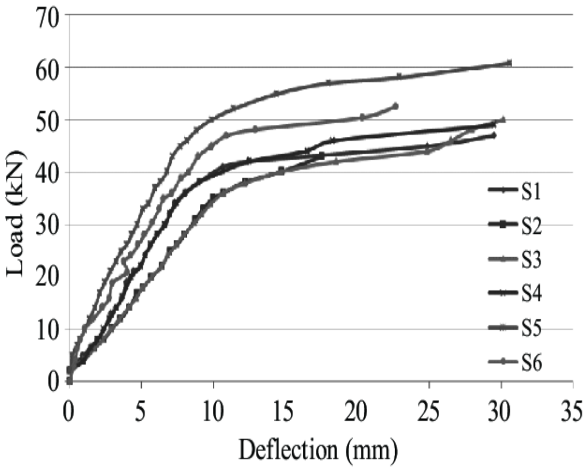
In this experimental study, empty hollow steel tubes, concrete filled steel tubes are casted and subjected to two point loading and the deflection of these beams are taken using strain gauges.M20 grade concrete is being use

Number of trails	Load in KN	Compressive strength in N/mm2
Trail 1	620.33	27.8
Trail 2	623.52	27.7
Trail 3	625	27.9

Average compressive strength for M20 =27.7 N/mm2.

FLEXURAL STRENGTH TEST Flexural strength, also known as modulus of rupture, or bend strength, or transverse rupture strength is a material property, defined as the stress in a material just before it yields in a flexure test. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural test technique.

Flexure test specimens were tested in a 200 KN capacity loading frame. In the test setup, at each load point and at the supports of the specimen a set of rollers were placed to allow free rotation. Thus the beam specimens were tested under a simple support condition. The load was applied along two lines spaced at one third of the effective span from either support. Linearly varying displacement transducers (LVDT) were placed at mid span and the two loading points. The load was increased gradually until the specimen fails and the corresponding ultimate moment capacity was calculated. LVDT readings are recorded at the appropriate load increments and the lateral deflection of the middle segment of the test beam subjected to pure bending was calculated using LVDT data.



Load versus deflection curve for EHST

Bending of concrete filled steel tubes

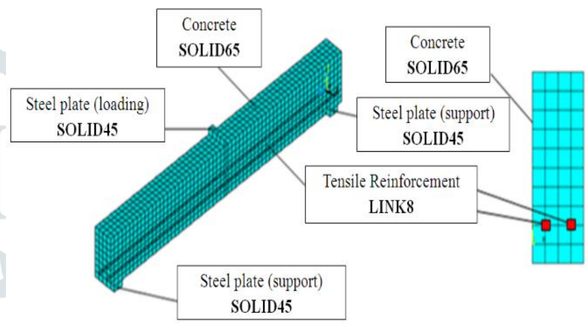
ANALYTICAL ANALYSIS: This paper presents the analytical and finite element behaviour of concrete-filled steel tube i.e. CFST columns. The objective is to compare the behaviour of CFST columns of circular and square cross sections under concentric axial loading. The load deformation characteristics were studied for different grades of concrete. The axial load carrying capacity for limit state of strength for both short and long CFST columns were tested in yielding and buckling respectively. The 8 noded 3D solid elements were used for finite element meshing in **ANSYS**-Workbench software. The research finding indicates that the circular cross section of CFST column is effective in resisting axial deflection as well as strength compared to square cross section having equal steel material.

Finite Element Analysis –

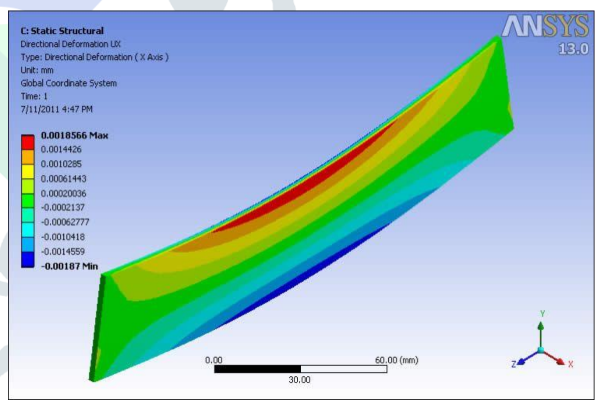
Recently, the software uses the Finite element method for the analysis and design of the structure. In ANSYS Workbench, analyses are created as systems, which can be combined in a project. The project is driven by a schematic workflow that manages connections between systems. The study involves the use of ANSYS workbench (16.0) software for analysis.

NUMERICAL PROCEDURE

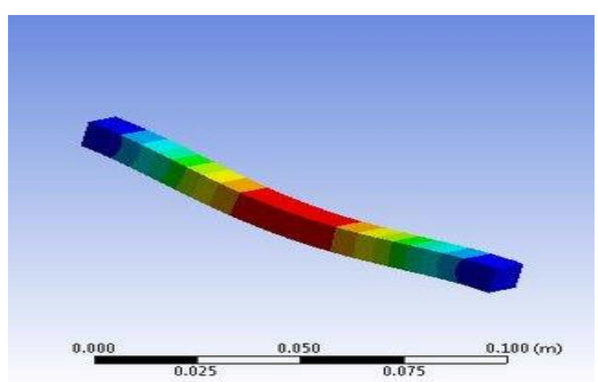
In order to investigate the behaviour of different shapes of concrete filled steel tubes, finite element analysis was conducted by using three dimensional program ANSYS (Version 15) software package. The cross sections of the CFT columns in the numerical analysis are four shapes circular, square, hexagonal and octagonal with 300 mm in length .The columns will be modelled by using ANSYS and results will be compared with the experimentally attained values. The model was meshed using free mesh which was generated with elements.



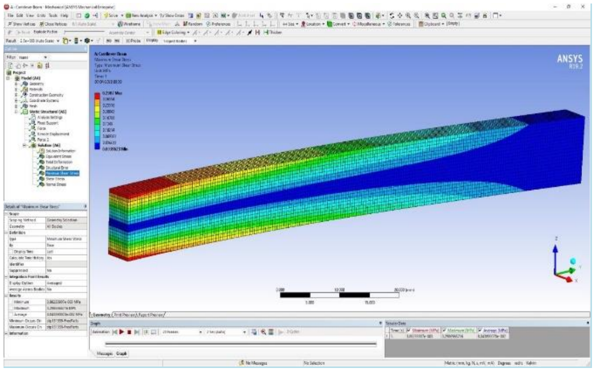
Model of Empty steel tube with fixed supports.



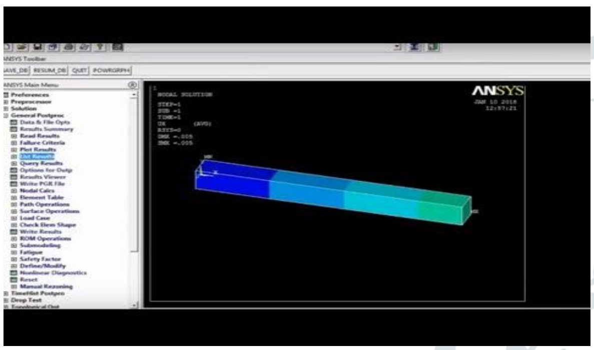
Total deformation of empty steel tube due to applied load.



Stress distribution of empty steel tube due applied load



Strain of empty steel tubes due to applied loads.



ANSYS Model of concrete filled steel tube

Comparision between strain due to applied load on EHST and CFST

Materials	Load (KN)	Total Deformation(m)	Stress	Strain
EHST	10	0.0131	4.64	0.0236
CFST	18	0.0125	5.03	0.0269

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