EXPERIMENTAL STUDY ON COCONUT FIBRE REINFORCED CONCRETE FILLED TUBULAR COLOUMNS

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***ABSTRACT*: In modern building constructions, steel concrete composite columns become more popular as they offer a number of advantages. Concrete – steel composite columns make use of the best performance of these constitute materials. This project presents an experimental study on the buckling behavior of steel circular column in-filled with coconut fiber reinforced concrete (CFRC) with the fiber aspect ratio 1.25% and subjected to axial loading. The size of hollow steel section chosen for the study is 350mm x 114mm x 3mm.A total of four stub columns. Which are classified into four different specimen was tested under axial loading. The presence of discrete discontinuous fibers in the body of the concrete can be expected to improve the resistance of conventionally reinforced structural members to cracking, deflection and other serviceability conditions. The fibers were added in concrete with volume fractions of 1.25%. The load carrying capacities of the stub column with various % of coconut fiber were compared. In the experimental observations it was found that the CFRC in-filled columns with 1.25% volume fraction of fiber have higher strength and ductility than the other two volume fraction of fibers (0.75% and 1%) studied.**

I.INTRODUCTION

1.1 General

The current trend is to reduce costs, improve productivity, quality and take full advantage of information technology and benefits from the new economy. As a result, enhanced research effort has focused attention on developing techniques for the combining steel and concrete effectively, called as steel-concrete composite structures. The steel tube serves as a formwork for casting the concrete, which reduces the construction cost. No other reinforcement is needed since the tube itself act as longitudinal and lateral reinforcements for the concrete core. The continuous confinement provided to the concrete core by the steel tube enhances the core's strength and ductility. The concrete core delays local buckling of the steel tube and prevents inward buckling, while the steel tube prevents the concrete from spalling.

The concrete in-filled tubular columns (CFT) behaves as a longitudinal and lateral reinforcement and are thus subjected to axial stress of longitudinal compression and hoop tension. At the same time concrete is also subjected to axial compression. Concrete in-filled tubular column have long been used in buildings and bridges and research had been carried out from the past 1970's CFT has been popular as structural members in buildings due to their excellent structural performance characteristics, which include high strength, stiffness and high ductility.

The orientation of the steel and concrete in cross section optimizes the strength and stiffness of the section. The steel lies at the outer parameter where it performs most effectively in tension and in resisting bending moment. The stiffness of the CFT is greatly enhanced because the steel, which has a much greater modulus of elasticity than the concrete, is situated farthest from the centroid, where it makes the greatest contribution to the moment of inertia.

The concrete forms an ideal core to withstand the compressive loading in typical applications and it delays and often prevents local buckling of the steel, particularly in rectangular CFT's Additionally, it has been shown that the steel tube confines the concrete core, which increases the compressive strength for circular CFT's and the ductility for rectangular CFT's.

1.2 COMPOSITE COLUMNS

Concrete in-filled steel columns have been used for earth quake resistant structures, bridges piers subjected to impact from traffic, columns to support storage tanks, decks of railway bridges, columns in high rise buildings and as piles. Because of the increased use of composite columns, a great deal of experimental and theoretical work has been carried out. One important advantage of infilled column is that construction is accelerated through separation of trades. Initially, a bare steel frame is erected to carry the gravity and construction loads during construction. As erection of building progresses, concrete is filled from lower level of columns to form the composite system that will resist the total gravity and lateral loads, thus considerable amount of labour, materials and construction cost can be avoided. According to the shape of cross section, there are mainly three different types of composite columns are principally in use, see Fig

- Concrete encased sections, Figure 1.2 (a, b and c)
- Concrete filled hollow section, Figure 1.2 (f, g and i)
- Partly concreted-encased sections. Figure 1.2 (d and e)

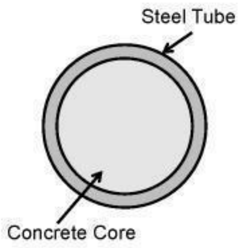
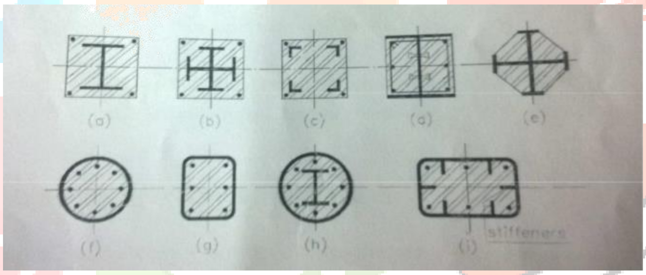


Fig 1.1 cross-section of a composite column

Fig.1.2 Typical cross-section of composite column



The steel box as a part of a composite column completely encases the concrete core so that the ductility of the encased concrete core is highly improved enhances the seismic resistant property. The enhancement of concrete filled steel columns in structural properties is due to the composite actions between the constituent elements. Under several flexural over load, concrete encasement cracks resulting in reduction of stiffness while the steel core can continue providing shear capacity and ductile resistance to subsequent cycles of overload. Partly concreted encased columns have high fire resistance, which is due to that the concrete part prevents the inner steel parts– structural steel as well as reinforcing bars from heating up too fast.

1.3. ADVANTAGES OF COMPOSITE COLUMNS

- The advantages of the CFT over other composite members are that the steel tubes provide form work for the concrete.
- The filled-in concrete from prolongs local buckling of the steel tube wall, the tube prevents excessive spalling of concrete and composite columns add significant stiffness to a frame compared to more traditional steel frame construction.

1.4 APPLICATION OF COMPOSITE COLUMNS

- In china, it is reported that more than thirty high rise buildings and 200 arch bridges have been built using cold formed steel due to the high strength and durability as well as large energy absorption capacity.
- Columns to support storage tanks
- Decks of railways
- Concrete filled steel tubular columns have been used for earthquake-resistance structures, bridge piers subject to impact from traffic.

1.5 COCONUT FIBER

Coconut fiber is a natural fiber extracted from the husk of coconut and used in products such as floor mats, doormats, brushes, mattresses, etc. Coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut. Other uses of brown coir (made from ripe coconut) are in upholstery padding, sacking and horticulture. White coir, harvested from unripe coconuts, is used for making finer brushes, string, rope and fishing nets.

Fig .1.3 Coconut Fiber

1.6 COCONUT FIBRE REINFORCED CONCRETE

In this study Coconut Fiber was used, therefore it is necessary to study the behavior of the Coconut fiber. Coconut fiber was used in concrete. Coconut Fiber Reinforced Concrete is comprised of cements containing fine and course aggregates and Coconut Fiber. A super plasticizer is often used to enhance the mix workability. Coconut Fiber products are available in a variety of types and sizes. The underlying principle however on all CFRC designs is to provide discontinuous reinforcement and effective crack control. Coconut Fibers reinforce in three dimensions throughout the entire matrix. They restrain micro-cracking and act as tiny reinforcing bars. The earlier a crack is intercepted and its growth inhibited the less chance it will develop into a major problem. Compared to plain or conventional reinforced concrete the most noticeable differences are improved ductility and post crack performance. Shorter fibers with a high fiber count offer superior first crack strength and better fatigue endurance.

1.7 ADVANTAGES OF CFRC

- Coconut Fiber Reinforced Concrete, a two phase composite material, having uniform distributed Coconut fibers, has better resistance against cracking, improved strength in shear, tension, flexure and compression and better toughness and ductility as compared to plain concrete.
- Coconut fiber - Fibers are strong, light in weight. The addition of coconut fiber can reduce the thermal conductivity of the composite specimens.
- The addition of randomly distributed fibers improved many properties of concrete, such as fracture strength, toughness, impact resistance, flexural strength and resistance of fatigue.

1.8 APPLICATION OF CFRC

The uses of CFRC over the past thirty years have been so varied and so widespread, that it is difficult to categorize them. The most common applications are pavements, tunnel linings, pavements and slabs, short Crete and now short Crete also containing silica fume, airport pavements, bridge deck slab repairs, and so on. There has also been some recent experimental work on roller-compacted concrete (RCC) reinforced with coconut fibers. The list is endless, apparently limited only by the ingenuity of the engineers involved.

1.9 NEED FOR PRESENCE STUDY

The previous studies have been carried out to investigate the behavior of CFT columns subjected to concentric, eccentric and seismic loadings. For axially loaded thin walled steel tubes, local buckling of the steel tube does not occur if there is a sufficient bond between the steel and concrete. CFT members provide excellent seismic resistance in two orthogonal directions as well as good damping characteristics.

From the previous study, there is a limited research on CFT columns filled with CFRC. Hence the present study focuses on the "behavior of coconut fiber reinforced concrete encased in steel tubes under axial loading".

1.10 OBJECTIVE OF THE PROJECT

The objective of this study is

- To examine the effects of coconut fiber reinforced concrete on the strength and structural behavior of composite columns.
- To determine the ultimate load carried by the stub column.
- To determine the strength obtaining percentage of coconut fiber.

II. LITRATURE REVIEW

- **Venkatesh et al.[1]** studied the principles of steel Hollow Structural Sections (HSS) from an aesthetic and structural point of view have long been recognized by Architects and Engineers in Canada, and more recently in the United States. However, when Building Codes require structural fire protection, the cost of providing such protection can be expensive for exposed members. Filling an HSS column with concrete not only improves the capacity of member through composite action at ambient temperatures but also provides fire endurance periods of up to 2 hours Depending on the load level, section size, concrete strength and reinforcing characteristics. Physical tests and parametric Studies recently completed at the National Fire Laboratory in Ottawa have resulted in design equations which predict the load carrying capacity and fire endurance period of concentrically loaded HSS columns filled with plain concrete, bar-reinforced concrete and steel fiber-reinforced concrete. The design method is presented, case studies are used to illustrate potential applications, and practical suggestions are made regarding construction techniques. The need for further research is also discussed.

J F Hajjar [2] examined the behavior of circular and rectangular concrete-filled steel tube beam-columns and braces under seismic loading. Concrete-filled steel tubes (CFTs) have been used throughout the world in structures of varying heights and structural configurations, both in non-seismic and in high seismic zones. This review summarizes the behaviors of circular and rectangular concrete filled steel tube beam-columns and braces, particularly focused on their behavior when subjected to cyclic seismic loading. It begins with a discussion of the monotonic behavior of CFTs subjected to axial, flexural, and torsional loading, and summarizes the effects on CFT behavior of creep, shrinkage, composite action and residual stresses. The synopsis of monotonic behaviors provides a basis for the subsequent discussion of research on the cyclic behavior of CFTs. The article concludes with a summary of publications. in which current CFT design provisions are outlined for several non-seismic and seismic specifications throughout the world.

Campione et al [3] discussed both the experimental and theoretical behavior of short tubular column filled with PCC and SFRC. The experimental, theoretical and compressive behaviors of short tubular columns filled with plain concrete and fiber reinforced concrete was examined. In the case of short columns in compression the presence of concrete in tubes increases the bearing capacity with respect to unfilled columns and this effect is more in the case of square section. The presence of hooked steel fiber reinforced concrete inside steel tubes determines higher values of deformation at the maximum.

L.H. Han [4] studied the behavior of stub columns of concrete-filled rectangular hollow sections (RHS) subjected to axial load A total of 24 specimens were studied. The main parameters varied in the tests are: (1) constraining factor (x) from 0.5 to 1.3, (2) tube width ratio (b) from 1.0 to 1.75. The main objectives of these tests were threefold: firstly, to describe a series of tests on composite columns, and secondly, to analyze the influence of several parameters such as constraining factor and width ratio on the behavior of stub concrete-filled RHS columns.

Shosuke Morino et al. [5] formulated design recommendations for the design of compression members, beam-columns, and beam-to-column connections in the CFT column system. The concrete-filled steel tube (CFT) column system has many advantages compared with the ordinary steel or the reinforced concrete system. One of the main advantages is the interaction between the steel tube and concrete: local buckling of the steel tube is delayed by the restraint of the concrete, and the strength of concrete is increased by the confining effect of the steel tube. Extensive research work has been done in Japan in the last 15 years, including the "New Urban Housing Project" and the "US-Japan Cooperative Earthquake Research Program," in addition to the work done by individual universities and industries that presented at the annual meeting of the Architectural Institute of Japan (AIJ).

Amir Fam et al. [6] presented an experimental work and analytical modeling for concrete-filled steel tubes subjected to concentric axial compression and combined axial compression and lateral cyclic loading. The objective of the study is to evaluate the strength and ductility of CFT short columns member under different bond strength and end loading conditions. Both bonded and unbounded specimens were tested including application of the axial load to the composite steel concrete section and to the concrete core. Research findings indicate that the bond and end loading conditions did not affect the flexural strength of beam-column members significantly. On the other hand the axial strength of the unbounded short columns was slightly increased, compared to those of the bonded ones, while the stiffness of the unbounded specimens was slightly reduced. Test results were compared with the available design specifications, which were found to be conservative. The paper also presents an analytical model capable of predicating the flexural and axial load strength of CFT members.

Mohamed Elchalakani et al., [7] described an experimental investigation of the cyclic inelastic flexural behavior of concrete-filled tubular (CFT) beams made of cold-formed circular hollow sections and filled with normal concrete. Cyclic bending tests were performed using a constant amplitude loading history on different CFT specimens with diameter-to-thickness ratios (D=t) ranging from 20 to 162.

E K Mohanraj et al.[8] tested twelve steel tubular columns of circular section filled with plain, fiber reinforced and partial replacement of coarse aggregate by rubber, granite, and construction and demolition (C&D) debris concrete. The specimens were tested under axial compression to investigate the effects of fiber, rubber, granite and C&D debris concrete on the strength and structural behavior of composite columns. Hollow steel column of similar specimen were also tested as reference columns. The test results were illustrated by load-deflection curves. Various characteristics, such as, strength, stiffness, ductility and failure mode are discussed. Interpretation of the experimental results indicates that the use of fiber reinforced, rubber, granite and C&D debris concrete as infill material has a considerable effect on the strength and behavior of composite columns.

Young et al. [9] investigated the behavior of high strength concrete filled high strength stainless cold formed steel tubular columns under the effects of shape of the stainless steel tube, plate thickness and concrete strength. The strengths obtained were compared with the design strengths calculated using the American, Australian, New Zealand standards. The strength to the axial strain relationship showed that the ductility of the columns decreases with the increase in the strength of concrete. Slender sections failed by local buckling. Compared to the strengths obtained experimentally, the strengths predicted by the codes were conservative. Based on the test results, recommendations were proposed for the design of concrete in filled high strength stainless steel tubular columns

Ju Chenn et al. [10] proposed a study on innovative X section with intermediate stiffeners of thin-walled concrete-filled steel stub column. The X section was firstly brake-pressed from structural steel sheets to form three edges open section with intermediate stiffener in each edge, then a plate with intermediate stiffener was welded to the open section to form the closed section. The intermediate stiffener was designed to enhance the local buckling stress of the thin-walled specimens. Stub column tests of both hollow steel tubes and concrete-filled steel tubes were performed. Material properties of the self-compacting concrete and steel used in the test specimens were also measured. Design methods specified in current design standard and proposed by other researchers are used to predict the design strengths of test specimens. It is shown that the predicted design strengths are conservative.

III. MATERIAL PROPERTIES

CEMENT

Specific gravity of fly-ash is 3.15

RIVER-SAND

Specific gravity of bottom-ash is 2.36

COARSE-AGGREGATE

Specific gravity of coarse aggregate is 3.10

IV. METHODOLOGY

4.1 Mix Design

Mix Proportion (M_{30})

S.No	Cement (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)	Water (litre)
1	413	706	1117	166
2	1	1.7	2.67	0.40

4.2 Mix proportion for ternary blended concrete

Percentage	Cement	Sand	Coarse aggregate	Coconut fibre
0	1.29	1.84	4	_
0.75	1.29	1.84	4	0.0096
1	1.29	1.84	4	0.0129
1.25	1.29	1.84	4	0.0161

V. TEST FOR CONCRETE

5.1 Test results for hardened concrete

Coconut fibre	Compressive strength		Durability test 1% HCl acid immersion		Tensile strength	
	7 days	28 days	7 days	28 days	7 days	28 days
0	19.8	30.2	12.20	20.15	0.97	1.24
0.75	20.2	31.3	14	22.35	1.06	2.04
1	21.2	33.5	15.2	24.76	1.29	2.51
1.25	25.6	36.9	19.36	27.29	1.48	3.21

5.2 Stub column test

S.NO.	SPECIMEN	VOLUME FRACTION OF SFRC	MAXIMUM DISPLACEMENT mm	ULTIMATE LOAD KN
1	**S1**	**0.75%**	**32**	**833**
2	**S3**	**1%**	**38**	**857**
3	**S2**	**1.25%**	**45**	**866.9**
4	**S**	**Hollow section**	**8.5**	**384.25**
5	**C**	**Concrete cylinder**	**5.8**	**429.45**

Compression Test on Cubes Compression Test on Concrete Cylinder

Stub Column test

VI. RESULT AND DISCUSSION

For stub columns, the in-fill substantially increases the load carrying capacity. All the columns tested have failed by crushing and seal weld. The failure of the column is studied with the ultimate load value and also with load vs. displacement graph & stress vs. strain graph. The Ultimate load carrying capacity by the column for 0.75% is 833.3 kN, 1% is 857.5 kN, 1.25% is 866.6 kN and hollow section is 384.25 kN. The percentage increase in strength of the column is directly proportional to the percentage of fiber added. The ultimate load increases as the percentage of fiber content increases. The special attention to be needed in the welded portion due to stress concentration the failure occurs quickly. The CFT columns are under constant axial load and showed generally prominent resistance characteristics in undergoing inelastic action. The infill in CFT CFRC concrete has good strength performance compared to ordinary M30 concrete. The failure of the column is studied with the ultimate load value and also with load vs. displacement graph & stress vs. strain.

VII. CONCLUSION

It gives good compressive, tensile, durability, and stub column of the concrete. By using this can able to recycle the waste material. Increasing the percentage of fibre the strength of the concrete also increasing. So it can use as a admixture and this recycled material used to reduce the coconut wastage

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