INVESTIGATION ON AXIAL CAPACITY OF CIRCULAR CONCRETE COLUMNS CONFINED WITH FERROCEMENT PRE-JACKETING

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Abstract - This paper presents an experimental study on axial capacity of circular concrete columns confined with Ferrocement pre-jacketing. In this research woven mesh is used as a pre-jacketing material to improve the behavior of structural circular column under axial compression load. The confinement effect over the circular column is uniform compared to the same of a non-circular column. In this study total 6 specimens are tested where crushed stone and clay burnt brick chips used as a coarse aggregate. For comparing the increased capacity of stress and strain with jacketed specimens, 2 specimens are non-jacketed as control specimen. Confined specimens showed higher strength than the unconfined specimens under compressive load. Besides, the stress–strain behavior indicates that double layer of Ferrocement jacket provides significant confining stress than single layer mesh.

Keywords - Woven wire mesh, ferrocement, pre-jacketing, wrap number, stress-strain curve.

I. INTRODUCTION

A column in architecture and structural engineering is a structural element that transmits, through compression, the weight of the structure above to the other structural elements below. Since reinforced concrete (RC) columns transfers load total collapse of RC building may occur due to change in service load and lack of column strength. A number of techniques have been employed for strengthening of RC columns. As a low cost material, Ferrocement has been widely used in developing countries as a productive method of repair and strengthening. Researchers conducted in the past have shown that the compressive strength of core concrete, ultimate concrete compression strain and ductility of strengthened column increased significantly if proper external confinement by mean of jacketing was provided. Researches also showed that Ferrocement could be used as an alternative effective technique to strengthen RC column with inadequate shear strength. The term Ferrocement implies the combination of a ferrous reinforcement embedded in a cemented matrix. There are some similarities between RC and Ferrocement like they obey the same principles of mechanics, they can be analyzed and designed according to the same philosophy. There are some differentiating factors also. Compared to RC it has homogeneous and isotropic properties in two directions, good tensile strength and high specific surface of reinforcement about two orders of magnitude as that of RC.

This research is aimed to study axial load carrying capacity of Ferrocement confined pre-jacketed columns, to evaluate the effectiveness of wire mesh confinement in strength deficient columns and the effect on axial capacity with double layer of jacketing.

II. STATE OF THE ART

Ferrocement components are of thickness in the order of 10-25 mm and uses rich cement- sand mortar; and the reinforcement consists of one or more layers of continuous/ small diameter steel wire. Wire mesh is of different diameter wires woven/ welded in different shapes (rectangular, square, hexagonal etc.). Ferrocement uses high volume fraction of reinforcement (2 to 8%) and the specific surface of reinforcement is considerably higher than RCC. In ferrocement, due to small spacing of reinforcement wire mesh it allows better dispersion of the load on the surface and cracks are minimized [1]. Moreover, the skeletal of desired shape can be fabricated with help of mild steel bars/mild steel sections used as spacer material, around which the mesh layers are, attached [6]. As the fabrication and application of wire mesh is easy task so it requires less skilled labor for casting. Due to the unique properties of ferrocement it can be widely accepted over conventional material like stone, brick, reinforced concrete, steel and timber. ferrocement can be applied to form structural components such as walls, floors, roofs, beams, columns, silos, swimming pools etc [3]**.** Fahmy et. al (1999) presented a method for repairing reinforced concrete columns using ferrocement laminates as a viable economic alternative to the highly expensive conventional jacketing methods by reinforced concrete or steel jackets. The results of an experimental investigation to examine the

effectiveness of this proposed method were reported and discussed including strength, deformation, ductility and energy absorption characteristics of the reported specimens. Twenty four reinforced column models were tested under concentric compression load. Each specimen was first loaded till failure or up to either % 67or % 85of the ultimate load of the control specimens [2]. Katuski and Abdullah (2003) had strengthened reinforced concrete columns with ferrocement jackets. They had used circular and square ferrocement jackets for strengthening square reinforced concrete columns with inadequate shear resistance. It was concluded that by providing external confinement over the entire length of reinforced concrete columns the ductility is enhanced tremendously [4]. Abdullah and Takiguchi (2003) investigated the square columns using both square and circular ferrocement simultaneously under compressive and cyclic loading [7]. Mohammad and Reza (2005) had performed a study to evaluate a retrofit technique for strengthening shear deficient short concrete columns. Ferrocement jacket reinforced with expanded steel mesh was used for confining the columns. It has been found that expanded meshes were more effective than ties in shear strengthening of concrete columns and also specimens strengthened with expanded meshes showed distributed fine shear cracks and higher ductility capacity [5]. Kondraivendhan and Pradhan (2009) investigated the use of ferrocement as an external confinement to concrete specimens. The effectiveness of confinement is achieved by comparing the behavior of retrofitted specimens with that of conventional specimens. The primary variable considered in the study, is concrete type. All other parameters such as size, shape, number of layers of wire mesh, and aspect ratio of the specimens were kept constant. The chosen section was circular cylinders with a size of 150 mm * 300mm [3].

III. METHODOLOGY

Total 6 column specimens were tested, 3 were brick specimens and remaining 3 were stone. All the specimens were cylindrical shape with 150mm diameter and 300mm height. The circular columns were jacketed with one or two layer of ferrocement wire mesh except two control specimens. These were non-jacketed columns for comparing capacity with jacketed columns. Test was done under concentric compressive load until failure. Two types of jacketing technique are taken into consideration, such as;
(i) Single layer ferrocement jacketing and (ii) Double layer ferrocement jacketing.

Materials	Characteristics
Stone	Crushed stone
Brick	Crushed clay burnt brick
Cement	Portland Composite Cement
Sand	Sylhet Sand
Ferrocement Jacket (Wire Mesh)	wire mesh was woven in square pattern and thickness of wire mesh was 0.8 mm as well as spacing of the wire mesh was 12.7 mm

Table 1: Materials Properties

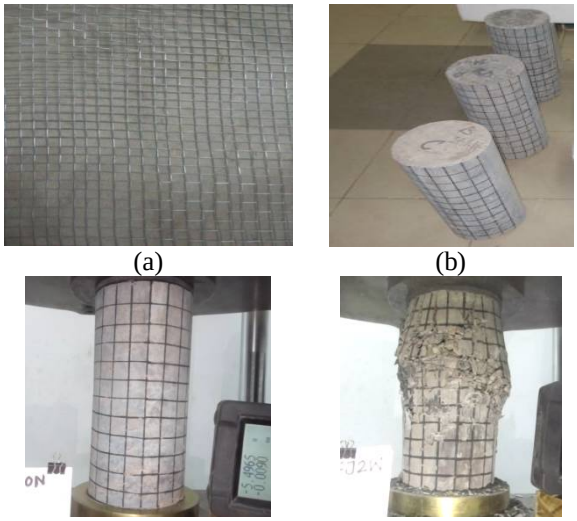


Fig 1: (a) Wire Mesh, (b) circular specimens, (c) testing of specimen and (d) failure pattern.

In this experiment pre-confinement is done and the process of this done by giving shape of the specimen using mold. Wire mesh of square opening was used for the confinement. Tied wire was used rather than welding. Then casting was done by using steel jackets as mold.
The mix design of stone and brick concrete are provided in the table

Coarse aggregate size (Stone & Brick)	25.4 mm passing and 19 mm retain (50%) 19 mm passing and 12.7 mm retain (50%)
Cement: Sand: Stone	1:2:4
Cement: Sand: Brick	1:2:4
w/c	0.5

Table 2: Mix Design of Concrete

Concrete was mixed by a concrete mixture machine. Then concrete is casted in steel mold. Mold is covered by polythene in bottom opening. Before casting it should be ensured that no cement water from concrete will be leaked. During casting a well distributed tamping was done. Hammering was also done for distributing water over the mold. After completing casting, casted columns were set free from steel sheet and it had been cured for 28 days in curing tank by submerging completely underwater**.** Then using Universal Testing Machine, compressive strength were measured of the specimens. The axial stress-axial strain curves plotted using this data. The lateral strain data are synthesized from HD video

clips implying the Digital Image Correlation Technique on the platform of MATLAB. The label used for the specimen is composed of letters and numbers. In figure it has been shown.

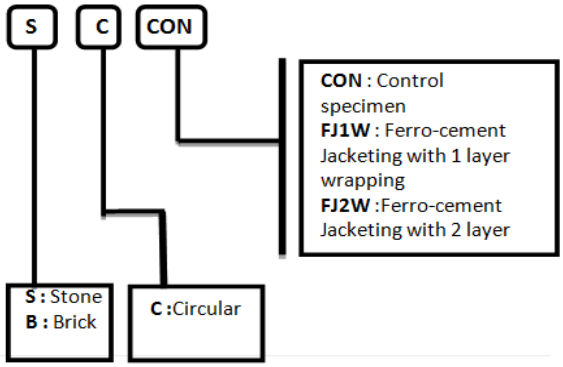


Fig 2: Typical legends

IV. RESULT AND DISCUSSION

In this analysis the following results are interpreted

- Performance of ferrocement jacketed circular column.
- Difference in axial capacity and stress-strain response of circular column due to variation in types of aggregate and wrap numbers.

4.1 Effects of number of wrap

From this study, we saw that column behaviour change due to the effects of number of wrap.

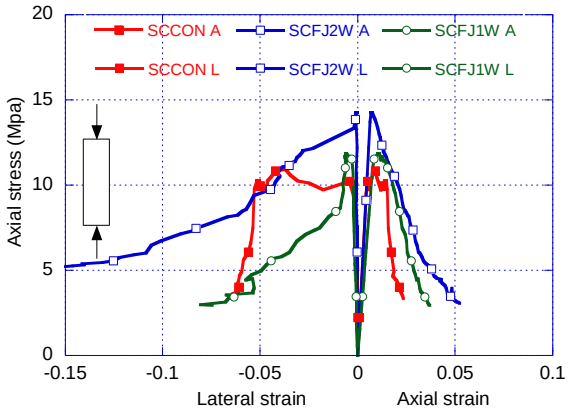


Fig 3: Comparison of axial stress vs axial strain and axial stress vs lateral strain behavior of circular stone concrete specimen.

Fig 3 showed graphical comparison between stone circular specimen control with single layer and with double layer mesh jacket. Here SCFJ1W showed 8.75% more axial stress than SCCON and SCFJ2W showed 30.6% more axial stress than SCCON. Besides SCFJ1W showed 57.3% more ultimate axial strain & 15.12% more ultimate lateral strain than SCCON whereas SCFJ2W showed 122.32% more ultimate axial strain and 210.19% more ultimate lateral strain than SCCON.

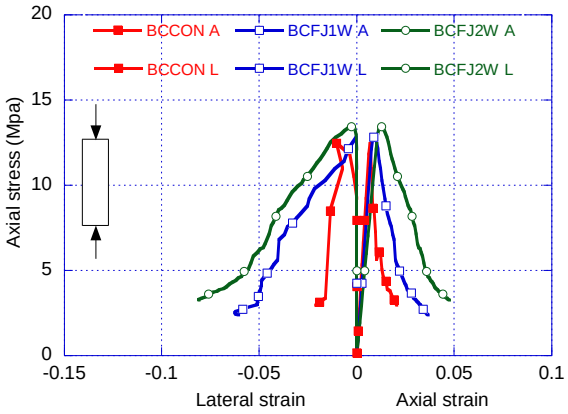


Fig 4: Comparison of axial stress vs axial strain and axial stress vs lateral strain behavior of circular brick concrete specimen.

Fig 4 showed graphical comparison between brick circular specimen control with single layer and with double layer mesh jacket. Here BCFJ1W showed 2.96% more axial stress than BCCON and BCFJ2W showed 7.96% more axial stress than BCCON. Besides BCFJ1W showed 79.19% more ultimate axial strain & 188% more ultimate lateral strain than BCCON whereas BCFJ2W showed 131.71% more ultimate axial strain and 284.76% more ultimate lateral strain than BCCON.

4.2 Effects of Aggregate

From this study, we saw that column behaviour change due to the changes of aggregate.

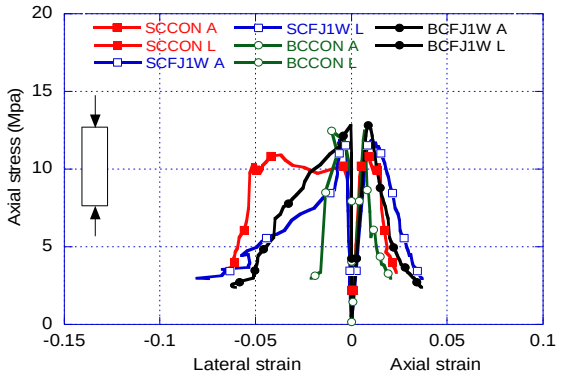


Fig 5: Comparison of axial stress vs axial strain and axial stress vs lateral strain behavior between SCCON, SCFJ1W, BCCON & BCFJ1W.

Fig 5 showed graphical comparison between single layer mesh jacketing with respect to control specimen for different aggregates. Here SCFJ1W showed 8.75% more axial stress whereas BCFJ1W showed 2.96% more axial stress than their control specimen. In case of ultimate axial strain BCFJ1W showed 79.19% increment whereas SCFJ1W showed 57.3% increment with respect to their control specimen. Similarly in case of ultimate lateral strain BCFJ1W showed 188% increment whereas SCFJ1W showed 15.12% increment with respect to their control specimen.

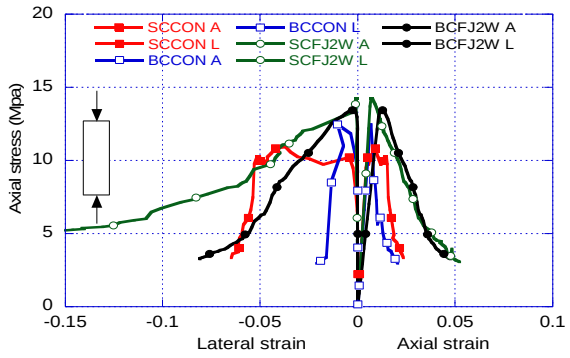


Fig 6 : Comparison of axial stress vs axial strain and axial stress vs lateral strain behavior between SCCON, SCFJ2W, BCCON & BCFJ2W.

Fig 6 showed graphical comparison between double layer mesh jacketing with respect to control specimen for different aggregates. Here SCFJ2W showed 30.6% more axial stress whereas BCFJ2W showed 7.96% more axial stress than their control specimen. In case of ultimate axial strain BCFJ2W showed 131.71% increment whereas SCFJ2W showed 122.32% increment with respect to their control specimen. Similarly in case of ultimate lateral strain BCFJ2W showed 284.76% increment whereas SCFJ2W showed 210.19% increment with respect to their control specimen.

Compressive Test Results	**Coarse Aggregate Type**					
	Stone			Brick		
	SCCON	SCFJ1W	SCFJ2W	BCCON	BCFJ1W	BCFJ2W
Maximum Axial Stress (MPa)	10.915	11.870	14.254	12.472	12.841	13.464
Ultimate Axial Strain	0.0235	0.0370	0.0523	0.0205	0.0367	0.0475
Ultimate Lateral Strain	0.0648	0.0746	0.2010	0.0210	0.0605	0.0808
Percentage Increase in Axial Stress (compare with control specimen)	-	8.75%	30.6%	-	2.96%	7.96%
Percentage Increase in Ultimate Axial Strain (compare with control specimen)	-	57.3%	122.32%	-	79.19%	131.71%
Percentage Increase in Ultimate Lateral Strain (compare with control specimen)	-	15.12%	210.19%	-	188%	284.76%
Percentage Increase in Axial Stress (compare with single layer specimen)	-	-	21.85%	-	-	5%
Percentage Increase in Ultimate Axial Strain (compare with single layer specimen)	-	-	65%	-	-	52.5%.
Percentage Increase in Ultimate Lateral Strain (compare with single layer specimen)	-	-	195%	-	-	96.8%.

Table 3: Summary of the Test Results

CONCLUSIONS

Based on the obtained test results, the following conclusion can be drawn:

1. As Expectation, the double layer of confined concrete column shows better result than single layer or unconfined specimens.
2. Considering axial stress, the result has shown 8.75% increase in axial stress for SCFJ1W and 30.6% increase for SCFJ2W as well asBCFJ1W has shown 2.965% increase and BCFJ2W has shown 7.96% increase compared to the control specimen.SCFJ2W has shown 21.85% increase when compared to SCFJ1W and BCFJ2W has shown 5% increase compared to BCFJ2W.
3. Considering ultimate axial strain SCFJ1W has increased for 57.3% and SCFJ2W has increased for 122.32% compared to the control specimen. BCFJ1W has increased for 79.19% and BCFJ2W has increased for 131.71% compared to the control specimen. SCFJ2W has shown 65% increase when compared to SCFJ1W and when BCFJ2W is compared to BCFJ1W, it has increased for 52.5%.
4. Considering Ultimate lateral strain SCFJ1W has increased for 15.12% and SCFJ2W has increased for 210.19% as well as BCFJ1W has increased for 188% and BCFJ2W has increased for 284.76% compared to the control specimen. SCFJ2W has increased for 195% when compared to SCFJ1W and when BCFJ2W is compared to BCFJ1W, the result showed 96.8% increase.

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