International Journal of Science, Technology and Management (IJSTM) ISSN (online): 2231-775X
Volume 1, Issue 1, 2025

Experimental Investigation on Axial Load Performance of RCC Short Columns Strengthened with Alternative Composite Wraps

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ABSTRACT

An overview of the need for column strengthening due to issues such as overloading, poor construction practices, and seismic activity. It emphasizes the significance of using alternative materials and techniques such as fiber-reinforced polymers (FRP) and self- compacting concrete (SCC) for enhancing structural integrity. Covers existing studies on the use of alternative materials in SCC, as well as the effectiveness of fiber-wrapped columns in improving the load-carrying capacity and seismic performance of reinforced concrete (RC) columns. Materials used in the study, including Ordinary Portland Cement (OPC), fly ash, manufactured sand, processed slag sand, and glass and jute fibers. The methodology outlines the process of preparing SCC mixes and casting reinforced concrete columns, which are then wrapped and tested under axial loading. Mix design of SCC using the Nan-Su method and the experimental setup for testing columns, including the casting, curing, and axial testing of both unwrapped and wrapped columns.

The results of the experimental study, divided into three phases: unwrapped columns, partial wrapping with gljute fibers, and fully wrapped columns. The findings highlight the improved performance of composite-wrapped columns in terms of load-carrying capacity, deformation, and stiffness.

Inroduces a new technique of composite wrapping, where alternating layers of glass and jute fibers are applied to the columns. Experimental results are compared with finite element analysis (FEA) using ANSYS, with less than 10% variation observed in displacement and failure load between experimental and analytical results. The analytical investigation confirmed that composite wrapping enhances column performance, with RM-based columns performing better than CM-based columns. Overall, the research confirms that composite wrapping using glass and jute fibers offers a promising

solution for improving the structural performance of columns, particularly when combined with alternative materials like fly ash and recycled aggregates. The study also highlights the potential of using these techniques as sustainable construction practices that contribute to reducing the carbon footprint of the concrete industry.

1. OBJECTIVE

1.Characterization of properties of materials

2.To develop a simple and convenient mix design procedure using alternative aggregate materials and to compare with conventional concrete mix of same strength.

3.Strength properties on RC column elements with composite wrapping, boundary condition is one end is hinged and another end is roller supported.

4.L/D ratio= 8

5.Strength properties of composite wrapping materials

i. Jute fibre

ii.Glass fibre

6.Experimental values are comparing with analytical values using software tools.

2. SCOPE

The Scope of the present study is to assess the structural performance of composite wrapped, SCC-made short columns. The literature review indicates that even though there are many investigations associated to full and partial wrapping of columns, there are very less studies associated to composite wrapping. A comparison between composite wrapped columns made of control mix and replaced mix SCC concrete and corresponding unwrapped columns is presented in this research work.

3. MATERIAL USED

Table 1: Materials used

Sl. No.	Material	Remark
1	Cement	OPC 53 grade
2	Fly ash	Class F
3	Fine aggregates	M-sand and PSS
4	Coarse aggregate	10 mm down size
5	Water	Potable
6	SP (VMA)	BASF-Master Glenium Sky 8233
7	Steel reinforcement	Fe500 TMT bars
8	Glass fiber	Sika-Wrap 430G
9	Natural fiber	Jute
10	Adhesive	SikaDur 330 - In

Table 2: Physical characteristics of cement

Sl. No.	Physical property	Value	Range	Reference
1	Specific gravity	2.93	2.90	IS: 4031(Part 11) – 1988 IS: 2720 (Part 3) – 1980
2	Standard consistency	30%	–	IS: 4031 (Part 4) – 2019
3	Fineness of cement	5%	Less than 10%	IS: 4031 (Part 1) – 1996
4	Initial setting time	33 min	Not less than 30min	IS: 4031 (Part 5) – 2019
5	Final setting time	178 min	Not more than 600min	IS: 4031 (Part 5) – 2019

4. EXPERIMENTAL

In this section viz., phase IV composite wrapping of columns using Jute and glass fiber applied in alternate layers was explored. The column sample designation adopted in this study based on wrapping type and mix type are tabulated in Table 1 and the details of measurements recorded are as reported in previous chapter.

The mix design was maintained same and the resulting compressive strength of concrete made with CM and RM was 34.05 MPa and 29.91MPa respectively.

4.1 Phase-IV: Composite wrapping of columns

Composite wrapping consisted of strengthening of columns with materials of different mechanical properties. In this study, glass and jute fiber was utilized as wrapping materials to a column alternately. The column length was divided in 5 layers with a height of 240mm. The odd numbered i.e., layer number 1, 3 and 5 were wrapped with glass fiber and layer 2 and 4 were wrapped with jute fiber. A pictorial representation of column with composite wrapping is presented in Figure 1.

The behaviour of composite wrapped columns cast using CM and RM under axial loading is discussed below,

The ultimate load carrying capacity of the columns cast with CM was found to vary from 490.7 kN to 670.8 kN with an average of 580.8 kN. The average failure stress and elastic modulus was 21.51 MPa and 23637MPa. It was interesting to note that RM with composite glass – jute wrapping resulted improved load carrying capacity as compared to column cast with CM. The average ultimate load carrying capacity was 1.15 times as that of composite wrapped columns cast with CM. The elastic modulus of RM columns was marginally low as compared to CM based composite wrapped columns. The load carrying capacity and elastic modulus of columns are presented in Table 3. The stress strain behavior of columns at centre height is presented in Figure 2.

Table 3: Results of Column Testing.

Mix Type	Type of Wrapping / Material		Failure Load (kN)		σ (N/mm2	E (N/mm2)	Axial Stiffness kN/mm
			Range	Average			
CM	Composite	Glass - Jute	490.7 – 670.8	580.75	120.76	23637	120.76
RM			622.1 – 717.1	669.6	87.20	22697	81.90

Table 4: Column samples designation

Mix Typ	Wrapping Type	Wrapping Material	Sample Designatic	Phase	No. of Column
CM	Composite wrappir	Glass fiber + Jute fiber	Type 1F	IV	6
RM	Composite wrappir	Glass fiber + Jute fiber	Type 2F	IV	6

Axial load versus axial deformation and lateral displacement was recorded as presented in Figure 3 and Figure 4. The stiffness for CM and RM based composite wrapped columns was 120.76kN/mm and 81.90kN/mm respectively. Composite wrapping columns exhibited significant resistance for lateral displacement. The maximum lateral displacement measured up to a load of 380kN was 0.54mm and 0.77mm for CM and RM- based columns respectively. The failure pattern of composite wrapped columns is indicated in Figure 6.5. Similar failure behavior as that of partial and fully wrapped columns was observed in composite wrapped columns.

4.2 Data for modelling

Engineering data describes a database of materials that were created manually based of experimental results obtained on constituent materials of the current study for modelling of columns in Ansys workbench. The various materials defined were steel of grade Fe500, glass fiber and jute fiber for wrapping the columns, and concrete of grade M30 in the engineering data section. The details of elements selected in the study is presented in Table 5. Various properties defined for every material incorporated in modelling a column are as shown in Table 5.

Table 5: Elements used for Modelling

Material	Element	Nodes
Concrete	Solid 65	8 Noded
Fiber	Shell 181	4 Noded
Steel Reinforcement	Link 180	2 Noded

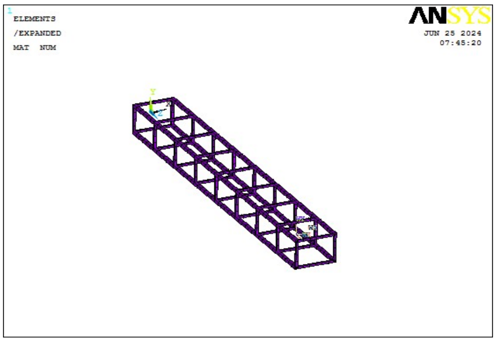

Figure 1: Model of reinforcement

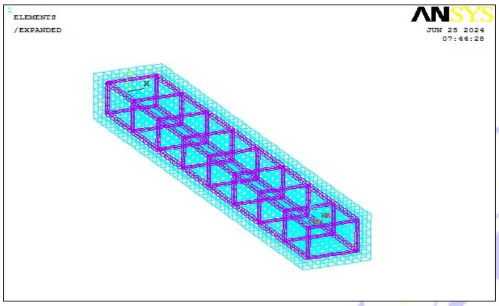

Figure 2: Meshing

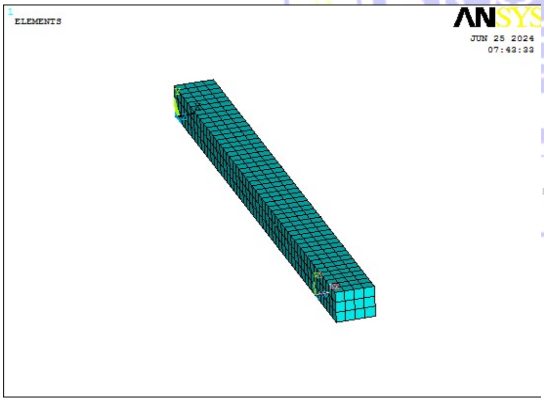

Figure 3: Model of RC Column

5.Conclusions

The current research is aligned towards exploring the behaviour of short columns of size 150mm ×180mm × 1200mm. The slenderness ratio of columns was restricted to 8. The simple supported end conditions were adopted for columns. Columns were cast using a SCC of M30 grade developed using Nan-Su method. The reinforcement in column was maintained constant. The research explores influence of alternate fine aggregates and secondary cementitious materials in development of concrete for structural applications and influence of wrapping on mechanical behaviour of columns.

In this research two types of fine aggregates viz., Manufactured sand (M-sand) and Processed slag sand (PSS) were used in development of SCC. Two types of fibers and three wrapping techniques were utilized for strengthening of column. Jute and glass fiber was used for wrapping of column. Partial, full and composite wrapping methods were adopted to explore the mechanical behaviour of column to assess it applicability in structural system.

Basic testing of constituent materials was assessed as per specifications of Bureau of Indian Standards (BIS). A total of 72 columns were tested for its load carrying capacity. All columns were tested for axial loading until failure and measurements such as displacement and strains were recorded at constant load interval. Based on detailed review of literature objectives were framed and investigations were carried out resulting in following conclusions

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