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Analysis of Columns Strengthened using Fibre Reinforced Cementitious Matrix Jackets

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Abstract: Maintenance, repair and strengthening of existing concrete structures, either reinforced or prestressed, are important activities of civil engineers. Nowadays different techniques are available for the strengthening. Various techniques were adopted for strengthening RC structures, namely, steel plates, external post tensioning, externally bonded Fibre-Reinforced Polymer (FRP), and near- surface-mounted FRP systems to increase shear and flexural capacity. During the last few decades, strengthening of concrete structural elements by fibre-reinforced polymer has become a widely used technique. But it has several disadvantages due to the epoxy resin like debonding of FRP from the concrete structure, unstable nature of the epoxy at higher temperatures etc. To overcome this, an upgraded system was introduced as an alternative for FRP known as Fibre Reinforced Cementitious Matrices (FRCM).

The objective of this paper is to investigate the feasibility of Fibre-Reinforced Cementitious-Matrix materials as an alternative external strengthening technique for RC members. Columns with circular geometry were wrapped with different fibre materials using cementitious matrix. The analysis was done using ANSYS software.

Keywords: RC columns, FRCM, Strengthening, fibre, ANSYS

I. INTRODUCTION

The repairing and strengthening processes are aims to improve the performance of the concrete members, restore and increase the strength and stiffness of the concrete, improve the appearance of the concrete surface, increase water tightness, prevent access of corrosive materials to the reinforcing, and improve the overall durability of the concrete members. Fiber reinforced polymers are powerful strengthening technique for various structural applications.

They are composite materials which are made from fibres and resins and have proven efficient and economical for the development and repair of new and deteriorating structures. Strengthening and increased durability against steel corrosion can be achieved in a RC structure by wrapping them with fibre reinforced.

But it has several disadvantages due to the epoxy resin like debonding of FRP from the concrete structure, unstable nature of the epoxy at higher temperatures and expensive and they are less effective or unable to apply on wet surface or at low temperature. So an upgraded system was introduced as an alternative for FRP for the rehabilitation of damaged concrete and masonry structures known as Fibre Reinforced Cementitious Matrices (FRCM). FRCM systems consist of two components, namely; the fabric mesh, which comes in various types of materials such as carbon, glass, and polyparaphenylene-ben-zobisoxazole and the mortar, which is a cement-based binder that attaches the fabric to the concrete substrate. Unlike FRP systems, FRCM are compatible with the concrete substrate in addition to their ability to include recycled materials in their matrix. It also reduces the steel reinforcement and control crack width.

The existing studies, however, have generally limited to experimental investigation with limited number of fibres. Most of them are concentrated on glass and carbon fibre. In this work, the effect of Fibre Reinforced Cementitious Matrix in strengthening of RC columns is done using ANSYS software. The circular shaped RC columns are used to analyze the compressive strength. Circular column wrapped using different fibre materials with cementitious matrix is analyzed. The fibres used in FRCM are glass, basalt, aramid and steel.

II. OBJECTIVE

To compare the structural performance of RC circularcolumn wrapped with different types of Fibre Reinforced Cementitious Matrix (FRCM).

III. METHODOLOGY

The thesis works deals with the study of circular column wrapped with different types of fibre reinforced cementitious matrix.

A. Modelling

The modelling is done using ANSYS software version 18.1 with SOLID 65 element type and rebar link 180. Four models were created with circular column having same diameter, height and material properties. Circular column with different fibre materials are modelled. They were analyzed and considered as the concrete column of fixed ends. From this analysis load carrying capacity and deformation of structures can be computed.

B. Structural Details

The structural details of circular column analyzed are shown in the table below.

Table I Structural Details Of Circular Column

Geometry	Dimensions
Diameter (mm)	300
Area (mm^2)	70686
Height (mm)	1000
Main bars	6 # 12mm dia
Lateral ties	8mm @ 200mm c/c

C. Material Properties

The material used are M20 grade concrete, cement mortar, steel and different fibres. The thickness provided for cement mortar in FRCM is 3mm and fibre is 0.5mm. 5 layers include three layers of cement mortar and two layers of fibre are provided alternately with total thicknessof 10mm. The strength, young's modulus and poisonsratio are shown in the tables below.

Table II Material Properties Of Concrete

CONCRETE	
Compressive strength	21.6 MPa
Young's modulus	26200 MPa
Poisson's ratio	0.15

Table III Material Properties Of Cement Mortar

CEMENT MORTAR	
Compressive strength	53.2 MPa
Young's modulus	10720 MPa
Poisson's ratio	0.20

Table IV Material Properties Of Steel

STEEL	
Compressive strength	552 MPa
Young's modulus	2×10^5 MPa
Poisson's ratio	0.30

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Table V Material Properties Of Fibres

Fibres	Tensile Strength (MPa)	Young's Modulus (MPa)	Poisson's Ratio
Glass	525.5	64400	0.25
Basalt	2700	85400	0.26
Aramid	3600	83000	0.36
Steel	2580	2×10^5	0.30

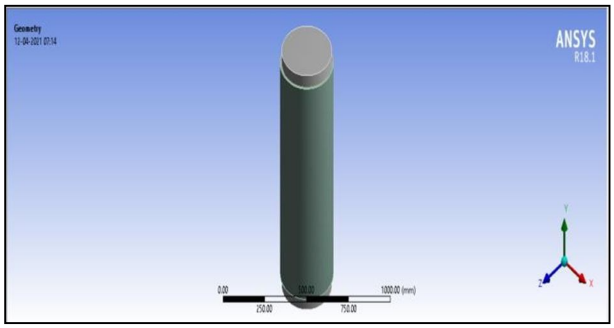

Fig 1 Model of circular column

D. Meshing and Loading

Meshing of the column is done using quadrilateral mesh which is a 4-node mesh. The element size of the mesh provided for concrete is 20mm and for mortar and fibres assweep mesh of 150mm.Loading is provided on the top area, as axial load of 2600N. The loading is given at the midpoint with fixed end support condition.

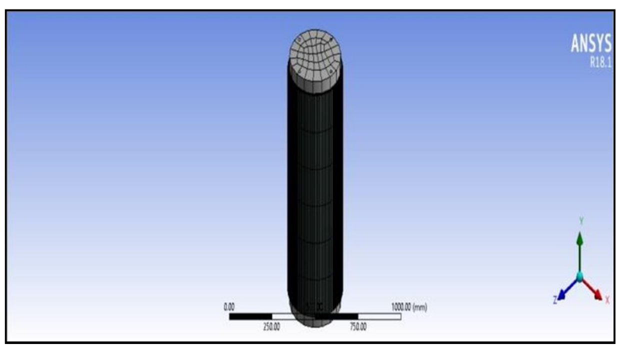

Fig. 2 Mesh model of circular column

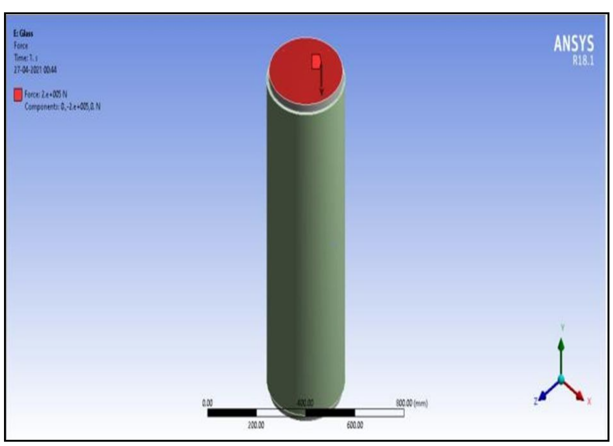

Fig. 3 Loading model of circular column

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E. Analysis of Circular Column

Static structural analysis determines the displacement, stresses, strains and forces in structures or components caused by loads. Static analysis is carried out by ANSYS software. Deformation and load carrying capacity is studied.

IV. RESULTS AND DISCUSSIONS

A. Static structural analysis

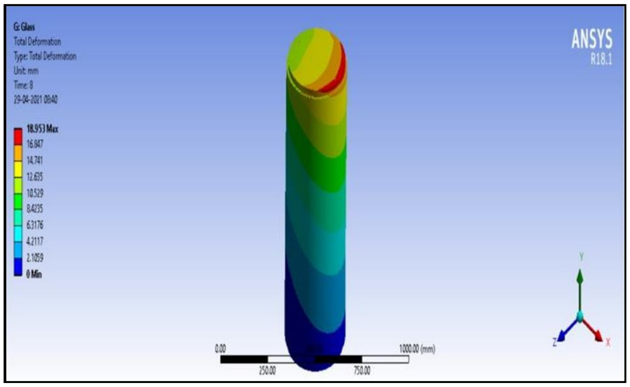

Fig. 4 Deformation diagram of circular column with GFRCM

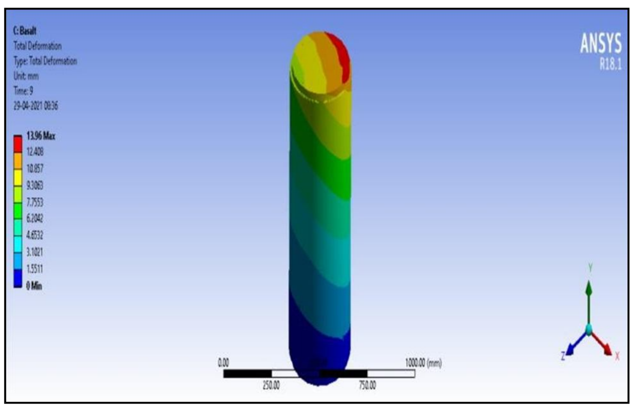

Fig. 5 Deformation diagram of circular column with BFRCM

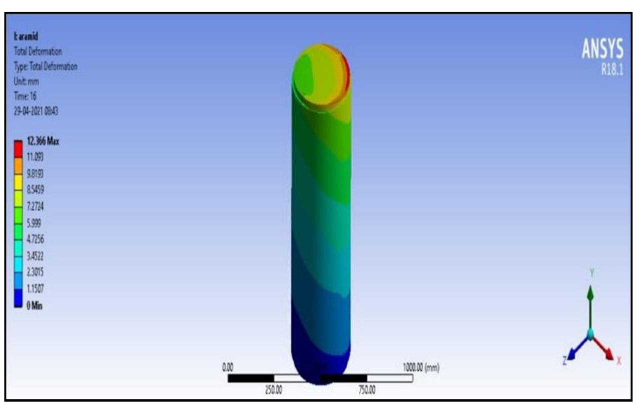

Fig. 6 Deformation diagram of circular column with AFRCM

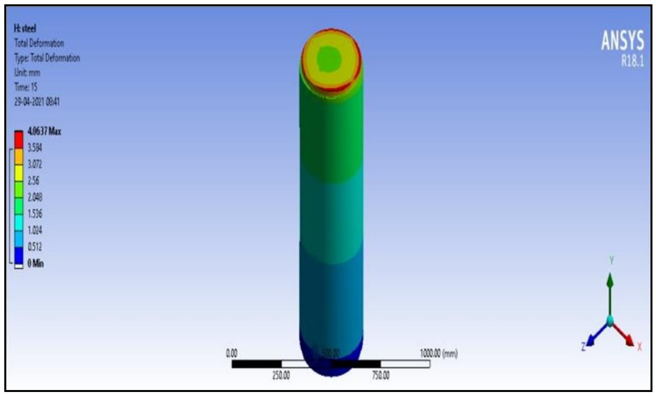

Fig. 7 Deformation diagram of circular column with SFRCM

Table VI Maximum Load And Deorfmation On Circular Column With Different Types Of Frcm

FIBRES	LOAD (kN)	DEFLECTION (mm)
Glass	1600	18.953
Basalt	1800	13.96
Aramid	1600	12.366
Steel	1500	4.063

Table VII Stiffness of Circular Column With Different Types Of Frcm

FIBRES	STIFFNESS (N/m)
Glass	0.77×10^{10}
Basalt	0.788×10^{10}
Aramid	0.77×10^{10}
Steel	0.74×10^{10}

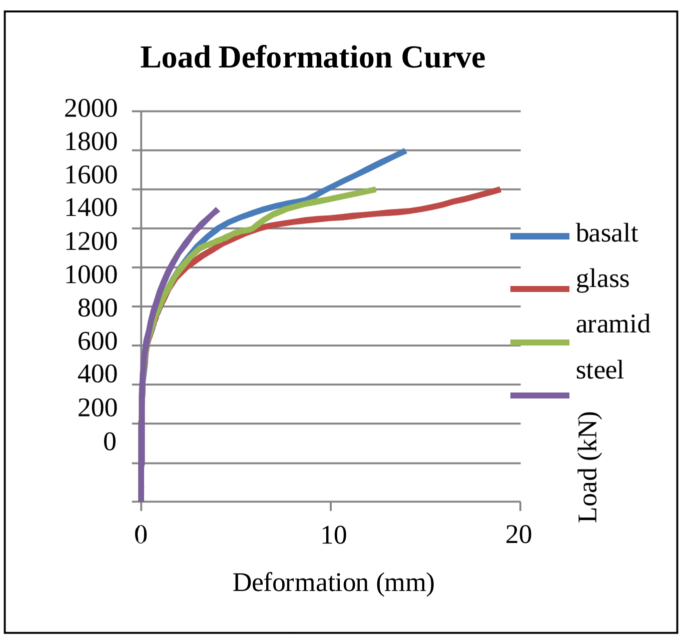

Fig 8 Load deformation curve

V. CONCLUSIONS

Circular column is analyzed using ANSYS software and results were compared. The following conclusions are obtained from the study.

A. Circular column wrapped with FRCM using basalt fibre shows more load carrying capacity than other fibres.
B. Circular column wrapped with FRCM using glassand aramid shows exact same load carrying capacity.
C. Circular column wrapped with FRCM using steelshows least load deflection characteristics, due toits similar stiffness value.

VI. ACKNOWLEDGEMENT

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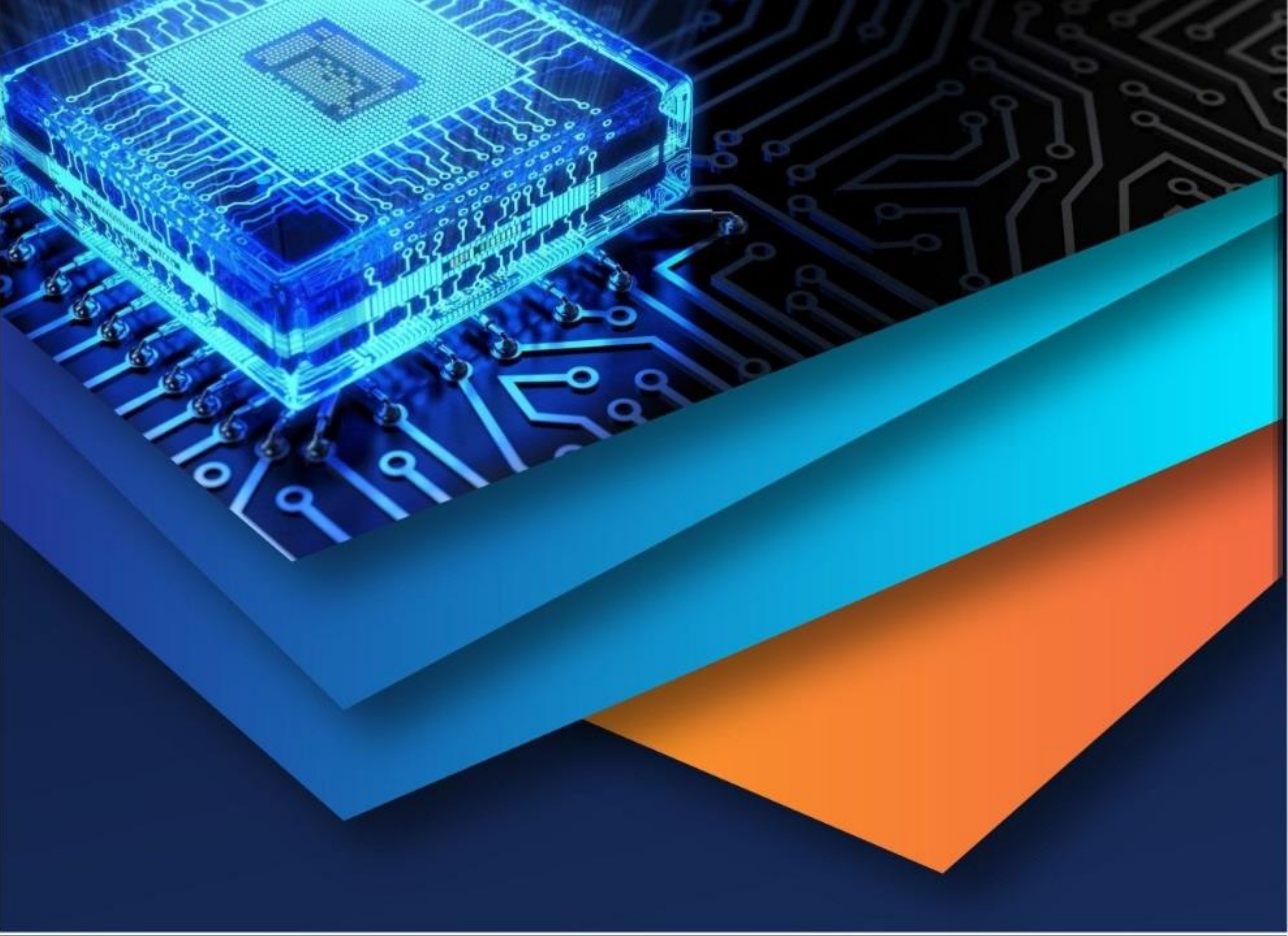

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