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Efficiency of Strengthening RC Column with Different Slenderness Ratio using Basalt Fabric

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Abstract:
Strengthening is needed in structural elements, due to many reasons like aging, poor construction, designing errors etc. Now, building or structure is not a mobile device that we can demolish it and then reproduce it.So strengthening is the best option to bring back the strength and serviceability of the building. RCC and Steel Jacketing, FRP wrapping are the most used techniques for strengthening purposeIn this thesis, axial strength enhancement is checked by wrapping of basalt fabric.Columns of different sizes are casted and tested in this thesis. Among all the results and conclusions, it is proved that strengthening can be done with the basalt fiber & it is good alternative of carbon fiber as an economical point of view

I. INTRODUCTION

Many older structures today are in the need of strengthening because of many factorsreasons. As a human body aged in the same way building or any structure is also aged in its whole life. The strength of any structure is gradually decreased with the time span. The deteriorated structure neither provides serviceability nor be able to take load for which it is designed. Now, Building or ant structure is not a mobile device that, we can demolish it & buy a new one or construct a new structure. So retrofitting & strengthening of the building is the only good option and very necessary for use the structure which fulfills all the safety and serviceability criteria. In 1960s, strengthening or retrofitting of older structures to resist higher design loads or increase the ductility has been accomplished with traditional material such as externally bonded steel plates and steel jackets. Now Conventional strengthening and retrofitting techniques are concrete-Jacketing and steel jacketing. Development of FRP materials in various forms and configurations offers an alternative design approach for construction of new structures and rehabilitation & strengthening of the existing civil infrastructure. The first use of FRP products was in reinforced concrete structures in 1980. There are many types of FRP materials available in market like CFRP, GFRP, AFRP& BFRP. By combining these fibers, basalt yarn is made and from yarn, fabric is made. Basalt fabric is of natural golden-brown colour. Based on fiber direction, fabric is classified in three categories Unidirectional fabric, Bi-directional fabric, Multi-directional fabric.

II. LITERATURE REVIEW

Literature on basics of basalt fibers are given to introduce the product in detail, as basalt is newly introduced material, very less literature has done with basalt fiber.

2.1 Basics of Basalt fibers

2.1.1 Singha (2012) concluded the results of basalt fiber. Itgives the whole basic details about the basalt fibers from starting to the end. it gives chemical composition of basalt rocks, characteristics of fiber, manufacturing of the fibers, mechanical and thermal properties of the basalt fibers and various application of fibers. It can be concluded that the basalt fibers have good mechanical and chemical properties compared to the carbon and glass fibers.

2.1.2 Dudhagi et al (2013) described the knowledge about thebasalt fiber from volcanic rocks. Also it gives an overview of the manufacturing process, properties and scope of the basalt fibers.

2.1.3 Mankodi gives the detailed knowledge about the newly introduced material basalt fabric and its composition. Also itdefines the characteristics of basalt fiber, mechanical-physical properties, electrical-chemical properties and its applications in civil engineering

2.2 Strengthening of Axial members using externally bonded FRP

Kumar et al (2014) have studied the"Durability Study on Basalt Fiber Reinforced Polymer (BFRP) Composites Wrapped Specimens for Retrofitting of RCC piles". They have casted total 36 nos of concrete cubes with and without wrapping of BFRP to observe the fluctuation in compressive strength during acid and fire resistance tests. The cubes were tested after 7, 30 and 70 days. They have concluded that very less decrement in compressive strength compared to control cubes. Thus it is proved that BFRP wrapping is durable in acid attack and fire resistant.

Modhe et al (2014) have done research on "Experimental Study ofAxially Loaded RC Short Columns Strengthened With Basalt Fiber Reinforced Polymer (BFRP) Sheets". Total 14 nos of column were casted with various configuration like single layer and double layer with basalt fiber. They have derived the load v/s deflection graphs from the axial load. They have concluded that load carrying capacity is increased in wrapped column. double layer of BFRP is most effective.

Thorhallson et al (2015) have studied the"Strengthening of concrete columns by wrapping basalt fiber matrix". They have

casted only cylinders of 100mm × 200mm size and tested for tensile coupon test & compression test on BFRP confined cylinders. Specimens were wrapped with basalt fiber in single, double and three layer wrap. They have concluded that confined cylinders show a good ductile behavior and increase the load carrying capacity in comparison of unconfined specimen.

III. MATERIAL & METHODOLOGY

3.1 MATERIALS: The basic materials used for this research work are given below with their properties and necessary details

Cement: An Ordinary Portland Cement (OPC) of 43 Grade of Ultra-tech brand was used for this work. Cement was bought from the same source throughout the research work.

Fine Aggregates: Fine aggregates used for the experimental processes were available locally. The fine aggregates that are to be used should be free from organic matter and dirt and dust. The fine aggregates that are to be used should also be free from clay, silt etc

Course aggregates: Coarse aggregates used for the experimental procedures were locally available. The coarse aggregates used for the experimental work should not contain any type of dust, soil, clay, weeds, organic matter etc.

Concrete: Concrete is the material that formed by mixing of cement & water combined with sand, aggregates, grit etc. Here, M25 Grade of concrete is used in whole work. Mix-Design report is prepared by Geo Test House, Vadodara for M25 concrete.

Basalt Fabric: Unidirectional Basalt fabric sheet is used for this whole research work. It has extra ordinary tensile strength of 2300-3500 MPa, that means 5 to 7 times more than steel. It is generally available from 0.5 to 1 m width and 100 m long in roll form.

Table.1. Mechanical Properties of basalt fabric

Properties	Values
Density	275 g/cm^3
Tensile strength	3500-4500Mpa
Elastic modulus	80Gpa
Elongation of break	3.18%
Fiber diameter	5-13 µm
Linear density	60-4200 Tex*
Temperature withstand	-200 to 850°C

Reinforcing Steel: In this experimental study, Reinforced Concrete Columns were casted. Fe-500, High Yield Strength Deformation (HYSD) bars confirming to IS: 1786-2008, used for this study. Here, 8mmØ steel used as Main reinforcement and 6mmØ @ 100;mm c/c for stirrups.

Epoxy: After casting, curing & surface preparation epoxy applied on column & then fiber will be wrapped on it. Here, Sikadur-31C epoxy was used manufactured by sika company.

3.2 Specification of Specimen

Column for Axial load testing: Here the specification of the size and dimensions of the column. Total 15 number of square columns, of 150mm × 150mm size and different height casted for whole experiment.

Table .2. Details about Specimens

Base	Length	Slenderness ratio (l/d)	Specimen
150mm x 150mm	0.6m	4	5
150mm x 150mm	0.75m	5	5

Control column CCX, CCY, CCZ: These are the control columns without any type of wrapping like plain column. Control columns show the load carrying capacity for plain columns.

Column CW_1X, CW_1Y, CW_1Z: In these type of columns, single layer of basalt fabric is applied on whole surface with 25% of overlap on face.

Column CW_2X, CW_2Y, CW_2Z: In these type of columns, double layer of basalt fabric is applied on wholesurface with 25% of overlap on face.

Column CW_3X, CW_3Y, CW_3Z: In these columns, a strip of 100mm width of basalt fabric is applied on whole surface @ 100mm c/c distance on face.

Column CW_4X, CW_4Y, CW_4Z: In these types of columns, only mid-portion of column excluding 100mm length from top and bottom is wrapped with basalt fabric.

Table.3. No of specimen and configuration of wrap

Slenderness of the column	No. of Specimens				
	Control Specimen	Full single wrap	Full double wrap	100mm strip	Mid-portion full wrap
4	1	1	1	1	1
5	1	1	1	1	1

3.3 Working Method:

Mixing of Concrete: Mixing of the ingredients is done with mixer machine & after the mixing, concrete is placed into the formwork & then compacted with steel rod by hand. At last surface is leveled for better finishing.

Casting of Columns & cubes: First of all, the moulds were lubricated with the oil in inner surface. Then steel cage is kept in the mould with proper cover arrangement in all sides. Then concrete is placed in the mould step by step and compaction is done with the steel rod with hand blows. After proper

compaction, the surfaces are leveled. After the 24 hours columns were unmolded.

Curing of specimens: After the unmolding of columns, immediate curing is done with on place by watering.

Application of Basalt fabric: First of all, the columns were grinded properly so that surface becomes rough. Also unevenness is leveled and smoothen by grinding. Then after epoxy is applied on the surface. Epoxy is made by mixing the resin and hardener with 2:1 proportion. Then fabrics are applied on the surface by hand-roller. One more important fact is that there should not be any air-hole left while wrapping the fabric. In case of double layer wrapping, there should be gap of 2 hours between each layer applied so that second layer does not disturb the first layer.

3.4 Experimental Setup:
In this experiment, different sizes of the axial members were casted. The column were tested in 100tonne capacity of Universal Testing Machine (UTM). Here, Axial compressive load was given to the columns. Also one strain gauge was fixed on the face of the column to check the axial displacement.

IV. RESULTS AND DISCUSSIONS

4.1 Results of 600 mm length of column: Table 4shows the axial deformation with respective loads and failure load of sample 600mm length

Table.4. Result analysis of 600mm (X) column

Specimens Axial Deformation (mm)	Load (KN)				
	CCX	CW_1X	CW_2X	CW_3X	CW_4X
1	68	48	117	69	73
2	86	102	238	124	132
3	94	193	331	176	198
4	100	238	456	213	244
5	131	326	-	237	294
Failure Loads (KN)	**247**	**338**	**568**	**273**	**302**

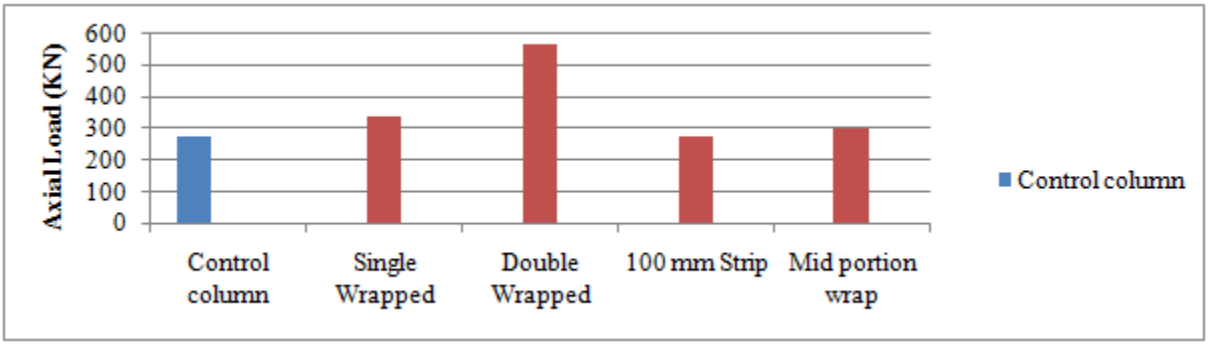

Figure .1. Failure Load for different wrapping pattern for 600 mm length column

The Ultimate load carrying capacity of X column increased as compared to its control column

- 37% for single wrap
- 130% for double wrap
- 11% for 100mm strip wrap
- 22% for mid portion wrap

4.2 Results of 750mm length of column: Table 5 shows the axial deformation with respective loads and failure load of sample 750 mm length.

The Ultimate load carrying capacity of Y column increased as compared to its control column

- 46% for single wrap
- 115% for double wrap,
- 24% for 100mm strip wrap
- 38% for mid portion wrap

Table.5. Result analysis of 750mm (Y) column

Specimens Axial Deformation (mm)	Load (KN)				
	CCY	CW_1Y	CW_2Y	CW_3Y	CW_4Y
1	72	98	119	61	67
2	97	113	183	98	112
3	118	179	269	151	159
4	152	205	354	177	186
5	169	149	392	208	228
Failure Loads (KN)	**197**	**288**	**423**	**243**	**271**

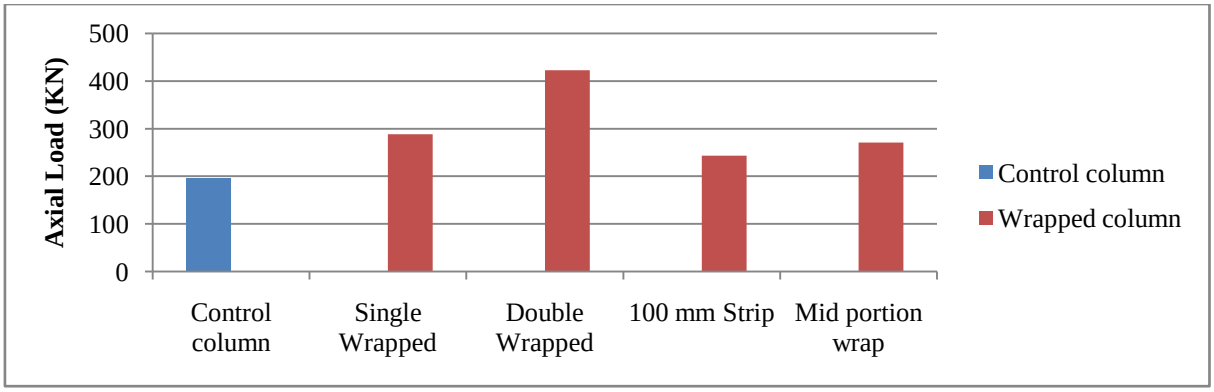

Figure .2.Failure Load for different wrapping pattern for 600 mm length column

V. CONCLUSIONS

Here are the conclusions that derived from the result analysis of the present experimental work. These experimental results clearly demonstrate the Basalt fabric wrapping can enhance the structural performance of RC column under axial loading by providing additional confinement to concrete without increasing original size of the column.

- Ultimate load carrying capacity of X (600mm) column increased as 37% for single wrap, 130% for double wrap, 11% for 100mm strip wrap & 22% for mid portion wrap compared to its control column.
- Ultimate load carrying capacity of Y (750mm) column increased as47% for single wrap, 114% for double wrap, 23% for 100mm strip wrap & 38% for mid portion wrap compared to its control column.

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