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STUDYING THE EFFECT OF LATERAL CONFINEMENT ON THE EFFICIENCY OF HISTORIC RC COLUMNS

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Abstract:

Columns are significant auxiliary components since they are the principle supporting components in RC structures.in a few cases the craving to change the action of the solid structure causes an expansion in the heaps on the structure. As of late new materials have been created to improve the presentation of these basic components. In this exploration, the square and rectangular solid sections were reinforced utilizing basalt strands and contrasted with glass and carbon filaments.

The practical program was conducted on five column specimen divided into three groups; all specimens have square cross-section, sized 200mm^2 x 150mm (height).

The first group consists of one column designated by CR1 with a variable stress. Where CR1 is Fcu=10N/mm² represents the behavior of control column reference specimens without any strengthening.

The second group consisted of two specimens' first specimen Is strengthened with two layer of Basalt Fiber for partial confinement and second specimen Is strengthened with two layers of Basalt Fiber for total confinement.

The third group consisted of two specimens' first specimen Is strengthened with one layer of carbon Fiber for partial confinement and second specimen Is strengthened with one layers of carbon Fiber for total confinement.

Test outcomes show that limiting of the R. C. segments utilizing various Types of fortifying outcomes in huge improvement of the general conduct of the sections. Wrapping utilizing BFRP and CFRP upgrades malleability and extreme quality too; the hypothetical outcomes had been determined by the ECP condition and contrasted with the exploratory outcomes. Through the reasonable investigation, obviously there is an improvement in the section limit and conduct of every fortified segment by basalt fiber and carbon contrasted with the unstrengthen segments. The outcomes in this investigation show that fortified solid sections reinforced via carbon fiber are progressively successful by increment the limit of the segment than the basalt fiber. In any case.

Keywords: Basalt Fiber, Carbon Fiber, square column, Confinement reinforcement concrete.

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I. INTRODUCTION

Columns are significant auxiliary components since they are the primary supporting components in RC structures. Erosion of customary steel causes splits in sections, which for the most part prompts disappointment in basic segments. These days, new materials are created to upgrade the presentation of auxiliary components. Confinement is generally applied to members in compression, with the aim of enhancing their load carrying capacity or, in cases of seismic upgrading, to increase their ductility. Traditional confinement techniques rely on their either steel hoops or steel jackets for upgrading. Indeed, it is well known that increasing the confinement action enhance that concrete strength and ductility and, in addition, prevents slippage and buckling of the longitudinal reinforcement. In seismic problem, Existing confinement pressure in either the potential plastic hinge or over the entire member (e.g. Cgai et al. 1991). This technique can also be useful in lap-splices zones [1]. A new technique for external confinement of reinforced concrete columns has been recently used widely, such technique is the application of circumferential wrapping with ACM (Advanced Composite Materials) such as BSRP (Basalt Sheets Reinforced polymers). Such technique relatively to old techniques is easy to apply. The most interesting advantages of these composite materials are the flexibility, lightweight, thin thickness, the non-corrosive nature, and ability to apply to columns by any shape easily.

A review of the state of the art concerning basalt fibers and their use as reinforcement phase in composite materials for applications in civil engineering field has been provided. Basalt fibers, obtained from melted natural basalt rocks and characterized by significantly cheaper production processes in comparison with other fibers (e.g., carbon and glass), exhibit very appealing physico-chemical properties: good strength and stiffness, high temperature resistance, long-term durability, acid and alkali resistance, heat and sound insulation, as well as good processability. These aspects, in addition to the high eco-sustainability levels of basalt fiber production and using, have induced a widespread diffusion of basalt-based products [8]. Column wrapping utilizing carbon and glass FRP systems increases the maximum axial stress in columns in both circular carbon-fiber wrapped columns and rectangular carbon-fiber wrapped columns, the stress increases to 24% and up to 26.8% increase in an axial load testing [9]. The unconfined and CFRP confined concrete columns cast with different types of mixing water and sand exhibit similar failure patterns, which means that the seawater and sea-sand have a negligible effect on the short-term mechanical performance of the specimens, especially for the confined columns[10]. Newly developed BFRP composite can be effectively used inimproving the overall compressive behavior of confined concrete [11].

It has been observed that for a CFRP-confined concrete column, the propagation of the initial defect may not lead to the global failure. In general, such a phenomenon alters the confining pressure provided by the FRP, leading to stress redistribution and weakening of the structure. Deformation behavior and final failure greatly depend on the initial defect size [12]. The axial behavior of the GFRP-confined expansive concrete was experimentally investigated. Results demonstrated that expansive concrete offered the active confinements, and thus compensates for the insufficiency of low FRP confinement, thereby leading to good post-peak performance in strain-hardening behavior, as compared to strain-softening one in the conventional concrete [14]. The carbon fiber reinforced polymer in the hoop direction can significantly increase the ductility of hollow core square reinforced concrete columns under concentric or eccentric loading. Compared to VHF and AHF columns, HF columns can sustain much larger deformation before failure. However, the increment of the compressive strength of FRP-confined hollow core columns is marginal [15]. An increasing trend of load carrying capacities is observed with increase in CFRP volumetric ratios at all eccentricities except at e=35mm where a slight reduction is observed. Load carrying capacities are also decreased with increase in eccentricities for all CFRP volumetric ratios [16].

II. EXPERIMENTAL WORK

Five R.C. columns with circular cross-section, sized 200mm^2 (croos section) x 1500mm (height), were manufactured and tested as shown in figure (3).

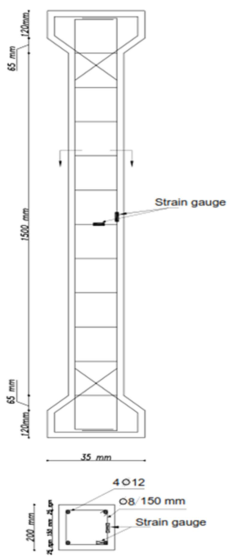

Fig. 1: Details of Typical Specimen.

Two parameters were considered in this study; strengthening shape and Strengthening Material. Details of tested specimens with different parameters are shown in table I.

TABLE I
EXPERIMENTAL PROGRAM.

Group NO.	Column NO.	Geometry (mm)	Strengthening Material	Strengthening Shape & Spacing (mm)	Parameter Study
1	C1	200*200	____	——	Control
2	C2	200*200	Basalt Fiber	Partial S = 150	Strengthening Shape
	C3	200*200		Total	
3	C4	200*200	Carbon Fiber	Partial S = 150	Strengthening Material
	C5	200*200		Total	

C= Column   Axial (Short Column) L = 1500 mm

The experimental work has been planned to investigate the difference in global behavior between conventional reference short rectangular columns constructed of normal strength concrete and those columns strengthened with different types of strengthening such as:

1- Basalt fiber strengthening.
2- Carbon fiber strengthening.

The test measurements include the first crack loads, failure loads, crack patterns, axial deformations, and concrete strains.Therefore, a total of five columns classified into three groups as shown in Table (1). The first group consists of one columns designated by C1 Where C1 represents the behavior of control column reference specimens without any strengthening.

The second group represents the Partial & total Strengthening Basalt Fiber group which consists of two columns designated by C2 & C3.

Where:

C2: Is strengthened with a Partial two layer of Basalt Fiber consists of 50mm width, spacing of 150mm

C3: Is strengthened with a total two layer of Basalt Fiber.

The third group represents the Partial & total Strengthening Carbon Fiber group which consists of two columns designated by C4 & C5.

Where:

C4: Is strengthened with a Partial layer of carbon Fiber consists of 50mm width, spacing of 150mm

C5: Is strengthened with a total one layer of carbon Fiber.

- The concrete mix was designed to achieve a target compressive strength of 10N/mm² after 28 days. The mix properties are shown in table II.

TABLE II
PROPERTIES OF CONCRETE MIX CONSTITUENTS USED IN THE EXPERIMENTAL WORK

Constituents	units	Contents (m³)
Cement	Kg	200
Sand	Kg	650
Water	Liter	160
Water-cement ratio	%	0.8
Coarse aggregate	Kg	1512

Each column is strengthened with 4ø12 mm longitudinal fortifying plain bars giving support proportion of 0.022 longitudinal way. For all sections, tied stirrups were given of Ø8 mm plain bars. Pitches of stirrups were 5.0 cm at the section closes and 20.0 c along segment stature. Though the stirrups are accumulated at the segment finishes maintaining a strategic distance from neighborhood disappointment at the segment finishes because of stress focus.

The electrical strain gauges are used to measure different strains of the columns. One strain gauge is used for each specimen to measure strain of reinforcement, the location of strain gauges at the first third of the column. All columns were tested up to failure in axial compression using universal testing machine having 1200000Newton capacity. The upper head was fitted with seat. Both end surfaces of the columns are capped using gypsum layer to ensure horizontal and smooth surfaces. Care is taken to load the columns axially and reduce any possible eccentricity of the columns. A swivel is placed between the machine and the upper top of the column to ensure uniform loading. as shown in figure 2

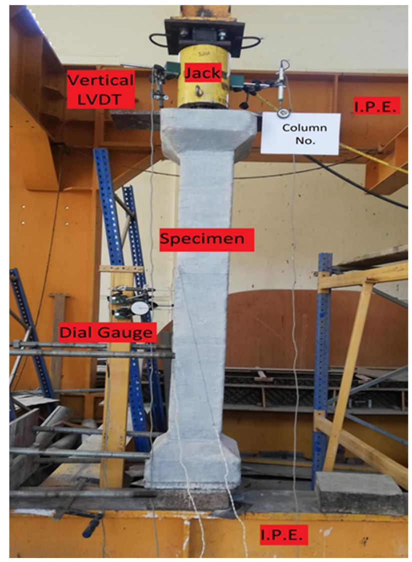

Fig. 2: Test Setup

III. TEST RESULTS AND ANALYSIS

In this part, the obtained test results are compared together and discussed to evaluate the effects of different types of strengthening on the column behavior. Columns responses are obtained in terms of load- displacement, ultimate load and axial strain.

A. ULTIMATE LOADS AND STRENGTH

The load and strength capacities for tested columns as measured experimentally are given in Table III. As shown in Table 3 and plotted on Fig.3, external confinement increased the ultimate strength capacity of the columns which strengthened using total sheets of basalt fiber (C3) & carbon fiber (C5) by 50% and 85%, respectively comparing to the reference column specimen capacity. Partial external confinement with space 150 mm increased the ultimate strength capacity of the columns which strengthened using partial sheets of basalt fiber (C2) and carbon fiber (C4) by 40% and 75%, respectively comparing to the reference column specimen capacity.

TABLE III
MEASURED LOADS AND STRENGTH CAPACITIES FOR TESTED COLUMNS

Column	Type of confinement	Ultimate load (kN)	stress at failure (N/mm^2)
C1	Control	400	10
C2	Partial basalt	560	14
C3	Total basalt	600	15
C4	Partial Carbon	700	17.5
C5	Total Carbon	740	18.5

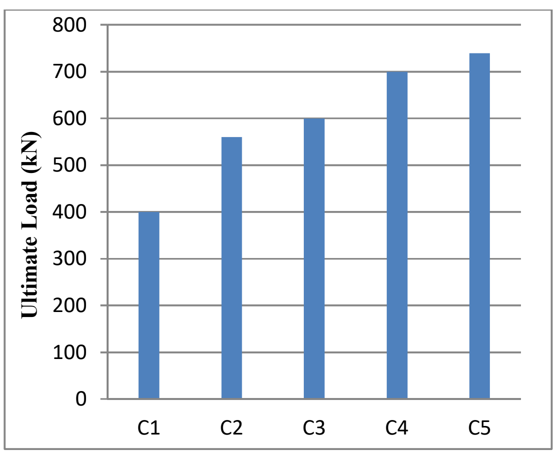

Fig. 3: Comparison of ultimate stress capacity for tested columns

B. TOTAL STRENGTHENING GROUP:

B-1: Crack Pattern for Total strengthening specimens:

From the observed crack pattern figures it is noticed that the behaviour of the total confinement of carbon and basalt fibers are all the same behaviour as they have cracks appear vertical and starting to propagate from upper third as shown in Figure (4). The crack pattern can be classified as crushing failure due to cutting of FRP wraps in the two specimens.

Fig. 4: Failure shape for carbon and basalt fibers respectively.

B-2: Load –Vertical strain curves for total strengthening specimens.

Figure 5 show a comparison between load – vertical strain for specimen C3 total basalt and C5 total carbon, which represent decrease in the vertical strain by 20.4 % & 52.7% respectively with reference to C1. It also shows that the enhancement in the ultimate strength capacity of the columns strengthened with total fibers are 7.8% and 52% respectively with reference to C1 as shown in Figure 5.

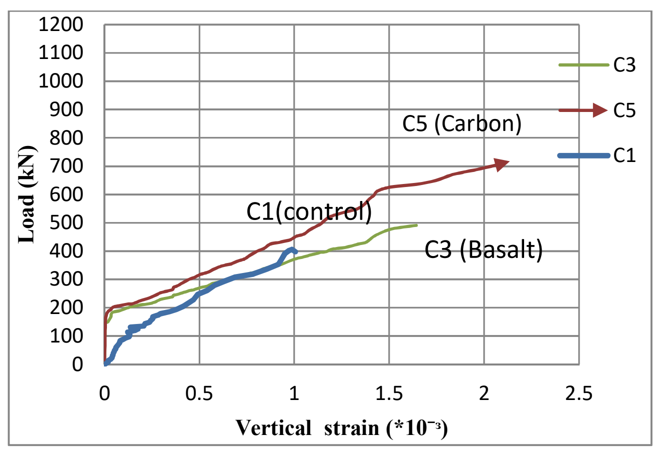

Fig. 5: load –Vertical strain curve for total strengthening group.

C: PARTIAL STRENGTHENING GROUP:

C-1: Crack Pattern for partial basalt strengthening specimens.

From the observed crack pattern figures it is noticed that the behaviour of partial basalt confinement fiber is close to the behaviour of the carbon fiber as it both have cracks appear vertical and starting to propagate from upper third as shown in Figure (6). The crack pattern can be classified as crushing failure due to cutting of FRP wraps in the three specimens.

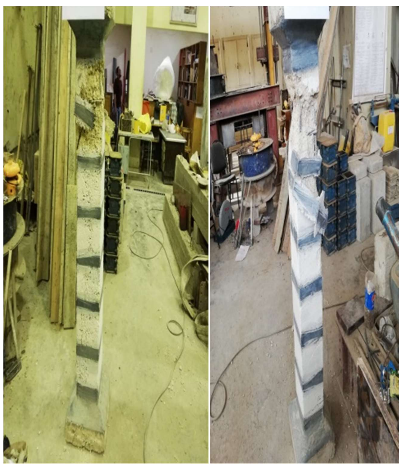

Fig. 6: Failure shape for basalt and carbon fibers respectively..

C-2: Load –Vertical strain curves for total strengthening specimens.

Figure 7 show a comparison between load – vertical strain for specimen C2 partial basalt, and C4 partial carbon, which represent the enhancement in the ultimate strength capacity of the columns strengthened with partial fibers are 4.4%, & 32.2% respectively with reference to C1.It also represents a decrease in the vertical strain by 2.15%, & 36.7% respectively with reference to C1.

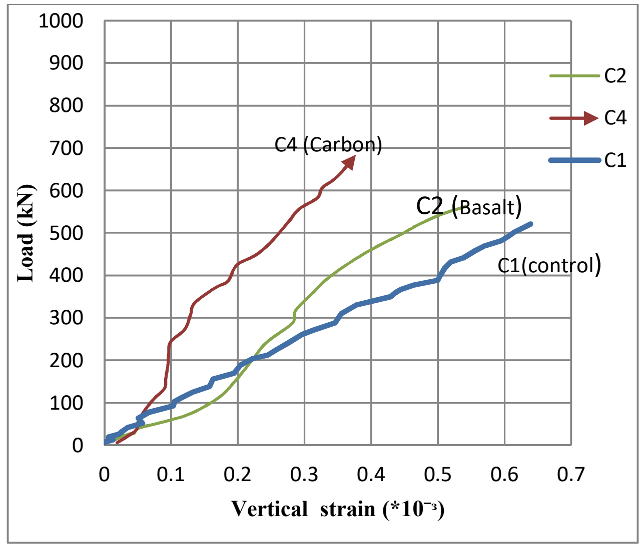

Fig. 7: load –Vertical strain curve for partial strengthening group.

IV. CONCLUSIONS

Based on the experimental and analytical studies carried out in this study, the following conclusions can be drawn:

1- Test results show that confining of the R. C. columns using different techniques of strengthening results in significant improvement of the general behavior of the columns

2- The comparison between enhancement in the ultimate load of columns strengthened with one layer of carbon fiber specimen (C4) and one layer of glass fiber specimen (C3) and two layer of basalt fiber specimen (C5) showed that glass fiber strengthening is not effective than that of other types where basalt fiber has increased 12% more than glass fiber while carbon fiber achieved increase with 40% . But by considering the lower cost of fibers, it can be said the BFRP gives good results.

3- Test results show that confining of the R. C. columns using different techniques of strengthening results in significant improvement of the general behavior of the columns. Strengthening using concrete jacket results in the best enhancements in load capacity (300%), flexibility and energy absorption. But this technique results in a concrete sector twice the original section.

4- The comparison between enhancement in the ultimate load of columns strengthened with 8 equally spaced strips one layer of glass fiber (C6) and 8 equally spaced strips one layer of carbon fiber (C7) and 8 equally spaced strips two layer of basalt fiber (C8) showed that glass fiber strengthening is not effective than that of other types where basalt fiber has increased 21% more than glass fiber while carbon fiber achieved increase with 52%.

5- The use of 2 layer basalt fiber for confining RC historical columns highly enhanced the load carrying capacity and ductility.

6- All kinds of confinements enhanced the energy absorption capacity for columns comparing to that of the reference specimen except specimen C6 (8 equally spaced strips 1 layer of glass fiber) and C8 (8 equally spaced strips two layer of basalt fiber). The increase in energy was 168%, 119%, 181% and 30% for specimen C2, C3, C4 and C5 more than that of reference specimen, respectively. While for Partial fiber group the increase reached 55% for columns C7. The column confined with 8 equally spaced strips 1 layer of glass fiber (C6) showed a little decrease in energy absorption 29% and (C8) showed a little decrease in energy absorption 88%.

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