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Experimental Study of Axially Loaded RC Short Columns Strengthened With Basalt Fiber Reinforced Polymer (BFRP) Sheets

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ABSTRACT: This paper presents the results of experimental study related to the strengthening of R C short columns strengthened with BFRP wrap under axial loading. For strengthening of reinforced concrete columns, total fourteen columns were cast and tested up to failure of the columns under axial loading. The columns were bonded with BFRP sheets in single layer and double layers with various configurations. Out of the fourteen columns two columns were control columns and remaining columns were strengthened with BFRP. The experimental results show that the columns strengthened with BFRP show high load carrying capacity and ductility index.
Keywords: Basalt Fiber Reinforced Polymer, Short Columns, Strengthened Columns, Ultimate Load, Ductility Index.

I. INTRODUCTION

Many older structures today are in the need of strengthening their existing civil engineering infrastructure. The reasons are deterioration by ageing or corrosion caused by environmental factors, load increase because of change of function in the structure or poor design which does not meet the present more stringent design requirements such as in earthquake areas. The low probability of major seismic events and high cost of structural rehabilitation make it difficult to justify economically. Strengthening or retrofitting of older structures to resist higher design loads or increase ductility has been accomplished with traditional materials such as externally bonded steel plates and steel jackets since in the 1960s. Concrete columns are important structural elements which are vulnerable for exceptional loads. In older structures, columns often have insufficient transverse reinforcement which is unable to provide sufficient confinement to the concrete core or to prevent buckling of the longitudinal reinforcement. This can lead to unacceptable premature strength degradation.

II. EXPERIMENTAL PROGRAM

The experimental work consisted of casting and testing of short columns. All columns had the same dimensions and reinforcement.

2.1 Details of the R. C. Columns:

The columns had circular cross section with 130 mm dia. and 700 mm height. 6 mm diameter steel bars were used for longitudinal reinforcement and 6 mm diameter stirrups were spaced at every 150 mm as lateral reinforcement. The mix was proportionate to target strength of 20 N/mm^2. The concrete consisted of coarse aggregate maximum size of 20mm locally available sand and 53 grade ordinary portland cement.

2.2 Preparation of the specimen:

The column was casted by using mould of PVC pipes. Specimens were filled using concrete and compacted using tamping rod. After 24 hr. mould was removed and place specimen in a water tank for 28 days.

The test column specimens were divided into seven groups.

Table 1 Column Specification

Column Marks	Description
SCC	Short Control Column
SCFWSL	Single Layer Full Wrap Short Column
SCFWDL	Double Layer Full Wrap Short Column
SCHSSL	Single Layer Horizontal Strip Short Column
SCHSDL	Double Layer Horizontal Strip Short Column
SCVSSL	Single Layer Vertical Strip Short Column
SCVSDL	Double Layer Vertical Strip Short Column

Strip of 50mm wide with 50mm gap between each strip. BFRP wrapping was done as per procedure given by manufacturer.

2.3 Test procedure and instrumentation:

All the short column specimen were tested on UTM (600kN) as shown in photo. The load was applied until complete failure took place. Axial deformation of column noted down at equal interval with help of dial gauge. Then ultimate load and corresponding deformation noted down. The load deformation curve was plotted.

Photo 1. Test set-up for short column

III. RESULTS AND DISCUSSIONS

The experimental result is as follows

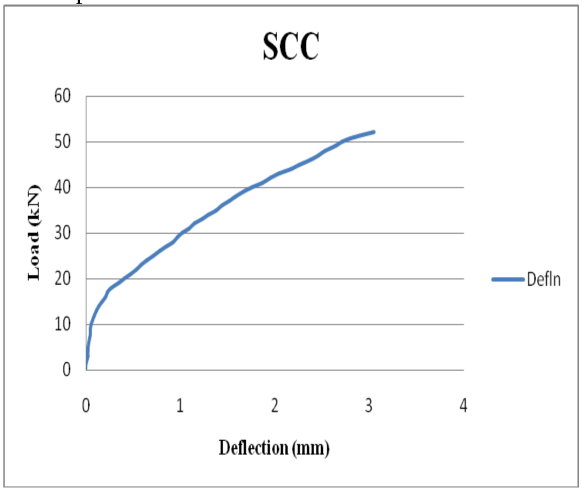

Fig. 1 Load versus deflection curve for short control column

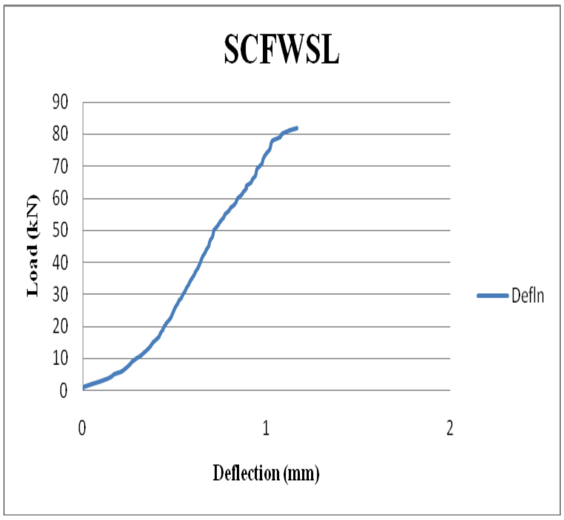

Fig. 2 Load versus deflection curve for single layer full wrap short column

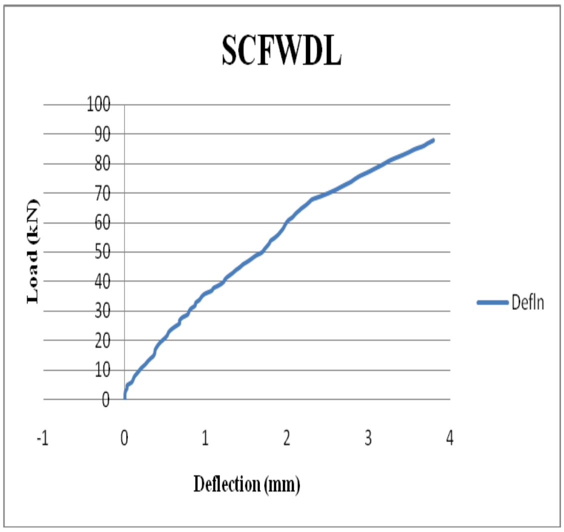

Fig. 3 Load versus deflection curve for double layer full wrap short column

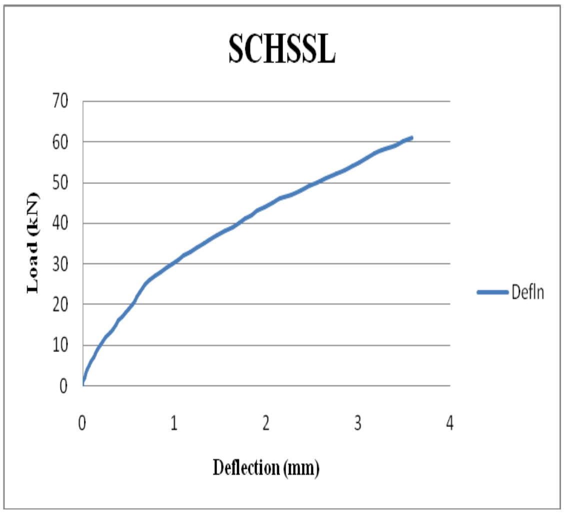

Fig. 4 Load versus deflection curve for single layer horizontal strip wrap short column

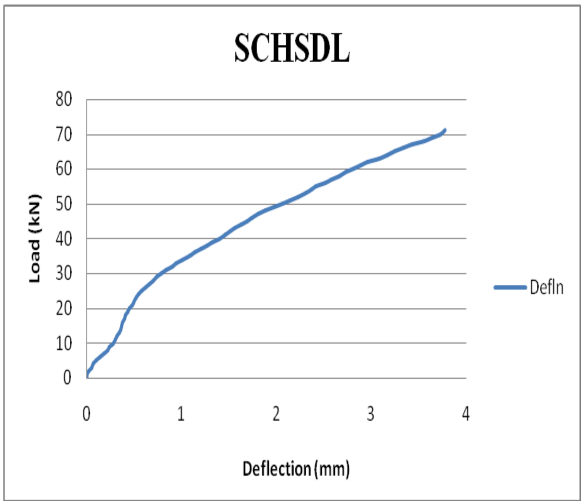

Fig. 5 Load versus deflection curve for double layer horizontal strip wrap short column

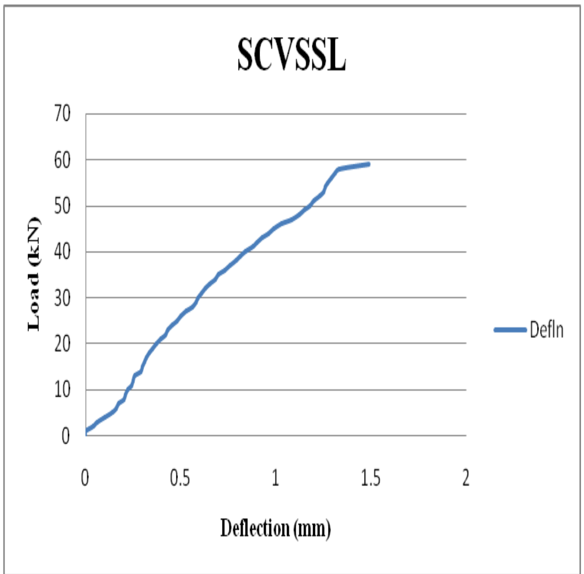

Fig. 6 Load versus deflection curve for single layer vertical strip wrap short column

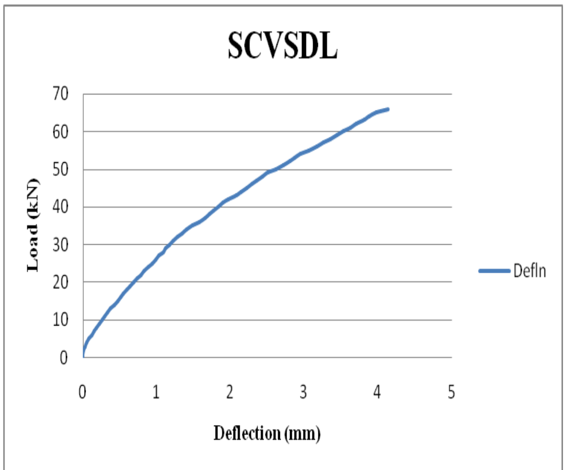

Fig. 7 Load versus deflection curve for double layer vertical strip wrap short column

3.1 Overall Results:

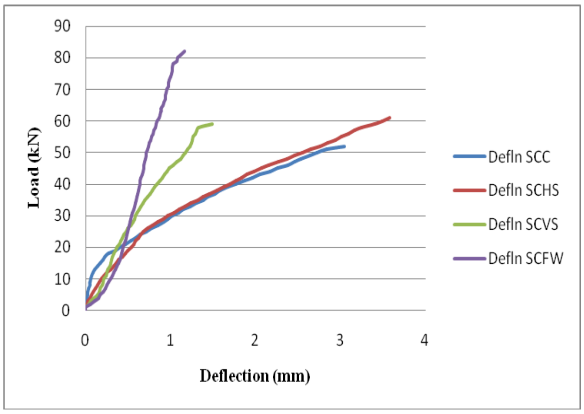

Fig. 8 Load versus deflection curve for single layer SCC, SCHS, SCVS and SCFW for short column

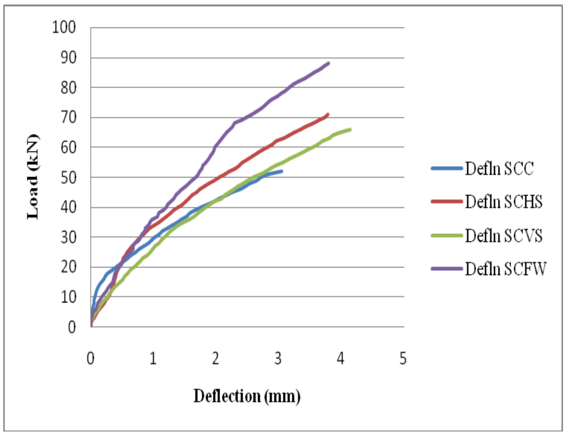

Fig. 9 Load versus deflection curve for double layer SCC, SCHS, SCVS and SCFW for short column

Test results of RCC columns with various cases of BFRP wrapping are given in Table. 2. The results are compared with control column.

Table 2. Overall results for Short columns with various cases of BFRP wrapping

Column Marks	Description	Ultimate Load (kN)	Percentage increase in ultimate load (%)	Ductility Index	Percentage increase in Ductility Index (%)
SCC	Short Control Column	52	--	1.00	--
SCFWSL	Single Layer Full Wrap Short Column	82	57	1.49	49

SCF WDL	Double Layer Full Wrap Short Column	88	69	2.00	100
SCHS SL	Single Layer Horizon tal Strip Short Column	61	17	1.35	35
SCHS DL	Double Layer Horizon tal Strip Short Column	71	36	1.65	65
SCVS SL	Single Layer Vertical Strip Short Column	59	13	1.47	47
SCVS DL	Double Layer Vertical Strip Short Column	66	26	1.63	63

3.2 Discussion:

It has been observed that the ultimate load of columns with BFRP wrapping using various configuration and layers are higher than that of columns without BFRP wrapping. The increase in ultimate load for columns single layer full wrap, double layer full wrap, single layer horizontal strip, double layer horizontal strip, single layer vertical strip, double layer vertical strip wrap are 57%, 69%, 17%, 36%, 13% and 26% respectively.

This increment in ultimate load is obviously due to confinement offered by BFRP to RC column. Full wrap BFRP confined column take more ultimate load. Means confinement offered by BFRP is responsible for increment in ultimate load.

It has been observed that the Ductility Index of columns with BFRP wrapping using various configuration and layers are higher than that of columns without BFRP wrapping. The increase in Ductility Index for columns single layer full wrap, double layer full wrap, single layer horizontal strip, double layer horizontal strip, single layer vertical strip, double layer vertical strip wrap are 49%, 100%, 35%, 65%, 47% and 63% respectively.

IV. CONCLUSIONS

- Load carrying capacity for double layer full BFRP wrap for Short column was increased by 69% as comparative to control column.
- The value of Ductility Index for double layer full BFRP wrap for Short column was increased by 100% as comparative to control column.
- By applying double layer of BFRP full wrap is most effective.
- BFRP confinement in lateral direction is responsible for increment in Ultimate load and Ductility Index.

REFERENCES

[1] Gang W., Zhi-shen W., Zhi-tao L., Hong-changW., Xian-qi H. "*The Outstanding Advantages of Applying Basalt Fiber Polymer (BFRP) in Structure Post-earthquake Strengthening and Rehabilitation*".

[2] Gang W., Yang W., Jianbiao J., Dongsheng G., Xianqi. (2010) "*Comparative Study on Seismic Performance of Rectangular Concrete Columns Strengthened with BFRP and CFRP Composites*".

[3] Garcia D., Alonso P., Jose S. T., Garmendia L., Perlot C. (2010) "*Confinement of medium strength concrete cylinders with basalt Textile Reinforced Mortar*". 13th International Congress on Polymers in Concrete.

[4] Jiang S., Dia T., Fu D., Wu Z., Li N. (2012) "*Experimental Study on Concrete Columns Confined byBFRP-PVC Tubes Under Uniaxial Loading*". Journal of Shenyang Jianzhu University (Natural Science) Vol. 28(1), pp. 23-29

[5] Ludovico M. D., Prota A., Manfredi G. (2010) "*Structural Upgrade Using Basalt Fibersfor Concrete Confinement*". Journal of Composites for Construction Vol. 14(5), pp. 541-552.

[6] Sim J., Park C., Young D. (2005)"*Moon Characteristics of Basalt Fiber as a Strengthening Material for Concrete Structures*". Composites Part: B 36(Elsevier), pp. 504-512.

[7] Thorhallsson E., Konradsson A., Kubens S.(2008) "*Concrete Cylinders Confined with Basalt Fibre Reinforced Polymer*".