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# Basalt Fibre Reinforced Polymer for Strengthening of Self-Compacting Concrete Compression Member

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**Abstract** The innovative findings that exploiting Identity reinforced concrete (RC) compression members can be stiffened with basalt fibre reinforced polymer (BFRP) textiles are shown in this research paper. It illustrates how to use BFRP to stiffen RC members. BFRP fabrics are less cost-effective, have a higher fracture strain, and are more durable than other fibre reinforced polymer (FRP) materials. Self-compacts are a new type of concrete, which can be able to place without the use of vibration. If the reinforcement is congested, it can flow freely under its own gravity, thoroughly filling the formwork and maximising compaction. Materials such as to increase the load capacity of decreased concrete as a reinforcing agent for columnar, basalt fiber-reinforced polymer (BFRP) is employed. The test matrix is strengthened by using BFRP fabrics. The column gets tested with increasing layers of BFRP fabrics. The increasing of two to nine layers of BFRP fabrics was used. It shows a significant strength increase in the maximum load bearing capacity, shear capacity, and ductility of concrete column. Ultimate load bearing capacity has been found to have increased by 92%. This technique of restoring and strengthening existing RC structures in place saves money and helps the environment of countries seeking to repair and maintain old infrastructure.

**Keywords** Basalt Fibre Reinforced Polymer, Cement, Physical and Chemical Properties, Self-Compacting Concrete (SCC), Workability, Hardened Concrete

## 1. Introduction

Many aged structures today contain civil engineering infrastructure that wants to be repaired [1]. The present situation of the construction sector shows a development in construction of massive and complicated structures, which frequently results in severe concrete conditions [2-5]. This may start showing up as poor performance under service stress, including such excessive deflections and cracking, or as lacking ultimate strength [6]. The lack of transverse reinforcement in older constructions makes it difficult to restrict the concrete core or avoid longitudinal reinforcement buckling [7-10]. This can result in abnormally rapid strength deterioration. One of the most significant achievements in the history of concrete development is the invention of concrete that self-compacts [11-13]. SCC is the concrete that flows under its own weight and entirely fills shuttering without segregation, even though the substantial reinforcing is present, and without creating any vibration and preserving homogeneity [14-18]. Fibers are fine pieces of reinforcing material that are mixed with cement, water fine and coarse aggregate in a concrete mix [19]. When the elasticity modulus of the fibre exceeds the concrete or mortar binder, the fibres become more load bearing and increase material's tensile strength. Fibers improve hardness and flexural strength of concrete, as well as decreasing creep strain and shrinkage.

Basalt fibre Reinforced Concrete (BFRC) is a thin, lightweight, and long-lasting concrete reinforced with basalt fibres. Single and double layer of BFRP sheets with various combinations were used to bond the columns. A little amount of study had done on the usage of BFRP fabric to strengthen flexural structural components from the outside (Bastani et al [20] and Jayasuriya et al [21] employed BFRP textiles to repair steel structural elements. The experiments used externally bonded BFRP textiles to repair the weaken steel column [27]. The effects of employing BFRP textiles to rehabilitate deep RC beams were examined by Duic et al [22]. Fiber reinforced composites have been shown to be more efficient than other forms of composites in various investigations. Due to the action of micro and macro cracks the bridging action is necessary, the fiber's principal role is to regulate cracks and raise the fracture toughness of the brittle material.

# 2. Materials

## 2.1. Basalt Fiber

Basalt fibre is just a substance formed from the minerals such as pyroxene, plagioclase, and olivine. Basalt fibre resembles fibreglass; however, it has higher physic mechanical properties and is far less expensive than carbon fibre. It can be used as a fireproof cloth in the aerospace industries, as well as a composite to build items like tripods, etc. Crushed basalt which is sourced from a carefully chosen quarry is a single ingredient used for basalt fibre manufacture. Basalt with a high acidity (over 46 percent silica concentration) and low iron content is preferable for the fibre manufacture. In contrast to other composites like glass fibre, no materials are added to the manufacturing process. Before being melted, basalt is simply cleaned. Basalt fibre is made by melting the crushed and washed rock at roughly 1500 °C (2730 °F). The molten rock is then extruded through small nozzles, resulting in continuous filament fibre reinforced polymer. The Table 1 lists the properties of Basalt fibre.

**Table 1.** Basalt fibre’s properties

| Properties | Value |
|---|---|
| Elastic modulus | 85–87 GPa |
| Tensile strength | 2.8–3.1 GPa |
| Density | 2.67 g/cm³ |
| Elongation at break | 3.15% |

## 2.2. Self-Compacts Concrete (SCC)

Personality concrete is a combination of new pavement that contracts when it is walked on, whose own gravity without the use of any additional materials or the need for external vibration (SCC). It is used in construction where concrete consolidation with vibrators is difficult. Self-compacting concrete provides filling and passing capabilities, as well as resistance to segregation. In its fresh state, SCC has excellent flow ability, enabling self-compaction and material consolidation without segregation problems.

# 3. Experimental Program

The most common method of FRP axial strengthening is to wrap fibre reinforced polymer around reinforced concrete columns. The columns with circular cross section have such a 130 cm wide and a 700 mm and a height Steel reinforcement of diameter 6 mm were utilised for longitudinal reinforcement, and stirrups of 6mm diameter were spaced evenly at 150 mm for lateral direction reinforcement. The columns were made with PVC pipes mould. It is important to completely wrap a reinforced concrete column with FRPs in order to adequately confine and improve the element. The FRPs that surround the column activate only if the member is enlarged laterally and exerts loads on the FRPs, unlike the Prestressed concrete columns' compressive and shear. This means that beam reinforcement is an active system, whereas column reinforcement is a passive system. Seven groups of column specimens were tested. Tab. 2 explains Test Column Specification.

**Table 2.** Test Column Specification

| Expansion | Test Column specimen |
|---|---|
| With a thin layer, a full wrap short column is produced | SCFWSL |
| Short control column | SCC |
| Horizontal Strip Short column with singleton layer | SCHSSL |
| With the double layer, a full wrap short column is created | SCFWDL |
| Vertical Strip short column with singleton layer | SCVSSL |
| Horizontal stripe columns with two layers | SCHSDL |
| Dual layers vertical stripe short columns | SCVSDL |

Each strip is 50mm broad, with a 50mm space between them. As per procedure given by manufacturer BFRP wrapping was done. The column specimen was tested at UTM and the applied load is continued till the failure causes. Short columns are constantly subjected to axial, lateral, and temporal loads. As a result of horizontal loadings, columns experience lateral deflection and breaking. Long columns exhibit lateral displacement and buckling even when just axially strained. Materials failure happens when tensions in steel and concrete exceed their yield stress, and the RCC tower falls. This form of failure is known as combined compressive and bend fracture. The column was hinged at both ends, and the column specimens were subjected to an axial compression load. To keep the specimen upright, a 5kN preload was applied. The load was applied with a 20kN increment. The axial deformation of the column is measured using a dial gauge at regular intervals. The curve of load deformation was drawn. Fig. 1 shows Setup for a test of SCC BFRP columns.

## 4. Results and Discussions

**Figure 1.** Setup for a test of SCC BFRP columns

The experimental results of column specimen are shown in Fig. 2 and Fig. 3.

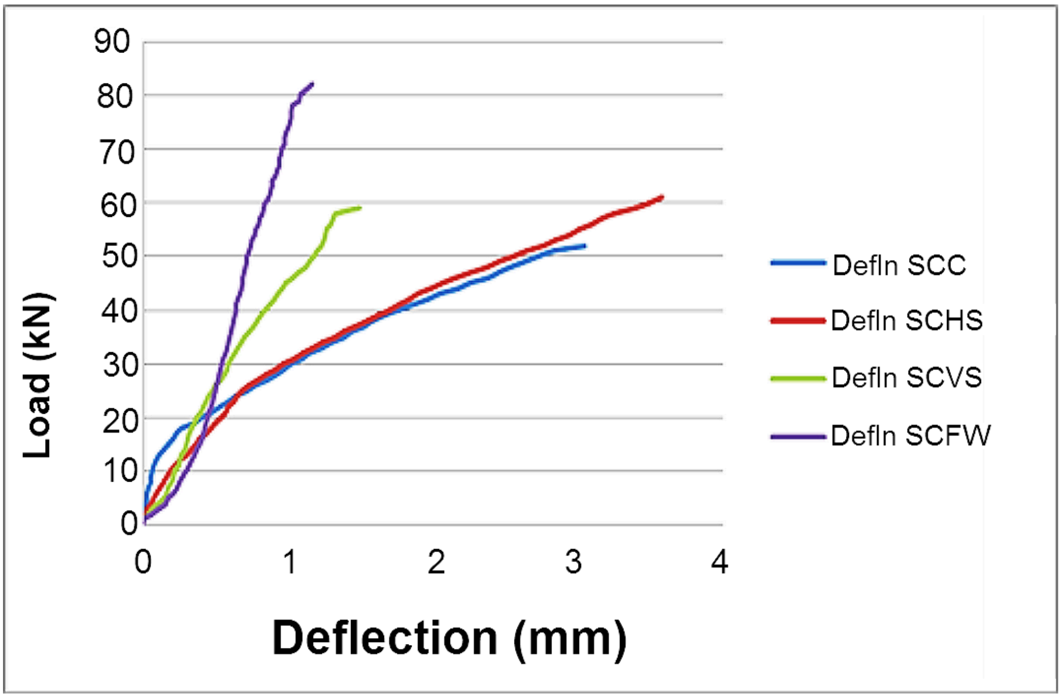


**Figure 2.** Short column load vs. single layer SCHS, SCC, SCVS, and SCFW deflection curve

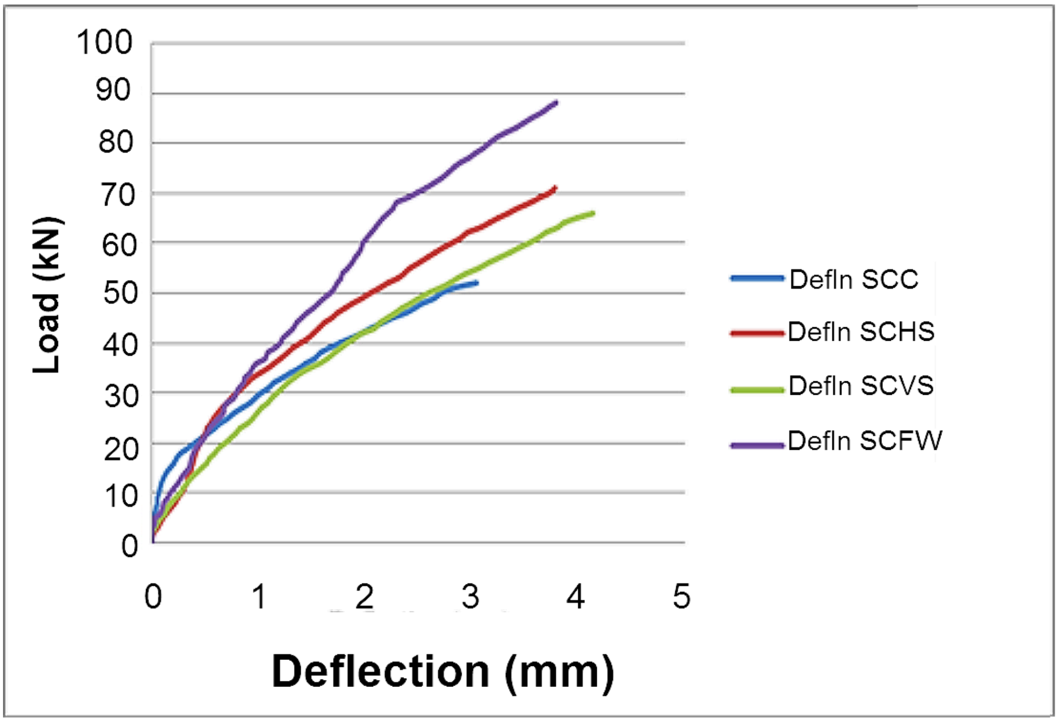


**Figure 3.** Load vs. short column double layered SCC, SCHS, SCVS, and SCFW deflection curve

**Table 3.** Overall findings for short columns wrapped in several types of BFRP

| Column specimen | Expansion | Maximum Load (KN) | Increase in percentage of ultimate load (%) | Ductility Index | Increase in percentage of Ductility Index (%) |
|---|---|---|---|---|---|
| SCFWSL | Singleton Layers Full Wrap Short Columns | 81 | 56 | 1.48 | 48 |
| SCC | Short control columns | 51 | - | 1.00 | - |
| SCFWDL | Double layer Full wrap short Columns | 87 | 68 | 1. 99 | 100 |
| SCHSSL | Single Layer Horizontal Strip Short Columns | 60 | 16 | 1.34 | 34 |
| SCHSDL | Dual Layers Horizontal Strip Short Columns | 70 | 35 | 1.64 | 64 |
| SCVSDL | Double Layer Vertical Strip Short Columns | 65 | 25 | 1.62 | 62 |
| SCVSSL | Singleton layers vertical strip Short Columns | 58 | 12 | 1.46 | 47 |

In Tab. 3, the numerical results of all seven specimens are given. As many numbers the quantity of hidden units of BFRP fabric used to strengthen RC structures increases the yield and ultimate loads increase.

**Table 4**. Statistical discussion for the maximum load and ductility index

| Group | Maximum Load (KN) | Ductility Index |
|---|---|---|
| Mean | 67.4286 | 1.5043 |
| SD | 12.8693 | 0.3032 |
| SEM | 4.8641 | 0.1146 |
| N | 7 | 7 |

Table 4 shows the statistical findings for the maximum load and ductility index. It depicts the columns specimen's mean, standard deviation, confidence interval of the mean, and response rate. The ultimate load of columns without BFRP wrapping has been found to be lower than that of columns wrapped in BFRP using various configurations and layers. The percentage increase in ultimate load is 56%, 68%, 16%, 35%, 12%, and 25%, respectively, for column test singleton layer full wrap, dual layer full wrap, layered horizontally strip, dual layered horizontally strip, single - layered vertically strip, dual layer vertically strips packaging. The ultimate load carrying capability is improved because to the confinement provided by BFRP to the RC column. As a result, the BFRP wrapping reinforces the self-compacting RC column. Fig. 4 displays the repairing process using BFRP sheet.

(a) chamfering column’s corner

(b) mixing the epoxy resin

(c) Installing the BFRP sheets

(d) Finish BFRP wrapping

**Figure 4.** Repairing process using BFRP sheet

## 5. Conclusions

The goal of this experiment was to see if employing externally bonded BFRP fabrics to strengthen RC columns was feasible. Flexural strength, Elastic modulus, Compression strength, split tensile strength, Compressive and fracture toughness are all improved when fibres are added to self-compacting concrete. Cement can be in two states: fresh and solidified, basalt FRSCC has superior characteristics. Because basalt fibre performance is less expensive than other regularly used fibres such as carbon, polypropylene, and others, it can be used to improve SCC properties. The increase in maximum The BFRP confining in the lateral direction is responsible for the load and the Flexure Index.

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