Retraction

Retraction: shear contribution of basalt fiber reinforced polymers bars (BFRP) reinforced light weight concrete (FRLWC) (IOP Conf. Ser.: Mater. Sci. Eng. 740 012062)

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This article has been retracted by IOP Publishing following an allegation that this article, including all images, have been taken from another source.

IOP Publishing agrees the text and figures appear identical to [1]. IOP Publishing has made multiple attempts to contact the author for an explanation. As IOP Publishing has received no response or evidence to refute this allegation, IOP Publishing is retracting this article.

If the authors wish to contest this retraction they are advised to contact researchintegrity@ioppublishing.org.

1. Abbadi, Abdulrahman 2018 Shear contribution of fiber-reinforced lightweight concrete (FRLWC) reinforced with basalt fiber reinforced Polymer (BFRP) bars MSc project, Universite Laval, Canada https://corpus.ulaval.ca/jspui/bitstream/20.500.11794/31848/1/34775.pdf.

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shear contribution of basalt fiber reinforced polymers bars (BFRP) reinforced light weight concrete (FKLWC)

Sara Benzemouli, Prof. Wang Zhenying
College of Aerospace and Civil Engineering, Harbin Engineering University, Harbin, Heilongjiang 150001, China.
Email Authors sarabnz1702@gmail.com

Abstract
This study evaluates both experimentally and analytically the shear behavior of basalt fiber-reinforced concrete (BFRC) beams reinforced longitudinally with basalt fiber reinforced polymer (BFRP) bars. A new type of basalt macro-fibers was added to the concrete mix to produce the BFRC mix. Fourteen beams were tested under four-point loading configuration until failure occurred. The beams were grouped in two groups A and B depending on their span-to-depth ratios. The test results showed that the addition of basalt macro-fibers to the concrete mix enhanced its compressive strength. A new modified model incorporating the type of the longitudinal reinforcement, the type of FRC used, and the density of concrete was proposed. The model of Ashour et al. – A (1992) was calibrated. The proposed model predicted well the shear capacities of the BFRC-BFRP beams. The shear capacities of the lightweight concrete beams tested by Abbadi (2018) were predicted with an average ratio the model predicted well the shear capacities of the SFRC beams reinforced with BFRP bars tested by Awadallah et al. (2014), it is recommendation that the proposed model be assessed on larger set of data than that presented in study the experimental program is presented.

1. Introduction:
Reinforced concrete (RC) structures are usually suffer from deterioration due to the corrosion of their internal steel reinforcement. Known for their superior corrosion resistance and high tensile strength, Fiber-reinforced polymers (FRP) bars became widely accepted to replace steel bars in RC structures. FRPs are produced from several fiber. Recently, basalt fibers, produce new FRP bars known as the basalt fiber-reinforced polymer (BFRP) bars. Basalt fibers are characterized by their high strength, non-corrosive nature, large strain at failure, and excellent heat and chemical resistances besides being environmentally friendly (Hassan et al. 2016; Wei et al. 2010). New discrete macrofibres, known as basalt MiniBarsTM, joined the fibers’ family to produce the basalt fiber-reinforced concrete (BFRC) Limited studies have been conducted to evaluate the shear performance of FRP reinforced structures cast with fiber-reinforced concrete (FRC). Therefore, the combination of both FRP, in the form of longitudinal bars, and the FRC mixes became an interesting point to investigate. This hybrid system might be the solution of the deterioration problem due to corrosion in conventionally steel-reinforced structures. In this study, the shear performance of the hybrid BFRC-BFRP systems is investigated both experimentally and analytically. Several parameters are taken into consideration such as the reinforcement ratios of the longitudinal BFRP bars, the dosage of the basalt fibers added to the mix, and the span-to-depth ratio of the member.
2. Experimental Program

2.1 Test matrix

The experimental program consisted of fourteen rectangular beams reinforced longitudinally with basalt fiber-reinforced polymer (BFRP) bars with two reinforcement ratios (ρ = 0.95 and 1.37%) and cast with three different types of fibers (basalt, polypropylene, and steel fibers) at two volume fractions (0.5 and 1%). The test matrix is shown in Table 2.1

Table 2.1 Test matrix

| Beam   | Type of fibers | No. of BFRP bars | ρ (%) | ρ/ρb | Volume fraction of fibers (%) |
|--------|----------------|------------------|-------|------|-----------------------------|
|        |                |                  |       |      |                             |
| Group A: Control beams |
| CL-10  | -              | 4 – 10 M         | 0.95  | 2.84 | -                           |
| CL-12  | -              | 4 – 12 M         | 1.37  | 4.10 | -                           |
| CN-10  | -              | 4 – 10 M         | 1.05  | 3.69 | -                           |
| CN-12  | -              | 4 – 12 M         | 1.52  | 5.35 | -                           |
| Group B: Beams with volume fraction of fibers = 0.5% |
| B-0.5-10 | Basalt       | 4 – 10 M         | 0.95  | 2.84 | 0.5                         |
| B-0.5-12 | Basalt       | 4 – 12 M         | 1.37  | 4.10 | 0.5                         |
| S-0.5-12 | Steel        | 4 – 12 M         | 1.37  | 4.10 | 0.5                         |
| P-0.5-12 | Polypropylene| 4 – 12 M         | 1.37  | 4.10 | 0.5                         |
| Group C: Beams with volume fraction of fibers = 1% |
| B-1.0-10 | Basalt       | 4 – 10 M         | 0.95  | 2.84 | 1.0                         |
| B-1.0-12 | Basalt       | 4 – 12 M         | 1.37  | 4.10 | 1.0                         |
| S-1.0-12 | Steel        | 4 – 12 M         | 1.37  | 4.10 | 1.0                         |
| P-1.0-12 | Polypropylene| 4 – 12 M         | 1.37  | 4.10 | 1.0                         |

* Beams reported from (El Refai et al. 2015)

The beams were divided into three groups: [A], [B], and [C] based on the fiber volume fraction used as shown in Table 2.1

2.2 Test specimen

Figure 2.1 shows the details of the beam specimens. The beams had a cross-section of 150×250 mm with a total span of 2400 mm and a shear span of 750 mm. The span-to-depth ratio, a/d, of all beams was 3.41. The BFRP bars were located at the tension face with a clear cover of 15 mm. Specimens of group [A] had no stirrups along their length whereas those of group [B] and [C] had double-leg 10M stirrups (diameter = 11.2 mm) in one of their shear spans. The stirrups in specimens of groups [B] and [C] were spaced at 100 mm, which corresponded to 0.46 d, where d is the depth of the tensile steel measured from the compression face. Two steel bars of 15M (diameter = 15.2 mm) acted as stirrups’ headers as shown in Figure 2.1. The shear spans with stirrups were cast with plain LWC while the rest of the beam was cast using FRLWC.

Figure 2.1: Specimens details (all dimensions in mm)
2.3 Materials
The constituents of the concrete mix are shown in Table 2.2. The mechanical properties of the BFRP bars used in this study are given in Table 2.3 and the sieve analysis and the grading curve of the aggregates are shown in Table 2.4. The physical properties and sieve analysis of natural sand are given in Table 2.5 and Table 2.6, respectively. Fly Ash Table 2.7 describes the properties. In order to ensure the workability of concrete

### Table 2.2: Quantity of mix design

| Type       | Quantity (kg/m³) |
|------------|-----------------|
| Cement     | 410             |
| Fly ash    | 50              |
| Water      | 190             |
| Coarse aggregates | 522             |
| Fine aggregates | 680             |

### Table 2.3: Mechanical properties of BFRP bars

| Type | Diameter | Cross sectional area (mm²) | Ultimate tensile strength (MPa)* | Modulus of Elasticity (GPa)* | Elongation at Ultimate* |
|------|----------|----------------------------|---------------------------------|-----------------------------|-------------------------|
| BFRP | 10       | 78.5                       | 1168                            | 50                          | 0.023                   |
| BFRP | 12       | 113.1                      | 1168                            | 50                          | 0.023                   |

* As reported by El Refai et al. (2015)

### Table 2.4: Sieve size and percent passing of Stalite aggregates

| Sieve (mm) | 20 | 14 | 10 | 5  | 2.5 | 1.25 | 0.63 | 0.315 | 0.16 | 0.08 |
|------------|----|----|----|----|-----|------|------|-------|------|------|
| Percentage passing | 100 | 98 | 64 | 3  | 2   | 2    | 1    | 1     | 1    | 1.2  |

Figure 2.2: Grading curve for Stalite crushed stone (data from suppliers)

### Table 2.5: The physical properties of natural sand used

| Test                                           | Measured |
|------------------------------------------------|----------|
| Gross density (LC 21-065)                      | 2,687     |
| Gross density S.S.S (LC 21-065)                | 2,700     |
| Apparent density (LC 21-065)                   | 2,724     |
| Absorption (LC 21-065) (%)                     | 0.50      |

### Table 2.6: Sieve size and percent passing of sand used

| Sieve (mm) | 10 | 5 | 2.5 | 1.25 | 0.63 | 0.315 | 0.16 | 0.08 |
|------------|----|---|-----|------|------|-------|------|------|
| Percentage | 100| 99| 94  | 82   | 52   | 20    | 6    | 2.6  |
Table 2.7: Properties of fly ash

| Property                      | Quantity |
|-------------------------------|----------|
| Silicon Dioxide (%)           | 43.8     |
| Aluminum Oxide (%)            | 22.9     |
| Iron Oxide (%)                | 18.7     |
| Total Calcium Oxide (%)       | 6.8      |
| Magnesium Oxide (%)           | 1.24     |
| Sulfur Trioxide (%)           | 0.38     |
| Alkalis (%)                   | 1.5      |
| Fire Loss (%)                 | 3.05     |

2.4 Fibers

Three types of fibers were used in this study namely basalt, steel, and polypropylene fibers. The properties of the fibers are given in Table 2.8.

Table 2.8: Properties of fibers

| Type               | Specific Gravity (g/cm³) | Length (mm) | Diameter (mm) | Aspect Ratio |
|--------------------|--------------------------|-------------|---------------|-------------|
| Basalt Fiber       | 1.9                      | 43          | 0.66          | 65.15       |
| Steel Fiber        | 7.85                     | 60          | 0.92          | 65          |
| Polypropylene Fiber| 0.92                     | 51          | 0.68          | 74          |

2.4.1 BFRP fibers

Newly-developed basalt macrofibers made of continuous basalt fiber-reinforced polymer bars were used in this study. The basalt fibers were characterized by their helix shape and rough surface to increase bond to concrete as shown in Figure 2.3.

Figure 2.3: Basalt fibers

2.4.2 Hooked-end steel fiber

The hooked-end steel fibers used in this study consisted of low carbon cold-drawn steel wire. Figure 2.4 shows the shape of steel fibers used.

Figure 2.4 shows the shape of steel fibers used
2.4.3 Polypropylene fibers
The polypropylene macro synthetic fibers in Figure 2.5 were used in this study.

Figure 2.5: Polypropylene fibers

2.5 Specimens preparation
Figure shows the different stages of preparing and fabricating of the beam specimens. First, the cages were fabricated as per the test matrix shown in Table 2.1. Finally, mixing started for one more minute before casting took place as shown in Figure 2.6. After casting, the concrete surface was finished using flat steel trowels. After finishing, beams were overlaid by wet burlap to prevent excessive evaporation of water. The cast beams were kept in their wooden forms for 48 hours. After dismantling the forms, the beams were cured for 28 days in the lab environment. All beams were painted after curing to be ready for testing as shown in Figure 2.8 to facilitate the visual observation of cracks during testing.

Figure 2.6: Fabrication of the beam specimens: (a) cage fabrication, (b) placing cages in wooden forms, (c) adding fibers to concrete, (d) concrete casting, (e) concrete finishing, and (f) curing of the test specimens

Figure 2.7: Painted beam specimen
2.6 Instrumentation of the test specimens

Figure 2.8: Strain gauge installation on BFRP bars: (a) rubbing the bars’ surface and (b) adhering strain gauges

Figure 2.9: Schematic drawing for inclined LVDTs (all dimensions are in mm)

2.7 Test setup

All specimens were tested in shear under four-point load configuration with a clear span of 2100mm, shown in Figure 2.9. Span where shear failure was expected as illustrated in Figure 2.9. The entire test was carried out under displacement control at a rate of 1 mm/min. Data from strain gauges and LVDTs were recorded using a 30-channel data acquisition system at a rate of 5 readings/second.

3. Conclusion

The conclusions and observations of the work conducted are summarized as follows.

Adding fibers with a volume fraction of 0.5% enhanced the compressive and tensile strengths of lightweight concrete. The geometry of fibers played an important role in increasing the number of flexural cracks. Beams cast with fiber-reinforced concrete showed less inclined shear cracks than those encountered in the control beams (without fibers). The discrepancy in the degree of inclination of the shear cracks could be attributed to the random distribution and orientation of fibers in concrete during mixing. The type of fibers significantly affected the gain in the shear capacities of the beams. The addition of steel fibers caused the highest stiffness at volume fraction of 1% at ultimate while the addition of 0.5 and 1% of polypropylene fibers showed the lowest stiffness at ultimate. Hooked-ends in steel fibers were effective in bridging.

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