ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 6, Issue 1, January 2017

Effect vibr-vacuumizing on bonding strength of basalt fibers to cementitious matrix

[1]Prof. Dr. Alexander Wandolovsky ,
[2]Asst.prof. Basheer N. Younis ,
[3]Student Of Phd. AL-hawari Yousef Riyed.
Kharkiv National University of Civil engineering and Architecture, Ukraine.

Abstract - This article presents effect vibr-vacuumizing (vibration +vacuum) on bonding strength of commercial basalt fibers to cement matrix. To investigate adhesion of basalt fibers to cement matrix a single fiber pull-out test setup is designed and fabricated. The specimens were prepared at the water-cement ratio of 0.4 and they were tested at 28 days of curing. Fiber's surface after pull-out test was also studied by microscopic analysis. Some interesting results were obtained from the pull -out test of different method forming.

Keywords: adhesion, pull-out test, interfacial interactions, polymeric fibers.

I. INTRODUCTION

The need for non-corrosive reinforcement of the construction industry has developed in the last decades. There have been several researches and tests of integrating basalt fibers into concrete structures, mainly concrete beams. The tests have shown improvements in strength and durability. In this review paper the focus is on the basalt fiber bars, the possible usage of such bars instead of the common steel reinforcement rebar. One of the benefits of using fiber reinforced polymer as a strengthening material in concrete is that it is non corrosive. In places where concrete structures are close to the sea, like houses or bridges, the maintenance of the concrete is needed on regular basis. In such conditions the common rebar is in constant danger of corrosion and therefore could become weak and hazardous in a short period of time. Basalt rock can be used to make not only basalt bars but also basalt fabrics, chopped basalt fiber strands, continuous basalt filament wires and basalt mesh. Some of the potential applications of these basalt composites are: plastic polymer reinforcement, soil strengthening, bridges and highways, industrial floors, heat and sound insulation for residential and industrial buildings, bullet proof vests and retrofitting and rehabilitation of structures (Ramakrishnan, V. & Panchalan, R., 2005).

The performance of basalt fiber depends on many factors, such as fiber material properties (fiber strength, stiffness, and Poisson's ratio), fiber geometry (fiber surface and cross section), fiber volume content, matrix properties (matrix strength, stiffness, Poisson's ratio), and interface properties (adhesion, frictional and mechanical bond) [2]. Bonding depends on the structure of the fiber-matrix interface. Fiber bonding to the cementitious matrix is an important and effective parameter on fiber reinforced cement composites. Also, the performance of fiber reinforced composites is strongly related to the debonding/ pull-out behavior of the fibers. For this purpose, the relationship between the pull-out load and the displacement of a fiber, when it is pulled out from the cement matrix, serves as an important parameter in the design of cement composite materials.

The aim of the present work is to characterize the effect vibr-vacuumizing on bonding mechanisms of polymeric fibers to cement matrices. To determine the bond strengths of polymeric fibers to cement matrix, pull-out test was employed. Besides the testing setup, it is also important to understand the way that pull -out specimens are prepared.. Fiber pull-out specimens were prepared with single filaments of basalt fibers. The surface of the used fibers after pull-out test was evaluated by optical microscope. The effect of vibr-vacuumizing on the pull-out results of fiber/cement matrix was also studied.

As early as in the 30s of the previous century vacuum compaction of concrete mixes has been used successfully in the construction of buildings and structures of mass concrete [1]. In practice, back at that time the advantages of vacuum compaction of concrete mixes in monolithic structures had already been convincingly proved. The main ones are the following: increase in labor productivity; reduction of the period of construction of buildings or individual structures; significant reduction in metal consumption (material consumption) by formwork; energy savings; reduction of specific consumption of cement; significant improvement in concrete quality. The technology vibr-vacuumizing, which provides the appearance of the positive properties of concrete as the rapid

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 6, Issue 1, January 2017
growth of strength in the initial period of hardening, reduction of time for the heat treatment of products, reduction of metal processing equipment by reducing the fleet forms and reduce drop / C, especially in the area of contact between the fiber and the component parts of the concrete. [2]. Vibr-vacuumizing technology significantly increases the degree of compaction of the concrete mix that enhances the adhesion of basalt fibers to concrete.

II. MATERIALS AND EXPERIMENTS

The studies were conducted in the laboratory of the department of building materials and products of the Kharkov National University of Construction and Architecture. The composition of concrete was calculated by the method of absolute volumes with its subsequent correction. It was investigated adhesion of basalt fibers with concrete which is casting by vibr-vacuumizing. Vibr-vacuumizing reduces the permeability of concrete, which is characterized by a decrease in the water absorption of the concrete [2]. By reducing the number of pores in the concrete when the water is released, the concrete strength will increase and therefore improve of the bond between fiber and concrete. The degree of compaction of the concrete mix at vibr-vacuumizing depends on the frequency and amplitude of the vibrator and the duration of vibration and vacuum [1]. When compacting concrete mixes oscillation amplitude was within the range of 0.3-0.7 mm at a frequency of about 3000 vibrations per minute. Owing to the depression created in the suction shield of concrete through the filter sucked air and water which are removed with a vacuum pump. Cement particles retained by special filter materials. There were two types specimens were prepared two specimens were casting by vibration and two specimens were casting by vibr-vacuumizing .Concrete Specimens details 4*4*16 cm", C: G = 1: 3 (as a filler applied Granite screening dust), humidity of the mixture (W / C) was used in the range of 0.5 ... 0.7. The apparatus of test samples is shown in figure 1

Fig 1 - Laboratory equipment for sample preparation by method vibr-vacuumizing.

Cement used in this study was ordinary Portland cement M400. The type of used fibers and their properties are given in Table 1. Figures 1-3 show the optical microscopic images of the longitudinal and cross-sectional surface of the fibers.

Table 1 - Properties of fibers.

Fiber Type ▸	Specific Gravity ▸	Tensile Strength ksi (MPa) ▸	Elastic Modulus, ksi (GPa) ▸	Strain at Break, in/in (mm/mm) ▸
Basalt	2.7	400-695 (2800-4800)	12,500-13,000 (86-90)	0.0315

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 6, Issue 1, January 2017

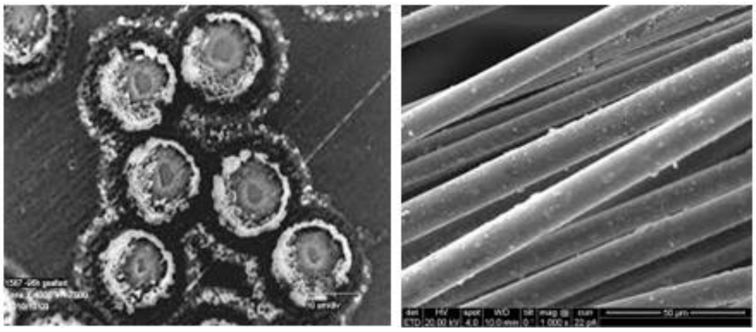

Fig 2. - Microscopic images of Basalt fibers: Cross-sectional, Longitudinal view of fiber surface

A. Specimen Preparation

Specimens for pull -out test were prepared by the equipment that shown in Figure 4. The specimens were prepared with a matrix made by 0.5 of water to cement ratio. Pull-out tests were carried out on specimens after 28 days of curing. The embedded length for all series was 10mm long. Figure 3 shows the pull-out specimen before test.

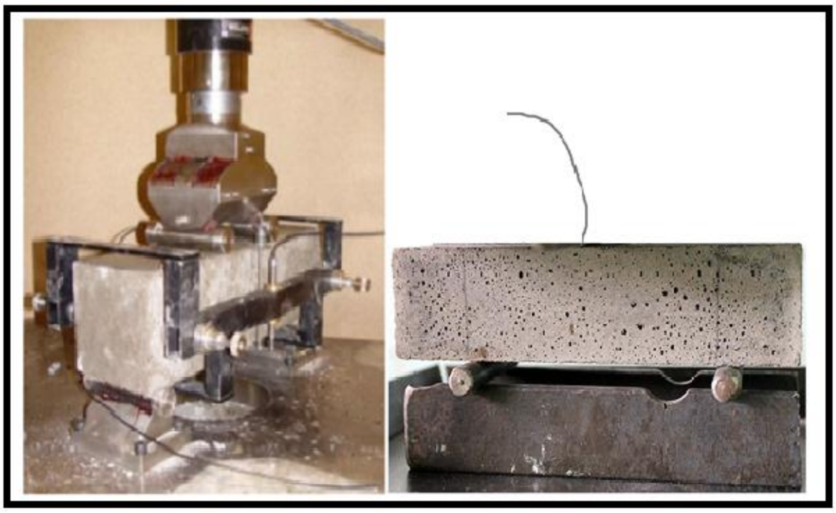

Fig 3 - The equipment of pull-out Figure 5 pull-out specimen after cutting sample preparation.

B. Pull-Out Test

To investigate the bonding characteristics, single fiber pull-out test was performed. The pull-out tests were carried out by a testing machine shown in Figure 3. The schematic representation of the test set-up can be seen in Figure 4. The free length of single fiber was 10mm.

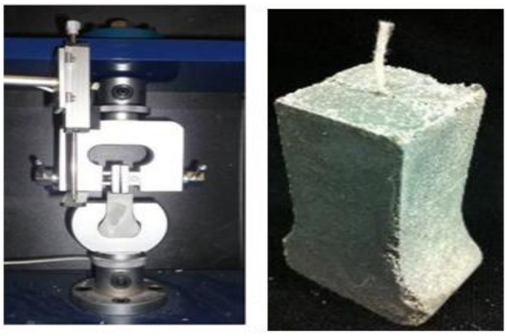

Fig 4 - Fiber single bullet from a test system setup

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 6, Issue 1, January 2017

III. RESULTS AND DISCUSSION

A. Pull-Out Test Results

The pull -out behaviors of all series are illustrated by the load-extension curves in Figures. 8-10. in all specimens, it was observed that pull-out force is increased by increasing in fiber displacement to a maximum force. Thereafter, it decreases to zero level because of fiber slippage, pulling out or failure. The analysis of specimens 1 fibers load-displacement curves shows that The concrete specimens were casting by vibration owned Pull -out curve at 28 days indicates that mechanical bonding between PP fiber and cement matrix is maximum. After complete deboning of specimens, fiber begins to slip-out, so pull-out force is decreased. In case of The concrete specimens were casting by vibr-vacuumizing fibers, At 28 days of curing time, fiber failure happens during pull-out process because of higher bonding strength to cement matrix, as shown in Figure 10. In all series, increasing curing ages 28 days, improves bonding strength. In general, improvement in cement hydration results in decreasing of the porosity of hardened paste. The cement maturity has direct effects on the fiber/matrix bond properties and finally stronger fiber/cement interface. As reported by Chan [9].

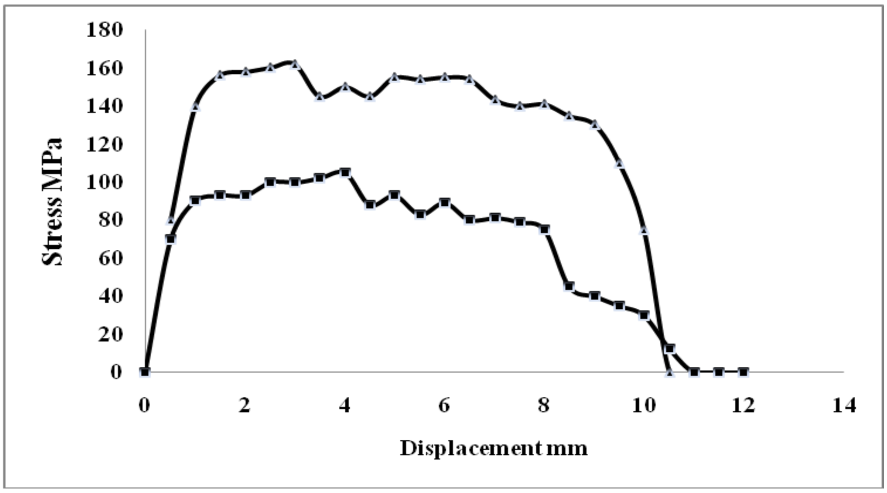

Fig 5- Pull-out behavior of fiber at different method forming concrete

Figure 5 shows pull-out curves of different fibers at 28 days of curing. It can be seen that fibers in The concrete specimens were casting by vibr-vacuumizing showed higher pull-out strength in comparison to fibers in The concrete specimens were casting by vibration . Figure 5. It is evident that some cement particles are present on fiber surface. Due to the none-round shape of these fibers, during pull-out process, mechanical bonding can be performed because of interlocking effect to cement matrix. The concrete specimens were casting by vibr-vacuumizing have much contacting surface to cement matrix which leads to increasing frictional resistance during pull- out. In the case of other fibers the concrete specimens were casting by vibration have less friction? However, in these specimens, due to bleeding of cement paste, water is collected on the surface of the fiber. Therefore, calcium hydroxide coarse crystals are produced at the fiber/cement interface. These crystals are enough big and coarse to deform fibers surface. So, during pull-out, fibers interlock to these crystals.

B. Microscopic Analysis

The analysis Figure 6 shows the chemical adhesion between cement and fibers in the concrete specimens were casting by vibr-vacuumizing. Due to the affinity between fiber and cement paste which are both hydrophilic, chemical adhesion can be produced. These observations and the image of pulled-out fibers indicate that fibers have both chemical and mechanical bonding to cement paste.

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 6, Issue 1, January 2017

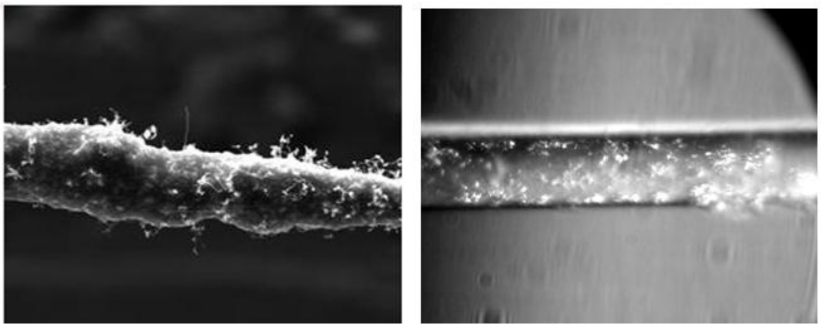

Fig 6 - fibers after pull-out process

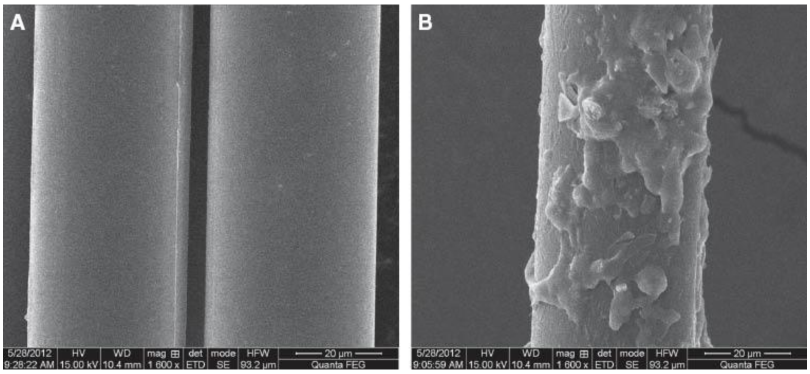

Fig 7 - crystallization of cement on fibers:

a- fibers in the concrete specimens were casting by vibration;

b- Fibers in the concrete specimens were casting by vibr-vacuumizing.

IV. CONCLUSION

Regarding to the pull-out behavior of fibers, it is resulted that fibers in the concrete specimens were casting by vibr-vacuumizing showed higher pull-out strength in comparison to fibers in the concrete specimens were casting by vibration. Microscopic analysis demonstrates that fibers in the concrete specimens were casting by vibration has no chemical bonding to cement matrix while the presence of cement hydrates particles on the surface. Based on the observation, it is found that mechanical bonding is more effective than chemical bonding in fiber/cement matrixes. The fibers in The concrete specimens were casting by vibr-vacuumizing have both mechanical and chemical bonding to cement matrix, due to using of vibr-vacuumizing technology for casting specimens. It should be noted that mechanical bonding in fiber/cement interface has an important role to enhance the mechanical performance of cement composite materials.

REFERENCES

[1] Evacuation of concrete construction experience in the United States. - M.: text book, 1947. - 15 p.

[2] Storozhuk NA Theoretical studies on the evacuation of concrete mixes / N.

[3] A. Storozhuk // Bulletin of Prydniprovs’ka State Academy of Civil Engineering and Architecture. - D.:Pdaba, 2012. - № 2 - 3. - P. 32 – 38.

[4] Pye, A. M., "A Review of Asbestos Substitute Materials in Industrial Applications", Journal of Hazardous Materials, **1979**, Vol. 3, 125-147.

[5] Kim, D. j., Naaman, A., El-Tawil E., S., "Comparative Flexural Behavior of Four Fiber Reinforced Cementitious Composites", Cement & Concrete Composites, Article in press, **2008**.

[6] Peled, A., Zaguri, E., Marom, G., "Bonding Characteristics of Multifilament Polymer Yarns and Cement Matrices", Composites: Part A, **2008**, Vol. 39, 930-939.

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 6, Issue 1, January 2017
[7] Bentur, A., "Role of Interfaces in Controlling Durability of Fiber-Reinforced Cements", Journal of Materials in Civil Engineering, **2000**, Vol.12, No. 1, 21725.

[8] Leung, C. K. Y., Ybanez, N., "Pull-out of Inclined Flexible Fiber in Cementitious Composite", Journal of Engineering Mechanics, **1997**, Vol. 123, No. 3.

[9] Najm, H., Naaman, A.F., Chu, T. J., Robertson, R. E., "Effects of Poly vinyl alcohol on Fiber Cement Interfaces. Part I: Bond Stress-Slip Response", Advance Cement Base Materials, **1994,** Vol.1, 115-121.

[10] Chan, Y. W., Li, V. C., "Age Effect on the Characteristics of Fiber/Cement Interfacial Properties", Journal of Materials Science, **1997**, Vol. 32, 5287-5292. .

AUTHOR BIOGRAPHY

[1]**Prof. Dr. Alexander Wandolovsky**, Professor, Doctor of science, Head of the branch of building materials and products , Kharkiv National University of Civil engineering and Architecture, Ukraine.

[2]**Asst.prof.Basheer N. Younis,** assistant professor, Department of Civil Engineering, Kharkiv National University of Civil engineering and Architecture, Ukraine.

[3] **AL-hawari Yousef Riyed.,** PhD Student, Department of Civil Engineering, Kharkiv National University of Civil engineering and Architecture, Ukraine.