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USE OF MODIFIED POLYMERIC COMPOSITION COATING TO IMPROVE BONDING BETWEEN GFRP, BFRP BARS AND CONCRETE

ВИКОРИСТАННЯ МОДИФІКОВАНОЇ ПОЛІМЕРНОЇ КОМПОЗИЦІЇ ДЛЯ ПОКРИТТЯ КОМПОЗИТНОЇ АРМАТУРИ З МЕТОЮ ПОЛІПШЕННЯ ЗЧЕПЛЕННЯ МІЖ АРМАТУРОЮ І БЕТОНОМ

ИСПОЛЬЗОВАНИЕ МОДИФИЦИРОВАННОЙ ПОЛИМЕРНОЙ КОМПОЗИЦИИ ДЛЯ ПОКРЫТИЯ КОМОПЗИТНОЙ АРМАТУРЫ С ЦЕЛЬЮ УЛУЧШЕНИЯ СЦЕПЛЕНЯ МЕЖДУ АРМАТУРОЙ И БЕТОНОМ

Annotation. Glass fiber-reinforced polymer bars are currently used in reinforced concrete. Different types of surface treatment were applied to the smooth rods in order to enhance bonding with concrete. Experimental results show that using bars coated with polymeric composite notably improve the bond strength. bars coated with polymeric composite lead to a stronger chemical adhesion with concrete. However, the effect of friction and interlocking forces produced by polymeric composite prevails over the chemical adhesion in the pull-out test.
Keywords: polymeric composition, bond strength, surface treatment, pull-out test, FRP reinforcement bar,BFRP reinforcement bar.
Анотація. У даний час в армованому бетоні використовується композитна арматура. Для гладких стрижнів застосовуються різні типи обробки поверхні, щоб поліпшити адгезію з бетоном. Експериментальні результати показують, що використання стрижнів, покритих полімерним композитом, помітно покращує міцність зчеплення, приводячи до більш сильної хімічної адгезії з бетоном.
Ключові слова: полімерна композиція,зчеплення, обробка поверхні, випробування на висмикування, базальтопластикова арматура, склопластикова арматура.
Аннотация. В настоящее время в армированном бетоне используется композитная арматура. Для гладких стержней применяются различные типы обработки поверхности, чтобы улучшить адгезию с бетоном. Экспериментальные результаты показывают, что использование стержней, покрытых полимерным композитом, заметно улучшает прочность сцепления, приводя к более сильной химической адгезии с бетоном.
Ключевые слова: полимерная композиция, сцпление, обработка поверхности, испытание на выдергивание, базальтопластиковая арматура, стеклопластиковая арматура.

Introduction

The use of fiber-reinforced polymers (FRP) as reinforcement in concrete structures is considered to be in the possible situations where corrosion is present. FRP bars have many distinct advantages over steel reinforcement; including a high strength-to-weight ratio, high durability, easier handling due to their light weight, high tensile strength, excellent fatigue characteristics and electromagnetic neutrality[1].

Typical applications of FRP composites include damage-strengthening columns, including [2,3] strengthening seismic retrofitting, [4,5] repair of corrosion-damaged columns, [6,7] as well as improvements in strength and stiffness of deteriorated structures. CFRP composites[8-10] Also, FRP composites can be used as internal reinforcements for concrete bridge decks.[11,12]. Since several types of FRP, bars are commercially available, with varying compositions and surface treatments, the interface bond of FRP-bar concrete is complex and quite different from that of steel reinforcement. It is well known that the behavior of the interface between the FRP and the concrete is the key factor controlling debonding failures in FRP-strengthened reinforced concrete (RC) structures. The bondage between concrete and reinforcing bars is the one of the key aspects with regard to both reinforced and pre-stressed concrete structures[13]

Main part

Additional techniques are required to improve the bond between the rebar and the surrounding concrete. Several techniques can be used, including surface deformations, sand coating, over-molding and new surface on the bar or a combination of the techniques. Many researchers have brought up various formulas to estimate the bond strength of deformed composite reinforcement and studied experimentally and numerically the use of composite reinforced bars as reinforcement in the concrete structures. [14].The mechanics of stress transfer by a bond between FRP bars and concrete was investigated by many authors.. However, with a more detailed study of the properties of basalt plastic reinforcement, it turns out that there is no information in the literature on the magnitude of its bond strength to the concrete and its dependence on the treatment of the external surface of BFRP and GFRP reinforcement in various ways to increase its bond strength to concrete. In order to increase the bond strength of the composite reinforcing bars to concrete, the polymeric composite was used as the main material and jute material. Jute is a plant fiber made from a Malvovia plant. The plant grows in the tropics of Asia, Africa, America, Australia, India and Bangladesh. Jute is used for making sackcloth, twine and other common products. A new study shows that as well as an inexpensive reinforcing

Table 1.

Main characteristics of the used oligomers

Characteristics	Brand oligomer	
	Epoxy resin ED-20 – two-component	Laproxide 503
Average molecular weight, g / mol	390-430	600-700
Content of epoxy groups,%	21,8	13-16
Density at 298K, kg / m^3	-	1095
Dynamic viscosity at 298 K, Pa . s	22,963	0,23
Volatile matter not more than,%	0,4	-
Hydroxyl groups, no more than,%	1,7	1,2

fiber for cement mortars [15]. In this case, the use of jute makes more crack-resistant, which in some cases is especially important, for example, in regions with sharp temperature changes, such as Jordan [16]. the hydrostatic pressure against the FRP bars due to the shrinkage of hardened concrete and the swelling of the FRP bars due to temperature change and moisture absorption[17-20] Other research works studied the use of sprayed short glass fiber with thermosetting resin over the surface of the bars as an effective way to transfer the load from concrete.[15] Lee et al.[21] have also investigated the effect of adhesive type, adhesive layer thickness, and overlap length. It was found that the joint strength was slightly dependent on the adhesive layer. An approximate adhesive layer thickness between 0.2 and 0.5 mm maximizes the joint strength.[21].

One of the most promising methods for modifying the surface of BFRP and GFRP is their treatment with epoxy polymeric materials that provide high adhesion to both basalt and glass surfaces, however, for exploitation in the climatic zone of Jordan, a specific set of technological requirements is required for these materials: Sufficient viability, good wettability, wide temperature range of operation, high adhesion properties. To get this set of requirements, we developed epoxy compositions based on di- and three epoxies with various hardeners and modifiers.

Experiments and results

The experiment was carried out in the laboratory of the Department of building Materials and Products of the Kharkov National University of Civil engineering and Architecture.): the composite rebars were coated by polymeric composite as an adhesive substrate,. The rods are held for 48 hours for complete adhesion (Fig. 1).The samples were made – cubes "15x15x10" cm, composition C: S: G = 1: 2: 4, (aggregate-sand Mk = 1.5 and crushed stone up to 10mm), mixture moisture (W / C) – 0.5. The bars of the reinforcement were installed vertically along the axis into the cubes-shapes to a depth of up to 10 cm together with the laying of the concrete mix and its subsequent vibration compacting.

Tests on the bonding strength of composite reinforcement with concrete by pull out were carried out on the experimental installation shown in Figure 2.

Determination of the strength of the adhesion of reinforcing bars to concrete was carried out according to the recommendations of the ACI industry (departmental standards-USA) [22]:

$$\tau = F / C_b . l \quad (1)$$

где τ – Average bonding strength, F – load, C_b – length of rebar surface, l – length of the composite bar.

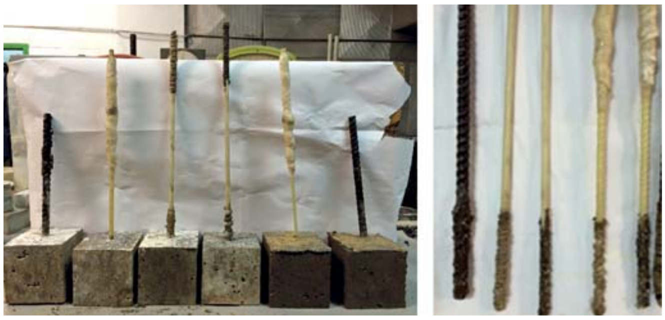

Рис. 1. Manufactured samples – cubes

Рис. 2. Laboratory installation for pull test

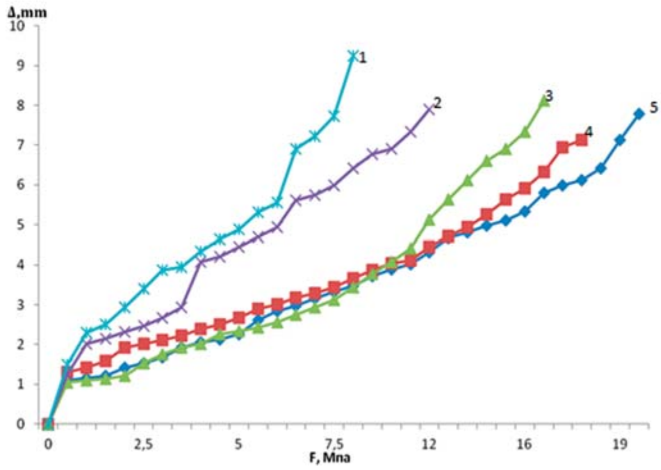

Рис. 3. Displacement – stress diagram – for the modified GFRP samples, 1 – GFRP, 2 – GFRP + modified jute fiber,
3 – GFRP + modified jute rope, 4 – GFRP + sand of granitic,
5 – GFRP + polymeric composite

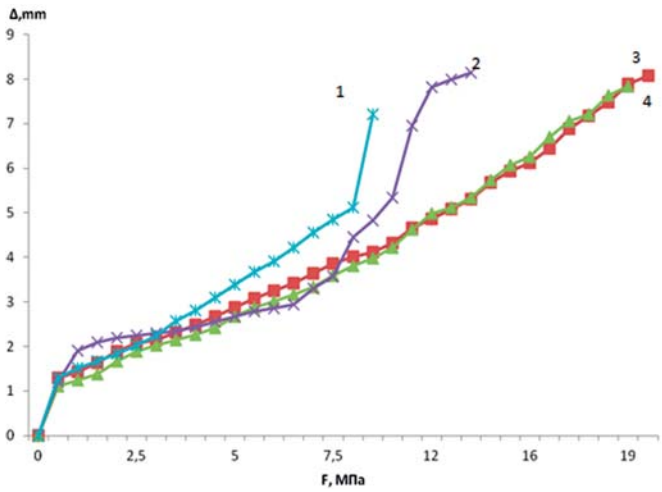

Рис. 4. Displacement- stress diagram- for the modified BFRP samples,
1 – BFRP, 2 – BFRP + modified jute fiber,
3 – BFRP + modified jute rope -, 4 – BFRP + sand of granitic,
5 – BFRP + polymeric composite

The influence of various methods of surface treatment of polymer-composite reinforcement on the force of its adhesion to concrete was investigated. For this purpose, sand of granitic, organic jute fiber, developed polymer composition, as well as direct spraying onto the surface of the reinforcement composite bar of the developed polymer composition immediately before its interaction with the concrete were applied to the surface of the reinforcement. Fig. 1 shows samples of modified GFRP and BFRP. Types of samples of GFRP and BFRP with different surface treatment methods The results of test are shown in the fig. 3-4.

Conclusion

From the data presented, it can be seen that the treatment of GFRP, BFRP with sand of granitic allows to slightly increase the adhesion strength to 13.1 and 14.4 MPa, which is apparently associated with an increase in the physic- mechanical component of adhesion (friction).

The use of the developed epoxy polymeric compositions allows to increase the adhesion strength up to 17.5 and 20.5 MPa due to the high degree of intermolecular interactions at the interface and increased wettability, penetration into the body of concrete to a depth of up to 5 mm, as a result of which the monolithic structure remains on the 80-90%, and the gap has a mixed adhesive-cohesive character (for concrete). At the same time, the use of impregnated organic jute fiber and fiber impregnated with the developed composition did not give the expected effect of bond strength 13.8 (14.9) and 15.6 16.5 MPa, respectively, which is apparently due to the fact that the fiber absorbed most of the epoxy resin composition, due to which the chemical component of adhesion decreased, and the increase in the mechanical component of adhesion could not block it.

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