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Experimental Investigation of the Effects of Naoh and KOH Solution on the Behavior of Concrete Square Columns Reinforced By JFRP Composites

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Abstract **-** The objective of this experimental study is to evaluate the effect of untreated and treated Jute fibers, on the behavior of concrete members. The first category of Jute fibers fabrics is treated in the alkaline treatment of 4% of NaOH solution and the second one in 2% of the Potassium hydroxide solution, during 24h in a liquor ratio of 10:1. In the case of specimens reinforced by treated fibers in 4% of NaOH have noted an increase of 25% compared to unreinforced specimens and 10.93% compared to untreated specimens. This concludes that the mechanical properties of the composite are enhanced by the treatment of the Jute fibers in 4% of NaOH. They become more compatible with the matrix, which increases the maximum load capacity of the reinforced specimens. On the other hand, it has seen that the treatment of fibers by 2% of Potassium hydroxide decreases the maximum load capacity of specimens reinforced by treaded fibers compared to untreated specimens. This means that the treatment by 2% of KOH has a negative effect on the properties of the Jute fibers fabrics.

Keywords**:** KOH solution, NaOH solution, reinforcement, adhesion, concrete, JFRP composites, epoxy resin.

1. Introduction

The use of composites has rapidly increased in different construction applications [1], [2]. In the case of concrete strengthening, they have been used as a material for external reinforcement concrete (RC) [3]–[6]. However, the majority of such applications are based on composites with non-degradable fibers such as E-glass, carbon and aramid, which has approved a great success in the field of upgrading reinforced concrete structures [7], [8]. Nevertheless, these fibers are not degradable at the end of their life, and their production emits C02 which impacting negatively the environment. As opposed, the natural fibers have different advantages; in particular, they are biodegradable and renewable [9]. In addition, they often have low densities and lower processing costs than synthetic materials[10], [11]. Those factors have drawn the attention of researchers to use the natural fibers or the bio-composites [12]. Among the few of studies which were conducted it's concluded form the suty of Tan,H.et al [13] that wrapping concrete columns with JFRP composites increased the ultimate load [14]. Results of a study revealed that the confinements with the FFRP composites increased greatly the compressive strength and ductility of concrete as compared to unconfined concrete[15]. It was noted that the stiffness and the maximum loads of concrete beams increase with the reinforcement by natural fibers plates [16], [17]. It concluded also that sisal fabric reinforced polymer composite system could be used as alternate fabric reinforcement in FRP, for flexural strengthening of RC beams [18]. However, the most important limitations hindering the use of natural fiber composites in high-performance structural applications are the weak interfacial bonding between the natural fiber matrix [19]. While the cellulose fibers are incompatible with the hydrophobic polymers, which leads to less interfacial adhesion between the fiber and the matrix. The modification of the surface of the fibers is necessary for making a perfect adhesion and in order to achieve this objective, chemical methods are one of the most effective solutions can increase the quality of the interface between the matrix and the fiber [19]–[23]. As they can decrease the strength of fibers as was indicated by the study made by Z.N.Azwa and B.F.Yossif [24], that the excessive treatment of natural fibers with KOH or NaOh could have a negative effect on the properties of the fibers. The composites chemically treated have also been reported to exhibit a relatively greater decrease in tensile strength, proving that treated composites undergo greater degradation than untreated composites [24],[25] .

This research work focuses on the effect of reinforcement of concrete square cube members using untreated Jute fibers and fibers treated in 4% of NaOH and in 2% of Potassium hydroxide during 24 hours in a liquor ratio of 10: 1. All the concrete members reinforced by composite materials based on Jute fibers are subjected to the compression test. This article is structured as follows: in the first section the materials used and the methodology followed are presented. The second section resumes the results obtained from the compression test in terms of Load-displacement behavior. In the third section presents the effect of surface treatment on fibers morphology.

2. Methodology

2.1. Treatment of Jute Fibers By Alkali Solution

Two kind of treatment of fibers were used the KOH and the NaOH. The first category of Jute fibers fabrics were impregnated in a liquor ratio of 10:1 of 2% of KOH solution and the second one in 4% of NaOH solution, the both of them have been left for 24 hours, under the following climatic conditions: 18°C and 88% relative humidity. The fibers are washed in distilled water whose PH reaches 7, so as to remove the residues of the alkali solution. Then, they are dried for 6 hours at 100°C.

2.2. Preparation of Specimens

The Jute fiber fabrics are applied to the concrete using the Sikadur™ 330 resin and hardener mixing ratio of 4:1. Table 1, resume the proprieties of the epoxy resin Sikadur™ 330. All the samples are cured under the ambient conditions for 7 days.

Table 1: Properties of sikadur 330.

Resin	**Density kg.dm3 mixed**	**Compressive strength *fc,a*[MPa]**	**Tensile strength *ft,a*[MPa]**	**Module of elasticity *Ea*[GPa]**	**Elongation at break,*εu*[%]**
Sika-dur 330	1.3	30(7 days + 23°C)	33.8 (7 days + 23°C)	4.5 (7days + 23°C)	0.9

3. Testing

3.1. Compression Test

All the specimens of Jute Fiber Reinforced Polymer reinforced concrete members are subjected to compression testing using the Universal Testing Machine WAW-600 E in the laboratory of Composite Materials, of the Faculty of Civil Engineering and Building Services, Gheorge Assachi Technical University, Iasi, Romania. The capacity of this machine is 600KN and the loading speed applied is 4KN/s. The results are obtained using the data acquisition system Maxtest software. Table. 2 groups the code abbreviations using for the specimens that were reinforced by the JFRP with and without treatment.

4. Results

4.1. Interpretation of Load-Displacement Behavior

The reinforcement of concrete by using the Jute fibers fabric reinforced polymer increases the maximum load capacity as shown in the Fig 1 and Fig.2. which an increase of 13% and 14.5% respectivelly, are noted, compared to unreinforced concrete members. The maximum load capacity of the specimens reinforced by the Jute fibers fibrics treated by 4% of NaOH have shown an increase of 25% compared to unreinforced specimens and 10.93% compared to untreated specimens (Fig.1). On the other hand, the specimens reinforced with fibers treated by 2% of KOH have shown a decrease of 14.3% compared to reinforced specimens with untreated fibers (Fig.2). However for the first category the specimens which displayed a higher value of displacement are the untreated specimens whereas for the second category the the treated specimens which displayed the highest displacement.

Table 2. Code abbreviations

Code	**Signification**
C1-R	Plain concrete (reference)
C1-JFRP	JFRP reinforced concrete
C1-JFRP-NaOH	JFRP reinforced concrete with fibers treated during 24 hours in liquor ratio of 10:1 of 4% of NaOH
C5-R	Plain concrete (reference)
C5-JFRP	JFRP reinforced concrete
C5-JFRP-KOH	JFRP reinforced concrete with fibers treated during 24 hours in liquor ratio of 10:1 of 2% of KOH

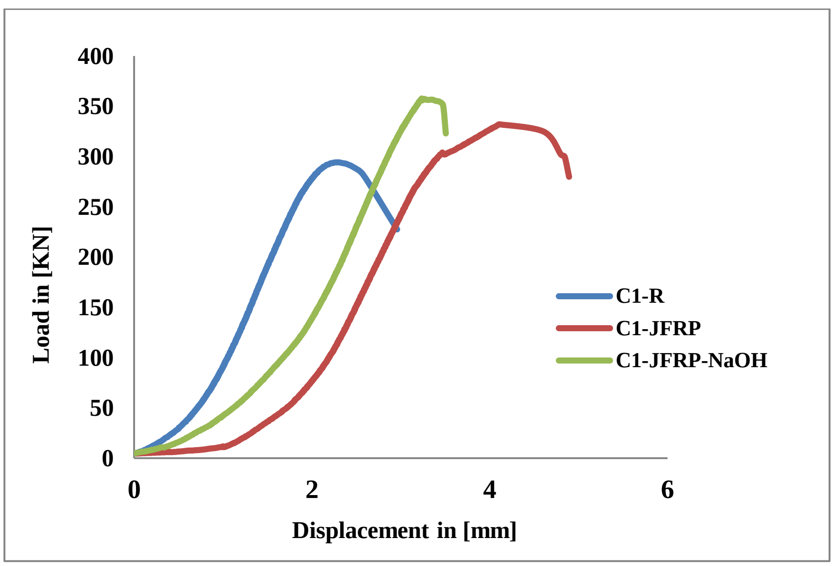


Fig. 1. Load-displacement curves for specimens reinforced with fiebrs treated in 4% of NaOH solution

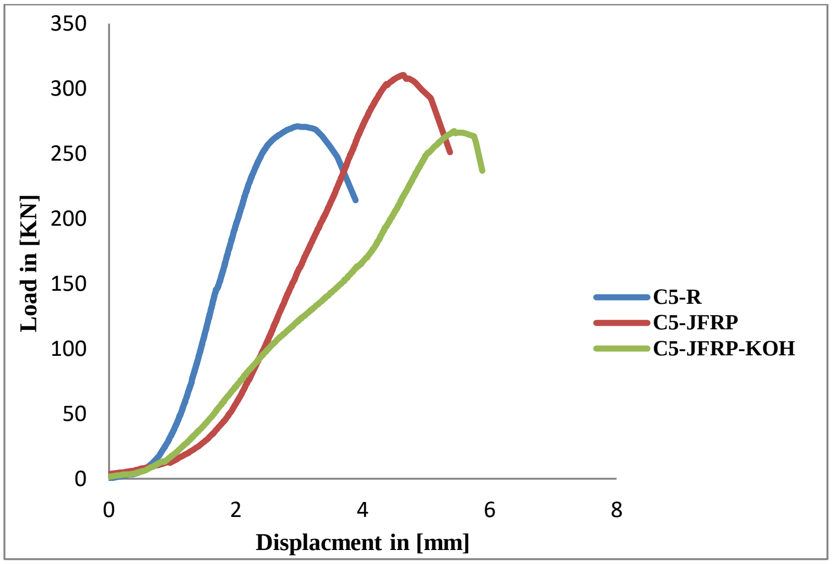
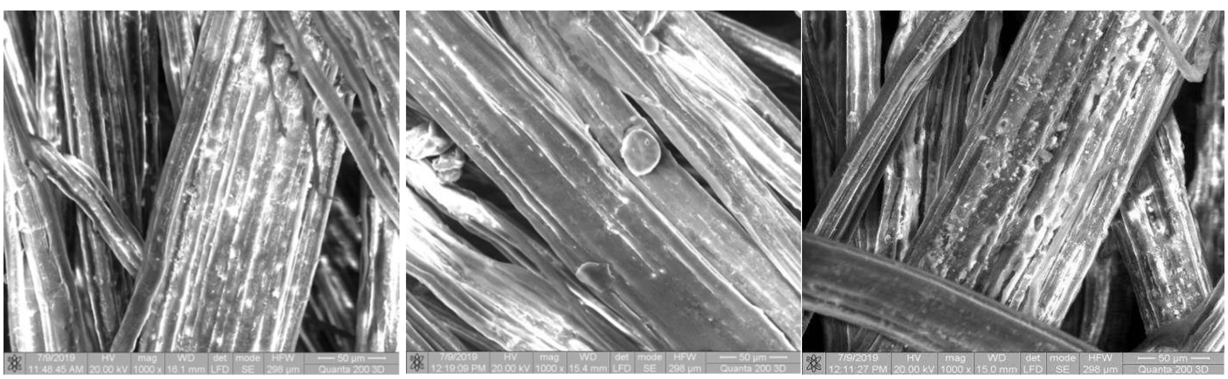


Fig. 2. Load-displacement curves for specimens reinforced with fibers treated in 2% of KOH solution

4.2. Effect of Surface Treatment on Fibers Morphology

Fig .3 presents the effect of surface treatment on fiber morphology. As shown in the Fig .3.b, the fibers are more cleanly with a smooth surface in the case of treated fibers by 2% of KOH solution than the untreated fibers. Contrarily, the Fig.3.C illustrates the presence of a large number of holes in the case of treated fibers by NaOH . The holes observed are formed following the degradation and detachment of the surface because a certain part of the primary wall, more specifically, the lignin and hemicelluloses, have been removed by the alkaline treatment.



(a) Untreated fibers *(b) Treated with KOH* *(c) Treated with NaOH*

Fig.3. Microscopic (SEM) view of Jute fibers

5. Conclusion

The following conclusions can be drawn from this study:

1) The resistance capacity of concrete can be increased by adding from the exterior the composite materials based on Jute fibers.
2) The Jute fiber-reinforced samples treated showed a clear increase in the case of treatment with 4% NaOH. This results in that the NaOH treatment can lead to an improvement of the interface between the fibers and the matrix which results in an increase of the breaking load.
3) The treatment of Jute fibres chemically in a concentration of 2% of potassium hydroxide weakens the properties of the fibres, which negatively influences the behaviour and strength of the samples reinforced with Jute fibers.

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