EFFECT OF SOME TYPES OF COATINGS ON THE PERFORMANCE OF REED IN CEMENT MEDIA

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Abstract

The recent years have witnessed some serious attempts to use wood and vegetable fibers, such as reed fibers, in concrete as reinforcement or as light weight aggregate due to its low cost and relatively high tensile strength.Unfortunately the durability of these materials in concrete media is very low due to the high PH value of concrete. The effect of some coatings on the tensile strength, modulus of elasticity and absorption of reed exposed to media of high PH value is investigated. The effects of these coatings on the modulus of rupture of cement mortar prisms reinforced with reed are also investigated. Many coatings, namely, epoxy paint, styrene –butadiene rubber (SBR), polyvinyl acetate (PVA), and liquid mastic were used. It is concluded that epoxy paint has shown the most superior qualities as a coating by exhibiting less absorption, higher tensile strength, higher modulus of elasticity and higher modulus of rupture.

Keywords: Reed, durability, modulus of rupture, epoxy, concrete, tensile strength, modulus of elasticity

Introduction

Many attempts have been made to use sawdust in concrete to reduce the density and improve the thermal conductivity of concrete or to make nailing concrete (Neville, 1995). Nailing concrete is a material into which nails can be driven or hammered .Several attempts were ,also, made to use vegetables fibres such as reed and bamboo as reinforcement to improve the tensile and flextural strength of concrete and cement mortar(Raouf,1975). Many investigations have been carried out scince 1914 in China to use bamboo as reinforcement in concrete (AL-Ossi and AL-Ali,1989). In 1939 ,many studies have been carried out by Datta in Germany in the same field. Such attempts have had economical advantages in the past by reducing demand on steel in war times.In some counteries ,rice husks have been used to make concrete (AL-Ossi and AL-Ali,1989).

The major problem facing these attempts is the detorieration of cellilose and hemicellilose in cement media as the PH value of cement paste is very high (aproximately 13) . One more point that must be mentioned is that the wood and vegetable fibers have also many other disadvantages:

1- These materials absorb or release water depending on their environments . These processes lead to volume changes and ,as a result, decrease the bond with surrounding matrix (AL-Ossi and AL-Ali,1989).)
2- The surface of vegetable fibers is unfortunately smooth which reduces the bond with the matrix.
3- The differences between the coefficient of thermal expansion of the vegetable fibers and that of cement mortar or concrete may lead to reducing the bond and ,in other cases, to disrupt the matrix materials.
4- The adverse effect of termite and fungi on wood and vegetable fibers.

In spite of these disadvantages reed has the advantage of relatively high tensile strength (about 150 MPa) , low density(0.413- 0.852 g\cm^3)(Abdul-Lateef and Al-Attar,2013) and low cost.

Many measures, however, were suggested to overcome these disadvantages (Gram, 1983and NCCL ,1986):

1- Using these fibers as bundles to decrease the surface area exposed to the matrix.
2- Using fibers saturated with water to eliminate moisture absorption .
3- Treating the fibers with certain chemical such as Sodium sulfate and Barium salts.
4- Overlaying the fibers with certain materials such as epoxy paint, asphaltic materials.
5- Reducing the PH value of the matrix by adding fly ash or by using high alumina cement.
6- Overlaying the external surface of concrete by water proofing materials.

The present work is designed to study the role of some coatings on reducing the harmful effect of concrete media on the mechanical properties of reed. To simulate the chemical action of concrete media, lime- saturated water was used for this purpose.

Literature review

1n 1988 Abdel-Rahman studied the durability characteristics of date palm frond stalks as Reinforcement in Structural Concrete (Abdel – Rahman, 1988).He concluded that asphaltic coating resulted in 10-100% decrease in water absorption of the samples.

Gram (Gram, 1983) suggested an accelerated method to assess the durability of natural fibers in high PH media by cyclic wetting and drying. In wetting cycle the fiber reinforced concrete sample were exposed to 50^{o} centigrade for 3 hours, in the other hand, in drying cycle the samples were exposed to 20 ^{o} centigrade and relative humidity of 95%.

Sink (NCCL, 1986) studied the resistance of some fibers (such as sisal and coir) to basic media .He concluded that coir has good resistance to such media.

G.Ramakhnaris and T. Sundararajan (Ramakhnaris and Sundararajan, 2005) presented the results of the variation in chemical composition and tensile strength of coir, sisal, jute and *Hibiscus cannabinus* fibers, when they are subjected to alternate wetting and drying and continuous immersion for 60 days in three liqued mediums namely, water, saturated lime and sodium hydroxide. Compressive and flexural strengths of cement mortar (1:3) specimens reinforced with dry and corroded fibers were determined after 28 days of normal curing. From the results it was observed that there was substantial reduction in the salient chemical composition of all the four fibers, after exposure in the various mediums. Coir fibers are found to retain higher percentages of their initial strength than all other fibers, after the specified period of exposure in the various mediums. The compressive and flexural strengths of all natural fiber reinforced mortar specimens using corroded fibers are less than the strength of the reference mortar (i.e. without fibers) and fiber reinforced mortar specimens reinforced with dry natural fibers.

G. Ramakrishna, et *al*, (Ramakrishna, et *al*, 2010) stated that durability of natural fiber cement composite can be evaluated on the basis of flexural toughness and it has a special significance. Toughness of a natural fiber composite can also be evaluated by impact tests, which helps in realistic assessment of ductility of the above composite. Evaluation of durability of a natural fiber composite by residual impact strength and flexural toughness index and their comparison are presented and discussed. Impact strength values could be used to assess the durability of natural fiber composites in contrast to the conventional ‘toughness indices’ used for composites, in general.

Experimental works

3-1- Materials:

3-1-1- Cement:

Ordinary Portland cement was used in this research. Table (1) shows the chemical and physical properties of this cement which conform to the Iraqi specification (I.Q.S 5,1984).

3-1-2 **–** Sand:

Natural sand from Karbala was used. It conforms to the Iraqi specification (I.Q.S 45-1984).

3-1-3- lime:

Lime was used to simulate the cement media. The PH value of the lime was tested and was found to be 12.7 which approximately equals the (PH) value of cement solution (12.9).

Other chemical properties of lime are shown in Table (2).

3-1-4- Reeds:

Three groups of samples were collected from three different places in Baghdad (Kadimiya, Latifiya,and Radwania)

3-1-5- Overlaying materials:

3-1-5-1- Liquid mastic:

This material which is usually used as water proofing agent is available in the local markets . It is in liquid state at normal temperatures.

3-1-5-2- Styrene –butadiene rubber (SBR):

This material is also available in the local markets .The type used in this research is Swiss-Egypt product. SBR is a mixture of approximately 75 percent butadiene (CH_2=CH-CH=CH_2) and 25 percent styrene (CH_2=CHC_6H_5). In most cases these two compounds are copolymerized (their single-unit molecules linked to form long, multiple-unit molecules) in an emulsion process, in which a soaplike surface-acting agent disperses, or emulsifies, the materials in a water solution.

3-1-5-3- Polyvinyl acetate (PVA):

Polyvinyl acetate is a rubbery synthetic polymer with the formula $(C_4H_6O_2)_n$. It belongs to the polyvinyl esters family with the general formula -[$RCOOCHCH_2$]-. It is a type of thermoplastic (12). This material was available in the local markets in small tines .The type used in this research is Syrian-Italian product.

3-1-5-4- Epoxy paint:

This material is available in the local markets . It is produced by Modern paint industries company (Iraq).

3-2 - Testing Program:

The following tests were carried out on reed mortar samples:

3-2-1- Absorption test:

Six reed samples from each group were weighed after being dried in oven to 65º centigrade .After that the samples were submerged in water for 48 hours and weighed again . The absorption was calculated according to the following equation:

$$\text{Absorption} = \frac{wet\ weight - dry\ weight}{dry\ weight} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

3-2-2- Tensile strength:

The authors failed to carry out this test in a universal testing machine for concrete or steel because the specimens crushed and badly damaged at the point of grips . Therefore, twelve specimens (six with a node in the free length and six without a node) for each sample were tested in the *Zwick 1454* tensile testing machine with capacity of 10 kN (Fig. 1). This machine is designed to test plastics and leather and is available in the Central Organization for Standardization and Quality Control, COSQC, Baghdad. The tested specimens were shaped as strips with the dimensions of (25×200) mm.

Fig. 1: The *Zwick 1454* tensile testing machine

3-2-3-. Modulus of elasticity:

The same machine (which has the capability of recording the elongation of reed specimen against the applied load) was used to obtain Modulus of elasticity.The modulus of elasticity of each sample was calculated by the following equation:

$$E = \frac{pl}{\Delta l\ A} \ldots\ldots\ldots\ldots(2)$$

Where:

E: modulus of elasticity, GPa.

P: applied load within elastic range, N.

L: span length between supports, mm.

A: cross-sectional area, mm^2.

Δl: elongation, mm.

3-2-4- Modulus of rupture:

(150*50*700) mm mortar prisms (cement 1: sand 3) were used for modulus of rupture test. The prisms were reinforced with 4 reed slices (1.5 cm width). The reinforcement ratio was 1%. Hydraulic compression machine of (2000) kN capacity ELE digital machines was used with a simple beam at the third-Point loading according to the (ASTM C 78-04). The ultimate tensile strength in flexural (modulus of rupture) was calculated using the following formula:

$$\mathbf{f_r = PL/bd^2} \;\ldots\ldots\ldots\ldots\ldots (3)$$

Where:

f_r: modulus of rupture, (MPa).

P: maximum applied load recorder by tested machine, (N).

L: average length of specimen, (mm).

b: average width of specimen, (mm).

d: average depth of specimen, (mm).

The reference sample without coating was tested at the age of 28 days, while the other samples were tested at 120 days after 30 cycles of wetting and drying of 48 hours duration.

4-Results and discussion:

Table (3) shows the results of absorption tests for reed samples with different types of coating. It is obvious that samples with epoxy paint exhibit less absorption than that of other samples. It means that this paint is the most efficient coating in decreasing the water absorption. It is also shown that all types of coatings used in this research have desirable effects on the water absorption of reed.

The results of tensile strength and modulus elasticity of reed samples, after exposure to water saturated with $Ca(OH)_2$ for 90 days, is shown in Table (4).The samples with epoxy paint showed the highest tensile strength and modulus elasticity. This is in line with the results of absorption tests. The lesser the water absorption the more efficient performance against the effect of deterioration due lime action.

It is also shown that the samples coated with mastic, PVA, and SBR showed less tensile strength and modulus elasticity than that of the reference sample. It could be attributed to the deterioration of cellulose and hemi-cellulose of fibers exposure to water saturated with lime.

The samples coated with epoxy, however, showed no decrease but increase in tensile strength and modulus elasticity. This may be due to the improvement of mechanical properties of reed resulting from epoxy application.

Table (5) shows the results of modulus of rupture results for mortar prisms reinforced with reed and exposed to 30 cycles of wetting and drying.

According to this Table, it could be stated that:

a- There is a decrease in modulus of rupture for sample without coating after exposure to wetting and drying cycles. It could also be attributed to the deterioration of cellulose and hemi-cellulose fibers exposed to water saturated with lime.

b- The decrease in modulus of rupture for samples reinforced with coated reed of PVA and SBR after exposure to wetting and drying cycles is less than that for samples without coating.

c- Samples with reed coated with epoxy paint exhibited increase in modulus of rupture. It is in line with the results of tensile strength and modulus of elasticity of reed samples.

Conclusion

For the investigated reed samples and mortar reinforced with reed, the following conclusions could be The samples of reed with epoxy paint exhibit less absorption compared to other samples.

1- After exposure to water saturated with $Ca(OH)_2$ for 90 days ,the samples with epoxy paint showed the highest tensile strength and modulus elasticity.
2- There is a decrease in the modulus of rupture for samples of mortar reinforced with uncoated reed and after exposure to drying and wetting cycles. Similar trend is shown by mortar reinforced with reed coated with PVA and SBR.
3- Mortar samples reinforced with reed coated with epoxy paint exhibited increase in modulus of rupture.

Table (1)
Chemical and physical properties of cement

Property	Result	Limits of Iraqi specifications
Fineness (Blaine)	3160 cm^2/ gm	2300
Initial setting time	170 min.	Min. 45 min.
Initial setting time	4:40 hr.	Max. 10 hr.
Compressive strength : 3-day 7-day	16 MPa 25 MPa	15 MPa 23 MPa
Soundness (Autoclave)	0.14%	0.8%
SO_3 %	1.8	2.8
MgO%	3	5
Loss on Ignition%	1.74	4
Insoluble residue %	1.15	1.5
Major compounds% C_3S C_2S C_3A C_4AF	34.3 37.4 9.0 10.0	- - - -

Table (2) Chemical properties of lime

Type of test	Result
CaO	70.16%
MgO	0.46%
AlO_3	O.6%
SiO_2	1.24%
Loss on Ignition%	25.94%

Table (3) Absorption of reed with different types of coating

Type of coating	Absorption % *
SBR	46.27
PVA	52.15
Mastic	30.82
Epoxy	26.12
Without coating (reference sample)	70.70

* Every result represents the average of 6 test results

Table (4)Tensile strength and modulus of elasticity of reed samples after exposure to water saturated with $Ca(OH)_2$ for 90 days

Type of coating	Tensile strength (MPa) *		modulus of elasticity (GPa)*
	Samples without knots	Samples without knots	
SBR	137.5	99.8	6.73
PVA	186.2	136.0	12.49
Mastic	154.9	119.0	8.04
Epoxy	196.5	145.8	14.69
Without coating (reference sample)•	171.4	126.8	12.56

*Listed result represents the average of 3 tests.

•Results of samples without exposure to lime solution.

Table (5)Modulus of rupture results for mortar prisms reinforced with reed and exposed to 30 cycles of wetting and drying

Type of coating	Modulus of rapture (MPa)*	Age day
Without coating	2.6	28
Without coating	2.1	120
SBR	2.6	120
PVA	2.4	120
Mastic	2.3	120
Epoxy	2.8	120

*Listed values are the average of 2 test results

References:

A.M Neville (Properties of Concrete) 4rd edition ,John Willy and sons, New York, 1995.

Raouf,Z.A.,(Dynamic Mechanical Properties Of Fiber- Reinforced Cement Composite) Ph.D thesis,Manchester,U.K.,1975

AL-Ossi,M. and AL-Ali,B.(New Reinforced Concrete).Baghdad 1989

Adil M. Abdul-Lateef and Tareq S. Al-Attar (Structural Behavior of Reed: Evaluation of Tensile Strength, Elasticity, and Stress-strain Relationships),InternationalJournal of Advanced Research in Engineering and Technology.Vol.4,Issue 1,India,2013

H.E. Gram ,(Durability of Natural Fibers in Concrete), Swedish Cement and Concrete Research Inst., Sweden.1983

NCCL,Pro. of (Use of Vegetable Plants and Their Fibers as Building Materials Symposium),Baghdad,1986

Abdel – Rahman ,H.H. (Physical ,Mechanical and Durability Characteristics of Date Palm Frond Stalks as Reinforcement in Structural Concrete),The International Journal of Cement Composites and Lightweight Concrete ,Vol.10,No.3,1988,PP.175-181

G.Ramakhnaris and T. Sundararajan (Studies on the durability of natural fibres and the effect of corroded fibres on the strength of mortar) Cement and Concrete Composites journal, Volume 27, Issue 5, May 2005, Pages 575–582

G. Ramakrishna, T. Sundararajan and S. Kothandaraman (EVALUATION OF DURABILITY OF NATURAL FIBRE REINFORCED CEMENT MORTAR COMPOSITE- A NEW APPROACH), ARPN Journal of Engineering and Applied Sciences, VOL. 5, NO. 6, JUNE 2010

Iraq Specification 5-84 (Portland Cement).

Iraq Specification 45-84 (Natural aggregate for use in concrete).

Murray, G. T. (1997), *Handbook of materials selection for engineering applications*, CRC Press, p. 242, ISBN 978-0-8247-9910-6.

ASTM C 78-04, “Standard test method for flexural strength of concrete", Annual Book of ASTM Standards, Vol.04.02, 2004.