Influence Of Treatment Palm Fibers On The Cement Based Composite Behavior

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Abstract

Since vegetable fibers as palm fiber are as a suitable reinforcement of cement-based matrixes used in structural applications. This paper was carried out to find out the optimum substitution of palm fiber in conventional cement-based matrix to produce lightweight matrix. In this research, palm fiber has been treated by immersing individually either in NaOH of 2% and calcium hydroxide, $Ca(OH)_2$ of 0.172% respectively. While alkali treatment applied on palm fibers reduces the water absorption capacity by removing hemicellulose and lignin or by imparting hydrophobicity. In addition, immersing the difference kinds of palm fibers in the water during 24h and dried 2 days at 50 °C before testing. And electron microscopy has used to study the fiber morphology. Moreover, the water absorption coefficient and water content of the palm fibers was determined according to the ACI standard. Furthermore, comparison tensile strength results between treated and untreated palm fibers were investigated. And for specimens casting, liquid mortar has been used where W/C =0.57 and the dimensions of the moulds depended on the percentage of fiber in the mixing. To confirmed deceasing compression strength by adding palm fibers, compression test has been realized by inclusion different percent, length and kinds of palm fibers in composite mortar.

Keywords: Palm fibers, Cement mortar, Treated fibers, Tensile test, Compression test.

1. Introduction

The fibers are used as primary reinforcement to increase both the strength and toughness of the composite. Hence, there is a need for further investigating properties of date palm fibers and understanding their contribution to the performance of fiber - cement composites. Fibers are also included in the matrix as the secondary reinforcement to control cracking induced by humidity or temperature variations or to provide post-failure integrity in the event of accidental overload or spalling [1]. Natural fibers have some advantages like low density, less abrasiveness, and lower cost when compared to inorganic reinforcing fibers, they also have some disadvantages such as mechanical and thermal degradation during processing, poor wettability and high moisture absorption. The date palm considered as one of the most cultivated palms around the world. Date palms have a fibrous structure, is considered one of the sources of natural fibers. The idea of reinforcing concrete with date palm fibers was studied by [2]. They had looked into the durability and mechanical properties of date palm surface fibers in hot-dry climate. They concluded that Male date palm surface fibers (MDPSFs) had the most tensile strength compared to other types of date palm fibers. The quality of natural-fiber reinforced concrete is judged mainly by their compressive strength [3], therefore compression test was considered as the basic test in most of the study on concrete mixtures contained Oil Palm Fiber (OPF), [4]. Therefore, date palm wood is a good candidate for realization of natural fiber composites with several applications: building materials, automobile and furniture industries. Nevertheless, like other natural fibers, date palm fibers have to be pretreated to produce moisture repellency and resistance to environmental effects and consequently to improve the mechanical properties [5]. In order to modify and clean the surface of natural fiber, alkali treatment is one of the most common methods employed. Alkali treatment has been reported to decrease the surface tension and to improve the interfacial adhesion between the fiber and matrix. Furthermore, in the literature, several possible explanations can be found discussing the positive effects of alkali treatment on the properties and structure of natural [6].

2. Research Significance

This paper surveys the influence of addation of the pretreatment of date palm fibers on behavior of fiber-cement composite. Experimental research was based on treatment the fibers with alkali solution. From different configurations obtained, we studied the physical and mechanical properties. To better understand the role of the pretreatment on the compression beavior, we compared different results between treated or untreated specimens.

3. Materials

3.1. Cement

Ordinary Portland Cement type CEM II 42.5 MPa was using.

3.2. Sand

0-2 mm sand diameter (S) and finesses modulus (FM) is 1.63 Brought from the Hania sea of Aljabal Alakhdar (green mountain).

3.3. Date palm fibers characteristic

3.3.1. Type of date palm fibers

In this research a palm tree was used from the coastal region of the Aljabal Alakhdar. The date palm tree was cut using a mechanical saw into small fractions, and then single fibers are manually obtained from palm sheets and separated with different sieves see figure 1. It then been sieved to make sure it is free from any impurities and the fibers are assured to be loosen and prepared to be cut into required length for consistency in this study. As the natural fibre adsorbs much water, the percentage of water adsorption of palm fibers should be determined first, and included in the mixing water content. Since such fibers should be having the same geometrically approximately for use in the experimental program, it is reasonable to generalize the similar physical properties to the same type of fibers. The basic physical properties of the extracted fiber are classified in the table 1.

Figure 1. Fibers extracted from palm tree.

Table 1. Types of fibers used and their physical dimensions.

Type of leafs	Form of fibers	Diameter	Length	Coefficient of absorption	Water content
		cm	cm	%	%
Date palm leaf root		0.15	11.4	142.74	19.79
Date palm leaf petiole		30	24.5	167.97	25.83
Date palm tree trunk		1	1.3	208.85	23.29
Date palm leaf sheath		1.18	8.3	131.56	15.38

Date palm leaf stalk		20	*118.5*	----------*	--------*
Fibrous		0.36	19	136.56	27.96
Leaf root hydrated		-----*	6.3	80.08	52.49
Kernaf mixed with trunk		-----*	8.6	195.15	28.36
Fibers remaining on a sieve 0.15 mm		0.15mm	----*	479.75	17.72
Fibers remaining on a sieve 0.3 mm		0.3mm	0.24	178.02	26.92
Fibers remaining on a sieve 0.6mm		0.6mm	0.53	347.54	17.49
Fibers remaining on a sieve 1mm		1mm	0.72	151.68	21.71
Fibers remaining on a sieve 2mm		2mm	*0.5*	141.53	20.16
Fibers remaining on a sieve 2.36 mm		2.36mm	1.21	43.30	55.02

* (----): unmeasured data.

3.3.2. Alkaline pretreatment of fibers

Natural fibers have a wide variation in its properties which may lead to an unpredictable fiber cement complex [7]. The hydrophilic behavior of fiber produces poor adhesion between fiber and matrix when the natural fiber is faced to develop composite material. This problem is mainly improved by several chemical treatment methods suggested by researchers. There are several studies evaluating the use of different types of natural fibers in concrete and mortar applications after treatment process, where fibers treated with 0.173% $Ca(OH)_2$ displayed better tensile strengths and stiffness properties than those treated with NaOH. Fibers have been treated with three methods as following before inclusion in the matrix: 1)-with water; 2)- NaOH of 2%; and calcium hydroxide, $Ca(OH)_2$ of 0.172% respectively. The fibers were immersed in the solution for an hour and then placed in an oven at 50°C for 24 h to dry, as shown in figure 2. This treatment improves the adhesive characteristics of the fiber surface by removing natural and artificial impurities as shown in figure 3.

a b c d

Figure 2. a. Leaf after putting it directly into the water; b. Leaf after 24h into the water; c. Immediately after applying the sodium hydroxide solution; d. fibers immersed in $Ca(OH)_2$ after 5min.

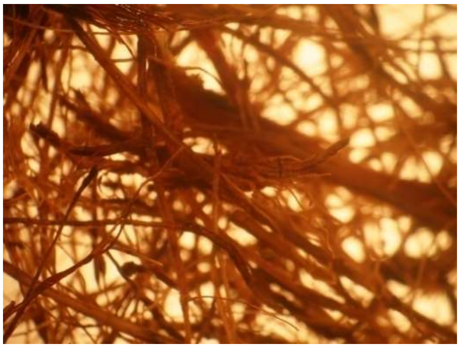
Figure 3. Fiber shape and water color after the treatment process.

3.3.3. Fibers morphology

Regular electron microscopy showed that treating date palm fibers before inserting them into concrete helps to remove impurities on the surface and thus improves the bonding between the two surfaces of the composite as shown in following figure 4:

Fibers without treatment.

Fibers without treatment.



Fibers treated with 2% of NaOH.

Fibers treated with 0.172% of $Ca(OH)_2$.

Figure 4.Structure of fibers without and with treatment.

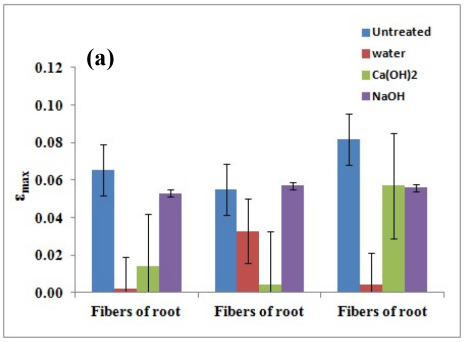
3.3.4. Tensile strength of fibers

Mechanical properties of date palm fibers were determined by tensile test. Mohamed et al. 2009,[8] has appeared that the nature of fiber does not have a unique strength rather a distribution of strength. Thus the test result obtained is the mean strength. Tensile strength is calculated from the ratio of maximum force and the cross-sectional area of a plane perpendicular to the fiber axis, while Young's Modulus is determined from the ratio of the strength and the maximum tensile strain. Important mechanical properties like tensile strength and Young's modulus usually increase as cellulose content and cell length increase [9]. Table 2 shows the mechanical behavior of untreated or treated root fibers.

Table 2. Mechanical properties of pretreatment fibers.

Type of fibers	Treatment	D	L	F	ε	A	σ	E
		cm	cm	N	mm/mm	mm²	MPa	MPa
Fibers of root	Untreated	0.6	3	100	0.066	28.27	3.54	54.00
Fibers of root	water	0.4	3.5	100	0.004	12.57	7.96	1821.59
Fibers of root	$Ca(OH)_2$	0.4	3.5	200	0.014	12.57	15.92	1143.82
Fibers of root	NaOH	0.4	3.5	200	0.056	12.57	15.92	284.93

Figure 5.a appeared that water treatment doesn't have influence on maximum deformation than alkali treatments. And it is clear that the untreated fibers have approximatly the same properties as treated fibers by the alkaline solution. Root fibers gave maximum resistance between 100-200N. it evidences that pretreatment fibers can improve max.tensile strength as shown in figure 5.b.



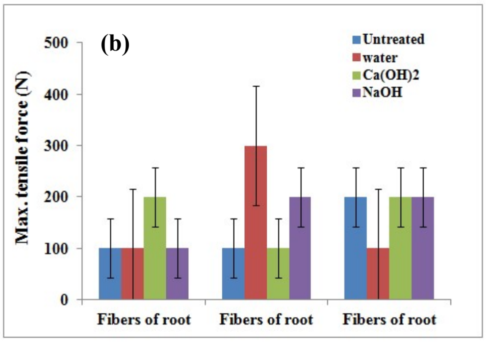


Figure 5. The effect of pretreatment on: (a) the date palm fiber's tensile strain and (b) the date palm fiber's max. tensile strength.

3.4. Specimens preparation

3.4.1. Mortar of reference

The design mix proportion of concrete grade 30 was used in this study. A mortar has been prepared as indicated in table 3. The reference matrix (Ref) initial time setting according to (C191-08) is 4.5h and final time after 9h. The 5 x 5 x 5cm and 7x7x7 cm test specimens are removed after 24 hours and then conserved in water for 28 days for mechanical testing. And mean compression strength is 35 MPa as shown in figure 6.

Table 3. Composition of mortar (kg/m3)

Water	200
Cement	350
Sand	585
W/C	0.57
Apparent density (g/cm3)	2.1

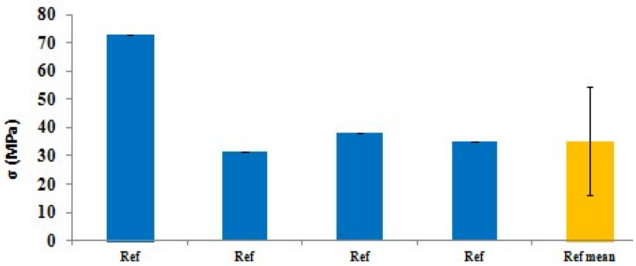


Figure 6. Max. and Mean compression strength of mortar.

3.4.2. Date palm fibers reinforced mortar

Date palm fiber was added in the concrete matrix by the subtraction of cement weight of 10 kg/m^3 and 250 kg/m^3. For all mixtures, water to cement ratio was fixed at 0.57, in addition, water absorption quantity of fiber was added in some mixed. More than 30 different mixtures were prepared for compression. The mix design was carried out based on fibers prepared in table 1. All the mixes are done after series of trial mixes is conducted to establish the mix with optimum strength. In the beginning, the mixing was done using the electrically mixer, but the fiber wrapped around the paddle, and cement and sand are deposited in the mixing bowl after adding water. For date palm fibers inclusions greater than 2.0%, poor workability as well as difficulty in preparing and obtaining monolithic compacted samples due to excessive separation of mortar components was encountered. Hence, it is recommended that such date palm fiber inclusion in mortars to be limited to less than 2.0% by weight. Therefore, mixing was done manually, where cement and sand were mixed, then fiber was added, and then water, taking care not to damage the fiber during mixing. The amount of absorption water was added according to the state of mixing, meaning if the mixture was dry, it was added, and otherwise the mixing water would be sufficient. For compressive specimens casting, it was cast into a 10 cm x 10 cm x 10 cm cube, but in most cases the dimensions of the moulds depended on the percentage of fiber in the mixing. So three dimensions are adopted: 5x5x5 cm^3; 7x7x7 cm^{3}and 10x10x10 cm^3. All specimens cured under the water and when we add water of absorption specimens cured in dry air. The specimens with low percentage of fibers are removed after 24h and then conserved in water for 28 days for mechanical testing, and the specimens with high percentage are removed after 48h and then conserved in dry air for 28 days.

4. Mechanical results of fiber-reinforced mortar

4.1. Compression test

Compression test was realized with hydraulic press of 200 kN. Test was preceded according to standards C 109/C 109M – 07 and machine starting which goes on with speed of 0.15 mm/min. Test the specimens immediately after their removal from storage water. Compressive strength is calculated from the ratio of total maximum load and the area of loaded surface.

4.2. Results and Discussion

Characterization of date palm fibers used as composites reinforcement appeared that efficacy using these fibers with low percentage. Figure 7 represent results of compressive load for ref, as well as for plant fibers mortars (krenaf, leaf, root, trunk and remaining fibers on sieves of 1mm diameter). The maximum strength is influenced by type of fibers, from where trunk fibers given minimum values of strength, take into account coefficient of variation. And fine fibers lead to improve the strength than thick fibers. Then, remaining fibers on sieve 1 mm has ameliorated the maximum strength of the leaf or root. Thus small diameter and untreated fibers lead to obtain more homogenize composite even if alkali solution leads to eliminate hydrophilic phenomena as previously indicated. The pretreatment methods as where NaOH solution leads to increasing the maximum strength of mortar than $Ca(OH)_2$ solution. As untreated fibers depend principally on fibers structure, figure 8. Which in turn can cause the maximum strength of untreated fibers is influenced by the percentage and palm fiber structure. Figure 9 shown that for same kinds of fibers and varied pretreatment process, increasing compressive strength using alkali solution than untreated fibers. And pretreatment with NaOH could be at least up to 20 % higher than under $Ca(OH)_2$ compressive load with % of fibers.depending of fibers kind.

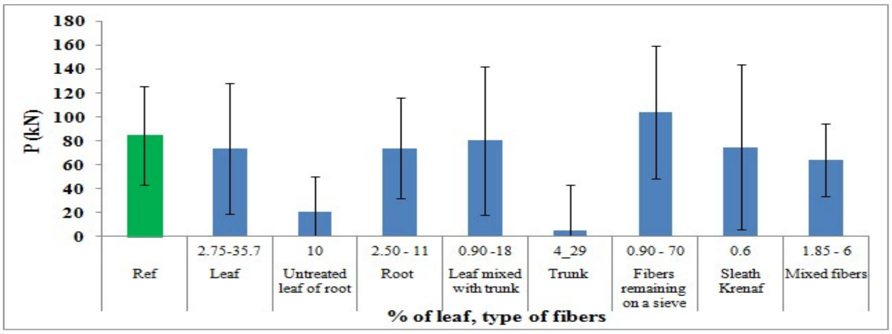


Figure 7. Influence % types of date palm fibers on maximum load.

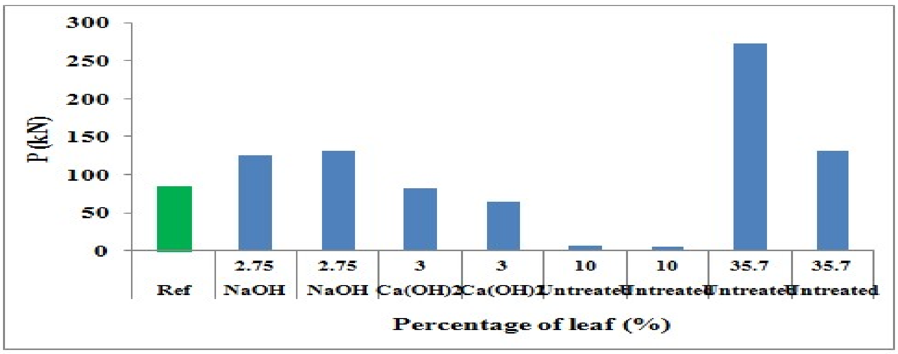


Figure 8. Influence % of leaf and pretreatment process on maximum load.

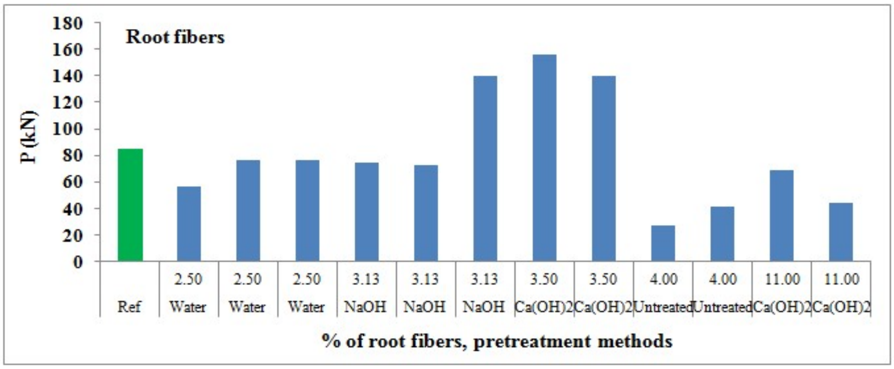


Figure 9. Influence % of root fibers (and pretreatment process on maximum load.

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