EFFECT OF CURING AND MIX DESIGN TYPES ON PERFORMANCE OF DATE PALM FIBRES REINFORCEMENT CONCRETE UNDER HOT DRY ENVIRONMENT

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ABSTRACT

The concrete is one of the most materials used in construction. However, its fragility remains a handicap of its mechanical behavior that is why it is armed with steel bars taking tensile strength. This material adapted with difficulties to desert climatic characterized by hot dry environment. Its mechanical properties, particularly the flexural strength, decrease with time under those similar climatic conditions. Furthermore the conventional concretes presented a high level of shrinkage and cracking in this environment. The reinforcement of concretes by fibres can offer some technical solutions for the improvement of theirs mechanical properties.

The use of fibres in the concrete became more and more a current practice in rehabilitation of structures and the applications are more and more developed. That is due to the capacity of this new composite material (concretes reinforced by fibre) to limit and to control the cracks, to improve the flexural and tensile strengths as well as to improve the shock resistance.

For health and economic reasons the researchers are actually oriented toward the reinforcement of concretes by vegetal fibres, notably for countries that possess these fibres in big quantity.

The study examines the effects of Volume fraction and length of fibres, also the curing types on the durability of date palm fibres reinforced concrete. The specimens were initially cured in the laboratory for 24 hours under normal climatic conditions: T = 20±2°C, and HR = 100%. After demoulding, they were cured during 28 days in three-types of environment. For the first type of environment, fibre-concretes specimens were placed in water at temperature varied from 20 to 25°C. For the second type of environment, they were placed in the laboratory at 32±2°C and 28±2 of HR but covered by canvas of jute fibres and watered 02 times every day at 6 am and 12 pm. For the third type of environment, they were placed in ambient atmosphere under uncontrolled hot-dry climate with severe field conditions. During June the mean monthly maximum temperature was 40 ±.5°C. the mean monthly minimum temperature was 30 ±.5°C. The percentage of relative humidity varied between 25% to 55%.

The aim of this study is to investigate the properties of date palm fibres and concretes reinforced with these fibres in hot-dry climate. The objective of this work is then to improvement the mechanical performance of concrete. It also endeavours to examine the possibility for valorization of these based natural resources in local construction. The local natural resources used in this study are the date palm fibres from Ouargla south of Algeria to substitute the asbestos fibres that present a dangerous problem on the human health.

In this paper are presented the mechanical properties of concretes reinforced by these fibres, in Sahara environment. The durability of date palm fibres reinforced concretes is given by the variation as function of time of its flexural properties. We show that, in hot dry climate, it is possible to improve the durability of date palm fibres reinforced concretes by using an appropriate curing.

KEYWORDS Date palm fibres; Concrete; Mortar; Fibre-Cement; Curing; Hot Dry climate; Strength; Durability; Microstructure; toughness.

INTRODUCTION

The concrete is the material the more used in the construction, but its fragility remains a handicap of its mechanical behaviour, that is why it is armed with bars of steel taking constraints of traction. But instead of arming the concrete, and especially the thin pieces that pose problems of measurements and protective of armatures we can think about incorporating fibres in all the material. Indeed different nature fibres are used like reinforcement of several materials in order to increase their mechanical resistances and to improve their stability.

The use of fibres in the concrete became more and more a current practice and the applications are developed. That is due to the capacity of this new composite material to limit and to control the cracks, to improve the flexural and tensile strengths as well as to improve the shock resistance.

The objective of this work is then to improvement the mechanical performance of concrete and hence the utilisation of date palms fibre in material construction, it is also to substitute the asbestos fibres that present a dangerous problem on the human health. In this paper are presented the mechanical properties of concretes reinforced by these fibres, in different hygrometric environment.

EXPERIMENTAL PROCEDURES

Materials

The natural fibres used in this research are from the surface of the trunk of male date palm. The male date palm surfaces fibres (MDPSF) are naturally weaved, and are pulled out from trunk in the form of nearly rectangular mesh (300-500 mm length and 200-300 mm width) formed with three superposing layers. It is easy to separate them into individual fibres of diameter of 0.1-0.8 mm in water. Tables 1 shows the upper, lower, and mean physical properties of MDPSF as well as the coefficient of variation (CV), whereas Table 2 gives mechanical properties of MDPSF [1]. Comparatively to what is reported in literature the mechanical performance of more common vegetable fibres [2-3], the MDPSF have average tensile strength and a weak elasticity modulus.

The cement CPJ-CEM II/A 32.5 was used. Tables 3 give the physical and mechanical properties of this cement.

Natural sand with bulk density 1660 kg/m^3 and a crushed aggregate slice-lime stone with bulk density 1600 kg/m^3 are used.

Table 1. Physical properties of MDPSF [1]

PROPERTY	LOWER-UPPER	MEAN-CV (%)
Diameter (mm)	0.1- 0.8	0.45 - 54.43
Bulk density (kg/m^3)	512 -1089	900 -17.64
Absolute Density (kg/m^3)	1300 - 1450	1383 - 5.52
Natural moisture content (%)	9.5 -10.5	10 - 5.00
Water absorption after 5 mim (%) under water	60 - 84	74 - 14.02
Water absorption to saturation (%)	97 - 203	132.5 - 20.56

Table 2. Mechanical properties of MDPSF [1]

CONDITION	NATURAL			
Fibre type	Specimen's length (mm)	Tensile Strength (MPa)	Elongation (%)	Modulus of Elasticity (GPa)
MDPSF	100	170±40	16±3	4.74±2
	60	240±30	12±2	5.00±2
	20	290±20	11±2	5.25±3

Table 3. Physical and Mechanical properties of used cements

CEMENT	FINENESS (m^2/kg)	SETTING TIME (min)	σ_C 28 DAYS(MPa)
CPJ-CEM II/A 32.5	3100	200	30

Mixture proportion

For the mix design concrete without fibres, the experimental method recommended by Baron-Lesage [4] and Gorisse [5] was used to obtain the optimum ratio of sand upon aggregate. Otherwise, for all mixes of fibre-concretes, the mass of cement and sand was kept equal to that of concrete without fibres. The percentage of fibres was varied but the mass of fibres plus aggregates was maintained constant. The mass fraction of the fibre were 0.2, 0.3, 0.4, and 0.5%, the lengths of fibre was 20, 40, and 60 mm. The workability of all concrete with VB test time was 20±5 s. The table 4 shows the mixture proportion. The fibres were initially immersed in water until saturation to avoid the absorption of mix water by the fibres.

Table 4. Mixture proportion

Aggregate (Kg)	Sand (Kg)	Cement (Kg)	Water (L)	Water/Cement
1139.394	740.606	400	220	0.55

Curing conditions

The specimens were initially cured in the laboratory for 24 hours under normal climatic conditions: T = 20±2°C, and HR = 100%. After demoulding, they were cured during 28 days in three-types of environment. For the first type of environment, fibre-concretes specimens were placed in water at temperature varied from 20 to 25°C (referenced Curing 1). For the second type of environment, they were placed in the laboratory at 32±2°C and 28±2 of HR but covered by canvas of jute fibres and watered 02 times every day at 6 am and 12 pm, (referenced Curing 3). For the third type of environment, they were placed in ambient atmosphere under uncontrolled hot-dry climate (referenced Curing 2) with severe field conditions. During June the mean monthly maximum temperature was 40 ±.5°C. the mean monthly minimum temperature was 30 ±.5°C. The percentage of relative humidity varied between 25% to 55%.

Speciments fabrication

Specimens of concrete with dimensions 70x70x280 mm were used for the bending 4 points tests. The test of bending in four-points test configuration, with 210 mm span is achieved on a device of bending CONTROLS type functioning with a hydraulic pressure system. The unit is composed appropriate in charge of a rigid structure supporting two supports. The range can be to adjust with precision while displacing supports toward the outside or toward the inside. The stake is achieved in charge by hydraulic pressure that makes displace the superior part downwards until contact with the device of loading situated superior in part of the specimens to the centre of supports.

Test methods

The strain of traction by bending test (σ_f) was determined using the equation 1 [6]

$$\sigma_f = 3.6\ M/bd^2 \qquad (1)$$

Where M is the failure moment of the test specimen and b and d are the width and depth of the specimen respectively

RESULTS AND DISCUSSIONS

The Table 5 and the figures 1, 2 and 3 show the variation of the strain of traction by bending test as function of mass fraction and length of fibres in different environment of cure.
According the results we show that the resistance to bending increases with the increase of length of fibres, but the maximum strain of traction was obtained by 0.4 % in mass fraction.
It is owed to the adhesion mainly stamps - fibres and has the possibility to stop cracks by fibres. One also notices a reduction of the resistance to the bending of specimens preserved to the free air in relation to specimens covered by canvas of jute or those preserved in water, This reduction is essentially owed to the big porosity of the material generated by the fast departure of the wastage water that influences on the formation of cement hydrates [3][4][5][6]. Curing 3 have a good effect on the strain of traction.

Table 5. Variations of the strain of traction according to the % in mass of fibre and for different lengths and different environment of cure at 28 days.

	Mass fraction	0	0.2	0.3	0.4	0.5
Length	environment	Middle strain of traction in MPa				
(mm)	C1	2.08	2.09	2.13	2.19	2.14
2 0	C2	2.02	2.08	2.09	2.13	2.10
	C3	1.59	1.60	1.67	1.70	1.68
	C1	2.08	2.10	2.14	2.24	2.20
4 0	C2	2.02	2.06	2.10	2.17	2.13
	C3	1.59	1.62	1.69	1.73	1.71
	C1	2.08	2.12	2.24	2.39	2.31
6 0	C2	2.02	2.08	2.17	2.24	2.19
	C3	1.59	1.65	1.71	1.78	1.76

With: C1: Curing 1; C2: Curing 2 and C3: curing 3

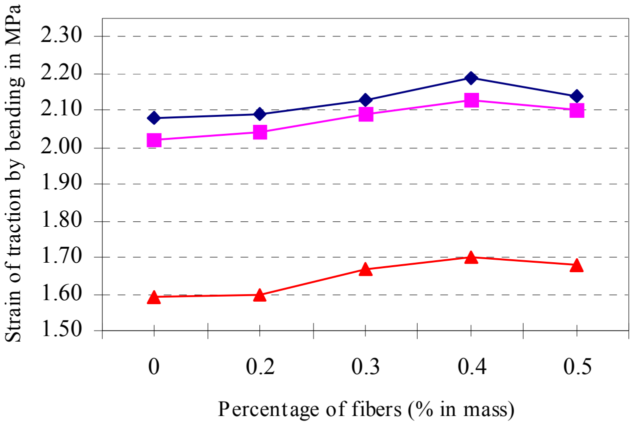

Fig. 1. Strain of traction as function of curing type and mass fraction of fibre; length of fibre = 20mm

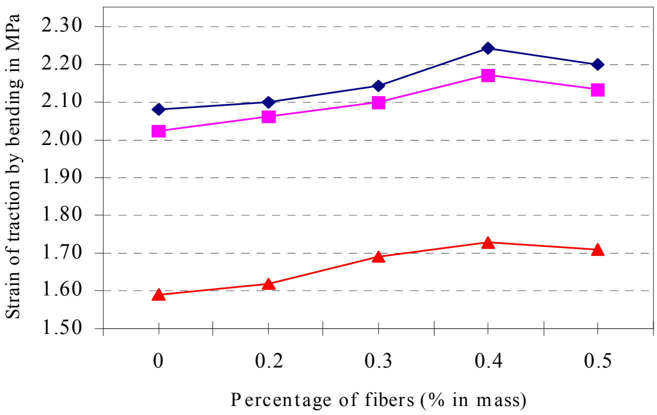

Fig. 2. Strain of traction as function of curing type and mass fraction of fibre; length of fibre = 40mm

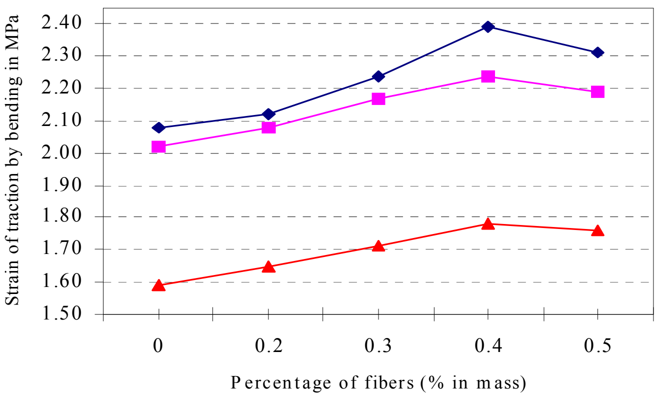

Fig. 3. Strain of traction as function of curing type and mass fraction of fibre; length of fibre = 60mm

C1: ; C2 : ; C3:

CONCLUSION

The addition of fibres in concrete changes behaviour rheological of this last completely and improve the mechanical features of the material considerably. The experimental results of the resistance to the bending of date palm reinforced concretes testify the biggest efficiency of fibres well for this type of solicitation. The resistance to the bending of concretes of plant fibres of palm increases with the increase of the fibre percentage and with their lengths. Therefore the plant fibre addition is beneficial on the resistance to bending.

In addition, one notice that the fall of the resistance in bending of specimens preserved in the free air is owed to the big porosity of the resulting concrete of the fast departure of the wastage water that is bothersome for the formation of cement hydrates mainly.

In the same way the procedure to cover concrete specimen's by canvas of jute and to water them per day 02 times is beneficial to prevent the fast departure of water and kept the concrete therefore to compactness close to the one preserved in water

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