STRUCTURAL AND RHEOLOGICAL CHARACTERIZATION OF VEGETABLE FIBERS REINFORCED CONCRETE PLASTER

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ABSTRACT

The present study considers the incorporation of the aggregates (sand, gravel) and a product of reinforcement (vegetable fibers of the palm trees) in the plaster, whose principal objective is the formulation of an air concrete which can replace the hydraulic concretes in certain uses and applications, while changing its brittle behavior of traction like any hydraulic binder. The analysis of the results shows that the vegetable fibers incorporated change completely the rheological behavior of material and increase considerably its flexural strength and its ductility, by improving its threshold of cracking. The mode of rupture of the composite depends on the length of fibers used.

1 INTRODUCTION

The incorporation of fibers in the plaster is realized in order to improve its tensile strength and to decrease its brittleness. The important assumption is that the fibers allow the stopping of the mechanism of cracking, by delaying the departure of the crack and by controlling it once that it appears. The addition of fibers in a concrete changes completely the rheological behavior of the fresh mixture. The studies made by Gutt [1] show that the fall of workability for a fiber concrete is all the more important when the report/ratio l/d (length / diameter) of fibers and the diameter of the gross aggregates are large and that the percentage of fibers is high. Concerning the mechanical properties of the fiber concretes, Nagaraja and Jawaharlal [2] has noted that the flexural strength of a concrete reinforced with vegetable fibers (bamboo) increases for various percentages by mass from 1% to 3%, then decreases for 4%. Khenfer and Morlier [3] showed from the study of the effect of length of fibers on the mechanical properties of cements reinforced with cellulose fibers that the modulus of elasticity depends only on the Young modulus of the components, their volumes and the distribution of fibers in the matrix. The studies [4] made on composites reinforced by various lengths of cellulose fibers shows that the energy of rupture grows with the increase lengths of fibers, it can reach 40 times of the matrix, when the mass of fibers is 10% by weight of the composite. In the present study and taking into account the parameter related to fibers such as their proportioning and their geometry on the mechanical effectiveness after hardening, we have tried to study the influence of the percentage by weight and length of fibers of the palm trees on the workability and the mechanical behavior of plaster concretes. The mechanical properties and physical are given by experiments and compared to the theoretical evaluations.

2. EXPERIMENTAL DETAILS

2.1 Fibers used

The fibers used are vegetable fibers of the snap rings of the palm trees from the area of Laghouat (Algeria) with negligible cost and a renewable source. These fibers have a clear brown color and a renewable source.

These fibers have a clear brown color and a circular cross section with a varying diameter from 0,20 to 0,70 mm, a density of (1540 ± 0,01) kg/m^3 and rate humidity (10±0,02) %. the lengths of fibers used, in this study, are respectively 10, 20, 30 and 40 mm. A chemical analysis and a study of the microstructure of fibers used were undertaken by electron microscope with sweeping at the institute of Pine of Bordeaux in France, by M.M Khenfer. The results obtained show the presence of oxygen and carbon atoms with an important percentage atomic compared to the other elements and that carbon is the most dominating element, which affirms the presence of the carboxylic groups coming from the components of cellulose.

2.2 Formulation of the composite

By using the basis composition of the plaster concrete given as an indication in the technical regulation of the building with plaster in Algeria C.N.E.R.I.B [5] and being based on the method of Baron-Lesage [6, 7, 8] adapted by Rossi [9], for the formulation of the metal fiber concretes, we try to determine the optimal granular composition while basing on the criterion of the good maneuverability. According to Gorisse [10], we fix a corresponding maneuverability to a variable settling between 6 and 9 cm, maneuverability wished for settling up for the structure concrete on building. The basis composition of the plaster concretes used and given by [5] is as follows: 5

- ❖ Plaster : 40 kg ;
- ❖ Grinding Gravel 5/15 : 60 - 80 kg;
- ❖ Extinct lime : 1- 1,5 kg ;
- ❖ Water : 16 - 24 L.

In the objective to determine the optimal granular composition of the Plaster concretes without fibers, we have proceeded by the following stages:

- We fix the report ratio E/P = 0,60 which is equal to the rate of mixing with saturation of the plaster.
- We vary the report ratio S/G while taking account of the S/P ratio fixed and equal to 0,50 by weight.

From the basis composition of the plaster concrete, we must keep all the proportions of (plaster, water, sand) and we vary the dosage of gravel from 60 to 80 kg with a step of 5 kg, we get the following reports/ratios S/G respectively: 0,33, 0,31, 0,29, 0,27and 0,25. For each percentage and each length of incorporated fibers, we measure the maneuverability by settling with the slump test for various S/G ratios. Concerning the admixture of the fiber concrete, we followed a method recommended by the Committee 544 A.C.I [11] and which consists in first of all mixing the gravel, sand, fibers then we add the plaster and water. As retardator of setting, we have used 6 % of extinct lime in water which gives a sufficient time for the implementation of the plaster concretes with fibers. The final product is versed in prismatic metal moulds with dimension 10x10x50 cm^3 for deflection four points and half prisms and the prism of 4x4x16 cm^3 for the test of compression [12] and for the determination of the density and the absorption of water. The moulds are placed on a mobile table for a few seconds to ensure a good distribution and a correct orientation of fibers in the matrix, and a good compactness of the composite. The specimens were unmoulded 24 hours afterwards, and then they were conditioned in the ambient air of the laboratory until 28 days age.

3. TESTING METHODS

The mechanical tests have been done on the same apparatus of the triaxial type with three scales of capacity 10, 20 and 50kN. The deflection is measured using an incremental position sensor in the medium of the lower face of the specimens. To be able to plot the curve load-displacement, the speed of the test of bending four is maintained constant and equal to 2 mm / min [13, 14]. The Young modulus is calculated by the slope of the curve load -displacement. The static energy of rupture is determined by the area under the curve load - displacement divided by the section of the specimens. The results of the density and absorption of water are obtained by weighing of the gypsum concrete specimens with fibers, after drying and immersion in water until stabilization of their weight; each measure is relative to six similar tests.

4. PRESENTATION AND COMMENT OF THE RESULTS

4.1 Influence of percentage and length of fibers on the optimal granular composition and the maneuverability

The maneuverability decreases when the dosage of fibers increases. This point has been mentioned in literature [15] and observed also during the mixture of our fiber concretes by the apparition of fiber winds and therefore a fall of maneuverability registered at the test of Abrams cone. Finally, what has been shown according to the fig.6 witch gives the variation of the maneuverability according to the percentage and the length of fibers, that the maneuverability decreases when the mass fraction of fibers increases, what it is can be explained by the fact that fibers play the same role like the gross granulates, that is to say when the content of the granulates increases, the maneuverability decreases. It is also shown on the same figure that the maneuverability decreases with the increase of the fiber length, it is due that fibers with the important length tend to tangle, therefore a weak maneuverability. In addition, the shape of fibers very stretched out, create rubbing that confer to the mixture an artificial cohesion and increase of the emptiness volume, what influences on the maneuverability and on the compactness of the concrete [14].

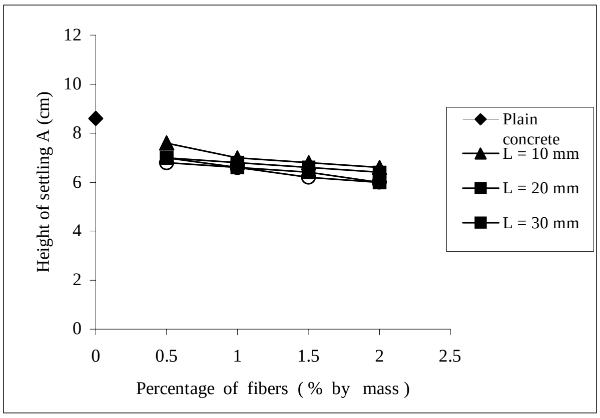

Figure 6: Influence of the percentage and the length of fibers on the maneuverability of the plaster concrete

4.2 Influence of percentage and the length of fibers on the mechanical and physical properties of the plaster concrete

The results of the variation of the mechanical and physical properties of specimens of the plaster concrete rein forced by various dosages of fibers with different length are presented in curves below.

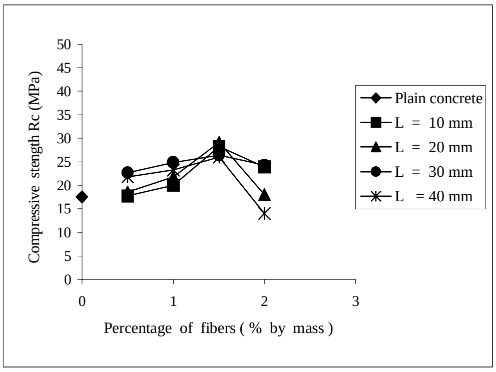

Figure 7: Variation of the compressive strength of plaster concretes with the dosage of fibers for different lengths.

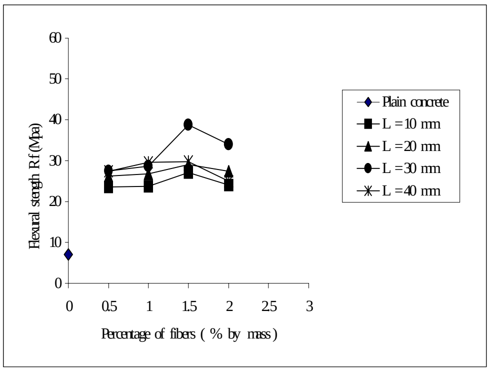

Figure 8: Variation of the flexural strength of plaster concretes with the dosage of fibers for different lengths

We remark according to the fig.7, that the compressive strength of the fibrous plaster concretes grows with the increase of dosage by mass of fibers, and in relation with the plain concrete until the value of 1,5 % of fibers, then it fall, it is owed to a bad maneuverability because of an excess of fibers in the matrix. We can also say that the addition of fibers disrupts the mineral skeleton of the concrete while creating emptiness inside the matrix and while increasing its porosity, witch gives a minimal strength. These observations are in agreement with most research done for different fibers concretes studied [16]. According to the fig. 8, we clearly notice that the flexural strength increase considerably with dosage and length of fibers. A clean improvement for different lengths is gotten for dosage of 1,5 % of fibers for 30mm length. After, a fall of the flexural strength is recorded for dosage of 2 % of fibers, what can always be translated by a loss of maneuverability that is owed to an excess of fibers and bad distribution of fibers in the matrix while increasing the porosity of the material and therefore a reduction of the flexural strength.

The figure 9 shows that the module of Young stay appreciably constant and it doesn't depend on the length of the reinforcing fibers used, on the other hand it grows with the increase of dosage of fibers. This point has already been mentioned in the literature, the module of Young only depends on the modules of the constituents, their volumes and their distribution in the matrix and justified by works [3].

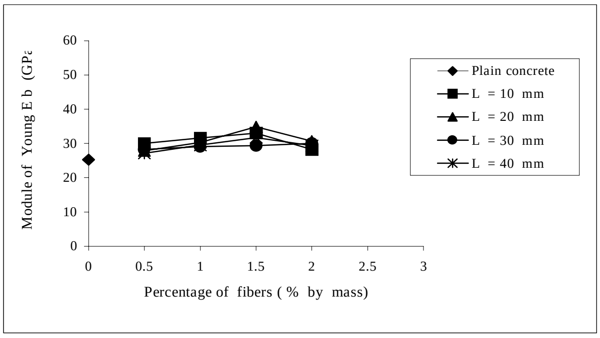

Figure 9: Variation of the module of Young strength of plaster concretes with the dosage of fibers for different lengths.

While examining the curves load-displacement for 1,5 % of fibers (optimal mass fraction) for different lengths fig.10, we note that the ductility of the composite is as much better when the length of fibers is important.

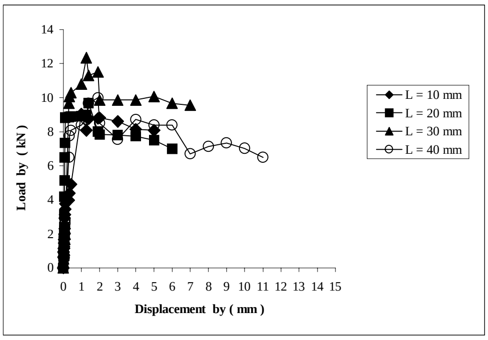

Figure10: Influence of the fiber length on the mechanical behavior of plaster

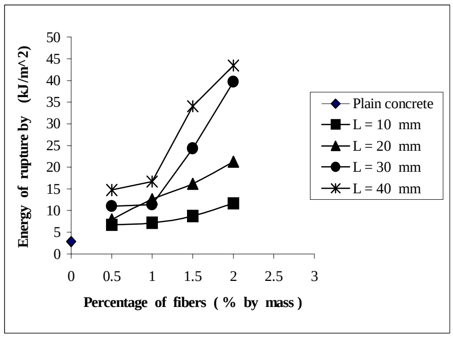

Figure11: Variation of the energy of Rupture of plaster concrete with the dosage of fibers for different lengths

According to the fig.11, we remark that the energy of rupture grows with the increase of the length and the dosage of the reinforcing fiber. That can be explained by the fact that the dissipation of the energy by the fiber will be as much bigger when rubbing will be important and therefore the plasticization of the fiber will be done on the important length, that ensure a neat improvement of fibers with a length of 40 mm.

5. CONCLUSIONS

The survey of the effect of the length and the dosage of fibers on the mechanical and physical properties of plaster concretes reinforced with the plant fibers of palm trees shows that :

The method of formulation of plaster concretes, reinforced with the fibers of palm trees, didn't drive us to make the optimization of mixture like that was the case of concretes of metallic fibers cement, a light vibration seems sufficient to have manageable and compact fiber concretes with a good orientation of fibers in the matrix. The compressive strength grows with the increase of the dosage of fibers used and decreases for certain elevated percentage and important fiber lengths because of a bad stake in work. The dosage and the length of fibers increase considerably the flexural strength, a neat improvement is the order of 5,5 times bigger than the one gotten for the plain plaster concrete (without fibers). The energy of rupture grows with the increase of the length and dosage, it is as much better for the fibers with important lengths where a good ductility of the composite. The module of Young varies appreciably with the dosage of fibers and it doesn't depend on the length of fibers.

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