THE STUDY OF THE PHYSICO MECHANICAL BEHAVIOUR OF A CONCRETE WITH LIMESTONE SAND RENFORCED BY SYNTHETIC FIBERS

Bendjillali Khadra[1] *, Goual M.Sayeh[1], Chemrouk Mohamed[2], Damene Zineb[1]

[1] Laboratory of Civil Engineering, University Amar Telidji, Laghouat, Algeria.
[2] Department of Civil Engineering, USTHB, Algiers-Algeria
* Email: k.bendjillali@mail.lagh-univ.dz

Abstract

Laghouat region (situated in the south Algeria) is among the parts of Algeria which have a large natural limestone deposit, which extends over the totality of the southern side of the Saharan Atlas. The exploitation of this material in the industry of coarse aggregates generates significant amounts of fine residues, currently badly or less exploited and meanwhile causes harm to the environment. In order to valorise this waste material and met the environmental requirements, the idea is to exploit these residues as limestone fine aggregate for concrete. Beside for enhancing the mechanical properties of concrete and exploit polypropylene fibres wastes resulting from the industry of brushes and sweep domestic, we decide to incorporate them in the limestone mortar.

The study of the physical and mechanical properties of the limestone mortars reinforced by polypropylene fibres are presented in this article, with fibre content percentage varies between 0.5 and 4 wt%. In view of results obtained, we advance that the workability of limestone mortars is inversely influenced by the percentage content and the ratio l/d of polypropylene fibre, while their mechanical properties are generally enhanced.

Key-words: Valorisation, Limestone Sand, Fibre, Reinforced Concrete, workability, Mechanical proprieties.

1. Introduction

Natural siliceous sand becomes progressively exhausted in many regions of the country and it is totally inexistent in others. However, millions of tons of fine aggregates with diameter less than 3mm produced from the crushing stations of limestone rocks are accumulated in the nature, and constitute a true environmental problem.

The objective of this study is the valorisation of this limestone waste by using it as fine sand for concrete mixes and hence replaces the river sand. On the other hand to resolve the problem of concrete cracks, which occur generally in the matrix (in mortar), the idea to incorporate fibers in the limestone concrete, appears very interesting. In spite of the many researches elaborated on the fiber reinforced concrete, it is still incapable to replace the hydraulic concrete due to its high cost and difficulties associated with its implementation. The cost price can be largely reduced if the used fibers are recuperated from waste materials. Fibers used in this study are polypropylene fibers resulting from waste of the fabricating of brushes and sweeps domestics. Due to their low weight, high deformation rate and does not react with cement elements, the polypropylene fibers are among the most used one for concrete reinforcement. In this research we studied the effect of synthetic fibers on the physical and mechanical behaviour of mortars prepared based on limestone sand.

2. Experimental Techniques

2.1. Properties of Materials

2.1.1. Sand

The sand used was limestone natural crushing sand with maximum diameter of 2mm, which results from the station of crushing of Ouazane situated in the North of the commune of Laghouat. The table1 gives the physical proprieties of the limestone sand.

Table.1: Physical proprieties of limestone sand

Relative Density	Finesse Modulus (Mf)	Sand Equivalent (ES)	Absorption (%)
2,52	1,8	63	2,5

Figures 1 and 2 illustrated the results of the grains size distribution and mineralogical analysis made on the limestone sand respectively.

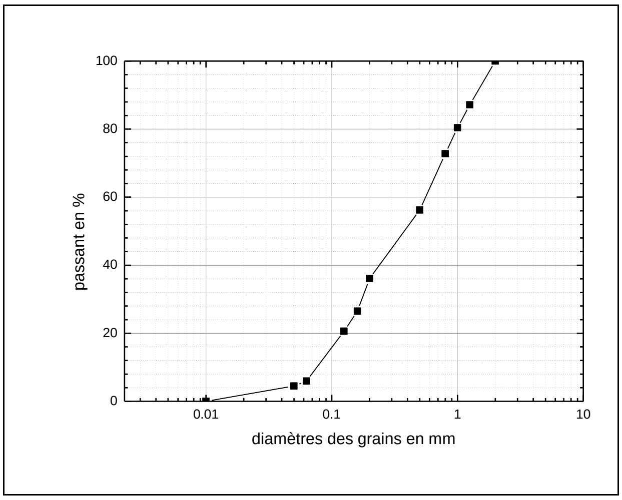

Figure.1: Grains size distribution of the limestone sand.

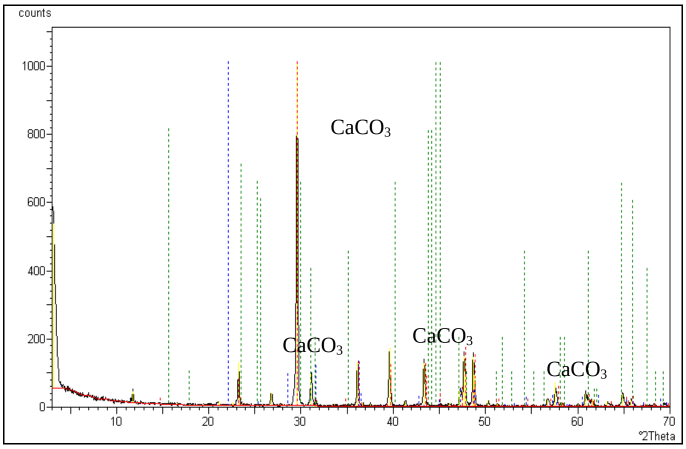

Figure.2: Mineralogical analysis of the limestone sand.

2.1.2. Cement

The cement used was Portland Cement consisted of class 42,5 with a specific gravity of the order of 3 g/cm^3 and a specific surface of 3200 cm^2/g. The chemical composition of cement is given in table 2.

Table.2: Chemical composition of cement

Component	SiO_2	CaO	AL_2l_3	Fe_2O_3	MgO	SO_3	K_2O	NaO_2	CaO
Ratio (%)	21,94	65,9	4,82	3,94	1,65	0,98	0,6	0,1	0,02

2.1.3. Fibres

Synthetic fibers introduced into the matrix were the polypropylene fibers resulting from waste of fabricating of domestic sweeps and brushes; their proprieties are given in table 3.

Table.3: Proprieties of polypropylene fibers

Length (mm)	Diameter (mm)	Specific Gravity	Absorption (%)	Tensile Strength (Mpa)	Deformation (%)
10- 20-30	0,62	1	0	86	58

2.2. Composition, Preparation, and Tests

The proportions by weight of the mortar mixture were 1:3 cement and sand, respectively. Water/cement ratio was found equal to 0.78 by test of workability. Polypropylene fibers were introduced in content percentages from 0.5 to 4 wt %. The measure of workability was made according to the French Standard NFP 18-452. Prismatic specimens (4×4x16cm) were prepared, demoulded after 24 hours of casting and then cured in water in 20C° until testing. The mechanical strength (flexural tensile strength through a three points and compressive strength) were determined according to the French Standard EN196-1.

3. Results and discussion

3.1. Workability

According to the figure 3, the introduction of polypropylene fibers was a negative effect on the workability of limestone mortars, this result was confirmed by the majority of reinforced concrete studies (Hashem and al, 2002) and (Belferrag, 2006). It can also notice that the incorporation of more than 1% of polypropylene fibers in limestone mortar present a large reduction in the workability, while (Edgington and al, 1974) recommends 2 % maximum steel fibers content. In another study (Chemrouk and al, 2006), a volume of 1% of steel fibers seemed to be a reasonable one for high performance concrete reinforced with steel fibers.

By increasing the ratio l/d of polypropylene fibers, the workability of mortars decreases. Nevertheless that the effect of the ratio l/d of fibers is less important than the effect of their content percentage.

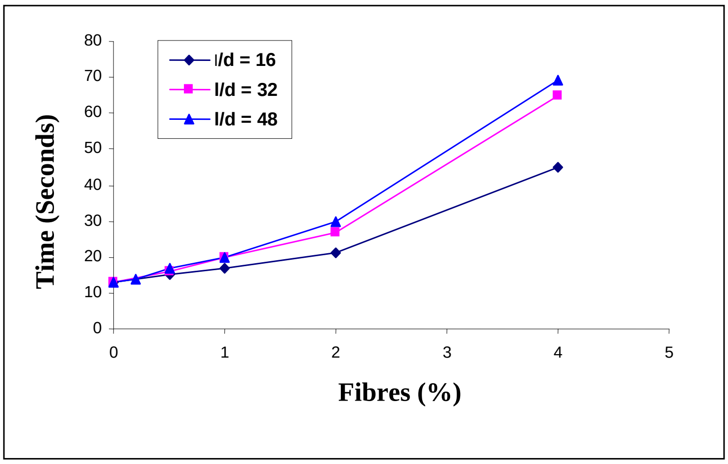

Figure.3: Effect of fibers addition in workability of limestone mortar

3.2. Flexural tensile strength

The figure 4 shows that the flexural tensile strength evolves with the content percentage and with the ratio l/d of the polypropylene fibers. This evolution is much more appreciated beyond 2 % of fibers; this is justified by the beneficial role of fibers to prevent cracks. Below 2 %, the effect is insignificant.

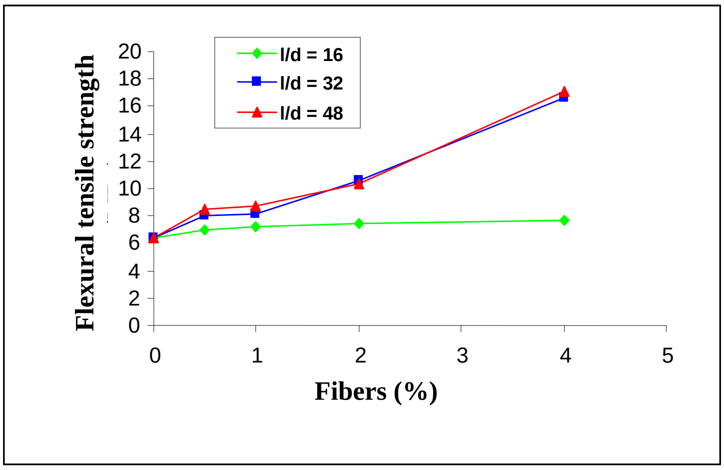

Figure.4: Behaviour to the flexural tensile strength of reinforced mortars

According to the figure 5, introduction of polypropylene fibers with ratio l/d = 32 and 48 into mortars confers them the same improvement in the tensile strength. This improvement possess between 26 % for 0.5 % and 162 % for 4 % of fibers in mortars reinforced by fibers with l/d = 32 and between 34 % for 0.5 % and 170 % for 4 % of fibers in mortars reinforced by fibers with l/d = 48.

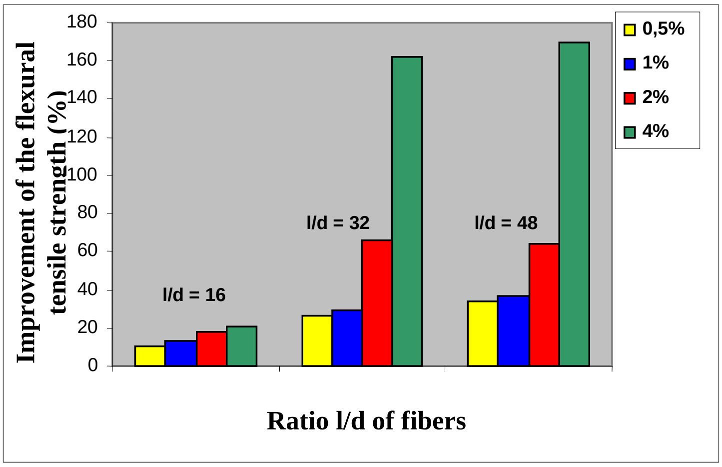

Figure.5: The improvement of the flexural tensile strength of reinforced mortars compared to that of mortars without fibers

3.3. Compressive strength

By examining the figure 6, we notice that the compressive strength is an increasing function with the amount of polypropylene fibers and with the ratio l/d also.

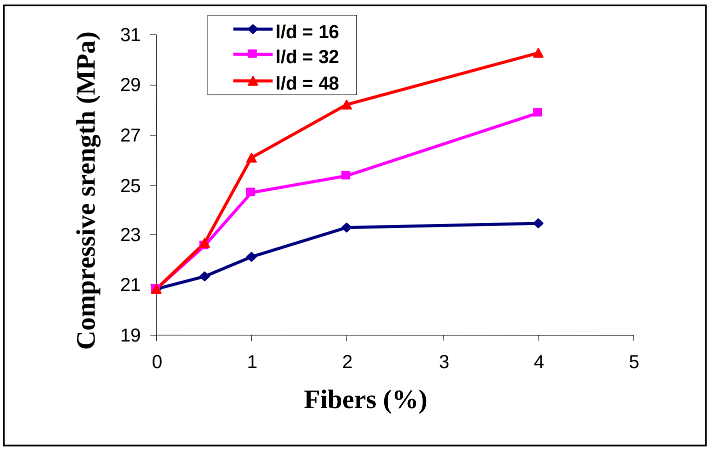

Figure.6: Behaviour to compressive strength of reinforced mortars

According to the figure 7 we can see that the improvement of the compressive strength compared to that of mortars without fibers is much weaker than this found in the flexural tensile strength. In mortars reinforced by 0.5 % of fibers with l/d = 48 for example, the compressive strength is improved by more than 7%, while the introduction of 4% of fibers with the same ratio l/d increases this rate beyond 45%. Nevertheless that the majority of the researches realized on reinforced concretes indicated that had no or a small evolution of the compressive strength (Ait Tahar, 2000), (Benamara and Redjel, 2003) and (García-Santo and al, 2005). These authors justified this decrease by the bad homogeneity of the concrete, by the high ratio of water or by the weak compactness of the concrete caused by the excess of fibers. But a recent study elaborated on the concrete of sand reinforced by metallic fibers noticed a significant improvement on the compressive strength (Belferrag, 2006).

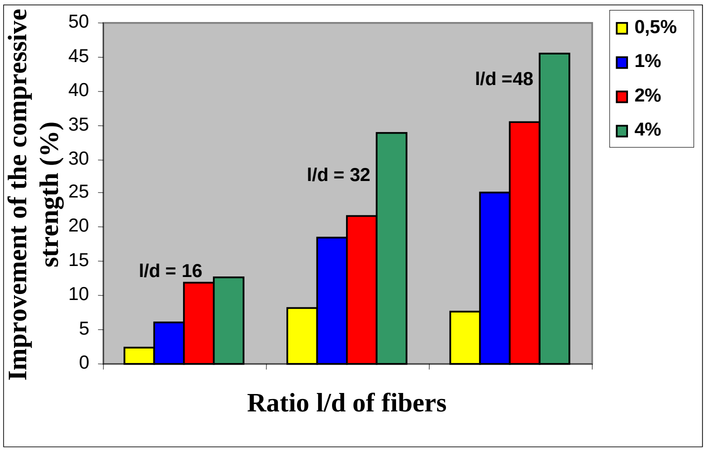

Figure.7: The improvement of the compressive strength of reinforced mortars compared to that of mortars without fibers

4. Conclusion

From this study, we were able to make the following conclusions:

* Incorporation of the polypropylene fibers in limestone mortars engenders a decrease of the workability.

* Beyond 1 % of polypropylene fibers, the addition of a plasticizing additive is a necessity to have a workable mortar.

* The role of the ratio l/d of the polypropylene fibers on the workability of limestone mortars has only a secondary role with regard to the role of their content percentage.

* Using synthetic fibers of polypropylene as element of reinforcement into limestone mortars produces a significant increment of their flexural tensile strength.

* Reinforcement of limestone mortars by polypropylene fibers confers them a small improvement of their compressive strength.

* Synthetic fibers presented a high strength to the tearing of the matrix.

* Beyond 2 % fibres, the test specimens crushed with tensile and compressive remained just fissured, in spite of the increase in the load.

5. Bibliography

Ait Tahar.K, 2000. “Etude expérimentale des poutres combinées en béton de fibres”. Annales du Bâtiment et des travaux publics, Série Bimestrielle, N° 3.

Belferrag.A, 2006. “Valorisation des fibres métalliques issues des déchets pneumatiques dans les bétons de sable de dunes”. Thèse de Magister, Université de Ouargla.

Benamara.D and Redjel.B, 2003. “Effet de l’incorporation de fibres métalliques sur le comportement mécanique du béton de sable à base d’un sable de dune”. Proceeding.Seminaire National de Génie Civil, Oran, 28-29Jan. Tome1, pp16-22.

Chemrouk.M, Boulekbache.B, Hamrat.M and Tahemi.T, 2006. “Steel fibre High Strength Concrete containing industrial by products as mineral additives”. Proceeding du 5eme Séminaire sur les Technologies du béton: “Le Béton, Construire Modern, Durable et Esthétique”, 25-26Oct, Alger.

Edgington.J, Hannant.D.J and Williams.R.I.T, 1974. “Steel fiber reinforced concrete”. Building Research Establishment, G.B, Current Paper, 17, CP 69/74.

García-Santo.A, Rincón.J.Ma, Romero.M. and Talero.R, 2005. “Characterization of a polypropylene fibered cement composite using ESEM, FESEM and mechanical testing”, Construction and Building Material, N° 19, pp396-403.

Hashem.M.A, Al-Mattarneh. and Zakiah.A, 2002. “Characterization of Natural Fibre Concrete using Destructive and Non-Destructive Testing Methods”. The 6th International Conference on Concrete Technology for Developing Countries, 21-24 October Amman- Jordan, pp551-560.