Construction and Building Materials 115 (2016) 464–477

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Improvement of the properties of a sand concrete containing barley straws – Treatment of the barley straws

M. Bederina [a,*], B. Belhadj [a], M.S. Ammari [a], A. Gouilleux [b], Z. Makhloufi [a], N. Montrelay [b], M. Quéneudéc [b]

[a] Structures Rehabilitation and Materials Laboratory, University A. Telidji, Laghouat, Algeria
[b] Research Unit EPROAD, University of Picardie Jules Verne, Amiens, France

HIGHLIGHTS

- Improvement of the properties of a sand concrete containing barley straws.
- The four selected treatments improved all the properties of the barley straw.
- The treated barley straws improved almost all the properties of the sand concrete.
- The hot water seems to be the best treatment followed by the varnish treatment.

ARTICLE INFO

Article history:
Received 4 March 2016
Received in revised form 18 April 2016
Accepted 18 April 2016

Keywords:
Sand concrete
Lightweight concrete
Barley straw
Treatment
Physico-mechanical properties
Thermal properties
Shrinkage
Microstructure

ABSTRACT

This work goes within the framework of the valorization of local materials and wastes, such as dune sand, barley straws and aggregate crushing waste. In this context, barley straws have been incorporated in a sand concrete in previous works in order to develop a new lightweight concrete and interesting results have been obtained. However a decrease in the mechanical strength and an increase in the dimensional variations have been recorded. The main objective of the present work is therefore to solve these problems. Indeed, it consists in improving the properties of the barley straws by applying different treatments before using them in order to improve the properties of the optimum composition of the studied lightweight concrete (15 kg/m^3 of barley straws). Among several treatments tested, four treatments have proved effective and therefore have been selected for the continuation of this study: the hot water, the gasoil, the varnish and the waste oil. These treatments adhere well to the outer surface of the barley straw and significantly increase its tensile strength without changing much of its mass and dimensions. Introduced in the sand concrete, the straws treated with the hot water gave good improvements in the flexural strength of the composite, they did not change much its density and its thermal characteristics remained acceptable. However, the gasoil was the most effective in reducing the shrinkage of the studied concrete, but no marked improvements in the other properties have been recorded. As to the varnish, this product improved most of the characteristics of the studied concrete, but the rates of increase were lower than those recorded in other treatments. Finally, it should be noted that the waste oil gave relatively good compressive and thermal results, acceptable flexural characteristics, but a high shrinkage and density.

1. Introduction

The orientation of the current research towards the development of eco-materials and their use in the construction field constitutes an environmental and sustainable approach which has an economical, technical and environmental interest. In addition to potential economic and technical interests in construction, this approach aims to limit greenhouse gas emissions, conserve natural resources, protect health, increase the comfort level, etc. [1].

The cement, for example, which is a primary constituent in the production of concrete, its demand currently increases from one year to another. This situation increases the concern of the specialists in the construction industry. However, the production of cement needs large quantities of raw materials and energy and at the same time releases an important quantity of CO_2 (coming from both the industrial process and the fuel combustion) into

* Corresponding author at: Civil Engineering Department, University Amar Telidji, BP 37G Laghouat, 03000, Algeria.
E-mail addresses: mdbederina@yahoo.com, m.bederina@mail.lagh-univ.dz (M. Bederina).

http://dx.doi.org/10.1016/j.conbuildmat.2016.04.065
0950-0618/

the atmosphere; which leads not only to more exploitation of natural resources but also to a higher rate of pollution.

In order to limit the CO_2 emission, the current researches tend to reduce the demand of cement by using mineral additions as partial cement replacement in concrete [2].

Moreover, the valorisation of local materials as well as the recycling of industrial wastes can solve a threefold problem: economical, technological and environmental problems. Indeed, this can improve certain performances and behavior of materials, minimize their expenses and reduce the energy consumption [3]. It is within this context that the present study has been led. A new composite has been developed by valorising different local materials and wastes such as the dune sand, the limestone fillers obtained from crushing aggregate waste, barley straws and some treatment product such as the engine oil.

Indeed, the barley straws have been already incorporated in sand concretes in order to develop a new lightweight concrete and significant results have been found, especially with regard to lightness, flexural strength and thermal insulation [4–7]. Nevertheless, high shrinkage and low mechanical strengths have been recorded [7]. The present work aims to solve these problems and even to improve other properties. For this, different treatments are considered and applied to the used barley straws.

Let us note that the barley straw is a lignocellulosic material which is abundant, as everywhere in the world, in the city of Laghouat (an arid region located south of Algeria). This material, which is an ecological material, is characterized by a renewable nature, an important lightness and a good thermal insulation [8]. Its reuse in construction is possible and could contribute to the realization of a sustainable and ecological construction. It should be noted that several studies have been performed in this context and many lignocellulosic materials have been incorporated in different matrices [5,9,10]. Regarding the straws, Bouhicha et al. used barley straws for the reinforcement of soil composites [11], Soroushian et al. used wheat straws for the preparation of a cementitious composite [12], Ashour et al. used both wheat and barley straws in earth plaster [13] and Yang et al. used rice straws fibers in composites [14]. As regards to Li et al. used hemp fibers in a cementitious composite [15]. Regarding the other lignocellulosic materials, Nozahic et al. used hemp fibers and sunflower rods [14] and Merta et al. used hemp fibers and elephant grass and wheat straw [15]. In all these study cases, encouraging results had been obtained.

The present work goes in the same way and has as a main objective the application of different treatments to the barley straws before their use in order to improve certain of the properties of the sand concrete. Let us note that according to literature, the treatments that can be applied to lignocellulosic materials [16–22] can be classified as follow:

(a) Physical treatments as for example an interface coating;
(b) Thermal treatments which generally consist of modifying the material chemical structure by the action of heat.
(c) Chemical treatments which generally consist of modifying the chemical structure of the material by the action of chemical products.
(d) Mixed treatments which can be made using two or more techniques of the previous treatments.

In the field of building materials, many types of treatments have been used by different authors. Bederina et al. used surface coating with cement, lime and cement-lime paste for wood shavings [16,22]. While Sellami et al. used two types of treatments to coat diss-based fibers, the first one consists of extracting sugars by distillation from Diss-fibers (extraction of the soluble substances) and the second consists in waterproofing boiled and washed Diss fibers to prevent water absorption (reduction in the rate of absorption) [23]. Jennifer et al. indicated that certain chemical treatments react better with different wood fiber types resulting in selected mechanical property enhancement [24]. Practically, all these treatments led to good results.

Moreover, it should be also noted that a cement replacement by three mineral additions was also used in this work which constitutes another economical and environmental aspect.

Finally, the main objective of the present work is to improve the physicomechanical properties of the barley straw sand concrete based on barley straws and to solve the problems posed by the use of untreated straws [7,10] using different treatments. So, on the basis of the previous works, we are going to attempt to apply different treatments to the barley straws before their use and assess their efficiency on the properties of the studied lightweight sand concrete.

2. Materials and experimental methods

2.1. Raw materials

The studied composite consists of sand concrete (sand, cement, fillers, water and admixtures [25–28] as a matrix and barley straws as inclusions. All components used for the development of this composite are characterized hereafter.

2.1.1. Sand

A river-dune sand (RDS: 0/5 mm) prepared by correcting the fine part of a river sand (RS: 0/5 mm) by a dune sand (DS: 0/0.63 mm) according to a mass ratio (RS/DS) = 1.7 [20].

RDS has a continuous particle size distribution with a fraction of the fine elements below 5% (Fig. 1) and their grains which seem to be rounded. It is also of a siliceous nature since X-ray diffraction analysis has been conducted on both RS and DS, and has demonstrated their essentially siliceous nature [16,28]. Moreover, the used sand is very clean which is shown by the obtained high values of the "Sand Equivalent". All the obtained physical characteristics of the used sand (RDS) are grouped in Table 1.

2.1.2. Cement

The binder used for the development of the studied composite is Portland limestone cement (CPL) of the type CPJ CEM/II A-L 42.5 R. It is a new class of cement that provides a similar performance to that of the conventional Portland cement but emits 10 times less CO_2. Its apparent and specific densities are 1030 kg/m^3 and 3030 kg/m^3 respectively and its Blaine specific surface area is 444.9 m^2/kg [7,10]. Its chemical analysis is shown in Table 2.

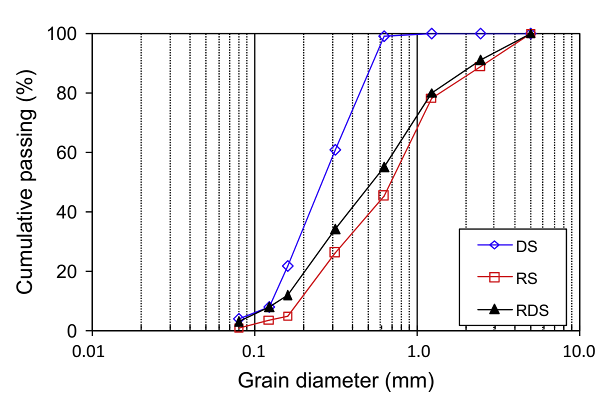

Fig. 1. Particle size distribution of used sands.