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Characterization of a lightweight concrete with sunflower aggregates

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Abstract

The present study aim to develop an ecological and innovative material in the buildings area. Nowadays, the use of plant aggregates for sustainable development of building materials is a requirement for reducing the effect of pollution generated by the heating or cooling of buildings. Among vegetable aggregates, those obtained from sunflower stems were documented to sustain the obtaining of an ecological concrete with improved thermal and acoustical properties.

In this research were obtained different variants of ecological concrete based on sunflower stalks as a partial replacement for mineral aggregates. There were determined the density and the mechanical properties of three variants of lightweight concrete comparatively to a reference concrete (RC) made with traditional sand and river gravel aggregates.

The obtained results showed that the replacement of mineral aggregates in a proportion of 50% with the sunflower aggregates led in a decreasing of mechanical properties of the concrete with sunflower aggregates comparing to the reference mix. On the other hand, the treatment of sunflower aggregates with solution of sodium silicate resulted in a significant improvement of the compressive and tensile strengths of concrete comparing to the concrete manufactured with untreated sunflower aggregates. The mechanical properties of the concrete with vegetable aggregates were below the reference concrete, but the successful reduction of the water absorption capacity of the plant aggregates in parallel with the strength increasing of the resulted concrete, lead to the conclusion that sunflower stalk waste can be used as partial replacement of the aggregates in concrete composition.

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1. Introduction

For a sustainable development of building materials, plant aggregates are more and more used for ecological constructions. Although hemp is one of the most used plant for obtaining of a sustainable concrete, with enhanced thermal properties, the woody part of the sunflower stalks is characterized by similar physical properties. Sunflower stem aggregates are with a close microstructure to hemp's one (both having a strongly honeycomb structure), and their chemical composition is nearly the same [1]. The sunflower use in concrete obtaining is more probably in our country due to its large availability, being considered an agricultural waste. Moreover, there is important to design new concepts of building materials using local resources, without incurring high additional costs [2]. In fact, collection and storage of sunflower stalks are performed using the available agricultural equipment.

Using the shredded sunflower stalk in the lightweight concrete production requires various chemical treatments applying to vegetables in order to reduce their water absorption and to decrease their interface incompatibility with the mineral matrix of the concrete [3]. Compared to conventional concrete, lignocellulosic concretes are generally characterized by a higher permeability and lower thermal conductivity, density, and compressive strength. Considering the last issue, these types of concretes are not recommended as bearing materials, but they are suitable as insulation ones, reducing the heating and cooling consumptions for buildings [4]. They also have promising acoustical characteristics [5,6].

The aim of this experimental study was to analyze the possibility of using the sunflower stalks as an ecological and sustainable alternative for mineral aggregates of the conventional concrete composition. In this regard, the density, manufacture method of the concrete with shredded sunflower stalk aggregates and mechanical properties of three variants of lightweight concrete, were comparatively investigated with a reference concrete (RC) made with traditional sand and stone aggregates. This study is important whereas the obtaining of a lightweight concrete with sunflower stalks as aggregates is an element of novelty in our country.

2. Materials and methods

The present study involved the development of concrete recipes with vegetal aggregates from the sunflower stem. For comparison, there were also performed a conventional C30/37 concrete recipe with the maximum aggregates size of 8 mm, developed according to [7]. It was used C30/37 class as reference concrete because it was predictable that the concrete strength will decrease by replacing conventional aggregates with vegetable ones (as lignocellulosic concretes have, in general, a low strength comparative to conventional concrete). By using a higher class of concrete as a starting point, it was intended to obtain an acceptable strength after replacing the aggregates. In the composition of this reference concrete were used:

- cement CEM II/A-LL 42.5R;
- aggregates: sand (0-4 mm diameter) and river gravel (sort 4-8 mm);
- additives: a superplasticizer based on policarboxilateter (Sika Plast 140) used for reducing water requirements while maintaining workability, and an accelerator based on rhodanid (Sika BE 5) used for concrete hardening and accelerating the cement hydration process;
- water for a water/cement ratio of 0.43.

All the concrete formulas with sunflower aggregates assumed the replacement of the mineral aggregates in a proportion of 50% by volume with vegetal aggregates. The concrete recipes from the study were with untreated sun-flower aggregates (CUSF), with sun-flower aggregates treated for a 50% reduction of water absorption capacity (CTSF50), and with sun-flower aggregates treated for a 75% reduction of water absorption capacity (CTSF75).

To obtain vegetal aggregates, the sunflower stalks were shredded in granules smaller than 5mm and fibers smaller than 25 mm, treated with sodium silicate solution (Fig.1), resulting in a reduction of water absorption from 402% (measured for untreated aggregates) up to about 200%. After the treatment applying, the granules were dried in a natural ventilated room at 25^0C. With these aggregates, CTSF50 was manufactured.