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Mechanical behavior of mortar reinforced with sawdust waste

Haveth Gil*, Andrés Ortega, Jhon Pérez

Politécnico Colombiano Jaime Isaza Cadavid, Facultad de Ingenierías, Carrera 48 N° 7-151, Medellín 050022, Colombia

Abstract

Compressive strength, density and dynamic elastic modulus of mortar reinforced with wood sawdust wastes (WSW) were investigated. Additions of 0, 0.5, 1 and 3% by weight of (WSW) were used. The mechanical influence of sawdust was followed after 7, 30 and 90 days of curing. Scanning electron microscope (SEM) was used to characterize the morphology of the composites and to find the adhesion behavior of sawdust. The results show that compressive strength increases with sawdust content up to 0.5%. Using sawdust content larger than 1%, produces mortars with an excessive loss of compressive strength, especially for 3% of WSW. Lightweight mortar was obtained only for 3% of WSW reaching a compressive strength of almost 25MPa after 90 days of curing. According to SEM results, a good adhesion was originated for 0.5 and 1% of WSW and for all WSW percentages used a positive effect on the post-cracking behavior was found.
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1. Introduction

Wood products and furniture can generate sawdust waste which is usually accumulated generating environmental problems. On the other hand, concrete is a widespread material used in the construction sector due to its capacity of compressive strength and ability to shape up in several geometric configurations. The problem with concrete arises in the manufacture of cement and its environmental burden associated to high production of carbon dioxide (CO_2) which is released to the atmosphere but also due to the diminishing of nonrenewable sources. Some authors reveal that for the production of every 600 kg of cement, approximately 400 kg of CO_2 is released [1]. In addition, concrete density is a major concern in terms of weight and transport of materials. This is the reason of the increasing building

* Corresponding author. Tel.: +57-4-3197900 ext 509
E-mail address: hhgil@elpoli.edu.co

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construction with lightweight concrete which usually offer advantages such as economical reduction and more environmental friendly composites.

Lightweight mortar using sawdust as reinforcement has become an important issue in recent years especially in tropical countries where this type of waste is produced in large quantities. The use of cement, sawdust and sand for making floor and wall panels has been fairly common in many parts of the world [2]. Torkaman *et al*. [3] investigated the effects of partial replacement of Portland cement by wood fiber waste for producing lightweight concrete blocks and they found that compressive strength of the concrete blocks decreased with increasing cement replacement. The waste is produced typically by two forms: powder and chips obtained from sawmill. Sales *et al*. [4] found that water treatment sludge and sawdust can be applied in concrete as a light weight coarse aggregate to obtain mechanical properties suitable for non-structural applications.

Sawdust waste incineration fly ash (SWIFA) has been employed to produce cement pastes and concrete mortars [5]. Some authors have used wood ash as replacement of cement in the production of concrete and mortar with good results [6]. However, some authors have found that the use of these type of ashes present low improvements on mechanical properties [5]. There is also evidence of successful addition of wood by-products in lightweight mortar up to 5% [7]. Bederina *et al.* [8] and Belhadj *et al.* [9]investigated the effect of wood shavings in mortars and they concluded that the material could be added to the cement matrix without any preliminary treatment. In general, the use of lightweight aggregates in concrete (such as wood chips) can be advantageous, by allowing reduced size of foundations and structural elements [7]. In this study an attempt was made to use wood sawdust wastes (WSW) for producing lightweight mortars and to obtain estimation of composite mechanical properties at different curing periods.

2. Experimental

2.1. Materials

WSW used in this investigation was of Colombian production and was categorized as WSW-coarse in terms of the particle size [10]. WSW was collected during sawing and then it was sieving. Material retain on sieve # 4 (4.76 mm) were used for all mixtures. Ordinary Portland cement type I of specific gravity of 3.1 was used to produce mortars. Quartz sand with size below 5 mm was also used in the composite.

2.2. Mortar preparation and testing of specimens

Water absorption test of approximately 1 g of WSW were performed by means of a RADWAG PMC 210/WH moisture analyzer at 105ºC. Lightweight mortars with a water/cement/sand ratio of 0.4:1:1 were manufactured. The content of WSW inside the mortars was of 0, 0.5, 1 and 3% by weight. The wood by-products were pre-soaked in water before mixing to prevent it from soaking the water meant for cement hydration [11,12].

The cement paste was mixed with added sand in a mechanical mixer at 60 rpm for 2 min with 40% of the total water required. Then, sawdust was gradually incorporated in the mixture and a further 40% of the water was slowly added. After using all sawdust, the remaining water was added followed by 1 min rest. Cube samples of 2 in x 2 in x 2 in were casting in steel forms to perform mechanical tests and density estimation after 7, 30 and 90 days of curing. Samples were stored during the first 24h in a curing box chamber at 100% of relative humidity (RH) and after that, they were demoulded and placed in and environment at 22 ± 2ºC and 78 ± 3% RH.

Each cubic specimen was tested for ultrasonic pulse velocity (UPV) using a CONTROLS Model E48 ultrasonic pulse velocity testing device. Compressive strength was evaluated according to ASTM C109 [13]. All experiments were performed by triplicate samples in order to get statistical variations of the data. A scanning electron microscope (SEM) model JSM6490-LV from JEOL Company was used to perform morphological observations on selected samples. The accelerating voltage used was 20 kV.

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