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# Lightweight wood chipping concrete durability

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**Abstract**

The recycling of wood chippings, an industrial waste product, has a potential use in the production of a lightweight mortar. In developing countries, the low cost and the proximity of supply makes this material a good candidate for local building applications. This study aims at examining the durability of a wood fibre lightweight concrete. Samples have been stored in humid and dry environments; compressive and flexural strength were measured and the microstructure examined using SEM. The material properties are improved when wood chippings are saturated with a sodium silicate solution; this is due to the improved bond between chippings and cement paste, resulting from the formation of CSH I and ettringite. The results are encouraging and indicate the feasibility of producing a lightweight concrete that conforms to the RILEM recommendations.


*Keywords:* Lightweight concrete; Wood chippings; Durability; Composite material; SEM

## 1. Introduction

In many countries, the wood industries generate a large amount of waste products. The low costs, the proximity of the sources and the potential pollution from wood wastes have led to studies into the possible use of the wood chippings as fibres in concrete. These types of material have several potential applications such as acoustic and thermal insulation, fire resistance cladding etc.

Several studies mention the use of wood ash as fillers in concrete or mortars [1–3], without revealing a great improvement in mechanical properties. Bouguerra et al. [4] included wood chippings (3–8 mm) in a cement and clay matrix and tested the water sorptivity: the macroporous wood aggregates reduced the capillary absorption inside the material. This composite material also displays good thermal and insulating properties [5]. Other natural fibres have also been studied (hemp [6], rice husks [7] or other vegetal fibres [8]): mortar mixes containing these admixtures display a good durability and are already used for insulating or coating applications.

We have developed a composite lightweight concrete, made of wood chippings, cement and water, that conforms with RILEM recommendations [9]. In a previous paper, Tamba et al. [10] described the physico-chemical properties of the wood chippings and the preparation procedure of this wood-based concrete, particularly the difficulty presented by the high water absorption properties of the wood.

In this paper, we report the study of the mechanical properties of lightweight wood chipping concrete and its durability when exposed to dry and humid environments. A new treatment of the wood chippings is proposed to improve the bonding at the wood–cement interface.

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## 2. Sample preparation

### 2.1. Materials

#### 2.1.1. Cement

A Portland cement CEM I 52.5 was used, manufactured by Lafarge (St Pierre-La-Cour, France). The chemical analysis of this cement is given in Table 1 and its mechanical properties, provided by the manufacturer, are summarised in Table 2.

#### 2.1.2. Wood chippings

Pine wood chippings display a continuous grading between 0.5 and 10 mm (Fig. 1). The fibrous nature of the chippings is revealed by SEM micrographs (Fig. 2). The network of capillaries in wood, which allow sap circulation, is responsible for the hydrophilic nature of wood. When mixed directly with cement, the wood chippings could potentially affect the water cement ratio; this could limit the water available for hydration due to migration of water into the wood particles. Tamba and co-workers [10] proposed to saturate the wood chippings with water and carried out an estimation of the kinetic of water absorption. After 24 h, the chippings are totally saturated with water.

Table 1
Chemical composition of CEM I 52.5

| Compound | % by weight | Compound | % by weight |
|---|---|---|---|
| Insoluble | 0.2 | $S^{-}$ | <0.01 |
| $SiO_2$ | 25.05 | $Cl^{-}$ | 0.022 |
| $Al_2O_3$ | 8.6 | Loss on ignition | 2.2 |
| $Fe_2O_3$ | 3.5 | Not detectable | 0.468 |
| CaO | 55.4 | Total | 100 |
| MgO | 0.9 | | |
| $K_2O$ | 1 | $CO_2$ | 1 |
| $Na_2O$ | 0.15 | Free CaO | 1.2 |
| $SO_3$ | 2.7 | Active alkaline | 0.75 |

Table 2
Mechanical properties of CEM I 52.5 (manufacturer analysis)

| Properties | Average |
|---|---|
| 2 day compressive strength (standard mortar) | 18 MPa |
| 7 day compressive strength (standard mortar) | 33 MPa |
| 28 day compressive strength (standard mortar) | 48 MPa |
| Initial set | 200 min |
| Soundness | 2 mm |
| Density | $2.99 \times 10^3$ kg m$^{-3}$ |
| Specific surface | 350 m$^2$ kg$^{-1}$ |
| Heat of hydration at 12 h | $140 \times 10^3$ J kg$^{-1}$ |

### 2.2. Saturation treatment

As stated wood chippings must be saturated with water before mixing with cement, in order to achieve adequate hydration of the cement; however, there exists the potential to improve the bond at the cement/wood interface. In a study on rice husks used as lightweight aggregates [11], it has been found that there is a pozzolanic effect due to the silica present in the rice husks. No silica has been found in pine wood, but it is possible to introduce silica by a saturation treatment. A solution of sodium silicate was prepared (100 g/l). The wood chippings were immersed in this solution for 24 h prior their use as aggregates in concrete.

### 2.3. Specimens

Mortar samples ($40 \times 40 \times 160$ mm$^3$) were manufactured using a mix of cement, wood chippings and water. The optimum wood/cement ratio was 3.6 [12]: a ratio of 3 was chosen for these tests (dry wood per lightweight mortar ≈600 kg m$^{-3}$). The water content, including saturation water, was adjusted to obtain a water/cement ratio of 0.75.

The samples were cured in a vapour chamber (20 °C, 95% RH) for 7 days. Then, they were removed from the mould and conditioned in controlled environment (20 °C,

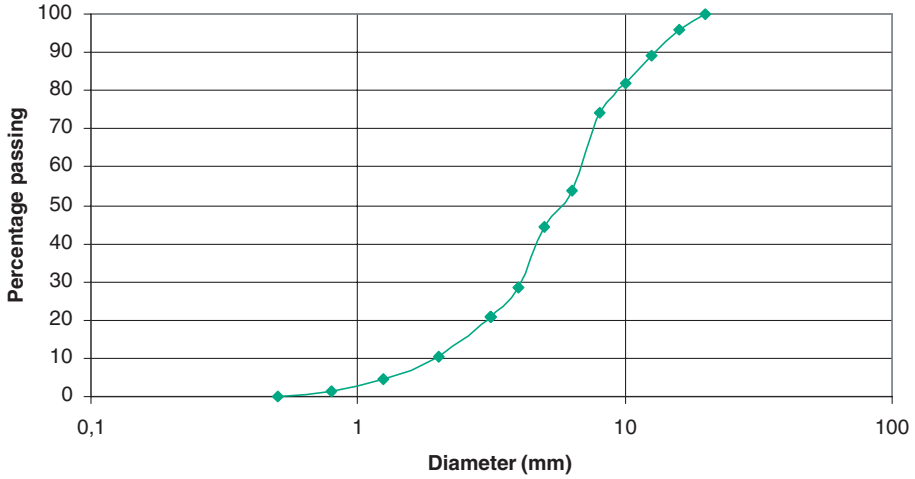


Fig. 1. Grading analysis of wood chippings.