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Study of Physical and Mechanical Properties of Wood Concrete

Silouantonda Kouamissa Papy[1,2*], **Nsongo Timothée**[3]

[1]Department of Civil Engineering, ITheMM EA 7548, University of Reims Champagne-Ardenne, Reims, France
[2]Laboratory of Mechanics, Energetics and Engineering, National Advanced School of Engineering, Marien Ngouabi University, Brazzaville, Republic of the Congo
[3]Faculty of Sciences and Technology, Marien Ngouabi University, Brazzaville, Republic of the Congo
Email: *papysilouantonda@gmail.com

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Abstract

This study highlights the of wood chip on the physical and mechanical characteristics of concrete. The objective is to promote iroko wood chip in the construction sector. The aim is to incorporate chip into concrete and to study its influence on the physico-mechanical properties of concrete. To conduct this study, the materials used were first characterized. Secondly the concrete was formulated and the concrete specimens were poured. Finally, the physical and mechanical characterizations of concrete were evaluated. For the formulation of concrete, the classic method of Dreux-Gorisse was used. The wood chip in the concrete was incorporated by volume substitution of aggregates. The incorporation of wood chip into concrete has had a significant influence on the physical and mechanical properties of concrete. Indeed, the wood chip in concrete has decreased its density, its mechanical strength in compression and its mechanical strength in tension by splitting to 34%, 89% and 45% respectively.

Subject Areas

Building Materials, Composite Materials, Wood Concrete

Keywords

Concrete, Wood Chip, Workability, Density, Mechanical Strength

1. Introduction

Wood chip in Congo is an environmental nuisance since it is mostly burned. This environmental problem must be addressed. Thus, we use iroko wood chip (abundant wood in Congo) in concrete and evaluate its influence on the physical and mechanical properties of concrete. Wood waste has already been the subject of several studies in the literature [1]-[27]. From these works of literature, it appears that wood chip in concrete reduces its density and gives it a loss of workability [7] [14] [26]. Indeed, the subsidence of wood chip concrete decreases with the increase in the chip rate. This loss of workability is due to the fact that a significant part of the mixing water is absorbed by the wood chip during mixing [23]. It has been observed that wood chip in concrete increases its water absorption capacity [1] [9] [23]; it reduces its mechanical strength. This loss of strength is all the more important as the rate of wood chip increases [4] [6] [8] [12] [17] [18] [19] [22] [23]; it also reduces the modulus of elasticity of concrete [17]. The treatment of wood chip makes it possible to limit or slow down the loss of mechanical properties of concrete [1] [9] [10] [11] [14] [16] [23] [25].

As for the thermal properties, the thermal conductivity and diffusivity of concrete decrease with the increase in chip [3] [5] [8] [13] [15] [20] [22] [24] [27]. The incorporation of wood chip into concrete improves its acoustic performance [17] [18] [21].

The present work revolves around the composition of the concrete elaborated, the determination of its workability and density, and the determination of its mechanical performance in compression and tensile splitting.

2. Materials and Methods

2.1. Identification of Materials Used

To carry out this work; the materials used for concrete are CEM II 32.5 R cement, rolled sand from the Congo River, two classes of crushed gravel and iroko wood chip. The iroko wood chip used is shown in **Figure 1**.

In accordance with standard NF EN 933-1, a particle size analysis test by sieving to identify sand, gravel and chip was carried out.

Figure 2 shows the carrying out particle size analysis test.

In accordance with standard NF EN 1097-6, an absolute density test of these materials was carried out. These densities are useful for concrete formulation.

Figure 1. Wood chip.

The particle size curves obtained from the study materials are shown in Figure 3.

The granular classes and absolute densities of these materials are presented in Table 1.

Figure 2. Column of sieves for particle size analysis.

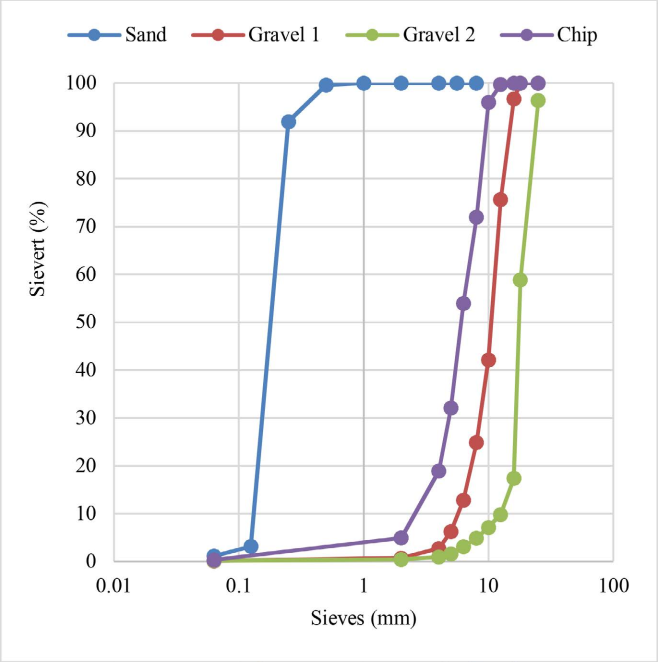

Figure 3. Particle size curves.

Table 1. Granular classes and densities.

Materials	Granular class	Absolute density (kg/m^3)
Cement	-	3100
Sand	0/0.5	2572 ± 8.03
Gravel 1	5/16	2630.30 ± 11.24
Gravel 2	10/25	2640 ± 15.17
Shaving	0.063/10	657

The sand with a particle size of 0 - 0.5 mm, is very fine sand.

The sand and the two classes of gravel used are ordinary aggregates since their densities are in the spindle of ordinary aggregates: 2500 to 2600 kg/m^3.

2.2. Water Absorption of Chip

The chip water absorption test was performed. This chip was previously dried in a controlled oven at a temperature of 50˚C. The chip material was considered dry when the mass variation of two successive weighings within 24 hours was less than 0.1%.

In accordance with the recommendations of RILEM TC 236-BBM [28], the chip water absorption test was performed at 1 minute, 30 minutes, 4 hours and 48 hours. It was determined in Equation (1):

$$W = 100\left(\frac{m_s - m_d}{m_d}\right) \quad (1)$$

In that equation, W is water absorption from chip (%), m_s is mass of submerged chip (g) and m_d is mass of dry chip (g).

2.3. Concrete Formulation

To formulate the concrete, the classical method of Dreux-Gorisse was used. Thanks to the particle size curves and absolute densities of the materials, the composition was determined. With the Dreux method, the composition of the concrete for a given strength and workability was determined by involving the water dosage and the maximum size of the aggregates.

For the composition of wood chip concrete, chip intrusion was made by substituting in volume the sand and gravel in percentage (0, 2.5, 5, 7.5, 10, 12.5, 15 and 20%). The total substituted volume is the volume of chip to be introduced into the concrete. The water/cement ratio for concrete under the assumption is 0.56, the same ratio is kept to evaluate the influence of chip on the workability of concrete.

The composition of concrete is presented in Table 2.

Table 2. Composition of concrete for 1 meter cube.

Type	Materials (kg)					
	Cement	Water	Sand 0/0.5	Gravel 5/16	Gravel 10/25	Chip 0.063/10
BSG0	400	225	559	438	677	-
BSG2.5	422	237	544	426	659	11
BSG5	444	250	529	415	641	23
BSG7.5	475	267	514	403	622	34
BSG10	507	285	499	391	604	45
BSG15	569	321	469	368	568	68
BSG20	633	357	439	344	532	90

When pouring concrete, the workability was determined using the Abrams cone subsidence test (Slum-Test) in accordance with standard NF EN 12350-2 [29].

After pouring the concrete and casting, the specimens were unmolded after 48 hours and stored at laboratory room temperature (24˚C ± 1˚C) until the test dates.

2.4. Mechanical Strength of Concrete

In accordance with NBN EN 12390-3, the compressive strength of concrete was determined by means of a concrete press. The specimens to be tested are subjected to an increasing load until they break. The concrete press for compression has a maximum capacity of 3000 kN with a loading speed of 0.50 MPa/s. This press is connected to the computer which directly displays the value of the resistance in MPa [30].

The mechanical tensile strength by splitting was determined by means of a concrete press. The specimens to be tested are subjected to an increasing load until they break. The concrete press for splitting traction has a maximum capacity of 150 kN with a loading speed of 0.05% ± 1% MPa/s. This press is connected to the computer which displays the maximum breaking force. The mechanical tensile strength by splitting is calculated in Equation (1) [31].

$$f_{ct} = 1.243 * 10^{-2} F_{\max} \quad (2)$$

In that equation, f_{ct} is the mechanical tensile strength by splitting (MPa) and $F_{\max}$ is the maximum breaking force (kN).

Figure 4 shows a specimen submitted in compression and one in tension by splitting.

(a) (b)

Figure 4. Specimen in compression (a) and in tensile (b) by splitting.

3. Resultats and Discussion

3.1. Water Absorption from Chip

The water absorption results of wood chip obtained are shown in Figure 5.

Up to 4 hours of immersion, the water absorption of the chip is exponential. Beyond that, it continues to grow but very slowly because at 48 hours, it has grown only 18% of its absorption at 4 hours.

3.2. Physical Properties of Concrete

The results of concrete workability obtained are presented in Table 3.

Although the workability of concrete has been fixed, in practice there have been some small variations in subsidence. Despite this variation, concrete is indeed plastic as fixed in the hypothesis.

The results obtained from the density of concrete are shown in Figure 6.

Has 2.5% chip; the density of fresh concrete decreased by 6% and hardened by 7%; to 20%, it fell in the fresh state by about 30% and in the cured state by about 34%. The higher the chip content in concrete, the lower its density. The density of concrete therefore decreases with the increase in the chip rate. These results are consistent with those found in the literature [7] [14] [26].

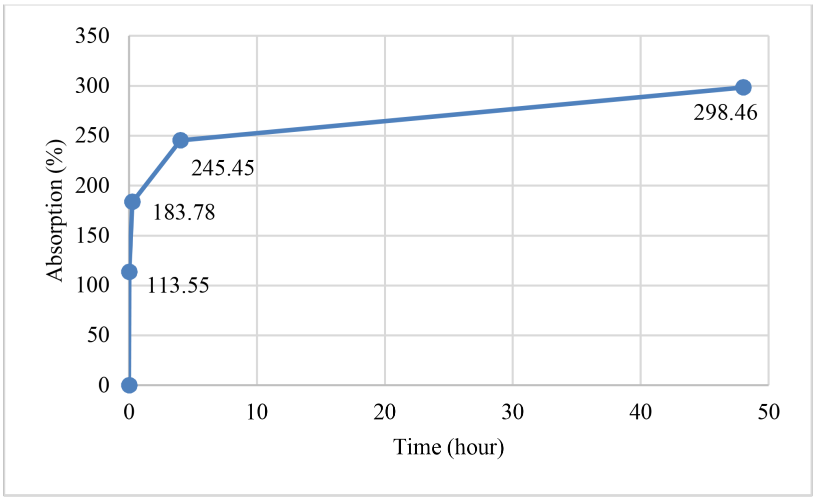

Figure 5. Water absorption from treated and untreated wood chip.

Table 3. Workability of concrete.

Type	Subsidence (cm)
BSG0	7.5
BSG2.5	7.5
BSG5	7.5
BSG7.5	7.5
BSG10	7
BSG15	6.5

3.3. Mechanical Properties of Concrete

The results of the compressive strength of the concrete obtained are shown in Figure 7. Each value reported is the mean of 4 trials.

A decrease in concrete strength of 36%, 55%, 59%, 65%, 71% and 89% respectively was recorded for chip levels of 2.5%, 5%, 7.5%, 10%, 15% and 20%. The higher the chip content, the lower the mechanical compressive strength.

The chip incorporated into the concrete, therefore, reduces its mechanical strength in compression. These results are consistent with those of [4] [6] [8] [12] [22] [23].

The results of the tensile strength of concrete are shown in Figure 8. Each value reported is the mean of 3 trials.

A decrease in resistance of 17%, 22%, 24%, 30%, 37% and 45% respectively was recorded for chip levels of 2.5%, 5%, 7.5%, 10%, 15% and 20%. The higher the chip content, the lower the tensile strength by splitting.

The chip incorporated into the concrete, therefore, reduces its tensile strength by splitting.

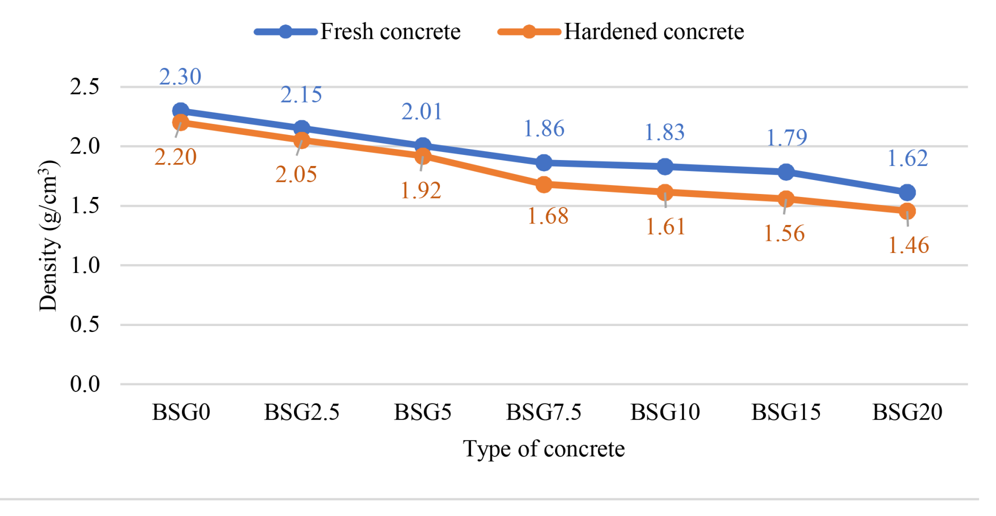

Figure 6. Density of concrete.

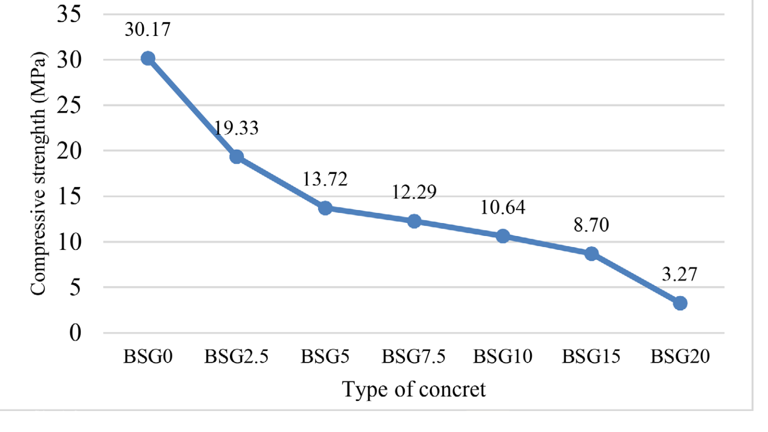

Figure 7. Mechanical compressive strength.

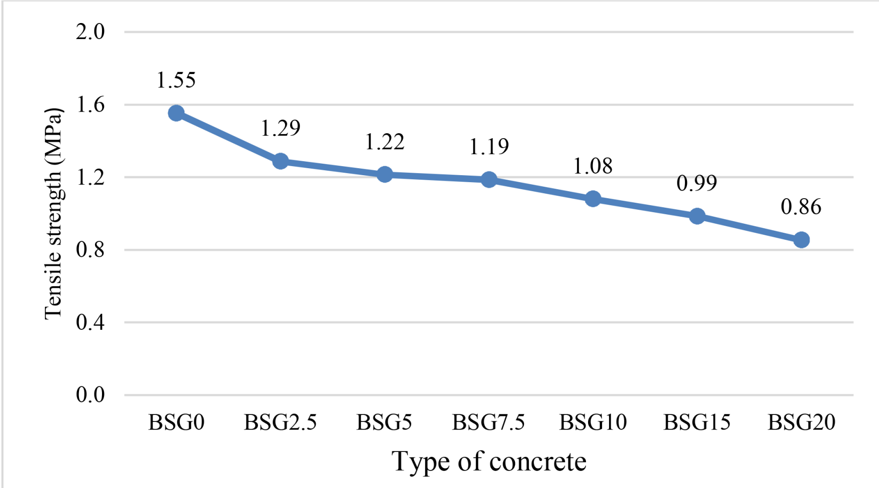

Figure 8. Mechanical tensile strength by splitting.

4. Conclusions

This experimental study highlighted the influence of wood chip on the physico-mechanical properties of concrete. The incorporation of wood chip into concrete has greatly influenced density and mechanical strength. Indeed, wood chip in concrete has reduced its density by 30% for substitution by 20%, its mechanical compressive strength by 89% and its mechanical tensile strength by splitting by 45%.

Wood chip in concrete lowered its mechanical compressive strength by about double what they lowered its mechanical tensile strength by splitting. This result is almost similar to all chip levels. Thus, the performance of wood chip concrete is better in splitting traction than in compression.

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Conflicts of Interest

The authors declare no conflicts of interest.

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