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Some Properties of Concrete Made with Wood Fibers

Junaid Kameran Ahmed[1]

[1]Department of Civil Engineering, Faculty of Engineering, Tishk International University, Erbil, Iraq
Correspondence: Junaid Kameran Ahmed, Tishk International University, Erbil, Iraq.
Email: junaid.kameran@tiu.edu.iq

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Abstract: One of the sustainable construction elements is using waste material, recycled materials in the concrete production process. Coarse aggregate has been obtained from a carpenter sawdust waste in TIU workshop / Erbil. Wood particles were used in different proportions of the cement content. The fresh properties of slump, and water absorption, and the compressive, flexural strengths were measured and discussed.

Keywords: Wood Fibers, Wood Fiber Concrete, Mechanical Properties

1. Introduction

For its suitability and adaptability with respect to the changing environment, the concrete must be such that it can conserve resources, protect the environment, economize, and lead to proper utilization of energy. To achieve this, major emphasis must be laid on the use of wastes and byproducts in cement and concrete used for new constructions.

Industrial waste creates the environmental and economic problem associated to their disposal. During the recent years there has been increasing focus on the application of discarded items and by-products from numerous sources in building works. Along with the environment protection, numerous studies were conducted on recycling of waste products as construction resources. One of such important waste is the sawdust which is comparatively plentiful and economical. Sawdust is waste produced by timber industries, obtained from cutting, sawing, or grinding of timber, Fig. 1. The development of sawdust concrete is still under investigation.

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Figure 1: Sawdust waste from the TIU workshop, Erbil

2. Literature Review

Some research works have focused on utilization of sawdust as a sand replacement (Oyedepo & Oluwajana, 2012; Mangi et al., 2019), however, this paper highlights the possible use of sawdust in concrete as light weight aggregate. It is expected that this information can be useful for the new researchers to discover more on sawdust concrete.

Mangi et al. (2019) presented a review paper focusing on utilization of sawdust, as to reduce environmental impacts poses by the waste products of furniture industry and a by-product of wood industry. As a conclusion, this review paper summaries the existing important ideas and useful information for the fellow researchers, as to enhance the utilization of sawdust to produce lightweight masonry units. It is recommended that considerable research is required on the sawdust cement blocks, which can deliver more confidence on their utilization as a green building construction material.

Memon (2016) published a research on sawdust concrete made at three different mix proportions of cement to sawdust of 1:1, 1:2 and 1:3 by volume. At these proportions mechanical and thermal properties like density, workability, strength, elastic modulus and heat transfer were investigated after, 7, 28 and 56 days of air curing. It was found that with the increase in the amount of sawdust, the workability and strength decreased however, in terms of thermal conductivity concrete with higher amount of sawdust performed very well. It was also found that the heat transfer of sawdust concrete decreased. Considering the overall physical and mechanical properties, sawdust concrete can be used in building construction.

3. Aim of work

This work is intended to study the fresh properties and to investigate the physical and mechanical properties of wood fiber concrete. Wood fibers were taken from the waste of the carpentry workshop of Tishk International University in Erbil, Iraq.

4. Experimental Program

The experimental program consists of casting and testing of fresh and hardened concrete having wood particles as fibers. Cement mortar without wood fibers is considered as the reference mix, with wood particles added at different percentages by weight of cement 0%, 5%, 10% and 20% consist as wood-fiber concrete mixes, and adding superplasticizer SP admixture. The main variables in this study include the added percentage of wood fibers on fresh and hardened properties.

4.1 Material Properties

Cement: The cement which used in this study was ordinary Portland cement (OPC) Type-I. conforming to Iraqi Specification No. 5/1984.

Fine Aggregate: Natural sand was used for concrete mixes in this study. The fine aggregate has 4.75mm maximum size with rounded-shape particles and smooth texture with fineness modulus of 2.84. The obtained results indicated that the fine aggregate grading and the sulfate content were within the limits of Iraqi Specification No. 45/1984. The specific gravity, sulfate content and absorption of the fine aggregate were 2.77, 0.18% and 0.77%, respectively.

Wood Fibers (wf): Wood fibers were taken from the carpentry dept. of the TIU university workshop / Erbil throughout this study. The wood is softwood, and the particles were collected from one saw machine. The coarser particles were taken with mean thickness of (1.1) mm. The specific gravity is 0.5.

Water: Portable water available in the laboratory was used for mixing and curing the concrete specimens.

Superplasticizer SP: SP is used to reduce the water content, increasing the early strength, and reducing the setting time. It is also extreme flow-ability, water reduction, high strength, and quality consistent product concrete. The amount of SP used was 1700 ml/m^3 based on manufacturer recommendations.

4.2 Mix Properties

The design of concrete mix is described in Table (1).

Table 1: Proportions of mix design

Mix NO	Replacement %	Water kg/$\boldsymbol{m^3}$	Cement kg/$\boldsymbol{m^3}$	Wood fibers kg/$\boldsymbol{m^3}$	F.Aggregate kg/$\boldsymbol{m^3}$	SP ml/$\boldsymbol{m^3}$
1	0	102	340	1000	650	1700
2	5	102	340	800	650	1700
3	10	102	340	600	650	1700
4	20	102	340	400	650	1700

4.3 Mixing Procedure and Casting

The objective of mixing is to obtain a uniform and consistent of cement, water, wood fibers, sand and any admixtures used in the concrete and also to meet the requirement of the standard. The wood fibers were soaked in water for 3 days, the air-dried under the sun for 3 days.

Mix procedure started with weighing all materials according to the mix design then placing the cleaned dry wood fibers into the pan first, then the sand and cement. Mixing all the dry material was made repeatedly until a homogeneous mix is obtained, then a deep crater was mad to receive the added water. Again, mixing is recommenced until you reach a clay consistency (homogenous material). Then the mixing is stopped and measure the slump within the range of 100mm and 200mm and casting the concrete into the forms. The compressive strength forms were cubes of 100mm side. The flexural strength forms were of 100mm×100mm ×300 mm prisms.

5. Results and Discussion

5.1 Workability

Fresh concrete was tested for its workability and consistency by performing the Slump test. The results showed that the slump value was medium as it was ranging from 20 mm to 65 mm. The measured concrete slump was 60 mm for wood fiber concrete, 65 mm for control mortar, which was within the limitation of 65±20mm slump for final compaction. Workability of sustainable wood fiber concrete was found by increasing the amount of the wood fibers used in the mixes.

5.2 Absorption

The amount of absorbed water for wood fiber concrete was in average 3.86% corresponding to 0.92% for control specimen. This finding is generally expected and explains the reduced compressive strength of wood fiber concrete as the fiber amount is increased. Al Numan (2004) found that the water absorption of sawdust concrete is greater than corresponding value for control specimens.

5.3 Density

The specimens' weight and corresponding density are listed in Table 2 and shown in Fig. 2 About 8% and 22% reduction in density resulted at 10% and 20% wood fiber content per cement, respectively. The concrete can be considered lightweight at 20% wood fiber content per cement, and more.

Table 2: Density of wood fiber concrete

Dosage %	Density (Kg/m^3)
0 %	2227
5 %	2191
10 %	2049
20 %	1732

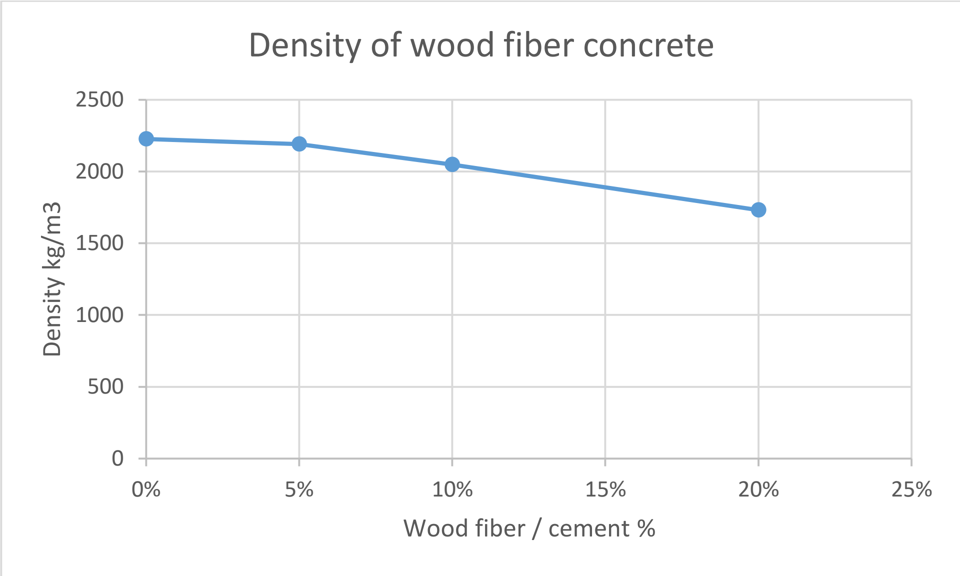

Figure 2: Density of wood fiber concrete

6. Flexural Strength

The specimens' flexural strengths are listed in Table 3 and shown in Fig. 3 About 16% and 13% increase in strength resulted at 5% and 10% wood fiber content per cement, respectively. However, at 20% wood fiber content per cement the strength was reduced by 19%. Wood particles act as fiber action at percentages below 10% but lose this characteristic at higher contents.

Table 3: Flexural strength of wood fiber concrete

Dosage %	Flexural Strength (MPa)
0 %	3.27
5 %	3.80
10 %	3.70
20 %	2.66

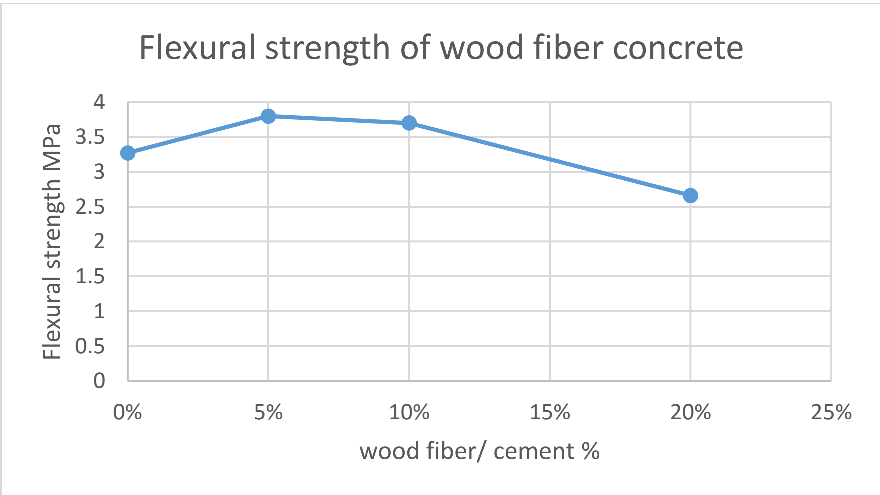

Figure 3: Flexural strength of wood fiber concrete

The mode of failure of flexural specimens was sudden breaking of the control specimens into two parts with straight vertical cut, Fig. 4a. For the wood fiber concrete, however, the breaking was of slower visible pace with crooked cut. This is due to the increased ductile properties due to the presence of coarse long wood fibers, Figs. 4b, 4c and 4d for 5%, 10% and 20% wood fiber/ cement content.

4a. Control specimen

4b. 5% wood fiber/cement specimen

4c. 10% wood fiber/cement specimen

4d. 20% wood fiber/cement specimen

Figure 4: mode of failure of wood fiber concrete flexural specimens

7. Compressive Strength

The specimens' compressive strengths are listed in Table 4 and shown in Fig. 5 About 28% and 54% reductions in strength were resulted at 10% and 20% wood fiber content per cement, respectively.

Table 4: Compressive Strength of wood fiber concrete

Wood fiber / cement %	Compressive Strength (MPa)
0 %	29.9
5 %	26.1
10 %	21.3
20 %	13.6

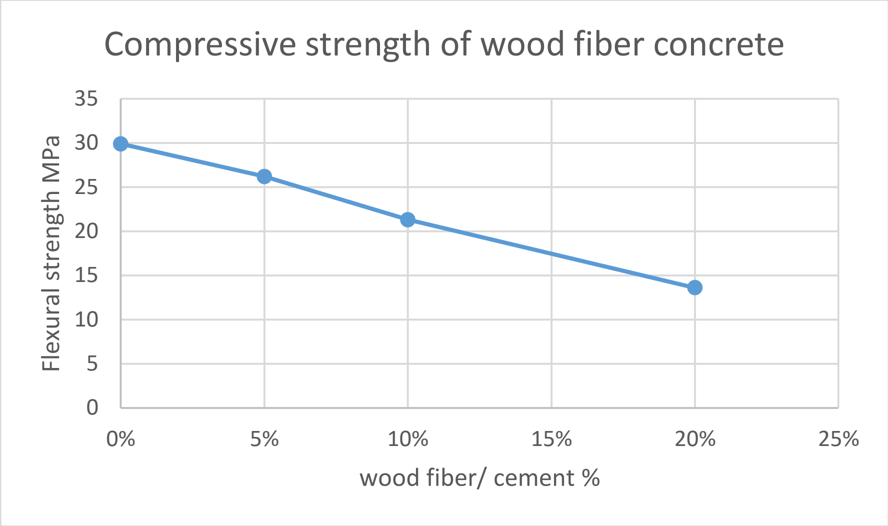

Figure 5: Compressive Strength of wood fiber concrete

The mode of failure of compressive specimens was sudden crushing of the control specimens with straight inclined cut, Fig. 6a. For the wood fiber concrete, however, the crushing was of characterized with multiple disconnected cracks. This is due to the to the presence of coarse long wood fibers, Figs. 6b and 6c for 10% and 20% wood fiber/ cement content.

6a. Conrtol specimen

6b. 10% wood fiber/cement specimen

6c. 20% wood fiber/cement specimen

Figure 6: mode of failure of wood fiber concrete compressive specimens

8. Conclusions

Wood particles/ fibers are the by-product of wood. It is considered as waste material but nowadays this waste material is utilized in the construction of the building as sawdust/ wood fiber concrete. It is utilized to make light-weight concrete and possess long duration heat transfer.

Due to the increased volume of wood particle wastes from carpenters and wood industries, which usually deposited in landfills in recent years, the transformation of recycling waste materials into useful products for reapplication in building and highway construction projects is recommended.

The utilization of wood particles is a good solution to the problem of an excess of waste material,

Based on our comparative analysis of test results of the basic properties of concrete with four different percentages of wood fiber / cement content (0%, 5%, 10% and 20%), the following conclusions are drawn:

1. The bulk density of fresh concrete is slightly decreased with increasing quantity of wood fibers.
2. The water absorption of wood fiber concrete is found greater than corresponding value for control concrete. The amount of absorbed water for wood concrete was in average 3.86% corresponding to 0.92% for control concrete.
3. The slump was considerably reduced as the RCA percentage increased.
4. About 16% and 13% increase in flexural strength was obtained at 5% and 10% wood fiber content per cement, respectively. However, at 20% the strength was reduced by 19%. Wood particles act as fiber action at percentages below 10% but lose this characteristic at higher contents.
5. About 28% and 54% reduction in compressive strength was resulted at 10% and 20% wood fiber content per cement, respectively.
6. Breaking of wood fiber concrete flexural specimens was of slower visible pace with crooked cut
7. Crushing of wood fiber concrete compressive specimens was of characterized with multiple disconnected cracks.

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