https://doi.org/10.26682/sjuod.2020.23.2.51

Journal of University of Duhok, Vol.23, No.2 (Pure and Eng. Sciences),Pp 658-664, 2020 (Special Issue)

EFFECT OF SAWDUST AS PARTIAL REPLACEMENT OF SAND IN CONCRETE

DABAN A. MUHEDIN [1,*], SANGAR J. QADIR [**], MADEH I. HAMAKAREEM [*] and AHMED J. HAMA RASH [*]

[*]Dept. of Geotechnical Engineering, Faculty of Engineering, Koya University , Koya Kurdistan Region-Iraq

[**]Dept. of Civil Engineering, College of Engineering, University of Sulaimani, Kurdistan Region-Iraq

(Accepted for Publication: December 8, 2020)

ABSTRACT

In the past, river sand was main choice for fine aggregate but due to nonscientific methods for excavation from river beds it has been depleted and leads to environmental concern. Most of the waste sawdust are being dumped into landfill areas which is undesirable because it has a negative impact on environment. This research investigated the effects of sawdust as partial replacement for fine aggregate in concrete structures. Compressive, tensile and flexural strength were investigated and evaluated at 7, 14 and 28 days. In this study four concrete mixes were prepared, first one was control mix and in other three mixes sand was replaced by the following percentages 5%, 10% and 15%. Results shows that by increasing the amount of sawdust in concrete samples; compressive, tensile and flexural strength will reduce. Compressive strength for 5% of sawdust replacement at 28 days was 26.2 MPa, while for 10% was 20.1 MPa and for 15% was 15.9 MPa. The test results, indicated that 5% of sawdust can be used in concrete structures.

KEYWORDS: Sawdust; fine aggregate; compressive strength; tensile strength; flexural strength

1. INTRODUCTION

Construction industry mainly depends on conventional materials such as cement, sand, gravel and water for making concrete. Concrete is one of the most used structural material globally for construction infrastructures due to its durability and quality, thus it needs large quantities of raw materials. River sand is mainly employed as fine aggregate in concrete which is come from river banks. In the past, river sand is only choice for fine aggregate but due to nonscientific methods for excavation from river beds it has been depleted and leads to environmental concern (Shoab Hussain, 2017). Global pollution and reduction in the resources of raw materials have challenged many researchers to find new or reuse new materials in concrete industry. These materials are waste or by-products that are coming from other industrial activities for example fly ash, glass powder and sawdust. In developing countries mostly waste materials are not managed properly as a result it has a negative impact on environment (Oyedepo Joseph, 2014).

Continually increasing world population are requiring constructing new buildings and shelters for settlement. As a result, new materials and techniques should be developed to construct buildings with regard to economy and environmental aspect on one hand and long term shortage of raw materials on the other hand. (Bdeir, 2012). In many countries, significant efforts have been made to reuse or reprocess

daban.abdulthahir@koyauniversity.org; sangar.qadir@univsul.edu.iq;
madih.izat@koyauniversity.org; ahmed.jabar@koyauniversity.org

[1]Corresponding author: Dept. of Geotechnical Engineering, Faculty of Engineering, Koya University Koya KOY45, Kurdistan Region-Iraq.

waste materials for use or in new products and materials. The amount of reuse waste materials has been increasing in developed counties ranges from 10% in Iceland to nearly 60% in Germany and Netherlands. In Australia, just in ten years from 1997 to 2007, waste recovery has increased from 40% to 62%. In field of construction and building industry, at least half of concrete is recovered for recycling compare to other materials in Australia (Crawford, 2011).

Sawdust which is not a familiar material in cement industry can be defined as an industrial waste comes from timber factories. The reason why it is not used widely is either because there is not encouragement for use it in cement industry or not available in large quantity. In the past in most areas sawdust uses as a source of fuel for cooking and huge amount of sawdust is dumped as waste material across the globe (A. Abdullahi, 2013) . Previously, in some areas before the invent of refrigerator sawdust was used in icehouses to keep ice frozen during the summer. In addition, sawdust can be used to make light weight concrete with satisfactory heat insulating and fire resistance value (Dilip Kumar, 2014). Sawdust is recommended to be used as waste material in concrete in order to protect more environmental aspect because as a result of been burnt, more carbon dioxide emissions appears which leads to pollute the environments (Akshay Sawant1, 2018). However, if untreated fresh sawdust is used as a fine aggregate, it is not only may cause a big problems regarding to very slow setting time but also it may lead to abnormal decrease of a concrete compressive strength which is the most important property for structural building design. (Pielert, 2006). Conversely, if sawdust particles prepared as saturation surface dry before casting and take enough water it could be reducing the curing time of concrete because sawdust particles could help hydration process at the center parts of concrete which is difficult to cure with water. Wood sawdust produce light weigh concrete and cost efficient at the same time because it is a waste material (Dilip Kumar, 2014) . Thus, this research study is presented to evaluate the potential use of sawdust in concrete and its effects on compressive, tensile and flexural strength of concrete.

2. EXPERIMENTAL INVESTIGATION

2.1 Materials used

Ordinary Portland cement from Mass Cement Factory is used in this study. Sawdust which is collected form a local carpenter shops. The fine and course aggregate were natural and locally available from river beds. Fine aggregate was sieved on sieve No.4 (size; 4.75 mm) and maximum size of coarse aggregate is 12.5 mm. In addition, the sawdust should have the same sieve analysis as sand. The normal drink water from the tap was used in this study. The quantities of materials were shown in table 1.

daban.abdulthahir@koyauniversity.org; sangar.qadir@univsul.edu.iq;
madih.izat@koyauniversity.org; ahmed.jabar@koyauniversity.org
[1]Corresponding author: Dept. of Geotechnical Engineering, Faculty of Engineering, Koya University Koya KOY45, Kurdistan Region-Iraq.

Table (1): Quantities of Materials

Sawdust percentage (%)	Cement	Sand	Sawdust	Coarse aggregate	Water	W/C ratio
0%	417 kg/m^3	873 kg/m^3	0 kg/m^3	896 kg/m^3	200 kg/m^3	0.48
5%	417 kg/m^3	830 kg/m^3	43.65 kg/m^3	896 kg/m^3	200 kg/m^3	0.48
10%	417 kg/m^3	785 kg/m^3	87.3 kg/m^3	896 kg/m^3	200 kg/m^3	0.48
15%	417 kg/m^3	742 kg/m^3	131 kg/m^3	896 kg/m^3	200 kg/m^3	0.48

2.2 Mix Proportion

In order to achieve the aim of this study four various mixes were used. The first mix was a control mix and did not contain any amount of sawdust while in the other three mixes the sand was replaced by sawdust with the ratios 5%, 10% and 15%. All mixes were prepared based on ACI 211 concrete mix design report. Both fine and course aggregate were washed and soaked in water for 24 hours to be prepared them as saturated surface dry. To get the required workability the sawdust particles was prepared as the same as of fine aggregate as shown in figure 1. Three common tests on concrete which are compressive strength, tensile strength and flexural strength were performed in this study. For each test 9 mold samples were prepared. The samples were casted and vibrated on shaking table, after 24 hours they are demolded and soaked in water tank until the day of testing. The samples were tested after 7 days, 14 days and 28 days. So, the total of 108 samples were casted and tested.

Fig. (1): Prepared Samples

3. RESULTS AND DISCUSSION

3.1 Compressive strength test

From Structural point of view, compressive strength is undoubtedly the most single important factor to determine the load carrying capacity of concrete structures. Figure (2), shows the experimental results for cube (100mm, 100mm, 100mm) compressive strength for 7, 14 and 28 days. Regarding to the results as the percentage of sawdust increased the value of compressive strength reduced from 45.4 MPa at 28 days to 15.9 MPa at the same curing age when 15% of sand replaced with sawdust. The compressive strength for the control mix (0% of sawdust) increased from 24.8 MPa at 7 days to 45.4 MPa at the 28 days. Similar trend can be seen in increasing compressive strength when 5%, 10% and 15% of sand is replaced by sawdust. The reason why compressive strength increasing smoothly for all samples would be related to the prepare the amount of materials based on ACI mix design on one hand and controlling the properties of materials on the other hand. For example, the sawdust particles

daban.abdulthahir@koyauniversity.org; sangar.qadir@univsul.edu.iq;
madih.izat@koyauniversity.org; ahmed.jabar@koyauniversity.org
[1]Corresponding author: Dept. of Geotechnical Engineering, Faculty of Engineering, Koya University Koya KOY45, Kurdistan Region-Iraq.

prepared as the same procedure of sand by washing and soaking in water for 24 hours to obtain saturation surface dry situation when mixing with other constituents. As a result, the negative effect of sawdust on both of workability and strength will be eliminated in the lab. Furthermore, when 5% of sand replaced by sawdust in concrete the compressive strength increased form 17.1 MPa at 7 days to 26.2 MPa at 28 days (i.e about 9% increment) which is a quite acceptable value in many engineering projects. (Akshay Sawant1, 2018) got nearly the same result 21.1 MPa at 28 days for 5% of replacing sawdust. Similarly, at 10% of sand replacement by sawdust the compressive strength increased from 11.9 at 7 days to 21.1 MPa at 28 days. According to (ACI213R-14, 2014) concrete with 10% replacement of sawdust can be used as lightweight concrete because its value is greater than 17 MPa. (Tilak L.N, 2018) reported at 10% of sawdust replacement at 28 days 24.13 MPa can be achieved. Compressive strength for 0% of sawdust at 28 days was 45.4 MPa while for 15% of sand replacement the strength reduced to 15.9 MPa (i.e about 30% decrement). Regarding to the figure 2 it is clear that the value of compressive strength of concrete decreases by increasing the amount of sawdust this could be due to the fact that sawdust contains some substances which are harmful for the cement and hydration process in general and hence the strength development. In addition, the air entrapped due to sawdust particles might be another reason in decreasing the concrete compressive strength. Density of concrete would be another factor for reducing strength of concrete. (Tilak L.N, 2018) reported that by using 10% of sand the density reduced by 4.02% and by using 15% of sand density reduced by 5.54%. Moreover (Tilak L.N, 2018) showed by replacing 100% of sand by sawdust the density would be eliminated by 75.92%. In addition, sawdust contains tannins and soluble carbohydrates which they are adversity affecting the setting time and hardening of Portland cement (Nathan, 2018).

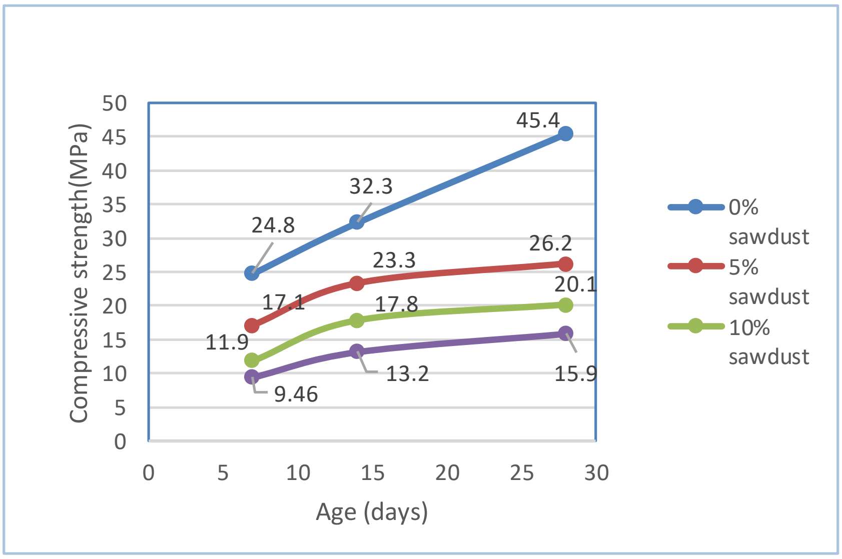

Fig. (2): Compressive strength test values

daban.abdulthahir@koyauniversity.org; sangar.qadir@univsul.edu.iq;
madih.izat@koyauniversity.org; ahmed.jabar@koyauniversity.org
[1]Corresponding author: Dept. of Geotechnical Engineering, Faculty of Engineering, Koya University Koya KOY45, Kurdistan Region-Iraq.

3.2 Split tensile strength test

Split tensile strength test is a standard and indirect way to determine the tensile strength of concrete. The results for tensile strength are presented in figure 3. A standard cylinder of concrete specimen (300 mm height, 150 mm diameter) were used to prepare the samples based on ASTM C296. However, due to its brittle in nature, concrete is weak in tension but it is an important property of concrete. Tensile strength plays an important role in safety of structures. The existence of cracks is a main reason of high stress concentrations and in that case tensile force is higher than tensile strength (Rahmat Madandoust, 2017). As it is shown in figure 3, tensile strength is reduced by increasing the amount of sawdust in concrete. For the control mix (0% of sawdust) the tensile strength has increased from 2.1 MPa in 7 days to 3.1 MPa in 28 days. Similar trend can be seen for all other percentages (5%, 10% and 15%) of sawdust by increasing the age of curing tensile strength would be increase. (Akshay Sawant1, 2018) nearly achieved the same results of this study, (4.33 MPa for control mix, 3.53 MPa for 5%, 2.02 for 10% and 1.13 MPa for 15%.

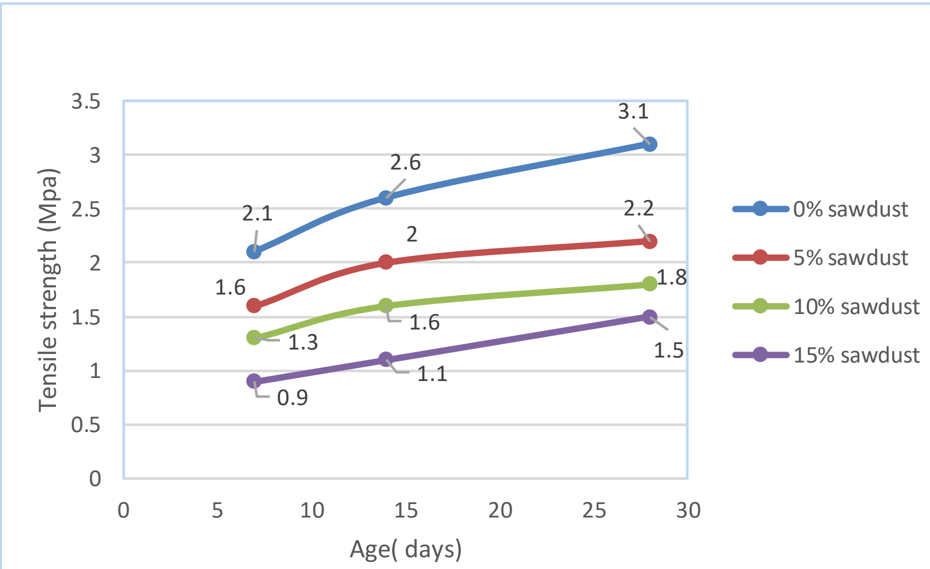

Fig. (3): Tensile strength test values

3.3 Flexural strength test

Flexural strength test is another common test to determine the tensile strength of concrete. Flexural strength is expressed as modulus of rapture and measured in normal standard size (150 mm, 150 mm, 500 mm) of specimen is used based on ASTM C293. The results for flexural strength are shown in figure (4). The results were very similar to tensile strength by increasing the amount of sawdust the flexural strength has reduces from 3.4 MPa at 28 days for control mix to 1.6 MPa at 28 days for 15% of sawdust replacement. But for all replacement percentages by increasing the time of curing flexural strength has increased. For example, for 5% of sand replacement flexural strength was 1.8 MPa at 7 days while it has increased to 2.4 MPa at 28 days. (Akshay Sawant1, 2018) obtain nearly the same results for 5% of sand replacement which was 2.43 MPa at 28 days.

daban.abdulthahir@koyauniversity.org; sangar.qadir@univsul.edu.iq;
madih.izat@koyauniversity.org; ahmed.jabar@koyauniversity.org
[1]Corresponding author: Dept. of Geotechnical Engineering, Faculty of Engineering, Koya University Koya KOY45, Kurdistan Region-Iraq.

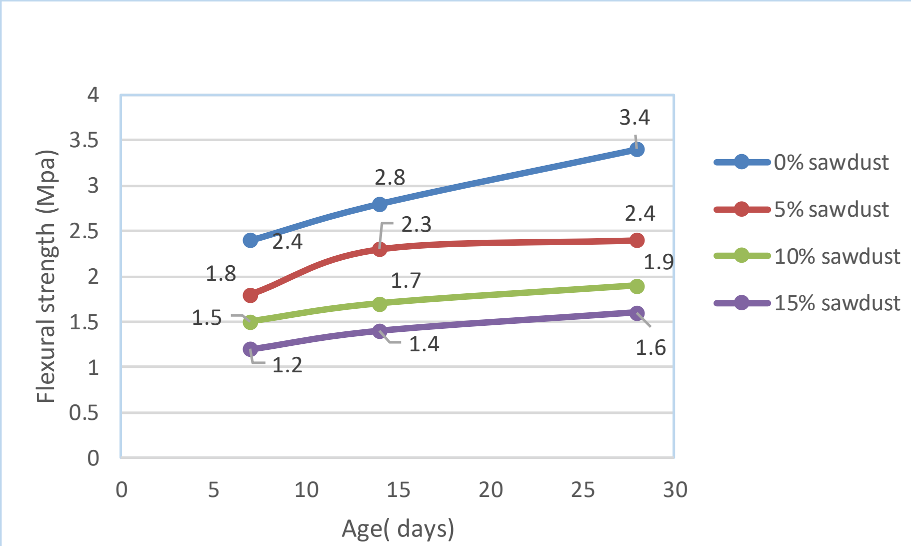

Fig. (4): Flexural strength test values

4. CONCLUSION

The following conclusions have been drawn from the current study:

1. Increasing the percentage of sawdust in concrete specimens led to reducing in compressive, tensile and flexural strength.
2. For compressive strength, 5% replacement of sand by sawdust, shows a satisfactory result (i.e. 26.2 MPa) at 28 days.
3. For compressive strength, 10% replacement the value would be 20.1 MPa and for 15% replacement the value would be 15.9 MPa at 28 days.
4. For spitting tensile strength, 5% replacement of sand the result would be 2.2 MPa at 28 days.
5. For flexural strength test, 5% replacement of sand the result would be 2.4 MPa at 28 days.

ACKNOWLEDGMENTS

We would like to express our great appreciation to both Peshawa M. Mustafa & Rekawt M. Qadir for helping in practical part of this project.

REFERENCES

A. Abdullahi, M. A. (2013). Partial Replacement of Sand with Sawdust in Concrete Production. *3rd Biennial Engineering Conference, Federal University of Technology*, (pp. 1-6). Minna.

ACI211.1-91. (2009). *Standard practice for selecing proportions for normal, heavyweight, and mass concrete (ACI211.1-91).* Americna Concrete Institute.

ACI213R-14. (2014). *Guide for Structural Lightweight-Aggregate Concrete.* American Concrete Institue.

Akshay Sawant1, A. S. (2018). Partial Replacement Of Sand With Sawdust In Concrete. *International Research Journal of Engineering and Technology* , Volume: 05 Issue: 03, 3098-3101.

ASTMC293. (2016). *Standard test method for flexural strenght of concrete (using simple beam with center-point loading).* ASTM standards.

ASTMC496. (2011). *Standard test method for splitting tensile strength of cylindrical concrete specimens.* ASTM standard.

Bdeir, L. M. (2012). Study Some Mechanical

daban.abdulthahir@koyauniversity.org; sangar.qadir@univsul.edu.iq;
madih.izat@koyauniversity.org; ahmed.jabar@koyauniversity.org
[1]Corresponding author: Dept. of Geotechnical Engineering, Faculty of Engineering, Koya University Koya KOY45, Kurdistan Region-Iraq.

Properties of Mortar with Sawdust as a Partially Replacement of Sand. *Anbar Journal for Engineering Sciences*, Vol.5, No.1, 22-30.

Crawford, R. H. (2011). *Life Cycle Assessment in the Buildt Environment* . New York: Spon Press.

Dilip Kumar, S. S. (2014). Low Cost Construction Material for Concrete as Sawdust. *Global Journal of Researches in Engineering, Civil and Structual Engineering* , 14 Issue 4 Version 1.0, 33-36.

Nathan, M. (2018). Effect of Sawdust as Fine Aggregate in Concrete Mixture. *International Journal of Engineering and Techniques* , Volume 4 Issue3, 1-12.

Oyedepo Joseph, S. D. (2014). Investigation of Properties of Concrete Using Sawdust as Partial Replacement for Sand. *Civil and Environmental Research*, Vol.6, No.2,35-42.

Pielert, J. F. (2006). *Significance of tests and Properties of Concrete & Concrete-Making Materials.* Bridgeport, NJ: ASTM International.

Rahmat Madandoust, M. K. (2017). Analytical Study on Tensile Strength of Concrete. *Romanian Journal of Materials*, 47 (2),204 - 209.

Shoab Hussain, S. K. (2017). Experimental Study on Partial Replacement of Fine Aggregate with Sawdust and Quarry Dust . *International Journal of Innovative Research in Technology* , Volume 3 Issue 12,197-200.

Tilak L.N, S. K. (2018). Use of Saw Dust as Fine Aggregate in Concrete Mixture. *International Research Journal of Engineering and Technology*, Volume: 05 Issue: 09, 1249-1253

daban.abdulthahir@koyauniversity.org; sangar.qadir@univsul.edu.iq;
madih.izat@koyauniversity.org; ahmed.jabar@koyauniversity.org

[1]Corresponding author: Dept. of Geotechnical Engineering, Faculty of Engineering, Koya University Koya KOY45, Kurdistan Region-Iraq.