Study on Suitability of Sawdust as an Alternate for Fine Aggregate in Concrete

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Abbreviations

CA	Coarse aggregate
FA	Fine aggregate
FST	Final setting time
IST	Initial setting time
NCC	Normal consistency of cement
OPC	Ordinary Portland cement
SD	Sawdust

1 Introduction

Concrete is a composite material made from a specific ratio of water, fine aggregate, coarse aggregate, and cement. The cement acts as a binder that binds all the fine and coarse aggregates together, hence forming one solid mass. Concrete is an essential construction material, due to its ease of workability and good compressive properties, although its tensile and flexural properties are very poor. According to some resources, mechanical strength characteristics of concrete perhaps enhanced through

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the addition of reinforcement materials and admixtures. Agricultural (organic) materials are usually used to replace synthetic materials, during the production of green concrete. Within the past two decades, there has been intensive campaign for green concrete, due to the climate change and environmental issues of synthetic materials. Applications of these green concretes are widely acceptable in several constructional works, due to their environmental friendliness, lightweight, cost-effectiveness, and their appreciable structural properties. Availability of agricultural materials is widespread in the rural areas where they are produced, and proper disposal of their waste products often becomes a problem. Several researches had incorporated natural materials in the production of hybridized green concretes.

Generally concrete is a material which is used next to water all over globe. As India is a developing country in which construction activities like infrastructure development, housing projects are rapidly increasing. So, one can presume the quantum of concrete for the completion of these projects without any shortage of resources. Based on the type of concrete application, 25–35% of total volume will be fine aggregate. The main reason for using natural sand as a fine aggregate in concrete compared to the other materials is because of its superior shape, size, and bonding characteristics. And, because of its low-cost and widespread availability, river sand is a popular building material. River sand has a spherical particle shape and a smooth texture due to long Term abrasion by water against the sand particle [1]. It also has a very low amount of silt and clay since it has been washed for years. India is a developing country with a yearly growth in the construction sector, particularly in structural and infrastructural constructions. As a result, demand for river sand has increased to keep up with the growth of the construction sector. On the other side, overuse of river sand resulted in a significant depletion of river sand. The removal of river sand from the riverbed has caused several environmental problems, including bank erosion, the loss of water-retaining sand strata, aquatic life disturbance, the lowering of the underground water table near the stream, and the loss of vegetation along the riverbank, all of which have an impact on the habitat above and below ground.

Sawdust is an unpopular material that is hardly employed in the construction as a building material, but it is commonly discarded as waste from furniture manufacturing industries and sawmill and because it is plentiful and has no practical value. From the literature studied, India produces approximately 30,000–33,000 T sawdust annually [2–6]. As a result, the study's objective is to achieve the optimum dosage of sawdust to use as a partial replacement for fine aggregate in concrete. In addition to the above, a novel approach is made by treating the sawdust and making it moisture free; meanwhile, binder material has been also replaced with supplementary cementitious material, i.e., fly ash.

Table 1 Physical properties of OPC-43

NCC	32.0%
Compressive strength (28 days)	47.5 N/mm^2

2 Materials

2.1 Cement

OPC-43 was used for the concrete production (Table 1).

2.2 Fly ash

Class-F fly ash is utilized for a fractional substitution of cement by 81 weight in concrete.

2.3 Water

Ground water of pH 7.3 is used for the concrete manufacturing.

2.4 Fine Aggregate

Locally available normal-graded natural sand (Zone-II)

Properties tested natural sand sawdust

Fineness modulus 3.04 2.21

Confirming to Zones II and III (Table 2).

Table 2 Physical attributes of FA and SD

Sp.gr	2.58	1.7

Fig. 1 Sawdust

2.5 Coarse Aggregate

20 mm downsize crushed granite was used for the concrete production.

2.6 Sawdust Preparation

Preparation of sawdust: used in this investigation collected from local furniture manufacturing cum sawmill in Noida. To completely dry the sawdust, it is oven dried at a temperature of 50 °C for 24 h before being ground into smaller pieces, making it easier to mix with regular concrete. In order to determine the gradation and zone of sawdust sieve, analysis test was conducted as per BS 882:1992. Sawdust passing through 4.75 mm sieve and retained on 75 µm sieve is selected for replacement of natural sand in concrete (Fig. 1).

3 Method

3.1 Particle Size Grading

The sieves analysis of the fine aggregates was determined in compliance with Indian Standard procedures.

3.2 Mix Ratio

A conventional mix ratio of 1:1.5:3 (C: FA: CA: 0.55) and water-to-cement ratio of 0.55 were adopted for the concrete production. During the course of the concrete production, the natural sand was replaced with 2.5, 5.0, 7.50, 10.0, and 12.5% of sawdust.

3.3 Concrete Preparation

Two sets of concrete were produced during the course of this study; one set was incorporated with fly ash (10% of the cement weight), while the other set was produced without fly ash. The constituent materials (fly ash, sand, gravel, cement, and water) were thoroughly mixed by using the mechanical mixing method. The fly ash was dissolved in appropriate amount water (water-to-cement ratio), to be used for the concrete production to form a starch solution. After obtaining a near homogenous material, the freshly mixed concrete was filled into a standard mold (150 mm × 150 m × 150 mm), in three layers. Each layer was then rammed thirty-five times. Then, the cast concrete cubes were covered and left under a shady for 24 h, before they were removed from the molds. All the concrete cubes produced were cured by total immersion in water. The compressive strength and split tensile strength test have been conducted as per IS provisions.

3.4 For Sawdust Experimental Work

The experimental activity entails completing a gradation analysis of SD in accordance with the BS 882:1992 standard grading and using the results to design a mix to meet the needed strength and quality of concrete. After that, the concrete is checked for its workability parameters in fresh state using the slump test and then concrete cubes and prism are cast for further examination of hardened properties. A total of 36 cubical specimens were casted and called M0, M1, M2, M3, M4, and M5 in order to conduct the strength tests.

For each combination, a total of six concrete cubes were cast and testing has been done at the same age of 7D and 28D for all blends. Prisms for each mix were casted and tested for 28 days only. The ratio of water-to-cement was set at 0.55. The casted cube and prism concrete specimens were kept for curing in a tank situated in laboratory and then tested their compressive strength and flexural strength at different ages as mentioned above (Table 3).

Table 3 Mix proportion

Mix	Cement (Kg/m^3)	Fly ash (Kg/m^3)	FA (Kg/m^3)	SD (Kg/m^3)	CA (Kg/m^3)	Water
M0	360	40	600	0	1200	220
M1	360	40	585	15	1200	220
M2	360	40	570	30	1200	220
M3	360	40	555	45	1200	220
M4	360	40	540	60	1200	220
M5	360	40	525	75	1200	220

4 Results and Discussion

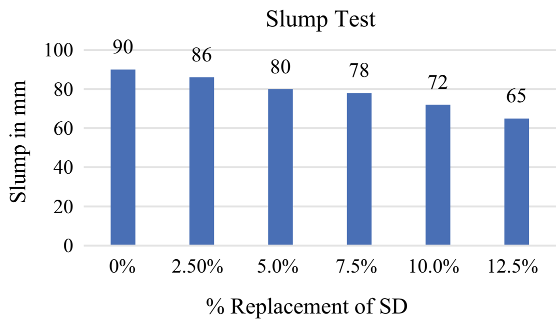
4.1 Particle Size Grading

The result revealed that the sand was well graded and met the BIS 87:2000 recommended. Indian Standard states that if sand had uniformity coefficient (Cu) higher, i.e., greater than 6 (Cu > 6), and also fine particles 160 content less than 5% (fines < 5%), the material or soil is considered as well graded and preferable for concrete production.

4.2 Workability (Slump Test)

The reason for the new substantial testing was to decide the functionality of each one of the six different blends. The slump test was utilized in this order to decide the consistency of the blend [7, 8]. The slump value obtained that for control mix was 90 mm, and shape of slump classed as true slump with high functionality according to the workability test results in Fig. 2. But the sawdust replaced mix has decreasing slump value; this may be due to water absorption characteristic of sawdust.

Fig. 2 Slump test



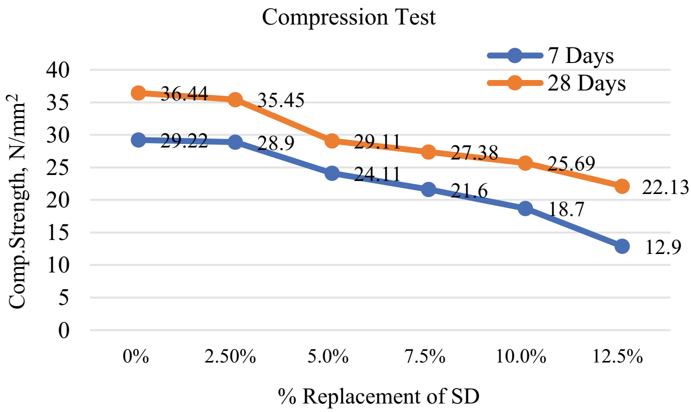


Fig. 3 Variation of compressive. Strength with age and percentage of SD

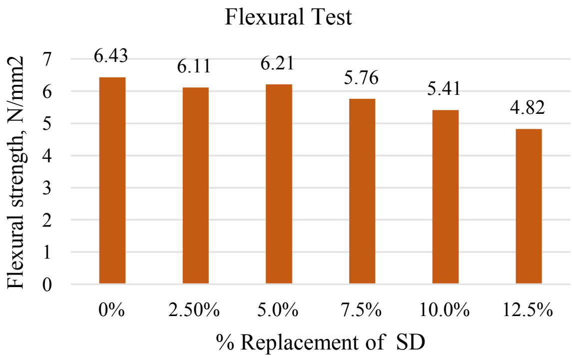
4.3 Compressive Strength

It was observed from the results that in (Fig. 3), the sawdust negatively affected the compressive strength of the concrete produced by higher replacements. At the age of 28D curing, one can observe steep decrease in the graph, as the sawdust volume increased from 2.5 to 12.5%. The results revealed that the compressive strength on the concrete decreased from 29.22 to 12.9 N/mm^2 for 7 days curing age and from 36.44 to 22.13 N/mm^2 for 28 days curing age, as the sawdust volume increased from 0 to 12.5%.

4.4 Flexural Strength

It was observed from the results that (Fig. 4), the sawdust had a negative effect on the flexural strength of the concrete produced [9, 10]. Test has been conducted on 28 days cured specimen, and the reduction in strength was observed from 6.43 to 4.82 N/mm^2 for 0–12.5% replacement of SD. But when compared to the percent of reduction in strength to that of flexural strength to compressive strength steep reduction is not observed in flexural strength. This may be due to the fibrous characteristic of the SD which is responsible for such trend.

Fig. 4 Variation of flexural. Strength with age and percentage of SD



5 Conclusion

This research aim was to evaluate the effect of using sawdust as partial replacement of sand, in concrete manufacturing. Based on the confined observe achieved on the workability and strength test conducted on SD concrete, the subsequent conclusions are drawn.

- Sawdust a waste material can be considered for partial substitute of natural sand in the concrete mix through adopting some initial treatment like drying and grading practice.
- Study shows the aptness of sawdust in concrete and quantifies the variation in strength properties and potential changes.
- Results indicate approximate strength equal to the conventional mix of M20 (1:1.5:3) grade can be obtained by replacing up to 10% of natural sand by sawdust.
- Optimum replacement of SD can be limited to 10% of total volume of fine aggregate beyond which a there is noticeable decrease in both compressive and flexural strengths.
- Furthermore, using SD reduces the density of concrete, making it lighter and appropriate for use as a lightweight construction material in a variety of civil engineering applications.
- From the above conclusions, the workability and mechanical properties of concrete blend are inversely relative with the quantity of SD brought into the concrete. More the addition of SD, the lesser will be the workability and strength of the mix. This phenomenon is because of excessive water absorption characteristics of SD.

Therefore, there is no extensive scope for using SD as complete substitute to fine aggregate in concrete.

References

1. S.N.C. Deraman, M.A.D.A. Rashid, S.A. Saad, N.M. Husain, S.A. Masjuki, Effects of durian sawdust as a partial replacement of fine aggregate in concrete, in *IOP Conference Series: Materials Science and Engineering* (2021)
2. P. Dixson Jeson, S. Karthikeyan, G. Manikandan, Experimental study on properties of concrete by partial replacement of cement with silica powder and fine aggregate with saw dust ash. Int. J. Civil Eng. Technol. (IJCIET) **8**(3), 680–687 (2017). Article ID: 235 IJCIET_08_03_068
3. Sustainable Construction and Building Materials, Springer Science and Business Media LLC (2019)
4. D. Suji, Experimental study on partial replacement of fine aggregate with quarry dust and sawdust. Int. J. Advance. Eng. Technol. Manage. Appl. Sci. **3**(6) (2016)
5. A.M. Joy, A. Jyothi, Partial replacement of fine aggregate with sawdust for concrete. Int. J. Technol. Res. Eng. **3**(9) (2016)
6. D. Kumar, Low cost construction material for concrete as sawdust. Int. J. Current Eng. Technol. E-ISSN 2277-4106, P-ISSN 2347-5161
7. U. Tomas, Ganiron, Effect of sawdust as fine aggregate in concrete mixture for building construction. Int. J. Adv. Sci. Technol. **63**, 73–82 (2014)
8. O. Joseph Oyedepo, S. Daniel, Investigation of properties of concrete using sawdust as partial replacement for sand. Civil Environ. Res. ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online) **6**(2) (2014)
9. Abdullahi, Partial replacement of sand with sawdust in concrete production. Published in *3rd Biennial Engineering Conference* (Federal University of Technology, Minna, May, 2013)
10. A.K. Minocha, Amit Bhatnagar Immobilization of arsenate (As5+) ions in ordinary portland cement: influence on the setting time and compressive strength of cement. Res. J. Environ. Toxicol. (2007)