Use of Saw Dust as Fine Aggregate in Concrete Mixture

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Abstract :- *This paper reports on experimental investigations on the effect of replacing fine aggregate with sawdust on the properties of concrete. A concrete mix of 1:1.5:3 is used while sawdust was used to replace 10%, 20%, 50% and 100% of sand by volume. The percentage reduction in density is 4.02%, 5.54%, 9.15% and 19.20% respectively while the corresponding percentage reduction in compressive strength was 28.54%, 53.95%, 67.10%,and 75.92% respectively, with respect to conventional concrete mix. As per the experimental results it was found that both the density and compressive strength of concrete decreased as the fraction of sawdust increased.*

Key Words: Compressive strength, Concrete, Sawdust, Light weight concrete, Fine Aggregate.

1. INTRODUCTION

Concrete is a mixture of cement, fine and coarse aggregates and water, which are mixed in a specific proportion to get a particular strength. Both cement and water react together chemically to form a paste, which binds the aggregate particles together. The mixture sets into a solid mass, which has significant compressive strength but less resistance towards tension [3]. The construction industry relies greatly on conventional materials such as cement, granite and sand for the making of concrete. The high and increasing cost of these materials has greatly hindered the development of housing and other infrastructural facilities in developing countries [16]. As the infrastructure of the entire planet is rising, the construction industry is in need of large amount of raw materials. As the use of raw materials increases the demand increases material [13]. The emerging concern of resource depletion and global pollution has challenged many researchers and engineers to pursue and develop new materials relying on renewable resources. These include the use of by-products and waste materials in building construction. Many of these by-products are used as aggregate for the production of lightweight concrete [2]. The most extensively used fine aggregate for the making of concrete is the natural sand mined from the riverbeds. However, the availability of river sand for the preparation of concrete is becoming scarce due to the extreme nonscientific methods of mining from the riverbeds, dropping of water table and sinking of the bridge piers among others, is becoming common treats [14]. The global consumption of sand as fine aggregate in concrete production is very high, and several developing countries have encountered some strain in the supply of natural sand in order to meet the rising needs of infrastructural development in recent years [9]. However, accumulation of unmanaged wastes especially in developing countries has resulted in an increasing environmental concern. However, the increase in the acceptance of using environmental friendly, lightweight construction materials in construction industry has brought about the need to study how this can be accomplished by benefiting environment as well as maintaining the material requirements affirmed in the standards. Since an enormous need has been placed on building material industry especially in the last decade due to the increasing population that causes a continuing shortage of building materials, the civil engineers have been challenged to convert the industrial wastes to useful building and construction materials [20]. Sawdust is an industrial waste, by-product of cutting, grinding, drilling, sanding, or otherwise pulverizing wood with a saw or other tool; it is composed of fine particles of wood. The main constituents of sawdust include cellulose, hemicelluloses, lignin and extractives. In an investigation on the use of sawdust as sand replacement to produce a low-cost and lightweight material for use in construction, [10]. It is one of the major underutilized by products from sawmilling operations. Generation of wood wastes in sawmill is an unavoidable hence a great efforts are made in the utilization of such waste [22]. Thus, this work examines the potential use of wood sawdust wastes to produce a low-cost and lightweight composite for construction and engineering purpose.

2. MATERIALS USED

1. **Saw dust**: Sawdust is also known as wood dust. It is the by-product of cutting, drilling wood with a saw or any other tool; it is composed of fine particles of wood. Certain animals, birds and insects which live in wood, such as the carpenter ant are also responsible for producing the saw dust. Sawdust's are produced as a small discontinuous chips or small fragments of wood during sawing of logs of timber into different sizes. The chips flow from the cutting edges of the saw blade to the floor during sawing operation.

Table 1: Physical Characteristics of Saw dust

Sl. No.	Properties	Value
1.	Optimum moisture content (%) (OMC)	19.80
2.	Maximum dry density(g/cc) (MDD)	1.40
3.	Specific gravity(G)	2.15

2. **Cement**: Cement used in the experiment work is ordinary Portland cement of grade 43 conforming to IS: 8112: 2013.The properties of cement are shown in following Table.

Table 2: Physical Properties of Cement

Sl. No.	Characteristics		value
1.	Specific gravity		3.12
2.	Standard consistency		37
3.	Setting time	Initial (min.)	Min 27
4.		Final (min.)	Max 613
7.	Retention on 63 micron sieve (%)		-

3. **Fine Aggregates**: Fine aggregate was purchased which satisfied the required properties of fine aggregate required for experimental work and the sand conforms to zone III as per the specifications of IS 383:1970.

Table 3: Physical Characteristics of fine aggregate

Sl. No	Characteristics	Value
1.	Specific gravity	2.7
2.	Fineness	2.71

4. **Coarse Aggregates**: Crushed granite of 20 mm maximum size has been used as coarse aggregate. The sieve analysis of combined aggregates confirms to the specifications of IS 383: 1970 for graded aggregates.

Table 4: Physical Characteristics of coarse aggregate

Sl. No	Characteristics	Value
1.	Specific gravity	2.64
2.	Fineness	6.816

5. **Water:** Water used was normal water from tap, which was free from salt and conforming the requirement of IS: 456-2000

3. METHODOLOGY

Ordinary Portland cement of grade 43 was used as a binding material which satisfies the requirements according to Indian standards, IS 8112: 2013. Coarse aggregate was obtained from a local quarry work. Sand was sourced from a local supplier in Noida. While sawdust of timber wood was obtained from a local carpenter. A concrete mix of ratio 1:1.5:3 by volume was used as control; to which the properties of the other mixes were compared. Sawdust was used to replace sand at percentages of 10%, 20%, 50% and 100% by volume. A water cement ratio of 0.45 was adopted. Sieve analyses of sawdust were carried out by using standard sizes of sieves. Concrete was produced by mixing the constituent raw materials in an electric concrete mixer. Twelve specimens of each mix were produced. Concrete was casted in cast iron moulds measuring 150mm× 150mm× 150mm internally. A total of sixty (60) specimens were casted in accordance with IS: 456-2000. After twenty four (24) hours of casting, the specimens were demoulded and placed in a curing tank until the day of testing. The compressive strengths of the samples were determined at 7, 14, 21 and 28 days of curing using a 1000kn compression testing machine. On the day of crushing, the specimens were removed from the curing tank, wiped clean with a soft towel and placed on the surface of the laboratory for approx two hours before crushing. The densities of the samples were decided by weighing and calculation of volume. The results presented are the intermediate value of three samples of the same mixture. All tests were conducted at the building materials laboratory in the department of civil engineering of the Jss academy of technical education, Noida.

4. SAMPLE CALCULATIONS

Sawdust replacement by 20%
Cement = 4.184 kg
Water = 1.883 liters
Coarse aggregate = 11.1396 kg
Fine aggregate = 7.324 kg
Volume of fine aggregate = 7.324÷ (2.65×1000) = 2.72×10^{-3} m^3
20% of fine aggregate is replaced:-
Volume of saw dust =0.20×2.72×10 = 0.544×10^{3} m^3
Mass of saw dust = $0.544\times 10^{-3}\times0.37\times10^{3}$ = 201.2 gm
Mass of fine aggregate used = $0.8\times2.72\times10^{-3}\times2.65\times10^{3}$ = 5.7664 kg
For accounting waste taking 30% extra Cement = 1.3×4.184 = 5.439 kg
Water = 1.3×1.883 = 2.5 liters

Coarse aggregate = 1.3×11.139 = 14.43 kg
Fine aggregate = 1.3×5.7664 = 7.495 kg
Saw dust = 1.3×201.2 = 261 gm

Density

Standard concrete density:-
Mass of concrete = 8.43 kg
Size of concrete block = 15cm×15cm×15cm
Volume of concrete = 3375 cm
Density = mass÷volume = 2497.77 kg/m
20% replacement of fine aggregate:-
Mass of concrete = 7.938 kg
Size of concrete block = 15cm×15cm×15cm
Volume of concrete = 3375 cm
Density = mass ÷ volume = 2352.55kg/m
Percentage reduction:-
[%change in Density = {(std. concrete density – concrete density with sawdust) x100} ÷std. concrete density]
%change in density = 5.54%

5. RESULTS

1. Compressive Strength

Table 5: Compressive Strength (N/mm^2)

Percentage Replacement of saw dust	Compressive Strength at Age(days)			
	7	14	21	28
10	15.03	21.68	23.55	24.13
20	9.99	14.03	14.88	15.55
50	7.054	9.99	10.22	11.11
100	4.97	7.16	7.33	8.13

It is seen from table 5 that for the control mix, the compressive strength of concrete at 10% replacement increased from 23.55N/mm at 21 days to 24.13 N/mm at 28 days to 11.11N/mm at 28 days .Similarly, at 100% replacement the compressive strength increased from 7.33N/mm at 21 days to 8.13 N/mm at 28 days .

2. Water absorption capacity of sawdust and Sieve analysis of sawdust

The calculated Percentage of water absorption capacity of sawdust was found to be 43%.

Table 6: Sieve analysis of saw dust

Sieve size	Weight retained (grams)	% weight retained	Cumulative retained %	Cumulative passing %
4.75mm	14	14	14	86
2.36mm	20	20	34	66
1.18mm	22	22	56	44
600 μm	16	16	72	28
425 μm	08	08	80	20
300 μm	04	04	84	16
150 μm	06	06	90	10
75 μm	04	04	94	06
Pan	06	-	-	-

3. Density

Table 7 shows the results of the average density of concrete specimens obtained from the tests. The density of concrete reduces as the sawdust content increases.

Table 7: Density (kg/m3)

Percentage Replacement of saw dust	Compressive Strength at Age(days)			
	7	14	21	28
10	2358.21	2367.56	2378.07	2395.25
20	2298.67	2311.68	2327.11	2352.55
50	2231.63	2246.09	2253.03	2260.44
100	2013.99	2036.73	2053.03	2076.44

Density of 10% of the control mix concrete increased from 2378.07kg/m at 21 days to 2395.25kg/m at 28 days .The density at 20% replacement increased from 2327.11kg/m at 21 days to 2352.55kg/m at 28 days, similarly at 50 % replacement the density increased from 2253.03kg/m at 21 days to 2260.44 kg/m at 28 days. At complete replacement, the density increased from 2053.03 kg/m at 21 days to 2076.44 kg/m at 28 days. The density of concrete increased with age.

4. Compressive strength and density reduction

The percentage reduction in compressive strength and density at 28 days is shown in the table below:

Table 8: Percentage reduction in compressive strength and density

Percentage Replacement of saw dust	Density (%)	Compressive strength (%)
10	4.02	28.54
20	5.54	53.95
50	9.15	67.10
100	19.20	75.92

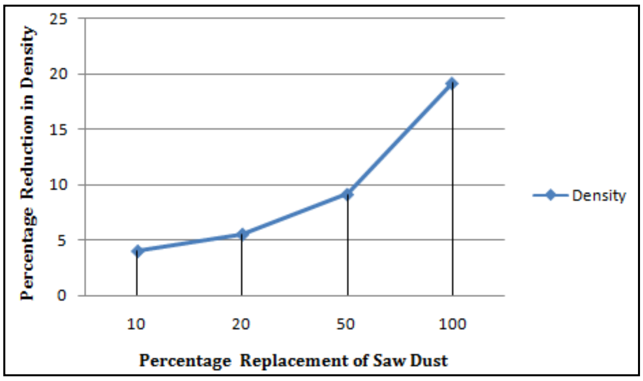

Figure 1: Percentage Reduction in Density

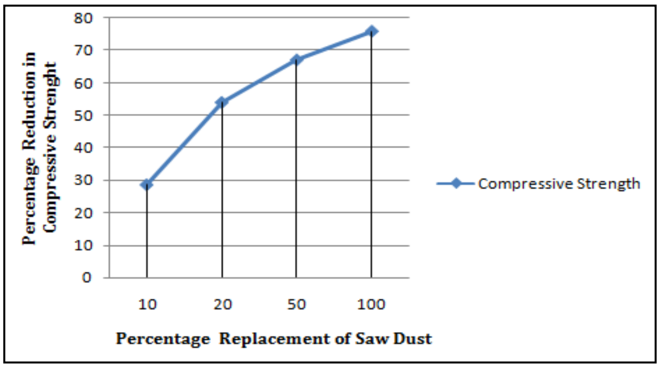

Figure 2: Percentage Reduction in Compressive Strength

6. CONCLUSIONS

From the above study the following conclusions have been driven:

i. There is a reduction in the compressive strength and density of concrete when the percentage replacement of sand by sawdust increased.

ii. It was found that the effect of sawdust on the strength of concrete was more enunciate than the effect on the density of concrete.

iii. This sawdust concrete can be used where compressive strength is not a major requirement.

iv. At least 14% replacement can potentially be used in making structural concrete.

v. To produce structural lightweight concrete sawdust can potentially replace 16% of sand.

vi. As the sawdust may be obtained at virtually no cost, the cost of concrete can potentially be cut down by replacing the sand with sawdust in concrete.

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