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Effect of Saw Dust on Strength Properties of Concrete

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Abstract**: The present study focuses on the utilization of saw dust as a partial replacement material for fine aggregate in concrete production. For the experimental investigation, Ordinary Portland Cement (53 Grade) was used, and fine aggregate was replaced with saw dust at varying proportions of 0%, 10%, 15%, and 20% by weight. The influence of saw dust on the workability and compressive strength of concrete was examined. Slump test was conducted to determine workability, while compressive strength tests were carried out at 7 days and 28 days of curing. The results indicate that the inclusion of saw dust up to 10% replacement produces satisfactory strength comparable to conventional concrete. However, higher percentages resulted in reduced workability and strength due to the lightweight and fibrous nature of saw dust. Hence, saw dust can be effectively used as a sustainable alternative to sand in non-structural and lightweight concrete applications
Keywords: Saw Dust, Fine Aggregate, Compressive Strength, Workability, Sustainable Concrete

I. INTRODUCTION

Regular concrete is generally composed of four major components, namely a) cement, b) water, c) fine aggregate (sand), and d) coarse aggregate (gravel or crushed stone). Sometimes, mineral admixtures or chemical additives are also incorporated to enhance specific properties of concrete. Aggregates occupy nearly 70–80% of the total volume of concrete, and therefore the quality and type of aggregate significantly influence its overall performance. The proper proportioning of these ingredients determines the strength, durability, and workability of the concrete mix. In recent years, the disposal of agricultural and wood-based wastes has become an environmental concern. To address this issue, researchers have focused on utilizing these wastes as alternative construction materials. One such material is sawdust, a by-product of timber industries and sawmills. Sawdust consists of fine wood particles obtained during the sawing and shaping of wood, and it is often available in large quantities as industrial waste. Improper disposal or open burning of sawdust contributes to environmental pollution and health hazards. Sawdust has potential pozzolanic and filler properties, making it a viable material for partial replacement of fine aggregate in concrete. When properly treated and used, sawdust can improve the workability and reduce the overall density of concrete, producing lightweight and sustainable construction materials. The utilization of sawdust in concrete helps conserve natural river sand and reduces the environmental impact associated with sand mining. The present study focuses on the use of sawdust as a partial replacement for fine aggregate in concrete. The experimental investigation examines the effect of varying percentages of sawdust (5%, 10%, 15%, 20%, and 25%) on the fresh and hardened properties of M25 grade concrete, including workability, compressive strength, split tensile strength, and flexural strength. The study aims to evaluate the feasibility of using sawdust as an eco-friendly and economical substitute in sustainable concrete production. This paper investigates the impact of Saw dust in concrete by partially replacing Saw dust with cement in the ratio of 0%, 5%, 10%, 15%, 20% and 25% by weight for M25 grade of concrete. The experimental study examines the slump of the fresh concrete, compaction factor, compressive strength, split tensile strength, flexural strength, and modulus of elasticity.

II. MATERIAL DETAILS

A. Cement

Ordinary Portland Cement (OPC) of 53 grade having specific gravity 3.14 and fineness 1% is used. The Standard consistency of cement is 32%. The initial and final setting times are 90 minutes and 162 minutes respectively.

B. Saw Dust

The sawdust used for this investigation was obtained from a local sawmill. Sawdust is a by-product generated during the cutting, drilling, and shaping of wood in timber industries.Chemically, sawdust is composed mainly of cellulose (40–45%), hemicellulose (25–30%), and lignin (20–25%), along with small amounts of resins and ash content.

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The specific gravity of sawdust used in this study was found to be approximately 1.3, and its moisture content ranged between 8–12%. The bulk density of sawdust was observed to be around 550–650 kg/m³, which is considerably lower than that of natural river sand.

Table -1: Chemical Properties of Saw Dust

Sl.no.	Component	Mass %
1	Silica (SiO_2)	71.0
2	Alumina (Al_2O_3)	1.9
3	Ferric Oxide (Fe_2O_3)	7.8
4	Calcium Oxide (CaO)	3.4
5	Magnesium Oxide (MgO)	0.3
6	Potassium Oxide (K_2O)	8.2
7	Sodium Oxide (Na_2O)	3.4
8	Phosphorus Pentoxide (P_2O_5)	-
9	Manganese Oxide (MnO)	0.2

C. Fine Aggregate

Regionally available river sand is used and it comes zone II as per Indian standards. The specific gravity of sand is 2.613. Fractions from 4.75mm to 150µare termed as fine aggregate, and the bulk density in loose state and rodded state are 1550.463 kg/m3 and 1699.945 kg/m3 respectively. The percentage of water absorption is 4.562%.

Table -2: Sieve Analysis of Fine Aggregate

Sieve size	Weight retained (kg)	Percent- age of weight retained	Cumulative percent-age retained	Percentage finer
4.75mm	0.016	3.2	3.2	96.8
2.36mm	0.026	5.2	8.4	91.6
1.18mm	0.068	13.6	22	78
600µ	0.166	33.2	55.2	44.8
300µ	0.096	19.2	74.4	25.6
150µ	0.114	22.8	97.2	2.8
Pan	0.014	2.8	-	0

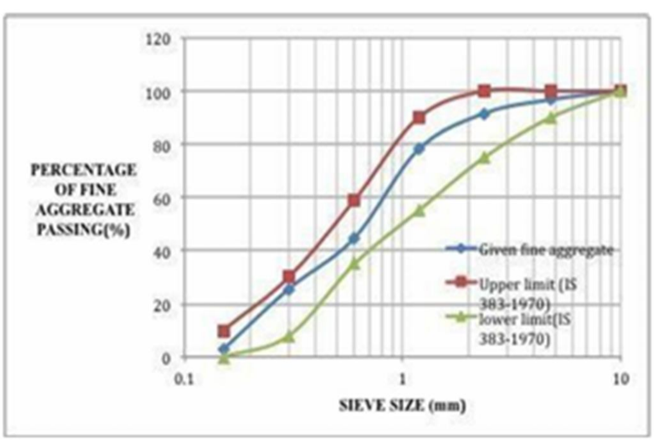


Chart -1: Particle Size Distribution of Fine Aggregate

D. Coarse Aggregate

The crushed aggregates of 20mm nominal size from the local source are used and its specific gravity is 2.31. The bulk density in loose state and rodded state are 1778.618 kg/m3 and 1907.981 kg/m3 respectively. The percentage of water absorption is 0.217%.

Table -3: Sieve Analysis of Coarse Aggregate

Sl. no.	Sieve size	Weight retained (kg)	Percent- age of weight retained	Cumulative percentage retained
1	80mm	0	0	0
2	40mm	0	0	0
3	20mm	1.34	26.8	26.8
4	10mm	3.66	73.2	100
5	4.75mm	0	0	100
6	2.36mm	0	0	100
7	1.18mm	0	0	100
8	600µ	0	0	100
9	300µ	0	0	100
10	150µ	0	0	100

E. Water

The locally available potable water accepted for local construction as per IS: 456-2000 [17] was used in the experimental investigation.

III. EXPERIMENTAL INVESTIGATION

Totally 72 concrete specimens were cast, out of which, 18 specimens were cubes, of standard dimensions 150mm*150mm*150mm and 18 were prisms with dimensions 400mm*100mm*150mm, were casted for compression test and flexural test respectively. Similarly, 36 cylinders of standard dimension 150mm*300 mm were cast for split tensile test and modulus of elasticity. Three specimens were cast for each percentage of replacement and were cured in the curing tank for 28 days and were tested.

A. Mix Details

The mix design of concrete was done as per IS 10262:2009 [21]. Totally six mixes were prepared; one of the mixes with no Saw dust content is called the control mix. The remaining five mixes were prepared by replacing cement partially with saw dust at specified ratios for M25 grade of concrete. The mixes were entitled as M0 for control mix and M1 - M5 for concretes with 5%, 10%, 15%, 20% and 25% Saw Dust respectively. The mix details are outlined in Table-4.

Table - 4: Mix Details

Mix designation	Cement (kg/m^3)	Fine aggregate (kg/m^3)	Saw Dust (kg/m^3)	Coarse aggregate (kg/m^3)	W/C ratio	Water (kg/m^3)
M0	394.320	639.168	0	1192.680	0.50	197.160
M1	374.604	636.502	19.716	1187.705	0.50	197.160
M2	354.888	633.836	39.432	1182.730	0.50	197.160
M3	335.172	631.170	59.148	1177.755	0.50	197.160
M4	315.456	628.504	78.864	1172.780	0.50	197.160
M5	300	624.562	98.580	1165.425	0.50	197.160

B. Workability

A good-quality concrete should have acceptable workability in the fresh condition and should develop sufficient strength. The workability of the freshly mixed concrete was determined using slump cone test and compaction factor test.

C. Compressive Strength

ompressive strength of saw dust blended concrete cubes was determined after 28 days curing and tested as per IS 516:1959 [18]. The rate of loading of compressive strength testing machine is 0.5 tonnes/sec.

D. Split Tensile Strength

Cylinders of size 150mm in diameter and 300mm in length were cast and cured for 28 days. Each split tensile strength result is the average of three specimens. The test was conducted in a compression testing machine as per the Indian code IS 516:1959[18] and the maximum load applied on the specimen at the failure was recorded and the strength was calculated by using appropriate equations.

E. Flexural Strength

Prism specimens that are cast and cured for 28 days were tested for maximum load. Flexural strength of concrete prism specimens containing various amounts of bagasse ash was determined.

F. Modulus of Elasticity

Modulus of elasticity of cylinder specimens was determined using a compressometer. The gauge length of the compressometer is 200mm and the least count of dial gauge is 0.002mm.

IV. RESULTS AND DISCUSSIONS

A. Effect of Saw dust on workability

1) Slump Cone Test

Table - 5 shows the slump values for all the concrete mixes. Since the water content was constant in all six mixes, the effect of saw dust on the workability of concrete can be better understood. As shown in Chart-2, the workability of concrete increases with the increase in the saw dust content. For control mix concrete, M0 the slump value was obtained as 70 mm, whereas for 25%, the slump was about 160 mm. It means the addition of saw dust content reduces the water demand in concrete.

Table - 5: Workability

% Saw Dust	Workability	
	Slump (mm)	*Compaction Factor*
0	70	0.86
5	85	0.91
10	90	0.91
15	100	0.92
20	125	0.92
25	160	0.93

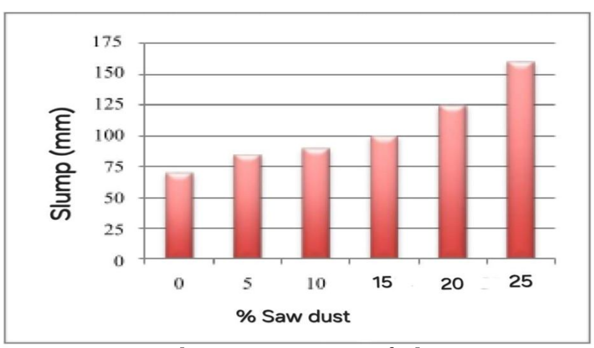


Chart -2: Variation of Slump

2) Compaction Factor Test

Chart-3 represents the influence of saw dust content on the compaction factor of all mixes at constant w/c ratio. The results indicate that unlike the M0 mix, other sa mixtures had high compaction factor values and acceptable workability.

B. Compressive Strength

Table-6 indicates the average compressive strength of all six mixes determined at the age of 28 days. Four mixes containing 5%, 10%, 15% and 20%, respectively Saw dust showed higher compressive strength than M0 mix, whereas M5 mix indicated lesser compressive strength than the M0 Table -6: Average Split Tensile Strength mix because the quantity of amorphous silica present in the mixture is higher than the amount needed to react with calcium hydroxide produced during hydration reaction, therefore reducing the overall strength of the specimen.

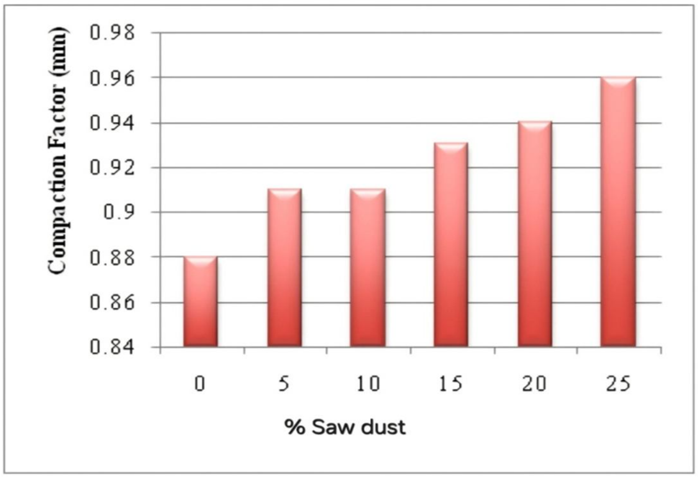
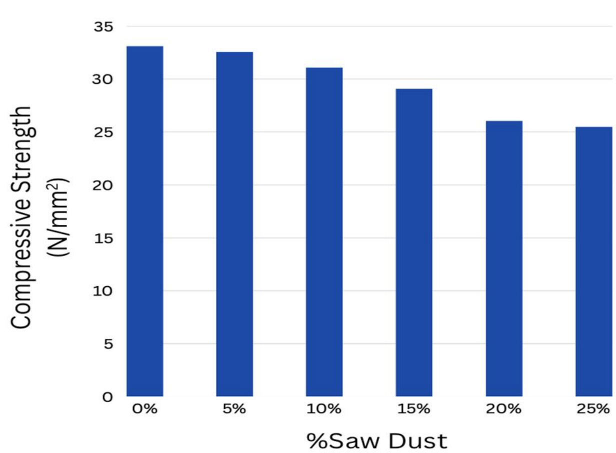


Chart -3: Variation of Compaction Factor

Table -5: Average Compressive Strength

Mix Designation	% Saw Dust	Average Compressive Strength (N/mm^2)
M0	0%	33.102
M1	5%	32.564
M2	10%	31.098
M3	15%	29.108
M4	20%	26.045
M5	25%	25.879



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C. Split Tensile Strength

The split tensile strength of saw dust blended cement concrete is more than M0 concrete mix up to 20% replacement of cement with saw dust (M4), as shown in Chart-5. Further increase in the level of replacement to 25% lead to marginal reduction in split tensile strength of the concrete, probably due to the dilution effect.

Table -6: Average Split Tensile Strength

Mix Designation	% Saw Dust	Average Split Tensile Strength (N/mm^2)
M0	0%	2.101
M1	5%	2.783
M2	10%	3.045
M3	15%	2.912
M4	20%	2.657
M5	25%	1.798

Chart -5: Variation of Split Tensile Strength

D. Standard Consistency of Cement

The results are given in Table-7, and Chart-6 indicates the variation in penetration of plunger for different water percentage with Saw Dust, with respect to control mix concrete. Highest penetration is obtained for 26% percentage of water and for

Table -7: Average Flexural Strength

Percentage of water	Quantity of water added(ml)	Vi-cats plunger pene- tration (mm)
26%	104	36 mm
28%	112	28 mm
30%	120	16 mm
32%	128	6 mm

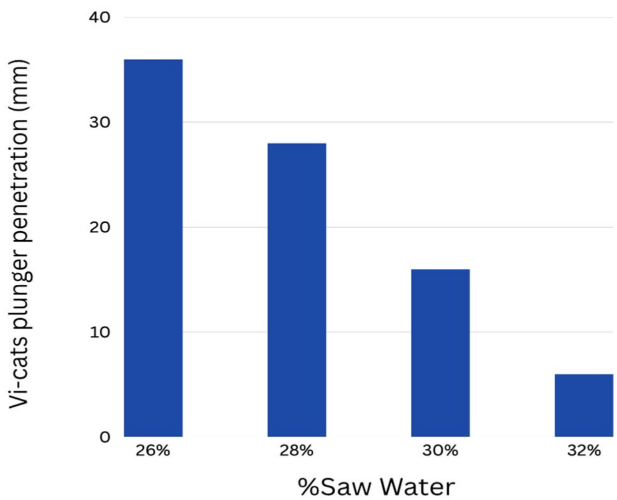

Chart -6: Variation of Penetration of Plunger

E. Modulus of Elasticity

Variation in Modulus of elasticity for different replacement levels is shown in Chart-7.

Table -8: Average Modulus of Elasticity

Mix Designation	% Saw Dust	Modulus of Elasticity $*10^4$ (N/mm^2)
M0	0%	4.72
M1	5%	5.02
M2	10%	5.12
M3	15%	5.07
M4	20%	4.86
M5	25%	4.66

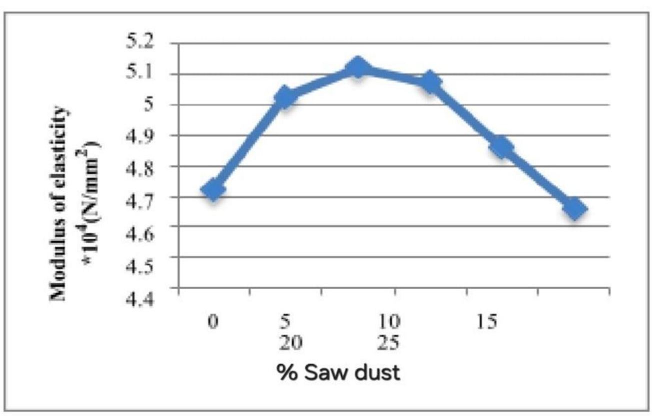

Chart -7: Variation of Modulus of Elasticity

The reasons for increase in strength up to 20% cement replacement of saw dust may be due to silica content, amorphous phase, fineness, specific surface area, degree of reactivity of saw dust and pozzolanic reaction between calcium hydroxide and reactive silica in saw dust in the alkaline environment as reported by previous works [2,3, 6,7]. At 25% saw dust, the strength decreases to a lesser value than that of control specimens. Therefore, 20% saw dust blended concrete seems to be the optimal limit.

V. CONCLUSIONS

From the present analysis, I've come to the following conclusion. Up to 20% of OPC can be replaced optimally with Saw Dust without any contrary effect on the desirable properties of concrete.

1) Partial replacement of cement by saw dust boosts workability of fresh concrete; therefore use of super plasticizer is not essential.
2) The results showed that the concrete with 10% Saw Dust replacement after 28 days of curing, showed maximum strength when compared to concrete with other percentage replacement mixes.
3) As the flexural tensile strength of Saw Dust concrete is more it can be used in slabs, beams etc., where higher flexural tensile strength is required.
4) In the economic point of view, the cement replaced by Saw Dust saves money.
5) Since saw dust is a by-product material, its use as a cement replacing material reduces the levels of wastage by the cement industry. In addition its use resolves the disposal problems associated with it and thus keeps the environment free from pollution.

VI. FUTURE WORKS

- The effect of different percentage replacement of cement by Saw Dust on the properties of the high strength concrete (M35, M40, M45 etc.,) is to be studied.
- Other properties of concrete like heat resistance and shear should be studied. It can also be studied in self- compaction of concrete.
- Durability aspects of saw dust should be studied.
- The behavior of structural elements such as beams, columns and slabs made with saw dust concrete should also be investigated.

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