Steel incorporated sawdust concrete

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Abstract. The constant increase in rate of cement in developing countries such as India has aroused the need to relate research to production. This Paper deals with subject of reducing the overall construction cost of concrete by partial replacement of Pozzolanic Portland Cement (PPC) with an optimum content of sawdust to reduce the cost and addition of Lathe Scrap Powder (LSP) to compensate the loss of strength due to replacement of cement by sawdust. PPC was replaced with 6%, 8%, 10%, 12% and 15% of sawdust to find the optimum percentage. LSP was then added in 0.25%, 0.5%, 0.75%, 1.0% and 1.5% to the sawdust concrete. After a time period of 7 days, 14 days and 28 days curing of standard size concrete cubes a compressive strength test was carried out, and the slump test was done on freshly prepared sample of concrete. Weight of the cubes was also found to calculate the bulk density of the steel incorporated sawdust concrete. Results show that on addition of 0.25% LSP on sawdust concrete indicated compressive strength (31.33) which was comparable to that of plain concrete (32.66).

1. Introduction

In any construction project the cost of construction materials may be up to 70% of the total cost incurred [1]. As the consumption of raw materials increases the demand on materials also increases [12]. Hence, to relax this demand, the search for an alternative binder or cement replacement materials led to the discovery of the potential of using industrial by-products and agricultural wastes as cementitious materials. If these fillers have pozzolanic properties, they impart technical advantages to the resulting concrete and thus enable larger quantities of cement replacement to be achieved [8]. However, the quality of concrete blocks is also a function of the method employed in the production and the properties of the constituent materials [2]. Commonly, along with the binding capacity of mortar and the coarse aggregates (the interfacial transition zone), the strengths of the mortar and the coarse aggregate influence the concrete strength on the whole [18]. The strength of aggregates is very high hence it is not a factor of influence to the normal strength of concrete. Therefore, only the mortar and the interfacial transition zone influence the concrete failure [19]. Previous researches have proven that the otherwise agricultural waste as pozzolanic materials which react with the lime produced as by-product of hydration of OPC to produce additional calcium silicate hydrate (C-S-H). The compressive strength of blended cement composites is increased due to this. [15], [16], [17].

Sawdust has pozzolanic properties and has been shown to react chemically with the calcium hydroxide released from the hydration of Portland cement, to form cement compounds [9]. Sawdust can be used as both, substitute for sand [10] as well as cement [11], leading to a reduction in either workability or compressive strength respectively. On replacing cement, the reduction in strength may be compensated for, by the use of fibers. Moreover, a ductile failure is experienced under compression, flexure and torsion along with the increase in fatigue resistance when steel fibred are used [3].
structural properties like impact resistance, flexural toughness and flexural strength increases with the use of these fibers [5]. At the same time strength, freeze-thaw durability and dry shrinkage also increases. However, on the other hand addition of carbon fibers decreases the electrical resistance [6] and density, while improving thermal conductivity, chemical stability and abrasion resistance [4]. Lathe scrap has also been known to increase the strength of concrete [13]. Apart from strength it also increases Radiation Shielding Capacity of Concrete [14]. Since the original aim of our work here is to reduce the cost of concrete it would be counterproductive to choose addition of Steel or Carbon fibers to compensate for the strength reduction, and hence the ideal decision here, is to combine the use of sawdust to reduce the cost and lathe scrap as an additive to account for the loss in strength without affecting the economy.

2. Materials and methods

2.1. Materials

- Sawdust: The Saw Dust used was obtained from Fabrication lab in Amrita University, Ettimadai. After collection, the sawdust was sun-dried for 24 hours. The dust passing through 150µm sieve was used.

- Lathe Scrap: Lathe scrap was acquired from the Lathe workshop, Amrita University, Ettimadai. The scrap was powdered as per the fineness needed so that it could mix properly with the mortar and increase the strength of concrete [5]. The grounded lathe scrap was about 0.5-1mm in length.

![Figure 1. 150µm Sieve](image1)

![Figure 2. Sawdust before sieving.](image2)

![Figure 3. Sawdust after sieving.](image3)

![Figure 4. Lathe scrap before pulverization](image4)

![Figure 5. Lathe Scrap after pulverization](image5)
Coarse Aggregate: The Aggregate available in Construction Materials Lab. Amrita University, Ettimadai and passing through 20mm sieve was used for this research work.

Fine Aggregate: The research was carried out with the sand present in the Construction Materials Lab. Amrita University, Ettimadai. The unwanted and impure particles were removed to satisfy the provisions of BS 882(1992).

Cement: The research work was carried with the use of Pozzolana Portland Cement.

2.2. Methodology

2.2.1. Initial tests on materials

The initial test on the various materials (Aggregates, cement and sawdust) such as sieve analysis, specific gravity, bulk density and fineness were done. These tests were conducted to find the basic engineering properties of materials and it is confirmed that they lie within the standards specified by IS codes.

2.2.2. Batching and mixing of materials

Batching of materials was done by volume. The percentage replacements of Pozzolanic Portland cement (PPC) by Sawdust taken were 0%, 6%, 8%, 10%, 12%, 15% and 20% respectively. For the comparison and to serve as a platform for checking the other samples a 0% replacement was done.

2.2.3. Concrete Mix Design

Sand, Gravel and Binders were mixed to form the concrete which was used for the various tests. The concrete mix design was done for M30 grade concrete. And the resultant ratio was found out to be 1:1.22:2.69 by weight. The work was mainly divided into two parts: one is to find the optimum content of sawdust and the other to study the change in properties of concrete due combined effect of sawdust and lathe scrap.

2.2.3.1. Determination of Optimum Content (OC) of Sawdust

- Preparations of concrete cubes: A standard mould size of 150 x 150 x 150 mm was adopted for the size of concrete cubes used in all tests. Total of seven various mixtures based on different sawdust percentages (0, 6, 8, 10, 12, 15 and 20). A three-layer compaction was done for the concrete mix. The sample cubes were removed from their moulds after 24 hours and cured in a water tank for 7 days.

- Testing of samples: The compressive strength for the concrete blocks was tested with the help of Compressive Testing Machine in the Strength of Materials Laboratory in Amrita University. Once the concrete block fails and the load at which the failure occurs is displayed on the dial, the machine stops functioning.

2.2.3.2. Study of change in properties due to combined effect of Sawdust and Lathe scrap

- Preparations of concrete cubes: A standard mould size of 150 x 150 x 150 mm was adopted for the size of concrete cubes used in all tests. Five mixes were prepared as given below.
The sample cubes were removed from their moulds after 24 hours and cured in a water tank for 7 days, 14 days and 28 days as per requirement. A curing for 28 days was done [7].

- Testing of samples: The compressive strength for the concrete blocks was tested with the help of Compressive Testing Machine in the Strength of Materials Laboratory in Amrita University Ettimadai. Once the concrete block fails and the load at which the failure occurs is displayed on the dial, the machine stops functioning.

7th Day Crisis:

After the 7th day test, three different cases could arise:

Case 1: If (0.5% fiber strength < 1% fs < 1.5% fs)
   i) Then cast 2%, 2.5% and so on.

Case 2: If (0.5% fiber strength > 1% fs > 1.5% fs) and
   i) 0.5 fs < str. sawdust concrete;
   ii) change material

Case 3: If (0.5% fiber strength > 1% fs > 1.5% fs) and
   i) 0.5 fs > str. sawdust concrete;
   ii) Cast 0.25% and 0.75

Figure 6. Samples in curing tank.
3. Results and discussions

3.1. Determination of optimum content of sawdust ash

To determine the optimum content of sawdust that can be added to the concrete, 7th day compressive strength of concrete cubes with various percentages of Sawdust were tested. The following table shows the result of the same:

**Table 1.** Seventh-day compressive strength.

| Saw Dust Ash Replacement (%) | Failure load (kN) | Compression Strength (N/mm²) |
|-----------------------------|-------------------|-----------------------------|
|                             | Sample 1 | Sample 2 | Sample 3 | Average | Sample 1 | Sample 2 | Sample 3 | Average |
| 0                           | 470      | 475      | 460      | 468      | 20.8     |
| 6                           | 400      | 395      | 380      | 391.7    | 17.39    |
| 8                           | 385      | 375      | 390      | 383.3    | 17.02    |
| 10                          | 360      | 390      | 385      | 378.5    | 16.80    |
| 12                          | 340      | 340      | 320      | 326.7    | 14.51    |
| 15                          | 320      | 340      | 315      | 325      | 14.44    |

**Figure 7.** Variation of Compressive strength.

Fig.7 shows the plot between the 7th day compressive strength and sawdust percentage. It is clear from the graph that there is a drastic decrease in the strength when the sawdust percentage is increased beyond 10. Hence the Optimum Saw Dust replacement can be taken as 10%.

3.2. Study of change in properties due to combined effect of Sawdust and Lathe scrap

The combined effect of saw dust and lathe scrap in properties of concrete was studied using slump test, compressive strength test and bulk density test as follows.
3.2.1. Slump Test
While mixing, as the content of lathe scrap powder increases there is a decrease in slump value, indicating reduced workability. Results of slump test on fresh concrete sample. The table given below gives the obtained results.

Table 2. Slump test results.

| Percentage (Lathe scrap) | Slump Value (mm) |
|--------------------------|------------------|
| Plain concrete           | 63               |
| Sawdust Concrete         | 48               |
| 0.25% Sawdust concrete   | 45               |
| 0.5% Sawdust concrete    | 45               |
| 0.75% Sawdust concrete   | 42               |
| 1.0% Sawdust concrete    | 41               |
| 1.5% Sawdust concrete    | 36               |

3.2.2. Compressive Strength
Compressive strength of any cube depends on its own composition. Here is the table showing test results for 7th day, 14th day and 28th day compressive strength:

Table 3. 7, 14, 28 day compressive strength

| Lathe scrap (%) | 7th day Compressive Strength (N/mm²)* | 14th day Compressive Strength (N/mm²)* | 28th day Compressive Strength (N/mm²)* |
|-----------------|---------------------------------------|----------------------------------------|----------------------------------------|
| Plain concrete  | 20.8                                  | 25.6                                   | 32.7                                   |
| Sawdust Concrete| 16.8                                  | 20.5                                   | 25.8                                   |
| 0.25% Sawdust concrete | 17.8                              | 23.8                                   | 31.3                                   |
| 0.5% Sawdust concrete | 17.6                              | 23.5                                   | 31.3                                   |
| 0.75% Sawdust concrete | 16.9                              | 22.1                                   | 28.3                                   |
| 1.0% Sawdust concrete | 16.5                              | 21.5                                   | 27.9                                   |
| 1.5% Sawdust concrete | 15.03                             | 18.3                                   | 22.3                                   |
3.2.3. Bulk Density
The bulk density was calculated by measuring the weight of each cube and then dividing it by volume. The table shows variation of bulk density with increase in lathe scrap percentage.

Table 4. Variation of bulk density.

| Lathe scrap (%)     | Weight (kg) | Density (kg/m³) |
|---------------------|-------------|-----------------|
| Plain concrete      | 8.126       | 2407            |
| Sawdust Concrete    | 7.908       | 2343            |
| 0.25% Sawdust concrete | 7.936      | 2351            |
| 0.5% Sawdust concrete | 7.940      | 2352            |
| 0.75% Sawdust concrete | 7.958      | 2358            |
| 1.0% Sawdust concrete | 7.960      | 2358            |
| 1.5% Sawdust concrete | 8.050      | 2385            |

4. Conclusion
From the above investigation the following conclusions were made:
The strength of the resultant lathe scrap incorporated sawdust cube was comparable to that strength of plain concrete and is greater than the design mix strength and hence can be used for ordinary construction works. The weight reduction achieved by replacing the heavier cement with the lighter saw dust was
clouded by the introduction of the relatively denser lathe scrap. Thus, only a marginal reduction in overall weight was effectively achieved in this work. The replacement of cement by 10% with saw dust makes the total cost of concrete go down by up to 10% of the total cement cost, excluding wastage. This not only reduces the cost but also reduces the impact on the environment caused during both manufacture of cement and also reduces the air pollution occurring during mixing of concrete and laying of concrete. Thus, not only is concrete made cheaper, it can also be made more environment-friendly. Hence it can be summarized as follows:

- Self-weight of concrete was marginally reduced.
- Optimum amount of lathe scrap was found out to be 0.25% of cement by weight.
- A saving of up to 10% of cost incurred in cement purchase can be achieved.

5. REFERENCES

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