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Original Article

Suitability of using sawdust in concrete as partially replaced fine aggregate

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ABSTRACT

To evaluate the compressive strength of concrete, an experimental study of sawdust used in structural concrete is the topic of this research. The purpose of the study is to compare how sawdust-containing concrete and concrete without sawdust perform in terms of strength attributes. Another goal is to lower the cost of new construction using sawdust to partially replace fine aggregates for low-priority projects like a road or sidewalks. A total of 36 concrete cylinders were built utilizing sawdust as a partial replacement for fine aggregate and was combined with fresh sand and stone chips as replacements of 0%, 2.5%, 5%, and 7.5% of the total fine aggregate, respectively. To determine the compressive strength of the concrete, cylinders were tested by destructing the cylinders with the help of a Universal Testing Machine. Analysis showed that the maximum compressive strength of a standard concrete cylinder was 20.23 Mpa with no sawdust, but an increase in the percentage of sawdust in concrete cylinders led to a corresponding reduction in compressive strength values. From the results, the optimum sawdust content was at 2.5% due to its corresponding highest compressive strength at 19.04 Mpa.

Keywords: Concrete, fine aggregate, sawdust, strength, universal testing machine

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INTRODUCTION

Concrete is a widely used construction material due to its high compressive strength and durability.[1,2] One way to improve the compressive strength of concrete is to replace a portion of the sand used in its mix design with an alternative material. The use of wastes such as palm kernel shells, coconut shells, and sawdust in construction would help to reduce over reliance on traditional materials such as cement, sand and crushed rock aggregates whose exploitation has resulted in negative environmental consequence.[3] Using of sawdust in concrete is an interesting possibility for economy on waste disposal sites and conservation of natural resources.[4] Sawdust is such material that may use as a partial replacement for sand in concrete mixtures.[5] Recycling of such wastes into new building materials could be a viable solution not only to the pollution problem, but also to the challenge of high cost of building materials currently facing by both the developed and developing countries.[6,7]

Sawdust is a by-product of the wood industry and is readily available in many parts of the world.[8] A large quantity of Timber materials changes into wastage Sawdust during processing. Sawdust is a highly variable material with differing particle size, chemical composition, density and colour.[9] It is a lightweight and low-density material that can use as a partial replacement for sand in concrete. With the increasing high building construction, the construction weight becomes important and this problem can be solved using lightweight concrete.[10-12] When sawdust mixes with concrete mixtures, it can eliminate the density making it lighter and easier to handle. Additionally, sawdust can improve the thermal insulation properties of concrete, making it suitable for use in cold climates. Saw dust is a waste when it is burnt, producing a lot of carbon emissions that pollute the environment.[13] If sawdust adds to concrete, there will be fewer emissions of carbon dioxide into the environment.

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Accumulation of unmanaged waste especially in developing countries has resulted in increasing environmental concerns whilst recycling of such waste as building materials appears to be a viable solution not only to such pollution problem but also to economic design of buildings.[14] The use of cement, sawdust and sand for making floor and wall panels has been fairly common in many parts of the world. The replacement of fine aggregates with sawdust can be beneficial for the building components.

But sawdust is organic and can decompose over time, leading to a reduction in the strength of the concrete. It can also increase the porosity of the concrete, making it more susceptible to moisture penetration and deterioration. Overall, the use of sawdust as a partial replacement for sand in concrete has both advantages and disadvantages. In a nutshell, the use of sawdust in concrete as a partial replacement for fine aggregate can be suitable, but it should be carefully considered based on the specific circumstances and requirements of the project. To study the effect of sawdust as a partial replacement for sand on the compressive strength of concrete, a lot of experiments can be conducted. Mix design can be prepared with varying percentages of sawdust as a partial replacement for sand. The compressive strength of the resulting concrete samples should then be tested and compared to determine the optimal percentages of sawdust for use in concrete mixtures.

MATERIALS AND METHODS

The main aim of this study is to examine the strength characteristics of concrete, sawdust [Figure1] has been used as a partial replacement for sand. Also, other aggregates like (fine of 4.75 mm size and coarse aggregate of size 20mm) were used. Sawdust samples were collected from Lalkhothi Timber & Saw Mills at Majar Road, Mirpur, Dhaka. It was sundried and kept in waterproof bags .sawdust is sieved through a 1.18 mm sieve. Portland cement is used as a binder material.

Physical tests like sieve analysis, specific gravity, and water absorption capacity tests shown in [Table 1] were done for aggregates. Concrete used for this study was made using a mix ratio of 1: 1.5: 3 and water to cement (W/C) of 0.55; batching of materials was done by weight shown in [Table 2]. After designing the concrete mix, batches of the concrete mix were cast into 4" x 8" standard cylindrical molds and were cured. Loading was 4KN/sec applied by the Universal Testing Machine over the cylindrical samples. Crushing patterns and crack surface images were taken for the specimens.

Slump Test

The result of the slump test shown in [Table 3] was carried out to determine the workability of concrete with different sawdust fractions as partial replacement of sand at 0.55 water cement ratio. The workability of concrete was observed to be decreasing as the percentage of sawdust replacement of sand in the mix increased. Since sawdust has a larger surface area to volume ratio it needs more water than sand.

Figure 1: Sawdust

Figure 2: Compressive strength test

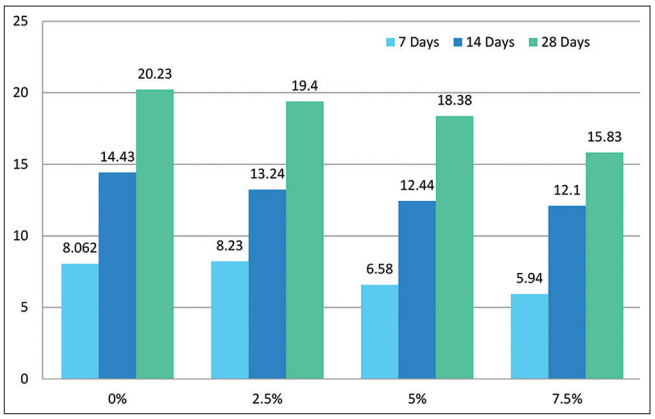

Figure 3: Compressive strength test result for 7, 14, and 28 days (Mpa) for 0%, 2. 5%, 5%, and 7.5% replacement of sawdust

Table 1: Physical properties of used material

Property	Sawdust	Sand	Stone chips
FM	2.48	2.89	7.23
Compacted bulk density Mg/m^3	0.14	0.83	0.92
Water content (%)	26.52	4.46	1.87
Specific gravity	0.36	2.4	2.97

Table 2: Amount of various materials for preparation of cylinders with mix ratio 1:1.5:3

S. No.	Cylinder No	% sawdust	Cement (kg)	Sand (kg)	Stone (kg)	Water (Litre)
01	9	0	6	10	21	3.3
02	9	2.5	6	9.75	21	3.3
03	9	5	6	9.5	21	3.3
04	9	7.5	6	9.25	21	3.3

Table 3: Slump value for different percentage of sawdust

% of saw dust	Slump value
0	70 mm
2.5	63 mm
5	55 mm
7.5	40 mm

Casting and Compaction of the Concrete

The concrete mixture was prepared by hand. A trial mix was done for every case before the final mix. At construction sites, all the elements, such as cement, sand, stone, and water put together in the mixture machine to produce concrete mix. However, in fact, it is not a good way to gain the proper strength of concrete. To ensure the quality of the matrix, the following procedure was used for mixing concrete. At first, all the coarse aggregate sand and cement were put together and mixed properly with the help of a Towel. After that, third of the water was mixed with the mixed aggregate. The concrete mixture was compacted before completing the mold. Every cylinder specimen was compacted by three layers. In each layer, there were a total of 25 blows. After the compaction of these mixtures, hammering and scaling was done to get a void-free surface and cylinder of the specimen.

Curing of Specimen

Concrete curing is done to maintain adequate moisture to control the temperature effect in cement hydration at early ages. Curing is done by ponding in this study. A chemical reaction between cement and water called hydration contributes to setting and hardening.

Compressive Strength Test

The compression strength of concrete is a measure of the concrete's ability to resist loads which tend to compress it.[15][16] The compressive or crushing strength of concrete is measured by the compression test shown in [Figure2]. It is evaluated by crushing cylindrical concrete specimens in a universal testing machine (UTM). Before the destructive tests of the cylinder, the entire cylinder specimen was carried out of the curing drum and left for drying. Before the test, all the specimens were capped properly to get a smooth and uniform surface for a concentrated load. Loading was 4kN/sec applied by the Universal Testing Machine to the specimen. For better results comparison, three samples were tested. The test was conducted at the age of 28 days.

RESULTS AND DISCUSSION

With increase in percentage replacement of sawdust by weight with sand, compressive strength goes on decreasing. Maximum strength is achieved at 2.5% replacement at 28 days as compared to other replacement. But Compressive strength generally increases with curing period. There is reduction in density of sawdust concrete with increase in percentage of sawdust in concrete. Laboratory investigation concludes that after 28 days compressive strength of the normal concrete specimen with no sawdust was increased by 20.23 MPa and a maximum of 19.4 MPa shown in [Figure 3] due to the addition of 2.5% Sawdust replacement which was 4.1% compressive strength reduction. As Sawdust contains some materials that are harmful to cement, the low compressive strength values of the concrete employed in this experiment may be related to this.

Full replacement is not recommended since it was discovered that 21.74% of the compressive strength decreased for 7.5% replacement of sawdust at 28 days as compared to 0% replacement. Although utilizing sawdust as fine aggregate in concrete is not recommended in its full, some percentage replacement is encouraged to determine the optimum percentage for lightweight concrete. In this study, optimum percentage was found for 2.5% sawdust replacement. For the reduction of environmental pollution and construction of low strength structures, optimum percentages of sawdust can be partially replaced as fine aggregates.

CONCLUSION

The use of sawdust in concrete mix resulted in a considerable reduction in the workability as the replacement level increased. The inclusion of sawdust in the concrete did not enhance its compressive strength. Though the results indicated the possible use of Sawdust as a structural material, it is recommended that its long-term behavior be investigated to evaluate this possibility. Further researches should be conducted to study other mechanical properties like flexural strength, tensile strength of this category of concrete. As the percentage of sawdust content increased in the mix, the compressive strength decreased. The low compressive strength values may be due to the air entrapped in the mortar mix which is known to cause a reduction in strength. As the amount of sawdust increases, the density of the concrete decreases. The reason for this could be

sawdust is very lightweight compared to sand. It may not be suitable for high-rise building and construction that withstands a high compressive load. This type of concrete can be used in low priorities construction work and low-rise buildings, sidewalks, more importantly when less strength is sufficient.

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