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EXPERIMENTAL STUDY TO COMPARE WORKABILITIES OF CONCRETE MADE WITH AND WITHOUT AGRO-WASTE MATERIALS

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Abstract

This study givess applications of some of the natural wastes of agriculture farming obtained from paddy fields to utilize it as partial replacement of aggregates or binder in green concrete. Replacement of OPC by these wastes escorts to mitigate CO2 emissions into the atmosphere which, in turn, provides relief to global warming. This study also shows the effect of the said wastes on the workability and strength performance of the green and hardened concrete. The principal findings of this research revealed that bio-based supplementary materials could be successfully incorporated through partial replacement of OPC in producing green concrete mixtures facilitating to protect environments from contaminations. Nonetheless, a momentous inevitability is experienced to comprehend it more appositely. These are essential for the incorporation of apposite supplementary materials to develop environmental friendly sustainable green concrete that not merely conserve the severe degradation of restricted natural resources but also shield from the pessimistic impact on environments, air, groundwater, soils, etc.

Keywords: concrete, waste, replacement, sustainable, natural

1. Introduction

The production of Portland cement is responsible for more than 5% of the world's CO2 emissions. Cement (OPC) can be partially substituted with green materials that possess pozzolanic properties in order to lessen its limitations. Many green materials, including fly ash and ground nutshell ash, have been successfully studied as partial cement substitutes. The current study focuses on using rice straw ash in place of some cement. This project investigates the effects of partially replacing cement in concrete with agro-waste and how that substitution affects the concrete's various properties.

Cement-based composites are developed in this study using varying percentages of straw ash as a cement substitute (0, 2.5%, 5.0%, 7.5%, 10%, 15%, 20%, and 30%). These mixes are prepared using a portable electric concrete mixer. The concrete specimens are poured into molds and allowed to cure for twenty-eight days at room temperature. The process takes twenty-four hours. The outside temperature is 20±3◦C, and the relative humidity is 55±10%.In order to maximize compressive strength and other pertinent properties, this research's primary goal is to examine the impact of varying percentages of chopped rice straw in various concrete mixes.

2. Materials and Methods

Cement-concrete specimens with 0%, 2.5%, 5.0%, 7.5%, 10%, 15%, 20%, and 30% straw ash as cement substitutes are created for the experimental program. The concrete is mixed using a portable electric concrete mixer. Concrete specimens are then poured into standard moulds of size 150mm×150mm and moulds are placed in a cool and dry place for 24 hours so that concrete can be set easily. After 24 hours from pouring, the specimens of concrete are unmoulded and left to cure in ambient conditions for the time of 28days. The ambient conditions are 24 ± 3◦C temperature of air and a 55±10% relative humidity.

2.1 Materials used

We need straw ash, which can be powdered wheat or rice straw. Sand and cement are used in place of these materials in mortar, and water is added to facilitate mixing and workability. To test the effects of these ingredients on concrete strength, agro-waste ash, cement, water, and coarse and fine aggregates were mixed in various amounts. The following materials with the given characteristics are used in making the concrete specimens.

- Ordinary Portland cement
- Rice-straw Fibers
- Aggregates
- Coarse Aggregates
- Fine Aggregates
- Water

Figure 1. Rice Straw Ash

The standard grade of concrete is used in the experiment. The grade of concrete that was used for making specimens was M25. In conducting the experimental investigations, a water cement ratio of 0.55 has been used after taking into consideration the workability and compaction requirements. The lower water cement ratio is avoided to prevent less compaction.

2.2 Concrete mix preparation and moulding

Concrete specimens are prepared in a cool and dry place. First of all, coarse aggregates are spread over flat ground. Over these aggregates fine aggregates i.e. sand spread uniformly over. Then both the aggregates are mixed thoroughly in the dry state to form a uniform mixture. Quantity of various ingredients is kept strictly as per the mix proportion which is derived according to the grade of concrete. Then cement is mixed dry with straw ash in specified proportions with 0%, 2.5%, 5.0%, 7.5%, 10%, 15%, 20% and 30% straw ash as a substitute for cement. The mixture of both types of aggregates is then mixed with cement. Water is added according to the quantity obtained by multiplying water cement ratio by the quantity of cement per specimen.

The mixture is thoroughly mixed to form a paste with a homogeneous consistency**.** This instance uses a 150 x 150 mm mould. The casting process for these cubes is also depicted on the right side of this figure. Grease is applied in the inner layers of mould so that the removal of hardened concrete is easier. The tamping rod used has a length of 100 mm. Every layer receives 25 tampings on average. The mixture is layered four to five times in the mold, with the same amount of tampings applied to each layer. Moulds are placed in a dry and cool place for 24 hours so that concrete can be set properly. After 24 hours, concrete specimens have been taken out from the moulds and kept submerged in the freshwater till the time of testing. Various tests performed to compare different properties of concrete and the effect of partial displacement of cement with agro-waste are explained in the next section.

2.3 Slump Testing

48 cubes have been cast and tested for different material ratios. 8 mixes are prepared and 3 cubes are prepared for each type of mix. These 3 cubes are tested as representatives of one mix and the average value obtained from these three cubes represents the property of that mix and is written as the result.

The quality of concrete known as workability is what establishes how much beneficial internal work is required to achieve complete compaction. In terms of compaction method and deposition location, it could also be described as the ease with which concrete could be 100% compacted. Consistency is not the same as workability. The latter denotes the extent of mobility or fluidity. For a given task, high-consistency concrete need not be workable. For instance, concrete that is suitable for a foundation might not be suitable for a slab. Different workabilities will be needed for slabs as well, for both vibration and manual compaction. It's because there are fewer requirements for workability.

Figure 2. Slump Cone Mould

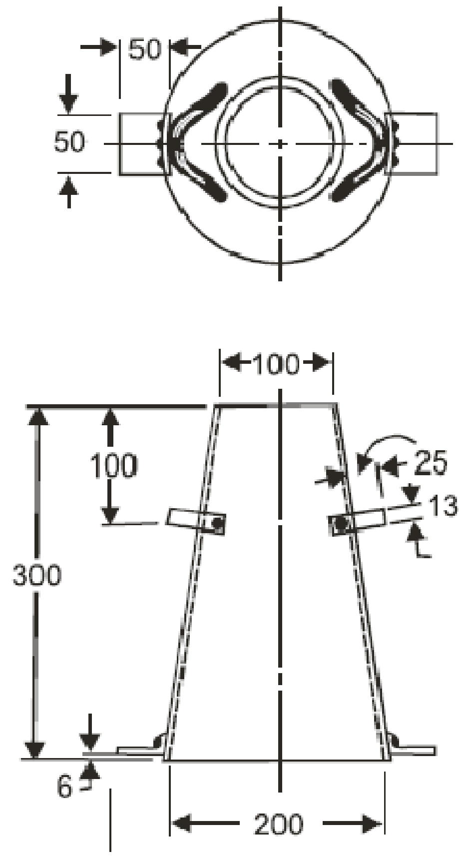

Figure 3. Dimensions of Slump Cone

The slump test is used to assess the consistency of fresh concrete in the field or in the lab when the nominal maximum aggregate size is limited to 38 mm. Figure 3.5 depicts the slump cone that was utilized for the test. The dimensions of the slump cone mould are given in Figure 3.6. The mould's internal measurements are 200mm for the bottom diameter, 100mm for the top diameter, and 300mm for the height. Four layers of freshly mixed concrete are poured into the mold, and each layer is compacted using 25 strokes of the tamping rod. The layers are compacted so that the rod covers the entire depth of the layer to be compacted and its bottom end impacts the layer below. When the mold is fully filled, the top layer is removed using a trowel or tamping rod to bring the concrete level. The mold is lifted carefully and slowly in a vertical direction to be removed right away. This permits the concrete to sink, and the instantaneous measurement of the slump is obtained by calculating the differential between the mould height and the specimen's highest point undergoing examination. The specimen's measured slump is expressed in millimeters of subsidence **(see Figure 3**).

The aggregate size used in the test is limited to 38mm. To remove aggregate particles larger than 38mm, the concrete is wet sieved by a 38mm screen if the aggregate size is larger. Table 3.2 lists the workability levels, the corresponding consistencies, and the slump values.

3. Results and discussions

3.1 Results

Approximately fifty cubes were formed and allowed to cure in a freshwater tank for seven and twenty-eight days. The fresh and hardened concrete underwent separate tests, one for workability and the other for compressive strength. Cubes are cast using varying amounts of materials that adhere to the ratio needed for concrete grade M25. The mix proportions and matching amounts of the different ingredients are shown in **Table 1**.

Table 1. Mix proportions and corresponding quantities of various ingredients

S.No.	Designation	Mix Ratio		
		Cement (kg)	Sand (kg)	Crop Residue (kg)
1.	Mix 1	5	5	0
2.	Mix 2	4.875	5	0.125
3.	Mix 3	4.75	5	0.250
4.	Mix 4	4.625	5	0.375
5.	Mix 5	4.50	5	0.50
6.	Mix 6	4.25	5	0.75
7.	Mix 7	4.0	5	1.0
8.	Mix 8	3.5	5	1.5

Table 1 shows the designation for mix proportions in column 2 and various amounts of cement, sand crop residue i.e. straw-ash in subsequent columns. It is clear from the values obtained in this table that for Mix 1, M25 grade mix will contain ingredients in the ratio of 1:1:2. So if 5 Kg of cement has been taken then amount of sand will be equal to 1×5 = 5 kg. The water cement ratio has been taken equal to 0.55. Similarly for Mix 2, 2.5% cement is replaced with crop residue while sand taken has been same in quantity as compared to Mix 1. So the quantities of various mixes are calculated as under.

For Mix 2, Quantity of crop residue = 2.5/100×5 = 0.125 kg
Quantity of cement = 5-0.125 = 4.875 kg

For Mix 3, Quantity of crop residue = 5/100×5 = 0.250 kg
Quantity of cement = 5-0.250 = 4.75 kg

For Mix 4, Quantity of crop residue = 7.5/100×5 = 0.375 kg
Quantity of cement = 5-0.375 = 4.625 kg

For Mix 5, Quantity of crop residue = 10/100×5 = 0.50 kg
Quantity of cement = 5-0.50 = 4.5 kg

For Mix 6, Quantity of crop residue = 15/100×5 = 0.75 kg
Quantity of cement = 5-0.75 = 4.25 kg

For Mix 7, Quantity of crop residue = 20/100×5 = 1.0 kg
Quantity of cement = 5-1 = 4.0 kg

For Mix 8, Quantity of crop residue = 30/100×5 = 1.5 kg
Quantity of cement = 5-1.5 = 3.5 kg

The values of slump obtained from workability test for every Mix are given in **Table 2**.

Table 2. Values of Slump for various mixes

S.No.	**Designation**	**Slump values (mm)**
1.	Mix 1	130
2.	Mix 2	115
3.	Mix 3	98
4.	Mix 4	85
5.	Mix 5	70
6.	Mix 6	55
7.	Mix 7	40
8.	Mix 8	35

The graph based on the slump values obtained in the above table is shown in **Figure 4**.

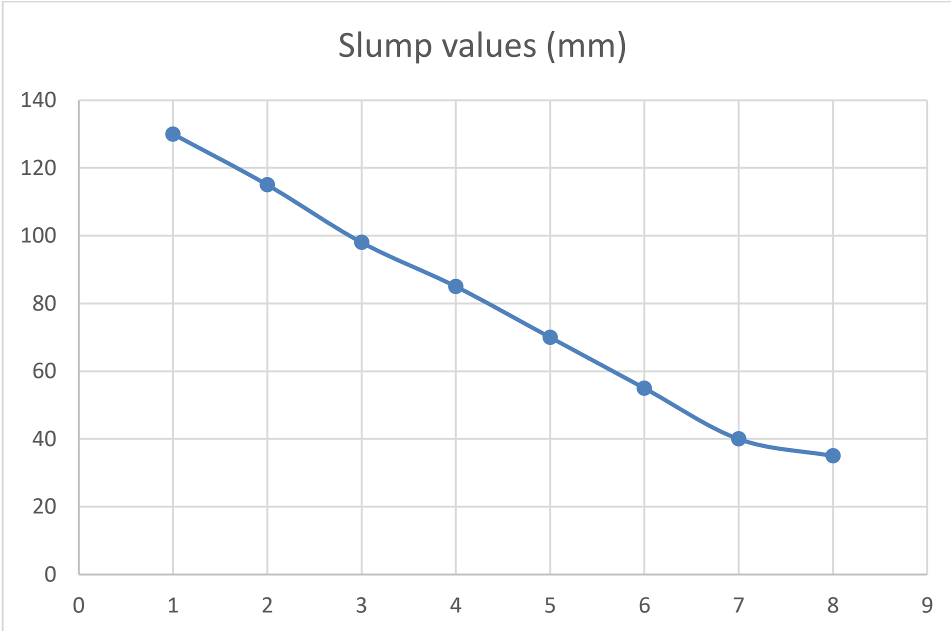

Figure 4. Graph showing Slump Value for Various types of Mixes

3.2 Conclusion

The graph shows that as the quantity of crop residue increases by replacing cement, the value of slump decreases. It means that workability decreases with increase in the quantity of crop residue.

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