Influence of Rice Husk Ash (RHA) on the Workability of Concrete

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Abstract

Rice husk ash (RHA) is the promising pozzolanic material which can be used with Portland cement in a specific proportion to produce durable concrete and with reduced impact of cement industry on environment. Effect of RHA on the fresh properties (i.e., Workability) of concrete has been studied. Workability means the ease with which the concrete can be placed and compacted without segregation. Thus, to produce a high-quality concrete, its workability is very important factor. To measure the workability of concrete slump test is the most common test that is performed. This test gives the general idea that the mix prepared is harsh, or flowable. In this study, RHA was added to concrete in different proportion as a binder. Results reveals that RHA can be used as a binder in sustainable construction.

Keywords: Slump; Workability; Rice husk ash; Concrete

1. Introduction

Construction industry is one of the leading industries in the world. India is a developing country where the rate of construction increases exponentially. The construction industry consumes high energy, depletes limited natural resources and emits large amounts of greenhouse gases. The construction sector plays a cardinal role in economic growth.

Global carbon dioxide emission is around 23% due to the construction industry [1]. Cement industry itself contributes to 8% of anthropogenic CO2 emission[2]. Also, the consumption of natural resources increases at a very fast pace, which will create some environmental issue. Hence, urgent need to find some alternative solution for these worsening issue in the very fast extended era of construction sector. Now a day many waste materials from industries and agricultural are being used in construction sector as an alternative for cement, sand, coarse aggregate and reinforcing material[3]. Many researchers were interested in studying the feasibility of various by products or waste materials (i.e. fly ash, marble powder, rice husk ash, iron dust etc.) produced during the manufacturing of various products. Especially the use of such waste with regard to the materials, used for the construction such as cement, fine aggregate and brick blocks etc.[4].

In the past two decades, the agro-waste was more studied in sustainable construction products. Rice Husk Ash (RHA) is the agro industrial waste which is generated by burning rice husk at the controlled temperature[5,6]. In country like India, which is one of the major rice producing country. The availability of the rice husk is very higher, which creates the problem of its disposal[7]. Due to the presence of husk is abundant, this can be used in concrete as a binder or fine aggregate. Concrete is the material which consists of cement, sand, aggregate and water. By mixing all of them in certain proportion it will form a good dense matrix[8].

The workability of concrete is one of the most important properties to prepare concrete with proper homogeneity. The workability of concrete is measured by various tests like slump test, compaction factor test, Vee Bee test etc. Slump of concrete depends upon the various Supplementary cementitious material used in concrete, its particle size, and their rate of hydration.

The slump of high-performance concrete (HPC), various studies have concluded. HPC slump can not only be determined by water content and maximum size of aggregate. Various researchers have used the linear regression and artificial neural network technique[9,10].

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The aim of this paper is to study the effect of Rice husk ash added concrete on the workability of concrete. RHA was added in concrete as a partial replacement of cement in different proportion varying from 5% - 25% (each 5% interval).

1.1. Materials

OPC 43 grade cement was used to produce M25 grade of concrete whose physical properties are given in Table 1. The appearance of OPC is grey in color with soft powder touch. RHA used in this research work also appeared grey with a dark tone. Visual inspection indicated smoother and shiner surface of RHA as compared with OPC. Figure 1 indicates the photographs of the OPC 43 grade and RHA as used in the experimental work.

Coarse aggregate (20 mm maximum size, water absorption 0.8%, density 2.61) and natural sand (water absorption 1%, density 2.65). The water used for the mixing is normal tap water. Fosroc auramix 300 superplasticizer was used with specific gravity 1.093 to produce concrete of desired workability for all the mixtures. The materials confirm to standard norms.

| Physical properties       | Cement |
|---------------------------|--------|
| Specific gravity          | 3.15   |
| Consistency (%)           | 32%    |
| Initial setting time (Min)| 106    |
| Final setting time (Min)  | 332    |

![ OPC and RHA](image)

(a) (b)

Fig. 1. (a) Cement (OPC) 43 grade; (b) Rice Husk Ash (RHA)

1.2. Testing Program

The slump test of concrete is done for the measurement of its workability. Also, it measures the consistency of the different batches of the mix produced. The slump basically looks like a frustum of cone whose standard dimensions are 300 mm height and its base is of 200 mm and a small opening at the bottom of 100 mm. The base is placed on a smooth surface and then concrete is poured. Cone is filled in three layers with each layer being tempted 25 times with a rod of 16 mm diameter. After filling the mould, the surface is levelled. The mould is lifted vertically, and the slump is measured with the rod. The observed settlement of concrete frustum is reported as the slump value.

The RHA was used as a pozzolanic material in concrete. The concrete was tested for slump properties. Different concrete mixtures were prepared were based on the IS 10262:2009 [11]. Water-to-binder ratio (w/b): 0.5; with all the RHA replacement by weight of cement, were done in this investigation. Different trial mixes were also prepared to adjust the quantity of superplasticizers, to maintain the slump ranges from 30-70 mm. Trial mix composition is shown in Table 2. Mixtures prepared by replacing 5%, 10%, 15%, 20%, and 25% of cement with RHA. Table 3 shows the mixture proportions in weight of materials. The slump of concrete was measured according to IS 1199: 1956 [12].
Table 2. Trial mix composition

| Materials (per m³) | Cement (kg) | RHA (kg) | Fine aggregate (kg) | Coarse aggregate (kg) | Water (kg) | Super Plasticizer (kg) |
|-------------------|-------------|----------|---------------------|-----------------------|------------|-----------------------|
| Trial mix 1: Control Concrete | 372         | --       | 700.87              | 1126.26               | 186        | --                    |
| Trial Mix 2: 25% RHA | 279         | 93       | 700.87              | 1126.26               | 186        | 1.67 (0.45%)          |

Table 3. Mixture proportion of concrete

| Materials (per m³) | Cement (kg) | RHA (kg) | Fine aggregate (kg) | Coarse aggregate (kg) | Water (kg) | Super Plasticizer (kg) |
|-------------------|-------------|----------|---------------------|-----------------------|------------|-----------------------|
| Plain Concrete    | 372         | --       | 700.87              | 1126.26               | 186        | --                    |
| 5% RHA            | 353.4       | 18.6     | 700.87              | 1126.26               | 186        | 0.55 (0.15%)          |
| 10% RHA           | 334.8       | 37.2     | 700.87              | 1126.26               | 186        | 0.55 (0.15%)          |
| 15% RHA           | 316.2       | 55.8     | 700.87              | 1126.26               | 186        | 0.55 (0.15%)          |
| 20% RHA           | 297.6       | 74.4     | 700.87              | 1126.26               | 186        | 0.93 (0.25%)          |
| 25% RHA           | 279         | 93       | 700.87              | 1126.26               | 186        | 1.67 (0.45%)          |

2. Experimental Investigation

2.1. Test Results and discussion

The requirement of superplasticizer (SP) for achieving the desired slump in the range of (30-70 mm) is shown in Table 3. For the attempt of desired slump, the concrete containing different proportion of RHA having higher water demand than those containing only Portland cement. Basically, this is due to the higher surface area and high carbon content of RHA [13–15]. The dosage of SP increases with the content of RHA. Fig. 2 shows the different slump value with the different RHA percentage.

3. Conclusions

- Slump of the concrete mix decreases with the increase in the content of RHA from 0% - 25%.
- Requirement of SP increases as the content of RHA increases due to its fine particle, its surface area is high. Which demands in higher water absorption. The water binder ratio is fix to 0.5 due to which the amount of SP increases.
- RHA added concrete having results quite similar to that of the control concrete with a lower cement consumption, thus help in reducing the CO2 emission during the production of cement.

By evaluating the results of slump test by using slump cone apparatus, following conclusions are drawn: Slump & Density By replacement of 0% to 25% (with increment of 5%) GL and 0% to 50% (with increment of 10%) GN into OPC, slump of the concrete mix was decreased gradually as compared to the slump of control mix concrete due to high water demand in the concrete mix.

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