Discussion Forum

Strength behaviour of self-compacting concrete mixes using local materials

Dear Sir,

This has reference to the paper titled 'Strength behaviour of self-compacting concrete mixes using local materials' authored by M. Rame Gowda, Mattur C. Narasimhan and Karisiddappa, published in the July 2012 issue of The Indian Concrete Journal, Vol. 86, No. 7, pp.54-60

In this paper authors have made an attempt to develop SCC mixes using locally prepared Rice Husk Ash (RHA) as a supplementary cementitious material. In addition, the locally available quarry dust as an alternative material to sand was used. The SCC mixes so designed were tested for their rheological and hardened properties. The author claims that the results confirmed the advantage of using RHA in the production of SCC. The paper is well written and lots of experimental results were presented which according to the discusser will help the researchers working in this area.

However the discusser would like to clarify few points on the use of rice husk ash and seeks some clarification about the results and the testing procedure.

The first clarification required is about the type of cement used. The authors have not mentioned the type and grade of cement. The fineness of cement, 228 m^2/kg reported is rather low though it satisfies the minimum requirement of 225 m^2/kg. The 7 and 28 days strengths satisfy the requirement of 43 grade cement. However the 3 day strength of 19.4 MPa is lower compared to 23 MPa required for 43 grade cement. The specific gravity is 3.1. From this it is clear that the cement is likely to be PPC type. This should be clarified as the minerals present in it affect the performance of the SCC.

Authors have used RHA obtained from uncontrolled atmospheric burning. This ash will not contribute to the beneficial properties of SCC as reported in the literature.[1,2] The LOI of 27.84% reported is very high, which is again a concern for use in any concrete. This value is very high for any pozzolana. It means that the RHA contains more unburnt carbon and this reduces the pozzolanic activity of the ash. The unburnt carbon it-self is not pozzolanic and its presence serves as filler to the mixture. The value obtained is higher than the generally reported values of 3 to 8% and as such the pozzolana is less effective and may not act as an effective SEM.[3]

It is mentioned that the mixture proportions were obtained from EFNARC method and the same is presented in Table 5 of their paper. Later the authors have mentioned that IS 10262:2000 mix design is used to get M25 grade concrete and the same can be altered as per EFNARC guidelines. However, this mix design details is not mentioned. It is clear that the EFNARC design presented in Table 5 is used in the present work. In this design, the rice husk ash is added at 2.5% rate up to 20% as a replacement to cement. As the RHA content increases, the water demand also increases as reported in the literature. In addition the fineness of RHA is 448 m^2/kg which is almost double compared to Cement which is 228 m^2/kg and its specific gravity is 2 compared to 3.1 of cement. It is obvious that for any replacement as a percentage by weight of cement, the water requirement is very high. However the authors have used the same water content and in addition the dosage of SP are decreased with an increase in VMA content. With this the rheological properties will be on to the lower side, thought the mixes satisfy the requirements. In addition the yield of the concrete per m^3 is also less which the authors should have mentioned. Authors have used IS 10262:2000, Recommended guide lines for concrete mix design, which is old code on concrete mix design. They should have used the new code IS 10262:2009, which permits the use of all supplementary cementing materials (SEMs) and also the mix design could have been be economized.[4,5]

Coming to the hardened properties, the addition of RHA has decreased the strength at all ages up to 28 days and for all replacement levels. At 180 days, the increase in strength is negligible at lower replacement level and for higher replacement level the strength has decreased substantially. From thus it is very clear that the RHA has not contributed to the strength and in particular to the early strength of concrete. Hence RHA is not acting as SCM and hence there is no advantage from strength point of view in contract to the title. These findings are against the established fact that cement pastes containing 5% to 20% RHA had higher compressive strengths than the control at all ages from 3 to 90 days, with the paste containing 10% RHA performing the best. It has been reported that the concrete incorporating 10% RHA had a higher compressive strength than the control cement concrete at all ages up to 180 days. Also, it contributes to the strength of concrete at early ages mainly by the fast pozzolanic reaction. Inclusion of RHA as partial replacement of cement enhanced the compressive strength of concrete, but the optimum replacement level of cement by RHA to give maximum long-term strength enhancement is about 20%.[6-8]

Due to its high pozzolanicity and its extreme fineness, RHA or Silica fume or metakaoline is considered to produce low permeability concrete. For a given w/cm ratio and cementitious materials content, the depth of water penetration is less in the RHA cement concrete as compared to plain cement concrete. The incorporation of RHA improved the water absorption properties of the Portland cement based materials because of a reduction of permeable voids. However the authors have reported that the water absorption increase as the percentage of RHA is increased (Figure 2 of their paper). It means the RHA has not contributed to the impermeability of the concrete as well.[9-11]

The authors have reported the split and flexural tensile strengths of SCC in Tables 9 and 10. The flexural strength of concrete in general is given by 0.7√fck and the split tensile strength by 0.4√fck. Though there are many equations of this type suggested by the various investigators for SCC, the difference in predicted tensile strength is rather negligible. The reported values of split and flexural tensile strengths are very low. In fact the flexural strength for any concrete, in an average, is 75% higher compared to split tensile strength of concrete, though this percentage is slight different for SCC. In addition the flexural tensile strength reported is less than that of split tensile strength. This is contradicting to the values reported in the literature. The discusser wants authors to look in this and explain for the possible variation.[12,13]

Generally, the findings reported in the literature highlight the role of RHA as an effective pozolana that increases strength and durability of Portland cement mixtures and that the performance of RHA is very comparable to that of silica fume. However, the compressive strength in such reports rarely crosses 50 MPa.[11-14] Using cement in the range of 400 -450, along with good supplementary material many ultra high performance concretes with compressive strength of 60-80 MPa or more can be produced. Keeping this point in mind, another point the discusser wants to highlight is about the use of 433 kg/m^3 of cement for producing strength in the range of 23 to 32 MPa. Even 300 kg cement per m^3 has a potential to produce concrete having strength in the range of 25 to 40 MPa depending on the w/c ratio. However suitable dosage of SP is required.[15,16] In the present work the authors have used 1 to 2.6 % of SP. Only advantage noticed in the authors work is the production of SCC with such high cement contents using RHA. The mix is definitely uneconomical for SCC looking to the advantages derived in the work. The authors should have tried multiple blends involving fly ash–silica fume, fly ash-slag-silica fume combination. These mineral admixtures are proven to produce high strength and high performance concrete. Such good quality SEMs are commercially available in the Indian market.

Utilisation of agricultural residue in various construction activities has been investigated for many years with limited commercial success. Rice husk are a residue produced in significant quantities in India. In 2009, it was estimated that the world production of rice was 480 million tonnes. With India currently producing about 95 million tonnes of rice, the potential for rice husk ash in our country is about 3.5 million tonnes. It was estimated that about 1/3 of the available husk in India can be collected and converted to ash for use as a Portland cement replacement. So, about one million tonne of rice husk ash is potentially available as a mineral admixture. What is important is to produce the quality RHA with controlled burning. During burning, it is observed that from 400ºC to 500ºC, the residue carbon oxidises with the majority of the weight loss occurring in this period. The silica in the ash is still in an amorphous form with high reactivity. Prolonged heating at temperatures beyond 700-800ºC produces essentially, crystalline silica. The relative proportion of the forms of silica in the ash depends not only on the temperature of combustion but also the duration. Combusting husk at below 500ºC and up to 680ºC under oxidising atmosphere can produce amorphous silica provided the hold time is controlled. Apart from influencing the degree of crystallinity, the time-temperature relationship also influences the specific surface area of the ash, a parameter which is closely related to the pozzolanic activity of the ash. The pozzolanic behavior of rice husk ash is the ability to react with calcium hydroxide at ambient temperature in the presence of moisture to form cementitious hydration products. Several researches have offered furnace designs for the production of this kind of ash and the same is well documented.[3,13]

From the point of utilization and proper disposal of agriculture wastes, the work is quite encouraging. The use of RHA or any mineral admixtures as a raw material in concrete is anticipated because of their voluminous availability and should be highly encouraged. The discusser congratulates the authors for taking such work.

yours faithfully,

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The author replies

Dear Sir,

I thank and appreciate the reader for raising a few important issues regarding the properties and usage of RHA in the development of SCC mixes.

The idea behind the investigation was to make use of locally available RHA and facilities for sustainable construction.

The type of cement used in the investigation was OPC 43. The fineness of cement was low because it was not stored properly in the laboratory.

The low-end technology and burning technique resulted in an RHA of poor quality. We used locally made lime burning kiln for ashing the husk in an uncontrolled manner at low temperatures to keep the cost low.

As a result, the RHA had more unburnt carbon than desirable. So it yielded poor strength properties. It is true that an unburnt material acts as a filler in concrete.

The water content was not increased in the present investigation as the required rheology was maintained by increasing the dosage of SP and VMA.

I do agree regarding the use of new code in place of the old one. However, both codes encourage the use of SCMs.

The results presented in the paper were constrained by the laboratory conditions and facilities available.

The procedure employed in the laboratory was similar to that in the EFNARC guidelines for SCC.

I do agree that there might be some variations in the results making the comparison with the results of empirical equations difficult. But I did not think of comparing the experimental results with the theoretical ones.

According to published information, India is the second largest rice producing country in the world after China. Because of the specific advantage of bulk availability of rice husk, we thought of using locally prepared RHA as an SCM to check the feasibility of applying a low end technology.

sincerely,

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