International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.9, No.05 pp 332-337, 2016

Rice Husk Ash as Supplementary Material in Concrete – A Review

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Abstract : Concrete is major civil engineering construction material, because the ingredients of concrete are locally available materials. In ordinary concrete the cement is used as major binding material. The usage of cement in concrete causes lot of environmental pollution due to emission of green house gases. So that it is necessary to reduce usage of cement by introducing new supplementary cementitous materials which are the by-products of industries to reduce debris. The rice husk ash is one of the by product which is released from paddy. The usage of rice husk ash in concrete leads to development of high strength concrete and also reduces the self weight of the structure. The main aim of this review paper is to show the modified properties of concrete by introducing rice husk ash.
Keywords : Rice husk ash, compressive strength, splitting tensile strength, corrosion resistance.

1. Introduction

In the middle of 20th century the burnt rice husk ash is used to production of tooth power used as fuel in cooking purpose and dish cleaning power due to lack of knowledge. By continuous research on properties of rice husk ash, the results shows that it contain high silica content which is more than 90%, it reduces shrinkage cracks and leads to increase the strength of concrete. The many researchers are done research on rice husk ash and they presented their results of modified concrete properties. The rice husk ash is obtained by burning of rice husk ash at temperature between 550^{o}C to 700^{o}C, then the rice husk may forms as cellular micro structure is produced. The rice husk ash has rich silica content of non-crystalline (or) amorphous silica form. It shows that rice husk can be used as supplementary cementitious materials due to its pozzolanic action.

The following reaction that will takes place in Rice husk ask concrete

$$Si + O_2 \longrightarrow SiO_2$$

When silicon burnt in the presence of Oxygen will form silica

$$C_3S \text{ (Cement)} + H_2O \longrightarrow CSH \text{ (gel)} + Ca(OH)_2$$

Due to hydration of cement will form CSH gel and Calcium hydroxide. But Calcium hydroxide is soluble product and unstable in concrete.

$SiO_2 + Ca(OH)_2 \longrightarrow CSH + SiO_2$

The highly reactive silica reacts with Calcium hydroxide that will leads to form again CSH (gel) which will leads to get higher strength than that of ordinary concrete.

2. Properties of Rice Husk Ask

The Physical and chemical properties of rice husk ask are given in Tables 1 & 2. XRD and SEM images are shown in Figs. 1 & 2.

Table 1. Physical properties and chemical properties of RHA [1]

Physical properties	Specific gravity (g/cm^3)	Mean particle size (µm)	Fineness: passing 45µm (%)
Mehta (1992)	2.06	N/A	99
Zhang et al. (1996)	2.06	N/A	99
Bui et al. (2005)	2.10	7.4	N/A

Table 2. Chemical properties and chemical properties of RHA

Constituent	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	Loss on ignition
Mehta (1992) [1]	87.2	0.15	0.16	0.55	0.35	0.24	1.12	3.68	8.55
Zhang et al. (1996) [1]	87.3	0.15	0.16	0.55	0.35	0.24	1.12	3.68	8.55
Bui et al. (2005) [1]	86.98	0.84	0.73	1.40	0.57	0.11	2.46	N/A	5.14
P.C Kumar et al (2013) [2]	93.80	0.74	0.30	0.89	0.32	N/A	0.28	0.12	3.37
Tugba Mutuk (2014) [1]	91.2	0.72	0.50	0.75	0.27	N/A	0.1	2.20	1.80

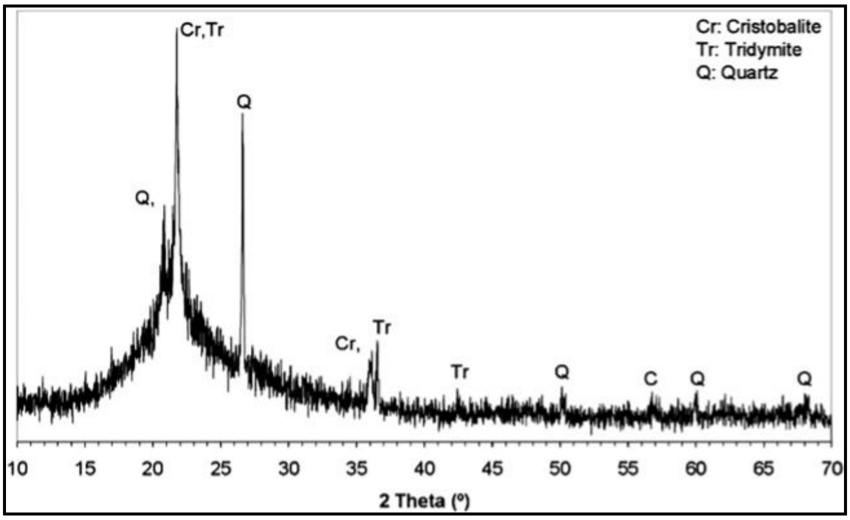

Figure 1. XRD pattern of Rice husk ash [3]

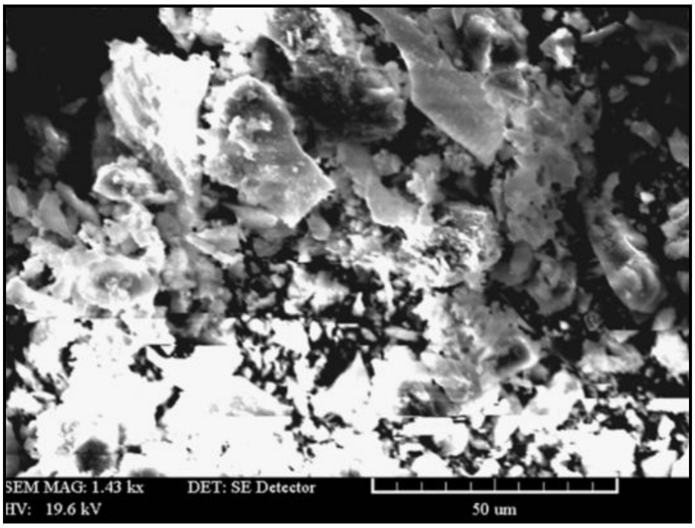

Figure 2. SEM micrograph of Rice husk ash [3]

3. Experimental Research

Mehta PK [4] has investigated on RHA is replaced with cement up to 50% of which will leads to get higher compressive strength than that of ordinary Portland cement concrete at 3 days earlier. Ravande Kishore et. al. [5] has concluded that the replacement of RHA in concrete the workability of concrete decreases with increase in RHA beyond 10 percentage. And they have found that optimum replacement of RHA is 10 % for both M40 and M50 grade blended concretes. They also concluded that the flexural and splitting tensile strength of M40 and M50 grade blended concretes has decreases with increase in percentage of RHA. M. Nedhi et. al. [6] has proposed that 40% of compressive strength of concrete was increased at 56 days and it was superior to silica fume in this regard and has higher compressive strength at 91 days than that of ordinary concrete. The R.H.A had a pozzolanic activity index has high as 117% at 7 days and 144% at 28 days.

Gastaldini et. al. [7] has proposed that the unit cost of concrete can be reduced by replacing 5% of RHA. And use of clear color RHA does not changes color and it can be recommended to use in R.M.C. They have concluded that the compressive strength of concrete and total shrinkage by increasing the RHA percentage. W.Chalee et. al. [8] has investigated about corrosion resistance of concrete under 5-years exposure in a marine environment. The usage of 15 to 35 percentage of Rice husk bark ash in concrete with a W/B ration 0.45 can be used to improve corrosion resistance of reinforcing steel in concrete under sea water because it produces good mechanical properties and good durability properties. B. Chatveera and P. Lertwattanaruk [9] had concluded that the use of ground black rice husk ash [GBRHA] replacing with Portland cement has decreasing the expansion, compressive loss and weight loss of cement mortar in nitric acid and acetic acid.

The durability of cement mortar exposed to acid attacks, when the percentage replacement of GBRHA in Portland cement was increased. The compressive strength loss and weight loss of cement mortar containing BRHA under acetic acid attack were higher than that of nitric acid. Up to 30% replacement of BRHA leads to decreasing the rate of expansion than that of ordinary cement mortar. V. Saraswathy and Ha-Won Song [10] have investigated on chloride penetration, permeability and corrosion resistance. The 30 percentage replacement of R.H.A reduces chloride penetration decreases permeability improves strength and corrosion resistance property. Shazim Ali Memona et. al. [11] has concluded that the RHA can be used to development of low cost SCC by incorporating 10 percentage replacements.

Nguyen Van Tuan et. al. [12] has studied usage of RHA to produce ultra high strength concrete [UHPC]. The compressive strength of UHPC containing RHA can reach at least 175Mpa at 28 days and 185Mpa at 91 days. The development of compressive strength of RHA modified sample is higher than those of both the ordinary concrete sample and the silica fume concrete. It also suitable for development of UHPC. The porosity of UHPC sample of 20 Percentage replacement of RHA is 10.32 percentages at 1 day and 7.63 at 7days and 5.76 percentages at 28 days and 4.92 percentages at 91 days. Sebnem Sargın et .al. [13] has evaluated that effect of RHA as filler in hot mix asphalt. The Best Marshall Stability was obtained by mixing 50 percentage of RHA with 50 percentages of lime stone will leads to filler rate mixture. Javad Torkaman et. al. [14] has investigated that using of fiber waste, rice husk ash, and limestone powder waste as cement replacement materials for lightweight concrete blocks. The water absorption and bulk density of concrete can be reduced by adding RHA. The test results show that the production of light weight concrete can be done by adding RHA.

V. Kannan and K. Ganesan [15] has investigated on Chloride and chemical resistance of self compacting concrete containing rice husk ash and Metakaolin [MK]. The good synergistic effect between MK and RHA on mechanical properties and durability of SCC. The test results of SCC blended with 15 percentage of MK and 15 percentage of RHA bad more durable and optimum level of replacement for OPC as supplementary cementitious materials. Saeid Hesami et. al. [16] has did research on effects of R Effects of rice husk ash and fiber on mechanical properties of pervious concrete pavement. They recommended that 12 percentage of RHA is more suitable for concrete pavements. The permeability of concrete decreases with increase in amount of RHA until to optimum RHA amount is reached. After it the permeability increases and the strengths are reduced. Gemma Rodríguez de Sensale [17] has investigated that effect of rice husk ash on durability of cementitious materials. The best resistance to chloride ion penetration is obtained with 15 percentage replacement of RHA in Portland cement for water/cementitious materials ratio 0.5 for Controlled combustion rice husk ash [CRHA][amorphous structure] and for 0.4 and 0.32 with Partially crystalline rice husk ash [RRHA].

The concrete containing RHA has found to be more resistance to sulfate attack and HCL solution. The alkali-silica reaction [ASR] has reduced by RHA, The concrete having CRHA inhibit greater expansion due to ASR than that of RRHA concrete. K. Ganesan et. al. [18] has investigated on optimum replacement of Rice husk ash for strength and permeability properties of concrete. The replacement of 30 percentage of RHA leads to following properties

i) The replacement of RHA with OPC of 35 percentage leads to reduce the water permeability and bleeding of concrete.
ii) The replacement of RHA of 28 percentage leads to reduction in chloride diffusion.
iii) The replacement of RHA about 75 percentage leads to reduction in chloride permeation.

Deepa G Nair et. al. [19], has investigated on Mechanical properties of Rice husk ash – High strength concrete. The compressive strength of concrete increased with replacement of RHA of 25 percentages with OPC beyond that the compressive strength decreases. The compressive strength increases for 0.35 and 0.4 water/binder ratio, beyond the increasing of water/binder ratio greater than 0.45 the compressive strength decreases. The maximum compressive strength is obtained for 0.4 water/binder ratio of 25 percentage replacement of RHA with OPC for concrete cubes. Due to pozzolanic property and filling ability of RHA the compressive strength of concrete cylinder contain 25 percentages RHA replaced with OPC is increased by 13 percentages than that of Ordinary concrete. The concrete containing 25 percentage replacement of RHA with OPC has 10 percentage higher flexural strength than that of ordinary concrete. But splitting tensile strength and bond strength will be increased up to 12 percentages for the same 25 percentage replacement of RHA and it also reduces porosity and bleeding.

Sata, et. al. [20] and Habeeb et. al. [21] has presented that the modulus of elasticity increased with the increase in compressive strength. Ahmadi et. al. [22] has observed that a decrease in the modulus of elasticity when the replacement of cement by RHA increases.

Conclusions

1. The compressive strength of blended concrete with replacement of RHA increase up to optimum level of 25 percentages.
2. The RHA can be used to produce ultra high strength and ultra high performance concrete.
3. The RHA can be used in SCC by introducing low cost housing techniques.
4. The workability will be reduced due to crystalline nature of RHA, so that to increase workability of the concrete in requires high dosage of super-plasticizers.
5. The RHA concrete has more durable and having resistant to ASR and having low weight loss and tendency to resistance nitric acid and acetic acid.

6. The RHA reduces the chloride penetration and water permeability.
7. The RHA increases the corrosion resistance capacity of concrete so it can be recommended for marine structures construction.
8. The splitting and flexural strength of concrete will be slightly increased by RHA.
9. The RHA can be recommended for hot mix asphalt for filling material.

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