Utilization of Rice Husk Ash in Reactive Powder Concrete

R.Sutharsan,PL.Meyyappan, M.AhamedAzik Ali

Abstract— Reactive Powder Concrete (RPC) is a special concrete with excellent mechanical and durability properties and it is differentiated with other forms of concrete in terms of production, mix proportion etc. Depending upon various parameters like composition and the curing temperature, its compressive strength ranges from 130 MPa to 750 MPa, bending strength varies as 29 to 51 MPa and Young's modulus results upto 50GPa to 75GPa.Though RPC possesses many outstanding properties, it has limited applications in the construction field. The usage of higher quantity of cement and Silica Fume causes the rise of production of RPC. In addition to that, the silica fume availability is also restricted. For a country like India, usage of SF is limited due to its high price. Also, mineral admixtures can be used as a suitable alternative. Hence in this research work, Rice Husk Ash (RHA) is used as a possible alternatives for replacing silica fume in RPC. RHA holds maximum amount of silica (approx. 96%) in amorphous form. In this research, an experimental research on mechanical and durability properties of RPC by partially replacing SF with RHA. The detailed literature survey on constituent materials, mix proportions and curing conditions of RPC were done. Also, the optimum temperature and duration for the thermal treatment of RHA were identified. The compressive strength of the specimens of partial replacement of Silica Fume using RHA were tested and the results were compared with control specimens compressive strength.

Key Words—Rice husk ash, Reactive powder concrete, Compressive strength, XRD, EDAX.

I. 1.INTRODUCTION

Reactive Powder Concrete is a very high performance concrete with a very good characteristics in terms of strength and durability. In general, Reactive Powder Concrete is a fibre -reinforced, super plasticised, SF cement mixed with very fine quartz in presence of lower W/C ratio. The compressive strength of 130 to 750 MPa can be achieved depending on the composition and method of curing.

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R.Sutharsan*, Department of Civil Engineering, Kalasalingam Academy of Research and Education, Krishnankoil, India. Email: r.sutharsan@klu.ac.in

PL. Meyyappan*, Civil department, Kalasalingam Academy of Research and Education, Krishnankoil, India. Email: meyyappan@klu.ac.in

Due to the non availability of coarse aggregate enhances the property of microstructure and helps in the performance of RPC. The addition of steel fibres helps to gain ductility strength and therefore steel reinforcement usage can be minimized or extincted. The conventional concrete has lesser durability and strength when compared to RPC. This status has been achieved by RPC because of its low water binding ratio which helps in very low porosity.

The high characteristic strength and durability helps the use of RPC in several practical applications such as high buildings, nuclear waste disposal and bridges with proper guidance of engineers.

Silica Fume (SF) is one of the major component in RPC. The pozzolonic reaction is much more initiated by using this silica fume. The silica fume has a behavior of extreme fineness and amorphous silica content which improves the process of hydration on reacting with lime. Due to the limited availability and higher cost of silica fume, it is not extensively used in developing countries. This makes to produce RPC with the minimum content of silica fume and gave the probability of finding suitable alternative materials which exhibits similar properties.

One of the substitution may be Rice Husk Ash (RHA), an agro waste product by burning rice husk. RHA is prepared by burning rice husk at suitable temperature under controlled conditions; The size of the particle ranges upto a maximum of 10 μm whereas in case of SF it may go upto 1 μm.

1.1 RHA- A Potential Alternative of SF

Rice husk is a by-product obtained from rice paddy mill. It has the volume of 1/5th of the total rice production in the world. The rice husk can be used as an admixture in concrete production of the construction industry. The usage helps in the disposal of the waste as a useful product because of its unique characteristics. This is mainly used in the construction industry because of its pozzolonic nature. The pozzolonic reaction is a major phenomenain which the

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construction field is searching for. This can be achieved by the presence of silica. The thermal activity and duration of the treatment helps to initiate the reaction with much more vigorous than its ideal one.The temperature normally we preferred would be 600°C for a limitation of 2 hours. RHA helps in the production of CSH gel.

Pierre Richard et al. (1995) conducted a research programme on the composition for RPC 200 and RPC 800 based on the basic principles of ultra-high strength ductile concrete. They concluded that thenon addition of coarse aggregate and an optimized mixture helps to form a strong binding cementious material which shows very good mechanical properties. **Andres Salas et al (2009)** investigated about production process of RHA. It was chemically treated before burning it. They found that the effectiveness of the RHA was improved when it was chemically treated before burning when compared to the thermally treated RHA (TRHA). The crystallization of silica in rice husks has been decreased by using acid treatment. Incorporation of Chemically treated RHA (ChRHA) in High-Performance Concrete enhances Compressive strength, flexural strength and also the durability properties by refining its pore structure. **Nguyen van Tuan et al (2010)** experimented the usageof RHA to produce Reactive Powder Concrete by replacing silica fume. RHA has a major composition of silica content and a wide area hence classified as ‘‘ highly active pozzolan" and used as an alternative for silica fume. **HalitYazici et al.(2013)** studied about comparison of the mechanical properties in autoclave and standard water curing condition. The conclusion he attained that several parameters like pressure and temperature paves a major role in the behavior of RPC. Particularly for the compressive strength, the strength exceeds to 200 MPa. **A.L.G.Gastaldini et al (2014)** investigated the effects of RHA on mechanical and shrinkage properties as well as chloride penetration by replacing cement with SF and RHA. The concrete mixes for variying proportions of mixing of RHA were studied . In addition to that the experiment has been extended to three water to cement binding ratio for better understanding about the RPC. **S.K. Antiohos et al (2014)** investigated the cause and effect of addition of silica and well treated RHA in terms of all mechanical and durability properties of different forms of concrete. If if was ground to 7000cm^2/kg we can have very good results. Further grinding of RHA will improve mechanical and durability performance in concrete.

II. EXPERIMENTS

2.1Materials

The RPC concrete mix uses the OPC grade of 53 cement was 53 Grade as per IS 12296- 1987. The specific gravity was found to be 3.10. The specific gravity of silica fume is in the order of 2.2 to 2.6. This helps for the better reaction of the silica fume with other materials and simultaneously which helps to improve the properties of the concrete.

Quartz sand of size less than 600μm is basically used. The particle size of the quartz used for the RPC is is l0μm.

To improve the workability of fresh RPC high range water reducing poly-carboxylate based super plasticiser is added to the mixture.

RHA is utilized as a suitable alternative mineral admixture to replace the Silica Fume in RPC.

Steel fibres constitute a special inclusion in RPC. The straight steelfibres used were 16 mm length with a dia of 0.12 mm. The fibres were inserted in the mixture of 2% of the volume of concrete. The volume of the fibre will not be increased because of its density.

TABLE 2.1.Physical properties of materials

Constituent Materials	Specific Gravity
Cement	3.10
Silica Fume	2.456
Quartz Sand	2.597
Quartz Powder	2.688
Rice Husk Ash	2.154

2.2 Experimental methods

In this study, the main constituent material of RPC namely silica fume is replaced by RHA at different proportions. The optimum temperature and time duration for thermal treatment of rice husk to produce

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amorphous ash with maximum silica content were found. For this X-Ray diffraction (XRD) test was performed on RHA obtained at various temperature and duration of thermal treatment.

1. Temperatures: 550°C, 600°C, 650°C, 700°C.

2. Durations : 1 hr, 2 hrs, 3 hrs, 4 hrs.

The EDAX test was performed on amorphous RHA samples to find the constituents and silica content of the samples. The control specimens and specimens with RHA were cast and tested for the 7 days and 28 days compressive strength.

Compresssive Strength

The compression test was carried out to find out the compressive strength in concrete. The compressive strength of a concrete cube depends upon constituents, w/b ratio, curing temperature, and proper shape of the cube. The cube specimen of standard size of 70.7mm x 70.7 mm have been used. (as per IS: 516-1959) were cast for finding 7 days and 28 days compressive strength. The cubes were tested in

For each mix, 12 specimens (6 for normal curing and 6 for steam curing) were tested to find the strength for both 7 and 28 days.

Processing of Rice HuskAsh

Raw rice husk consist of several impurities and carbon content in the sample. This can be eliminated from the RHA by heating to a higher temperature under controlled conditions. Samples were collected for various temperatures of 500°C and 700°C. For each temperature, samples were taken out for every 1 hour of duration up to 4 hours and hence the collected samples were named on the basis of time and temperature to which is to subjected.After the collection of samples it were sent for XRD at Alagappa University, Karaikudi and for EDAX at Karunya University, Coimbatore. The obtained XRD and EDAX are summarized below, from the values obtained best suitable sample was fixed.

Fig 2.1: Treated Rice Husk Ash

III. RESULTS AND DISCUSSION

3.1 The result of the combined effect of RHA and SF on the compressive strength of RPC

Control specimen and specimens with silica fume replaced by RHA were tested for compressive strength in both 7 and 28 days. The test results of the specimen are shown in Table 3.1 and 3.2.

TABLE 3.1Compressive Strength of Specimen withRHA

RX -% of Rice husk ask in the concrete
SY - % of Silica fume in the concrete

S. No	Specimen	7 DaysCompressive Strength	
		Normal curing	Steam curing
1	R10S90	150.35 MPa	163.32 MPa
2	R20S80	158.64 MPa	170.41 MPa
3	R30S70	172.78 MPa	185.63 MPa
4	R40S60	134.68MPa	146.43MPa
5	R50S50	125.61MPa	138.94MPa

TABLE 3.2 Compressive Strength of Control Specimen

S. No	Curing Condition	7 Days	28 Days
		Compressive Strength	Compressive Strength
1	Normal curing	114.3 MPa	136.9 MPa
2	Steam curing	122.3 MPa	146.95 MPa

The compressive strength of RPC does not significantly decrease up to 30% replacement of Silica Fume by RHA.

3.2 XRD and EDAX of RHA on RPC

The XRD and EDAX tests were carried out for different temperatures (550°C to 700°C) for a duration variation from 1 hour to 4 hour with an interval of 1 hour duration.
The test analysis results are shown below.

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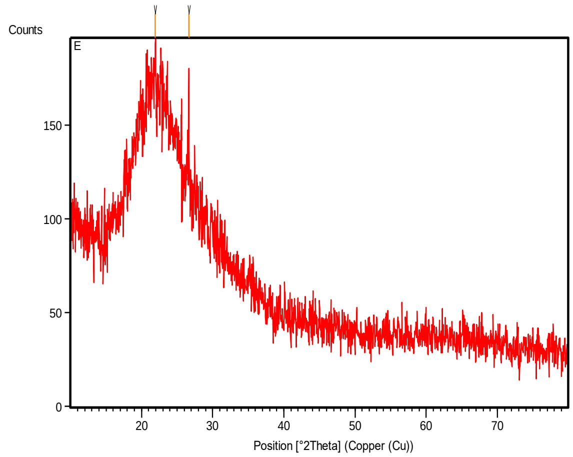

Fig 3.1 XRD of RHA at 600°C- 2 Hrs.

TABLE 3.3 EDAX of RHA at 600°C-2 Hrs

Element	Weight%
O k	47.71
Si k	45.80
C k	5.56
K k	0.81
Al k	0.11

From the XRD values, the refraction of the chemical properties were analysed whether it was an amorphous state or in the crystalline state. The arrangement of the atoms in the disorder manner is due to the refraction and diffraction properties is due to the amorphous state and if it is in orderly manner it shows the crystalline nature. evenif the silica content is more those conditions will not be selected for treating Rice husk.

The RHA obtained at the different burning conditions of 550°C to 700°C temperatures at 1 hr, 2hrs, 3hrs and 4hrs duration were having their arrangement of atoms in disorder manner during diffraction and hence the nature of these RHA were purely amorphous in nature.From EDAX test results of amorphous RHA samples, the RHA of 600°C at 2 hrs duration exhibit the maximum silica content of 45.80%by weight with a minimum carbon content of 5.56%.

The RHA of 550°C at 1 hr, RHA of 550°C at 2 hrs, RHA of 550°C at 3 hrs and RHA of 550°C at 4 hrs were having the minimum silica content 34.07%, 34.42%, 34.42% and 35.36% and carbon content 2.68%, 4.70%, 4.70% and 1.27% respectively. The RHA of 600°C at 1 hr and RHA of 600°C at 2 hrs were having the silica content 33.00% and 41.96% and carbon content 0% and 5.56% respectively.

The silica content of RHA of 650°C at 1 hr, RHA of 650°C at 2 hrs, RHA of 650°C at 3 hrs and RHA of 650°C at 4 hrs were 40.15%, 40.25%, 37.94% and 39.84% respectively without carbon content.

The RHA of 700°C at 1 hr, RHA of 700°C at 2 hrs, RHA of 700°C at 3 hrs and RHA of 700°C at 7 hrs were having the silica content 37.18%, 41.71%, 39.37% and 39.35% respectively without carbon content.

The RHA of 600°C at 4 hrs were having the minimum silica content of 14.93% by weight and maximum carbon content of 8.93% by weight.

This test results show that RHA which has 600°Cfor 2 hours shows amorphous ash with maximum silica content and lower carbon content.

IV. CONCLUSION

The properties of RPC and RHA was studied and the constituent materials of RPC, mix proportioning of RPC and the temperature and duration for controlled burning of rice husk and also the influence of properties of RHA and SF on RPC were analysed. Inclusion of RHA does not have much impact on the decrease of the compressive strength of RPC compared to that of SF, RHA is added and also the combination of SF and RHA can increase the total cement replacement percentage up to 40% to produce RPC.

By XRD and EDAX analysis, the optimum temperature and duration were found out for burning rice husk to obtain amorphous ash with maximum silica content. The amorphous ash with maximum silica content obtained at 600°C for 2 hours gave the convincing result for the silica fume replacement.

The addition of RHA does not significantly decrease the compressive strength of RPC compared to that of SF, when less than 30% RHA is added.The steam curing enhances the compressive strength which provides an additional support to the improvement of the strength.

The Strength pattern of RHA and silica fume mixed concrete shows the increased value at a certain level(30% Flyash and 70% Silica fume) and it decreases. Further analysis of materials if some additive admixtures and the improvement of the reaction of the materials within them paves the strength of the material

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AUTHORS PROFILE

Mr. R. Sutharsan completed his M.E in Structural Engineering in Thiagarajar College of Engineering, Madurai in the year 2016. He completed his Bachelor of Engineering under Anna University in the year 2013. He is working as Assistant Professor in Department of Civil Engineering at Kalasalingam University, Tamilnadu, India. His main thrust research areas is Fiber reinforced concrete.

Dr. PL. Meyyappanhas completed his graduation and post-graduation from Bharathiyar University and Karunya University respectively. He completed his PhD from Kalasalingam University. He has 13 years of teaching experience. He has completed 2 sponsored research projects from TNSCST and published more than 25 papers in peer reviewed journals and conferences. He is a life member in ISTE, IEI, IGS, ISET, ISRS. He is serving as Editorial Board Member and Reviewer in various reputed Journals.

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