

UTILIZATION OF RICE HUSK ASH AND FOUNDRY SAND AS PARTIAL REPLACEMENT MATERIALS IN FIBRE REINFORCED CONCRETE- A LITERATURE REVIEW

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Abstract:- Concrete is one of the most widely used materials in the construction industry. Concrete is homogeneous mixture of cement, sand, coarse aggregate and water. Cement production gives rise to CO₂ emissions and being responsible for about 5% of the CO₂ emissions in the world. The availability of the natural river sand is decreasing due to the over exploitation of river sand. In order to reduce the usage of cement and river sand, partial replacement can be done and an eco-friendly concrete should be produced. Rice Husk ash and used Foundry sand are used as partial replacement materials. Fiber reinforced concrete is one of the recent trends in construction industry, using of the fibers reduces cracks in the concrete and improves tensile strength. In this study Literatures are reviewed to understand the feasibility of using Rice Husk ash and foundry sand in Fiber reinforced Concrete. The material testing carried out shows that the materials that are to be used for the concrete are of the required quality and strength.

Key Words: Concrete, Fiber reinforced Concrete, Rice Husk ash, Foundry sand, materials.

1. INTRODUCTION

Concrete is a composite material composed of gravels (coarse aggregate), sand (fine aggregate) and cement (binder). Concrete have inherently brittle nature and have some dramatic disadvantages such as poor deformability and weak crack resistance in the practical usage. Also their tensile strength and flexural strength is relatively low compared to their compressive strength. Fiber-reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers are usually used in concrete to control cracking due to plastic shrinkage and to drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibers produce greater impact, abrasion and shatter resistance in concrete.

The worldwide consumption of sand as fine aggregate in concrete production is very high and several developing countries have encountered some strain in the supply of natural sand in order to meet the increasing needs of infrastructural development in recent years. Therefore, it is

necessary to replace natural sand in concrete by an alternate material either partially or completely without compromising the quality of concrete. Foundry sand which is a byproduct that is obtained from the metal industries is a good alternative for the natural sand as it is produced in abundant quantities and is used only for the landfilling purpose which may also pollute the land. Thus the partial replacement of the natural sand with foundry sand maybe a good alternative for the reducing the usage of natural sand and also reduces the causes of dumping of the foundry sand.

Cement being one of the main ingredients in the concrete is used in a large quantity in the construction industry. The production process of the cement leads to the rise of CO₂ emissions generated by the calcinations of CaCO₃ and being responsible for about 5% of the CO₂ emissions in the world. Thus it causes a great threat to the environment by increasing the global warming. Rice Husk Ash (RHA) is one of these waste products which are generated as a by-product of rice paddy milling industries. When it is properly brunt it has high SiO₂ content and can be used for cement replacement. Rice husk ash exhibits high pozzolanic characteristics and contributes to high strength and high impermeability of concrete.

1.1 Fiber Reinforced Concrete

Fiber Reinforced Concrete can be defined as a composite material consisting of mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibers. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers. Fiber is a small piece of reinforcing material possessing certain characteristics properties. The fiber is often described by a convenient parameter called aspect ratio. The aspect ratio of the fiber is the ratio of its length to its diameter. Typical aspect ratio ranges from 30 to 150. The amount of fibers added to a concrete mix is expressed as a percentage of the total volume of the composite (concrete and fibers), termed "volume fraction" (V_f). V_f typically ranges from 0.1 to 3%. The aspect ratio (l/d) is calculated by dividing fiber length (l) by its diameter (d). If the fiber's modulus of elasticity is higher than the matrix (concrete or mortar binder), they help to carry the load by increasing the tensile strength of the material.

The polyester fiber increases tensile strength. It has greater impact resistance of fiber reinforced concrete and it reduces permeability. Polyester fiber arrests drying shrinkage and controls cracking. It Reduces rebound loss-Brings direct savings and gains. It increases flexibility and abrasion resistance.

1.2 Foundry Sand

Ferrous and nonferrous metal casting industries produce several million tons of by-products in the world. Waste foundry sand (WFS) are major by-product of metal casting industry and successfully used as a land filling material for many years. But use of waste foundry sand for land filling is becoming a problem due to rapid increase in disposal cost. In an effort to use the WFS in large volume, research has been carried out for its possible large scale utilization in making concrete as partial replacement of fine aggregate.

1.3 Rice Husk Ash (RHA)

RHA is a carbon neutral green product. Lots of ways are being thought of for disposing them by making commercial use of this RHA. Rice husk ash is a very fine pozzolanic material. The utilization of rice husk ash as a pozzolanic material in cement and concrete provides several advantages, such as improved strength and durability properties, reduced materials costs due to cement savings, and environmental benefits related to the disposal of waste materials and to reduce the carbon dioxide emissions. Rice husk ash essentially consists of amorphous or non-crystalline silica with about 85- 90% cellular particle, 5% carbon and 2% K₂O. Each tonne of paddy produces about 40 kg of RHA. There is a good potential to make use of RHA as a valuable pozzolanic material.

2. LITERATURE REVIEW

This chapter deals with the various earlier researches done on the general behavior of concrete using rice husk ash, foundry sand and fibers. They have been summarized and given below

2.1 Review of Literature about Foundry Sand

Pathariya Saraswati C et al., (2013) this research is carried out to produce a low-cost and eco-friendly concrete. This paper demonstrates the use of waste foundry sand as a partial replacement by fine aggregate in concrete. An experimental investigation is carried out on a concrete containing waste foundry and in the range of 0%, 20%, 40%, and 60% by weight for M-25 grade concrete (PPC). Material was produced, tested and compared with conventional concrete in terms of workability and strength. These tests were carried out on standard cube of 150*150*150* mm for 7, 14 and 28 days to determine the mechanical properties of concrete. Through experimental result we conclude that the compressive strength increases with increase in partial replacement of waste foundry sand, maximum compressive strength is obtained at 60% replacement of fine aggregate by

waste foundry sand. The split tensile strength decreases with increases in percentage of waste foundry sand.

Augustine Uchechukwu Elinwa et al., (2014) an evaluation on the use of spent foundry sand (SFS) in the production of concrete has been carried out. The material SFS was properly characterized and used in proportions of 0 %, 10 %, 20 %, 30 % and 40 % by weight of fine aggregate and cured under laboratory conditions for up to 90 days. The work also confirmed that SFS can substantially reduce the effects of absorption in concrete to about 8 % to 28 %, when cured for 90 days and at different replacement levels. This is good for durability of concrete. However, the compressive strength decreased as the replacement levels increased and performed optimally at 10 % replacement. Linear regression models developed on the experimental data are significant and adequate.

Vema Reddy Chevuri et al., (2015) The experimental work is mainly concern with the study of mechanical properties like compressive strength, split tensile strength and as well as flexural strength of concrete by partial replacement of artificial sand by foundry sand as fine aggregate. Tests over carried out on cubes, cylinders to studies the mechanical properties of concrete using foundry sand and compare with concrete with natural sand as fine aggregate. Artificial sand was replaced with five percentages (0%,5%,10%,15%& 20%) of Waste Foundry Sand by weight. A total of five concrete mix proportions are made with and without foundry sand. Compression test, splitting tensile strength test and flexural strength test were carried out to evaluate the strength properties of concrete at the age of 7 & 28 days. Test results showed a nominal increasing strength and durability properties of concrete by the addition of waste foundry sand as a partial replacement of natural sand. The workability of foundry sand increases. The compressive strengths were increased with increase in the foundry sand in the concrete mix up to 60% and will decrease after 60% up to 100%. The split tensile strengths were increased with increase in the foundry sand in the concrete mix up to 60% and will decrease after 60% up to 100%.

Sarita Chandrakanth et al., (2016) This paper identifies a potential use of wastes from foundry industry and construction industry for utilization in construction industry and represents the experimental investigation on utilization of foundry waste as a partial replacement of natural sand by 0%, 20%, 40%, 60%. Concrete mixtures were produced, tested and compared in terms of strength with the conventional concrete. These tests were carried out to evaluate the strength for 7 and 28 days. It is found that compressive strength of concrete mix is increases with increase in percentage of waste foundry sand as compare to normal concrete. It was maximum for 40% replacement after that it reduces. It is also found that split tensile strength increases with increase in percentage of waste foundry sand up to 40% replacement after that it reduces. It is also found that flexural strength increases with increase in percentage of waste foundry sand up to 40% replacement after that it

reduces. Average compressive strength at 28 days increased by 3.96%, 8.857% & 5.37% as compared to conventional concrete. Average split tensile strength at 28 days increased by 9.3088%, 22.07% & 7.048% at 28 days as compared to conventional concrete. Average flexural strength at 28 days increased by 21.29%, 28.07% & 15.93% as compared to conventional concrete.

2.2 Review of Literature about Fibre Reinforced Concrete

Dr. Vagheesha S. Mathda et al., (2016) the present work deals with results of experimental investigation of effect of use of Recron 3S polyester fiber on compressive strength of concrete. This has resulted into casting, curing and testing of 27 cube specimen of size (150 X 150 X 150) mm. In present work specimens are tested for resulting compressive strength by using Recron 3S fibers. Fiber percentages taken for casting are varied from 0.2% to 1.8% for compressive strength at an interval of 0.2% by weight of cement. The second objective for conducting project is to calculate workability and comparing normal and fiber reinforced concrete. Testing properties of cement, fine aggregate, coarse aggregate was done in accordance with the specifications in relevant Indian Standards. Indian Standard (IS 10262:2009) [5] method of mix proportioning was used for mix proportioning. The standard concrete (M30) is considered as reference concrete for comparing the results. Fiber content was varied from 0.2% up to 1.8 % at an interval of 0.2 % by weight of cement. Workability of Recron 3S fiber reinforced concrete decreases with the increment of fibers. The water is absorbed by Recron 3S fibers so causing decrement in workability. The workability of concrete is higher at 0.2% of fiber but decreases as percentage of fibers increases. Recron is beneficial for commercial use, as only 0.2-0.4% by weight of cement Recron 3S is sufficient for getting better compressive strength of concrete. The optimum dosage of Recron 3S fiber for maximum compressive strength is 0.2%.

Y. M. Ghugal S.V. Naghate et al., (2016) In this investigation effects of extruded polyester fibers on the performance of concrete in green and hardened states are studied. Fiber content is varied from 0.5% to 5% at an interval of 0.5% by weight of cement. With the increase in fiber content the workability and wet density decreased continuously. The maximum increase in compressive strength at the age of 7 and 28 days upto 9.49% and 6.08%, respectively, is observed over the normal concrete both at 1.0% of fiber volume fraction. It is observed from the results that the value of flexural strength increased up to 1% of fiber content at the age of 7 days and 28 days by 14.29% and 4.68%, respectively, over the normal concrete. The load deflection behavior showed the improvement in the ductility of this concrete composite. Very good crack control for this concrete composite is observed at 5% of fiber content. The pull-out length of fiber is observed to vary with fiber content and its maximum value is observed at 5% of fiber content. The elastic constants obtained for this fiber reinforced concrete are found to vary in the normal range.

Revanasiddappa Madihalli, Naveen Kumar B M et al., (2017) The present study involves use of polyester fiber for 0%, 1%, 1.25% and 1.5% of cement content and slag sand at 0%, 10%, 15% and 20 % as replacement of fine aggregates respectively. From the experimental results it can be observed that as the percentage of fibers increases up to 1.25% there is an increase in the compressive strength and split tensile strength of the plain cement concrete. Also there is an enhancement of the flexural strength of the reinforced concrete members with the variation of polyester fibers up to 1.25%. Further increase in the percentage of polyester fibers shown decrement in the strengths of both plain and reinforced concrete.

Alex Tharun P J et al., (2018) this paper shows the results of a study undertaken to enhance the property of Fly Ash concrete with polyester fiber. In this investigation the M-30 Grade of concrete having a mix proportion of 1:2:3:4:28 is prepared. For the experimental study 6 different mixes are prepared. One conventional mix, 10% cement is replaced by fly ash for next 5 composition. One normal mix, mix with 0.025% polyester fiber, mix with 0.05% polyester fiber, mix with 0.075% polyester fiber and mix with 0.1% polyester fiber. The results which are obtained are compared with the control specimen. The compressive strength obtained for 28 days containing fly ash 10% and polyester fiber 0.025% is found to be 41.33N/mm². Compressive strength is 21.5% increased, Split tensile strength is 65.5% increased and Flexural strength is 66.66% increased when compared with the control specimen for 10% fly ash replacement and polyester fiber 0.025%.

2.3 Review of Literature about RHA

Karthik M. P. et al., (2017) This paper describes the experimental study on strength characteristics of M40 grade concrete in which cement is partially replaced by rice husk ash. Rice Husk Ash (RHA) is one of these waste products which are generated as a by-product of rice paddy milling industries. In this study, the strength related properties such as compressive strength, splitting tensile strength, flexural strength were calculated in which concrete specimens produced with 0%, 10%, 12.5% and 15% of the RHA as the cement replacement percentages. Specimens were tested at the ages of 7 and 28 days. Finally, concluded that the RHA replacement level of 12.5% in M40 grade concrete showed higher when compared to other replacement levels.

Ashwini B.V et al., (2017) In this study Ordinary Portland cement (OPC) was replaced with Rice husk Ash (RHA) by weight at 0%, 10%, 20%, 30%, and 40%. On fresh concrete, compacting factor test was carried out and on hardened concrete cubes of 150mm Compressive Strength test was carried out after 3, 7, and 28 days of curing. According to the results of the compressive strength, addition of 20% of RHA shows a better result when compared with conventional concrete and flexural strength also increases for 20% RHA replacement.

I.B. Ologunagba et al., (2015) This study examined the feasibility of using rice husk ash as partial replacement for concrete. The experimental investigation consists of testing 40 concrete cubes of mix ratio 1:2:4. The variables considered are (i) Concrete without rice husk (control) (ii) Concrete with 5% cement content replaced by rice husk (iii) Concrete with 10% of cement content replaced by rice husk (iv) Concrete with 15% of cement content replaced by rice husk (v) Concrete with 20% of cement content replaced by rice husk. Slump and compacting factor tests were carried out to check the effect of Rice Husk Ash on the workability of fresh concrete. The tests were carried out in accordance with the requirements of BS 1881. Compressive strength was determined at curing age 7,14,21 and 28 days. Finally concluded that Rice husk ash a good material that can supplement cement to some extent but the rice husk ash is permissible to 15% replacement of cement. However, 10% has a good strength which can be applied for normal concrete without adverse effect or reduced strength but the water/binder ratio must be adhered to as 0.44 water/binder ratio has appreciable and acceptable strength for normal concrete.

Abdul Fareed Babu, Seeram Bhanupravalika et al., (2018) this paper shows the results of a study by replacing cement partially with RHA in different percentages of 7.5%, 10%, 12.5%, 15% and 17.5%. It was found that 15% replacement of cement with RHA gives higher strength and it is the Optimum RHA (ORHA) replacement. For further increase of strength, two varieties of fibres namely lathe waste fibres and steel fibre was added with ORHA replaced cement concrete in percentages of 0.5%, 1.0%, 1.5% and 2.0% by weight of concrete. Cement replaced with 15% Rice husk ash has contributed to achieving desired strength of concrete. Addition of 1.5% lathe waste fibres to cement replaced ORHA concrete improves the compressive strength, splitting tensile strength and flexural strength in percentages of 17.47 %, 17.54%, and 40.13% respectively. Addition of 1.5% steel fibres to concrete enhances the compressive strength, splitting tensile strength and flexural strength in percentages of 29.79%, 15.44%, and 47.61%, correspondingly.

Aishwarya T.R et al., (2018) This work presents the benefits from various ratios of rice husk ash (RHA) on concrete indicators with proportions of 5, 10, 15, 20, 25% RHA by the weight of cement in addition to this a constant amount of 30% waste foundry sand (WFS) by the weight of crushed stone sand has been replaced in the concrete and it has been compared with control concrete with no additives. M20 concrete with water cement ratio of 0.5 has been used. The combined effect of foundry sand of 30% and rice husk ash with increased percentage results in the decrease of slump by 41.66% and compaction factor by 16.66% compared to ideal concrete. The decrease in slump and compaction factor is due to the presence of micro and meso pores in RHA and also due to the water absorbing capability of RHA. The increase of compressive strength by 13% is seen in the combination of RHA10% and WFS 30%. This is due to

increased RHA content results in improper pozzolonic action and slows down hydration process in concrete. The combination of RHA10% and WFS30% shows the increased split tensile strength and flexural strength by 28.71% and 66.66% than the control concrete. The combination of RHA10% and WFS30% is found to be the optimum content for the compressive strength, split tensile and flexural strength.

2.4 Observations From Literature Review

- RHA is the waste material which is produced in the rice growing region and it is obtained from burning of rice husk, which is by-product of rice milling. It is estimated that 1000kg of rice grain produce 200kg of rice husk; after rice husk is burnt, about 20 percent or 40kg would become RHA.
- RHA can be used to replace cement to a certain extent, by reducing the usage of cement we could reduce the emission of Co₂ which contributes to a major portion of global warming.
- RHA should be replaced for a small percentage of cement as replacement of higher percentage leads to decrease in strength. In most of the literature the optimum percentage of RHA is around 15%.
- The usage of foundry sand as a replacement for the river sand would reduce the land pollution cause by the foundry sand and also it would be economically feasible to use foundry sand to a certain extent in concrete as the river sand cost is increasing day by day. In most of the literature the optimum percentage of foundry sand successfully replaced sand is around 30%.
- The addition of the polyester fiber to the concrete reduces the crack that may develop in the concrete and it also increases the tensile strength of the concrete and a slight rise in the compressive strength of the concrete but higher percentage use of the fiber may lead to difficulty in mixing and placing of the concrete. The optimum percentage of fiber is found to be less than 1%.

3. MATERIAL TESTING

3.1 Cement

The Ordinary Portland Cement of 43 Grade conforming to IS 12269 – 1987 was used in this study. The specific gravity and initial setting of OPC 43 grade were 3.15 and 35 minutes respectively.

3.2 Fine Aggregate:

Locally available river sand conforming to grading zone II of IS 383 – 1970. Sand passing through IS 4.75mm Sieve will be used with the specific gravity of 2.65.

3.3 Coarse Aggregate

Machine crushed angular granite metal of 20mm nominal size from the local source was used as coarse aggregate. The specific gravity and water absorption of coarse aggregate were investigated as 2.68 and 1.17%. The impact value and abrasion factor of coarse aggregate were 14.13% and 24.6%.

3.4 Waste Foundry Sand

Waste foundry sand (WFS) was obtained locally from shanthi casting, Coimbatore. WFS were used as a partial replacement of fine aggregate (natural river sand). Metal poured in the foundry is grey iron. The sand was tested for various properties like specific gravity, water absorption etc., and in accordance with IS 2386-1963.

3.5 Polyester Fiber

Table -1: Properties of fibers

S.No	FIBER PROPERTIES	POLYESTER
1	Length (mm)	6
2	Shape	Straight
3	Size/Diameter(mm)	0.035
4	Aspect Ratio	171.42

4. CONCLUSION

Detailed literature survey gives us a theoretical knowledge about the utilization of RHA, waste foundry sand and Polyester in conventional concrete. From these literatures it is understood that partial replacement of RHA upto 15% shows good physical and mechanical properties in concrete and cohesiveness of concrete increased and the partial replacement of the foundry sand upto 30% shows good results and the optimum percentage values of fiber is found to be less than 1%. The material testing carried out shows that the materials that are to be used for the concrete are of the required quality and strength.

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