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Effect of Partial Replacement of Portland Cement with fly Ash, Rice Husk Ash and Bagasse Ash on Chemical and Mechanical Properties of Concrete

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Abstract - *The aim of this review paper is to investigates the growth of chemical and mechanical properties of concrete to determine the workability, performance and durability of by optimal replacement of cement with ratio of Fly ash (FA), bagasse ash (BA), and Rice husk ash (RHA) with three categories of fly ash in terms of weight were performed for the replacement of cement. Materials with pozzolanic properties, plays an important role in the production of high performance concrete and emission reduction. There has been an improvement in the use of admixture by concrete industries. Waste utilization would not only be economical, but may also significant result in source of global carbon dioxide (CO2) emissions, and environmental pollution control. This investigation discovers the effects on the behavior of concrete produced from cement with combination of FA, RHA and BA at different proportions on the mechanical properties of concrete (compressive strength, flexural strength, and split tensile strength). Also find out the optimum percentage these materials as partial replacement of cement concrete.*

Key Words: Fly Ash (FA), Rice Husk Ash (RHA), Bagasse Ash (BA), Cement Replacement, Compressive Strength, Tensile Strength.

1. INTRODUCTION

Researchers are working on formulating mixed cements by obtaining suitable pozzolanic agricultural by-products such as rice husk ash, and bagasse ash that could partially replace OPC in making cement composites. In hydration of Portland cement, calcium hydroxide [Ca(OH)2] is obtained as one of the hydration products. Pozzolanic material is mixed with Portland cement, reacts with the Ca(OH)2 to produce additional calcium-silicate-hydrate (C-S-H), which is the main cementing component. Thus the pozzolanic material decreases the quantity of the deleterious Ca(OH)2 and increases the quantity of the beneficial C-S-H. Therefore, the cementing quality is improved if a good pozzolanic material is mixed in suitable quantity with Portland cement. Studies of possible modifications to concrete's components will have a huge impact on the usage volume of those components directly around the world because of the massive amount of concrete created annually (Joshaghani Et Al. 2014). Utilizing these material have vital influence on emission reduction and global warming. Concrete is mix of cement, water and aggregates. The admixtures may be added in concrete in order to increase some of the properties desired specially. Fly ash is the general pozzolan and is found extensively applied generally in concrete works. It is commonly recognized that the employment of fine fly ash upgrades the qualities of concrete. Even though the porosity of the paste is improved on account of the inclusion of fly ash, the average pore size gets reduced, resulting in a minimal porous paste. The interfacial domain of the interface between aggregate and the matrix also becomes superior in view. The optimum volume of fly ash is not only with the application, but also with composition and proportions of all the materials in the concrete mixture. A measureable undefitanding of the effectiveness of fly ash as admixture in concrete is significant for its effective utilization. There is Later efforts towards an effective application led to rational methods of incorporating fly ash in concrete, considering the two concretes (with or without fly ash) can be made to reach the same strength at a given age by regulating their water cementitious materials ratios. This done either by adjusting the quantity of fly ash introduced for replacing the cement or through the "cementing efficiency factor" of fly ash. fly ash shows very little cementing efficiency at the early ages and performances rather like fine aggregate (filler), but at later ages the pozzolanic property becomes effective leading to a considerable strength improvement. This obviously means that the cementing efficiency of fly ash increase with age because of the pozzolanic reaction. Bagasse is a major by-product of the sugar industry, which is utilized in the same industry as an energy source for sugar production (Xie et al. 2001). Sugarcane contains 25 -30% bagasse, whereas industry recovered sugar is about 10%. Bagasse is also used as a raw material for paper making because of its fibrous texture, and about 0.3 tons of paper can be made from one ton of bagasse. The ash produced by the controlled burning of agro waste materials below 700°C incinerating temperature for 1 h transforms the silica content of the ash into an amorphous phase (Amin et al. 2009), and the reactivity of amorphous silica is directly proportional to the specific surface area of ash (Ali et al. 2009). The ash so manufactured is pulverized or ground to the required fineness, then mixed with cement to produce a blended cement. Thus, the agricultural ash properties depend on burning time, temperature, cooling time, and grinding conditions.

1.1 Scope of paper

Fly ash, Rice husk ash and Bagasse ash is found to be superior to other supplementary materials like slag, and silica fume. The underlying reason for the current exploration is to precisely assess Fly ash, Rice husk ash (RHA) and bagasse ash (BA) chemically, physically and miner logically differentiated to explore the feasibility of their employment as a cement replacement in the concrete industry. BA and RHA used in this study is efficient as a pozzolanic material. Using of them helps in reducing the environment pollution and emission reduction during the disposal of excess these materials. Cement is costly material, so the partial replacements of these materials reduces the cost of concrete.

2. Literature review

M. Sivakumar, Dr.N. Mahendran. (2014) Researchers investigated the strength and permeability of concrete by optimal replacement of cement with adding fly ash, rise husk ash with 5%, 10%, 20%, 30%, 40%, were performed for the replacement of cement and addition of a persistent 5% egg shell powder in every replacement. He has assessed the physical and chemical attributes of fly ash, rice husk ash and egg shell powder. The restraints measured for examination involved compressive strength, splitting tensile power, flexure force, water permeability, sorptivity, total charge passed acquired from swift chloride permeability test (RCPT) and tempo of chloride ion diffusion according to the diffusion coefficient. The result showed that the properties of concrete going to up to 30% of cement replacement by combined FA (15%), RHA (15%) with additive ESP (5%). They got that these replacement is considerably better to the ordinary Portland cement concrete. [1]

Arunav Chakraborty, Anasuya Goswami. (2015) In this paper researchers reduced the amount of cement by replacing it with fly ash and rice husk ash as a construction material. He has been observed that by increasing the percentage of Fly Ash and Rice Husk Ash (RHA) with cement the properties of the concrete increases significantly. Researchers Denote that the reaction between Portland Cement and Water releases calcium hydroxide as a byproduct which makes the concrete porous, weak and endurable. He found that fly ash has more influence than rice husk ash due to fly ash contains high amount of SiO2. Also they mentioned that by using both, fly ash and rice husk ash as a replacement of cement in concrete, the compressive strength of cement can be decrease and consumption of cement can be reducing and has influence in emission reduction and global warming. [2]

P. Kathirvel, V. Saraswathy, S. P. Karthik, A. S. S. Sekar. (2012) The researchers used binary blending and ternary blending for improving the performance of the concrete. They characterized the optimum percentage of SCMs fly ash, RHA and LP in a quaternary mix, with increasing the strength and durability. The result showed that the quaternary mix is very effective in increasing the compressive, tensile and flexural strength along with durability of the concrete. They investigated that in quaternary blending, there is an increase in compressive, flexural strength and split tensile for cement with 20 % fly ash, 10 % of LP and 10 % of RHA. In durability test quaternary-blended cements has better influence in all aspects of corrosion. the quaternary mix is fund to increasing the strength and corrosion resistance. [3]

Yun Yong Kim, Byung Jae Lee, Velu Saraswathy, Seung Jun Kwon. (2014) In this experimental studies Compressive strength test results showed that alkali-activated RHA geopolymer mortars have shown better performance to the control system. By studies and experimental test RHA can be used as a replacement material for OPC. Experimental work during casting investigated effect on method of curing and NaOH concentration on compressive strength, also the optimum mix proportion of geopolymer mortar. After 7 and 28 days' compressive strengths were 31 N/mm2 and 45 N/mm2 for the 10 M alkali-activated geopolymer mortar of casting when cured for 24 hours at 60°C. The result showed that, increase in curing period and concentration of alkali activator, compressive strength will increase. They found that geopolymer concrete is very less weight loss when compared to steam-cured mortar specimens. In addition, they have studies on fluorescent optical microscopy and X-ray diffraction (XRD) have shown the formation of new peaks and increase the polymerization reaction which id develop strength and hence RHA has great potential as a replacement for ordinary Portland cement concrete. [4]

Naraindas Bheel, Muneer Ali Jokhio, Javed Ahmed Abbasi. (2020) Researchers analyzed the characteristics of concrete by replacing cement with Rice Husk Ash (RHA) and Fly Ash (FA). They analyzed the performance of concrete conducting a slump test, and describe indirect tensile and compressive strength. RHA and FA by 5% (2.5% RHA + 2.5% FA), 10% (5% RHA + 5% FA), 15% (7.5% RHA + 7.5% FA) and 20% (10% RHA+10% FA) by weight replaced with cement. 90 concrete samples were cast with mix proportions of 1:2:4 and 0.55 water/cement ratio. for measuring compressive and split tensile strength Cube and cylindrical samples were used after 7 and 28 days. After 28 days, compared to the predictable sample the 5% RHA+5% FA sample's, increased compressive strength by 16.14% and, tensile strength was developed by 15.20%. Result obtained that the highest measured slump value was 42mm for the conventional sample, the lowest was 20mm for the 10%RHA+10%FA. The highest density achieved after 28 days was 2392kg/m3 for the conventional sample, the lowest was 2288kg/m3 for the 10%RHA+10%FA. The optimum water absorption achieved after 28 days was 4.65% for the 10%RHA+10%FA sample. When cement was replaced by 5%RHA and 5%FA, strength improved by 14.5% and 16.14% compared to the conventional mix, while it was reduced by 13.7% and 12.90% in the 10%RHA+10%FA sample. In the end optimum

hardened properties were achieved by using 5% RHA and 5% FA as cement replacement material in concrete. [5]

H.S. Thinda, Yadvinder Singha, Bijay Singhb, Varinderpal Singhb, Sandeep Sharmaa, Monika Vashistha.B, Gobinder Singha. (2012) Worked on the research to determine rice husk ash, bagasse ash and coal fly ash land application and effect on crop productivity and nutrient uptake in rice. Investigation the possibilities to use these waste materials as soil amendments to produce productivity of rice–wheat system (RWS) conducted for three and half years. They found that the beneficial effects of RHA and BA in increasing grain and straw yield of RWS were spectacular, although the effects of RHA and BA were more distinct when applied to wheat than rice. The significant increase in grain and straw yields of RWS with the application of RHA and BA seems to be attributed to the increased availability of nutrients and favorable effects of ashes on soil physical conditions and microbial processes. [6]

Vishvanath. N. Kanthe, Shirish V. Deo, Meena Murmu. (2018) Parametric study done on the binary and ternary blend cement mortar using with the fly ash (FA) and rice husk ash (RHA) as partial replacement of ordinary Portland cement (OPC). binary blend was used with the variation of 5–20% FA and RHA as partial replaced of OPC and for ternary blend 10% RHA along with 10, 20 and 30% FA as partial replacement of cement. The teste on mortar cubes were included compressive strength, the microstructure of mortar matrix and durability. The maximum compressive strength was attained using 10% RHA, 10% FA for binary blend and for ternary blend 10RHA10FA and beyond that, the strength was similar to control mix (CM). They determined that mix is very effective on increasing the strength and durability of cement mortar by saving cement and also environmental friendly. They found that the compressive strength of ternary blend cement mortar mix due to the packing of better particles, pozzolanic reaction is higher than the binary and control cement mortar. Result of UPV test showed the improved durability of cement mortar ternary blend, then binary blend by the addition of FA and RHA possibility due to the increase in cement hydration product which is related to the high content of silica present in RHA and alumina present in the FA. [7]

Sumrerng Rukzon.A, Prinya Chindaprasirt. (2018) In this investigation researchers presented the utilize of bagasee ash as a pozzolanic material for producing high-strength concrete. They replaced Portland cement type I (PC) with finely ground bagasee ash. The concrete mix replaced with 10%, 20% and 30% of BA respectively. They determine the properties of concrete like compressive strength, tensile, the porosity, the coefficient of water absorption, the rapid chloride penetration and the chloride diffusion of concrete. They determined by experimental test that, incorporation of BA up to 30% replacement level increases the resistance to chloride penetration. Utilization of 10% of bagasse ash produced concretes with good strength and low porosity. Reasonably, the replacement of 30% BA is acceptable for manufacturing high-strength concrete. They produced strength of concrete by the combination of the finely ground bagasse ash. In conclusion, the incorporation of BA significantly improves the resistance to chloride penetration of concrete by increasing pozzolanic reaction, by enhancing the precipitation sites of hydration products and by reducing Ca(OH)2 of concrete. [8]

Ettu L.O, Ajoku. C.A, Nwachukwu. K.C, Awodiji C.T.G, Eziefula U.G. (2013) The variation of OPC-Rice Husk Ash (RHA) composites strength with percentage RHA were investigated. They test 231 concrete cubes, sand Crete cubes, and soil Crete cubes of 150mm x 150mm x 150mm were produced at percentage OPC enhancement with RHA of 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, and 50% and crushed to attain their compressive strengths at 3, 7, 14, 21, 28, 50, and 90 days of curing. Result showed that the compressive strength values of the OPC-RHA blended cement composites at all percentage replacement of OPC with RHA were much lower than the control values at 3-21 days, but increased to become comparable to and even greater than the control values at 50 to 90 days of curing. [9]

Himanshu Jain, Sanjay Saraswat, Devansh Jain. (2014) evaluated the compressive strength of rice husk ash (RHA) as a partial replacement for PPC in concrete. They found the optimum % (0, 8, 10, 12, 14, 16) of (RHA) as partial replacement of cement for M35 grade of concrete. They indicated that using of rice husk ash as a pozzolanic in combination with PPC in the structure industry has a good influence. From the study conducted, RHA is a pozzolanic material that holds the potential to be applied as partial cement replacement material and can lead to the sustainability of the building stuff. [10]

R.Srinivasan, K.Sathiya. (2011) In this investigation Bagasse ash has been analyzed chemically and physically, and partially replaced in the ratio of 0%, 5%, 15% and 25% by weight of cement in concrete. They have tested fresh concrete includes slump cone test, compressive test, split tensile strength, flexural strength and modulus of elasticity at the age of seven and 28 days was obtained. The result showed that the strength of concrete increased as percentage of bagasse ash replacement increased. [11]

Noor Ul Amin. (2011) Worked on recycling of bagasse ash as a cement replacement in concrete. They investigated The impact of bagasse ash content as a partial replacement of cement on physical and mechanical properties of concrete, including compressive strength, splitting tensile strength, chloride diffusion, and resistance to chloride ion penetration. The results showed that bagasse ash is an alternative admixture and pozzolan with the optimal replacement ratio of 20% cement, which reduced the chloride diffusion by more

than 50% without any adverse effects on other properties of the hardened concrete. [12]

V. Kanthe, S. Deo, M. Murmu. (2018) In this paper worked on the study of combined effect of Fly Ash (FA) and Rice Husk Ash (RHA) on properties of concrete as partial replacement of Ordinary Portland Cement (OPC). They mix was used with 10% RHA along with 10, 20 and 30% FA as partial replacement of cement and tested concrete properties like strength, workability, durability. In experimental result, The SEM and EDX result shows the porous structure of RHA particle with higher content of silica, the compressive strength of ternary blend concrete was higher than control concrete. The highest strength was observed for R10F20 concrete mix. [13]

Alireza Joshaghani, Mohammad Amin Moeini. (2017) In this paper researchers investigated the influence of Rice husk ash(RHA) and bagasse ash as replacement materials on the properties of the concrete. They replaced Portland cement by RHA and SCBA at a rate of 10–30% and 10–25% by weight of cementitious materials. Based on the former research studies to cast the mortar, replacement dosages were selected. Compressive strength testes checked to evaluated mechanical performances of the specimens. Also they have performance electrical resistivity, rapid chloride migration test (RCMT), and acid resistance of mortars tests. They found that rice husk ash was more effective to increasing the mechanical properties of concrete. In the durability tests ternary mixtures were more durable when compared to the control mixture of SCBA and RHA. [14]

3. CONCLUSIONS

• The compressive strength of mortars with the incorporation of SCBA and RHA was found to improve at ages of 28 and 90 days compared to the control mixture. Also, the compressive strength of specimens was slightly improved with an increase in SCBA and RHA content from 10 to 20%, while there was a significant decline with the replacement of 25 and 30%. RHA was found to be more effective in the case of strength. Also, incorporating both RHA and SCBA at the same time does not necessarily increase the strength.
• According to RCMT test results, both replacement materials improved the migration coefficient at the ages of 28 and 90 days. In addition, by increasing the replacement level, the migration coefficient considerably decreased. The reason is mainly due to the fact that the higher amount of SCBA delivers more SiO2 to react with Ca(OH)2.
• Compressive strength increases with the increase in the percentage of Fly ash and Rice Husk Ash up to replacement (22.5%FA and 7.5% RHA) of Cement in Concrete for different mix proportions. The maximum 28 days split tensile strength was obtained with combination of 22.5% Fly ash and 7.5% rice husk ash mix in all combinations which was less than control concrete. The maximum 28 days' flexural strength was obtained with combination of 22.5% fly ash and 7.5% rice husk ash mix. The percentage of water cement ratio is reliant on quantity of RHA used in concrete. Because RHA is a highly porous material. The workability of concrete had been found to be decrease with increase RHA in concrete.
• To maintain constant flow ability, addition of RHA alone required an increase in water–binder ratio. Combinations of RHA with LS decreased the water–binder ratio by more than 28%.
• The unit weight of the SCC decreased with increasing RHA content and increased with increasing LS content. Combinations of RHA and LS were lighter than the control and LS mixtures. Combined LS/RHA mixtures exhibited some blocking in the Vfunnel test and an increase in J-ring step height, but overall provided improved workability.
• The compressive strength decreased at higher water–binder ratios and increased RHA or LS content. Suitable levels of fine aggregate replacement by RHA and LS provide development of high compressive at early ages due to filling effects and pozzolanic reactions.
• It is possible to produce high-strength concrete with the combination of the finely ground bagasse ash. The incorporation of 30% of BA decreases the chloride penetrations and improves the strengths of concrete. The results indicate that the concretes containing up to 30% of BA exhibit the compressive strength in the range of 65.6–68.6 MPa (at 28 days), which is higher than that of the control concrete (101–105%). In conclusion, the incorporation of BA significantly improves the resistance to chloride penetration of concrete by increasing pozzolanic reaction, by enhancing the precipitation sites of hydration products and by reducing Ca(OH)2 of concrete.

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