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REDUCTION IN ENVIRONMENTAL PROBLEMS USING AGRICULTURAL SOLID WASTE IN REACTIVE POWDER CONCRETE- A REVIEW

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ABSTRACT

Concrete is the most widely used construction material and, for the most part, is produced using nonrenewable natural resources and energy intensive processes which emit greenhouse gasses. There exists an opportunity to improve the sustainability of this industry by further exploring the use of alternative materials. Reactive Powder Concrete (RPC) is a developing composite material that allows the concrete industry to optimize the material usage by generating economically benefits and helps the structure to become more strong, durable and sensitive to environment. This paper reviews various literatures related to possibility of production of Reactive Powder Concrete with various supplementary use of Rice Husk Ash and Sugarcane Bagasse Ash .Environmental hazardous can be reduced by using Rice Husk Ash(RHA) and Sugar-cane bagasse ash (SCBA), which are the agricultural solid waste ,in concrete industry as a replacement for cement.

KEYWORDS: *Reactive Powder Concrete (RPC), Rice Husk Ash(RHA),Sugarcane Bagasse Ash(SCBA).*

I. INTRODUCTION

Reactive Powder Concrete (RPC) is a developing composite material,a new type of Ultra High Strength Concrete. This will allow the concrete industry to optimize material use, generate economic benefits, and build structures that are strong, durable, and sensitive to environment.RPC is composed of very fine powders (cement, sand, quartz powder and silica fume), steel fibres (optional) and super plasticizer. The particle sizes of fine powders used in RPC is in the range of 0.02–600 lm. The super plasticizer, used at its optimal dosage, decreases the water to cement ratio (w/c) while improving the workability of the concrete. A very dense matrix is achieved by optimizing the granular packing of the dry fine powders. This compactness gives RPC ultra-high strength and durability[6]. Reactive Powder Concretes have compressive strengths ranging from 200 MPa to 800 MPa.Instead of using Silica Fume,in this project,High silica containing Rice Husk Ash is going to be utilized.RHA is an agro-waste material which is obtained by by burning of rice husk and produces reactive amorphous silica which contains approximately 90% silica. The pozzolanic nature of RHA due to high silica content makes it a valuable supplementary cementitious material (SCM) for utilization in cement-based materials. Today researches all over the world are focusing on ways of utilizing either industrial or agricultural wastes as a source of raw materials for the construction industry .Rice husk ash (RHA) and silica fume (SF) have a similar chemical composition and a very high specific surface area, but RHA is not an ultra-fine material like SF. The high specific surface area of RHA originates from its internal porosity. For this reason RHA is expected to behave differently from SF in terms of the hydration and the resulting microstructure of concrete.

Another waste material using in this reactive powder concrete is Sugar Cane Bagasse Ash.Bagasse is an abundant waste produced in sugar factories after extraction of juice from Sugarcane. The huge supply of bagasse needs meaningful disposal.Burning of bagasse as fuel leaves bulk quantity of ash called sugar cane bagasse ash or SCBA and sugar cane bagasse ash is recently accepted as a pozzolanic material .Since, there is a continuous increase in the production of sugar worldwide and approximately 1500 Million tons of sugar cane are annually produced all over the world, which leaves about 40-45% bagasse after juice extraction.

Studies have shown that waste materials is successfully used in all kinds of existing and future concrete structures, by replacing cement sometimes up to 70%. They provide environmentally safe, stable, and more durable and low cost construction materials. Solid waste can be managed by utilizing such agricultural waste materials or byproducts which is a solution for some serious environmental issue.

II. LITERATURE REVIEW

Parameshwar N. Hiremath and Subhash C. Yaragal did their project on the topic of “Effect of different curing regimes and durations on early strength development of reactive powder concrete”.The early strength development of Reactive Powder Concrete (RPC) has been investigated under different curing regimes and compared with standard water curing condition. Four different curing regimes ,ambient air curing, hot air curing, hot water bath curing and accelerated curing, have been considered. Among the four different curing regimes, hot water bath curing gives higher strength that is 112 MPa for 12 h duration. Under combined curing conditions, the early strength development was possible within 36 h which is greater than the 28 days compressive strength of water curing.The combined curing regime has considerably enhanced the compressive strength of RPC by about 63% as is evident by the rise in compressive strength from 110 MPa (standard curing) to 180 MPa (combined curing). The strength increases to 155 MPa with increase in temperature under 200 ^{0}C hot air curing condition for 7 days.

Masdar Helmi , Matthew R. Hall , Lee A. Stevens and Sean P. Rigby have studied the “Effects of high-pressure/temperature curing on reactive powder concrete microstructure formation”.This paper presents static pressure of 8 MPa and heat curing at 240 ^{0}C for 48 h on microstructure formation. Heat treatment accelerated the propagation of microcracks due to thermal expansion of the solid phases, volumetric expansion of the air and increased pressure within entrapped voids. Heat curing preceded by pressure treatment resulted in the highest compressive strength at 7-days, but decreased by 16% at 28-days. Heat curing increased the density by up to 5% , pressure treatment increased density by up to 7%, and pressure followed by heat treatment increased density by 12% . Heat curing treatment increased the mean compressive strength by 32% for without pressure and by 41% for with pressure at 7-day. However, at 28-day the compressive strength of both decreased by 5% for without pressure and 16% for with pressure. Heat curing has a very significant effect on 7-day compressive strength and, which is most likely related to acceleration of the pozzolanic reaction.

Davood Mostofinejad, Mojtaba Rostami Nikoo and Seyed Arman Hosseini did their project on the topic “Determination of optimized mix design and curing conditions of reactive powder concrete (RPC)”.This study investigates the compressive strength of non-steel microfiber reinforced RPC by utilizing different mix designs under various curing conditions to determine the optimal practical conditions and parameters that would lead to maximum RPC compressive strength.In this study ,the procedure considerably enhanced the compressive strength of the specimens about 174% as evidenced by the rise in from 85 MPa (28 days) to 233 MPa (13 days).From the different cure treatment plans applied ,the combined cure treatment, including 3 days of autoclave cure treatment at 125 ^{0}C followed by 7 days of heat cure treatment at 220 ^{0}C represented more effective performance due to resulted superior mechanical properties at a minimum curing time. In this RPC, mix is designed with a cement quantity of 1100 kg/m3, a water/cement (w/c) ratio of 0.16, a water/cementitious binder (w/ct) ratio of 0.14, a silicafume/cement (sf/c) ratio of 0.3, and a superplasticizer/cement(sp/c) ratio of 0.03 to get optimum values for the parameters involved.

Huseyin Yigiter , Serdar Aydin , Halit Yazici and Mert Yucel Yardimci have done their project on "Mechanical performance of low cement reactive powder concrete (LCRPC)".Possibility of producing a Reactive Powder Concrete replaced with class –C fly ash upto 60%.RPC is a Ultra High Strength cement based material having 200-800 MPa compressive strength.Compressive strength value greater than 200 MPa was accomplished with LCRPC with cement content as low as 376 kg/m^3 . Satisfactory mechanical strength were obtained even in standard water curing and performance of RPC composite can be reached ultimate values even in 2 days after heat treatment.

Tao Ji , Cai-Yi Chen and Yi-Zhou Zhuang have studies about "Evaluation method for cracking resistant behavior of reactive powder concrete" .In this paper steel fiber content has the most significant effect on the cracking resistant behavior of RPC. Cracking resistant behavior of RPC can be evaluated from the Cracking ages and cracking coefficients. The earlier crack age means the poorer cracking resistant behavior of RPC, and the higher cracking coefficient denotes the poorer cracking resistant behavior of RPC.Cracking resistance behaviour of RPC is improved with increase in steal fibre content. The cracking resistant behavior of RPC reaches the optimum when steel fiber content is 3% by volume of RPC and it declines slightly when the steel fiber content reaches 4% from 3% by volume of RPC.

Wei Zhou , Haibo Hu and Wenzhong Zheng did their study on"Bearing capacity of reactive powder concrete reinforced by steel fibers". Steel fiber-reinforced reactive powder concrete improves the behavior of steel fiber post-tensioned anchorage zones by enhancing the tensile strength of fiber.The pressure testing results indicate that cracking loads are close to failure loads.Although expansion occurred in the middle of the blocks at failure, integrity was maintained for all of specimens. A comparison of the SFR-RPC samples, with and without ducts, shows a weakening effect indicating there was a change in the cracking load and a decrease of bearing capacity for SFR-RPC without a duct. Prior to failure cracking of specimens occurs at two or more loading level, the initial visible cracks in the mid zone are wider than those in the end zones. A wedge zone forms ahead of the bearing plate in specimens with non-fibrous RPC. A similar wedge develops in the SFR-RPC specimens, but it is not evident because the steel fibers alone guarantee integrity and thereby prevent splitting. As the duct on the wedge weakens which results in delaying the cracking of specimens and the bearing capacity decreases. The specimen stiffness during wedge formation is constant prior to cracking, it decreases with the increase of duct diameter.

Ahmed Al-Tikrite and Muhammad N.S. Hadi have studied about "Mechanical properties of reactive powder concrete containing industrial and waste steel fibres at different ratios under compression".This paper investigated the influence of type, (industrial micro steel fibre (MF), industrial deformed steel fibre (DF) and waste steel fibre recovered from discarded tyres (WF)), content and geometry of steel fibre on the mechanical properties of reactive powder concrete (RPC) in terms of compressive strength, tensile strength, modulus of elasticity and stress-strain behaviour under compression. Steel fibres were added to RPC at 1%, 2%,3% and 4% of the total volume.Iindustrial hybridization fibre (HF) and waste-industrial hybridization fibre (WHF) are the two forms of steel fibres' hybridizations . Test demonstrated that the flowability of RPC significantly affected due to the addition of DF and WF ,and the highest increase in the compressive strength, tensile strength, modulus of elasticity, peak stress and the corresponding strain achieved when 4% MF added and toughness of RPC increased by 249.8 %.The inclusion of HF increased the RPC toughness by 245%. The toughness was increased with the increase in the volume content of steel fibres in the RPC. WF is considered as a promising material in the structural applications and can fully or partially replace industrial steel fibres in RPC.

K. Ganesan , K. Rajagopal and K. Thangavel have studied about "Evaluation of bagasse ash as supplementary cementitious material".This study reported that the effects of Bagasse ash content as a partial replacement of cement on physical and mechanical properties of hardened concrete. In the test results we can see that Bagasse Ash is an effective mineral admixture, with 20% as optimal replacement ratio of cement. It can be seen that the particles of BA are nearly four times finer than those of OPC and the finer particles of BA are more uniform in their distribution which contains silica mostly in amorphous form . Bagasse ash replaced with 25% and 30% resulted that the strength decreases to a lesser value when compared to that of control specimens. Optimum replacement ratio of Ordinary Portland Cement is up to 20%.OPC with well-burnt bagasse ash have any adverse effect on the desirable properties of concrete. Development of high early strength,A reduction in water permeability and appreciable resistance to chloride permeation and diffusion are the specific advantages of such replacement .

V. S. Aigbodion, S. B. Hassan, T. Ause and G.B. Nyior published a paper on the topic "Potential Utilization of Solid Waste (Bagasse Ash)".In this paper, in order to evaluate the possibility of their use in the industry, Bagasse Ash has been chemically and physically characterized. Different studies carried out on Bagasse Ash are X-ray diffractometry determination of composition and presence of crystalline material, scanning electron microscopy/EDAX examination of morphology of particles, as well as physical properties and refractoriness . In XRD analysis of the ash, it reveals that Quartz:(SiO2), Cliftonite:(C), Moissanite:(SiC) and Titanium Oxide:(Ti6O) as the primary compounds. The presence of prismatic, spherical and fibrous structure are revealed by SEM/EDAX analysis, which also have similar compound with the XRD analysis. The Bagasse ash with a density of 1.95g/cm^3 is able to withstand a temperature of up to 1600^{o}C. This study indicates that the presence of oxides and carbon in the ash will make it suitable for refectory and ceramic products such as insulation, membrane filters and structural ceramics. Ash with fine particle size characteristics, implies that this bagasse ash can be used as facing sand moulding during casting operations.

Ravande Kishore, V.Bhikshma and P.Jeevana Prakash have done a project on "Study on Strength Characteristics of High Strength Rice Husk Ash Concrete".This study investigates the mechanical properties of high strength concrete with different replacement levels of ordinary Portland cement by using Rice Husk Ash. The strength effect of High-strength concrete of various amounts of replacement of cement viz., 0%, 5%, 10%, 15% with Rice Husk Ash of both the grades were compared with that of the high-strength concrete without Rice Husk Ash at curing period of 7, 28 and 56 days have been obtained. Rice husk ash at 28 days has shown quite encouraging and interesting results. As the replacement of cement by RHA in concrete increases, the workability of concrete decreases by 27% slump and 9% compaction factor. Replacement of cement with Rice Husk Ash leads to decrease in the compressive strength improved the workability. In this study, the optimum replacement of rice husk ash is found to be 10% in both the grades of the concrete. The rate of increase with age of concrete was good for the replacement levels and was on par with the conventional cases at early ages. The optimum replacement level of Rice Husk Ash is found to be to10% for both M40 and M50 grades of concrete.

Guilherme Chagas Cordeiro , Romildo Dias Toledo Filho , Luís Marcelo Tavares and Eduardo de Moraes Rego Fairbairn studied about "Ultrafine Grinding of Sugar Cane Bagasse Ash for application as Pozzolanic Admixture in Concrete".Here in this paper the role of mill type and grinding circuit configuration is investigated which is grinding in laboratory. Different size distributions were produced by the different mills and milling configurations. Pozzolanic activity of the ground ash was directly correlated to its fineness which is characterized by its 80% passing size or Blaine specific surface area. Estimated electric power consumptions required to render SCBA a pozzolanic material were to be in the order of 42 kWh/t in an industrial ball mill operating dry and in closed circuit with a classifier. There is no measurable change in mechanical behavior in a high-performance concrete in partial replacement of Portland cement (10, 15 and 20% by mass), but improved rheology and resistance to penetration of chloride ions. It is estimated that about 250 kWh/t of specific grinding energy would be required in the same mill to reach the fineness of SCBA to make it capable of replacing Portland cement as it is, with no loss in compressive strength. The application of an ultra finely ground SCBA produced by vibratory grinding allowed the production of high-performance concrete with the same mechanical response up to a 20% replacement as the concrete prepared solely using Portland cement which is also resulted in the improvements in rheology of concrete in fresh state and resistance to chloride-ions penetration.

Sagar W. Dhengare, Dr.S.P.Raut, N.V.Bandwal and Anand Khangan had a study on "Investigation into Utilization of Sugarcane Bagasse Ash as Supplementary Cementitious Material in Concrete".Investigations were based on the utilization of agricultural waste like sugar cane bagass ash in high strength concrete which are replaced with 0%, 10%,15%, 20%,25% and 30% of BA respectively.To get fine powder of bagasse ash ,it was sieved through No. 600 sieve. The mix design used for making the concrete specimens was based on previous research work from literature. The water –cement ratios varied from 0.44 to 0.63. At 7, 28, 56 and 90 days tests were performed in order to evaluate the effects of the addition SCBA on the concrete. Final test result indicate that the strength of concrete increase when 15% SCBA replaced with cement , higher compressive strength than that control concrete. The maximum flexural strength obtained is at 15% SCBA replacement in both M25 and M35grade of concrete for 28 days curing and the maximum split tensile strength obtained is at 10% SCBA replacement in M25 and in case of M35 it is at 10% SCBA replacement for 28 days curing. Use of super plasticizer is not essential as the partial replacement of cement by SCBA increases workability of fresh concrete.

Asma Abd Elhameed Hussein, Nasir Shafiq, Muhd Fadhil Nuruddin and Fareed Ahmed Memon have studied “Compressive Strength and Microstructure of Sugar Cane Bagasse Ash Concrete”.The study is regarding the effectiveness of replacement of sugar cane bagasse ash along with cement. It bagasse ash was replaced ordinary Portland cement with 0, 5, 10, 15, 20, 25 and 30%, respectively. Ash on workability, compressive strength and microstructure of Interfacial Transition Zone (ITZ) of concrete was examined. The results showed that inclusion of Sugar cane Bagasse Ash in concrete up to 20% level significantly enhanced the compressive strength of concrete at all ages; the highest compressive strength was obtained at 5% SCBA replacement level. It was observed that at 15% bagasse ash replacement level, the interfacial transition zone was homogeneous and there was no gap between the coarse aggregate and the paste matrix. Optimum replacement is considered as level up to 20% SCBA in concrete. In the new cement mix of 25% and 30% SCBA improved the compressive strength after 28 days.

M.Jamil , A.B.M.A Kaish , S.N.Raman and M.F.M.Zain have done their project on “Pozzolanic Contribution in Rice Husk Ash in cementious system”.Rice husk is an established supplementary cementitious material which contribute filler and pozzolanic effect.This study was carried out to find the maximum pozzolanic or chemical contribution of RHA in cementitious system in terms of replacement percentage.Due to high silica content ,RHA is considered as a highly reactive pozzolanic material when it is burnt under controlled conditions.The replacement percentage is determined as 14.3% for ASTM type-1 cement with 55% of C_3S and 19% of C_2S. This percentage could vary with the change of RHA composition or type of cement used. Results may also vary depending upon the percentage of C_3S and C_2S present in cement.

Josephin Alex , J.Dhanalakshmi and B.Ambedkar studies were carried out on the topic of “Experimental Investigation on Rice Husk Ash as cement replacement on concrete production”. CO_2 emission has increased due to cement manufacturing and improper disposal of rice husk ash leads to land fill and airpollution problems. In this paper they studied that Mechanical strength increased with decrease in RHA size and 20 wt% replacement is optimum for 15 and 60 min grounded samples.As the grinding time increases size of RHA particles decreases.Grinding time does not have any significant impact on the loss on ignition of the RHA sample.Pozzolanic activity can be improved by grinding .Finer RHA fractions exhibit better chapelle activity.

Ki-Bong Park , Seung-Jun Kwon and Xiao-Yong Wang have completed a project on the topic of “Analysis of Effects of Rice Husk Ash on Hydration of cementitious materials”. Rice Husk Ash (RHA), a highly reactive pozzolanic material,is widely used as a mineral admixture to produce high-performance concrete. They find that compared to the plain Portland cement paste, the hydration degree of the cement in the cement–RHA blends is improved due to the dilution effect. The calcium hydroxide contents in the cement–RHA blends decrease with the increase in the RHA replacement ratio. The proposed hydration model is verified by using experimental data on the RHA blended concrete with different water-to-binder ratios and different RHA substitution ratios. Influence of factors such as water to binder ratio, the RHA replacement ratio, the absorbed water in RHA internal pores, the fineness of RHA and amorphous SiO_2. RHA particles may absorb a certain amount of free water into their pores during the mixing and the degree of hydration of the cement in the UHPC is lower than that the degree of hydration of the cement in control Portland cement paste.

Jayaminkumar A. Patel and Dr.D.B .Raijiniwala did their project on “Experimental study on use of Sugar-cane Bagasse Ash in concrete by partially replacement with cement” .Sugarcane Bagasse ash generated in sugar mills creating environmetal issues as landfill.In this paper they compared normal M25 grade concrete with M25 garde of concrete replaced by 5% wt of SCBA in order to check the feasibility of sugar cane bagasse ash in concrete..Strength of concrete increased with the use of sugarcane bagasse ash with reduction in the consumption of cement. In this work sugar cane bagasse ash is taken from one of the sugar mill of south Gujarat (INDIA).

Prashant O Modani and M.R Vyawahare have studied about “Utilization of Bagasse Ash as a Partial Replacement of Fine Aggregate in Concrete”.Today the studies on wastes utilization would not only be economical, but may also help to create a sustainable and pollution free environment. Bagasse ash mainly contains aluminum ion and silica. In this paper, untreated bagasse ash has been partially replaced in the ratio of 0%, 10%, 20%, 30% and 40% by volume of fine aggregate in concrete. The result of fresh concrete tests like compaction factor test and slump cone test were undertaken along with hardened concrete tests like compressive strength, split tensile strength and sorptivity shows that bagasse ash can be a suitable replacement to fine aggregate. In its purest form the bagasse ash can prove to be a potential ingredient of concrete since it can be an effective replacement to cement and fine aggregate.

Hayder Hasan , Liet Dang, Hadi Khabbaz, Behzad Fatahi and Sergei Terzaghi have studied about " Remediation of Expansive Soils Using Agricultural Waste Bagasse Ash".The aim of this research is to utilize the sugarcane bagasse ash as a pozzolanic material to reduce the lime content for curtailing soil movement and improve the compressive strength of compacted expansive soil, while avoiding the adverse health and environmental problems that can be induced due to the disposal of this material. The outcomes of these tests clearly demonstrate that stabilisation of expansive soils using bagasse ash and hydrated lime not only improves the strength, but also facilitates to cope with environmental concerns through reduction of sugar industry waste material.

R.Srinivasan and K.Sathya studied "Experimental Study on Bagasse Ash in concrete". SCBA is a fibrous waste product of sugar refining industry , along with ethanol vapour. Bagasse ash mainly contain aluminium ion and silica.BA is partially replacing in a ratio 5%,10%,&15% by weight of cement. In their final results, SCBA in blended concrete had significantly higher compressive strength, tensile strength and flexural strength comparing to ordinary concrete. Cement could be advantageously replaced with SCBA max up to 10%.Density of concrete decreases with increase in SCBA, that it became light weight concrete.

III. CONCLUSION

A few studies have been carried out on the ashes obtained directly from the industries to study pozzolanic activity and their suitability as binders, partially replacing cement. Therefore it might possible to use sugarcane bagasse ash (SCBA) as cement replacement material to improve quality and reduce the cost of construction materials such as mortar, concrete pavers, concrete roof tiles and soil cement interlocking block etc. Due to the usage of sugarcane bagasse ash lime content can be reduced which means that we can use less amount of cement in the concrete mix. In its purest form the bagasse ash can prove to be a potential ingredient of concrete since it can be an effective replacement to cement and fine aggregate max up to 10%.

This RHA in turn contains around 85–90% silica which is mostly in amorphous state, but depends on the burning temperature and time. RHA particles may absorb a certain amount of free water into their pores during the mixing and the degree of hydration of the cement in the UHPC is lower than that the degree of hydration of the cement in control Portland cement paste. Hence we can use such rice husk ash for the production of ultra high strength concrete and make the world pollution free as well.

Based on these reviews partial inclusion of waste instead of 100% cement has been found to be environmentally safe, stable, durable as well as economical.

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