Effects of Partial Replacement of Portland Cement and Fine Aggregate with Bagasse Ash, Rice Husk Ash and Waste Foundry Sand on Mechanical Properties of Concrete- A Review

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Abstract - *The aim of this review paper is to investigate the improvement of mechanical properties of concrete by optimal replacement of cement and fine aggregate with ratio of bagasse ash (BA), Rice husk ash (RHA) and waste foundry sand (WFS) in terms of weight, which Portland cement is partially replaced by bagasse ash with Rice husk ash composition and Fine aggregate is partially replaced by waste foundry sand. Some chemical tests are required to show how they react about each other and to check the pozzolanic properties of Materials. Nowadays for emission reduction and high performance concrete production, the scientists are working on pozzolanic properties of materials. In the other case, waste Utilization would be economic and has noteworthy Result in source of global carbon dioxide (CO_2) emission, and environmental pollution control. This study finds the influences on behavior of concrete with the partial replacement of cement and fine aggregate at different proportions on the mechanical properties of concrete (compressive strength, flexural strength and tensile strength).*

Key Words: Sugarcane Bagasse Ash (SCBA), Rice husk ash (RHA), Waste foundry Sand (WFS), Mechanical Properties.

1. INTRODUCTION

Recently the waste materials are increasing everywhere from different things and they need to be recycled and use for different aspects. In concrete technology, the materials which are used in it, made from natural resources. Cement, fine aggregate and coarse aggregate are the most important parts of concrete. One highlighted cement usage is to paste and stick the parts of concrete to each other in the existence of water. When cement and water mixes to each other a reaction happens which causes to be sticky between sand, coarse aggregate and make a complete solid. Nowadays, for Co2 emission reduction the researchers and scientists decided to work on cost reduction and waste reduction of materials. In this case, they have investigated that from natural ash wastes can use in concrete as partial replacement of cement for example, sugarcane bagasse ash, rice husk ash or waste foundry sand as partial replacement of fine aggregate. Performance of these materials in concrete is directly related to their material characteristics (A. Bahurudeen 2015). Ordinary Portland cement (OPC) consists of calcium oxide, silica, and iron oxide in suitable amounts. In cement production, the chemistry of the WFS as a source of silica is more important than its grain size and shape. WFS is one of the highest-quality silica sources for the cement industry. Experiments were conducted by replacing 20% of aggregates in concrete mixtures with the WFS and increases of up to 10% were achieved in water absorption and capillary absorption values. +is increase reduced compressive strength (CS) by a certain amount. (Neslihan Dog˘an-Sag˘lamtimur 2018 [26])

The combustion of sugarcane bagasse is one of the most common practices, resulting in the production of an additional residue, the sugarcane bagasse ash (SCBA). Chemical and mineralogical composition of SCBA makes it a potential supplementary material in Portland cement blends and also in geo-polymeric binders. Fineness, crystallinity, and the presence of unburned particles are crucial for the development of pozzolanic reactivity and for having good mechanical performance. Durability of SCBA-based mortar and concrete is appropriate, and in many cases 20% replacement of cement can be carried out without significant performance loss. Also, SCBA and sugarcane straw ash are good candidates for preparing geo-polymeric binary systems. SCBA is an agro-industrial waste material composed mainly of silicon dioxide, which has been extensively used in Portland cement blended mortars and concretes.

Bulk density of rice husk is low and lies in the range 90–150 kg/m3. The chemical composition of RHA is significantly dependent on combustion conditions, and the burning temperature must be controlled to keep silica in an amorphous state. In order to develop pozzolanic activity, such ashes will be required to be ground to a very fine particle size which is likely to make their use financially unviable. also Substantial energy and cost savings can result when industrial by-products are used as a partial replacement for the energy intensive Portland cement. Among the different existing residues and by products, the possibility of using rice husk ash in the production of structural concrete is very important for India. Rice husk ash is hazardous to environment if not dispose properly. (Satish H. Sathawane 2013 [22])

1.1 Scope of Paper

The investigation of using partial replacement of cement with the combination of RHA and SCBA and fine aggregate with WFS. Furthermore, to find optimum proportion for each material in case of having a good efficiency on cost, mechanical properties of concrete (compressive strength, tensile strength, flexural strength, permeability and workability). Using of them benefits in reducing the environment pollution and emission reduction during the disposal of excess these materials. Ordinary Portland Cement is costly material, so the partial replacements of these materials reduces the cost of concrete. Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar:

1.2 Literature Review

A. Bahurudeen, Deepak Kanraj, V. Gokul Dev and Manu Santhanam. (2015) Indicated that Sugarcane bagasse ash is mainly composed of amorphous silica and can be used as a Pozzolanic material in concrete. The utilization of bagasse ash as a supplementary cementing material through systematic processing and characterization offers a profitable and environment-friendly alternative to its disposal. Concrete with bagasse ash replacement showed equal or marginally better strength performance compared to control concrete, even at 3 days. The results clearly indicate that concrete of the same grade can be produced with up to 25% replacement of cement by SCBA. Heat of hydration of concrete containing SCBA based cements with 10% and 20% replacement was studied using adiabatic calorimetry. The total heat as well as the peak heat rate of bagasse ash blended concrete was found to be lesser than the control mix. Resistance of concrete against chloride and gas penetration significantly increased with increase in bagasse ash replacement. Drying shrinkage behaviour of SCBA replaced concretes was similar to that of OPC concrete. Sugarcane bagasse ash can be used as cement replacement in blends up to 25% to produce good quality concrete. [1]

Aukkadet Rerkpiboon, Weerachart Tangchirapat, Chai Jaturapitakkul. (2015) found that the highest compressive strength of Bagasse ash concrete was obtained when the replacement of Ordinary Portland Cement by Ground Bagasse ash was 20% by weight of binder. This compressive strength means that BA20 concrete could be considered to be high strength concrete at the ages of 90 days, because the strength of the Bagasse ash concrete was more than 55 MPa. The use of Ground Bagasse ash to replace Ordinary Portland Cement at up to 50% by weight of binder in concrete did not have any effect on the modulus of elasticity of the concrete. The modulus of elasticity of GBA concrete depends on its compressive strength and is similar to that of conventional concrete. Concrete with 50% of GBA produced at least 90% compressive strength as compared to control concrete (CT concrete) at the age of 28 days. [2]

Vasudha D. Katare, Mangesh V. Madurwar. (2017) Argued that, Reasonably, 25% replacement level of cement by sugarcane biomass ash in producing sustainable blended concrete is considered as an optimum replacement. It gives satisfactory results of physio mechanical, durability, and strength properties of blended concrete. The application of SCBA waste in the construction industry could be the best solution to the solid waste management. Its use does not contribute to any CO2 emissions. The controlling parameters responsible for the pozzolanic properties of sugarcane biomass ash are namely, crop species and its growing conditions, including regions, combustion temperature and its duration, cooling duration, ash collection methods, and grinding conditions. It is clear that the particle size distribution of the SCBA is normally finer compared to the (OPC) Ordinary Portland Cement, Because of the highly rough and porous nature of the SCBA, its specific surface area is higher than that of OPC. Depending upon the industrial operations and combustion conditions the chemical properties/composition of SCBA varies. Mostly, a higher proportion of silica and lime compounds were observed in its composition. Incorporation of SCBA for the partial replacement of cement has adverse effects on the slump of blended concrete. Water absorption of the blended concrete increased with an increase in SCBA content. The strength of SCBA blended concrete at the early age curing (i.e. 28 days) have marginal decrease with the increase in SCBA content, but at the later age, an increase in strength was observed due to pozzolanic activity. [3]

A. Rajasekar, K. Arunachalam, M. Kottaisamy, V. Saraswathy. (2018) Resulted that Incorporation of Treated Bagasse Ash improves the workability, compressive strength, resistance to chloride ion penetration and decreases the rate of water absorption. Concrete mix with 15% cement replacement exhibited a superior performance. Heat curing seems to be more efficient in improving the properties of concrete compared to normal curing and steam curing. It is possible to use treated bagasse ash in the production of Ultra High Strength Concrete with superior performance due to the pozzolanic action of treated bagasse ash. [4]

Juliana Petermann Moretti a, Sandra Nunes, Almir Sales. (2018) Achieved that, replacing cement by up to 30% SCBA, in terms of weight, had no significant effect on mortar fresh state properties or mortar resistivity at 28 d. SBA respect to cement was found to be significant only for the compressive strength at 28 d, and yet its effect was relatively small. The variable w/c had the most significant effect on almost all the mortar response variables. No significant increase in mortar compressive strength (7–17%) or mortar resistivity (15–28%) was observed from 28 to 91 d, which can be attributed to the low pozzolanic activity of SCBA. Concrete test results revealed that SCBA can successfully be used as a filler material in Self Compacting concrete that exhibits good self-compacting ability and strength levels, as well as, durability indicators result adequate for many current civil engineering applications. [5]

P. Jagadesh, A. Ramachandramurthy, R. Murugesan. (2018) discussed that, the mean of theoretical Ordinary SCBA blended concrete density is 2409 kg/m3 and that of Processed SCBA blended concrete density is 2422 kg/m3, indicates that the pore volume of P-SCBA blended concrete is filled by finer processed SCBA. The enhanced strength is about 28% compared to control for 10% partial replacement cement by P-SCBA. Up to 20% partial replacement of OPC by P-SCBA, strength enhancement is observed compared to control. Relationship between Modulus of Rapture (MOR) and Modulus of Elasticity (MOE) of SCBA blended concrete is derived with and without the density of concrete and cylinder compressive strength with appropriate constants, and partial replacement of Portland cement by sugarcane bagasse ash is up to 30%. [6]

Seyed Alireza Zareei, Farshad Ameri, Nasrollah Bahrami. (2018) Explained that, partial replacement of cement with SCBA improved the performance of lightweight concrete more than the other concrete types. The 5% SCBA content improved the strength properties of ordinary and lightweight concretes. Incorporation of 5% BA as a partial replacement of cement in lightweight and self-compacting concretes led to an increase in the impact resistance by 50%. Water demand increases with an increase in SCBA content due to carbon content and also irregular and porous material of SCBA. Inability of SCBA to fill the pores of concrete was the reason of increased amount of water absorption. It was found that incorporation of SCBA up to 5% improved the performance of concrete in terms of durability and impact resistance. Increase in water absorption in OCBA concrete is possibly due to the low ability of bagasse ash aggregates to fill the pores. [7]

Sumrerng Rukzon, Prinya Chindaprasirt. (2012) have gotten that, the incorporation of 30% of BA decreases the chloride penetrations and improves the strengths of concrete. Reasonably, the substitution of 30% BA is acceptable for producing high-strength concrete. 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]

Gemma Rodrı´guez de Sensale. (2006) Reported that, The Rice husk ash (RAH) concrete had higher compressive strength at 91 days in comparison with that of the concrete without RHA. The increase in compressive strength of concretes with residual RHA is better justified by the filler effect (physical) than by the pozzolanic effect (chemical/physical). The increase in compressive strength of concretes with RHA produced by controlled incineration is mainly due to the pozzolanic effect. It is concluded that residual RHA provides a positive effect on the compressive strength of concretes at early ages, but in the long term, the behaviour of the concretes with RHA produced by controlled incineration was more significant. [9]

K. Ganesan,*, K. Rajagopal, K. Thangavel. (2008) Confirmed that, as high as 30% by weight of OPC can be replaced with reburnt rice husk ash without any adverse effect on strength and permeability properties. A linear relationship is found to exist among three measured transport properties, namely sorptivity, chloride penetration in term of total charge passed in coulombs and chloride diffusion coefficient. In the case of compressive strength and chloride permeation properties, standard practice of curing for 28 days is found to be adequate. Prolonged curing up to 90 days is found to be beneficial only from the point of view of improving the resistance to water absorption. [10]

Alireza Naji Givi*, Suraya Abdul Rashid, Farah Nora A. Aziz, Mohamad Amran Mohd Salleh. (2010) wrote that, RHA-blended concrete with average particle size of 95 micro meter has shown a reduction in water permeability only after 90 days' moisture curing. Partial replacement of cement by RHA improved workability of fresh concrete for both used average particle sizes. However, the RHA with average particle size of 95 micro meter gave rise to higher slump values for comparable cases. Replacement of cement up to maximum of 15% and 20% respectively by 95 and 5 lm rice husk ash, produces concrete with improved strength. s. Also the percentage, velocity and coefficient of water absorption significantly decreased with 10% cement replacement by ultra-fine rice husk ash. Moreover, the workability of fresh concrete was remarkably improved by increasing the content of rice husk ash especially in the case of coarser size. In addition, decreasing rice husk ash average particle size provides a positive effect on the compressive strength and water permeability of hardened concrete but indicates adverse effect on the workability of fresh concrete. [11]

Hwang Chao-Lung, Bui Le Anh-Tuan, Chen Chun-Tsun (2011) Explained that, the compressive strength of concretes with up to 20% ground RHA added attain values equivalent to that control concrete after 28 days. After 91 days of curing, the electrical resistance of all RHA concrete becomes higher than 20 kΩ-cm. The strength efficiency of cement in ground RHA concrete is much higher than that of the control concrete. it is possible to obtain RHA concrete with comparable or better properties than those of the control specimen (without RHA) with a lower consumption of cement, thus reducing the CO_2 emissions during the production of cement. [12]

Rawaid Khan, Abdul Jabbar, Irshad Ahmad, Wajid Khan. (2012) Directed that, Concrete mixture containing 25% RHA as a replacement of OPC produced the same strength as the concrete containing 100% OPC. Therefore, this concrete could be used to reduce environmental problems associated with OPC production and RHA dumping. Higher proportions (40%) of RHA could be used for non-structural works where strength is not critical. The RHAC mortar containing RHA has more resistance to chemical attacks than OPC concrete without RHA. [13]

Gustavo J.L. Coppio, Maryangela Geimba de Lima, Julia W. Lencioni. (2019) Specified that, The steel industry generates large amounts of waste foundry sand (WFS) in landfills. Compressive strength tends to decrease with the use of waste foundry sand as a fine aggregate. The compressive strength of concrete with the use of waste foundry sand tends to be smaller the greater the content of the fine materials and residues contained therein. According to the composition and content of residues and fine materials of the waste foundry sand used as a small aggregate, the surface electrical resistivity of the concrete may be larger, smaller, or even equal to that of concrete molded with natural sand. [14]

Gurpreet Singh, Rafat Siddique. (2012) did research on an experimental work which Natural sand was replaced with five percentages (0%, 5%, 10%, 15%, and 20%) of WFS by weight. Partial replacement of sand with WFS (up to 15%) increases the strength properties (compressive strength, splitting tensile strength and modulus of elasticity) of concrete. Maximum increase in compressive strength, splitting tensile strength and modulus of elasticity of concrete was observed with 15% WFS, both at 28 and 91 days. Inclusion of WFS increases the Ultrasonic pulse velocity (USPV) values and decreased the chloride ion penetration in concrete, which indicates that concrete has become denser and impermeable. WFS can be suitably used in making structural grade concrete. [15]

Anthony Torres, Laura Bartlett, Cole Pilgrim. (2017) Designated that, Compressive strength, splitting tensile strength, flexural strength, and modulus of elasticity were not impacted by either the replacement of natural coarse aggregate with that of coarse foundry waste or the replacement of natural fine aggregate with that of fine foundry waste up to the 30% replacement investigated. Using both coarse and fine foundry waste together in one PCC mixture decreases the compressive strength, splitting tensile strength, flexural strength, and modulus of elasticity above a 20% natural aggregate replacement. general foundry waste can be used to partially replace virgin aggregates in PCC, which can save natural resources and increases the amount of foundry waste recycled annually. Both virgin coarse and fine aggregate were replaced by mass at 10%, 20%, and 30%. Two mixture groups replaced individual constituents separately (coarse and fine), and one mixture group replaced both coarse and fine in the same mixture. [16]

Gritsada Sua-iam , Natt Makul, Shanshan Cheng, Prakasit Sokrai. (2019) originated that, to achieve the targeted flow slump of SCC (70.0 ± 2.5 cm), the FDW replacement of up to 50%wt increases the superplasticizer requirement more than the control SCC and SCC mixed with RHA while decreasing the fresh density compared to the control SCC. SCC containing RHA and FDW has higher compressive and splitting tensile strengths than the control SCC. It is possible to use RHA and FDW as materials in the production of economically friendly SCC. Not only can the replacement of OPC reduce CO2 emissions by decreasing the OPC but the recycling of fine aggregate as partial replacement in river sand can also develop sustainability of SCC production. [17]

Ehsan Yaghoubi, Arul Arulrajah, Mohammadjavad Yaghoubi, Suksun Horpibulsuk. (2020) showed that, the chemical composition of both WFS and Recycled glass (RG) was dominated by silica. The pH values of both materials were 9.4–9.5 deeming them suitable for usage as a construction fill material without environmental risks. The WFS had more sub-angular particles and was classified as a poorly-graded sand, while the RG particles were angular and the RG was classified as a well-graded sand. The maximum dry densities obtained for WFS and RG were almost equal, whereas the optimum moisture content of WFS was about 0.5% greater than that of RG. WFS had a lower shear strength compared to the RG, suggesting that a slighter embankment batter slope is required for WFS. The stress–strain behaviour of WFS under Consolidated drain CD direct shear test was similar to that of a loose sand with a strain hardening behaviour. by increasing the confining pressure, the stiffness of WFS increased at a higher rate compared to that of the RG. This will not only reduce the environmental consequences of using natural sands in the construction industry but also prevent the continuously growth of lands being occupied as landfills for disposal of and also WFS being stockpiled in landfills. [18]

Pendhari Ankush R, Demse Dhananjay G, Nikam Madhuri E, Karpe Balraj E. (2017) designated that, Waste foundry sand can be effectively used as fine aggregate in concrete. Replacement of fine aggregate with foundry sand gives optimum strength at 30% replacement then there was a marginal decrease in the strength. At 30% replacement of sand gives maximum strength at the age of 28 days. The flexural strength also gives the maximum result at 30% and at the age of 28 days. After which it shows decrease in the strength. Thus the foundry sand is the good replacement of fine aggregate. [19]

Alireza Joshaghani, and Mohammad Amin Moeini, (2018) in this research Portland cement was replaced by RHA and SCBA at a rate of 10–30% and 10–25% by weight of cementitious materials, respectively. 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. 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. Electrical resistivity test results of mortars showed that electrical resistance values increased with the incorporation of SCBA and RHA. Almost all the specimens had the same weight loss until 56 days exposed to acid. However, the results obtained at 180 days showed that the control sample had the highest weight loss, which was more than 49%. Incorporating SCBA and RHA was found to be effective in the case of strength loss, since the greatest loss in compressive strength among all the mixture designs was found to be for the control sample. [20]

Muhammad Hamza Hasnain, Usman Javed, Ather Ali, Muhammad Saeed Zafar. (2020) described that The flow of SCC reduced when ashes were replaced from 0 to 30% of sand, thus the demand for water and superplasticizer content increased. However, the replacement of the blended ashes enhances the viscosity of the mixes. The hardened density of the mixes reduced at replacement level, whereas the compressive strength increased at higher curing ages due to the chemical reactivity of the ashes. the 20% replacement of RHA and BA classified it as lightweight structural concrete with the compressive strength and density values of 20 MPa and 1816 Kg/m3 , complying with ACI 213R-Guidelines for structural lightweight concrete. Therefore, it can be used in several structural configurations to reduce the dead load of the structural members. [21]

Satish H. Sathawanea, Vikrant S. Vairagadeb and Kavita S Kene. (2013) stated that Fly ash and Rice husk ash are found to be superior to other supplementary materials like slag, and silica fume. Due to low specific gravity of RHA which leads to reduction in mass per unit volume, thus adding it reduces the dead load on the structure. Used of Fly ash and Rice husk ash helps in reducing the environment pollution during the disposal of excess Fly ash and Rice husk ash. Cement is costly material, so the partial replacements of these materials by Rice husk ash reduces the cost of concrete. 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. [22]

Rupali Subhasmita Padhi, Rakesh Kumar Patra, Bibhuti Bhusan Mukharjee, Tanish Dey. (2018) researched that The use of RHA as replacement of cement in both natural and recycled aggregate concrete reduced workability of the mix. This reduction in workability increased with increasing RHA percentages and it was more pronounced in case of RCA which could be attributed the high water absorbing of RHA and RCA. However, workable concrete having slump value nearer to 50 mm could be achieved with the use of 10–15% RHA in concrete mixes containing 100% RCA. The 7 days CS decreased with increasing the quantity of RHA in both natural and recycled mixes owing to the slow pozzolanic activity of RHA during early days of curing. The results of 28 and 90 days CS indicated that enhancement in RHA (%) reduced the CS and substantial reduction in CS could be seen for the concrete mixes containing 20%- 35% RHA. However, the rate of decrease in strength in 28 days and 90 days with RHA(%) was substantially higher than that after 7 days which could be attributed the enhanced pozzolanic activity of RHA. Moreover, the CS of concrete after 28 days more than 30 MPa could be achieved by incorporating 15% RHA and 100% RCA in concrete mixes. Reduction in split tensile and flexural strength was detected with the substitution NCA by recycled ones and this type of behavior of concrete was because of inferior nature of RCA as compared to natural aggregates and formation of weaker interfacial transition zone. Modulus of elasticity was found to be reduced by 30% with the 100% replacement of NCA by RCA which was primarily attributed to inferior mechanical properties of RCA as compared to corresponding properties of NCA. However, no significant effect of incorporation of RHA on the modulus of elasticity of both normal and recycled aggregate concrete mixes was detected as the modulus of elasticity was primarily governed by the nature of coarse aggregates and the addition pozzolanic substances had no significant impact on this property of concrete. Reduction in density, increase in water absorption and volume of voids was found when 100% substitution of coarse aggregates was carried out. This change in water absorption, density and volume voids in concrete 100% RCA could be due to the less dense and more porous adhered mortar present in RCA. Furthermore, significant reduction in density, enhancement in water absorption and volume of voids was detected for concrete mixes containing 25%-35% RHA. Incorporation of RCA in concrete mixes reduced the rebound number and ultrasonic pulse velocity of concrete. Moreover, no significant effect on these parameters was observed with use of 10–15% RHA and beyond this level this parameters of concrete was affected significantly. Sustainable cement based construction material incorporating 100% recycled coarse aggregates and 10–15% rice husk ash could be feasible with desired fresh and hardened properties. Therefore, use of 10–15% RHA in concrete mixes containing 100% RCA can be recommended for practical application in various construction sectors. [23]

Syed M.S. Kazmi, Safeer Abbas, Muhammad A. Saleem. (2016) Finalized that RHA and SBA can be potentially used in the production of lighter clay bricks. It was observed that 15% replacement of clay with SBA and RHA wastes result in approximately 15% and 4% lighter bricks respectively, compared to that bricks without RHA and SBA. This decrease in the weight of bricks can reduce the overall dead load and consequently economical structures can be constructed. the compressive and flexural strengths decreased with increased proportions of RHA and SBA. The porosity increased with increasing amount of RHA and SBA leading to increase in water absorption. Bricks incorporating 5% of RHA and SBA showed water absorption less than approximately 18% and 21% respectively; therefore, can be used as moderate weather resistive bricks. On the other hand, these bricks with high porosity usually have good insulation properties. Resistance against sulphate attack was improved by incorporating 5% of RHA and SBA, which shows that these bricks may be used in sulphate environment for better performance. Moreover, it was observed that the resistance against efflorescence has been significantly improved by incorporating SBA and RHA. The incorporation of RHA and SBA up to 5% in burnt clay bricks can be effectively used for massive scale brick production leading to economical and sustainable construction. [24]

G.C. Cordeiro, R.D. Toledo Filho, L.M. Tavares, E.M.R. Fairbairn. (2012) Concluded that The partial replacement of Portland cement by both SCBA and RHA caused slight increase in yield stress and small reduction in plastic viscosity in both conventional and high-strength concretes due to the higher content of ultrafine particles comparing to the references. The compressive strength of ternary conventional and high strength concretes containing both types of ashes was either kept constant or increased when compared to the reference mixtures. These results show that RHA is more effective than SCBA in causing increase of compressive strength owing to its higher pozzolanic activity. The cement replacement by 40% of RHA-SBCA decreased significantly the maximum adiabatic temperature rise of conventional concrete. [25]

2. Conclusions

According to the perspectives of literature review, a number of important conclusions can be drawn.

- Resistance of concrete against chloride and gas penetration significantly increased with increase in bagasse ash replacement.
- Partial replacement of cement by RHA improved workability of fresh concrete for both used average particle sizes.
- The maximum 28 days' flexural strength was obtained with combination of 22.5% fly ash and 7.5% rice husk ash mix.
- Partial replacement of sand with WFS (up to 15%) increases the strength properties (compressive strength, splitting tensile strength and modulus of elasticity) of concrete. Maximum increase in compressive strength, splitting tensile strength and modulus of elasticity of concrete was observed with 15% WFS, both at 28 and 91 days. Inclusion of WFS increases the Ultrasonic pulse velocity (USPV) values and decreased the chloride ion penetration in concrete, which indicates that concrete has become denser and impermeable.
- Decreasing rice husk ash average particle size provides a positive effect on the compressive strength and water permeability of hardened concrete but indicates adverse effect on the workability of fresh concrete.
- For 25% replacement level of cement by sugarcane biomass ash in producing sustainable blended concrete is considered as an optimum replacement. It gives satisfactory results of physio mechanical, durability, and strength properties of blended concrete.
- Directed that, Concrete mixture containing 25% RHA as a replacement of OPC produced the same strength as the concrete containing 100% OPC.
- Residual RHA provides a positive effect on the compressive strength of concretes at early ages, but in the long term, the behavior of the concretes with RHA produced by controlled incineration was more significant.

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