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Utilization of Waste Materials (Sugarcane Bagasse Ash and Recycled Coarse Aggregate) in Concrete: A Review

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Abstract - This paper summarizes the ongoing research on use of waste materials like Sugarcane Bagasse Ash (SCBA) and Recycled Coarse Aggregate (RCA) in Concrete manufacture. The usage of waste substances in concrete manufacture, presents an exceptional approach to a number of the environmental agonize and issues associated with waste management. The main focus of this paper is to study the various works carried out by the researchers on the effects of Sugarcane Bagasse Ash (SBCA) as partial replacement of cement in concrete and also the effect of replacing Natural Coarse Aggregate (NCA) with Recycled Coarse Aggregate (RCA) in Concrete. The key results obtained by the previous research studies are listed and the issues are highlighted that are not yet well understood and need further investigation.

Index Terms - Natural Coarse Aggregate (NCA), Recycled Coarse Aggregate (RCA) in Concrete Sugarcane Bagasse Ash (SBCA), and Waste Materials.

INTRODUCTION

Waste reuse and recycling are among present day society's environmental prime concern and thus domains to which sizeable effort are being devoted now a days**.** Ordinary Portland cement is one of the major construction materials used far and wide. Now a day's cement is replaced by waste from industries, such as waste from steel industries-blast furnace slag, waste from thermal power plants-fly ash and waste from silicon and ferrosilicon industry-silica fume, as a supplementary material. Furthermore, agricultural wastes which include wheat straw ash, rice husk ash and sugarcane bagasse ash which possesses pozzolanic properties hence are also being used as cement replacement material. Pozzolanic materials contains silica (SiO_2) and when these pozzolanas are added to cement chemical reactions occur. During the process of hydration, the released free lime reacts with the silica available in the pozzolanic material and forms additional calcium silicate hydrate (CSH), which is a new hydration product [12]. Subsequently, ameliorating the mechanical properties of concrete.

Fig 1

Sugarcane Bagasse

India produces 300 million tons of sugarcane per year [13] and hence large quantity of sugarcane bagasse is available from sugar mills. Sugarcane bagasse is burnt and partly used as fuel at the sugar industries. Generally, bagasse ash is abandoned in landfills and is now hampering the environment.

Reusing of waste concrete is advantageous and important from the perspective of ecological conservation and successful use of assets. For the effective utilization of concrete waste from the demolished structures, the aggregates from this concrete can be reused in fresh concrete. Utilizing recycled aggregate is undeniably a foremost step in regard to sustainable development in the concrete industry and governance of construction waste. Recycled aggregate (RA) is a feasible alternative to natural aggregate, which helps in safeguarding the environment. Irregularity of the aggregate properties is one of the critical parameters that affect the use of recycled aggregate.

LITERATURE REVIEW

Numerous studies have been carried out on the use of sugarcane Bagasse ash in creating modified concrete. It is now widely accepted that there is a remarkable prospective for demolish debris recycling and using the recycled aggregates for development of concrete to optimize economic and environmental gain. These studies fortify the view of usage of huge cumbersome waste in the construction. The profuse findings in this field are as mentioned below: -

K. Ganesan, K. Rajagopal, K. Thangavel (14) investigated the effects on physical and mechanical properties of indurated concrete by partial replacement of cement with bagasse ash. Investigations included water absorption, compressive strength, permeability characteristics, splitting tensile strength, resistance to chloride ion penetration and water chloride diffusion. They found that up to 20% ordinary Portland cement can be ideally replaced with well burnt bagasse ash without any disadvantageous effect on the expedient properties of concrete. Specific advantages of such replacement are high early strength development, reduced water permeability and considerable chloride permeation resistance and diffusion.

Nuntachai Chusilp, Chai Jaturapitakkul, Kraiwood Kiattikomol (15) investigated the physical properties including heat evolution, compressive strength and water permeability of concrete with ground bagasse ash. In their study a ball mill was used to ground the bagasse ash. Grounded bagasse ash was sieved by IS sieve No 325untill less than 5% by weight particles were retained. This sieved bagasse ash was replaced by Type I Portland cement at 10%, 20%, and 30 % by weight of binder. Findings revealed that lower heat evolution, reduced water permeability and an acceptable strength with respect to the standard concrete can be achieved by using ground bagasse ash as a pozzolanic material in concrete.

Sumrerng Rukzon, Prinya Chindaprasirt (16) partially replaced Portland cement type I with bagasse ash finely grounded. Chloride diffusion, Coefficient of water Absorption, Compressive strength, Porosity and the rapid chloride penetration of concretes were obtained by partially replacing the cement by weight in concrete mixtures with 10%, 20% and 30% of bagasse ash respectively. Tests outcomes indicated that adding bagasse ash up to 30% replacement level escalates the resistance to penetration of chloride and is produces high strength concrete.

Khaldoun N. Rahal and Abdul (17) made plain concrete with recycled coarse aggregate and studied its effects. Considered parameters included Poisson ratio, longitudinal modulus of deformation, compressive strength, workability, density, depth of water penetration under pressure and the stress–strain diagram. The findings of the study revealed that this modified concrete needed more water than the conventional concrete to gain the same workability. In concrete made with 100% recycled aggregate the Density declines by around 7%, with rising replacement rates.

Jianzhuang Xiao, Jiabin Li, Ch. Zhang (18) conducted experiments to analyze the stress–strain curve and the compressive strength of concrete with recycled aggregate for various percentage replacement of recycled coarse aggregates. Recycled coarse aggregates were replaced for various percentages of replacements viz., 0%, 30%, 50%, 70% and 100%, respectively and these concrete specimens were tested under Uniaxial compression loading. Failure behavior and the influences of the recycled coarse aggregate contents on the elastic modulus, the compressive strength, the peak and the ultimate strains of recycled coarse aggregate is given special attention.

Sherif Yehia, Kareem Helal, Anaam Abusharkh, Amani Zaher, and Hiba Istaitiyeh (19) discussed the appropriateness of manufacturing concrete with 100% recycled aggregates to match durability and strength requirements for various applications. Some of the physical and mechanical properties which contribute to the durability and strength of concrete are absorption, shape, texture, specific gravity, gradation and aggregate strength. The experimentation emphasizes on the analysis of mechanical and physical characteristics of the recycled aggregate. Based on the experimental analysis, it was concluded that concrete with sustainable durability and strength could be manufactured if high packing density is attained.

Sepani Senaratne, Gregory Lambrousis, Olivia Mirza, Vivian W. Y. Tam, Won-Hee Kang (20) analyzed distinct methods of enhancing the strength of recycled aggregates, in order that it could be broadly used in the industry. Findings of the study revealed that use of Recycled Aggregate in concrete impart and acceptable substitute to Natural Aggregate, and showed successful results in structural applications by several researchers. Although, insufficient utilization of Recycled Aggregate as a structural material

was noticed. This resulted in carrying out qualitative discussions with industry professionals in search of hurdles and supporters affect the use of RA in structural applications. This research suggested that further areas which require research such as life cycle cost analysis and experiments, using pre-cast constructions and also revealed several allowing and obstruction factors in using the RA as a structural material.

Noor-Ul Amin (21) explored the effects of bagasse ash when partially replaced in cement on mechanical and physical properties of hardened concrete such as splitting tensile strength, compressive strength, chloride diffusion and resistance to chloride ion penetration. Based on the test conducted it was concluded that bagasse ash can be optimally replaced by 20% weight of cement and also is an effective pozzolan and a mineral admixture. Reduction by more than 50% in chloride diffusion is observed without any disadvantageous effects on other properties of hardened concrete.

Eduardo M.R. Fairbairn, Branca B. Americano, Guilherme C. Cordeiro, Thiago P. Paula, Romildo D. Toledo Filho, Marcos M. Silvoso (22) prepared a model to evaluate the reduction in emission of CO_2 and the possibility to provide certified emission reduction credits. The model was evolved within the structure of methodology set by the United Nations Framework Convention on Climate Change for the Clean Development Mechanism. It was concluded in this study that partially replacing sugarcane bagasse ash reduces CO_2 emission into the atmosphere and is a pozzolan which partially replaces clinker in production of cement, thus qualifying as a product for CDM projects.

Gritsada Sua-iam, Natt Makul (23) investigated the impact of mixing limestone powder with self-compacting concrete mixtures wherein fine aggregate was replaced with bagasse ash. Fine aggregate was replaced by volume of bagasse ash and limestone powder with variable percentage (10%,20%,40%,60%,80% and 100%). This volumetric percentage replacement effectively enhanced the hardened properties and workability of self-compacting concrete.

A.Bahurudeen, Deepak Kanraj, V. Gokul Dev, Manu Santhanam (24) studied the manufactruring of sugarcane bagasse ash based blended cements with various levels of replacement of sugarcane bagasse ash and also the behavior of concrete with such cements in concern with the heat of hydration, compressive strength, drying shrinkage and durability. Findings revealed that concrete with sugarcane bagasse ash remarkably improve its performance. Also, additional strength gains due to pozzolanic reaction, low heat of hydration, notable reduction in permeability were observed for bagasse ash blended concrete compared to control concrete.

R.Srinivasan, K.Sathiya (25) this study characterizes partial replacement of cement by weight with bagasse ash in different percentage as 0%, 5%, 15% and 25%. Several fresh concrete tests hardened concrete tests were conducted. They found that as the percentage of bagasse ash is increased the strength of concrete also increases.

Francisco Agrela, Auxi Barbudo, Antonio Ramirez, Jesus Ayuso, María Dolores Carvajal, Jose Ramon Jimenez (26) investigated the source of waste from construction and demolition which are used in recycled aggregate, the processing plant for recycled aggregate production that manufactures the material which are treated with cement and the genuine use of recycled aggregate in a construction project. Investigations concluded that using these aggregates in roads is utterly acceptable from point of view of economy and environment, the mixed recycled aggregates are a good substitute to natural materials.

Fabiana da Conceicao Leite, Rosangela dos Santos Motta, Kamilla L. Vasconcelos, Liedi Bernucci (27) conducted and experimental program to analyze the practicality of using aggregate from recycled waste from construction and demolition of structures in pavement applications. The results show that recycled waste from construction and demolition may be utilized as aggregates in base and subbase layers for roads with low volume.

Javier Tavira, Jose Ramon Jimenez, Jesus Ayuso, Maria Jose Sierra, Enrique Fernandez Ledesma (28) evaluated the mechanical properties in lab and in situ of mixed recycled aggregates obtained from wastes of construction and demolition which is used as unbound materials for base and subbase. An experimental study specifying the properties of recycled aggregates also long-term behavior of these materials under actual traffic and weather conditions was carried out. Studies found that substandard mixed recycled aggregates can be utilized as alternatives for natural aggregates. The surface roughness values attained from the experimental road shows sustainable behavior.

Surender Singh, G.D. Ransinchung R.N, Solomon Debbarma, Praveen Kumar (29) considered waste from road section (Reclaimed Asphalt Pavement) and agricultural industry (Sugarcane Bagasse Ash) for manufacturing of concrete mixes for investigation.5 mixes were developed by partially replacing natural aggregates with coarse reclaimed asphalt pavement and fine reclaimed asphalt pavement in the percentage of 50%and 100 %. 3 mixes were developed containing 100% reclaimed asphalt pavement aggregates mixed with 10% and 15% of bagasse ash partly relaced in cement. They found that, blending 10% bagasse ash remarkably enhanced the durability and mechanical properties of 100% reclaimed asphalt pavement concrete. Also, amalgamations of reclaimed asphalt pavement aggregates mixed with bagasse ash reduces total cost of concrete per cubic meter by more than 40% when compared to controlled concrete. It was suggested to replace 10% by weight of cement with bagasse ash in reclaimed asphalt pavement concrete as it provides strength to the pavement also beneficial economically and environmentally.

Mary Vancura, Lev Khazanovich, and Derek Tompkins (30) proposed to reconsider the utilization of recycled aggregate in slabs of rigid pavements. Details of using recycled aggregates as a structural component in pavement were mentioned. They found that using recycled aggregate in concrete in an acceptable way can expand beyond by just using it as filling material in base layer of pavement. Using recycled aggregates in concrete in the lift of lower PCC of a composite pavement permits several opportunities as economical and sustainable for reusing recovered materials, also advantageous for environmental incentives for road construction.

V.Ayan, S. M. N. Azadani, J. R. Omer, M.C. Limbachiya (31) evaluated the sturdiness behavior of recycled aggregates mixed with natural aggregates in concrete. Three main factors such as amount of traffic, moisture content in highway pavements and the temperature conditions were involved in performance assessment. Based on the evaluation it was found that the materials were suitable for loose subbases for moderate amount of traffic non-frosty condition from the point of view of sturdiness. Also, they are acceptable for low amount of traffic with less moisture and freezing weather.

Mrs.U.R.Kawade, Mr.V.R.Rathi, Miss Vaishali D. Girge (32) in this study sugarcane bagasse ash is physically and chemically distinguished and replaced partially by 0%,10%,15%,20%,25% and 30% by weight of cement in concrete. The properties of fresh concrete and hardened concrete are tested and compared. It is found that the strength of concrete increases by up to 15% when replaced with sugarcane bagasse ash.

Er Aman Joon, Irfan Ahmad Najar, Heemant Gulati (33) studied with a vision to produce and create greener methods of construction to reduce the pollution from cement and other materials used in construction. In manufacturing of paver blocks for low traffic loading bagasse ash is used which may develop the pavements for city roads., village roads or other district roads. It was found that using bagasse ash in paver block production resulted in less environmental problems as compared to control concrete. Which further reduces global warming and pollution. Economy is achieved in construction and maintenance cost when cement is replaced with bagasse ash to produce paver block.

Togay Ozbakkaloglu, Aliakbar Gholampour and Tianyu Xie (34) performed tests to get the different strength parameters also elastic modulus, workability, drying, shrinkage and water absorption. Test specification include the replacement percentage of recycled aggregate, coarse aggregate size and methods of mixing used in concrete development. It was found that characteristics of various recycled aggregates concrete mixes with similar compressive strength are influenced by the size and content of coarse aggregate. With less contents of recycled aggregate, it is feasible to manufacture recycled aggregate concrete with properties similar to those of natural aggregate concrete.

Abrahams Mwasha, M. ASCE, and Rakesh Ramnath (35) proposed a technique based on particle packing optimization for preparing high strength concrete with recycled aggregates and pre-soaking of recycled aggregates. The study showed that high compressive strengths concrete with lower slump develops by drying the recycled aggregates before concrete production.

Eva Remisova, Martin Decky, Milan Mikolas, Matej Hajek, Lubos Kovalcik, Martin Mecar (36) comparative study of the mechanical properties of the structural layers of road pavements constructed with recycled and natural aggregate. It also highlights associated functions of results achieved from in situ and in laboratory by CBR measuring method used to find bearing capacity of stated layers.

CONCLUSION

This paper focuses on two different aspects of material replacement in standard concrete. Firstly, partially replacing cement with Sugarcane Bagasse Ash and Secondly partially replacing natural aggregate with Recycled Coarse Aggregate.

In the above discussion, most of the authors studied replacement of Portland cement with well burnt Bagasse ash and its effects on the aspired characteristics of concrete. Benifits of such replacement are the attainment of high early strength, diffusion, reduction in water permeability, and appreciable resistance to chloride permeation.

Also, authors have studied the feasibility of partially replacing Recycled coarse Aggregate with natural Coarse Aggregates in concrete. These studies suggested that it is possible to manufacture Recycled Aggregate Concrete with durability and mechanical properties which are similar to those of natural aggregate concretes having the same compressive strength.

Studies have been carried out on the possibilities of using these recycled materials (Sugarcane Bagasse Ash and Recycled Coarse aggregate) in concrete individually, but there are some studies based on actual uses of Recycled Aggregates from construction and demolition waste and Sugarcane Bagasse Ash from Sugarcane Industries, hence needs further exploration.

The review of the work done by the researchers show that a considerable progress has been made in terms of utilization of bagasse ash as partial replacement to cement and natural aggregates being replaced partially by recycled coarse aggregates in concrete. But, availability of laboratory research and experimental data on the use of bagasse ash as partial replacement to cement with natural aggregates being 100% replaced by recycled coarse aggregates in concrete is still lacking. Also, use of such recycled concrete for various application such as use in pavements, structural members etc needs to be further explored.

REFERENCES

[1] Bentur A. Cementitious materials – nine millennia and a new century: Past, present and future. ASCE J Mater in Civil Engineering 2002; 14(1):1–22.

[2] Cook JD. Rice husk ash. In: Swamy RN, editor. Concrete technology and design. Cement replacement material, 3. London: Surrey University Press; 1986. p. 171–95.

[3] Mehta PK. Technology alternatives for use of rice husk. Approp Tech 1983:7.

[4] Mehta PK. Properties of blended cement made from rice husk ash. ACI Mater J 1977; 74(9):440–2.

[5] Mehta PK. Rice husk ash – A unique supplementary cementing material. In: Malhotra VM, editor. Proceeding of the international symposium on advances in concrete tech, Athens, Greece; 1992. p. 407–30.

[6] Moayad N, Al-Khalaf, Yousiff HA. Use of rice husk ash in concrete. The Int J Cem Compo Lightweight Concr 1984;6(4):241–8.

[7] Mehta PK. Rice hull ash cement. . . high quality acid resisting. ACI Mater J 1975;72(5):235–6.

[8] Smith RG, Kamwanga GA. The use of rice husk for making a cementitious material. Use of vegetable plants and fibres as building materials. Joint symposium RILEM/CIB/CCL. Baghdad; 1986. P.E85–94.

[9] Zhang MH, Malhotra V. High-Performance concrete incorporating rice husk ash as supplementary cementing material. ACI Mater J 1996;93(6):629–36.

[10] Biricik H, Akoz F, Berktay I, Tulgar AN. Study of pozzolanic properties of wheat straw ash. Cem Concr Res 1999; 29:637–43.

[11] Demirbas A, Asia A. Effect of ground hazel nutshell, wood and tea waste on the mechanical properties of cement. Cem Concr Res 1998; 28(8):1101–4.

[12] Boating AA, Skeete DH. Incineration of rice hull for use as a cementitious material; The Guyana experience. Cem Concre Res 1990; 20:795–802.

[13] Balasubramanian SV, Ratnavelu KN. Budget performance of sugar industry: 2000–2001. In: Proceeding of South India sugar mills association 2001, India.

[14] K. Ganesan, K. Rajagopal, K. Thangavel "Evaluation of bagasse ash as supplementary cementitious material" Cement & Concrete Composites 29 (2007) 515-524.

[15] Nuntachai Chusilp, Chai Jaturapitakkul, Kraiwood Kiattikomol "Utilization of bagasse ash as a pozzolanic material in concrete" Construction and Building Materials 23 (2009) 3352-3358.

[16] Sumrerng Rukzona, Prinya Chindaprasirtb "Utilization of bagasse ash in high-strength concrete" Materials and Design 34 (2012) 45-50.

[17] Khaldoun N. Rahal and Abdul-Lateef Al-Khaleefi "Shear-Friction Behaviour of Recycled and Natural Aggregate Concrete-An Experimental Investigation" ACI Structural Journal/November-December 2015 725.

[18] Jianzhuang Xiao, Jiabin Li, Ch. Zhang "Mechanical properties of recycled aggregate concrete under uniaxial loading" Cement and Concrete Research 35 (2005) 1187– 1194.

[19] Sherif Yehia, Kareem Helal, Anaam Abusharkh, Amani Zaher, and Hiba Istaitiyeh "Strength and Durability Evaluation of Recycled Aggregate Concrete" International Journal of Concrete Structures and Materials Vol. 9, No.2, pp.219-239, June 2015.

[20] Sepani Senaratne, Gregory Lambrousis, Olivia Mirza, Vivian W. Y. Tam and Won-Hee Kang "Recycled concrete in structural applications for sustainable construction practices in Australia" Procedia Engineering 180 (2017) 751 – 758.

[21] Noor-ul Amin "Use of Bagasse Ash in Concrete and Its Impact on the Strength and Chloride Resistivity" JOURNAL OF MATERIALS IN CIVIL ENGINEERING 2011, 23(5): 717-720.

[22] Eduardo M.R. Fairbairn, Branca B. Americano, Guilherme C. Cordeiro, Thiago P. Paula, Romildo D. Toledo Filho, Marcos M. Silvoso "Cement replacement by sugar cane bagasse ash: CO2 emissions reduction and potential for carbon credits" Journal of Environmental Management 91 (2010)1864-1871

[23] Gritsada Sua-iam, Natt Makul "Use of increasing amounts of bagasse ash waste to produce self-compacting concrete by adding limestone powder waste" Journal of Cleaner Production 57 (2013) 308-319.

[24] A. Bahurudeen, Deepak Kanraj, V. Gokul Dev, Manu Santhanam "Performance evaluation of sugarcane bagasse ash blended cement in concrete" Cement & Concrete Composites 59 (2015) 77–88.

[25] R.Srinivasan, K.Sathiya "Experimental Study on Bagasse Ash in Concrete" International Journal for Service Learning in Engineering Vol. 5, No. 2, pp. 60-66, Fall 2010 ISSN 1555-9033.

[26] Francisco Agrelaa, Auxi Barbudoa, Antonio Ramirezb, Jesus Ayusoa, Maria Dolores Carvajalb, Jose Ramón Jimenez "Construction of road sections using mixed recycled aggregates treated with cement in Malaga, Spain" Resources, Conservation and Recycling 58 (2012) 98– 106.

[27] Fabiana da Conceicao Leite, Rosangela dos Santos Motta, Kamilla L. Vasconcelos, Liedi Bernucci "Laboratory evaluation of recycled construction and demolition waste for pavements" Construction and Building Materials 25 (2011) 2972–2979.

[28] Javier Tavira, Jose Ramon Jimenez, Jesus Ayuso, Maria Jose Sierra, Enrique Fernandez Ledesma "Functional and structural parameters of a paved road section constructed with mixed recycled aggregates from non-selected construction and demolition waste with excavation soil" Construction and Building Materials 164 (2018) 57–69.

[29] Surender Singh, G.D. Ransinchung R.N., Solomon Debbarma, Praveen Kumar "Utilization of reclaimed asphalt pavement aggregates containing waste from Sugarcane Mill for production of concrete mixes" Journal of Cleaner Production 174 (2018) 42-52.

[30] Mary Vancura, Lev Khazanovich, and Derek Tompkins "Reappraisal of Recycled Concrete Aggregate as Coarse Aggregate in Concretes for Rigid Pavements" Transportation Research Record 2113.

[31] V.Ayan, S. M. N. Azadani, J. R. Omer, M.C. Limbachiya "Assessment of Toughness Performance of Recycled Aggregates for Use in Highway Pavement" Airfield and Highway Pavement 2013: Sustainable and Efficient Pavements ASCE 2013.

[32] Mrs.U.R.Kawade, Mr.V.R.Rathi, Miss Vaishali D. Girge "Effect of use of Bagasse Ash on Strength of Concrete" International Journal of Innovative Research in Science, Engineering and Technology Vol. 2, Issue 7, July 2013.

[33] Er Aman Joon, Irfan Ahmad Najar, Heemant Gulati "Design of low Volume Traffic Pavements Using Bagasse Ash" International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 p-ISSN: 2395-0072.

[34] Togay Ozbakkaloglu, Aliakbar Gholampour and Tianyu Xie "Mechanical and Durability Properties of Recycled Aggregate Concrete: Effect of Recycled Aggregate Properties and Content" J. Mater. Civ. Eng., 2018, 30(2): 04017275.

[35] Abrahams Mwasha, M. ASCE, and Rakesh Ramnath "Manufacturing Concrete with High Compressive Strength Using Recycled Aggregates" J. Mater. Civ. Eng., 2018, 30(8): 04018182.

[36] Eva Remisova, Martin Decky, Milan Mikolas, Matej Hajek, Lubos Kovalcik, Martin Mecar "Design of Road Pavement Using Recycled Aggregate". IOP Conference Series: Earth and Environmental Science 44 (2016) 022016.

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