RESEARCH PAPER | Engineering | Volume : 6 | Issue : 3 | March 2016 | ISSN - 2249-555X | IF : 3.919 | IC Value : 74.50

Evaluation of Sustainable Green Concrete With Partial Replacement of Cement By Banana Leaf Powder and Cattle Bone Powder

KEYWORDS: Banana Leaf Powder, Cattle Bone Powder, Green Concrete, Supplementary Cementitious Material, Sustainability.

Ramya M	Mercy Shanthi R
Ph.D Scholar, School of Civil Engineering, Karunya University, Coimbatore	Associate Professor, School of Civil Engineering, Karunya University, Coimbatore,

ABSTRACT *Aim of this thesis is to reduce the CO2 emission by reducing the cement consumption in construction industry there by creating an environmental friendly sustainable green concrete for modern construction world. Supplementary Cementitious Material (SCM) can partially replace cement in concrete and thereby reduces the consumption cement. Already material like fly ash, groundnut shell ash, rice husk ash, leaf ash, periwinkle shell ash are used as SCM's to reduce the cement content with increase in strength parameters. But, when SCM's are used in ash form, loss of energy and emission of CO2 creates negative impact. An alternate method of using waste materials as SCM in powder form increases the strength parameters of concrete. Combination of waste Banana Leaf Powder (BLP) and Cattle Bone Powder (CBP), when used as SCM increases the strength of concrete. Banana leaf Powder serves as an alternate binding material where as Cattle Bone Powder, rich in calcium content improves the binding property of cementitious substances with aggregates thereby improves the bond strength between cement phase and aggregate phase. Compressive strength test on hardened concrete of M20 grade of concrete is conducted and the strength increase by about 20-30% at 28 days. Also cracking in BLP and CBP used concrete is lesser than that of the control specimen.*

INTRODUCTION

Concrete is by far the most widely used construction material worldwide. CO2 emissions from 1 ton of concrete produced vary between 0.05 to 0.13 tons. 95% of all CO2 emissions from a cubic yard of concrete is from cement manufacturing. Globally, the cement industry accounts for approximately 5 percent of current anthropogenic carbon dioxide (CO2) emissions. World cement demand and production are increasing significantly, leading to an increase in this industry's absolute energy use and CO2 emissions. Although studies from around the world identify a variety of sector-specific and cross-cutting energy-efficiency technologies for the cement industry that have already been commercialized, information is scarce and/or scattered regarding emerging or advanced energy-efficiency and low-carbon technologies that are not yet commercialized. [1]

Sustainable Green Concrete

Green Concrete as the name suggests is eco friendly and saves the environment by using waste products generated by society. Focusing solely on CO_2 emissions from cement and concrete production increases the perception that concrete is not sustainable which is inaccurate since operationally concrete has substantial sustainability benefits. Removal of prescriptive specification restrictions and focusing on performance and the use of incentives is an effective way to encourage sustainable concrete with low CO_2 emissions. CO_2 is the main threat in causing global warming of the environment. Though attempts have been made to reduce CO_2 emissions in environment by all possible means, but have not found a suitable replacement for it till date. It is important to reduce CO_2 emissions through the greater use of SCM. [2]

One of major issues associated with green concrete is how the waste cementitious materials affect concrete properties compared with the conventional Portland cement concrete. Another important issue is whether all the benefits and barriers of producing green concrete have been adequately understood or addressed. In addition, it is unknown whether a consistent understanding of the current status of green concrete exists between academia and industry. Despite the potential benefits from using "green" raw materials in concrete production, there are barriers to the wide application of potential SCMs. Using waste streams as concrete ingredients could improve certain types of concrete properties while undermining some others. Lack of quantitative data on properties of concrete using waste materials is one of the major barriers. Cost effectiveness would be the driving force for the industry to implement "green" concrete. The construction and building product industry is conservative in nature due to the fear of product failure, which becomes a barrier to the utilization of waste materials. [3]

Supplementary Cementitious Materials (SCM's)

The use of SCM"s was done from the ancient Greeks who incorporated volcanic ash with hydraulic lime to create a cementitious mortar. The major benefits of SCM is its ability to replace certain amount of Portland cement and still able to display cementitious property, thus reducing the cost of using Portland cement. The SCMs can be divided into two categories based on their type of reaction: hydraulic or pozzolanic. Hydraulic materials react directly with water to form cementitious compounds, while pozzolanic materials which by themselves do not have any cementitious property but when used with Portland cement, react to form cementitious combination. It chemically reacts with calcium hydroxide (CH), a soluble reaction product, in the presence of moisture to form compounds possessing cementing properties. The most commonly used supplementary cementitious material at present stage in India is fly ash. Other supplementary cementitious materials used are Rice Husk Ash (RHA), Saw dust ash (SDA), Pozzocrete (P), Quartz Sand (QS) and Egg Shell (ES). [6]

Alternate Binding Material

Cement is used today because of the widespread abun-

Volume : 6 | Issue : 3 | March 2016 | ISSN - 2249-555X | IF : 3.919 | IC Value : 74.50

dance and affordability of the limestone that is its major component. A suitable alternative cement binder would need to maintain the availability and quantities necessary for the industry to continue production at rates and costs that are comparable to the cement production. [7]

The high cost of cement, used as binder, in the production of mortar, sandcrete blocks, lancrete bricks and concrete has led to a search for alternative. In addition to cost, high energy demand and emission of CO2, which is responsible for global warming, the depletion of lime stone deposits are disadvantages associated with cement production. [8]. The continuous increase in the price of Portland cement is attributed to the insufficient production rate of the raw materials when compared with the demand rate in the construction industries.[9]. The cementing quality is enhanced if a pozzolan is blended in suitable quantity with Portland cement. Hence, Agricultural by-product pozzolans have been used in the manufacture and application of blended cements. [10]

The use of alternative materials derived from waste materials result in two folds advantages – conservation of natural resources and disposal/reduction in the size of waste heaps. [11]. Hence Banana Leaf wastes and Cattle Bone wastes are selected as alternate binding material. Banana Leaf is a waste material and is available in plenty of quantity. Though banana leaf is an organic decomposable material, due to its time of decomposition and volume of waste from day to day activities, its disposal is critical. Similarly, Cattle bones are also dumped in large quantities in disposal yards and creates bad odor thereby creates air pollution and diseases. Hence it is necessary to dispose the above said waste in short span of time through an efficient way. Banana leaf wastes are collected and dried. After drying, banana leaves are crushed through commonly available milling machine to powder form. This BLP is rich in micro and macro scale fibers. When BLP is used to partially replace cement in concrete, it exhibits binding property. Also the fibres in BLP improve the bond strength of cement and aggregate phases. Dried banana leaves are shown in fig.1 and BLP is shown in fig.2

Fig.1 Dried Banana Leaves

Fig.2 Banana Leaf Powder

METHODOLOGY

Selection of Materials for Concrete

Ordinary Portland cement, 53 Grade, with specific gravity 3.15 is used for concrete. Fine Aggregate is selected from locally available river sand of grading zone II and specific gravity 2.6. Coarse aggregate is selected from locally available crushed blue granite stones of nominal size 20mm and specific gravity is 2.75. Dried and powdered banana leaf powder is used as supplementary cementitious material for partial replacement of cement.

Mix Proportion

M20 grade of concrete is proposed for this work. Mix ratio of 1:1.5:3 is adopted for cement, fine aggregate and coarse aggregate. Water cement ratio of 0.5 is adopted at medium level of exposure. Potable water with pH value 7.4 is used for concreting works. Cement quantity is taken with reference to weigh batching and 20% of weight of cement is replaced with BLP.

Fig.3 Concrete Mix in Fresh State

Casting of Concrete Specimens

Cement and BLP are mixed in a dry pan and the mixture is then added with measured sand quantity in dry state. Coarse aggregates are wetted with water and they dry mixture (Cement+BLP+Sand) is added with coarse aggregate. Water is slowly added and the concrete is mixed until it reaches the casting consistency. Medium level degree of supervision is required for this mixing work. The concrete mixture is tough to workable. Suitable admixture is required to improve the workability of BLP used concrete.

Fig.4 Fibrous texture finishing

Volume : 6 | Issue : 3 | March 2016 | ISSN - 2249-555X | IF : 3.919 | IC Value : 74.50

SEM micrograph observation

Banana Leaf powder is fibrous in nature and the fiber particles are distributed in uniform cluster fashion. Texture of particles is flaky and elongated. Surface area of individual particles is more than that of individual particles of cement. Dried and powdered plasma in the BLP acts as distribution medium for the fibers, which is expected to improve bond strength of aggregate and cement phase when used in concrete. SEM image of banana leaf powder is shown in Fig.5.

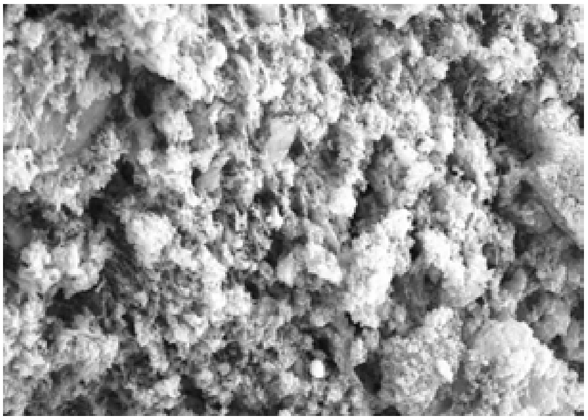

Fig.5 SEM Image of Banana Leaf Powder

RESULTS AND DISCUSSION

Test Results of Concrete

Compressive Strength

Hardened concrete specimens are tested at 3 days, 7 days, 14 days and 28 days of water curing period. Compressive strength values are recorded and the results are given in Table.1

Table.1 Compressive Strength Results of BLP used concrete cubes

Specimen	Ageing	Control Specimen (in MPa)	20% BLP Used Specimen (in MPa)
Cube – 1	3 days	12.70	5.60
Cube – 2	7 days	17.50	15.30
Cube – 3	14 days	18.90	20.45
Cube – 4	28 days	21.40	24.90

Failure at Cracking and Collapse State

Failure of the cube specimens under compression loading is analyzed at cracking state and collapse state. The results are compared with that of the control specimen. It is observed that control specimen develops thick vertical cracks at the time of failure and also spalling of concrete occurs at cracking state itself. Some detachment of coarse aggregate from the cement matrix is also noted. But in BLP used concrete, there is no spalling of concrete at cracking state. Only inclined thin cracks are developed and no signs of vertical cracks in the failed specimen. Spalling of concrete occurs in the collapse state only. Also there is no detachment of bond between coarse aggregate and cement matrix even at collapse state. Test specimen at cracking state and collapse state are shown in Fig.6 and Fig.7 respectively.

Fig.6 Test Specimen at Cracking

Fig.7 Test Specimen at Collapse

CONCLUSION

20% replacement of cement by supplementary cementitious material made with waste banana leaf powder increases the compressive strength of concrete by about 20-30% at 28 days. BLP used concrete takes 14 days to develop the target mean strength and after 14 days the strength development is more than that of the control specimen. BLP exhibits pozzolonic property and it is also taking part in hydration process. Cracking in BLP used concrete is lesser than control specimen.

Furthur, concrete specimens are to be tested for organic growth at an age of 90 days, 180 days and 360 days. Also the chemical properties of BLP are to be investigated to identify the reactive components which are responsible for its pozzolonic behavior of BLP. Tensile strength testing of BLP used concrete is under investigation.

Furthur, Ternary blended cement concrete incorporating combined mass of BLP and CBP is casted for various percentage combinations and are to be casted and tested for both compressive and tensile strength. Based on literature survey, composite SCM material made with BLP and CBP at ratio of 2:1 is expected to maximize the strength parameters and therefore this percentage inclusion of BLP and CBP may be used for medium cadre concrete where higher strength development is required than the use of 100 percent portland cement as the only binder.

ACKNOWLEDGEMENTS

The authors would like to express their sincere thanks to the Management, Karunya University, Coimbatore for the support and facilities provided to pursue this study.

REFERENCES

[1] Emerging Energy-efficiency and CO2 Emission-reduction Technologies for Cement and Concrete Production, Ali Hasanbeigi, Lynn Price, Elina Lin, China Energy Group, Energy Analysis and Environmental Impacts Department Environmental Energy Technologies Division Lawrence Berkeley National Laboratory

[2] "What is Green Concrete?" Karthik H. Obla, The Indian Concrete Journal April 2009.

[3] An Investigation of Current Status of "Green" Concrete in the Construction Industry, Ruoyu Jin and Qian Chen, 49th ASC Annual International Conference Proceedings.

[4] Trends and developments in green cement and concrete technology, Mohammed S. Imbabi, Collette Carrigan, Sean McKenna, International Journal of Sustainable Built Environment (2013).

[5] Concrete and Sustainable Development, Vesa Penttala, American Concrete Institute (ACI) Materials Journal, V. 94, No. 5, September-October 1997.

[6] A Study of Future Trend for Sustainable Development by Incorporation of Supplementary Cementitious Material's, Chirag J. Shah, Vyom B. Pathak, Rushabh A. Shah, International Journal of Inventive Engineering and Sciences (IJIES) ISSN: 2319–9598, Volume-1, Issue-11, October 2013.

[7] Geopolymers: An Environmental Alternative to Carbon Dioxide Producing Ordinary Portland Cement, Erin McNulty, Senior Comprehensive Paper, Department of Chemistry, The Catholic University of America, April 2009.

[8] A review of partial replacement of cement with some agro wastes, manasseh joel, nigerian journal of technology, vol. 29 no 2, june 2010.

[9] Stability of groundnut shell ash (GSA)/ordinary portland cement (OPC) concrete in Nigeria, T.C. Nwofor and S. Sule, Pelagia Research Library Advances in Applied Science Research, 2012, 3 (4):2283-2287

[10] Strength of Binary Blended Cement Composites Containing Pawpaw Leaf Ash, L. O. Ettu, J. C. Ezeh, and M. S. W. Mbajiorgu, International Journal of Advancements in Research & Technology, Volume 2, Issue5, May-2013 ISSN 2278-7763

[11] Characteristics of Bamboo Leaf Ash Stabilization on Lateritic Soil in Highway Construction, Olugbenga O. Amu and Akinwole A. Adetuberu, International Journal of Engineering and Technology Vol.2(4), 2010, 212-219.

[12] Experimental Study on Concrete with Bamboo Leaf Ash, P. Asha, A. Salman, R.Arun Kumar,International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-3 Issue-6, August 2014

[13] Comparative evaluation of concrete properties with varying proportions of periwinkle shell and bamboo leaf ashes replacing cement, Umoh, a.a. and femi, o.o., ethiopian journal of environmental studies and management vol. 6 no.5 2013.

[14] Banana leaves ashes as pozzolan for concrete and mortar of Portland Cement, Rodrigo C. Kanning, Kleber F. Portella, Mariana O.G.P. Bragança, Marcelle M. Bonato, Jeannette C.M. dos Santos, Construction and Building Materials 54 (2014) 460–465

[15] The Physicochemical Characteristics Of Plantain (Musa Paradisiaca) And Banana (Musa Sapientum) Pseudostem Wastes, U.D. Akpabio, D.S. Udiong and A.E. Akpakpan, Advances in Natural and Applied Sciences, 6(2): 167-172, 2012, ISSN 1995-0772

[16] Utilization of ground waste seashells in cement mortars for masonry and plastering, Pusit Lertwattanaruk, Natt Makul, Chalothorn Siripattarapravat, Journal of Environmental Management 111 (2012) 133-141

[17] Machine crushed animal bones as partial replacement of coarse aggregates in lightweight concrete, Javed Ahmad Bhat, Reyaz Ahmad Qasab and A. R. Dar, Asian Research Publishing Network (ARPN) Journal of Engineering and Applied Sciences, VOL. 7, NO. 9, SEPTEMBER 2012, ISSN 1819-6608

[18] Improvement of black cotton soil with cattle bone powder Iorliam, A. Y., Obam, S. O. and Owinizi, S. A., American journal of scientific and industrial research © 2012, Science Huβ, http://www.scihub.org/AJSIR ISSN:2153-649X, doi:10.5251/ajsir.2012.3.3.175.180

[19] A Comparative Analysis and Characterization of Animal Bones as Adsorbent, Abubakar Mohammed1*, Alechenu A. Aboje2, Manase Auta2 and Mohammed Jibril3, Pelagia Research Library, Advances in Applied Science Research, 2012, 3 (5):3089-3096, ISSN: 0976-8610

[20] The suitability of partial replacement of cement with rice husk ash and bone powder in concrete structures, D. A. Opeyemi, O. O. Makinde, International Journal of Emerging Technology and Advanced Engineering Website: www.ijetae.com (ISSN 2250-2459, Volume 2, Issue 9, September 2012)