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Review on Application of Rice Husk Ash Based Concrete Composite and Preparation Conditions of Rice Husk Ash

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Abstract: *Within the past few decades, fabricating 1 ton of standard cement (OPC) will transmit about 1 ton of carbon dioxide. With the increase of demand for cement production, the global carbon dioxide emission has increased by 8%, resulting in huge ecological problems. The continuous development of construction and cement industry has aggravated air pollution and human health damage. Therefore, environmentalists and governments at home and abroad call for the use of other environmentally friendly Supplementary Cementitious Materials to strictly control the carbon dioxide emission rate. Rice husk, as the biggest by-product in rice generation, has been ignored for a long time, and the way of successful utilization of rice husk has not been found. Subsequently, renewable cement based on rice husk cinder (RHA) can be made. This paper analyzes the application prospect of RHA in ordinary silicate concrete and the influence of RHA preparation conditions on RHA, hoping to provide reference for the application of RHA in ordinary silicate concrete.*

Keywords: *Rice husk ash, concrete composite, preparation conditions*

1. Introduction

In the past few decades, the production of 1 ton of ordinary cement (OPC) will emit nearly 1 ton of carbon dioxide, and with the increase of demand for cement production, the global carbon dioxide emission has increased by 8%, resulting in huge ecological problems. The continuous development of construction and cement industry has aggravated air pollution and human health damage. Therefore, environmentalists and governments at home and abroad call for the use of other environmentally friendly Supplementary Cementitious Materials to strictly control the carbon dioxide emission rate. Rice husk, as the largest by-product in rice production, has been neglected for a long time, and the way of effective utilization of rice husk has not been found. In addition, a small part is used for bioelectricity, preparation of water glass, preparation of activated carbon, animal feed and wine fermentation. Rice husk has high silica content and can produce pozzolanic reaction in OPC. In this manner, renewable cement based on rice husk cinder (RHA) can be made. Utilizing financial, productive and green (RHA) as a supplementary cementitious fabric in concrete can move forward the physical and mechanical properties of concrete, and adjust to the reason of green natural security.

2. RHA Application Overview

One of the foremost important and widely cultivated cereal crops within the world is rice, moment as it were to wheat within the add up to developed zone [1-3].

China is the world's largest producer of rice. Table 1 lists the global rice production of selected countries from 2002 to 2020 (million tons).

The rice is embedded in a natural protective shell that botanical scientists call flower scales and is commonly called rice husk (RiH). RiH accounts for almost 20% of the weight of rice [5]. RiH is an agrarian by-product of rice plants, bookkeeping for approximately one-fifth of the weight of rice. Its structure comprises of,cellulose (50%), lignin (25-30%), silica (15-20%) and dampness (10-15%) [3], which is burned to produce a new waste, often called rice husk ash (RHA). As the rate of increment of rice abdicate expanded, the number of RHA expanded essentially. Due to the nearness of undefined silica in RHA, RHA can be utilized in a assortment of applications [4], such as biological power generation, preparation of sodium silicate, preparation of activated carbon, animal feed, wine fermentation [7]. Be that as it may, the characteristics of RHA depend basically on the chemical substance of RiH and the combustion temperature and time. Due to its tall substance of silica and tall particular surface region, RHA is an greatly dynamic crude fabric for volcanic cinder innovation. Due to its high specific surface area, RHA can be used to fill the voids in concrete and improve the interface transition zone (ITZ) between cement base and aggregate to improve the density and porosity of concrete [8]. Hence, calcium hydroxide substance is ordinarily diminished due to the auxiliary hydration response caused by RHA particles [9].

Table 1: Rice output of some countries in the Asia from 2002 to 2020 (million tons)

Year	China [4]	India [2,5,6]	Indonesia [2,5,6]	Bengal [2,5,6]
2002	174.53	123	48.7	39
2003	160.65	-		
2004	179.08	127	53.4	42.3
2005	180.58	-	-	-
2006	181.71	-	-	-
2007	186.38	133.7	64.4	47.7
2008	192.61	-	-	-
2009	196.19	-	-	-
2010	197.22	120.6	66.4	49.4
2011	202.88	-	-	-
2012	206.53	-	-	-
2013	206.28	-	-	-
2014	209.60	-	-	-
2015	212.14	160	90	45
2016	211.09	-	-	-
2017	212.67	163	74	53
2018	212.12	167	77	55
2019	209.61	-	-	-
2020	211.86	183	82	66

Up to now, RHA has achieved good results in all aspects of the construction field due to its good microstructure and excellent volcanic ash activity [10,11]. The execution of RHA ordinarily depends on the strategy of pretreatment and degree of warm treatment [12]. Because the properties of silica in RHA can change with the change of pretreatment and heat treatment. Therefore, the production of active silica from RHA is an important issue to be solved for its wider application in energy conservation and environmental protection [13,14]. The use of RHA in concrete can effectively reduce the cost, and through RHA as an auxiliary cementitious material can improve the mechanical properties and durability of concrete. However, the use of RHA can bring some problems, such as the emission of a certain amount of carbon dioxide during the incineration of RHA, which increases the carbon footprint of concrete preparation [15,16]. Therefore, how to prepare and process RHA correctly is an essential research content. Compared with ordinary Portland cement, RHA is more environmentally friendly and conducive to environmental protection, and can also improve the microstructure of concrete [17].

Adding RHA into concrete as an auxiliary cementing material can produce strong, corrosion resistant, acid leaching resistant, sustainable development and low cost RHA-based concrete composite [18]. And with the development of time, more and more attention to sustainable development of green concrete at home and abroad, and gradually become the main content of the construction industry. Therefore, this paper analyzes the influence of RHA on concrete from the preparation conditions of RHA. In order to illustrate the feasibility of RHA as an auxiliary cementitious material of concrete and the practicability of green clean concrete.

3. Overview of RHA preparation conditions

As an agricultural by-product, RiH itself has good combustibility and is often used for thermal power generation in China. However, compared with other energy sources, due to its chemical composition and physical properties, it produces a larger volume of RHA, and RiH can easily obtain 15% to 20% ash (dry

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state) and about 70% silica content even without controlling combustion temperature and time [1,19]. In rural China, the treatment method of RiH is generally placed near the farmland for burning, and the remaining RHA will be discarded in the farmland for natural degradation. This will pollute the land and produce a lot of carbon dioxide and PM2.5 during incineration. This not as it were squanders the accessible asset of rice husk, but too includes a negative affect on the common environment [20,21]. She Yuexin et al. [22] studied the active components of rice husk and showed that rice husk contains 39% ~ 42% carbon, 30%~34% oxygen, about 5% hydrogen, 0.6% nitrogen and 16%~23% inorganic components. The inorganic components are mainly silicon and a few other metal oxides. The main organic components in rice husk are cellulose, lignin, pentosan and a small amount of protein and vitamin. The skeleton of rice husk is composed of amorphous, amorphous silicon. When RIH burns, it will only retain silica that cannot be decomposed at low temperature (20% by mass), and the rest natural components such as cellulose (40% by mass) and lignin (20% by mass) will be incinerated [23].

With the rapid development of materials science, higher requirements are put forward for the preparation of materials, that is, to broaden the scope of application, improve the accuracy and speed, the need to constantly improve the traditional preparation method, and adopt new preparation technology.

The treatment methods of rice husk ash include incineration and milling. Incineration can be divided into two categories, the first is natural incineration, the second is controlled temperature incineration. There used to be more of the first category. For the second type, some researchers suggest the use of cyclone furnace, fluidized bed, brick incinerator and drum incinerator. From the existing literature, most use fluidized bed incineration method to prepare rice husk ash.

Mehta believes that amorphous silicon can be obtained if the incineration temperature is below 500℃ and the oxidation condition is kept for a long enough time or the maximum incineration temperature is kept at 680℃ for 1min [24]. However, He Lingxia et al. [25] tried the compressive quality and flexural quality of concrete after supplanting silica rage with rice husk cinder at two combustion temperatures of ≥800℃ and ≤600℃. Beneath the combustion environment of ≥800℃, the movement of rice husk fiery remains is lower than that of moo temperature rice husk fiery debris (≤600℃). Beneath the same substitution rate, the compressive quality and flexural quality of moo temperature rice husk cinder concrete at the age of 28 days are higher. Ouyang Dong et al. [26] believed that under the low multiple of SEM, it could be seen that after the incineration of rice husk, part of the pulverized rice husk ash obtained from the incineration at 600℃ was broken and part of the ash remained unchanged. A magnified observation of the outer surface showed that the rice husk had a dense structure, and the observation of the inner surface also showed that the rice husk had a dense structure, which indicated that the inner and outer surfaces of rice husk each had a film composed of dense SiO_2, which would not produce micropores after burning.

Although RHA contains a higher proportion of nonsolid silica at higher combustion temperatures, it still requires ash from grinding to be used as a cement-based auxiliary cementitious material. RiH is utilized in a few cases as fuel for little control plants. In this case, the normal RiH combustion temperature is 740℃ [27]. In this case, ash is simultaneously worn away, producing small particles of ash (<0.375mm) [3]. The fiery debris fabric created as a rule has approximately 80% SiO_2 substance, counting undefined and crystalline silica particles [28]. RHA has a high average particle size (about 50 μm) but a wide particle size distribution (50-60000m^2/kg) due to its exceedingly permeable structure, which makes it profoundly receptive [17]. Therefore, it is necessary to grind RHA to improve its fineness, so as to increase the specific surface area of RHA and enhance its activity [29].

Although RHA is widely used in concrete, it also has adverse effects. For example, the high specific surface area of RHA leads to high water absorption, which requires the addition of water to ensure the performance of RHA matrix concrete. Therefore, it is possible to reduce the final strength of RHA matrix concrete due to increased water incorporation [23]. It moreover changes the setting time of the concrete. Be that as it may, when the quality of cement supplanted by RHA is controlled, the impact of RHA on the properties of concrete can be viably controlled. When the substitution rate is 10%-30%, the physical and mechanical properties of concrete can be successfully made strides.

4. Conclusion

By analyzing the application scope and preparation conditions of RHA, the following conclusions can be drawn:

(1) The characteristics of RHA primarily depend on the chemical substance of RIH and combustion

temperature and time. Due to its tall substance of silica and tall particular surface region, RHA is an amazingly dynamic crude fabric for volcanic fiery debris technology.

(2) When the burning temperature is 600℃-700℃, RHA can burn completely, so as to progress its silica substance and improve the pozzolanic movement of RHA.

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References

[1] Gandhi, H.; Tamaskar, A.N.; Parab, H.; Purohit, S. Extraction of silica from rice husk ash. J. Basic Appl. Eng. Res. 2016, 2, 330–333.
[2] Paris, J.M.; Roessler, J.G.; Ferraro, C.C.; Deford, H.D.; Townsend, T.G. A review of waste products utilized as supplements to Portland cement in concrete. J. Clean. Prod. 2016, 121, 1–18.
[3] Gravitt, D. Eco-efficient construction and building materials. Constr. Manag. Econ. 2013.
[4] National Bureau of statistics of the people's Republic of China. China Statistical Yearbook [J]. Beijing: China Statistics Press, 2020
[5] Aprianti, E.; Shafigh, P.; Bahri, S.; Farahani, J.N. Supplementary cementitious materials origin from agricultural wastes-A review. Constr. Build. Mater. 2015.
[6] Thomas, B.S. Green concrete partially comprised of rice husk ash as a supplementary cementitious material–A comprehensive review. Renew. Sustain. Energy Rev. 2018.
[7] Wang Hongyan, Wang Daolong, Li JianZheng, Wang Yajing, Gao Chunyu, Qi Qunyuan, Bi Yuyun. Estimation and development and utilization of rice husk resources in China [J]. Jiangsu agricultural science, 2012: 306-308
[8] Souza Maelson M., Anjos Marcos A.S., Sá Maria V.V.A… Using scheelite residue and rice husk ash to manufacture lightweight aggregates [J]. Construction and Building Materials, 2021, 270:
[9] De Paula, M.O.; Ferreira Tinoco, I.D.F.; de Souza Rodrigues, C.; Osorio Saraz, J.A. Sugarcane bagasse ash as a partial-port-land-cement-replacement material. DYNA 2010, 77, 47–54.
[10] Rodrigue Kaze Cyriaque, Adesina Adeyemi, Laure Lecomte-Nana Gisèle, Sontia Metekong Jordan Valdès, Van Essa Kamga Samen Liliane, Kamseu Elie, Melo Uphie Chinje. Synergetic effect of rice husk ash and quartz sand on microstructural and physical properties of laterite clay based geopolymer [J]. Journal of Building Engineering, 2021, 43:
[11] Selvaranjan Kajanan, Gamage J.C.P.H., De Silva G.I.P., Navaratnam Satheeskumar. Development of sustainable mortar using waste rice husk ash from rice mill plant: Physical and thermal properties [J]. Journal of Building Engineering, 2021, 43:
[12] Faried A. Serag, Mostafa Sahar A., Tayeh Bassam A., Tawfik Taher A.. The effect of using nano rice husk ash of different burning degrees on ultra-high-performance concrete properties [J]. Construction and Building Materials, 2021, 290
[13] Shen, Y. Rice husk silica derived nanomaterials for sustainable applications. Renew. Sustain. Energy Rev. 2017.
[14] Shen, Y.; Zhao, P.; Shao, Q. Porous silica and carbon derived materials from rice husk pyrolysis char. Microporous Mesoporous Mater. 2014.
[15] Poorveekan K., Ath K.M.S., Anburuvel A., Sathiparan N.. Investigation of the engineering properties of cementless stabilized earth blocks with alkali-activated eggshell and rice husk ash as a binder [J]. Construction and Building Materials,2021,277:
[16] Marques Beatriz, Almeida João, Tadeu António, António Julieta, Santos Maria Inês, de Brito Jorge, Oliveira Micaela. Rice husk cement-based composites for acoustic barriers and thermal insulating layers [J]. Journal of Building Engineering, 2021, 39:
[17] Prasara, A.J.; Gheewala, S.H. Sustainable utilization of rice husk ash from power plants: A review. J. Clean. Prod. 2017.
[18] Antiohos S.K., Tapali J.G., Zervaki M., Low embodied energy cement containing untreated RHA: A strength development and durability study [J]. Construction and Building Materials, 2013, 49:455-463.
[19] Al-Khalaf, M.N.; Yousif, H.A. Use of rice husk ash in concrete. Int. J. Cem. Compos. Light. Concr. 1984.
[20] Singh, B. Rice husk ash. Waste Suppl. Cem. Mater. Concr. 2018.
[21] Siddique, R. Waste Materials and by-Products in Concrete; Springer: Berlin, Germany, 2008.

ISSN 2663-1563 Vol. 4, Issue 2: 7-11, DOI: 10.25236/AJAGE.2022.040202

[22] She Yuexin, Li Jinzhu, Cao Maobai, Liu Yuyi, Jiang Dingyun, Liu Huabo. Review on Application Research Progress of rice husk ash and concrete mixed with rice husk ash[J]. Concrete, 2016(06):57-62

[23] Chindaprasirt, P.; Kanchanda, P.; Sathonsaowaphak, A.; Cao, H.T. Sulfate resistance of blended cements containing fly ash and rice husk ash. Constr. Build. Mater. 2007.

[24] MEHTA P K.The chemistry and technology of cements made from rice-husk ash[C].Proceedings of UNIDO/ESCAP/RCTT Workshop on Rice-Husk Ash Cement, Peshawar, Pakistan, Regional Centre for Technology Transfer[A]. Baghalore, India, 1979:113-122.

[25] He Lingxia, Yin Jian, Tian Dongmei, Liu Yuying, Ren Haibo, sang Zhenghui. Effect of rice husk ash on the strength of reactive powder concrete [J]. Journal of natural science of Xiangtan University, 2016,38 (02): 23-28

[26] Ouyang Dong, Chen Kai. Microstructure and chemical activity of rice husk ash from low temperature incineration [J]. Journal of silicate, 2003 (11): 1121-1124.

[27] Chindaprasirt, P.; Cao, T. The properties and durability of high-pozzolanic industrial by-products content concrete masonry blocks. Bricks Blocks Des. Prop. Durab. 2015.

[28] Habeeb, G.A.; Fayyadh, M.M. Rice husk ash concrete: The effect of RHA average particle size on mechanical properties and drying shrinkage. Aust. J. Basic Appl. Sci. 2009, 3, 1616–1622.

[29] Chindaprasirt, P.; Rukzon, S. Strength, porosity and corrosion resistance of ternary blend Portland cement, rice husk ash and fly ash mortar. Constr. Build. Mater. 2008.