Physical and Chemical Properties of Rice Husk Ash and Ground Granulated Blast Furnace Slag- A Review

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ABSTRACT: Rice Husk Ash and Blast furnace Slag are two abundantly available industrial waste products in India. Rice Husk Ash is generated by the steam boilers used in industries while blast furnace slag is produced as a waste during the production of iron in blast furnace. In the past these materials are disposed of on nearby landfills causing much soil pollution and also had a hazardous effect on the environment. Also due to various regulations for disposal of wastes and lack of space it was a big problem for the industries to get rid of these materials. But both these materials have pozzolanic properties and can be used as a replacement of cement in construction practices to obtain high performance concrete. These materials when used as a replacement of cement can substantially decrease the CO_2 emission due to cement manufacturing. This review paper focuses on the various studies related to the physical and chemical properties of Rice Husk Ash and Ground Granulated Blast Furnace Slag that makes them suitable to be used as a replacement of cement and also in the production of Portland Pozzolana Cement. Some other uses are also reviewed.

Keywords: - Rice husk ash (RHA), ground granulated blast furnace slag (GGBFS), pozzolanic properties, industrial wastes.

I. INTRODUCTION

For the sustainable development of the concrete industry it is essential to use the industrial and agricultural wastes. India is a major rice producing country and the husk generated is mostly used as a fuel in boilers for producing energy giving ash as the waste product. About 20 million tons of Rice Husk Ash (RHA) is produced annually in India. This RHA is a great environmental threat causing damage to the land and the surrounding area where it is dumped. Therefore commercial use of RHA is an alternative solution for the disposal problem. But this RHA is very rich in silica content and also the particle size is small and comparable to the size of cement particles. Thus it can be used with cement as an admixture thereby imparting improved properties to the concrete and also as a cost effective solution to obtain High Performance Concrete (HPC).

According to the definition by the American Concrete Institute (ACI) granulated blast furnace slag is a glassy granular material obtained when molten blast furnace slag is rapidly chilled generally by immersion in water. This granular material is then grinded to obtain ground granulated blast furnace slag (GGBFS). It has high quantities of silicon oxide (SiO_2) and Calcium Oxide (CaO). Extensive studies had been carried out to determine the physical and chemical properties of blast furnace slag and RHA so that they can be used as an admixture with the cement. Various types of concrete had been developed over the years by using these waste materials with concrete like self-compacting concrete, lightweight concrete, high performance concrete etc. Extensive researches are still going on in this area to obtain highly silicious particles and materials containing finer particles so that highly improved properties can be obtained for the concrete structures and also to reduce the consumption of cement whose production is a major source of greenhouse gases emission. These developments are not only required by the concrete industry but are also essential for the mankind for a development with minimum deterioration of the environment.

II. LITERATURE REVIEW AND PREVIOUS WORKS:-

A. REVIEW ON RICE HUSK ASH

A. A. Ramezanianpour, M. Mahadi Khani(2009)

Studied the quality of major and minor oxide elements present in the rice husk ash by using X-Ray Fluorescence technique (XRF).The chemical composition of RHA indicated that the material is mainly composed of silicon Dioxide. The temperature in the furnace for burning rice husk was maintained below 750^{0}C. Also to determine the crystalline compounds present in the RHA, X-Ray Diffraction (XRD) was carried out.

Madhumita Sarangi, S. Bhattacharya, R.C Behera (2009) studied the rice husk ash at different temperatures (700-1100^{0}C) in the presence of air. The changes in morphologies, compositions and phase transitions were studied critically by scanning electron microscopy, energy dispersive spectroscopy and X-ray diffractometry, respectively. Crystallite size and the amount of silica obtained from RHA at each temperature were worked out using X-Ray diffractometer plots. The amount of silica with respect to other carbonaceous volatile matter was calculated from the XRD plot.

G. Rama Rao, A.R.K Shastri and P.K Rohatgi(1989) studied the chemical properties of RHA and deduced that RHA contains mostly silica(90-95%) besides minor amount of calcium, potassium, phosphorus, magnesium, sodium and sulphur along with trace amount of aluminium, manganese and iron. In their study they made the RHA by using a box furnace.The temperature was raised in intervals of 100^{0}C. Due to high content of silica it can be used as a source of silica extraction which is further utilized in rubber industry, in cosmetics and in toothpaste industry.

S. Faiziev (2003) studied the use of RHA as a highly reactive pozzolana and its utilization in the concrete industry in making high strength concrete. It is also utilized as a replacement of cement and silica fume or as a mineral admixture in manufacturing of low cost concrete blocks .Nowadays blending of reactive RHA in cement has become a common recommendation in most of the international building codes.

The chemical composition of RHA generally available in India is given in Table 1.

Table 1:-

Chemical Constituents	Range of chemical constituents(% by mass)
SiO_2	82.5-97
Fe_2O_3	0.54
CaO	0.1-1.31
MgO	0.01-1.96
K_2O	0.1-2.54
Na_2O	0.01-1.58
P_2O_5	0.01-2.69
SiO_3	0.1-1.23
Carbon	2.71-6.42

The various Physical properties of RHA are given in the table 2:-

Table 2:-

Physical Property	**Value for RHA**
Fineness(m^2/kg)	360
Loss of ignition (%)	5.9
Bulk Density(kg/m^3)	96 - 160

Although the value of physical and chemical properties of RHA may vary according to the type of rice, soil and the geographical conditions.

B. REVIEW ON GROUND GRANULATED BLAST FURNACE SLAG:-

W.A Tasong et al. (1999) studied the chemical composition of ggbfs by using X-Ray diffractometry technique and electron microscopy. He deduced that GGBFS comprises mainly of CaO, SiO_2, Al_2O_3 and MgO. He found that it has the same main chemical constituents as cement but in different amounts.

K. Wang et al. (2005) studied the particle size distribution of GGBFS by using a laser diffraction particle analyser and they deduced the morphology of the particles by Scanning Electron microscopy. They used the samples from 4 different types of mills and then studied the effect of type of milling on the particle size distribution.

Stanley J. Virgalitte et al.(2000) studied the various physical and chemical properties of GGBFS as a chairman of ACI Committee 233.They deduced that the properties of GGBFS is determined by the ores, fluxing stone, and impurities in the coke charged into the blast furnace. Typically, silicon, calcium, aluminum, magnesium, and oxygen constitute 95 percent or more of the blast-furnace slag. They studied that GGBFS can be obtained by rapid quenching of molten slag in water and then grinding it in rolling mills.

The range of chemical composition of GGBFS are given in the TABLE 3

TABLE 3:-

Chemical constituents	Range of Chemical Constituent (% by mass)
SiO_2	32-42
Al_2O_3	7-16
CaO	32-45
MgO	5-15
S	0.7-2.2
Fe_2O_3	0.1-1.5
MnO	0.2-1.0

The various physical properties of GGBFS are given in TABLE 4.

TABLE 4:-

Physical Properties	Value for GGBFS
Fineness(m^2/kg)	275
Soundness(mm)	10
Loss of ignition(%)	3
Bulk Density(kg/m^3)	1200

Some More Experimental Results:-

Apart from all the data shown above the experiments to find out the specific gravity was conducted for RHA and GGBF and sieve analysis was done on RHA.

A. Specific Gravity Test:-

The sample of RHA and GGBFS was dried in oven for 24 hours and then the specific gravity test was conducted. The results of the test are given in the Table 5.

TABLE 5:-

	Specific Gravity
RHA	2.0
GGBFS	3.03

B. Sieve Analysis of RHA:-

Sample of RHA was taken from Rice husk burning power plant boiler. This sample was dried for 24 hours in oven .Then 500gm of sample was taken for sieve analysis. The results of the sieve analysis of RHA are given in Table 6.

Table 6:-

S.NO	NO.OF SIEVE (SIZE)	RETAINED	% RETAINED	Cumulative %	% FINER
1	4.75	0	0	0	100
2	2	1	0.2	0.2	99.8
3	1.0	5	1	1.2	98.8
4	425*	24	4.8	6	94
5	212*	90	18	24	76
6	125*	330	66	90	10
7	75*	15	3	93	7

***sizes are in microns**

The rest part of the sample that was finer than the 75 micron sieve was collected in the base pan. It weighed 35 grams and was discarded as dust.

III. CONCLUSIONS

As early in this review paper many research papers of various authors is studied and on the basis the following conclusions are drawn:-

1. RHA and GGBFS are two very useful industrial waste products that can be used with cement as a replacement as an admixture.
2. These materials contain a large amount of silica (SiO_2) and Calcium Oxide (Ca O) and can impart good binding charecteristics to the concrete.
3. The physical and chemical properties of RHA and GGBFS are very much similar to the Ordinary Portland Cement and can be utilized both as a component for cement manufacture and also as mineral admixtures in concrete.
4. The fineness of the particles of RHA and GGBFS can be easily controlled by using suitable grinding methods to satisfy the requirements of any project.
5. These materials when used in appropriate proportion with cement can impart very high strength and durability to the concrete and

thus are used in the formation of High Performance Concrete (HPC).

6. Utilising these materials as a component of concrete is also beneficial to the environment because if dumped as waste, these material can cause severe hazards to the nearby land and environment.
7. These materials are abundantly available in every country and can be used as a partial replacement of cement as production of cement is a major cause for CO_2 and other greenhouse gas emission.
8. These materials can also be used in the generation of nano particles to be used with concrete with a potential to improve the properties.
9. RHA and GGBFS are much cheaper as compared to cement and thus can be used as a cost effective solution to obtain high performance concrete.
10. As the specific gravity of RHA is very low as compared to that of cement thus it can be efficiently used in the formation of Light Weight Concrete.
11. The fineness of these materials is very good thus it can fill the pores in the concrete giving good surface finish and high strength.Almost 94% particles pass through 212 micron sieve.
12. As RHA and GGBFS contain a very large amount of silica these can be used as a raw material to obtain silicon which is a very useful material for the formation in silicon chips and computer parts.

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