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Performance characteristics of Ternary blended concrete using RHA and GGBS

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Abstract: This paper studies about two secondary cementitious materials , that is about an industrial waste GGBS and an agricultural waste RHA . Nowadays, ternary blended concrete is achieving popularity by overcoming the disadvantages of binary blended concrete . This work mainly deals with the study of fresh properties and strength of ternary blended concrete with Ground Granualted Blast Furnace Slag (GGBS) and Rice Husk Ash (RHA) replacing the ordinary Portland cement by 0%,10%,20%,30% . Compressive strength, flexural strength and split tensile strength tests were carried out on hardened concrete after 7 , 14 and 28 days of curing.

OPC-RHA-GGBS ternary cement concrete could be used as lightweight concrete in civil engineering and building works. The observations were critically analyzed and the different attributes of the various mixes were correlated with the RHA content in the mix.

Keywords: RHA,GGBS,pozzolona ,compressive strength

I. INTRODUCTION

Researchers of cement studied a viable method for replacing cement by using Supplementary Cementitious Materials (SCMs). SCMs are commonly industry byproducts or raw materials, such as slag, limestone, fly ash, silica fume, natural pozzolan. Whether binary blended or even ternary blended, SCMs can replace part of cement without sacrificing equivalent engineering properties is to be investigated. The addition of SCMs in concrete has dramatically increased along with the development of concrete industry, due to the consideration of cost saving, energy saving, environmental protection and conservation of resources. However, environmental concerns both in terms of damage caused by the extraction of raw material and carbon dioxide emission during cement manufacture have brought pressures to reduce cement consumption by the use of supplementary materials. Use of these byproducts facilitates sustainable development. High Performance Concrete(HPC) is the latest development in concrete. It has become more popular these days and is being used in many prestigious projects.

To create a sustainable environment cement is replaced with two different materials.This forms a ternary mixture .Ternary concrete mixtures include three different cementitious materials.This report includes combinations of portland cement, slag cement, and a third cementitious material.

Ternary concretes is used mainly in

- General construction (residential,commercial, industrial)
- Paving
- High performance concrete
- Precast concrete
- Masonry and masonry units
- Mass concrete
- Shotcrete

Ternary mixtures can be designed for: high strength, low permeability ,corrosion resistance, sulphate resistance, ASR resistance and elimination of thermal cracking.

The optimum mixture proportions for ternary blends, as with other concrete, will be dependent on the final use of the concrete,construction requirements and seasonal considerations. As with other concrete, cold weather will affect the early strength gain and mixture proportions may need to be adjusted to assure job-site performance.

A. Objective

The main objective of this paper is to study fresh properties and the strength of ternary blended concrete with Ground Granualted Blast Furnace Slag (GGBS) and Rice Husk Ash (RHA) replacing the ordinary Portland cement by 0%,10%,20%,30% of pozzolon blend containing 30% RHA and 70%GGBS**.**

B. Scope

Concrete with SCM often displays slower hydration, accompanied by slower setting and lower early-age strength, especially under cold weather conditions. Most of the SCMs are industrial by-products. These materials are generally not used as cements by themselves, but when blended with OPC, they make a significant cementing contribution to the properties of hardened concrete through hydraulic and/or pozzolanic activity. SCMs are increasingly used in concrete because of the advantage that it reduces economic and environmental concerns by utilizing industrial wastes, reducing carbon dioxide emissions, and lowering energy requirements for OPC clinker production and also it helps to improve the concrete properties, such as workability, impermeability , ultimate strength, and durability, including enhanced resistance to alkali-silica reactions, corrosion of steel, salt scaling, delayed ettringite formation and sulphate attack.

C. GGBS-Ground Granulated Blast Furnace Slag

It is obtained by quenching molten iron slag from a blast furnace in water or steam and hence produces a glassy granular product that is then dried and ground into a fine powder.

Density - 3.0 g/cm^3
Specific Surface -5,000 cm^2/g
Activity - 87.0 %

It is mainly used as a mineral additive for concrete production and substitutes for cement .Two major uses of GGBS are in the production of quality-improved slag cement, namely Portland Blast furnace cement (PBFC) and high-slag blast-furnace cement (HSBFC), with GGBS content ranging typically from 30 to 70%; and in the production of ready-mixed or site-batched durable concrete.
Slag cement can be used as the main additive. Quenching of iron and GGBS is shown in figure 1.

Fresh Concrete

i. Increases fluidity
ii. Facilitates workability and settlement
iii. Decreases water need
iv. Reduces shrinking when dried
v. Decreases heat of hydration
vi. Slows down heat evolution
vii. Increases density of concrete

Hardened Concrete

i. Increases durability
ii. Increases ultimate resistance
iii. Provides strength development for up to 720 days
iv. Increases lifetime of concrete (app. 200 years)
v. Minimizes alkali-silica reactions in aggregate
vi. Increases resistance to aggressive environments (acid, sulphate, chloride)
vii. Increases high temperature resistance
viii. Reduces thermal cracks

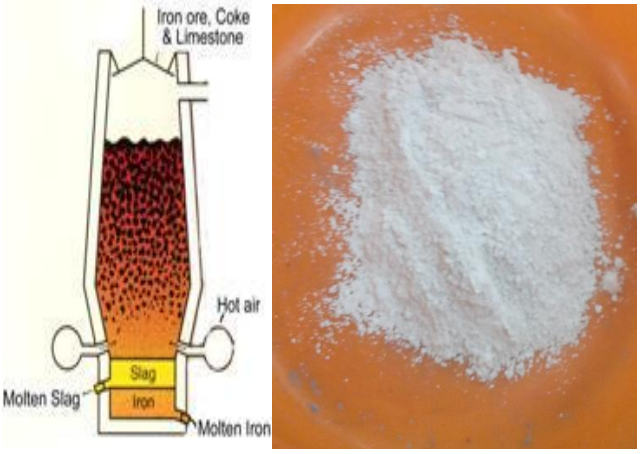

Fig 1 :Process of quenching of iron slag and GGBS.

D. RHA-Rice Husk Ash

Rice milling produces a byproduct known as husk and about 22% of it is rice husk. It contains about 75% organic volatile matter and 25% of weight of husk is converted into ash during firing process. RHA contains around 85%-90% amorphous silica. RHA (25 microns) fills the interstices in between the cement in aggregate. Thus it can reduce the amount of cement in the concrete mix.

Husk surrounds the paddy grain. During milling of paddy about 78 % of weight is received as rice , broken rice and bran . Rest 22 % of the weight of paddy is received as husk. This husk is used as fuel in the rice mills to generate steam for the parboiling process. India is a major rice producing country , and the husk generated during milling is mostly used as a fuel in the boilers for processing paddy , producing energy through direct combustion and or by gasification.

Fig 2:-RHA –Rice Husk Ash(RHA contains 85%-90% amorphous silica.)

About 20 million tones of RHA is produced annually. This RHA is a great environment threat causing damage to the land and the surrounding area in which it is dumped. Lots of ways are being thought of for disposing them by making commercial use of this RHA.

II. PROCEDURES

A. **Methodology**

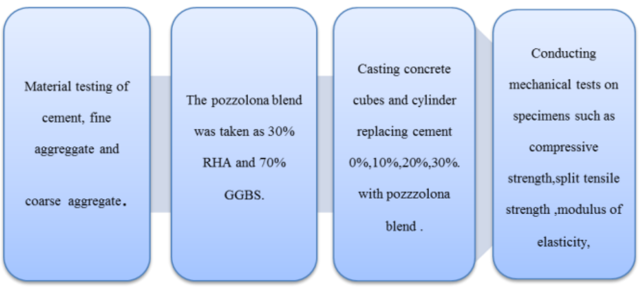

Fig 3 –Methodology flow chart

1) First Step

RHA was collected from Shree Shree Goursundar Rice and Oil mills, Bargarh, Orissa .GGBS was collected from Erode.

Material such as cement, sand and aggregates were collected from nearby industrial sources.

2) Second Step

Basic characteristics of cement such as consistency, intial setting time, final setting time, specific gravity were obtained by conducting test. Specific gravity tests were conducted for RHA and GGBS. Workability tests were conducted on fresh concrete. The proportion taken for replacing cement is 30RHA and 70 GGBS.

3) Third Step

The mix calculations were done for each replacement. Then the cubes and cylinders were cast. The cube specimen having size 150×150×150 were tested for 7^{th} ,14^{th} ,28^{th} day tests and cylinder been tested for 28^{th} day for modulus of elasticity and split tensile test.

B. Constituent materials

i. OPC 43 grade - OPC 43 cement shall conform to IS:8112-1989 and the designed strength of 28 days shall be minimum 43 MPa.
ii. GGBS - An industrial waste produced from quenching. The use of GGBS in addition to Portland cement in concrete in Europe is covered in the concrete standard EN 206:2013.
iii. RHA -Rice husk ash (RHA), a waste material made available from the rice industry.
iv. Fine aggregate -Fine aggregate used is M-sand that is manufactured sand.
v. Coarse aggregate-As per IS 2386(Part 1)1963. 20mm size of aggregate was taken.
vi. Admixture used Glenium Sky 8233 -Master Glenium SKY 8233 is an admixture of a new generation based on modified polycarboxylicether. Master Glenium SKY 8233 is free of chloride & low alkali. It is compatible with all types of cements.
vii.

C. Mix Proportion

Mix design was done according code IS 10262 for mix design of pozzolona.

Mix proportion of cement:pozzolona:fine:coarse

For 30% replacement of cement
1 : 0.42 : 1.63 : 2.96
For 20% replacement of cement
1 : 0.25 : 1.43 : 2.59.
For 10% replacement of cement
1 : 0.11 : 1.27 : 2.306.

III. SPECIMENS CAST

Before casting, workability tests were conducted by adding an admixture Glenium SKY 8233.The product has been primarily developed for applications in high performance concrete where the highest durability and performance is required.Then the cubes and cylinder were cast .

From workability test

- 10% replacement of cement -adding 0.6% of admixture.
- 20% replacement of cement- adding 0.75% of admixture.
- 30% replacement of cement –adding 0.9% of admixture.

Fig 6 Cube and cylinder cast

IV. RESULTS OF EXPERIMENTAL INVESTIGATIONS

The cubes were tested after 7 ,14 and 28 days of curing and the cylinders were tested after 28 days of curing.

For 30% replacement of cement the cube and cylinder are named as P30. Similarlly for 20% replacement as P20 and for 10% replacement as P10.

A. Compressive Strength

The test result are shown below in the table.

Table 1 7th and 14th day observation.

SPECIMEN NAME	7th DAY TEST AVERAGE LOAD (kN)	STRENGTH (N/mm^2)	14th DAY TEST AVERAGE LOAD(kN)	STRENGTH (N/mm^2)
NT	606.66	26.8	663.33	29.48
P30	420.00	18.66	660.00	29.33
P20	673.33	29.92	506.66	22.51
P10	586.66	26.07	606.66	26.96

Table 2 28th day observations.

SPECIMEN NAME	28th DAY TEST LOADS(kN) OF 3 CUBES			STRENGTH (N/mm^2)
NT	780	780	780	35
P30	720	720	720	32
P20	740	740	740	33
P10	520	520	510	23

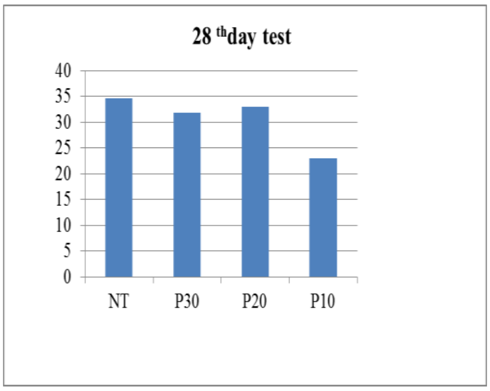

Fig 7 Column chart showing compressive nature of concrete cube.

The optimum proportion obtained in replacement of cement in concrete with pozzolona blend 30RHA and 70GGBS is P20.

B. Split tensile strength

Split tensile strength is done for finding the tensile strength of the cylinder.Cylinder is marked and placed horizontally in compressive testing machine and the observations are noted.

Fig 8 Split tensile test

Table 3 Split tensile results

Replacement of cement	Load (k N)		Split Tensile Strength(N/mm^2)
0%	200	200	2.83
10%-P10	240	250	3.46
20%-P20	210	210	2.97
30%-P30	200	195	2.79

Optimum split value is obtained for 10% replacement of cement with pozzolona blend.

C. Modulus of elasticity

Modulus of elasticity is done using an extensometer.

Fig 9 Using extensometer and compressive strength machine.

The modulus of elasticity is calculated for conventional(NTC) and replacement of cement with pozzolona blends(P10,P20,P30).

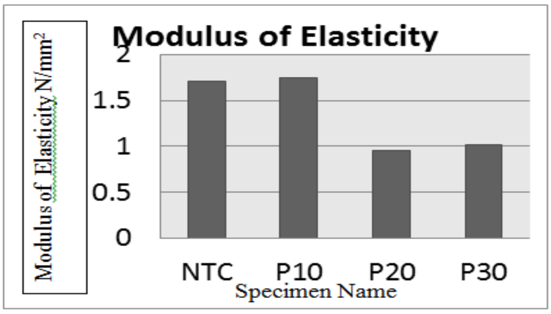

Fig 10 Modulus of elasticity obtained for specimens.

P10 shows maximum modulus of Elasticity from the above chart.

Hence, the compressive strength was maximum for 20% replacement and for split tensile and modulus of elasticity maximum obtained was for 10% replacement of cement.

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