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INVESTIGATION ON MECHANICAL PROPERTIES OF CEMENT BY PARTIAL REPLACEMENT OF POZZOLANIC MATERIALS

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ABSTRACT: With the recent rapid increase in population the need for infrastructure development increased exponentially. This increased demand for new infrastructure is feeding the global demand for building materials like ordinary Portland cement (OPC), which is the main binding constituent for producing concrete. Currently, the global demand of the OPC is around 4 billion tons , which is second most required material after water and it is expected that this figure will increase by 8–10% in the coming years . The production of cement is a highly energy intensive process which releases one-tonne of carbon dioxide (CO2) for every tonne production of cement. It is estimated that by theyear2020,the CO2emission will rise by 50% from the current levels. These findings have put increased pressure on the concrete construction industry, thus, a key challenge is to reduce the amount of cement used in concrete mixtures. Replacing Portland cement with mineral admixtures such as fly ash, blast furnace slag (BFS), and silica fume has been a widely adopted strategy due to their pozzolanic reactivity and latent hydraulic activity . Hence, the researchers are currently focusing on waste material having cementing properties, which can be added as partial replacement of cement which reduces cement production then the Green House gasses emission is also reduced. Itaids in sustain-able management of the industrial waste. The concrete industry is constantly looking for supplementary cementations material with the objective of reducing the solid waste disposal problem. GGBS, Rice husk ash (RHA) is among the solid wastes generated by industry. This research is carried out in three phase, in first phase mix of M50 grade concrete with OPC 53 with replacement of 0%,10%,20%,30%,40% of mineral admixtures (GGBS& Rice husk ash)in second phase mix of M50 grade concrete with Special cements of OPC 53 S with replacement of 0%,10%,20%,30%,40% of mineral admixtures (GGBS & Rice Husk Ash). In phase three the comparison of strength obtained from above two phases.Finally20% of GGBs and rice husk ash are replaced in the OPC 53 grade cement and OPC 53S special cements. Among that OPC 53 S special cement is used in the construction of railway sleepers which gives more compressive strength compared to OPC cement .This special cements is finer than ordinary cements. The research work have been extensively executed in almost all areas of testing like compressive, spilt tensile, and flexural strength.

Keywords: Cement, OPC 53 S, GGBS, Rice husk ash (RHA).

1.INTRODUCTION

Use of concrete is globally accepted due to ease in operation, mechanical properties and low cost of production as compared to other construction materials. An important ingredient in the conventional concrete is the Portland cement. Production of Portland cement is increasing due to the increasing demand of construction industries. Therefore the rate of production of carbon dioxide released to the atmosphere during the production of Portland cement is also increasing. Generally for each ton of Portland cement production, releases a ton of carbon dioxide in the atmosphere. The green house gas emission from the production of Portland cement is about 1.35 billion tons annually, which is about 7 % of the total greenhouse gas emissions. Moreover, cement production also consumes significant amount of natural resources. Therefore to reduce the pollution, it is necessary to reduce or replace the cement from concrete by other cementitious materials like fly ash, blast furnace slag, rice husk ash, etc.

Ingredients of the concrete are

Cement

Aggregate

Water

Cementinious materials (GGBS & Rice husk ash)

1.1 Cement: Cement is a material with adhesive and cohesive properties. It is a binder material in concrete, when it is mixed with aggregates and water it turns the particles into a whole compound. Cement is a most important and costliest ingredient of concrete. It is obtained by burning a mixture of the siliceous, argillaceous and calcareous material in definite proportions. The temperature to which the mixture must be burnt is about 1400^{o}c. The clinker so obtained is cooled and powdered to the required fineness. The product so obtained is cement .It consists of different properties are obtained by mixing the above components in different proportions along with small percentages of other chemicals. Portland cement is the most important type of cement which is widely used.

1.1.1 TYPES OF CEMENT: By altering the proportions of the ingredients of cement, by adding other ingredients or by changing the intensity of grinding, different types of cement useful for particular situations can be manufactured. IS 456-2000 has recognized the following types of cements for construction purpose.

I.Ordinary port land cement confirming to

a) 33 Grade (**IS 269**)

b) 43 Grade (**IS 8112**)

c) 53 Grade (**IS 12269**)

II. Rapid Hardening Cement (**Indian standard:8041**)

III. Portland Slag Cement (**Indian standard:455**)

IV. Hydrophobic Cement (**Indian standard: 8043**)

V.PortlandPozzolonaCement(**Indian standard:1489**)
VI.Low heatPortlandCement(**Indian standard:8042**)
VII.SulphateResistingPortlandCement(**Indian standard:1233**)
VIII.White Portland Cement (**Indian standard:8042**)
IX.High Alumina Cement (**Indian stranded :6452**)

In our project the Ordinary Portland Cement of 53 grade cement and Ordinary Portland Special cement of OPC 53 S cements are used.

Special Cements (OPC S):

The Special Cements are a special type of cements which are used for the specified requirements. Among its OPC 53 S is the special type of cements which are used for construction of sleepers. OPC represents Ordinary Portland Cement, 53 represent the compressive strength of cement after 28 days curing, and S represents the special cements. The main differences between Ordinary Portland Cement and Ordinary Portland Special cements is the

- Min Fineness - 225m^2 /kg for OPC53 &370m^2/kg for OPC 53 S as per IS4031 (part -2)
- Chemical composition -
- Maximum Tricalcium aluminate content, is10.0 % by mass,
- Maximum Tricalcium silicate, 45.0%by mass

It is specialty cement as per specifications which is manufacturing, concrete obtained by the Indian Railways vide their specification No.IRST-40 for manufacturing concrete sleepers. Where there was an amendment (No.6) to I.S 12269, IRST-40 cement and then, this was considered under the ambit of BIS. It is then designated as 53-S Ordinary Portland cements and conforms to BIS specification Indian standard: 12269-1987. 53-S OPC's which has negligible chloride content protects it against corrosion. High fineness enhances workability and high early strength enables improved mass production cycle of Railway Sleepers. Not only from the main usage i.e. is in the manufacture of concrete sleepers, which can also be put to use in pretest concrete elements, high rise buildings where early strength is required.

1.2 AGGREGATE:

The aggregate have a definite influence on the strength of hardened concrete. The durable, strong, chemically inert and well graded which are used for construction. The aggregate occupy about 75% of the volume of concrete and they greatly influence the properties of concrete. These gives body to the concrete and reduce the shrinkages effect of cement and make the concrete durable. Aggregates are classified as fine aggregates and coarse aggregates:

The sands which passes 4.75 mm Indian Stranded sieve by the Indian stranded code 383-1970 and contains only so much coarse material as is permitted for various grading zones.

The coarse aggregate are those most of which will 4.75 mm IS sieve contain only finer material which is evolved by different

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types described in Indian Standard 383-1970.

1.3 Water

Water is the most important & least expensive ingredient of concrete.

It plays an important role in mixing, laying, compaction, setting & hardening of concrete.The strength of concrete depends on the quality & quantity of water used in the mix.

The functions of water in the concrete mix are given below:

- It acts as a lubricant for the fine and coarse aggregate & makes the mixture workable.
- It acts chemically with cement to form the binding paste.
- It is employed to damp the aggregate surface in order to prevent them from absorbing water vitally necessary for chemical action.
- It facilitates the spreading of aggregate.
- It helps to flux the cementing material over the surface of the aggregate.
- It enables the concrete mix to flow into moulds.

1.3.1 Quality Of Mixing Water In Concrete

The water to be used for preparing the concrete should fulfil the following requirement.

- ✓ It should be fresh & clean.
- ✓ It should be free from organic impurities injurious amounts of acids or alkalies, hygroscopic, greasy & oily substance.
- ✓ It should be free from iron, vegetable matter, or any other substance which is likely to have an adverse effect on concrete or reinforcement.
- ✓ It should be fit for drinking purpose.
- ✓ The PH value shall generally be between 6 and 8.

1.4 Cementinious materials (GGBS & Rice husk ash)

1.4.1 Use of Rice Husk Ash as Filler Material In this work: Rice Husk Ash was used as a mineral admixture. Rice husk is an agricultural residue obtained from the outer covering of rice grains during milling process. It constitutes 20% of the 500 million tons of paddy produced in the world. Initially rice husk was converted into ash by open heap village burning method at a temperature, ranging from 300°C to 450°C. When the husk was converted to ash by uncontrolled burning below 500°C the ignition was not completed and considerable amount of unburned carbon was found in the resulting ash. Carbon content in excess of 30% was expected to have an adverse effect upon the pozzolanic activity of RHA. The ash produced by controlled burning of the rice husk between 550°C and 700°C incinerating temperature for 1 hr, transforms the silica content of the ash into amorphous phase. The reactivity of amorphous silica is directly proportional to the specific surface area of ash. 5 The ash so produced is pulverized or ground to required fineness and mixed with cement to produce blended cement. About 600 million tons per year of rice paddy was produced all over the world out of which an estimated 120 million tons in year 2010-2011 was grown in INDIA. Rice husk is the outer covering of the rice grain that is removed as a result of milling process on rice kernel. Huge amounts of RHA obtained after burning of rice husk, probably has no use at all and getting rid of it is also a problem. India is an agriculture based economy, every year produces a considerable amount of byproducts such as rice husk. In this world fighting with the enemies like global warming and shortage of natural construction materials, Scientist, Engineer everyone is looking something alternatives which minimize the environment degradation as well as provide comparable output to the traditional materials. The Rice Husk Ash is one these material boost our believe we can reduce amount of cement used and save a lot money we use to pay on cement as well as saving environment.

1.4.2 GGBS: Use of Ground Granulated Blast Furnace Slag (GGBS) as filler Material Impact heater slag is a by-item which got in the fabricate of pig-iron. It is an item delivered by the mix of the gritty constituents of iron-mineral with the limestone flux at high temperature in the impact heater (around 150000c). The liquid slag is quickly extinguished by a hose of water to yield a lustrous granular item called granulated impact heater slag. Hydrated slag's, granulated or palletized, give an indistinguishable hydrates from Portland bond i.e., C-S-H and AF1 stages. As they respond more gradually with water than Portland concrete, they can be enacted by various courses: synthetically in nearness of lime and sulfate activators, physically by pounding or thermally. Slag, which is acquired by pounding the granulated impact heater slag, is exceedingly pozzolanic in nature. Concrete substitution levels of slag can be much higher than that of other pozzolanic materials, for example, Fly fiery debris and silica smolder. By and large, GGBS has higher "CaO" content than different pozzolanas. In INDIA Ground-granulated impact heater slag (GGBS) is gotten by extinguishing liquid iron slag (a by-result of iron and steel-production) from an impact heater in water or steam, to create a shiny, granular item that is then dried and ground into a fine powder.

2. WORKING METHODOLGY

Properties of Materials:

Cement: The cement used for this present study JPJ (OPC 53) grade cement conforming all conditions of IS 8112-1989. It is most recently manufactured, is of uniform color and also free of lumps. The physical property of the cement is determined considering codal provisions. Fineness of cement, normal consistency, specific gravity, setting time, soundness test, and compressive strength of cement, is determined.

Special cements:

OPC 53-S is a special type of cement. It is an example for Portland pozzolona cement. It is generally used in construction of railway sleeper and marine structures.

It is a specialty cement, manufactured as per specifications originally formulated by the Indian Railways vide their specificationNo.IRS T-40 for manufacturing concrete sleepers. However, there was, IS 12269, IRS T-40 cement and then, this was brought under the ambit of BIS. It is now designated as 53-S Ordinary Portland cements and conforms to Misspecification IS: 12269-1987. 53-S OPC's negligible chloride content, protects it against corrosion. High fineness enhances workability, and high early strength enables improved mass production cycle of Railway Sleepers. Apart from its main usage in the manufacture of concrete sleepers, it can also be put to use in concrete elements or high rise buildings where early strength is required.

Properties	Test values
Specific gravity	2.73
Bulk density	1.67
Water absorption	0.5
Fineness modulus	6.6
Aggregate impact value	24%

Physical properties of OPC-53grade and OPC-53-S grade cements

PROPERTITES	OPC 53	OPC 53-S
Fineness of cement	8%	1%
Standard consistency	32%	35%
Specific gravity	3.15	3.15
Initial setting time	40 minute	22 min
Final setting time	330 minute	150 min
Soundness	2mm	2mm

Fine Aggregate:

The sand which is used is comes under Zone –III as per IS 383-1970. The physical properties like zoning of sand, bulk density, specific gravity are determined according to the codal provisions Sieve analysis of fine aggregate.

Physical properties of fine aggregate:

Properties	Test results
Specific gravity	2.52
Fineness modulus	2.2
Bulk density	1.69

Coarse Aggregate: The coarse aggregate used is from well-established quarry, satisfying the code IS 383:1970. The mixture of coarse aggregates is used of only 20 mm .the material is of uniform color and has good angular shape. The physical properties like fineness- modulus, specific-gravity bulk-density, water-absorption, aggregate-impact, and crushing value.

Rice Husk Ash: Properties of RHA Rice Husk Ash are a Pozzolanic material. It is having different physical & chemical properties. The product obtained from R.H.A. is identified by trade name Silpoz which is much finer than cement. A residual RHA obtained from open field burning. The material was carefully homogenized and prepared in two conditions:

Natural RHA (NRHA): the ash was only dried, homogenized, and packed to enhance the transport to the laboratory. Grinded RHA (GRHA): after drying and homogenization process the RHA was

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ground in a laboratory ball mill by one hour for optimization.

Physical Properties of R.H.A.

Sr. No.	Particulars	Properties
1	Colour	Gray
2	Shape Texture	Irregular
3	Mineralogy	Non Crystalline
4	Particle Size	< 45 micron
5	Odour	Odourless
6	Specific gravity	2.3
7	Appearance	Very fine

GGBS: Ground Granulated Blast Furnace Slag (GGBFS) is a byproduct of the steel industry. Blast furnace slag is defined as "the non-metallic product consisting essentially of calcium silicates and other bases that is developed in a molten condition simultaneously with iron in a blast furnace." In the production of iron, blast furnaces are loaded with iron ore, fluxing agents, and coke. When the iron ore, which is made up of iron oxides, silica, and alumina, comes together with the fluxing agents, molten slag and iron are produced. The molten slag then goes through a particular process depending on what type of slag it will become. Air cooled slag has a rough finish and larger surface area when compared to aggregates of that volume which allows it to bind well with Portland cements as well as asphalt mixtures.GGBFS is produced when molten slag is quenched rapidly using water jets, which produces a granular glassy aggregate.

Physical Properties of GGBS.

Colour	Off-white
Specific gravity	2.9
Bulk density	1200
kg/m3Fineness	350m2/kg

MIX DESIGN: The grade of concrete depends up on the mix design of the concrete. The mixes up to M20 are nominal mix, i.e. M5, M10, M15, M20. Whereas the mix above M20 is designed mix. The mix design is based in strength criteria and durability criteria used for moderate environment. The ratios by weight of cement, fine aggregate and coarse aggregate are obtained using the specifications given in 10262-2009 are given below. These proportions are maintained strictly same throughout the casting process to obtain a uniform standard and workable concrete mix. Normally Cubes were tested for compressive strength after 7and28 days curing. In this project the, 7,28days tests are conducted.

The process of considering required amount of ingredients of concrete and also calculating their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredients of concrete is governed by the required performance of concrete in two states, namely the plastic and the hardened states. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes of vital importance

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The compressive strength of hardened concrete which is generally considered to be an index of its other properties, depending upon many factors, e.g. w/c ratio quality and quantity of cement, water, aggregate, exposure conditions, material properties, mixing, placing, compaction and soaked

In this project we consider the design specifications such as grade of concrete is M 50,exposure condition is severe, W/C as 0.4, slump of 100mm. required quantity of cement fine aggregate coarse aggregate is designed and final mix proportions is obtained. By considering the above design specifications and by considering the codal provisions in IS 10262-2009. The obtained mix design for By considering the 7 days 28 days compressive strength of all trail mix design the mix proportions is considered. So considering the trail mix calculations the mix proportions consider to this work is cement, sand, coarse aggregate, water for 1 m3 is given below.

Cement = 465kg
Sand = 589 kg
Coarse aggregate = 1188.5 kg
Water = 186liter

3. TESTS ON CONCTRETE

HARDENED CONCRETE:

The tests performed on the cured concrete are compressive strength, flexural strength, split tensile strength.

Preparation of specimen:

Before placing the concrete in the mould is its interior surface and base plate were lightly oiled to prevent the unevenness of the specimen. The mixed concrete is placed in the oiled mold in layers, each layer of having 5cm thick. After placing each layer it is pampered 30 times using a slandered tampered rod. The strokes penetrated into the underlying layer and the bottom layer was ridded throughout its depth.

Curing of test specimen:

As soon as the concreting is completed, the mould is stored in a place free from vibration, for 24 hours. Later the specimen is unmolded and submerged in a fresh water tank for curing.

3.1 Compressive strength:

After 28 days of curing the sample cubes are tested for compressive strength under compressive testing machine. The test samples are taken out from curing tank at least 4 to 5 hours of testing. For one trail at least three specimens are to be tested.

Fig 1 – testing of cubes for compressive strength

The cube is placed under the compressive testing machine in a way that the load should be applied opposite faces of the other than the casted faces. The load is applied on the cube continuously at the rate of 140kg/cm^2/min. the load is applied till the load break down and no more load can be taken i.e. the red needle returns back. The ultimate load is noted. The compressive

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strength is determined by dividing the ultimate strength by cube cross sectional area. Similarly the remaining two specimens are also tested. The average of the three specimens of one particular batch of mix gives the compressive strength. The variation of the strength of individual strength should not exceed more than 15%. If exceeded repeat the test.

3.2TEST FOR SPLIT TENSILE STRNGTH:

The specimens are tested for tensile strength for 28 days on split tensile testing machine. Specimen, preferably from different batches, should batches, should be made for testing for each selected age, specimen are removed from water before 4 to 5 hours of testing.

Fig 2 testing of specimens for split tensile strength

Where as in cylinders they are placed under the compressing testing machine in a way that the load is applied along the length of the cylinder. Continuous load at the rate of 140 kg/cm^2/min is applied till the maximum resisting load is attained, i.e. the red needle returns back. The ultimate load is noted. Split tensile strength of the specimen is calculated by diving the two times of the load during the test by dividing the two times of the load during the test by the surface area, calculated from the mean dimensions of the section. For one particular batch the average of the specimen are to be done. The average of the three specimens of one particular batch of mix gives the compressive strength. The variation of the strength of individual strength should not exceed more than 15%. If exceeded repeat the test.

4.2.3TEST FOR FLEXURAL STRENGTH:

Flexural strength of the concrete is done using the universal testing machine. The bearing surface of the supporting and loading rollers of the machine should be cleaned. The prism should be placed under the rollers in such a way that the load is applied on the uppermost surface of the casted mould. The prism should be marked at the spacing of 13.3cms a part.

Fig 3 testing of specimens for flexural tensile strength

The loading should be applied continuously at the rate of 180kg/cm2/mm in without any shock. The load is applied gradually until the specimen fails the failure load is to be noted. It is to be noted at which part the

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failure i.e. whether in first one third or second one third. Based on part in which failure occurred the flexural strength

4. RESULTS AND DISCUSSIONS

COMPRESSIVE STRENGTH:

Result representing the compressive strength values from 7days and 28 days at various replacement levels i.e. at 0 % to 40 % replacement of GGBS & Rice Hush Ash in both OPC 53 and OPC 53 S cements.

COMPRESSIVE-STRENGTH REULTS:

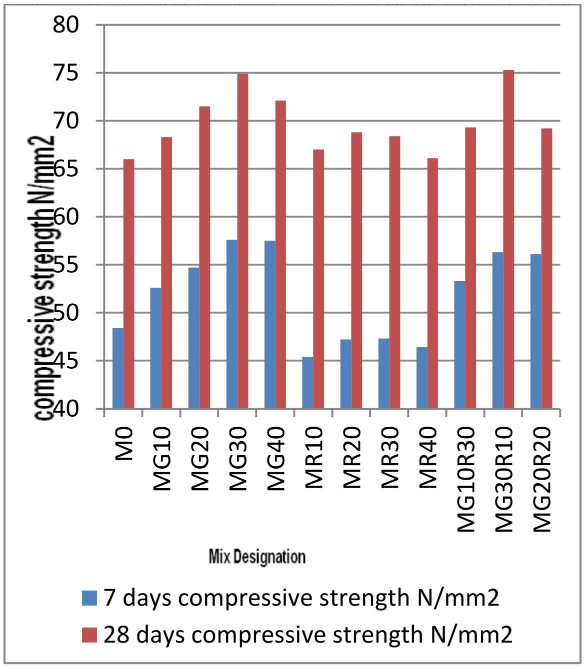

Fig: 4 shows compressive strength of conventional concrete verses various proportions of GGBS and rice husk ash Mix for 7days and 28 days

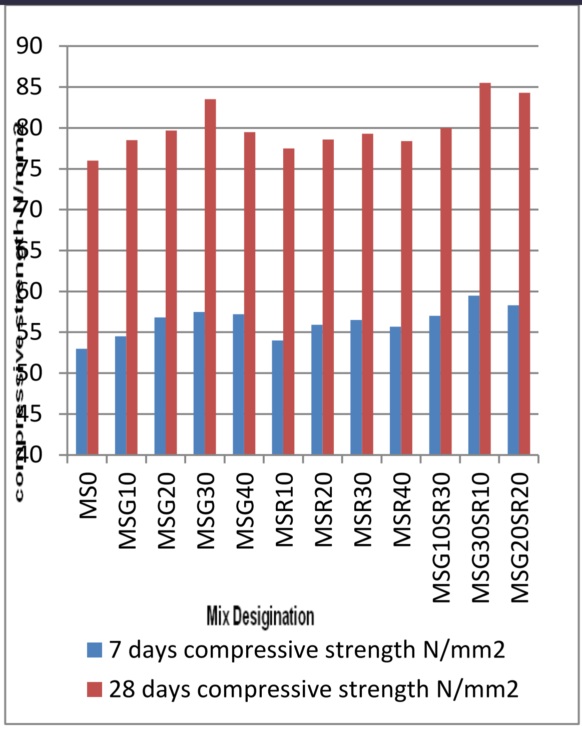

Fig: 5 shows compressive strength of special concrete verses various proportions of GGBS and rice husk ash Mix for 7days and 28 days

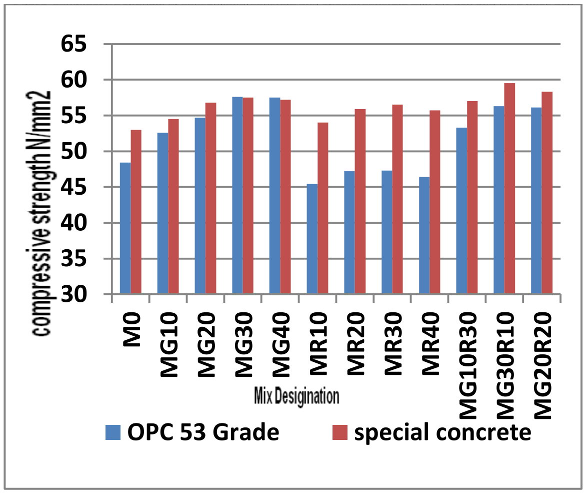

Fig: 6 shows compressive strength of conventional concrete and special concrete verses various proportions of GGBS and rice husk ash Mix for 7days

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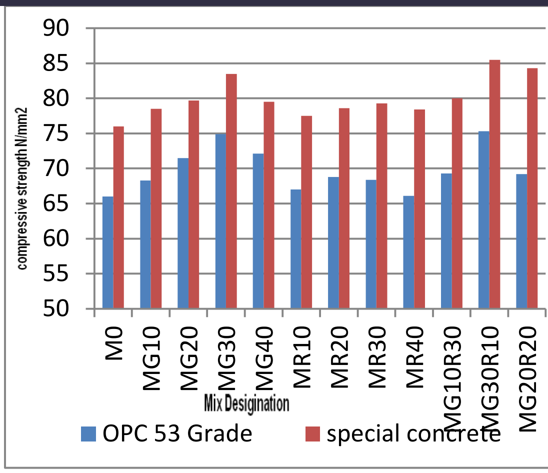

Fig: 7 shows compressive strength of conventional concrete special concrete verses various proportions of GGBS and rice husk ash Mix for 28days.

5.2 SPLIT TENSILE STRENGTH RESULT:

The standard size of cylinders of 300mm long and 150 mm diameter, cylinders are casted with the designed mix proportions in both OPC 53 and OPC 53 S ,and they are tested the specimens after 28 days curing in normal water.

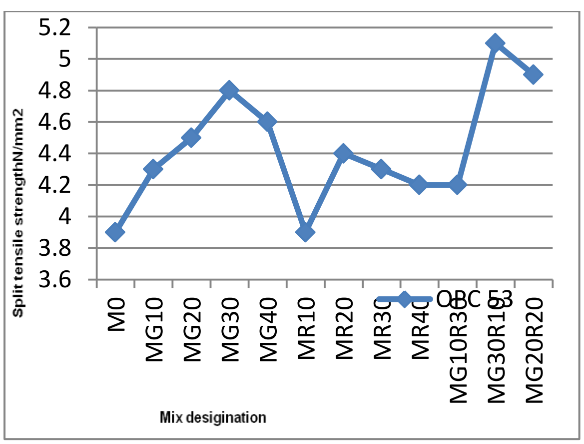

Fig: 8 shows split tensile strength of conventional concrete verses various proportions of GGBS and rice husk ash Mix for 28days

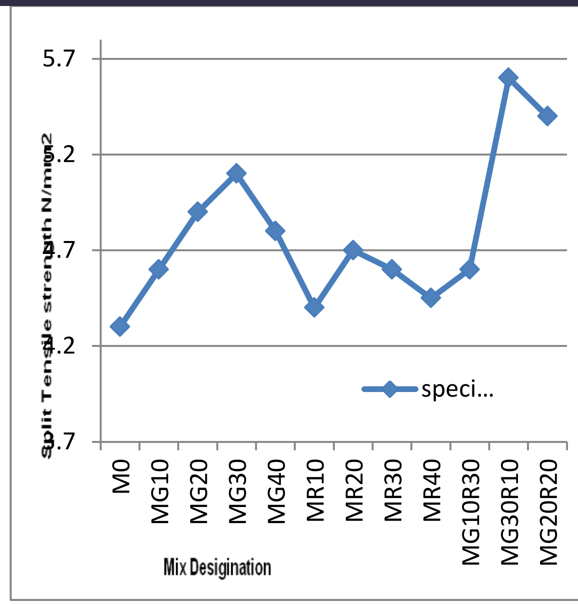

Fig: 9 shows split tensile strength of special concrete verses various proportions of GGBS and rice husk ash Mix for 28days

FLEXURE STRENGTH:

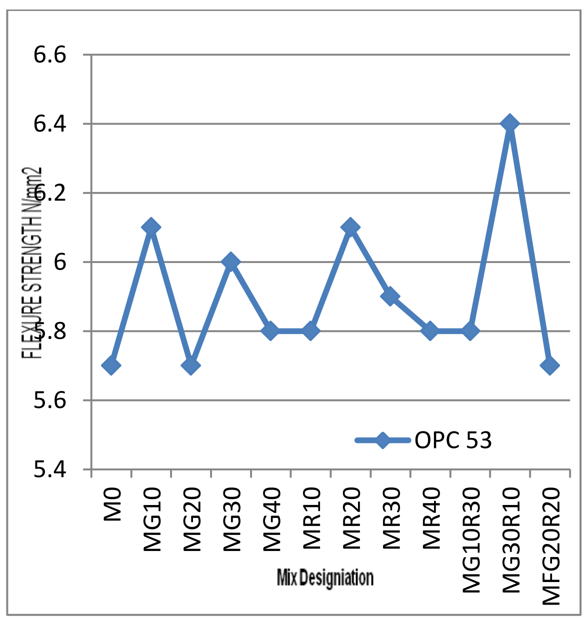

Fig: 10 shows flexural strength of conventional concrete verses various proportions of GGBS and rice husk ash Mix for 28days

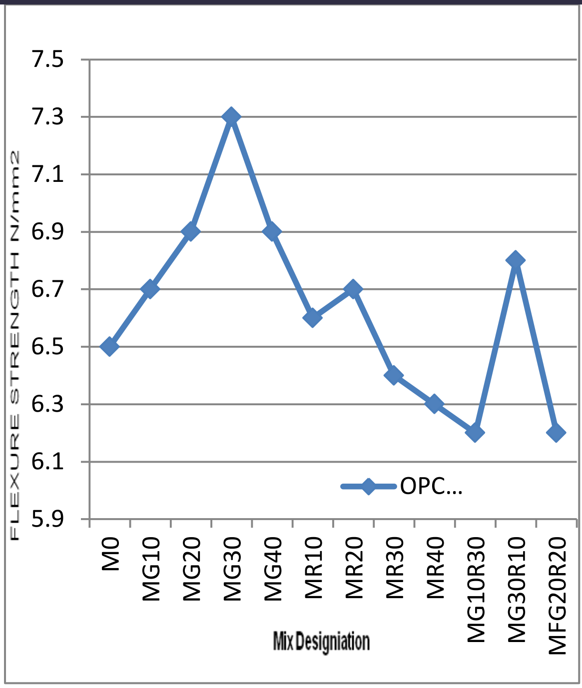

Fig: 11 shows flexural strength of special concrete verses various proportions of GGBS and rice husk ash Mix for 28days

5. CONCLUSIONS

1. The compressive strength result of concrete when replaced up to 30 % of GGBS is more than conventional aggregate concrete at the end of 28 days for normal curing
2. The split tensile, flexure strength result of when replaced up to 30 % of GGBS is more than the conventional aggregate concrete at the end of 28 days for normal curing.
3. The degree of workability is normal in special concrete is same up to 40 % level of replacement.
4. An increase of around 16.3 %, compressive strength for OPC 53 cement concrete when replaced with 30% of GGBS OPC 53 cement at the of 28, 56 90 days normal curing.
5. An increase of around 20.2 %of compressive strength is observed for OPC 53S cement concrete when replaced with 30% of GGBS& 10% Rice Hush Ash.
6. An increase of about 3.1 % of split tensile strength at 30 % replacement level after 28 days normal curing when the GGBS is replaced with OPC 53
7. An increase of about 3.9 % of split tensile strength at 30 % replacement of GGBS& 10% Rice Hush Ash after 28 days normal curing when the is replaced with OPC 53 S
8. An increase of about 5.15 % of flexural strength at 10 % replacement level after 28 days normal curing when the GGBS, Rice Hush Ash is replaced with OPC 53 grade cement
9. An increase of about 3.12 % of flexural strength at30% GGBS& 10 % of Rice Husk Ash replacement level after 28 days normal curing when the GGBS& Rice Husk Ash is replaced with OPC 53 S grade cement
10. Among all the mixes the 30% of GGBS&10% Rice Hush Ash as the more compressive strength

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