PERFORMANCE STUDY ON GGBS CONCRETE WITH PARTIAL REPLACEMENT OF FINE AGGREGATES BY ROBO SAND

A PROJECT REPORT

In partial fulfillment for the award of degree of

MASTER OF TECHNOLOGY

IN

CIVIL ENGINEERING

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Under The Guidance of

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2017

LOVELY PROFESSIONAL UNIVERSITY

CERTIFICATE

Certified that this project report entitled "Performance study on GGBS concrete with partial replacement of fine aggregates by robo sand" submitted by Praveen Pandey (41400010) student of Civil Engineering Department of LOVELY PROFESSIONAL UNIVERSITY, Phagwara, Punjab who carried out the project work under my supervision.

This report has not been submitted to any other university or institution for award of any degree.

Signature

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DECLARATION

I hereby declare that the project work entitled "Performance study on GGBS concrete with partial replacement of fine aggregates by Robo sand" is an authentic record of my work carried out as requirements of Project for the award of degree of Master of Technology in Civil Engineering from Lovely Professional University, Phagwara, under the guidance of **Mr.Paramveer Singh**, during January to May, 2017.This matter embodied in this report has not been submitted in part or full to any other university or institute for the award of any degree.

Signature

Praveen Pandey (41400010)

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For getting success in any field of life one only needs guidance and inspiration, both being very important as they help at each and every step in achieving the goal. "Its felt that words to be very insufficient, less and outplace to some extent in context of expressing sincere feeling to the people who contributed in completion of this project is no more than a mere ritual". So we thank all our teachers, our friends who have helped us in completion of this project.

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ABSTRACT

This capstone project reports the results of experiments on construction materials. The construction materials are making the idea of sustainable construction more believable every day. As more and more “green” buildings are constructed, builders and designers are beginning to develop more effective techniques for producing savings in both energy and materials usage. Green building movement is a relatively young phenomenon in the construction world. New methods nowadays, as the world population growth increase significantly, the used for more houses, buildings, and other infrastructures become major agenda for developing countries. India is one of the developing countries adopting sustainable development agenda as national strategy.

In this report, GGBS & Robo sand will chemically and physically characterized and will be used as partial replacement in the ratio of 0%, 10%, 20% and 30% by weight of cement and sand in concrete. Fresh concrete tests like compaction factor test and slump cone test will be taken as well as hardened concrete tests like Compressive strength, Split Tensile strength, Flexural strength at the age of 7 and 28 days will have been done for M30 grade of concrete. Test results will compared with conventional concrete and Ultimate Concrete for GGBS & robosand with different percentages used as partial replacement.

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LIST OF ABBREVIATIONS

S. NO.	ABBREVIATION	DESCRIPTION
1.	GGBS	Ground Granulated Blast Furnace Slag
2.	SCM	Supplementary Cementatious Materials
3.	CO2	Carbon di-oxide
4.	M30	M-Mix , 30- Strength of concrete after 28 days
5.	OPC	Ordinary Portland cement
6.	FM	Fineness Modulus
7.	SG	Specific Gravity

CHAPTER 1

INTRODUCTION

1.1 General

Concrete is the most famous and extensively used building material, owes to its advantageous properties, production and maintenance over steel and timber. Concrete is a matrix consists of basic ingredients namely binding material, fine aggregate, coarse aggregates and water. Conventional binding material cement has now become expensive and its production involves undesirable environmental consequences such as heavy production of Carbon dioxide (CO2). Conventional fine Aggregate, River sand has become scarce and its excessive use causes degradation of river bed and reduction in ground water recharge. To offset with these two challenges, an attempt has been made to produce concrete with supplementary and alternative materials. Ground granulated blast furnace slag which is byproduct of steel production, has been used to partially replace the cement. Quarry stone dust, a by-product from crushing process during quarrying activities has been used as an alternative fine aggregate that completely replaces the river sand which is far superior to river sand in all aspects. Various combinations have been made with different proportions of Cement, Ground Granulated Blast Furnace Slag, Quarry stone dust, Coarse aggregate and Water. Properties of concrete have been studied in fresh and hardened state for all combinations made and deducted the conclusions.

Concrete is very weak in tension and is brittle. Idea of using GGBS and quarry stone dust for improving the properties of building materials is very old. First applications include the addition of clay bricks reinforced horsehair plaster and asbestos reinforced ceramics. With the development and strengthening of reinforced concrete there is increase in the strength and ductility, but requires careful and intelligent placement of concrete.

Ingredients of concrete now became scarce and expensive. Production and excessive use of some conventional ingredients of concrete causes undesirable environmental consequences. Natural River sand is one of the constituents used in the production of concrete has become expensive and scarce. Hence there is a large demand for alternative building materials that replace the river sand without scarifying desired properties of concrete in fresh and hardened states. The crusher dust produced from granite crushers is one of such alternative building materials that replaces the river sand and named as quarry stone dust. It is popularly known by several names such as Crushed sand, Rock dust, Green sand, Robosand, Poabs sand, Barmac sand, and Pozzolona sand.

This Robo sand is far superior to conventional river sand and its unit price is little less or near to river sand. Conventional binding material in concrete is cement which has now become expensive and its production is not an eco-friendly activity. Hence there is great demand for alternative and supplementary cementitious materials. Ground Granulated Blast Furnace Slag (GGBS) is byproduct from iron manufacturing process.

Alternatively, use of fibres in reinforced or unreinforced concrete can provide good results. Latest development of fibre-reinforced concrete was started in the early sixties. Addition of fibres in the concrete can make it more homogeneous, consistent and isotropic material. When concrete cracks, randomly oriented fibres begin to work, stop the crack formation and propagation, and thus to improve the strength and ductility. The failure modes are either broken bond between the fibres and the matrix or hardware failure. This report sets state-of-the-art fibre concrete was investigated and reported results of surgical tests carried out on the properties of fibre reinforced concrete with local materials.

It is supplementary cementitious material which partially replaces the cement in concrete. GGBS unit price is almost half of the price of cement. Its replacement has considerable advantages in properties of concrete in fresh and hardened state. A study is required to assess the effects of combination of GGBS and quarry stone dust in fresh and hardened state of concrete.

1.2 Objective and Scope

- The main objective of the present report is to study High Performance Concrete incorporating GGBS and quarry stone dust resulting in required strength characteristics. In the present investigation we design mix for M30 has been calculated using IS 10262-2009 for both conventional concrete and partially replaced concrete.
- Tests were conducted on cubes, cylinders and beams to study the strength of concrete by using GGBS and quarry dust and the results were compared with the Natural Concrete. During the present study, 0%, 10%, 20% and 30% of traditional cement and fine aggregates were replaced with GGBS and quarry dust. Compression, split tensile and flexural strengths were found after 7 days and 28days of curing.
- High performance concrete conforms to a set of standards above those of the common applications such as high strength, high workability, high elastic modulus, low permeability and high durability.
- Concrete is generally a mixture of cement, fine and coarse aggregates and water. In order to minimize the cost of construction and to utilize the waste product from the iron industry beneficially, cement is replaced with Ground Granulated Blast Furnace Slag partially in various proportions.
- GGBS is a byproduct of the steel industry and is obtained when molten slag is quenched rapidly with the utilization water jets. GGBS is a non - hazardous and non - metallic waste of the iron industry is eco-friendly and helps in improving the strength, workability and durability characteristics of the concrete. River sand which is one of the basic ingredients in the manufacture of concrete has become highly scarce and expensive.
- Hence, the crusher dust which is also known as quarry stone dust can be used as an alternative material for the river sand. Stone dust possesses similar properties as that of river sand and hence accepted as a building material. Stone dust basically contains angular particles with rough texture that pass through 4.75 mm sieve.

CHAPTER 2

LITERATURE REVIEW

2.1 Ground Granulated Blast funace Slag

Many researchers have been carried out studies on GGBS in the past years to assess the properties and its behaviour. Some of the works carried out are discussed below.

K.Ganesh Babu presented an effort to quantify the 28days cementatious efficiency of ground granulated blast furnace slag in concrete at the various replacement levels. The replacement levels in the concrete studied varied from 10% to 80% and the strength efficiencies at the 28days were calculated. Strength efficiency factor varied from 1.29 to 0.70 for percentage replacement levels varying from 10% to 80%.Overall the prediction of the strength of concretes varying from 20 to 100MPa with GGBS levels varying from 10% to 80% by this method was found to result in a regression coefficient of 0.94 which was also the same for normal concretes.

Pazhani.K presented that the slump value for 100% replacement of fine aggregate with copper slag increases by 60-85 mm. The replacement of 30% of cement by GGBS decreases the water absorption by 4.58%, chloride ion permeability by 29.9% and pH value by 0.39%. The replacement of 100% of fine aggregate by copper slag decreases water absorption by 33.59%, chloride ion permeability by 77.32% and pH value by 3.04%.

Venu Malagavelli investigated the characteristics of M30 concrete with partial replacement of cement with GGBS and sand with the crusher dust. Compressive strength and split tensile strengths of cubes and cylinders were increased as the % of crusher dust increased. The % of increase in compressive strength were 19.64 and 8.03% at the age of 7 and 28 days and % of increase in split tensile strength was 1.83% at the age of 28 days by replacing 30% sand with crusher dust with 1.5% admixture. The % of increase in compressive strength of concrete was 11.06 and 17.6% at the age of 7 and 28 days by replacing 50% of cement with GGBS and 25% of sand with crusher dust.

M.C.Nataraja investigates, shows that the compressive strength of cement mortar increases as the replacement level of GGBS increases. This increase is not substantial. However for 100% replacement the strength decreases marginally compared to 100% natural sand. From this it is clear that GGBS sand can be used as an alternative to natural sand from the point of view of strength. Use of GGBS upto 75% can be recommended.

Mahesh Patel investigated the characteristics of M35 concrete with partial replacement of cement with GGBS and sand with crusher sand. Compressive & Tensile strength tests were carried out on cubes and cylinders. Based on the results the compressive strength and split tensile strength were increased as the % of crusher sand increased & 50% of cement can be replaced with GGBS. The % increase of compressive strength of concrete is 10.04 and 16.54% at the age of 7 and 28 days by replacing 40% of cement with GGBS and 20% of sand with crusher sand.

Oormila.T.R & T.V. Preethi carried out a study on soil characteristics was treated with various percentages of GGBS (15%, 20% & 25%) and UCS test was performed. From the UCS value it was found that soil treated with 20% of GGBS gives the optimum strength when compared with the virgin soil with an increment of 73.79% for 21 days of curing.

2.2 Quarry Stone Dust

Many researchers have been carried out investigated on stone dust in the past years to assess the properties and its behaviour. Some of the works carried out are discussed below

S.L. Beckwith, J.M. Justice, L.H. Kennison, B.J. Mohr investigates the performance of two metakaolins as Supplementary Cementatious Materials (SCMs) was evaluated at 8% by weight cement replacement. The metakaolins varied by their surface area (11.1 vs. 25.4 ECO25%/g). Performance of metakaolin mixtures was compared to control mixtures at water-to- cement ratios of 0.40, 0.50, and 0.60 where no SCM had been used and to mixtures where silica fume had been used as partial replacement for cement. In both mixtures containing metakaolins, compressive, splitting tensile and flexural strengths increased, as well as elastic modulus, as

compared to control mixtures. Setting time was reduced in the pastes with both metakaolins. Additionally, considering durability, both metakaolins reduced rapid chloride ion permeability and expansion due to alkali-silica reaction when compared to control and silica fume mixtures.

In general, the finer of the two metakaolins proved more effective in improving concrete properties, although both performed superior to silica fume.

Vishnumanohar investigates by carried out stone dust (finely graded silica) is a locally available, low cost, and inert industrial solid waste whose disposal is a matter of concern likes construction waste. On an overall, the stone dust can be comparable to the natural river sand. The stone dust satisfies the zone II gradation for not only to partially replace the sand, but for making good concrete. From the obtained results we observed that the maximum strength is achieved by 15% of fine aggregate replacement with stone dust in concrete. While increasing the percentage of stone dust the compressive strength value is getting decreased. From the SEM analysis, at a 15% replacement the mix remains homogeneous as the micro pores are filled and the transition zone is densified. Higher the percentage of fine aggregate replacement higher was the strength activity index. The strength activity index nearly varies linearly with percentage replacement of fine aggregate with stone dust. The maximum strength activity index was 1.49 at 15% replacement level. From the experimental investigation it was found that 15% replacement level is the optimum level.

CHAPTER 3

MATERIALS

3.1 MATERIAL

The materials used in research are:

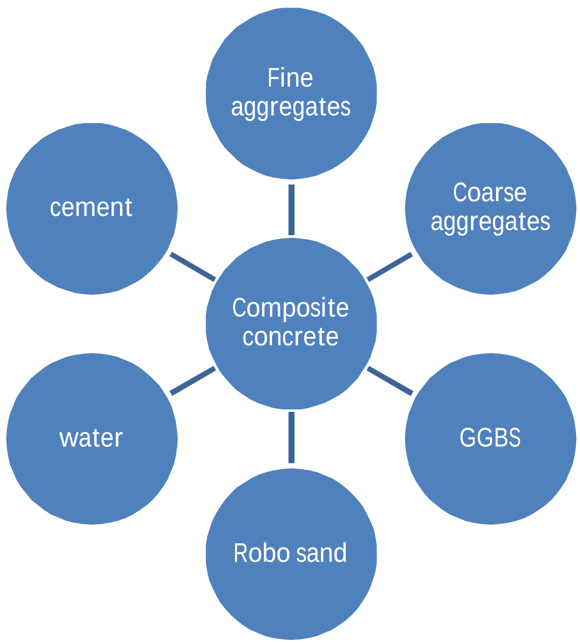

Fig.3.1 Composition of composite concrete

1. Portland cement (43 grade)

2. Fine aggregate (4.75 mm down)

3. Coarse aggregate (20 mm down& 10 mm down)

4. Robosand

5. GGBS

6. Water

3.1.1 Cement

Ordinary Portland cement of 43 grade conforming to Indian Standard IS 12269-1987 was used throughout the experimental program. Cement must develop the appropriate strength. It must represent the appropriate rheological behavior. Generally same types of cements have quite different rheological and strength characteristics, particularly when used in combination with admixtures and cementing material.

Fig. 3.2 OPC grade 43

3.1.2 Fine Aggregate

Fine aggregate (sand) used for this entire investigation for concrete was river sand conforming to zone-II of IS: 383-1970. Fine aggregate normally consists of natural, crushed, or manufactured sand. The physical properties of fine aggregate like specific gravity, gradation and fineness modulus are tested in accordance with IS :2386.

3.1.3 Coarse Aggregate

Coarse aggregate crushed granite of 20 mm down and 10 mm down size has been used as coarse aggregate. The physical properties of coarse aggregate like specific gravity, Bulk density, impact value, gradation and fineness modulus are tested in accordance with IS: 2386.

Fig.3.3 Coarse aggregates

3.1.4 Ground Granulated Blast Furnace Slag

Ground Granulated Blast Furnace Slag (GGBS) is a by-product from the blast-furnaces used to make iron. These operate at a temperature of about 1,500 degrees centigrade and are fed with a carefully controlled mixture of iron-ore, coke and limestone. The iron ore is reduced to iron and the remaining materials form a slag that floats on top of the iron. This slag is periodically tapped off as a molten liquid and if it is to be used for the manufacture of GGBS it has to be rapidly quenched in large volumes of water. The quenching optimizes the cementitious properties and produces granules similar to coarse sand. This 'granulated' slag is then dried and ground to a fine powder.

Fig. 3.4 GGBS

3.1.5 Robo sand

Quarry Stone dust is a fine aggregate that is produced by crushing stone, gravel, or slag. Used for aggregate material less than 4.75 mm that is processed from crushed rock or gravel or from quarry during stone crushing and intended for construction use. Stone dust is a material of high quality, in contradiction to non-refined surplus from coarse aggregate production.

3.1.6 Water

The water, which is used for making concrete and for curing, should be clean and free from harmful impurities such as oil, alkali, acid, etc, in general, the water, which is fit for drinking should be used for making concrete.

CHAPTER 4

EXPERIMENTAL STUDY

4.1 General

Experiments were carried out on cement and aggregates and then later on the resulting concrete, in order to evaluate various parameters of the materials and the concrete, to determine whether the materials and the concrete give the expected results.

4.2. Material testing

4.2.1. Cement

4.2.1.1.FINENESS TEST

To determine the fineness of cement by dry sieving as per IS: 4031 (Part 1) – 1996.The principle of this is that we determine the proportion of cement. The apparatus used are 90µm IS Sieve, Balance capable of weighing 10g to the nearest 10mg, A nylon or pure bristle brush, preferably with 25 to 40mm, bristle, for cleaning the sieve. Sieve shown in pic below is not the actual 90µm sieve. Its just for reference.

Fig 4.1 Sieves

Procedure

i) Weigh approximately 10g of cement to the nearest 0.01g and place it on the sieve.

ii) Agitate the sieve by swirling, planetary and linear movements, until no more fine material through it.

iii) Weigh the residue and express its mass as a percentage R1,of the quantity first placed on the sieve to the nearest 0.1 percent.

iv) Gently brush all the fine material off the base of the sieve.

v) Repeat the whole procedure using a fresh 10g sample to obtain R2. Then calculate R as the mean of R1 and R2 as a percentage, expressed to the nearest 0.1 percent. When the results differ by more than 1 percent absolute, carry out a third sieving and calculate the mean of the three values.

Reporting of Results

Report the value of R, to the nearest 0.1 percent, as the residue on the 90µm sieve.

4.2.1.2CONSISTENCY

The basic aim is to find out the water content required to produce a cement paste of standard consistency as specified by the IS: 4031 (Part 4) – 1988. The principle is that standard consistency of cement is that consistency at which the Vicat plunger penetrates to a point 5-7mm from the bottom of Vicat mould.

Fig.4.2 Vicat's apparatus

Procedure to determine consistency of cement

i) Weigh approximately 400g of cement and mix it with a weighed quantity of water. The time of gauging should be between 3 to 5 minutes.

ii) Fill the Vicat mould with paste and level it with a trowel.

iii) Lower the plunger gently till it touches the cement surface.

iv) Release the plunger allowing it to sink into the paste.

v) Note the reading on the gauge.

vi) Repeat the above procedure taking fresh samples of cement and different quantities of water until the reading on the gauge is 5 to 7mm.

4.2.1.3 INITIAL AND FINAL SETTING TIME

We need to calculate the initial and final setting time as per IS: 4031 (Part 5) – 1988. To do so we need Vicat apparatus conforming to IS: 5513 – 1976, Balance, whose permissible variation at a load of 1000g should be +1.0g, Gauging trowel conforming to IS: 10086 – 1982.

Procedure to determine initial and final setting time of cement

i) Prepare a cement paste by gauging the cement with 0.85 times the water required to give a paste of standard consistency.

ii) Start a stop-watch, the moment water is added to the cement.

iii) Fill the Vicat mould completely with the cement paste gauged as above, the mould resting on a non-porous plate and smooth off the surface of the paste making it level with the top of the mould. The cement block thus prepared in the mould is the test block.

A) INITIAL SETTING TIME

Place the test block under the rod bearing the needle. Lower the needle gently in order to make contact with the surface of the cement paste and release quickly, allowing it to penetrate the test block. Repeat the procedure till the needle fails to pierce the test block to a point 5.0 ± 0.5mm measured from the bottom of the mould.The time period elapsing between the time, water is added to the cement and the time, the needle fails to pierce the test block by 5.0 ± 0.5mm measured from the bottom of the mould, is the initial setting time.

B) FINAL SETTING TIME

Replace the above needle by the one with an annular attachment. The cement should be considered as finally set when, upon applying the needle gently to the surface of the test block, the needle makes an impression therein, while the attachment fails to do so. The period elapsing between the time, water isadded to the cement and the time, the needle makes an impression on the surface of the test block, while the attachment fails to do so, is the final setting time.

4.2.1.4 SPECIFIC GRAVITY TEST OF CEMENT

Procedure

Weigh a clean and dry Le chatelier flask with its stopper (W1). Place a sample of cement upto half of the flask and weight with its stopper(W2). Add kerosene to cement in flask till it is about half full. Mix thoroughly with glass rod to remove entrapped air. Continue stirring and add more kerosene till it is flush with the graduated mark. Dry the outside and weigh(W3). Entrapped air may be removed by vacuum pump, if available. Empty the flask, clean it refills with clean kerosene flush with the graduated mark wipe dry the outside and weigh (W4).

Calculations

$$\text{Sp gr.} = \frac{(W2) - (W1)}{(W2-W1) - (W3-W4)\ 0.79}$$

Where W1 = weight of empty flask

W2 = weight of flask + cement

W3 = weight of flask + cement + kerosene

W4 = weight of flask + kerosene

0.79 = specific gravity of kerosene

4.2.2 Fine Aggregates

4.2.2.1 FINENESS MODULUS OF FINE AGGREGATES

Fineness modulus of fine aggregate is an index number which represents the mean size of the particles in sand. It is calculated by performing sieve analysis with standard sieves. The cumulative percentage retained on each sieve is added and divided by 100 gives the value of fineness modulus of fine aggregate.

Fine aggregate means the aggregate which passes through 4.75mm sieve. To find the fineness modulus of fine aggregate we need sieve sizes of 4.75mm, 2.36mm, 1.18mm, 0.6mm, 0.3mm and 0.15mm. Fineness modulus of finer aggregate is lower than fineness modulus of coarse aggregate.

The apparatus used are standard sieves, dry oven and digital weight scale.

Fig. 4.3 Sieves

Procedure to determine the fineness modulus of fine aggregates

i) Take a sample of fine aggregate in pan and placed it in dry oven at a temperature of 100 – 110°C. After drying take the sample and note down its weight.

ii) Take the sieves and arrange them in descending order with the largest sieve on top.

iii) Pour the sample in the top sieve and close it then hold the top two sieves and shake it inwards and outwards, vertically and horizontally. After some time shake the 3rd and 4th sieves and finally last sieves.

iv) After sieving, record the sample weights retained on each sieve. Then find the cumulative weight retained. Finally determine the cumulative percentage retained on each sieves. Add the all cumulative percentage values and divide with 100 then we will get the value of fineness modulus.

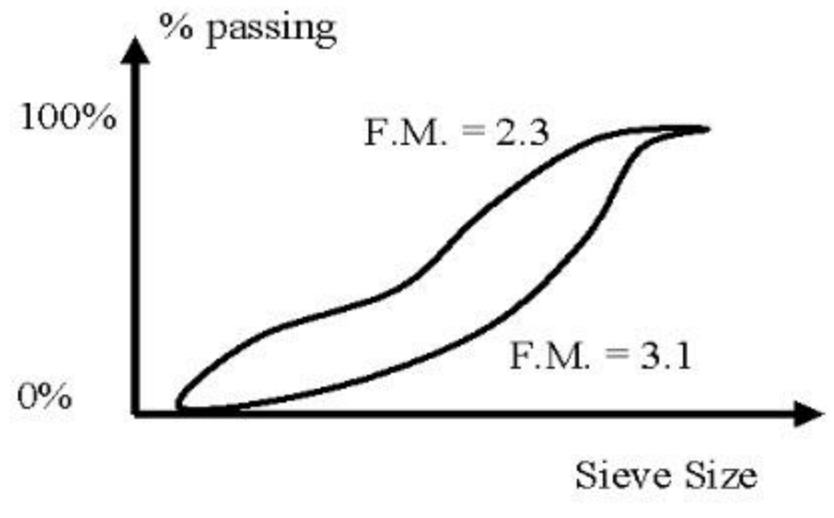

Fig. 4.4 Fineness modulus range for concrete sand

IS Sieve Designation	Percentage Passing for			
	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
10 mm	100	100	100	100
4·75 mm	90-100	90-100	90-100	95-100
2·36 mm	60-95	75-100	85-100	95-100
1·18 mm	30-70	55-90	75-100	90-100
600 micron	15-34	35-59	60-79	80-100
300 micron	5-20	8-30	12-40	15-50
150 micron	0-10	0-10	0-10	0-15

Fig. 4.5 IS classifications of zones (IS 380 – 1970)

4.2.2.2 SPECIFIC GRAVITY OF FINE AGGREGATES

The apparatus required are a weighing balance not less than 3kg capacity, oven maintained at temperature of 100- 110 degree C, pycnometer with 1litre capacity, a tray not less than 32 cm^2 area, filter paper and funnels.

Fig 4.6 Pycnometer

Procedure to determine the specific gravity of fine aggregates

i)Take about 500g of sample and place it in the pycnometer.

ii) Pour distilled water into it until it is full.

iii) Eliminate the entrapped air by rotating the pycnometer on its side ,the hole in the apex of the cone being covered with a finger.

iv) Wipe out the outer surface of pycnometer and weigh it (W).

v) Transfer the contents of the pycnometer into a tray , care being taken to ensure that all the aggregate is transferred.

vi) Refill the pycnometer with distilled water to the same level.

vii) Find out the weight (W1).

viii) Drink water from the sample through a filter paper.

ix)Place the sample in oven in a tray at a temperature of 100ºC to 110º C for 24±0.5 hours during which period ,it is stirred occasionally to facilitate drying .

x) Cool the sample and weigh it (W2).

Calculation

Sp Gravity of fine aggregates = W2 / (W2- (W-W1))

4.2.3 Coarse Aggregates

4.2.3.1 SPECIFIC GRAVITY OF COARSE AGGREGATES

The apparatus required are weighing balance not less than 3kg capacity, oven maintained at a temperature of 100 to 110 degree C, a wire basket not more than 6.3mm mesh, a stout water tight container, two dry soft absorbent clothes and a shallow tray of area not less than 650 cm^2.

Fig. 4.7 Wire basket

Procedure to determine Specific gravity of coarse aggregates

i) Take 2 kg of aggregate. Sample larger than 10mm.

ii) Wash the sample thoroughly to remove finer particle and dust.

iii) Place the sample in a wire basket and immerse it in distilled water at a temperature between 22 and 32 degree C with a cover of at least 5 cm of water above the top of the basket.

iv) Remove the entrapped air by lifting the basket containing the sample 25 mm above the base of the tank and allowing it to drop per second, care being taken to see that the sample is completely immersed in water during the operation.

v) Weigh the sample in water at a temperature of 22oC-32oC and note the weight as W1.

vi) Remove the basket and aggregate from water and allow to drain for a few minutes.

vii) Empty the aggregate from the basket to a shallow tray.

viii) Immerse the empty basket in water jolt 25 times and then note the weight in water as W2.

ix) Place the aggregates in oven at a temperature of 100 to 110 degree C for 24+- 0.5 hours.

x) Remove it from the oven and cool it and find the weight and note it as W3.

Calculations

Specific Gravity = W3 / (W3- (W1-W2))

4.2.4. TEST RESULTS

4.2.4.1. Cement

Cement Properties Grade of Cement – OPC 43

Fineness - 2 % (Dry Sieving Method)

Specific Gravity - 3.12

Consistency - 31 %

Initial Setting Time - 38 minutes

Final Setting Time - 210 minutes

4.2.4.2. GGBS

Specific Gravity - 2.89

4.2.4.3.Fine Aggregates

River Sand Properties

Zone – II

Fineness modulus – 2.78

Specific Gravity - 2.62

4.2.4.4. Quarry Stone Dust

Zone – II

Fineness Modulus - 2.81

Specific Gravity - 2.68

4.2.4.5. Coarse Aggregates

Specific Gravity - 2.65

Water Absorption – 0.39%

CHAPTER 5

MEHODOLOGY

5.1 General

In this chapter the method of research and design mix have been described for various percentages of replacement of GGBS and quarry stone dust with cement and sand respectively.

Concrete specimens were casted using 0%, 10%, 20% and 30% of replacement of cement by GGBS and fine aggregate with stone dust. Cubes of standard size 150mm were casted and tested for 7 and 28 days compressive strength. Standard cylinders of size100mmx 200mm (diameter x height) were casted and tested for 7 and 28 days for split tensile strength. Also standard prisms of size 500mm x 100mm x 100mm (length x width x height) were cast and tested for 28days for flexural strength and observed the percentage of water absorption in both quarry Stone dust and Natural sand.

5.2 Mix Design

5.2.1. Introduction

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required strength,durability and workability as possible as economically is termed the concrete mix design. The ingredient proportioning of concrete is given by the required performance of concrete in two states, namely 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. The compressive strength of hardened concrete which is generally considered to be an index of its other properties, depends upon many factors, e.g. quality and quantity of cement, water and aggregates; batching and mixing; placing, compaction and curing. From technical point of view the rich mixes may lead to high shrinkage and cracking in the structural concrete, and to evolution of high heat of hydration in mass concrete which may cause cracking.

5.2.2. Types of Mixing

5.2.2.1. Nominal Mix

In the past the specifications for concrete prescribed the proportions of cement, fine and coarse aggregates. These mixes of fixed cement aggregate ratio which ensures adequate strength are termed nominal mixes. These mixes provide a marginal strength, however, due to the variability of mix ingredients the nominal concrete for a given workability varies widely in strength.

5.2.2.2 Standard Mix

The nominal mixes of fixed cement aggregate ratio vary widely in strength and may result in varied mixes. For this reason, the minimum compressive strength has been included in many specifications. These mixes are termed standard mixes.

IS 456-2000 has designated the concrete mixes into a number of grade as M10, M15, M20, M20, M25, M30 and M40. In this designation the letter M refers to the mix and the number to the specified 28 day cube strength of mix in N/mm^2. The mixes of grades M10, M15, M20 and M25 correspond approximately to the mix proportions (1:3:6), (1:2:4), (1:1.5:3) and (1:1:2) respectively.

5.2.2.3 Design Mix

In these mixes the performance of the concrete is specified by the designer but the mix proportions are determined by the producer of concrete, except that the minimum cement content can be laid down. This is most rational approach to the selection of mix proportions with specific materials in mind possessing more or less unique characteristics. The approach results in the production of concrete with the appropriate properties most economically. However, the designed mix proportions for the prescribed performance.

It is a performance based mix where choice of ingredient and proportioning are left to the designer to be decided. The user has to specify only the requirement of concretes. The requirement in fresh concrete are workability and finishing characteristics, whereas in hardened concrete these are mainly the compressive strength and durability.

5.2.3. Factors affecting the choice of mix proportions

The various factors affecting the mix design are:

Compressive strength

It is one of the most important properties of concrete and influences many other describable properties of the hardened concrete. The mean compressive strength required at a specific age, usually 28 days, determines the nominal water cement ratio of the mix. The other factor affecting the strength of concrete at a given age is the degree of compaction this is cured at a prescribed temperature. As we know according to Abraham's law the strength of fully compacted concrete is inversely proportional to the water cement ratio.

Workability

The degree of workability required depends on three factors. These are the size of section to be concreted, the amount of reinforcement, and the method of compaction to be used. For the narrow and complicated section with numerous corners or inaccessible parts, the concrete must have a high workability so that full compaction can be achieved with a reasonable amount of effort. This also applies to the embedded steel sections. The desired workability depends on the compacting equipment available at the site.

Durability

The durability of concrete depends upon the aggressive environmental conditions. High strength concrete is generally more durable than low strength concrete. In the situations when the high strength is not necessary but the conditions of exposure are such that high durability requirement will determine the water cement ratio to be used.

Maximum nominal size of aggregates

The workability of concrete increase with increase in maximum size of the aggregate. In general larger the size of aggregate smaller is the cement requirement. However the compressive strength tends to increase with the decrease in size of aggregate.

Grading and type of aggregates

The grading of aggregate influences the mix proportions for a specific workability and water cement ratio. Coarser the grading leaner will be mix which can be used. Very lean mix is not desirable since it does not contain enough finer material to make the concrete cohesive.

The type of aggregate influences strongly the aggregate cement ratio for the desired workability and stipulated water cement ratio. An important feature of a satisfactory aggregate is the uniformity of the grading which can be achieved by mixing different size fractions.

Quality Control

Quality control can be estimated statistically by the variations in test results. The variation in strength results from the variations in the properties of the mix ingredients and lack of control of accuracy in batching, mixing, placing, curing and testing. The lower the difference between the mean and minimum strengths of the mix lower will be the cement content required. The factor controlling this difference is termed as quality control.

5.2.4 Concrete mix proportion as per IS 10262:2009

An M30 grade of concrete was designed as per the provisions of IS 10262:2009

1) Target Mean Strength (F_{ck}):

$F'_{ck} = F_{ck} + 1.65*S$ [IS 10262:2009, Clause 3.2]

F_{ck} = characteristic compressive strength = 30 N/mm^2

S = standard deviation = 5 [IS 10262:2009, Table 1]

$F'_{ck} = 30 + 1.65*5$

$F'_{ck} = 38.25\ N/mm^2$

2) Water – Cement Ratio: [IS 456:2000, Table 5]

Min cement content = 320 Kg/m^3

Max cement content = 450 Kg/m^3

Max w/c ratio = 0.45

3) Water Content: [IS 10262:2009, Table 2]

Nominal maximum size of aggregates = 20 mm

Max water content = 191 Kg/m^3

4) Cement Content

w/c ratio = 0.45

cement= 191/0.45 = 425 Kg/m^3

5) Mix Calculations

i) Volume of concrete= $1m^3$

ii) Volume of cement= (425/3.12)*(1/1000)= 0.136 m^3

iii) Volume of water=(191/1)*(1/1000)= 0.191 m^3

iv) Volume of aggregates= 1-(0.136+.191) = $0.673m^3$

v) (Volume of coarse aggregates/Total volume of aggregates) = .61

vi) Volume of fine aggregates= (1- 0.61)* 0.673 = $0.262m^3$

vii) Mass of fine aggregates= 0.262*2.62*1000= 686.4 Kg

viii) Mass of coarse aggregates= 0.41*2.65*1000= 1086.5 Kg

6) Ratio = Cement: Fine aggregates: Coarse aggregates: Water Content

= 425: 686.4: 1086.5: 191

=1: 1.6: 2.6: 0.45

5.2.4.1. Mix proportions for cube

Volume of mold= (0.15*0.15*0.15)= 0.003375m^3

Design volume = 1.52* 0.003375= 0.0513m^3

S.No	Cement(kg)	Fine Aggregates(kg)	Coarse Aggregates(kg)	Water(kg)	GGBS (15% fixed)(Kg)	Quarry Stone dust(kg)
1.	3.078	4.135	6.79	1.39	-	-
2.	2.62	3.72	6.79	1.39	0.46	0.41(10%)
3.	2.62	3.31	6.79	1.39	0.46	0.83(20%)
4.	2.62	2.9	6.79	1.39	0.46	1.24(30%)

Table 1 Mix proportion of cube

5.2.4.2. Mix proportions for cylinder

Volume of mold= (3.14*0.05*0.05*0.2)= 0.00157m^3

Design volume = 1.52* 0.00157= 0.00238m^3

S.No.	Cement(kg)	Fine Aggregates(kg)	Coarse Aggregates(kg)	Water(kg)	GGBS (15% fixed)(Kg)	Quarry Stone dust(kg)
1.	1.43	1.93	3.16	0.64	-	-
2.	1.21	1.74	3.16	0.64	0.21	0.19(10%)
3.	1.21	1.54	3.16	0.64	0.21	0.38(20%)
4.	1.21	1.35	3.16	0.64	0.21	0.58(30%)

Table 2Mix proportion of cylinder

5.2.4.3. Mix proportions for beam

Volume of mold= (*0.1*0.1*0.5)= 0.005m^3

Design volume = 1.52* 0.005= 0.0076m^3

S.No	Cement(kg)	Fine Aggregates(kg)	Coarse Aggregates(kg)	Water(kg)	GGBS (15% fixed)(Kg)	Quarry Stone dust(kg)
1.	4.56	6.12	10.07	2.05	-	-
2.	3.88	5.51	10.07	2.05	0.68	0.61(10%)
3.	3.88	4.89	10.07	2.05	0.68	1.22(20%)
4.	3.88	4.28	10.07	2.05	0.68	1.84(30%)

Table 3Mix proportion of beam

CHAPTER 6

CONCRETE TESTING

The fresh concrete was tested for the workability by the slump cone test and the hardened concrete was tested for the compression, split tensile and flexure test.

6.1 Slump Cone Test

Slump cone test has been adopted to measure the workability of concrete. The slump cone was placed on a horizontal and non-absorbent surface and filled in 3 equal layers of fresh concrete, each layer being tamped 25 times with standard tamping rod. The top layer was struck off level and the mould is lifted vertically without disturbing the concrete cone. The subsidence of concrete in millimeters was measured as the slump.

Types of slump

i) Collapse

In a collapse slump the concrete collapses completely.

ii) Shear

In a shear slump the top portion of the concrete shears off and slips sideways.

iii) True

In a true slump the top portion of the concrete shears off and slips sideways.

Fig. 6.1 Slump Test

6.2Compression test

Cubes of dimensions 150 x 150 x 150 mm were casted and cured for various curing periods. Compression testing machine of capacity 1000KN has been to test the cubes and to measure the compressive strength of concrete. Rate of loading was 5.2 KN per second. Peak load divided by cross sectional area of cube was estimated as compressive stress. The average compressive stress of 3 cubes was recorded as compressive strength of concrete.

Fig.6.2 Compression Test

6.3.Split Tensile Strength test

Cylinders of 100 mm diameter and 200 mm length were casted and cured for various curing periods. Universal Testing Machine of capacity of 1000KN has been use for this test. Rate loading was 2.5 KN per second. The below formula was to calculate the split tensile strength of concrete. From theory of elasticity the following formula for the evaluation of the splitting tensile strength fct is obtained.

$$Fct = 2P/(3.14 \times d \times L)$$

P = Peak load

d = diameter of cylinder

L = length of cylinder

Fig. 6.3 Split Tensile Test

6.4 Flexure Strength Test

Beams of dimensions 100 x 100 x 500 mm were casted and cured for various curing periods. Central Point Loading method has been adopted for this test. Test has been performed in the Universal Testing Machine of capacity 1000KN. Rate of loading was 0.1KN per second. Peak load was determined and flexural stress of each specimen was calculated. Average of value of 3 specimens was recorded as flexural strength of concrete.

Fig. 6.4 Flexure test

6.5 TEST RESULTS

6.5.1 Slump Test

S.No.	Mix	Slump (mm)
1.	Normal concrete(without replacement)	80
2.	Concrete with 15% GGBS and 10% quarry stone dust	79
3.	Concrete with 15% GGBS and 20% quarry stone dust	77
4.	Concrete with 15% GGBS and 30% quarry stone dust	74

Table 4 Slump Values

6.5.2 Compression Test

S.No	Mix	7 days(N/mm^2)	28 days(N/mm^2)
1.	Normal concrete(without replacement)	19.12	28.76
2.	Concrete with 15% GGBS and 10% quarry stone dust	16.38	27.71
3.	Concrete with 15% GGBS and 20% quarry stone dust	18.09	29.36
4.	Concrete with 15% GGBS and 30% quarry stone dust	17.89	28.26

Table 5 Compression Test

6.5.3 Split Tensile Test

S.No	Mix	7 days(N/mm^2)	28 days(N/mm^2)
1.	Normal concrete(without replacement)	3.07	3.63
2.	Concrete with 15% GGBS and 10% quarry stone dust	2.93	3.21
3.	Concrete with 15% GGBS and 20% quarry stone dust	3.16	3.97
4.	Concrete with 15% GGBS and 30% quarry stone dust	2.56	3.09

Table 6Tensile Test

6.5.4 Flexure Test

S.No	Mix	7 days(N/mm^2)	28 days(N/mm^2)
1.	Normal concrete(without replacement)	4.13	5.09
2.	Concrete with 15% GGBS and 10% quarry stone dust	3.97	4.82
3.	Concrete with 15% GGBS and 20% quarry stone dust	4.47	5.28
4.	Concrete with 15% GGBS and 30% quarry stone dust	3.66	4.57

Table 7Flexure Test

CHAPTER 7

CONCLUSION

In this report, an attempt has been made to study the effects of GGBS as an alternative to cement and quarry stone dust as an alternative to fine aggregate on concrete properties. Combinations of quarry stone dust and GGBS were prepared and effects of these combinations on concrete properties have been studied.

The non availability of river sand has led to the search of an alternate material for the fine aggregates that can replace the river sand.Quarry stone dustmore economical was found to be best alternative of fine aggregate to River sand which satisfied all technical specification specified in the Indian Standard Codes and it contained no impurities. The GGBS which is also a waste generated by the industry proves to be a replacement of cement in concrete thus to reduce the emission of the CO_2 from the cement production.

The effects of M30 design mix(1: 1.6: 2.6) with water cement ratio as 0.45 have been studied. The comparison of results were done with 0% replacement.

i) The slump was found to be decreased on increasing the percentage of the quarry stone dust. This is due to the reason that the quarry stone dust has high initial water absorption.

ii) The 28 days compressive strength of 15% GGBS and 20% quarry stone dust was found to be increased.

iii) The split tensile strength also shows the increase at 15% GGBS and 20% quarry stone dust.

iv) The flexure strength of 28 days was found to be increased by replacing 15% of cement by GGBS and 20% of river sand by quarry stone dust

Hence using Ground- granulated blast furnace slag and quarry stone dust in concrete mix proved to be useful to solve environmental problems and reduce some extent the need of cement in large quantity. Therefore, it is recommended to reuse these wastes in concrete to move towards sustainable development in construction industry.

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