Effect of Percent Replacement of Substitute Material in Mixed Concrete

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Abstract: Sustainable materials like GGBS and Pond Ash are the by products from steel industry and thermal power plants, those can be available in very cheap cost as compare to cement and natural sand. The use of pond ash in concrete as replacement to natural sand, reduce the load on environment.

The compressive strength of GGBS concrete increases as the GGBS content is increased up to the % which the compressive strength decreases. There is an optimum level for the efficient use of GGBS content, which yields the highest strength. The favorable results are obtained with 40% to 50% replacement of GGBS to cement. 20% of pond ash as natural sand replacement is found to be the optimum. By keeping the 40% of GGBS constant in concrete and replacement of sand with Pond Ash up to 20% gives the desire strength of concrete. It has been observed that use of GGBS in concrete up to 40% to 50% replacement to cement reduce the cost of concrete up to Rs. 450/- to 50/- per m^3. Concrete is a major component of construction and if cost of concrete is reduced it will automatically reduce the cost of construction project.

Key words: Pond Ash, Compression Strength, GGBS

INTRODUCTION

Energy generation is increasing day by day due to rapid industrialization. Energy generation through thermal power plants is very typical now days. Pond ash (PA) is available in large quantities from these thermal plants. Pond ash utilization helps to reduce the consumption of natural resources. Today natural sand is being used and it is costly so it is require to be replacing by Pond Ash. Use of alternative material in concrete such as industrial by - product coal Ash (Fly Ash and Pond Ash) is an important eco efficiency drive. It is also the social responsibility of researchers to encourage the “beneficial use of industrial by- products in order to preserve resources, conserve energy and reduce or eliminate the need for disposal of industrial waste in landfills. And to get some of the important engineering properties like increase in compressive strength with low capillarity and water absorption, Pond Ash are being preferably used in various percentages and the perfect strength combination of GGBS replacement and pond ash percentage is found out.

PROBLEM STATEMENT:

In almost every construction activity, concrete is widely used. As cement is getting costlier and demand for cement is growing day by day, investigators have been trying to replace cement with other materials to save money either by maintaining the properties using waste materials or by enhancing the properties using selected materials. This paper is an attempt, to study various engineering properties of a concrete made with cement which is replaced by ground granulated blast furnace slag. To maintain the engineering properties, replacement of natural sand with pond ash which is manufactured and is easily available by thermal power plants, has been used in various proportions. The experimental investigation includes basic tests for cement, and conventional tests for concrete such as compressive strength have been taken up.

OBJECTIVES OF PROJECT WORK:

- To replace the cementitious material and fine aggregate (i.e. river sand) with sustainable material.
- To find perfect combination of GGBS and Pond Ash
- To find optimum percent replacement by GGBS.
- To reduce the percent of cementitious material and use sustainable material on that replacement of percentage.To optimize the cost.

METHODOLOGY:

In this present study partial replacement of cement and sand has done by using GGBS and Pond Ash. The grade of concrete is M40. In this cube and beam specimens are casted and cured for 3 days, 7 days and 28 days.

A. Test Procedure

1) Compressive Strength Test

The cubes were taken after a curing period of 3 days, 7 days and 28 days from water tank, surface dried and tested using a compression testing machine. These cubes were loaded on their sides during compression testing machine and the exerted perpendicularly to the direction of casting. The compression strength of concrete with partial replacement of cement and sand with GGBS and Pond Ash.

Cement used = OPC 53 Grade

Sp. Gravity Of Cement =3.15

Sp. Gravity Of Coarse Agg.=2.69

Sp. Gravity Of Fine Agg. =2.73

Water Absorption in Coarse Agg. =0.4%

Water Absorption in fine Agg. = 0.3%

B. Test Data for Materials

Test results of Concrete Cubes specimens for M40 Grade

Material and Its Dry wt.

Cement = 435kg/m3

Water = 165 kg/m3

Fine Agg. = 676 kg/m3

Coarse Agg.= 1201 kg/m3

Chemical Admixture = 4.35 kg/m3

Water – Cement Ratio = 0.38

C. Cost Analysis:

1) OPC cement cost – Rs. 4600/- per Tonne Rs. 230/- per 50 kg
2) GGBS cost – Rs. 2800/- per Tonne Rs. 140/- per 50kg

EXPERIMENTATION

Experimental Program and Concrete Mix Design:

Concrete Mix Design for M40 Grade:-

(a)Grade designation: M40

(b) Type of cement: OPC 53 grade

(c) Maximum nominal size of Aggregate: 20 mm

(d) Minimum cement content: 300 kg/ m3

(e) Maximum water-cement ratio: 0.40

(f) Workability: 75 mm slump

(g) Exposure condition: Moderate (For RCC)

(h) Degree of supervision: Good

(i) Type of aggregate: Crushed angular aggregate

(j)Maximum cement content: 450 kg/m3

5.1.1.2 Test Data for Materials

a) Cement used = OPC 53 grade conforming to IS 8112

b) Specific gravity of cement = 3.15

c) Specific gravity of:

Coarse Aggregate = 2.69

Fine Aggregate = 2.736

d) Water absorption:

Coarse aggregate = 0.4%

Fine aggregate = 0.3%

e) Free surface moisture:

Coarse aggregate = Nil

Fine aggregate = Nil

Mix Design Procedure

Step-l: Target Strength for mix Proportioning

f'ck = fck + 1.65 s

where

f'ck =target average compressive strength at 28 day,s

fck =Characteristic compressive strength at 28 day,s

s = standard deviation.
standard deviation, s = 5 N/mm^2,

Therefore, target strength = 40+ 1.65 x 5, = 48.25 N/mm^2.

Step-2: Selection of w/c ratio

Maximum w/c ratio = 0.40, Based on experience, adopt w/c ratio as 0.38

Adopt smaller of the two values,

w/c = 0.38, 0.38<0.40, hence O.K.

Step-3: Selection of water content

Maximum water content for

Size of agg. 20 mm = 186 lite (For 25 to 50 mm slump range)

Estimated water content for 100 mm slump = 186 + (3/100) x 186

= 191.58 liter say 192 liters

Step-4: Calculation of cement content

Water-cement ratio = 0.38

Water used = 165 litre

Cement content = 165/0.38

= 434.21 kg/m³ say 435 kg/m³

As per IS: 456-2000. Table-5. Minimum cement content for moderate exposure condition = 300kg/m³.

420 kg/m3 > 300 kg/m³, hence, O.K.

Step-5: Coarse aggregate and Fine aggregate content

volume of coarse aggregate corresponding to 20 mm maximum size Aggregate and fine aggregate grading (Zone-I) for water cement ratio 0.50 = 0.62.

corrected proportion of volume of coarse aggregate for water-cement ratio of 0.38 = 0.644.

volume of coarse aggregate = 0.644

Volume of fine aggregate content = 1-0.644 = 0.356

Step-6: Calculation of Mix Proportions

The mix calculations per unit volume of concrete shall be follows:

a) Volume of concrete **= 1 m³**

b) Volume of cement=(mass of cement / specific gravity of cement)x (1/1000)

= (435/3.15) x (1/1000) **= 0.138 m3**

c) Volume of water = (mass of water / specific gravity of water) x (1/1000)

= (165/1) x (1/100) **= 0.165 m3**

d)Volume of chemical admixture (Superplasticizer)(@ 1.0 percent mass of cement)

= (mass of chemical admixture / specific gravity of chemical admixture) x (1/1000)

=(4.35/1.20) x (1/1000) **= 0.0036 m³**

e)volume of all in aggregates

= [a-(b+c+d)]

= [1-(0.138+0.165+0.0036)] **= 0.6934 m3**

f)Mass of coarse aggregate
= e x volume of coarse aggregate x specific gravity of coarse aggregate x 1000

= 0.6934 x 0.644 x 2.69 x 1000 **= 1201 kg**

g) Mass of fine aggregate

= e x volume of fine aggregate x specific gravity of fine aggregate x 1000

=0.6934 x 0.356 x 2.736 x 1000 **=676 kg**

Step-7 : Mix Proportions for Trial No. l :

Cement = 435 kg/m3

Wate = 165 litre,

Fine aggregate = 676 kg/m3,

Coarse aggregate = 1201 kg/m3

w/c ratio = 165/435 = 0.38

We may use 50% 0f 10 mm sizeand 50% of 20 mm size of aggregate.

Quantity of 10 mm size aggregate =50% of total coarse aggregate= 600.5kg /m3

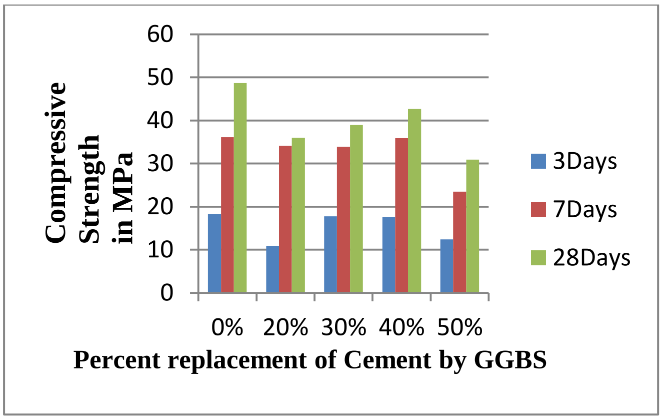
Quantity of20mmsizeaggregate =50% of total coarse aggregate = 600.5 kg/m3

RESULT AND DISCUSSION

6.3 Compressive strength

Table No. 6.16 compressive strength on % replacement of GGBS(MPa)

Compressive Strength					
Curing days	CC	20% GGBS	30% GGBS	40% GGBS	50% GGBS
3 Days	18.28	10.92	17.74	17.59	12.36
7 Days	36.07	34.07	33.84	35.85	23.48
28 Days	48.63	35.96	38.92	42.61	30.89

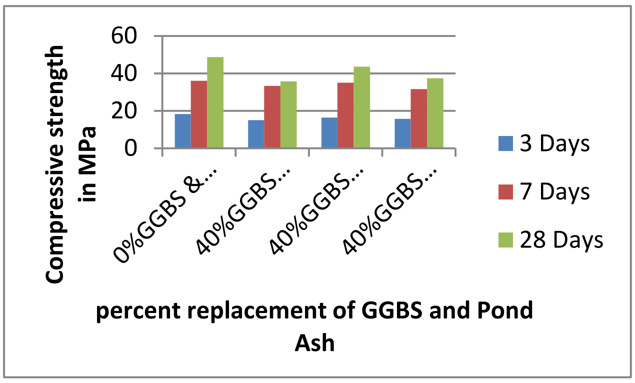


Graph .Compressive strength on % replacement of GGBS

The compressive strength of concrete with partial replacement of cement with GGBS. The compressive strength (3 days, 7 days and 28 days) of cubes decreases with different percentage of GGBS. It is also observed that at 40% of GGBS replacement acceptable because it gives strength above 40 N/mm² for grade of M40 even though this is less as compare to control concrete. Experimental results shows that, as percentage of GGBS increases in concrete alters compressive strength of concrete. Partial replacement of 40% of cement by GGBS gives maximum compressive strength beyond that percentage of GGBS there is reduction in strength of concrete at all curing ages.

Compressive strength on % replacement of GGBS and Pond Ash (MPa)

Compressive Strength				
Curing days	Control Concrete	40% GGBS+10% PA	40% GGBS+20% PA	40% GGBS+30%PA
3 Days	18.28	14.89	16.32	15.57
7 Days	36.07	33.25	35.02	31.59
28 Days	48.63	35.06	43.55	37.29



Graph . Compressive strength on % replacement of GGBS and Pond Ash

Compressive strength of concrete with partial replacement of cement and sand with GGBS and Pond ash is shown in the above graph. As seen in Graph the compressive strength (3 days, 7 days and 28 days) of cubes decreases with different percentage of GGBS and Pond Ash. It is also observed that at 40% of GGBS and 20% of pond ash replacement acceptable because it gives strength above 40 N/mm² for grade of M40 even though this is less as compare to control concrete. For a particular percentage replacement early age (3, 7 and 28 days) compressive strength is relatively lower but it rises as age increases.

CONCLUSIONS:

1. The normal consistency increases with replacement of cement by pozzolanic material such as GGBFS.

2. Satisfactory results are obtained with 40% to 50% replacement of GGBS to cement.

3. By keeping the 40% of GGBS constant in concrete and replacement of Pond Ash with 20% gives a satisfactory results.

4. In case of normal concrete, part replacement of cement by GGBFS decreases the compressive strength. However, satisfactory results are not obtained with 20% to 30% replacement.

5. The use of sustainable material like GGBS as replacement for cement in concrete is more effective as environmental point of view.

6. It has been observed that use of GGBS in concrete up to 40% to 50% replacement to cement reduce the cost of concrete. Concrete is a major component of construction and if cost of concrete is reduced it will automatically reduce the cost of construction project.

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