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Partial Replacement of Cement by Ground Granulated Blast Slag (GGBS) and Addition of Activated Charcoal Powder (ACP)

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Abstract- Concrete is a versatile Material. In construction industry the use of concrete is increasing rapidly. Many researches have been made to use waste material as it will eliminate the disposal problems and also reduce the burden on natural resources consumption, pollution. The sustainable development is characterized by application of industrial waste to improve mechanical properties of concrete. The study examines the possibility of using GGBS as a replacement for cement in various percentages like 10%, 20%, 30% and 40% by the weight of concrete and find the optimum replacement percentage. Also use of Activated Charcoal Powder(ACP) in 1%, 2% and 3% by the weight of cement to enhance the properties of concrete. The grade of concrete is M40. Then the optimum of ACP+GGBS was studied and compared with the conventional concrete. Compressive strength test taken for 7 days, 14 days, 28 days, 56 days and 90 days reswpectively. Split tensile strength test and Flexural strength test taken for 28 days of curing. So it was observed that optimum replacement was at 30% GGBS and optimum addition was at 1% ACP.

Key words: GGBS, ACP, Replacement, Addition, Optimum, Compressive strength, Flexural Strength, Split Tensile Strength.

1. INTRODUCTION

The GGBS is a by-product in the manufacture of iron and the amounts of iron and slag obtained are of the same order. Iron ore, coke and limestone are fed into the furnace and the resulting molten slag floats above the molten iron at a temperature of about 1500°C to 1600°C. After the molten iron is tapped off, the remaining molten slag, which consists of mainly siliceous and aluminous residue is then water quenched rapidly, resulting in the formation of a glassy granulate. This glassy granulate is dried and ground to the required size, which is known as GGBS.

Activated carbon reduces the presence of pores in conventional concrete, which enhances the performance of concrete. This research will be focused on mechanical properties of concrete and identify the significant parameters which influence the strength of concrete.

Utilization of such wastes as cement replacement materials and as addition may reduce the cost of concrete production and also minimize the negative environmental effects with disposal of these wastes.

2. MATERIALS AND METHODS

Sample Collection

Materials are Collected from various Sources. Few of them are taken from the suppliers.

Activated charcoal Powder

Mix Proportion

The Conventional Concrete of M40 grade with constant Water/Cement ratio of 0.40 was prepared without replacement of cement. Cement was partially replaced by GGBS with 10%, 20%, 30% and 40% and adding ACP with 1%, 2% and 3% .

Casting

15 Cubes per sample of size 150 X 150 X 150 mm is casted for Compressive Strength Test. 3 Beams per sample of size 700 X 150 X 150 mm for Flexural Strength Test and 3 Cylinders for Split Tensile Strength Test and cured this samples for various days.

Casting of concrete into moulds

Curing

Casted samples were cured in curing tank for curing period of 7 days, 14 days, 28 days, 56 days, and 90 days.

Mixing of materials for casting

MATERIALS:

Cement:Out of the total production, Ordinary Portland Cement accounts for about 80-90%. Many tests were conducted to cement some of them are Consistency tests, Se Time tests, Soundness tests, etc.

Table 1 : Chemical properties of Cement

Sr. No.	Chemical Properties	Limits(%)
1	CaO	61–67
2	SiO_2	19–23
3	Al_2O	2.5–7
4	Fe_2O_3	0 – 7
5	SO_2	1.55 – 4.55

Table 2 : Physical Properties of Cement

Sr. No.	Property	Result
1	Brand Of Cement	53 Grade OPC
2	Standard Consistency	35%
3	Initial Setting Time	30 minutes
4	Final Setting Time	600 minutes
5	Specific Gravity	3.15

Fine Aggregate: Fine aggregate is locally available, free from debris & soil & crushed sand is used.

Table 3 : Properties of Fine Aggregate

Property		Result
Fineness Modulus		2.78
Specific Gravity		2.62
Bulk Density (Kg/m^3)	Loose	1585
	Compact	1690

Coarse Aggregate: The crushed aggregates used were 20 mm nominal maximum size and are tested as per Indian standards and results are within the permissible limit.

Table 4 : Properties of Coarse Aggregate

Property		Result
Fineness Modulus		6.15
Specific Gravity		2.625
Bulk Density (Kg/m^3)	Loose	1470
	Compact	1530

GGBS: It is a by-product in the manufacture of iron and the amounts of iron and slag obtained are of the same order. Iron ore, coke and limestone are fed into the furnace and the

resulting molten slag floats above the molten iron at a temperature of about 1500°C to 1600°C. After the molten iron is tapped off, the remaining molten slag, which consists of mainly siliceous and aluminous residue is then water quenched rapidly, resulting in the formation of a glassy granulate. This glassy granulate is dried and ground to the required size, which is known as GGBS.

Table 5 : Chemical Properties Of GGBS

Chemical	Constituent Portland	GGBS
CaO	65%	40%
SiO_2	20%	35%
Al_2O_3	5%	10%
MgO	2%	8%

Activated Charcoal Powder: It is carbon created from carbonaceous materials like bamboo, coconut husk, willow peat, wood, coir, lignite, coal, and petroleum pitch. Activated carbon can be produced by physical activation or chemical Process.

3. TESTING

Compression testing:

Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. We carried out compressive strength test on cubes for 7 day , 14 day, 28 day, 56 day and 90 days of curing

Compressive strength testing

Flexural Strength

The flexural strength of 150mm×150 mm cross, 700mm concrete beam was determined according to BS EN 12390-5:2009: Testing hardened concrete: Flexural strength of test specimens after 28 days of curing. A load was applied on the specimens with an increasing rate until failure of the specimen occurred. Strength is calculated by the following formulae:

1) if a<200 then $fb= 3Pa/bd^2$

2)if a>200 then $fb= PL/bd^2$

Figure 2: Flexural Strength Test.

Sr. no.	ACP	Weight
1	1%	4.7 kg
2	2%	9.4 kg
3	3%	14.1 kg

Split Tensile Strength:

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The cylinder used had 150 mm radius and 300mm height. The strength is calculated by using formula 2P/3.14 Dl

Figure 3: Split Tensile Strength.

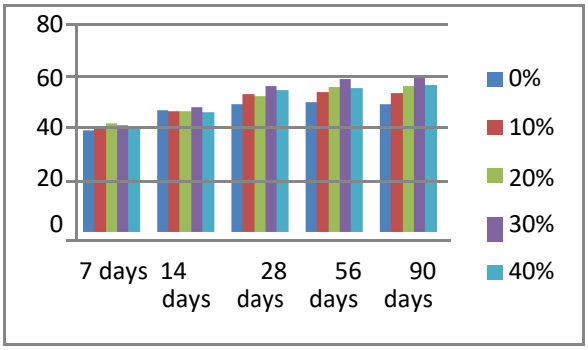
Sr	Material	0%	10%	20%	30%	40%
1	Cement	470	423	376	329	282
2	10 mm	461	461	461	461	461
3	20 mm	691	691	691	691	691
4	Sand	648	648	648	648	648
5	Water (ltr)	160	160	160	160	160
6	Admixture (ltr)	4.7	4.7	4.7	4.7	4.7
7	GGBS	0	47	94	141	188

Table 6 : Mix design proportion for GGBS replacement(1m^3)m40 Grade Concrete.

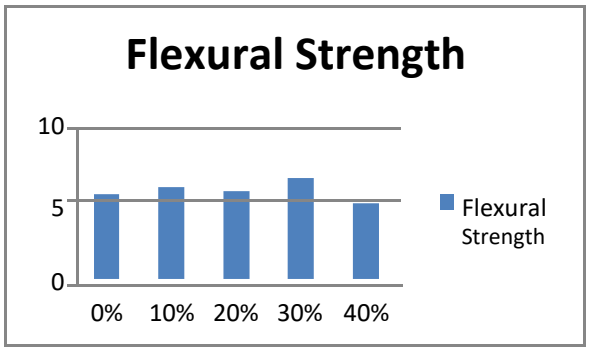
COMPRESSIVE STRENGTH					
	0%	10%	20%	30%	40%
7 days	39.10	40.35	41.90	41.10	39.90
14 days	46.90	46.40	46.50	47.90	45.90
28 days	49.25	52.90	52.25	56.20	54.40
56 days	50.10	53.90	55.70	58.80	55.40
90 days	49.10	53.55	56.00	59.90	56.40
FLEXURAL STRENGTH					
	0%	10%	20%	30%	40%
28 days	5.35	5.81	5.57	6.38	4.80
SPLIT TENSILE STRENGTH					
	0%	10%	20%	30%	40%
28 days	4.38	4.06	4.07	4.63	3.50

Table 9: Reslts for replacement of cement by ggbs

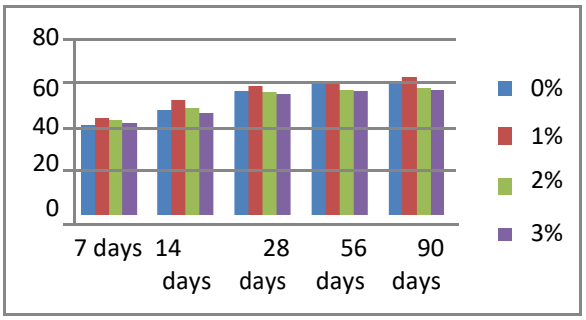
RESULTS:



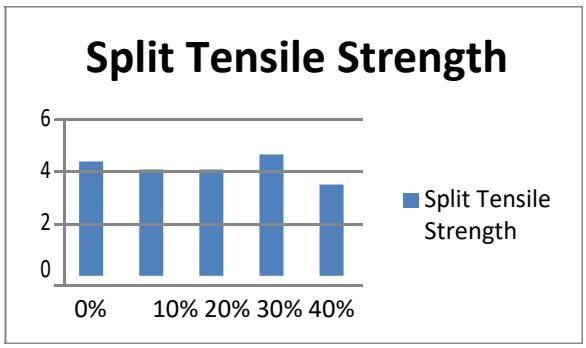
Graph 1: Compressive Strength test Result



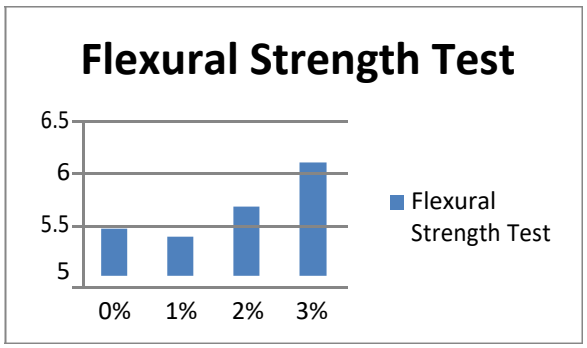
Graph 2: Flexural Strength test Result of 30% GGBS + ACP GGBS



Graph 4: Compressive Strength result for



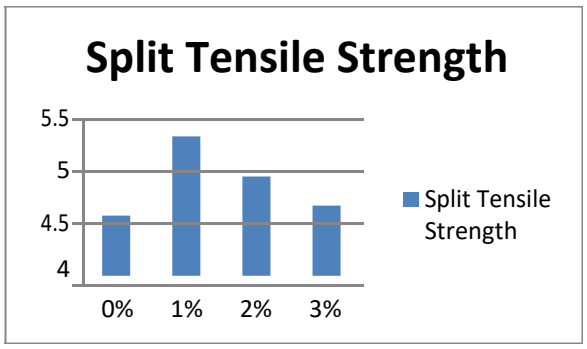
Graph 3: Split Tensile Strength Test result of GGBS



Graph 5: Flexural Strength Result of 30% GGBS + ACP

Compressive Strength Test				
	0%	1%	2%	3%
7 days	41.20	44.50	43.20	42.15
14 days	48.10	52.30	49	46.50
28 days	56.40	58.80	56.10	55.10
56 days	59.80	61.20	57.10	56.40
90 days	60.30	62.80	57.90	57.00
Flexural Strength Test				
	0%	1%	2%	3%
28 days	5.45	5.37	5.66	6.08
Split Tensile Strength Test				
	0%	1%	2%	3%
28 days	4.57	5.33	4.95	4.67

Table 10: Result for 30% GGBS (Optimum) along with Addition of ACP.



Graph 6: Split Tensile Strength Test results for 30% GGBS + ACP

- It gives good strength when compared to normal mix , 30% replacement of cement by GGBS was the most satisfying results
- Partial replacement of GGBS decrease the environmental pollution such as ground pollution, water pollution etc
- Partial replacement of GGBS increase the strengths at 10%,20%,30% as well as decrease the strength at 40%,50%.
- It also reduce the cost of construction
- From the results of research that has been carried out the concrete with an additional mixture of charcoal as much as 1% of the weight of cement has better strength when compared with normal concrete or concrete with additional charcoal by 4%, and 6%.
- The greater than 2% additional charcoal, concrete experiences a decrease in strength, but the strength to additional charcoal of 6% concrete is still better than normal concrete.

CONCLUSION

- From this study, it is concluded that the Combination of GGBS and Activated Charcoal Powder is a good substitute for cement in the concreting works
- Partial replacement of GGBS decrease the environmental pollution such as ground pollution, water pollution etc.
- Partial replacement of GGBS increase the strengths at 10%,20%,30% as well as decrease the strength at 40%,50%.
- It also reduce the cost of construction. Thus the workability is improved by the partial replacement of the GGBS with cement.
- The replacement of cement by GGBS not only increases the compressive strength but also reduces the cement content which eventually decrease in emission of CO2.
- Activated carbon due to its structure developed, large surface area, strong adsorption capacity, high mechanical strength, low bed resistance, good chemical stability, easy regeneration, durability and other advantages, received great attention and extensive research, known as 21 centuries one of the most advanced materials.
- Activated carbon reduces the presence of pores in conventional concrete, which enhances the performance of concrete.
- The combination of 30% GGBS and 2% ACP gave higher results for Flexural Strength
- And the combination of 30% GGBS and 1% ACP gave higher results for Split Tensile Srength.

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