An Experimental Study on Concrete with Partial Replacement of GGBS and Ceramic Waste

P.Ramalingam[1] R.Navaneethakrishnan[2] M.Sankaran[3] J.Subashchakaravarthi[4] B.Vijay[5]
[1]Associate Professor [2,3,4,5]UG Student
[1,2,3,4,5]Department of Civil Engineering
[1,2,3,4,5]Sri Shanmugha College of Engineering and Technology, Salem, Tamilnadu, India

Abstract— Waste management is one of the most common and challenging problem due to generation of industrial ceramic waste in the world. Waste is dumped away which result in environmental pollution threatening both agricultural and public health. GGBS is one of the industrial by product from the iron and steel making industries. This paper aims to study the suitability of blast furnace slag and ceramic waste from crushed fuse. In this project an attempt has been made to determine the optimum mix proportion of GGBS in fine aggregate with 30% replacement of cement by ceramic waste. In this research study the cement has been replaced by ceramic waste is constantly at 30 % and fine aggregate has been replaced by GGBS accordingly in the range of 0%, 10%, 20%, 30%, 40% and 50% by weight of fine aggregate in M20 grade concrete. In this study the above concrete mixtures were produced, tested and compared in terms of compressive strength, flexural strength and split tensile strength to conventional concrete. From this result analysis, for 30% replacement of cement with ceramic waste, the optimum value of GGBS to be used within the concrete mix with a water cement ratio of 0.5 was determined as about 40%. The compressive, flexural and split tensile strength of optimal concrete was found 45%, 53.4% and 64.9% higher than the reference concrete respectively. The finding revealed that use of ceramic fuse waste and GGBS leads to strengthening of concrete properties.
Key words: Partial Replacement of GGBS, Ceramic Waste

I. Introduction

Concrete is most widely used material on earth after water. Concrete is a composite material composed of granular materials like coarse aggregate embedded in a matrix and bound together with cement or binder which fills the space between the particles and glues them together. Almost three quarters of the volume of concrete is composed of aggregates. To meet the global demand in the future, it is becoming a more challenging task to find suitable alternatives to natural aggregate for preparing of concrete. Ceramic are determined that it is a class of nonmetallic and inorganic solids which are subjected to high temperature in manufacturing of ceramic products in industry. The fuse waste which is dumped in land filling and pit or vacant spaces causes the environmental pollution which is dangerous for human health.

Blast Furnace Slag is a solid waste discharged in large quantities by the iron and steel industry in India. The re-cycling of these slag will become an important measure for the environmental protection. Due to many years of Research the slag that is a by-product in Iron and Steel production is now in use as a material in its own right in various sectors.

By using the replacement of waste materials offers cost reduction, energy saving and few hazards in environment.

II. Material Used

A. Cement

The Pozzolanic Portland Cement of 53 grade whose specific gravity of cement is 3.05, normal consistency of the cement was found 32% and the initial and final setting time were found as 28 min and 296 min respectively were used.

B. Coarse Aggregate:

The coarse aggregate with 20 mm nominal size having the specific gravity 2.76 was used. The impact Value is 10.4%. And the water absorption of the coarse aggregate is 0.5%.

C. Fine Aggregate

Locally available river sand is used as per IS 383:1970, sand is conforming to Zone II. Specific gravity of the sand used is 2.38. And the water absorption value is 0.45%.

D. GGBS

Ground Granulated Blast-Furnace slag (GGBS or GGBFS) is obtained by quenching molten iron slag (a by-product of iron and steel making) from a blast furnace in water or steam to produce a glassy, granulated product that is then dried and ground into a fine powder.

E. Fuse Carrier Powder

Broken Fuse were collected from private electrical shop at Erode and crushed them into powder by using Los Angeles abrasion test machine from lab. Impact value of fuse carrier is 25.45.From the crushed waste fuse carrier powder passed through 90 micron sieve confirming IS 460:1962 to use as a partial replacement to cement. Specific gravity of a crushed waste fuse carrier powder is 2.35.

F. Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, the quantity and quality of water are required to be looked into very carefully.

III. Methodology

In this experimental study there were several process were involved which were carried out at several durations and done according to the requirements of this experimental study. The first process of the experimental study was the collection of literature reviews. The literature reviews were studied thoroughly and analyzed. From the literature reviews the valuable consideration sand suggestions were noted and the study is carried out with the help their guidance. The various materials used in the study were selected and prepared for the use. The material that is chosen for the partial replacement of the cement in ceramic waste and fine aggregate in GGBS. The ceramic waste was collected from the "Private Electrical

Shop", Erode. The fuse was then grinded manually. The grinded fuse is then sieved before mixing the concrete. The GGBS was collected from the "PRIVATE CORPORATION LIMITED", mecheri. After collection of all the materials to be used in the study, the materials were subjected to various tests to determine the quality and strength in order to use in the experimental study. The next process in the experimental study was mix design as per the Indian Standards. The casted specimen were cured for 28 days and it is been tested for its compression, flexural and split tensile.

IV. MIX DESIGN

M20 grade of concrete was designed by following the specimen is given in the IS 10262:1982. Water-Cement ratio (w/c) was selected as 0.5 based on conducting slump test for different design trails. Mix proportion obtained for M20 mix is 1:1.36:3.2

Specimen details		M_0	M_1	M_2	M_3	M_4	M_5	M_6
Cem-ent	% of cement	100	70	70	70	70	70	70
	% of ceramic waste	0	30	30	30	30	30	30
F.A	% of natural Sand	100	100	90	80	70	60	50
	% of GGBS	0	0	10	20	30	40	50
W/C Ratio		0.5	0.5	0.5	0.5	0.5	0.5	0.5
SLUMP VALUES		73	70	68	66	63	61	59
VEE BEE VALUES		8	8.5	9	9.5	10	11	13

Table 1: Percentage of Cement and Fine Aggregate Replaced

V. WORKABILITY

A. Slump Cone Test

The object of this test is to find out workability of freshly mixed cement concrete. Workability is the capacity of being worked without extra labour and loss in strength. The strength of cement concrete entirely depends upon the correct percentage of water. This experiment gives the relation between the percentage of water & slump. Slump is the fall in vertical height of a freshly prepared concrete with respect to its standard mould height.

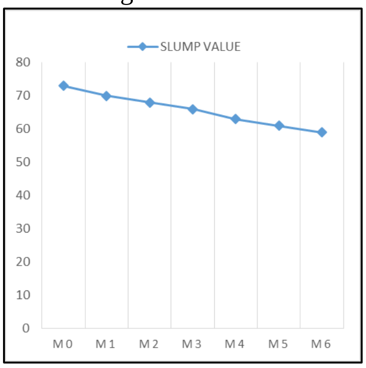

Fig. 1: Slump Values for Different Proportion

B. Vee-Bee Consistometer Test

The vee-bee consistometer measures the remolding ability of concrete under vibration. The test results reflect the amount of energy required to remold a quantity of concrete under given vibration conditions. The vee-bee consistometer is applicable to concrete with slumps less than 50mm. Placing the slump cone inside the sheet metal cylindrical pot of the consistometer. The glass disc attached to the swivel arm is turned and placed on the top of the concrete pot.

The electrical vibrator is switched on and simultaneously a stop watch is started. The vibration is continued till such a time as the conical shape of concrete disappears and the concrete assumes cylindrical shape. Immediately when the concrete fully assumes a cylindrical shape, the stopwatch is switched off the time required for space of concrete to change from slump cone shape to cylindrical shape in seconds is known as vee-bee degree.

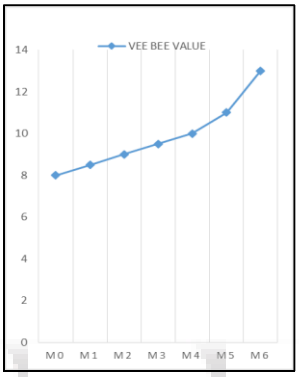

Fig 2: Vee-Bee Value for Different Proportions

VI. TESTING

A. Compressive Strength

For every percentage of replacement 9 cubes have been casted. Among them 3 cubes were tested on the 7th day, then te next 3 cubes were tested on the 14th day and the remaining 3 cubes were tested on the 28th day. Totally 54 cubes were casted and tested.

Specimen details	**Compressive strength test (N/mm^2)**		
	7 days	**14 days**	**28 days**
M0	15.11	17.92	25.18
M1	22.67	26.37	30.82
M2	17.18	19.7	28.73
M3	19.7	24.29	30.91
M4	24.46	28.46	34.52
M5	28.29	33.33	36.59
M6	15.55	18.96	28.86

Table 2: Compressive Strength with Different Proportions

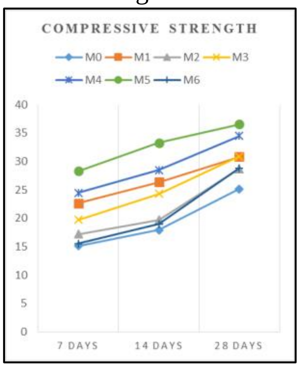

Fig 3: Compressive Strength Value for Different Proportions

B. Flexural Strength

For every percentage of replacement 9 beams have been casted. Among them 3 beams were tested on the 7th day, then the next 3 beams were tested on the 14th day and the remaining 3 beams were tested on the 28th day. Totally 54 beams were casted and tested.

Specimen detai1s	Flexural strength test (N/mm^2)		
	7 days	14 days	28 days
M0	3.67	4.83	7.17
M1	5.67	7.17	8.6
M2	4.17	5.17	7.5
M3	5.83	7.0	8.5
M4	6.58	7.83	9.17
M5	7.83	9.67	11
M6	4.17	5.33	6.33

Table 3: Flexural Strength with Different Proportions

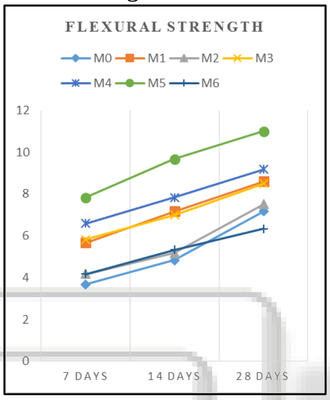

Fig 4: Flexural Strength Value for Different Proportions

C. Split Tensile Strength

For every percentage of replacement 9 cylinders have been casted. Among them 3 cylinders were tested on the 7th day, then the next 3 cylinders were tested on the 14th day and the remaining 3 beams were cylinders on the 28th day. Totally 54 cylinders were casted and tested.

Specimen details	Split tensile strength test (N/mm^2)		
	7 days	14 days	28 days
M0	1.19	1.45	2.17
M1	1.93	2.17	2.92
M2	1.4	1.75	2.78
M3	2.22	2.64	3.07
M4	2.49	2.92	3.31
M5	2.83	3.30	3.58
M6	1.30	1.61	2.62

Table 4: Split Tensile Strength with Different Proportions

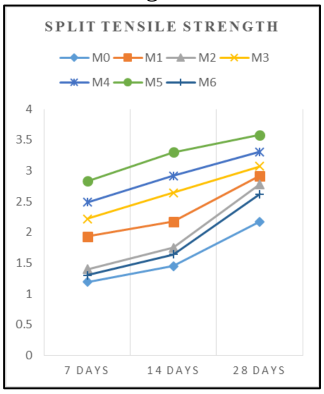

Fig 5: Split Tensile Strength Value for Different Proportions

VII. Conclusion

Based on the analysis of experimental results and discussions there upon the following conclusions are made.

- The compressive strength, flexural strength and split tensile strength of M20 grade concrete increase when the replacement of cement with ceramic powder 30% and the replacement of fine aggregate with GGBS upto 40% replaces and further replacement of fine aggregate with GGBS decreases the compressive strength.
- The compressive, flexural and split tensile strength of optimal concrete was found 45%, 53.4% and 64.9% higher than the reference concrete respectively.
- It is the possible alternative solution of safe disposal of ceramic waste and GGBS
- Workability of concrete is gradually decreased, as the percentage of replacement increases which is found by using slump test
- In order to overcome this all economic as well as eco-friendly material used in concrete and the concrete strength will increase.

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