International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 05, May - 2017

Experimental Investigation on Strength of Ternary Blended Concrete

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Abstract **- Concrete is the most widely used construction material in civil engineering industry because of its high structural strength and stability. The concrete industry is constantly looking for supplementary cementitious materials (SCMs) with the objective of reducing the solid waste disposal problem. Replacement of cement using waste material having cementing properties, without compromising on its strength, which will result in decrease of cement production thus reduction in emission in greenhouse gases in addition to sustainable management of waste. Ground Granulated Blast Furnace Slag (GGBS) is the solid waste generated by iron and steel industry which can be used to replace cement. Along with GGBS, an agro-industrial waste product of sugar mills, Bagasse Ash is also used to replace cement in concrete without compromising its strength. A concrete mix of grade M_{30} was investigated by keeping water-binder ratio as 0.36. In this work, Compressive , split tensile strength and modulus of elasticity property of the concrete is reviewed by replacing OPC of 43 grade by 0%, 10%, 20%, 30% of maximum pozzolanic action giving proportion of the blend containing GGBS and bagasse ash. This paper presents an experimental study of Strength of ternary blended concrete.**

Index Terms - GGBS, Bagasse Ash, Ternary blended concrete, SCMs

I. INTRODUCTION

The utilization of waste materials in concrete manufacture provides a satisfactory solution to some of the environmental concerns and problems associated with waste management depending upon the nature of work. Cement, fine aggregate, coarse aggregate and water are mixed in specific proportions to produce plain and fresh concrete. Due to limited availability of natural resources and rapid urbanization, there is a shortfall of conventional building construction materials. The need to conserve traditional natural resources that are facing depletion have obliged engineers to look for alternative materials. The production of conventional building materials consumes a lot of thermal and electrical energy and in turn pollutes air, water, and land.

Disposal of solid waste generated from agricultural and industrial production activity is the other serious problem in developing countries like India. The accumulation of these wastes is not only a burden to the industry, but also affects the environment adversely. Therefore, development of new technologies to recycle and convert waste materials into reusable materials is critically important for the protection of the environment and sustainable development of the society.

In this paper ordinary Portland cement is replaced by blended combination of 40% bagasse ash and 60% GGBS in 10%, 20%, 30%. After Casting concrete cubes and cylinders, Compressive Strength test and Split tensile strength test also modulus of elasticity using extensometer is conducted in compression testing machine and compare the obtained result with M_{30} conventional concrete cubes.

II MATERIAL DESCRIPTIONS.

A. Cement

The Ordinary Portland Cement [OPC] (43 grade) used in the present work is of Dalmia brand.

B. Aggregate

Coarse aggregate of 20mm size is used whereas M-sand is used as fine aggregate.

C. Bagasse ash

Bagasse ash used in this project was sieved through 300 micron sieve and the ash passing through 300 micron sieve was rolled on abrasion testing machine with steel charges. Bagasse ash was sieved through 300 micron sieve to remove the unburned particles. The rolled Bagasse ash was then sieved through 90 micron sieve to make the fineness of Bagasse ash as same as cement. The Bagasse ash for the project was collected from Ponni sugar industry, Erode, Tamilnadu.

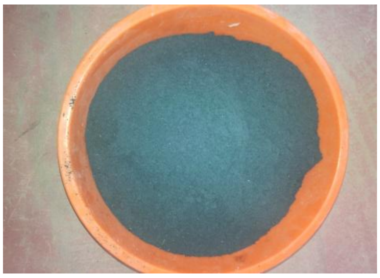

Fig. 1. Bagasse ash

D. Ground Granulated Blast furnace Slag (GGBS)

Ground granulated blast furnace slag is obtained by quenching molten iron slag from a blast furnace in water or steam to produce a glassy granular product that is then dried and ground in to fine product. GGBS is used to make durable concrete structures in combination with ordinary Portland cement and other pozzolanic materials.

Fig 2. GGBS

E. Superplasticizer

The use of superplastisizers permit the reduction of water to the extend upto 30 percent without reducing workability. These polymers are used as dispersants to avoid particle segregation and to improve the flow characteristics of suspensions. Their addition to concrete or mortar allows the reduction of water to cement ratio, not affecting the workability of mixtures and enables the production of self-consolidating concrete and high performance concrete. In this work we use the super plasticizer Master Glenium sky 8233, it is a high performance super plasticizer based on polycarboxylic ether for concrete.it is used in high performance concrete where highest durability and performance is required.it is free of chloride and low alkali.

Fig. 3. Master Glenium sky 8233

F. Concrete mix proportion

Concrete mix proportion of M_{30} grade is shown in Table I.

TABLE I
MIX PROPORTION

Water	Cement+ pozzolana	Fine aggregate	Coarse aggregate
186	511.50	581.19	1054.40
0.3636	1	1.136	2.061

III. CASTING OF CONCRETE CUBE SPECIMENS

Measured quantity of cement, natural sand, GGBS, Bagasse ash, coarse aggregate and water with respect to the mix proportion were taken. Cement, natural sand and pozzolonic material are mixed thoroughly in a mixing tray, until a uniform colour is obtained. Coarse aggregate were added in to this uniform mixture and continue the mixing. A required amount of water is added to this to obtain the required concrete mix. The concrete mix is filled in to the mould in three different layers. Each layer is tamped 25 times to expel the entrapped air.

Remoulded the specimen after a period of 24 hours. Cured the specimen for 28 days. Control mix was prepared. Different mixes with 10, 20 and 30% of replacement of cement by pozzolanic material was cast. Nine cubes and 3 cylinders of each mix were cast.

Fig. 4.Casting of cube specimens

IV. COMPRESSIVE STRENGTH TEST ON CONCRETE CUBES

Compression test is the most common test conducted on hardened concrete. The compressive test is carried out on specimens cubical in shape. The cube specimen is of size 15 x15 x 15 cm. The compression tests were conducted after 7days, 14 days, 28 days, 56 days and 90 days. The test was conducted according to IS specifications [IS. 516-1959].Testing of cubes was done in 7th, 14th and 28th day of curing. The testing is done to determine the compressive strength of the concrete using the compressive strength testing machine. There are three cubes for each percentage of cementitious material (0, 10, 20, and 30%) with corresponding percentages of Glenium sky by weight of cement.

1. Taken out the specimens from the curing tank and clean its surface.
2. Measured the dimensions nearest to 0.2 mm and note its weight.
3. Placed the specimen in the machine in such a manner that the load is applied to opposite sides of the cubes as cast, i.e., not to the top and bottom.
4. The load is applied without shock and increased continuously at a rate of approximately $14N/mm^2$per minute.
5. The maximum load taken by each specimen.

$$Compressive strength = Maximum Load / Cross sectional area$$

Fig. 4.Testing of cube specimens

Fig. 5.Tested cube specimens

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TABLE II
COMPRESSIVE STRENGTH OF CONCRETE CUBES

Specimen	Cement replacement %	Glenium sky dosage (% mass of binder)	Compressive strength at 7 days in N/mm^2	Compressive strength at 14 days in N/mm^2	Compressive strength at 28 days in N/mm^2
T30	30%	0.6%	28.74	31.40	33.77
T20	20%	0.7%	29.62	32.44	36.70
T10	10%	0.5%	30.96	33.48	39.51
Control Mix	0%	0.3%	26.96	31.70	37.40

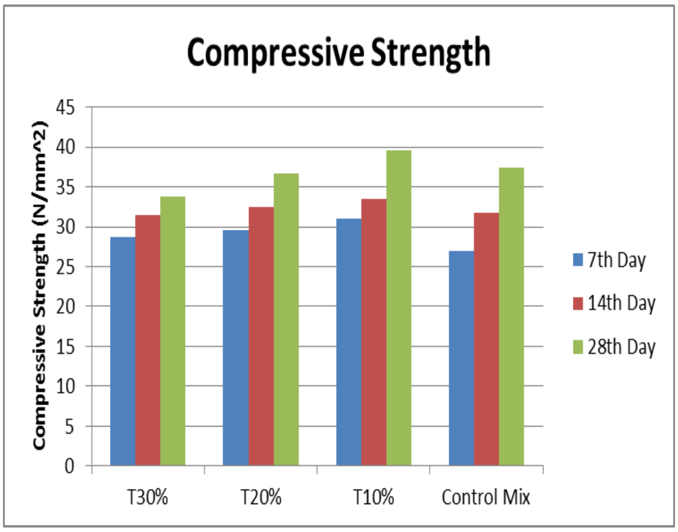

Fig. 6.Graph showing compressive strength of concrete

V. SPLIT TENSILE STRENGTH TEST ON CONCRETE CUBES

This test was done to determine the split tensile strength of concrete at the age of 28 days by using cylinder specimen having 15 cm diameter and 30 cm length. There are three cylinders for each percentage of cementitious material (0, 10, 20, and 30%). The cylinder specimens were tested on compression testing machine of capacity 2000KN. The bearing surface of machine was wiped off, cleaned and loose sand or other materials should be removed from the surface of the specimen. The load applied was increased continuously at a constant rate until the resistance of the specimen to the increasing load breaks down and no longer can be sustained. The maximum load applied on specimen was recorded.

Fig.7. Spilt tensile strength test

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TABLE III
SPLIT TENSILE STRENGTH OF CONCRETE

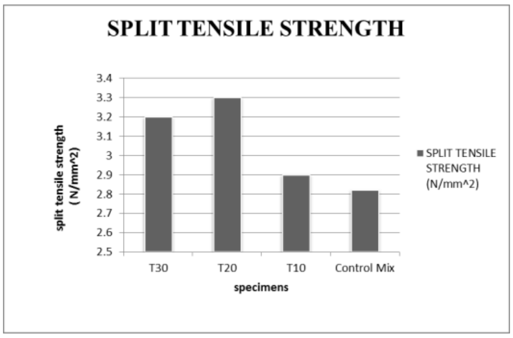

Fig. 8.Graph showing split tensile strength test result

Name of the Specimen	Cement replacement %	Glenium sky dosage (% mass of binder)	Split tensile strength at 28 days in N/mm^2
T30	30%	0.6%	3.2
T20	20%	0.7%	3.3
T10	10%	0.5%	2.9
Control Mix	0%	0.3%	2.82

VI. MODULUS OF ELASTICITY USING EXTENSOMETER

The modulus of elasticity or Young's modulus is the constant of proportionality between stress & strain. It increases with density, age & strength of concrete. This test was done to determine the modulus of elasticity of concrete in compression. This test is conducted in cylinder having 15 cm diameter and 30 cm length. Testing of modulus of elasticity was done at the age of 28 days. There were three cylinders for each percentage of cementitious material (0, 10, 20, and 30) with corresponding percentages of Glenium sky by weight of cement.

1. Tested three modulus concrete cubes for compressive strength and determine the average compressive strength.
2. Attached the Compressometer to the cylinder such that gauge points are symmetrical about the centre of specimen and in no case near to the end of specimen.
3. Placed the specimen in the testing machine and centre it accurately.
4. Applied the load continuously and without shock at a rate of $14N/mm^2$ per minute until an average stress of $(C+0.5)$ is reached where C is one-third of the average compressive strength of the cubes calculated to the nearest$0.5N/mm^2$.
5. Maintained the load at this stress for at least one minute and reduce it gradually to an average stress of $0.15N/mm^2$.
6. Applied the load a second time at the same rate until an average stress of $(C+0.15)$ is reached.
7. Maintained this load for 1 minute.
8. Reduced the load gradually to a stress of $0.15N/mm^2$.
9. Applied the load a third time and take Compressometer readings at ten approximately equal increments of stress up to an average stress of$(C+0.15)N/mm^2$.
10. Readings were taken at each stage of loading with as little delay as possible.
11. If the overall strains observed on the second and third readings differ by more than 5%, repeat the loading cycle until the difference in strain between consecutive readings at $(C+0.15)N/mm^2$ does not exceed 5%.

Fig 9. Modulus of elasticity test using extensometer

TABLE IV
MODULUS OF ELASTICITY OF CONCRETE

Specimen	Modulus Of Elasticity (N/mm^2)
T30	35166
T20	37433
T10	36450
CONTROL MIX	28710

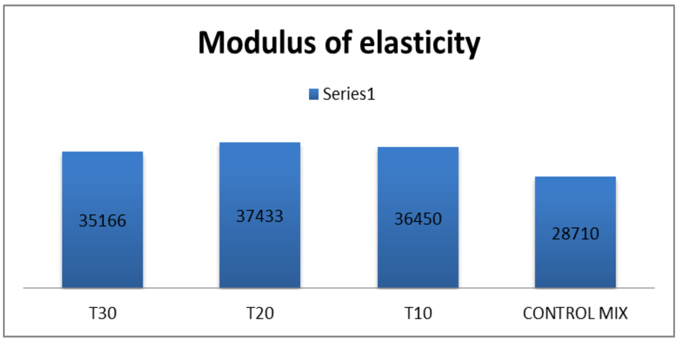

Fig 10. Modulus of elasticity of concrete specimen

VII. CONCLUSIONS

From the test results and calculated strength values, the following conclusions are drawn:

- 10% replacement of cement by high pozzolanic activity blend shows 5.64% increase in compressive strength than control mix where as 20% and 30% replacement shows 98.12% and 90.3% of the compressive strength of control mix.
- 20% replacement of cement shows 30.38% and 17% increase in modulus of elasticity and split tensile strength respectively than control mix. Other replacements (10%, 30%) also indicate significant increase on split tensile strength and modulus of elasticity of concrete.

ACKNOWLEDGMENT

The author would like to thank Dr. P G Bhaskaran Nair , PG Dean, Department of Civil Engineering, Sree Narayana Institute Of Technology, Adoor for his support, encouragement and valuable suggestion during the project. Author would also extend gratefulness to Neethu Mohan V M who greatly helped in my Endeavour.

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