Assessing The Strength Properties of Concrete By The Partial Replacement of EPS For Coarse Aggregates And GGBS For Cement

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Abstract- *This paper reports the results of an experimental investigation into the properties of hardened concrete containing expanded polystyrene beads with partial replacement of coarse aggregates and partial replacement of cement with GGBS. The results showed that the strength, stiffness and chemical resistance of polystyrene aggregate concrete of a constant density were affected by the water to cement ratio. An attempt is made to examine the structural lightweight concrete by partially replacing coarse aggregates by expanded polystyrene (EPS) beads. Here the size of EPS bead is 2.5mm is used. Additionally, Ground Granulated blast furnace slag is partially replaces to increase the bond strength between the EPB beads and cement paste. Thus increasing the compressive strength of EPS concrete. To this aim, various mixtures are produced by replacing 5%,10%, 15%,20% 25%, 30% of Coarse aggregate volume with EPS beads, substituting cement with 40% Ground granulated blast furnace slag (GGBS). These mixtures are evaluated through a comprehensive test program, including measuring compressive strength, splitting tensile strength and flexural strength. Structured light weight concrete of strength of about 14.3 MPa is successfully developed.*

Keywords- GGBS- Ground Granulated Blast furnace Slag, BFC- Blast Furnace Slag, CA- Coarse Aggregate,EPS.

I. INTRODUCTION

Concrete is most widely used construction material in the world because of its ability to cast in any form and shape. The strength and durability of concrete can be changed by making appropriate changes in its ingredients like cementations material, aggregate and water and by adding some special ingredients. Hence concrete is very well suited for a wide range of applications. The cement stabilization of peat has been prevalent traditionally throughout the years across the world. However, the drawbacks associated with the manufacturing process of cement finally lead to a great climatic change and environmental threats. Therefore, considering this issue, the present study encourages the use of industrial waste, ground granulated blast furnace slag (GGBS) and agricultural waste, rice husk ash (RHA) as a partial replacement of cement in the stabilization of Indian peat. .The compressive strength generally increases with age at curing, but it decreases densities and strength when EPS beads increased accordingly. The spilt tensile strength decreases when EPS beads replaced content increased accordingly.

II. MATERIALS

A.CEMENT

In this present investigation Ordinary Portland Cement of 53 Grade with a brand name (Bharathi cement *)* is used. Tests are conducted in accordance with the Indian standards confirming to IS-12269:1987.

Table 2.1 - Physical properties of cement

SL No	PHYSICAL TEST	RESULT	REQUIRMENTS AS PER IS-12269:1987
1	Fineness (%)	8%	Not more than 10% as per IS 4013 part 1
2	Standard consistency (%)	28%	Not more than 30% as per IS 4031 part 4
3	Initial setting time (minute)	33mins	Not less than 30 minute as per IS 4031 part 5
4	Final setting time (minute)	125mins	Not more than 600 minute as per IS 4031 part 5
5	Specific gravity	3.15	IS 2730 part 3

B.FINE AGGREGATES

Locally available river sand has been used as fine aggregate in the present study. Sieve analysis is carried out

and the grading curve is shown. The grading curve of fine aggregate confirms to zone II of IS 383-1970.

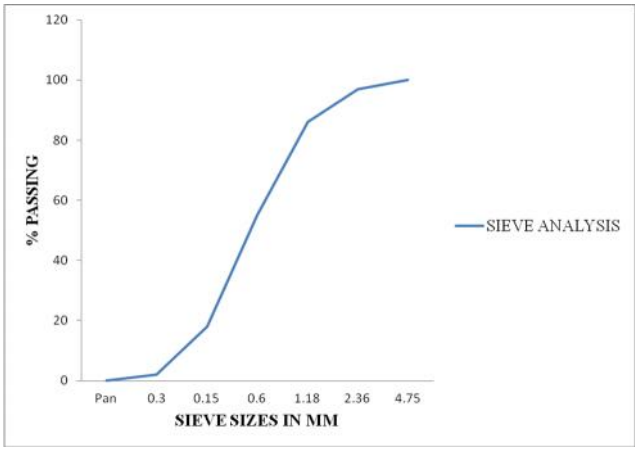

Figure 2.1 - Sieve analysis of fine aggregate

C. COARSE AGGREGATE

For the experimental work, locally available crushed stone aggregates from Apcon crushers of size 20 mm and 12.5 mm downsize are used and the various test carried on the aggregate as per IS 2386-1968. . The test results for physical properties of fine and coarse aggregates are shown in table below.

Table 2.2 - Sieve Analysis of Coarse aggregates

SIEVE SIZE (MM)	% OF FINER
20	100
10	41.52
4.75	0
Total Cumulative % Retained	276.2
Fineness Modulus	2.76

D.WATER

Water is used for mixing and curing as per IS 456:2000. From durability consideration water cement ratio should be restricted as in case of normal concrete and it should preferably be less than 0.4 are tested for their important properties before utilizing them for making concrete.

E. GGBFS (Ground Granulated Blast Furnace Slag)

GGBFS (Ground Granulated Blast Furnace Slag) is a by-product of the iron/steel manufacturing industry. The molten slag from the production of iron in a blast furnace is rapidly cooled by high pressure water jets which subjects the slag to instantaneous solidification in the form of granules, these are then dried and ground to a similar fineness to CEM I Class (42.5 N) in a tube mill.

Figure 2.2 - Ground granulated blast furnace slag

Table 2.2 - Physical properties of GGBFS

SL No	PHYSICAL TEST	OBTAINED VALUE
1	SPECIFIC GRAVITY	2.91
2	Density g/cm^2	3
3	Maximum Dry Density (KN/m^2)	2.56gm/cc

F.EPS (Expanded Polystyrene)

EPS or Expanded Polystyrene is a rigid cellular plastic originally invented in Germany in 1950. It has been used in packaging solutions since 1958. It is 98% air but the rest is made from tiny, spherical EPS beads – themselves made only of carbon and hydrogen. Expanded polystyrene is a stable, low density Foam and consists of discrete air voids in a polymer matrix. The polystyrene beads can be easily incorporated into mortar or concrete to produce lightweight concrete with a wide range of density. Applications of polystyrene concrete were they include curtain walls, cladding panels, tilt-up panels and composite flooring systems. Polystyrene concrete was used to produce load-bearing concrete blocks, sub-base material for a pavement, as the material of construction for floating marine structures. It was suggested that an overlaying layer of polystyrene concrete could provide protection to structures against impact loading. In the past, the use of polystyrene beads in concrete produced segregation due to extreme lightness and hydrophobic nature of the untreated Beads.

Figure 2.3 - EPS (Expanded Polystyrene Beads)

Table2.3 - Physical properties of EPS

SL No	PHYSICAL TEST	OBTAINED VALUE
1	SPECIFIC GRAVITY	0.011
2	DENSITY	8.5kg/m^3
3	Compressive strength	0.09Mpa
4	Flexure strength	0.23Mpa
5	Water Vapor permeability	1.43 Perm-cm

III. EXPERIMENTAL PROGRAM

A. MIX DESIGN PROCEDURE FOR M15 GRADE CONCRETE

The Mix Design of Concrete as per IS 10262:2009

Table 3.1 - Stipulations for Proportioning

Grade designation	M 15
Type of cement	OPC 53 grade
Maximum nominal size	20mm of aggregate
Maximum w/c ratio	0.55 (Experimental value)
Type of aggregate	Crushed angular aggregate

B. LABORATORY TESTS

The tests conducted on hardened properties of concrete are

- Compressive strength
- Split tensile strength
- Flexural strength

Compressive Strength

The specimen like cube and cylinder undergoes lateral expansion when subjected to compressive load. When fibers are added it restrains the expansion in lateral direction. The restraint exercised depends on friction developed between concrete matrix and fiber. Compression test is conducted on hardened concrete. It can be done for both cube and cylinder but for the present work compression test is carried for cube specimens. The cube specimen of size 150x150x150mm is used. Concrete is filled into the mould in 3 layers each of approximately 5cm deep. It is de-molded after 24+/-2 hrs of casting and cured. The specimens are removed from water and surface dried and finally tested in compression testing machine. The cube is placed over loading platform of compression testing machine and load is gradually applied over the cube until the specimen failed and no load is sustained further more. Design engineers use the specified strength to design structural elements. This specified strength is incorporated in the job contract documents and is called design strength of concrete. The concrete mixture is designed to produce an average strength fc' higher than the specified strength such that the risk of not complying with the strength specification is minimized. To comply with the strength requirements of a job specification, the following acceptance criteria apply:

1. The average of three consecutive tests should equal or exceed the specified strength fc'.
2. No single strength test should fall below fc' by more than 500 psi (3.45MPa) or by more than 0.10fc' when fc' is more than 5000 psi (35 MPa).

Figure 3.1 - Test Setup of Compressive experimental work

Figure 3.2 Failed Speciman

The first contribution of this work is the development of a new model identification approach "bi-objective" that can efficiently capture the strength variability in addition to the mean strength. After studying the effect of the way of selection the core locations, a method was proposed to select these locations depending on the NDT measurements "conditional selection" that improves the quality of assessment without additional cost. A third innovation was the development of a procedure to identify the relation between the number of cores and the accuracy of the estimation. Finally recommendations were derived in order to provide more reliable estimated values.

Split Tensile Strength

Direct measurement of tensile strength of concrete is difficult. Usually concrete is week in tension but when it reinforced with fibers, which is having good tensile strength, on a whole the concrete tensile strength increases. The cylinders to be tested are kept horizontally between loading surfaces of the testing machine. At the top and bottom of the cylinder surface, two metal plates were placed for uniform distribution of loads. Till failure occurs the load was applied at a uniform rate, usually failure occurs at the vertical diameter of the specimen and the maximum load at failure was noted. The test procedure is repeated for all four series of concrete specimens. One of the important properties of concrete is "tensile strength" as structural loads make concrete vulnerable to tensile cracking. Tensile strength of concrete is much lower than its compressive.

Figure 3.3 - Cylinder casted for Experimental work

Flexural Strength

In the experimental work, the flexure strength is carried on beams of size 100 × 100 × 500mm. the loading system for flexure test is of two kinds, central point loading and two point loading. Usually flexural strength obtained by two points loading will be less than the central point loading. Flexural strength is an indirect measure of the tensile strength of concrete slab at the point of failure in bending.

IV. RESULTS AND DISCUSSION

Present experimental investigation is carried out on M - 15 concrete with 40% of GGBFS by weight of cement. and 0%,5%,10%, 15%, 20%, 25%, 30% of EPS (Expanded polystyrene beads) by weight of coarse aggregate .

A.COMPRESSIVE STRENGTH

The compressive strength for all series of concrete specimens with respect to variation in EPS and constant GGBS which are cured for 7, 14 and 28 days is shown in the below table.

Table 4.1 - Compressive strength of concrete specimens test results

Sl No	Concrete type	Compressive Strength (MPa)		
		7 days curing	14days curing	28 days curing
1	Plain concrete	14.01	15.2	16.83
2	5% EPS 40% GGBS	12.1	12.5	13
3	10% EPS 40% GGBS	12.5	13.01	13.7
4	15% EPS 40% GGBS	13.3	13.9	14.3
5	20% EPS 40% GGBS	12.8	13.1	13.5
6	25% EPS 40% GGBS	12.1	12.7	12.9
7	30% EPS 40% GGBS	11.9	12.1	12.3

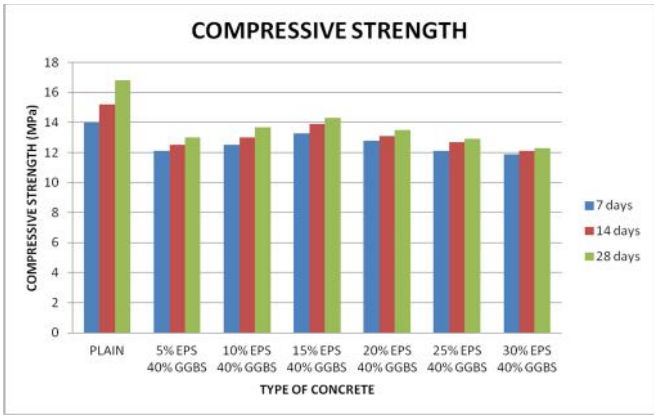

Figure 4.1 - Compressive strength of all series

B.SPLIT TENSILE STRENGTH

The Tensile strength for all series of concrete specimens with respect to variation in EPS and constant GGBS which are cured for 7, 14 and 28 days is shown in the below table.

Table 4.2 - Split Tensile strength of concrete specimens

Sl No	Concrete type	Compressive Strength (MPa)		
		7 days curing	14days curing	28 days curing
1	Plain concrete	1.37	1.49	1.65
2	5% EPS 40% GGBS	1.19	1.23	1.28
3	10% EPS 40% GGBS	1.23	1.28	1.34
4	15% EPS 40% GGBS	1.30	1.36	1.40
5	20% EPS 40% GGBS	1.26	1.29	1.32
6	25% EPS 40% GGBS	1.19	1.25	1.27
7	30% EPS 40% GGBS	1.17	1.19	1.21

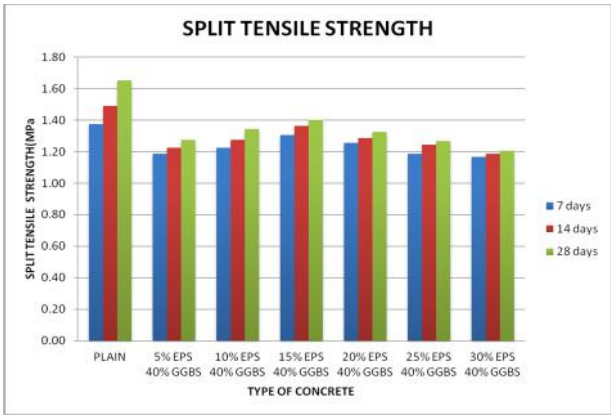

Figure 4.2 - Split Tensile strength of all series

C.FLEXURAL STRENGTH

The Flexural strength for all series of concrete specimens with respect to variation in EPS and constant GGBS which are cured for 7, 14 and 28 days is shown in the below table.

Table 4.3- Flexural strength of concrete specimens

Sl No	Concrete type	Compressive Strength (MPa)		
		7 days curing	14days curing	28 days curing
1	Plain concrete	1.96	2.13	2.41
2	5% EPS 40% GGBS	1.69	1.75	1.82
3	10% EPS 40% GGBS	1.75	1.82	1.92
4	15% EPS 40% GGBS	1.86	1.95	2.00
5	20% EPS 40% GGBS	1.79	1.83	1.89
6	25% EPS 40% GGBS	1.69	1.78	1.81
7	30% EPS 40% GGBS	1.67	1.69	1.72

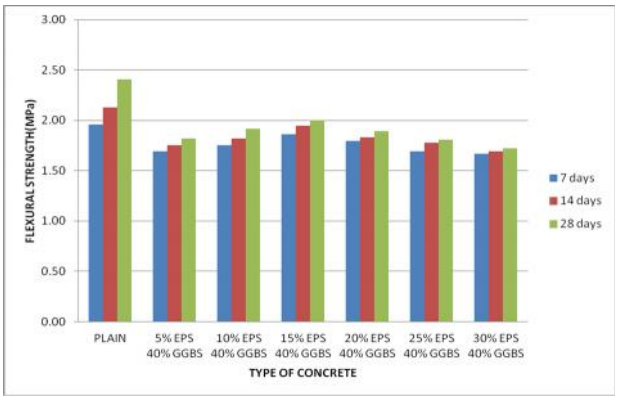

Figure 4.3 - Flexural strength of all series

By testing the cube specimens through compression testing machine, it can be shown that the Flexural strength of 15%EPS with 40%GGBS yielded maximum strength compared to other specimens.

V. CONCLUSIONS

- Initial finding have shown that the lightweight concrete using EPS beads has a desirable strength to be an alternative construction material for the construction of partition wall, foot path, parapet wall, bed concrete.

- EPS concrete gives good workability and could easily be compacted and finished. Workability increases with increase in EPS content.
- The compressive strength of EPS concrete is less than Conventional concrete.
- The replacement by using EPS is a best alternate non-structural building material and it is best way for best disposal.
- It will reduced the landfill and pollution since, waste material are used.
- Optimum level of replacement of aggregate by EPS beads is found to be 15% to obtain better compressive strength, split tensile strength and flexural strength.
- The compressive strength generally increases with age at curing, but it decreases densities and strength when EPS beads increased accordingly.
- The spilt tensile strength decreases when EPS beads replaced content increased accordingly
- The flexure strength decreases when EPS beads replaced content increased accordingly.

REFERENCES

[1] L.R.Manjunatha and Dr.Sandhya.R.Anvekar "Ready-mixed concrete, a boon to modern day's fast track construction projects and a research study on Customers" Preference ,Perceptions on quality, timely delivery and durability aspects of Ready Mixed Concrete (RMC):"EPC & I Magazine, April 2013

[2] Roshan Gawale1, Shubham Mishra2, Harshal Sambare3, Jidhnesh Kothari4, Assistant Prof. Monali Patil5 LIGHT WEIGHT COCRETE BY USING EPS BEADS IJIRSE VOL2 Issue 3 , March 2016

[3] Kirti Padmawar1 Pranali Gajbhiye2 Abhishek Sahare3 Nikeeta B. Dethe4 Light Weight Flyash Brick using Expanded Polystyrene (EPS) IJSRD - International Journal for Scientific Research & Development| Vol. 5, Issue 1, 2017

[4] Abhijit Mandlik1, Tarun Sarthak Sood2, Shekhar Karade3, Sangram Naik4, AmrutaKulkarni5 Lightweight Concrete Using EPS International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438.

[5] R. Sri Ravindrarajah & A. J., Tuck "Properties of Hardened Concrete Containing Treated Expanded Polystyrene Beads", School of Civil Engineering, University of Technology, Sydney, New South Wales, Australia.

[6] Bing Chen, Juanyu Liu., "Properties of lightweight expanded polystyrene concrete reinforced with steel fiber", Cement and Concrete Research, 2004, 34, 1259–1263.

[7] O.H. Ling, D.C.L. Two, "Properties of EPB RHA lightweight concrete bricks under different curing conditions" Construction and Building Materials, 2011 25, 3648 – 3655.

[8] A. Sadrmomtazi, J. Sobhani, M.A. Mirgozar, M. Najimi., " Properties of multi-strength grade EPB concrete containing silica fume and rice husk ash" Construction and Building Materials, 2012, 35, 211 – 219.

[9] Ramazan Demirboga &, Abdulkadir Kan.,"Thermal conductivity and shrinkage properties of modified waste polystyrene aggregate concretes" Construction and Building Materials 35 ,2012,35, 730 – 734.

[10] D. S. Babu, G. K. Babu, and W. Tiong-Huan, "Properties of lightweight expanded polystyrene aggregate concretes containing fly ash," Cement and Concrete Research, vol. 35, no.6, pp. 1218–1223, 2005.