EXPERIMENTAL INVESTIGATION ON PREVIOUS CONCRETE WITH OPTIMUM UTILIZATION OF GGBS AS A PARTIAL REPLACEMENT OF CEMENT

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Abstract: Pervious Concrete is a special type of concrete used to allow water to intentionally pass through the surface of a pavement and allow storm water to eventually absorb back into the surrounding soils. Pervious concrete pavement is unique and effective means to meet growing environmental demands. This paper also shows the effect of supplementary cementitious material such as blast furnace slag (GGBS) and variation on the strength performance of pervious concrete. This paper presents the details of an experimental investigation carried out to use GGBS as a partial replacement to cement in concrete in an attempt to investigate the compressive strength of concrete and flexural strength of concrete. For control concrete, IS method of mix design is adopted and considering this a basis, mix design for replacement method has been made. Four different replacement levels of GGBS namely 5%, 10%, 15% and 20% are chosen for the study to utilize GGBS in the production of concrete. Cubes of 150 x 150 x 150 mm and beams of size 100 x 100 x 500 mm were cast, cured for 7 days and 28 days and then tested to record the compressive strengths and flexural strengths to compare with control concrete. The results have been analyzed and useful conclusions have been drawn.

***Index Terms* – Cement, GGBS, Aggregates.**

I. INTRODUCTION

Nowadays Pervious concrete has become significantly popular, because of its potential contribution in solving environmental issues. Pervious cement concrete pavement is a mixture of gravel or stone, cement, water and little or no sand which creates an open cell structure that allows water and air to pass through it. Pervious concrete is a type of concrete with significantly high water permeability when compared to the normal concrete. The main purpose of pervious concrete is to drain off the water from the ground surface, so that storm water runoff is reduced and the groundwater is recharged. It can be used for lower traffic roads, shoulders, sidewalks, tennis court and parking lots. According to EPA (Environmental Protection Agency's) storm water runoff can send as much as 90% of pollutant such as oil and other hydrocarbon. The ability of pervious concrete to allow water to flow through itself recharges ground water and minimizes the extent of pollution and storm water runoff. Pervious concrete is considered a sustainable building alternative for concrete and asphalt pavement parking lots because it provides pollution mitigation and storm water management. Pervious concrete acts as a filtration device for storm water and turns the entire parking area, pathway, or other paved surface into a retention treatment basin

Different researchers conducted investigations on porous concrete to evaluate their mechanical properties. Malhotra (1976) designed concrete mix to achieve permeability and conducted strength tests on cube and cylinders. Menninger (1998) conducted many experiments and determined the relationship between compressive strength and water cement ratio at different days of curing, the relationship between compressive strength and water content, and the relationship between compressive strength and Unit Weight. The author concluded the maximum compressive strength is achieved between 0.3 to 0.35 water cement ratios. Karthik H.obla (2010) carried research on pervious concrete for its use in reducing the runoff from a site and recharging ground water levels. The ratio of permeability of concrete is depended to size of aggregate and the density of the concrete Hydraulic properties of the pervious concrete were evaluated and concluded that by 20% void content in concrete is adequate to attain sufficient strength. S.O. Ajamu, A.A. Jimoh, & J.R. Oluremi (2012) conducted studies on strength characteristics of pervious concrete and concluded that strength depends on the size of aggregate and material proportions. The maximum compressive strength was when use 9.38 mm size of course aggregate and maximum permeability was in 18.75 mm of size of course aggregate. Rasiah Sriravindrarajah(2012), Neo Derek Huai Wang, and Lai Jian Wen Ervin(2012) conducted experimentation on pervious concrete using natural aggregates and recycled aggregates and evaluated compressive strength and permeability properties. Darshan S. Shah(2013) et.al investigated the engineering properties of pervious concrete and its use in rural roads to prevent run off. Ammar A. Muttar(2013) improved the mechanical properties of pervious concrete by adding propylene fibers and found significant improvement in compressive strength. M. Uma Maguesvari, and V.L.Narasimha (2014) conducted studies on porous concrete at various cement contents and different sizes of aggregates. It was concluded that permeability decreases with increase of cement content. M. Harshavarthana Balaji(2015) at el designed ecofriendly porous concrete for use in parking areas to increase the ground water recharge. Silica fumes is used in place of fines and investigated the engineering properties. Ghanim Hussein Qoja(2016) et.al conducted studies on porous concrete and established the relationship among the parameters aggregate – cement ratio, unit weight, permeability and strength.

II. Materials Used

The details of various materials used in this investigation are listed below.

2.1. Cement Used

The cement used in this study ordinary Portland cement Ultratech 43 grade conforming to I.S:8112-1989.

Table 1: Physical properties of Ordinary Portland Cement

SL. No.	Characteristics	Test results	Recommended values	IS Standards
1	Normal consistency	32%	Not less than 30%	IS:4031-Part 4-1988
2	Initial setting time Final setting time	65 min 270 min	Not less than 30 min Not more than 600 min	IS:4031-Part 5-1988
3	Specific gravity	3.10	3.0 – 3.15	IS:4031-Part 11-1988
4	Fineness of cement by sieving through No. 9 (90 microns)for a period of 15 min	2%	Not more than 10%	IS:4031-Part 1-1996
5	Soundness test (Le-chateliers Exp.)	2 mm	Not more than 10mm	IS:4031-Part 3-1988
6	Compressive strength of cement 3 days 7days 28days	 24 Mpa 33.8 Mpa 45 Mpa	 Not less than 23 Mpa Not less than 33 Mpa Not less than 43 Mpa	IS:4031-Part 6-1988

2.2. Coarse-aggregate Used

Crushed granite aggregate available from local sources has been used. To obtain a reasonably good grading, 46% of the 20mm passing 12.5mm retained aggregates, 36% of 12.5mm passing 9.5mm retained aggregates and 18% of 9.5mm passing 4.75mm retained aggregates are used in the production of concrete. The specific gravity of coarse aggregate is 2.69.

2.3. Water Used

Water available in the college campus conforming to the requirements of water for concreting and curing as per BIS: 456-2000. The pH value should not be less than 6.

2.4. GGBS

Properties of GGBS is as follows

Table 2: Chemical Composition of GGBS

SL.NO	Chemical Compound	Abbreviation	Percentage (%)
1	Silica	SiO_2	26-38%
2	Aluminium Oxide	AL_2O_3	10-24%
4	Calcium oxide	CaO	30-50%
5	Magnesium Oxide	MgO	1-18%
6	Sodium Oxide	Na_2O	0.27%
7	Potassium oxide	K_2O	0.37%

III. Methodology

The main aim of the experimental program is to study the physical properties of concrete. Cement is partially replaced with GGBS in the proportion of 0% (Reference mix), 5%, 10%, 15% and 20% by weight. The materials (Cement and Coarse Aggregates) are weighed and dry mixed thoroughly after the measured amount of water for Water cement ratio of 0.35 is added and the material is mixed thoroughly until it becomes uniform. Replacement of cement by GGBS from 0% to 20% by weight is done. Concrete produced are filled in 150mm× 150mm × 150mm and 100mm× 100mm × 500mm moulds. After 24 hours of casting, the specimens are de-molded and kept for curing.

The specimens were tested at different ages (7 and 28 days of curing) for compressive strength and flexural strength in accordance with Bureau of Indian Standards. For each trail, 3 cubes and 3 beams were cast and tested at the age of 7 and 28 days. The average values of compressive strength and flexural strength were adopted in each case.

IV. DISCUSSIONS OF TEST RESULTS

4.1.Effect of age on compressive strength of concrete w.r.t different % replacement of GGBS:

Table 3 represents tabulated values of the compressive strength of GGBS concrete w.r.t age

Table.3 Compressive strength of GGBS concrete w.r.t age

Percentage of GGBS	Compressive Strength (Mpa)	
	7days	28days
0% GGBS	14.07	17.33
5% GGBS	11.85	17.62
10% GGBS	12.51	17.25
15% GGBS	11.48	21.33
20% GGBS	14.96	23.85

Figure 1 represents the Effect of age on compressive strength of concrete w.r.t different % replacement of GGBS

Fig.1 Effect of age on compressive strength of concrete w.r.t different % replacement of GGBS.

From this figure, it can be observed that the compressive strength increases for all the percentages of replacement of GGBS from 7days to 28days, but the early strength gain is maximum for 20% replacement of cement by GGBS and it increases by

37.27% for 28days. The early strength gain is minimum for 0% replacement of cement by GGBS, but it increases by 36.11% for 28days.

4.2. Effect of age on flexural strength of concrete w.r.t different % replacement of GGBS:

Table 4 represents tabulated values of the flexural strength of GGBS concrete w.r.t age

Table.4 Flexural strength of GGBS concrete w.r.t age

Percentage of GGBS	**Flexural Strength (Mpa)**	
	7days	**28days**
0% GGBS	3.98	4.51
5% GGBS	4.26	4.59
10% GGBS	4.61	4.72
15% GGBS	3.14	4.65
20% GGBS	3.11	4.60

Figure 1 represents the effect of age on flexural strength of concrete w.r.t different % replacement of GGBS

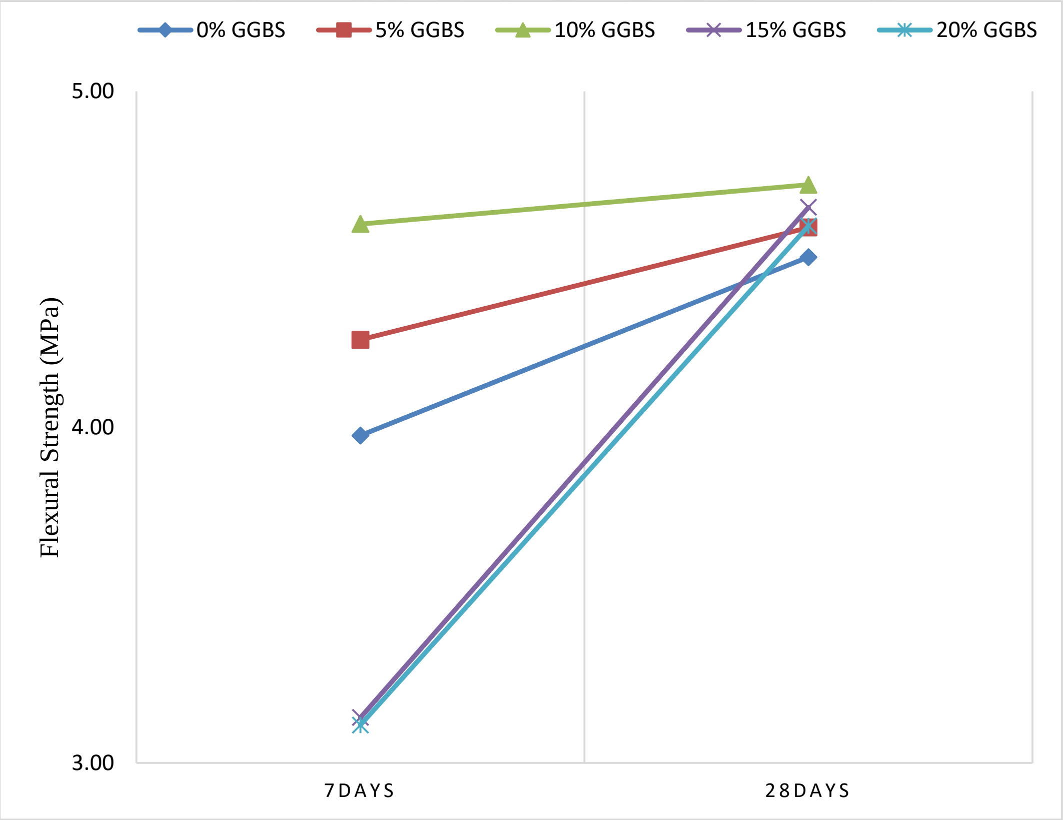

Fig.2 Effect of age on flexural strength of concrete w.r.t different % replacement of GGBS.

From this figure, it can be observed that the flexural strength increases for all the percentages of replacement of GGBS from 7days to 28days, but the early strength gain is maximum for 10% replacement of cement by GGBS and it increases by 2.48% for 28days. The early strength gain is minimum for 20% replacement of cement by GGBS, but it increases by 32.22% for 28days. Though the early strength gain of 20% replaced concrete is less, it has a significant rise in flexural strength by 28 days while compared to 11.78% increase of ordinary concrete. However, the flexural strength of concrete reduces for other percentages of GGBS.

V. Conclusions

The present investigation establishes the superiority concrete produced with partial replacement of cement by GGBS to stand well compared to ordinary concrete. The important conclusions of the present paper are summarized below.

1. The compressive strength of the concrete with partial replacement of GGBS increases with increasing the percentage of GGBS.

2. GGBS can be added to cement concrete as partial replacement of cement up to 20% without any significant reduction in any of the property of concrete. This will result in the reduction in the cost of concrete to some extent.

3. The flexural strength of the concrete with partial replacement of GGBS increases with increasing the percentage of GGBS to some extent.

4. GGBS can be added to cement concrete as partial replacement of cement up to 10% without any significant reduction in any of the property of concrete. This will result in the reduction in the cost of concrete to some extent.

5. Though the early flexural strength gain of 20% replaced concrete is less, it has a significant rise in flexural strength by 28 days while compared to 11.78% increase of ordinary concrete.

6. Pervious concrete is the relatively new concrete for the pavement construction in rural areas having cost benefits and pervious concrete can be extensively used worldwide because of their environmental benefits and hydraulic properties.

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