An Experimental Investigation on Polypropylene Fibre and Glass Fibre in High Performance Concrete using GGBS as Partial Replacement of Cement

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Abstract: **This paper presents that the experimental investigation on High Performance Concrete (HPC) using GGBS as partial replacement of cement in various percentages (0% 10%, 20%, 30%, 40% & 50%) of concrete. The past research works were bring to promote an ordinary concrete into special concrete (HPC). Material properties are evaluated by conducting a laboratory tests (physical properties and mechanical properties). The addition of glass fibre in different percentages (0%, 1%, 2%, 3% & 4%) and polypropylene fibre in different percentages (0%, 0.1%, 0.2%, 0.3% & 0.4%) by volume of cement content. To achieve higher workability CONPLAST SP 430 is added in concrete mix. The grade of concrete M_{35} is used. The two different fibres of concrete mixes were casted by in the form of cubes, cylinders and prisms. Thus the experimental results shows that polypropylene fibre in HPC concrete mix is more effective than glass fibre in HPC concrete mix.**

Keywords: ***GGBS (Ground Granulated Blast Furnace Slag), Glass fibre, Polypropylene fibre, High Performance Concrete (HPC), Super plasticizer.***

I. INTRODUCTION

Concrete is probably the most widely used construction material in the world. Concrete is a mixture of cement, water, and aggregates, with or without admixtures. Only for specific function the concrete grade can be increased to 50 Mpa and above. This specific function of high performance concrete (HPC) cannot be achieved by Ordinary Portland Cement (OPC). It is achieved not only by reducing water cement ratio but also by replacement of cement with some mineral admixture like Silica fume, Ground Granulated Blast Furnace Slag (GGBS), Metakaolin and Fly ash etc with chemical admixtures. The main constituent in the conventional concrete is Portland cement. Cement production is consuming significant amount of natural resources [1-4].

The incorporation of supplementary cementitious material is GGBS is a mineral admixture, which improves mainly the mechanical properties of concrete and reduces the cement consumption by replacing part of cement with these pozzolanic materials. Moreover, only limited studies have been carried out in India on the use of slag for the development of high performance concrete with addition of polypropylene fibers and glass fibers. Portland cement concrete possesses a very less tensile strength, limited ductility and little resistance to cracking [5,6].

Propagation of internal micro cracks in the concrete which reduces the tensile strength. It has been identified that the addition of small, firmly spaced and evenly dispersed fibers to concrete would act as crack arrester and evenly dispersed fibers to concrete would act as crack stop and would substantially improve its mechanical properties of the concrete. In this study the addition of polypropylene and glass fibers are added to concrete, leads to improvement in cracking and tensile strength. In HPC, materials and admixtures are prudently selected and proportioned to form high early strengths and high durability beyond conventional Portland cement concrete [14-16].

The admixtures like fly ash, silica fume, ground granulated blast furnace slag (GGBS), are added both for strength and durability and acts as an eco-friendly product. A high-range water-reducing admixture may provide a required

low water/cement ratio, as low as 0.30. This paper presents the study of high-performance concrete by replacing the 10%, 20%,30%,40% and 50% replacement of GGBS and 0.1% ,0.2% and 0.3% glass fibre and polypropylene fibre replacement. Tests were conducted on concrete cube, cylinder and prism to study compressive strength, split tensile strength and flexural strength. The results are compared with the normal conventional concrete and to find out the optimum mix proportions [15-18].

II. METHODOLOGY

Step 1: literature collection - To collect the past related works of journals and implement to this research work, to fulfill the aim of the work.

Step 2: material property study - The material (GGBS) was collected from JSW steel plant at salem and physical properties are determined by conducting lab tests.

Step 3: specimen preparation - All the specimens (cubes, cylinders and prisms) are casted by adding in two (glass and polypropylene) fibers. Also increase the high strength of concrete added a 3% of volume of cement content.

Step 4: testing of specimen - The concrete have taken for curing periods at after completion of 7 days and 28 days. The testing of all the specimens (cubes, cylinders and prisms) were determined by compressive strength test, split tensile strength test and flexural strength test.

Step 5: results - Finally, all the test results are compared to adding of both glass and polypropylene fibers in HPC.

III. MATERIALS USED

3.1 Cement

Ordinary Portland cement, 43 Grade conforming to IS:8112-1989 [4] was used. The specific gravity of cement was 3.15.

3.2 Fine aggregate

Locally available river sand conforming to Grading zone II of IS: 383 1970[5] was used.Its specific gravity was 2.6.

3.3 Coarse aggregate

Locally available crushed granite stones conforming to graded aggregate of nominal size 20 mm were used. Its specific gravity was 2.84.

3.4 Ground Granulated Blast furnace Slag (GGBS)

Ground granulated blast furnace slag obtained from local steel plant and its shows high pozzolanic and binding property. GGBS (figure 1 (a)) is obtained by quenching molten iron slag (a product of iron and steel making) from a blast furnace in water or stream, to produce a glassy, granular product that is then dried and ground into a fine powder. The specific gravity of ground granulated blast furnace slag is 2.85.

3.5 Super Plasticizer

Commercially available sulphonated naphthalene formaldehyde based super plasticizer (CONPLAST SP 430) was used as chemical admixture to enhance the workability of the concrete.

3.6 Glass fibers

Glass fiber is a light weight, extremely strong & robust material. The glass fiber (figure 1 (a)) type used here is E glass with 50mm fiber length & 0.1 mm diameter. The aspect ratio of the glass fiber is 500.

3.7 Polypropylene fibers

RECRON 3S type polypropylene fibres (figure 1 (b)) of density 946 Kg/m3 are used in experimental study.

(a) (b) (c)

Figure.1 material collection (a) glass fibre (b) polypropylene fibre (c) GGBS

IV. MIX PROPORTION

The concrete mix is designed for M_{35} grade as per IS 10262-2009 and IS 456-2000.Table 1 show that Ingredients for High Performance Concrete.

Table 1 Ingredients for High Performance Concrete

Description / MIX ID	Mix proportion	Cement kg/m^3	GGBS kg/m^3	Fine Aggregate kg/m^3	Coarse aggregate kg/m^3	Chemical admixtures kg/m^3	Water / cement ratio
M35	1:2.04:2.86	309	131 (40% of weight of cement)	786	1108	0.92 (0.3% of weight of cement)	0.4

V. SPECIMEN PREPARATION

The experimental investigation consists of casting and testing of 9sets along with control mix. Each set comprises of 15 cubes, 6 cylinders and 6 beams for determining compressive, tensile and flexural strengths respectively. By taking different percentage of GGBS, along with steel & glass fibers individually as a partial replacement of cement will be replaced accordingly with the different percentages by weight of slag and different percentages by weight of steel fiber and glass fiber. The concrete was filled in layers and compacted. The specimens were removed after 24 hours.

VI. EXPERIMENTAL WORK

The mechanical properties of HPC were determined by conducting tests i.e (i) compressive strength test of concrete cubes (figure 2 show that cube compressive strength test set up for (a) 3% of polypropylene fibre added (b) 0.3% of glass fibre added), (ii) split tensile strength test of concrete cylinders (figure 3 show that cylinder spilt tensile strength test set up for (a) 3% of polypropylene fibre added (b) 0.3% of glass fibre added), (iii) flexural strength test of concrete prisms (figure 4 show that prism flexural strength test set up for (a) 3% of polypropylene fibre added (b) 0.3% of glass fibre added).

(a) **(b)**

Figure 2 cube compressive strength test results for M35 grade with 40% of GGBS (a) 0.3% of glass fibre in HPC (b) 3% of polypropylene fibre in HPC

(a) **(b)**

Figure 3 Cylinder split tensile strength test results for M35 grade with 40% of GGBS (a) 0.3% of glass fibre in HPC (b) 3% of polypropylene fibre in HPC

(a) **(b)**

Figure 4 Prism flexural strength test results for M35 grade with 40% of GGBS (a) 0.3% of glass fibre in HPC (b) 3% of polypropylene fibre in HPC

VII. RESULTS AND DISCUSSION

The different percentages (0%, 10%, 20%, 30%, 40% & 50%) of GGBS as partial replacement of cement added in concrete cubes are conducting by compressive strength test (figure 5 show that optimizing the results for GGBS in HPC). The 40% of GGBS in concrete mix obtain maximum compressive strength for 7 days and 28 days of curing period [8,9]. The optimum mix of 40% GGBS with 3% polypropylene fibre in concrete mix shows maximum compressive strength, split tensile strength and flexural strength (figure 6 show that Cube results for % of Polypropylene fibre added , figure 8 show that cylinder results for % of Polypropylene fibre added and figure 10 show that prism results for % of Polypropylene fibre added). The optimum mix of 40% GGBS with 0.3% glass fibre in concrete mix shows maximum compressive strength, split tensile strength and flexural strength [10,11] (figure 7 show that Cube results for % of glass fibre added in HPC figure 8 show that cylinder results for % of Polypropylene fibre added , figure 9 show that cylinder results for % of glass fibre added and figure 10 show that prism results for % of Polypropylene fibre added in HPC figure 11 show that prism results for % of glass fibre added).

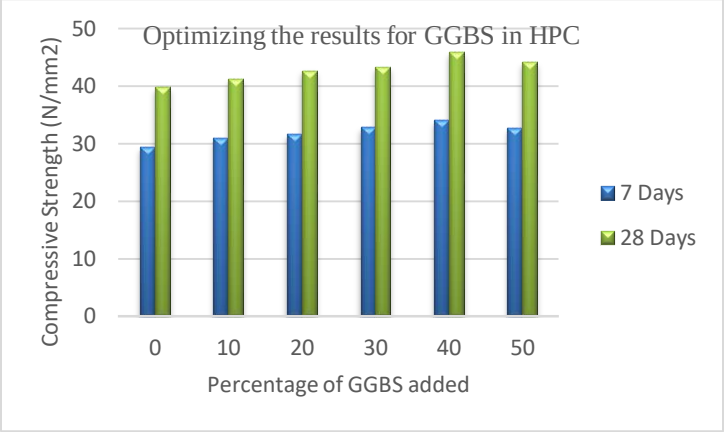

Figure 5 optimizing the results for GGBS in HPC

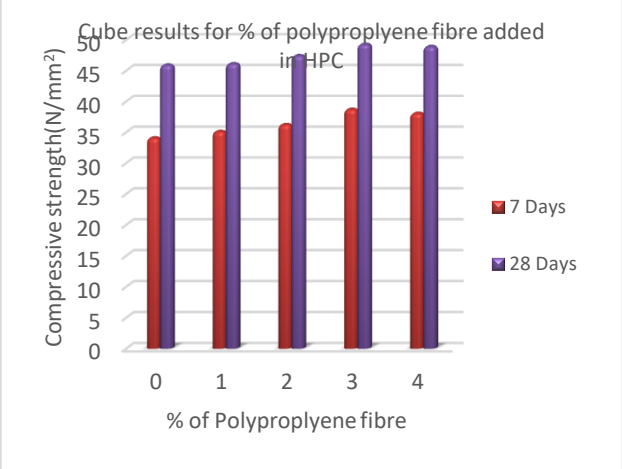

Figure 6 Cube results for % of Polypropylene fibre added

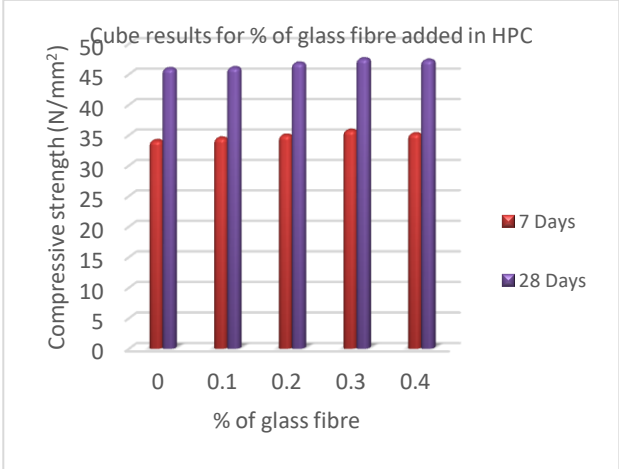

Figure 7 Cube results for % of glass fibre added

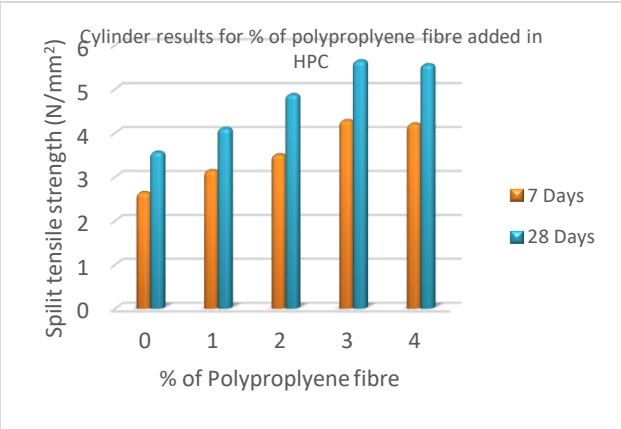

Figure 8. Cylinder results for % of Polypropylene fibre added

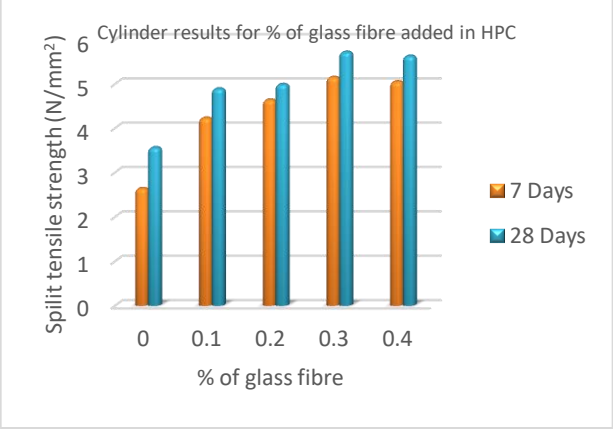

Figure 9. Cylinder results for % of glass fibre added

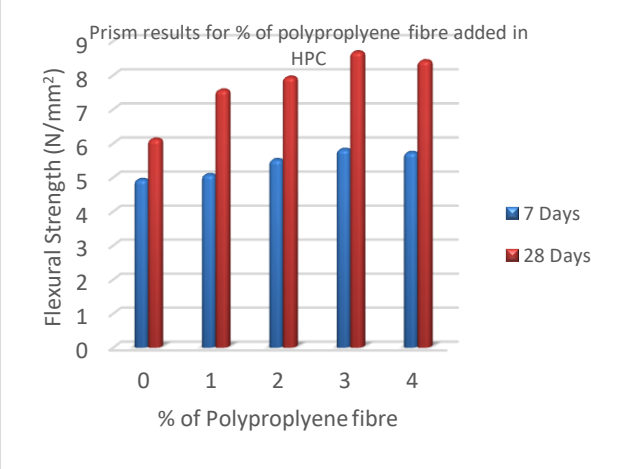

Figure 10 Prism results for % of Polypropylene fibre added

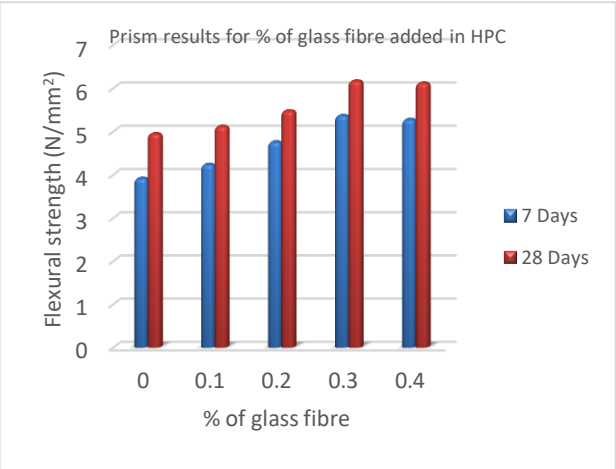

Figure 11 Prism results for % of glass fibre added

VIII. CONCLUSION

From the study of experimental results and discussion there upon the following conclusions can be drawn,

- The optimum quantity for partial replacement of cement by GGBS was obtained at 40% of weight of cement.
- The partial replacement of cement in the sense of to reduce a cement content in the concrete and also to save the construction costs.
- The concrete mix of 40% GGBS and 0.3% glass fibre has the maximum compressive strength, Split tensile strength and Flexural Strength.
- The concrete mix of 40% GGBS and 3% polypropylene fibre has the maximum compressive strength, Split tensile strength and Flexural Strength.
- The experimental test results show that the polypropylene fibre more effective than glass fibre.

8.1 Future Extending Work

- Based on experimental investigation the optimum mix was identified and further development of this research work, to evaluate the durability property and ultimate load behavior of the beam element in future study.
- Non-Destructive testing techniques can be done for the concrete specimen

References

[1] Anjali Prajapati, Piyush Prajapati, Mohammed Qureshi (2017), "An experimental study on high performance concrete using mineral admixtures", International Journal of Engineering Development and Research, Volume 5, Issue 2, PP: 2080-2086.

[2] Arivalagan. (2013) "Sustainable Studies on Concrete with GGBS as a Replacement Material in Cement" . Jordan Journal of Civil Engineering, Volume 8, No. 3, pp.15-19.

[3] Indian standard code recommended by the method of concrete Mix Design, (IS: 10262-2009), New Delhi.

[4] M.S Shetty Concrete Technology, Reprint (2003) S. Chand & Co. New Delhi.

[5] Praveen kumar S R, Manjunath K A, G. Narayana (2016), "A Comparative Study On Mechanical Properties of SCC By Partial Replacement Of Cement With Fly Ash & Ggbs With the Use of Glass Fibers", International Journal of Research in Engineering and Technology, Volume: 05 Issue: 08, PP: 161-165.

[6] Saidani, M, D.Saraireh, and M.Gerges (2016) "Behaviour of different types of fibre reinforced concrete without admixture", Engineering Structures, 113, 328-344

[7] Sekhar Reddy M V, Ramana Reddy I V, Mohan Reddy K M and Abibasheer Basheerudeen A, (2012), "Durability of High Performance Concrete containing Supplimentary cementing materials using Rapid Chloride Permeability Test" International Journal of Structural And Civil Engineering Research, Vol.1(1), pp. 92-98.

[8] V. Prathima, R. Isnakula, S. Nadhim, (2017) Comparative Study of Conventional Concrete With Banana Fiber Modified Concrete, 3 pp.2–5.

[9] J. Torres Agredo, R.M. de Gutiérrez, C.E. Escandón Giraldo, L.O. González Salcedo, (2014) Characterization of sugar cane bagasse ash as supplementary material for Portland cement, Ing. e Investig. 34 pp.5–10.

[10] IS: 8112- 2013, Ordinary Portland Cement, 43 Grade - Specification,Bureau of Indian Standards, New Delhi, India., Indian Stand.

[11] T. Gupta, S. Kothari, S. Siddique, R.K. Sharma, S. Chaudhary, (2019) Influence of stone processing dust on mechanical, durability and sustainability of concrete, Constr. Build. Mater. 223 pp.918–927.

[12] M. Venkatasudhahar, R. Velu, K. Logesh, R. Ganesh, (2017) Effect of surface modification and hybridization of natural fiber on mechanical properties of nylon epoxy hybrid composites, Int. J. Mech. Eng. Technol. 8 pp.264–281.

[13] Fasil MohiUd Din (2017) Experimental investigation on mechanical properties of kevlar fiber, Int. J. Eng. Technol. 4 pp.3466–3473.

[14] Bureau of Indian Standards, Method of Tests for Strength of Concrete, IS 516 - 1959 (Reaffirmed 2004). (2004) New Delhi, India.

[15] Ahmed Fathi, Nasir Shafiq, M.F. Nuruddin, Ali Elheber, (2013) Study the effectiveness of the different pozzolanic material on self-compacting concrete, ARPN J. Eng. Appl. Sci. 8 (4) pp.95–102.

[16] Dubey Sanjay Kumar, Chandak Rajeev, (2012) Development of self compacting concrete by use of portland pozzolana cement, hydrated lime and Silica Fume, ISCA J. Eng. Sci. 1 (1) pp.35–39.

[17] EFNARC (2002), Specification and guidelines for Self Compacting Concrete EFNARC (European Federation of producers and Applications of Specialist Products for Structures)

[18] J. Anto, S. Vigneshkannan, R. Devananth, S. Manju,(2019) Experimental investigation on strength properties of Recron fibre with fly ash in concrete, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2019.06.765.