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Partial Replacement of Cement by Glass Powder and Sand by Fly Ash in High Performance Fibre Reinforced Concrete

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Abstract— **The purpose of this project is to study the Mechanical properties of High Performance Fiber Reinforced Concrete with partial replacement of cement by glass powder and also with the partial replacement of sand with the Fly Ash at constant percentage. Tests on hardened concrete such as compressive strength, split tensile strength and flexural strength of M70 grade of HPFRC mixes were conducted. Replacement level of fly ash with river sand is kept constant as 30%. The various Glass powder combinations used in concrete mixes are 10%, 15% and 20%. Concrete specimen with 15% glass powder and 30% fly ash has shown maximum compressive strength, split tensile strength and flexural strength compared to other combinations.**

Keywords— **concrete, high performance fibre reinforced concrete, glass powder, compressive strength, split tensile strength.**

I. INTRODUCTION

High-performance concrete is defined as a concrete meeting special combination of performance and uniformity requirements that cannot always be achieved routinely using conventional constituents and normal mixing, placing, and curing practices. High-performance concrete (HPC) exceeds the properties and constructability of normal concrete. Normal and special materials are used to make these specially designed concretes that must meet a combination of performance requirements. Special mixing, placing, and curing practices may be needed to produce and handle high-performance concrete.

High-performance concrete almost always has a higher strength than normal concrete. However, strength is not always the primary required property. For example, a normal strength concrete with very high durability and very low permeability is considered to have high performance properties. By using by-products such as silica fume with super plasticizer we can achieve high performance concrete, which possess high workability, high strength, and high modulus of elasticity, high density, high dimensional stability, low permeability and resistance to chemical attack. HPC is often called "durable" concrete because its strength and impermeability to chloride penetration makes it last much longer than conventional concrete.

Super plasticizers are used in these concrete to achieve the required workability; moreover different kinds of cement replacement materials are usually added because low porosity and permeability are desirable. Silica fume is the one of the most popular pozzolnas, whose addition to concrete mixtures results in lower porosity, permeability and bleeding because their oxides (SiO_2) react with and consume calcium hydroxides, which is produced by hydration of ordinary Portland cement. The main results of pozzolanic reactions are: lower heat liberation and strength development; lime-consuming activity; smaller pore size distribution. Researches shows that the optimum percentage of cement replaced by silica fume is 10% for achieving maximum compressive split tensile, flexural strength and elastic modulus.

An experimental study was conducted by Gunalaan Vasudevan and Seri Ganis Kanapathy pillay[1] to investigate the effect of using waste glass powder in concrete. Laboratory work was conducted to determine the performance of control sample and concrete with used waste glass powder. The performance of these types of concrete was determined by the workability test, density test and compressive strength test. The workability of concrete is determined using slump test and compacting factor test. Meanwhile, compressive strength test is done to determine the strength of concrete. For each type of concrete, a total of six 150mm x 150mm x 150mm cubes were cast. The cubes were tested at the ages of 7, 14 and 28 days to study the development of compressive strength. The results indicate that the concrete with using waste glass powder were able to increase the workability of concrete and also the compressive strength. However, the density is reduced compare to standard mixture of concrete.

The study conducted by Sunny O. Nwaubani and Konstantinos I. Poutos[2] shows that the amount of incorporated waste glass largely influenced properties of the cement mortar. It is evident from these results that ground glass could enhance the properties of the final concrete product if used at the right level of replacement. The fineness of the particles used have also been shown to have very important influence. It must be at least as fine as the cement powder for the advantage of pozzolanic activity to become evident in the short-term. Increasing the amount of glass in mortar causes a general decrease of compressive strength, but the decrease becomes less evident with prolonged curing time. The particle size distribution of waste glass used was the key factor influencing the strength development.

P.Nath and P.Sarker [3] conducted test on effect of Fly Ash on the Durability Properties of High Strength Concrete concluded that Fly ash in concrete decreased drying shrinkage when the w/c ratio and the binder content were adjusted to achieve the same 28-day strength of the control concrete. Incorporation of fly ash reduced the segregation of concrete in early age and it decreased further at six months. The fly ash concretes yielded better resistance to chloride ion penetration both at 28 and 180 days.

Song and Hwang [4] investigated the mechanical properties of high – strength steel fibre-reinforced concrete. The properties included compressive and splitting tensile strengths, modulus of rupture, and toughness index. The steel fibres were added at the volume fractions of 0.5%,1.0% and 2.0%. The compressive strength of the fibre-reinforced concrete reached a maximum at 1.5% volume fraction, being a 15.3% improvement over the HSC. The splitting tensile strength and modulus of rupture of the fibre-reinforced concrete improved with increasing the volume fraction, achieving 98.3% and 126.6% improvements, respectively, at 2.0% volume fraction.

II. METHODOLOGY

Selection of each material likes Cement, Aggregates, Chemical, and mineral admixtures and water of appropriate quality is very crucial to find strength studies on cement concrete.

Cement: Ordinary Portland cement, 53 Grade conforming to IS: 12269 – 1987. Specific gravity of cement is 3.15.

Fine Aggregate: Locally available river sand confined Grading zone II of IS: 383-1970. Specific gravity of fine aggregate is 2.6.

Coarse Aggregate: Locally available crushed blue granite stones conforming to graded aggregate of nominal size 12.5 mm as per IS: 383 – 1970. Its specific gravity is 2.75.

Glass Powder: Finely powdered glass of size 75 µm. Its specific gravity is 2.58. **Mineral Admixture:** Fly ash class F obtained from Mattur Thermal Power Plant which confines as per IS 3812-2000.

Chemical Admixture: A commercially available sulphonated napthalene formaldehyde based super plasticizer (CONPLAST SP430) was used as chemical admixture to enhance the workability of the concrete.

Fibre: Steel fibres of crimped type is used.

Silica fume - Obtained from sri muruganarul enterprises, coimbatore conforming to ASTM C 1240 as mineral admixture in dry densified form.

Water - Potable water as per IS 456-2000.

The mix design was done for M70 grade concrete based on the Asian Journal of Civil Engineering vol.15, no.3(2014).

TABLE 1
NOMINAL MIX PROPORTION

Water in litre	Cement (kg/m^3)	Silica Fume (kg/m^3)	Fiber (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	Super plasticizer (kg/m^3)
172.5	540	35	10.8	739.466	1036.19	10.782

The fine aggregate is replaced by 30% fly ash and the cement content is replaced by glass powder in three proportions as follows. 2% steel fiber is added to the mix. Super plasticizer CONPLAST SP430 is added 1.875% to the weight of binder. The identification, mix proportion and quantity of material taken for one meter cube of High Performance fiber reinforced concrete mixes are given in Table 2.

Mix 1 = 10% Glass powder + 30% Fly Ash
Mix 2 = 15% Glass powder + 30% Fly Ash
Mix 3 = 20% Glass powder + 30% Fly Ash

TABLE 2
VARIOUS MIX PROPORTIONS

Mix	Cement (kg/m^3)	S.F (kg/m^3)	G.P (kg/m^3)	Fiber (kg/m^3)	Fine Aggregate (kg/m^3)	Fly Ash (kg/m^3)	Coarse Aggregate (kg/m^3)	Water (lit)
M1	486	35	54	10.8	517.629	221.84	1036.19	172.5
M2	459	35	81	10.8	517.629	221.84	1036.19	172.5
M3	432	35	108	10.8	517.629	221.84	1036.19	172.5

Concrete cubes of size 150mm x 150mm x 150mm and cylinders of size 150mm diameter and 300mm height were casted for the above proportions of concrete to test the compressive strength, the split tensile strength and flexural strength.

III. RESULTS AND DISCUSSIONS

The slump values were analysed for different combinations and result shows the decrease in slump value with increase in percentage of glass powder.

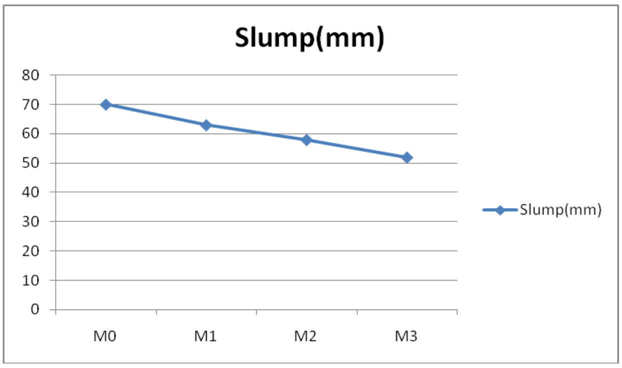

Fig 1. Slump Value for Various Mixes

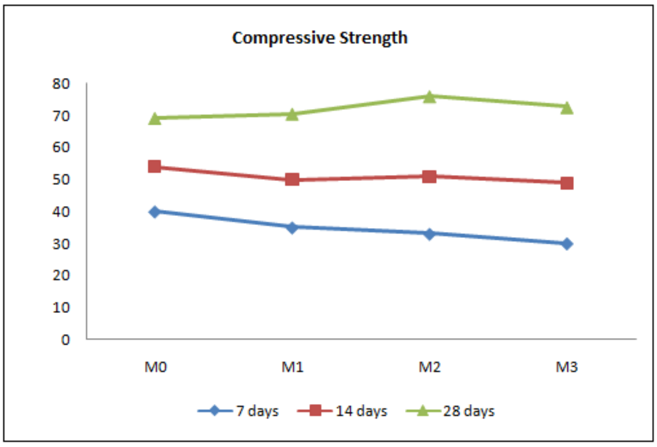

Fig 2. Compressive Strength results

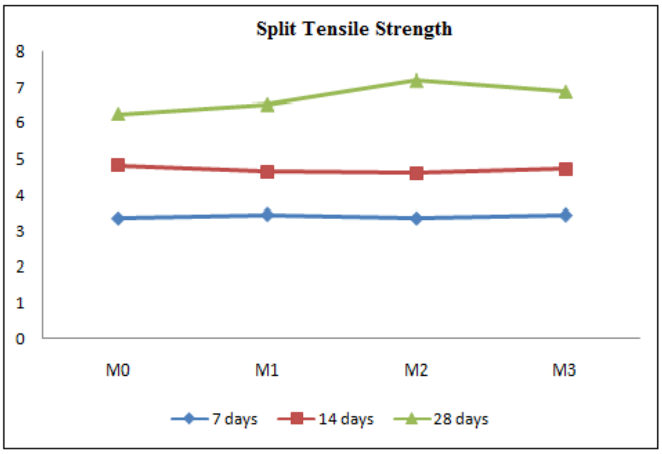

Fig 3. Split Tensile Strength Results

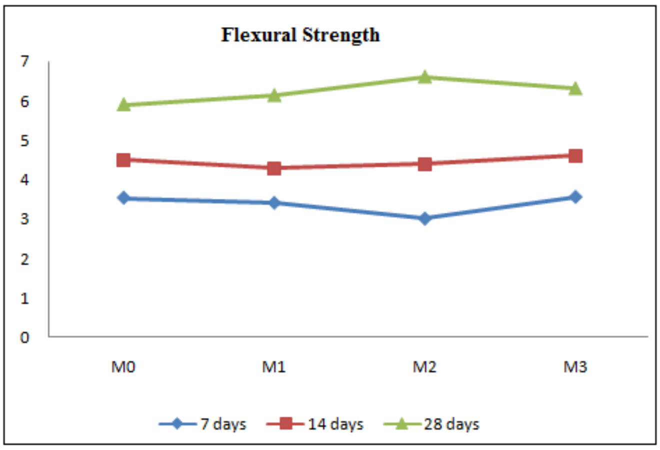

Fig 4. Flexural Strength Result

The test results exhibit the increase in the strength with the addition of glass powder and fly ash. When compared with the nominal mix the other mixes shown increase in strength at the end of 28 days.

IV. CONCLUSION

Addition of Glass Powder and Fly Ash leads to a increase in compressive strength, Split tensile and Flexural strength. Maximum compressive strength, Split tensile and Flexural strength develop in M70 grade high performance fibre reinforced concrete by adding G.P 15 percent of cement and fly ash 30 percent of fine aggregate. Compressive strength increases by about 6-15 percent, the split tensile strength by about 8-15 percent and the flexural strength by about 7-12 percent at the end of 28 days.

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