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DETERMINATION OF STRENGTH PROPERTIES OF CONCRETE WITH POLYVINYL ALCOHOL (PVA) IN POWDER AND FIBRE FORMS

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Abstract –

This study aims to determine the performance of concrete in terms of strength upon the addition of polyvinyl alcohol in two forms in powder form and in fibre form along with ground granulated blast furnace slag. The initial stage involves studying the strength properties of concrete with PVA powder at replacement levels of 0.3%, 0.6%, and 1% percent by weight of cementitious material. The second stage involves assessing the properties of concrete with PVA fiber at dosages of 0.3%, 0.6%, and 1% by weight of cementitious material. Ground granulated blast furnace slag will be used as a partial replacement of cement by 10% common in both the cases. The comparison of performance of two mixes will be done based on the results of workability, Compressive strength and flexural strength. Finally the optimum ranges of PVA powder and PVA fiber will be reported for enhanced performance of concrete based on observations.

Keywords- PVA powder, PVA fiber, GGBFS.

1. Introduction

1.1 General

Several studies are conducted on concrete to make that material economical In that research several materials are being found to satisfy all the demands of concrete.concrete is having huge demand over construction industry. So discovery of new material that satisfies the original properties of concrete can fulfill the industry demand.Therefore, studies have been conducted for using other alternative materials for cement.

GGBFS (Ground granulated blast furnace slag) GGBFS, is a byproduct of iron and steel industry. GGBFS powder is having a very fine size of less than 45 microns.In order to achieve that nano size, They are in two processes. The first is pelletization, which uses a mix of water jet and air to cool the molten material. In the second procedure, a water jet is utilised to cool the molten material from the industry.. The tiny particles are subsequently processed to 45 m with a surface area ranging from 400 to 600 m2/kg.

Poly vinyl alcohol is a byproduct of the petroleum industry, and this study aims to improve the strength attributes of concrete using this material. PVA material is regarded safe and eco-friendly. Internal curing is a technology that enhaces hydration process. nevertheless, by using this PVA material, the evaporation standards in the concrete can be reduced when compared to ordinary concrete.

Vinyl acetate monomer is the primary raw source for PVA powder. PVA is made by polymerizing and partially hydrolyzing vinyl acetate. In the presence of an alkaline catalyst, an alcohol, typically methanol, is hydrolyzed. PVA fibres are monofilament fibres produced by wet spinning, heat treatment, and crimping-oiling in normal temperature water. They have excellent dry heat stability, as well as physical and mechanical qualities. They are also famous for their ability to totally dissolve in water at particular temperatures.

2. Literature review

Several studies are being conducted with PVA powder and PVA fiber and respect to conclusions are being drawn.

1. Hong-Hu Chu, B. Siddiq, F. Aslam, and others. In their research, they investigated the effects of polyvinyl alcohol powder and fly ash combined, and they found that while blending a small amount of PVA powder up to 1% and fly ash up to 10% increased the compressive strength, applying the same mixture to the curing conditions of standard air curing caused the compressive strength to decrease.

2. The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong An experimental investigation He's done on dissolution of PVA powder into recycled aggregates in water medium. The results showed that these recycled aggregates obtain characteristics of normal aggregate by dissolving into PVA solution.

3. Tao Ji, Yudong Xie, Xujian Lin, Hanfei Li They investigated the bonding process of a magnesium phosphate cement motor and a regular Portland motor. Using PVA powder as a bonding agent, the results revealed that when 0.4% PVA material was used, the bond strength increased and when 0.6% PVA material was used, agglomeration occurred and the bond strength decreased.

4. Yangtze University , Jingzhou, In this university, an investigation was conducted on the increase in compressive strength by using PVA fibre. It was concluded that by using a PVA fibre compressive strength can be increased, but here rubber powder is partially replaced with cement and the variation in strength is absorbed to be decreased, so PVA fibre is being added to compensate, even though the strength is increased when PVA fibre is added into conventional concrete no increase in strength is observed in this combination.

5. Fardin Mahmoudi a , Jamal A. Abdalla a,⇑ , Rami A. Hawileh a , Zhigang Zhang, The main objective is to study the composition of GGBFS with Polyethlene and polyvinyl alcohol. In both cases the replacement of polyethylene and polyvinyl alcohol is two percent by volume fraction full snow the result showed that an increase in compressive strength and fracture strength seems to be more in PVA fiber replacement.

6. Bukola Oni, Jun Xia, Mengdi Liu This study aims On the investigation of using Kevlar, polyvinyl alcohol fibers and ultra high molecular weight polyethylene fibers in plain concrete. Paving pics are

being designed using aci method for 4 mixes strength of the paving pics is being increased at a replacementlevel of 0.3% by weight of cement.

7. Masood.A And Ahmad.S have done the research on usage of glass powder and PVA fibers in concrete and they observed increase in the hardening properties of concrete but there is a slight decreasing in the fresh properties of concrete.

8. MOHD Mustafa Al Bakri Abdullah and HENRY Limantono It was also demonstrated that the use of glass powder and silica fume boosted the tensile strength by up to 27.22%. Split tensile strength increased by 200% when PVA fibres were added, compared to the split tensile strength of control mix

9. Santosh Kumar Karri1 , G.V. Rama Rao2 , P.Markandeya both workability and compressive strength are increased for both M20 and M40 grade concretes. At a replacement level of 40% maximum compressive strength attained.

10. Ishwar Chandra Thakur, Prof. Sheo Kumar, Prof. J.P.Singh. Standard consistency of OPC increases by incorporation of GGBS.It is increases from 0 to 20% when GGBS increases from 10 to 70%.this strength parameters shown decreasing trend at 3 days and 7 days while at 28 days it is increases giving the optimum at 40%.At 40% replacement level the strength is observed to increase by 5.16% than control mix strength.

3. Objectives

3.1 Objectives of research-

1. The main objective is to replace PVA powder and fiber for cement and to determine the strength properties.

2. Comparing the mechanical characteristics of M30 grade concrete with PVA powder and PVA fibre with GGBS content as 10% by weight of cement.

3. Finding the optimum dosage of PVA powder and PVA fiber.

4.Materials and methodology-

4.1 Materials used-

4.1.1 Cement-

Type of cement used is OPC 53 grade from JSW cement. The individual properties of the cement were determined to ensure that they met the limits specified in the IS: 12269-1987 standard. The specific gravity is 3.15.

4.1.2 Coarse aggregate-

The coarse aggregates originate from a combination of naturally existing rock fragments and crushed granite. Concrete strength qualities may also be affected by the coarse aggregate form. As per IS: 383-1970, in the study coarse aggregate of size 20mm is used. The specific gravity of the aggregate is obtained as 2.74.

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4.1.3 Fine aggregate-

In this study the river sand found locally is used, which was passing through a 4.75mm IS sieve and conforming to grading zone II of IS: 383. The specific gravity of fine aggregate is obtained as 2.65.

4.1.4 Ground Granulated Blast Furnance Slag-

GGBFS is a by product of iron and steel industry that can be used as binding material as a replacement for cement. It consists of silicate and aluminosilicates that are to be periodically removed from the blast furnanace slag. The physical properties depends upon the cooling process of the dust material received from it either by quenching process or by pelletization process.The specific gravity of GGBFS is obtained as 2.85.The material is procured from Gogga Minerals and Chemicals,Hospet,Karnataka.

4.1.5 Water –

Drinkable water was used to mix and cure the concrete. Oils, acids, alkalis, salts, biological matter, and other pollutants that could impair concrete should be avoided in the water used to mix concrete, including free water on the aggregates.

4.1.6 PVA solution-

PVA Solution is prepared by dissolving PVA powder in one liter of distilled water, after that it is cooled for 24 hours in open air. The obtained solution is added into concrete Deducting the original water content. The specific gravity of PVA powder is obtained as 1.2. The material is procured from Kurauray Asia pacific private limited, Singapore.

Fig 1- Preparation of PVA solution

Fig 2- PVA powder

Table 1 - Table showing properties of PVA powder

property	**values**
Appearance	White granular solid
Melting points	230 - 240°C
Bulk density at 20	610 - 670 kg/m³
Flash point	Not applicable
pH (40g/L 20°)	4.5-6.5
Solubility in water	Water-soluble

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4.1.8 PVA fibers-

PVA fibers are Produced by the process of dissolution, spinning, heating, Cutting and bailing of PVA powder. The material is procured from fiber source alwarthirunagar, Chennai.

Fig 3 - PVA fibre

4.2 Methodology-

In this study in order to evaluate the strength of M30 grade concrete using PVA powder and PVA fiber The analysis is classified into six stages

1. Determining the fresh properties of M30 plain concrete by conducting slump cone test.

2. Determining the hardened properties of M30 plain concrete at 7 days and 28 days.

3. Determining the workability of M30 grade concrete with PVA powder and GGBFS as replacement for cement.

4. Determining the hardened properties of M30 concrete includes PVA powder and GGBFS as replacement for cement at 7days and 28 days by conducting compression and flexure tests.

5. Determining the workability of M30 concrete includes PVA fiber and GGBFS as replacement for cement.

6. Determining the hardened properties of M30 concrete with PVA fiber and GGBFS as a replacement for cement at 7days and 28 days.

For all the above stages Specimens are casted under 8 groups with 0%, 10% GGBFS along with 0.3%, 0.6%, 1% of PVA powder and PVA fiber. These variations are done for both PVA powder and fiber.

Table 2 -Table showing Mix ID

S.no	Mix ID
1.	Control Mix
2.	10% GGBS for cement
3.	0.3%PVA powder + 10% GGBFS
4.	0.6%PVA powder+10% GGBFS
5.	1% PVA powder + 10% GGBFS
6.	0.3% PVA fiber + 10% GGBFS
7.	0.6% PVA fiber + 10% GGBFS
8.	1% PVA fiber + 10% GGBFS

5. Results and discussion-

5.1 Workability-

From the results of slump cone test it has been observed that the increase in dosage of PVA powder from 0.3% to 1% has resulted in increase in slump values from 95mm to 125mm.

Thus it can be concluded that the workability will increase with increase in pva powder dosage.

Whereas, with the addition of PVA fiber the concrete has shown a decreasing trend in slump values with increase in dosage of fiber content from 0.3% to 1%.

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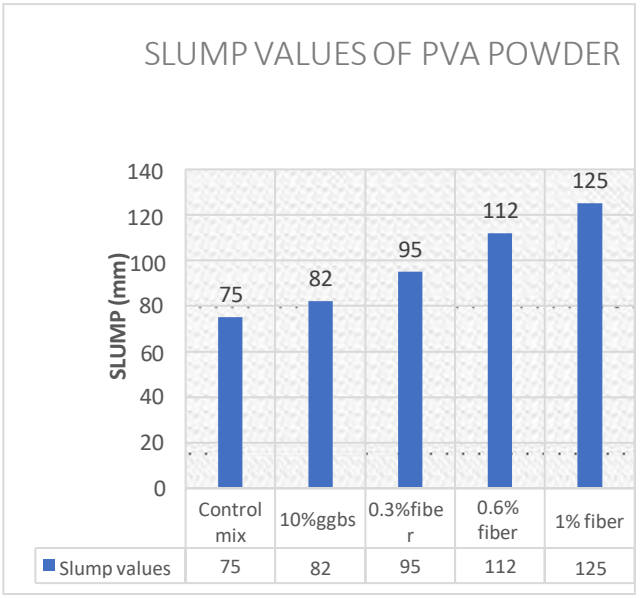

Fig 4- Chart showing Slump values of PVA powder

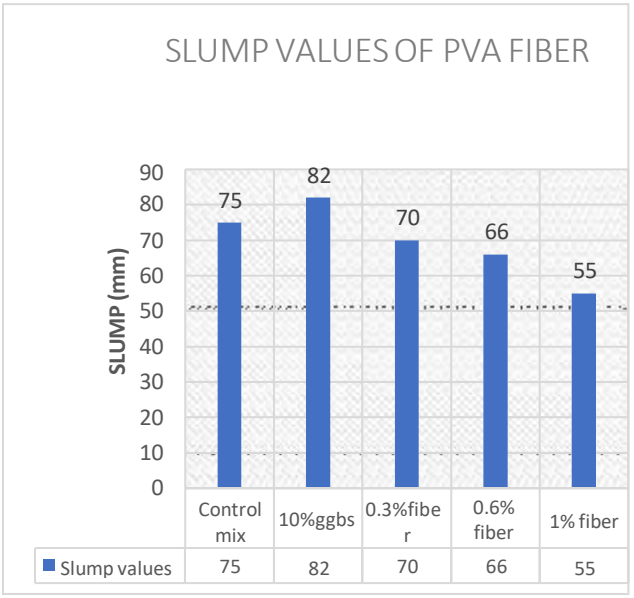

Fig 5- Chart showing Slump values of PVA fiber

5.2 Compressive properties-

The mix with 10% GGBFS as replacement of cement has shown a slight increase in compressive strength for both 7 and 28 days.

With the additional PVA powder of 0.3%, the compressive strength decreased for both 7 and 28 days.

The maximum compressive strength was found to be 32.6 Mpa and 47.3 Mpa at 7 and 28 days respectively for mix with PVA powder 1% .

Whereas, The mix with PVA Fiber of 1% has registered maximum compressive

strength of 31.35 Mpa and 45.4 Mpa at 7 and 28 days respectively.

Thus, It concludes from the test results that both PVA powder and PVA fiber has resulted in increased compressive strength values with increasing dosage.

However, the mixes with PVA powder has shown higher compressive strength variables in comparison with Mixes containing PVA fiber.

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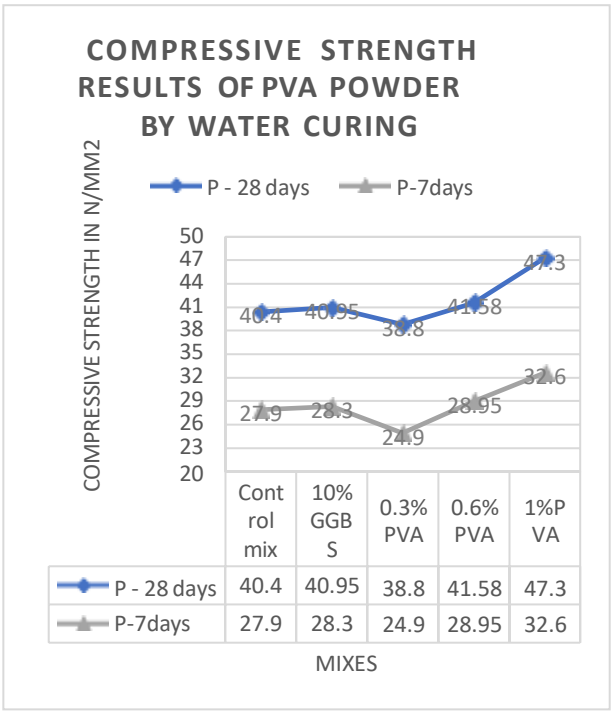

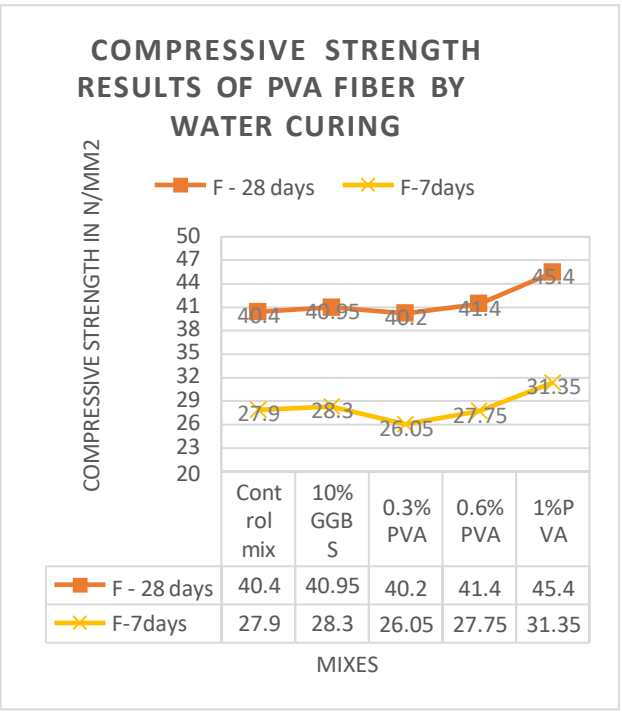

Fig 6- compressive strength values of PVA powder

Fig 7- compressive strength values of PVA Fiber

5.3 Flexural properties-

The maximum Flexural Strength determined as 4.9 Mpa and 4.4 Mpa at 7 days and 28 days respectively for mix with PVA fiber 1% .

Whereas, The mix with PVA powder of 1% has registered maximum flexural strength of 4.53 Mpa and 4.1 Mpa at 7 days and 28 days respectively.

Thus, It can be concluded from the test results that both PVA powder and PVA fiber has resulted in increasing compressive strength values with increasing dosage.

However, the mixes with PVA fiber has shown higher flexural strength variables in comparison with Mixes containing PVA powder.

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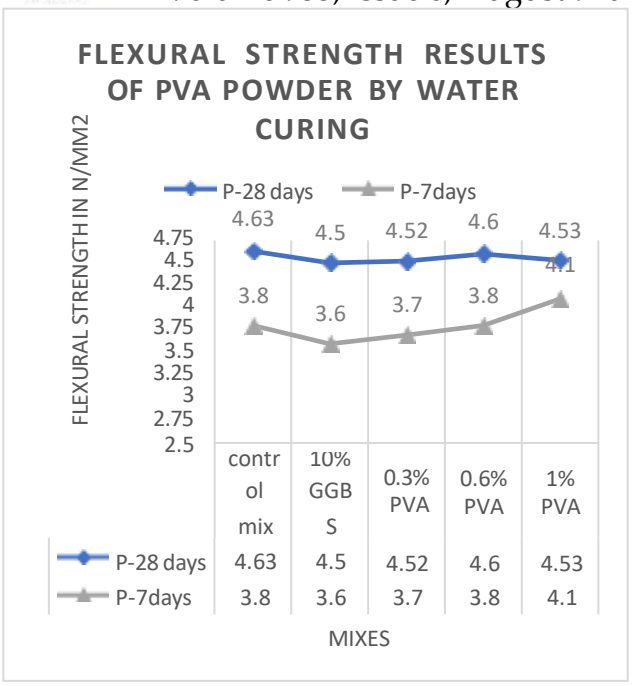

Fig 8- Flexural strength values of PVA powder

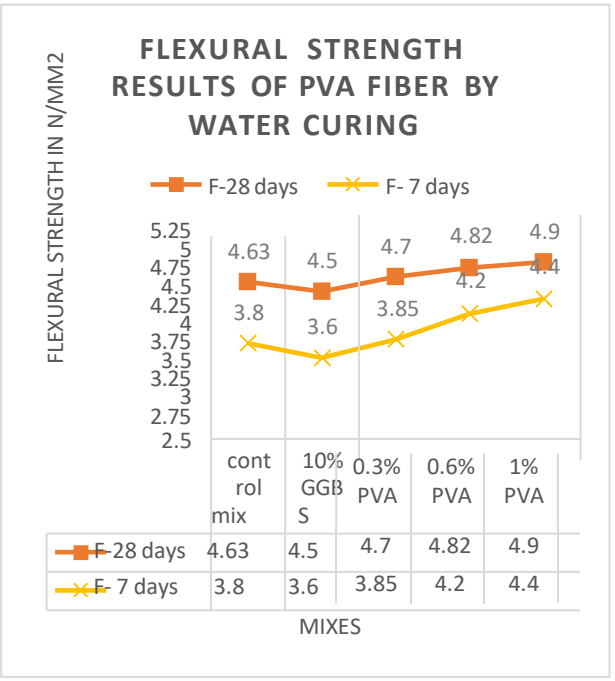

Fig 9 - Flexural strength values of PVA Fiber

6. Conclusions-

After analysing the fresh properties and hardened properties for 7 and 28 days in various replacements, It is concluded as follows.

1. From the results of slump cone test it has been observed that the increase in dosage of PVA powder from 0.3% to 1% has resulted in increase in slump values from 95mm to 125mm.Thus it can be concluded that the workability will increase with increase in pva powder dosage. Whereas, with the addition of PVA fiber the concrete has shown a decreasing trend in slump values.
2. The mix with 10% GGBFS as replacement of cement has shown increase in strength for both 7 and 28 days.
3. The maximum compressive strength was found to be 32.6 Mpa and 47.3 Mpa at 7 days and 28 days respectively for mix with PVA powder 1% .Whereas, The mix with PVA Fiber of 1% has registered maximum comparison strength of 31.35 Mpa and 45.4 Mpa at 7 days and 28 days respectively.
4. It can be concluded that, the mixes with PVA powder has shown higher compressive strength variables in comparison with mixes containing PVA fiber.
5. The maximum Flexural strength was found to be 4.9 Mpa and 4.4 Mpa at 7days and 28 days respectively for mix with PVA fiber 1% . Whereas, The mix with PVA powder of 1% has registered maximum flexural strength of 4.53 Mpa and 4.1 Mpa at 7 days and 28 days respectively.
6. It can be concluded that, the mixes with PVA fiber has shown higher flexural strength variables in comparison with mixes containing PVA powder.

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