Effect of Plastic Fibres on Strength of Concrete By Partial Replacement of Cement In Concrete With Vitrified Polish Waste And Flyash

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Abstract- *Concrete is one of the vast materials used for the construction of structures. It is a composite material which consists Coarse Aggregate, Fine Aggregate, Cement and with required proportions. Concrete is widely used construction material for various types of structures due to its structural stability and strength. Materials required for producing large quantities of concrete are taken from the earth's crust. Amongst the solid waste the most prominent ones are fly ash (FA), blast furnace slag, rice husk ash, silica fume, Vitrified Polish Waste and demolished construction materials. This study is aimed to use Vitrified Polish Waste (VPW) along with Fly Ash (FA) in concrete to improve the strength properties of VPW – FA – Cement Concrete. Thus, the primary objective of this study is to understand the possibilities of use of VPW and FA in concrete. Investigations were systematically conducted on performance of VPW concretes in terms of strength properties like compressive strength and splitting tensile strength, along with slump cone test to determine the workability at various stages of replacement of waste material for various grades like M30, M40. VPW and FA replaced concretes were tested for 7,14 and 28 days, also by adding Waste Plastic Fibers (WPF) to the VPW – FA – Cement Concrete with various proportions like 0%, 0.5%, 1.0% and 1.5%.*

I. INTRODUCTION

Concrete is composite material which consists of cement, coarse aggregate, fine aggregate and water in required proportions. Concrete is a material which used for the purpose of construction in now a day. Due to its composite nature concrete is weak in tension but strong in compression. Basic Principle involved in the increase in strength of concrete is heat of Hydration.

Concrete has been employed in construction exposed to the action of sea water for as long as concrete has been used. Example of concrete used by the Romans 2000 years ago in structures exposed to sea water on the shores of the Mediterranean Sea are still intact. When concrete is to be employed under conditions in which it will be exposed to the effects of sea water, cognizance should be taken of these effects and appropriate precautions taken. However, generally, these precautions are not drastic, and do not involve the selection and use of unusual materials or procedures nor cause any significant increase in cost of production. The effects of sea water on concrete may conveniently be examined by considering, first, the factors characteristic of the sea-water exposure that can affect concrete; second, the elements of the specific concrete involved that may be affected by these factors; third, the consequences of the interaction of sea water with the concrete; and, finally, the precautions that should be taken to avoid undesirable performance of the concrete due to its interaction with sea water.

Most seawater is similar in com position, containing g about 3.5% soluble salts (chlorides and sulphates) by weight. The pH of sea - water varies from 7.5 to 8.4, averaging about 8.2. Concrete ex- posed to seawater may deteriorate from the combined effects of chemical and physical processes:

- Sulfate attack
- Leaching of lime (calcium m h y- dioxide)
- Alkali-aggregate expansion
- Salt crystallization from alternate wetting and drying
- Freezing and thawing

Objective

The aim of the project is to compare the compressive strength of concrete with different grades at curing under Normal water & Marine water.

II. REVIEW OF LITERATURE

STRUCTURAL PROPERTIES OF CONCRETE

The studies have been conducted largely based on the structural properties of concrete and have been discussed below.

Compressive Strength

The compressive strength of concrete is one of the most important and useful properties of concrete. Strength is a measure of amount of stress acquired to fail a material.

Tensile Strength

It is attributed to the heterogeneous and complex structure of concrete it is mentioned that tensile strength of concrete is in the order of 10-15% of the compressive strength. The reason for such large difference between tensile and compressive strength is attributed to the heterogeneous and complex structure of the concrete.

Shear Strength

It is engineering is a term used to describe the strength of a material or component against the type of yield or structural failure where the material or component fails in shear. Although pure shear is not encountered in concrete structures, an element may be subjected to the simultaneous action of compressive, tensile and shearing stress. Although the Coulomb-Mohr theory is not exactly applicable to concrete.

Bond Strength

Compatibility of two materials act together to resist the external load is called bond strength. In fact, the strength of concrete is really derived from the bond between paste and aggregates.

Impact Strength

Impact strength is of importance when concrete is subjected to repeated falling object, as pile driving, or a single impact of a large mass at a high velocity. The principal criteria are the ability of the specimen to with stand the high blows.

TYPES OF CONCRETE

The mechanical properties of concrete can be improved by adding admixtures, plasticizers and super plasticizers. The different types of concrete are

- Normal Strength Concrete,
- High Strength Concrete,
- Fiber Reinforced Concrete,
- High Performance Concrete,
- Self-consolidating Concrete.

Normal Strength Concrete

Normal strength concrete is a composition of aggregate, sand and cement. Mix designs below M40 are termed as Normal strength concrete. These are used in ordinary construction of structures such as buildings, water tanks etc. There is no extra admixtures are added in these types of concrete. Normal strength concrete is weak in tension and strong in compression.

High Strength Concrete

High-strength concrete has a compressive strength generally greater than 6,000 pounds per square inch (40 MPa = 5800 psi). High-strength concrete is made by lowering the water-cement (W/C) ratio to 0.35 or lower.

***High-Performance Concrete*:**

High-Performance Concrete is a relatively new term used to describe concrete that conforms to a set of standards above those of the most common applications, but not limited to strength. While all high-strength concrete is also high-performance, not all high-performance concrete is high-strength.

Self-Consolidating Concrete

During the 1980s a number of countries including Japan, Sweden and France developed concretes that are self-compacting, known as self-consolidating concrete in the United States. SCC can save up to 50% in labour cost due to 80% fast pouring and reduce wear and tear on the form work.

Fiber Reinforced Concrete

The term fiber reinforced concrete (FRC) is defined by ACI Committee 544 as a concrete made of hydraulic cements containing fine or fine and coarse aggregates and discontinuous discrete fibers.

Past Studies:

In India production of electricity threw coal is one of the major productive systems, which gives lot of Fly Ash (FA) as bi-product is create lot of waste disposal problem. Fly Ash (FA), produced after burning of Coal has high reactivity and pozzolanic property. Indian standard code of practice for plain and reinforced concrete IS 456-2000, recommended use of FA in concrete but does not specify quantities. Chemical compositions of FA are affected due to burning process and temperature. Silica content in the ash increases with higher the burning temperature. As per study by Houston, D. F. (1972)

FA produced by burning rice husk between 600 and 700 $^{\circ}C$ temperatures for 2 hours, contains 90-95% SiO_2, 1-3% K_2O and < 5% unburnt carbon. Under controlled burning condition in industrial furnace, conducted by Mehta, P.K. (1992), FA contains silica in amorphous and highly cellular form with 50-1000 m^2/g surface area. So use of FA with cement improves workability and stability, reduces surface area. So use of FA with cement improves workability and stability, reduces heat evolution, thermal cracking and plastic shrinkage. This increases strength development, impermeability and durability by strengthening transition zone, modifying the pore-structure, blocking the large voids in the hydrated cement paste through pozzolanic reaction. FA minimizes alkali-aggregate reaction, reduces expansion refines pore structure and hinders diffusion of alkali ions to the surface of aggregate by micro porous structure.

III. METHODOLOGY

Materials Used and Their Properties

The details of the various materials used in the laboratory experimentation are reported in the following sections.

Cement:

An OPC 53 Grade Ultra Tech Cement was used in this investigation. The quantity required for this work was assessed and the entire quantity was purchased and stored property in casting yard. All tests were conducted in accordance with IS codes.

Sand

For the present study, the Fine Aggregate i.e. Sand has been brought from the Godavari River from Rajahmundry. The gradation test conducted on aggregates showed that they met specifications requirements. Aggregate size less than 4.75 mm is considered fine aggregate.

Coarse Aggregate

For the present study, the coarse aggregate of 20mm size has been brought from Prathipadu Village, Guntur and Andhra Pradesh.

Fly Ash

For the present study, the Industrial waste Flyash was brought from Dr. Narla Tata Rao Power Station, Vijayawada Chemical Properties of Flyash were shown in below table.

Table 3.1 Chemical Composition of Fly Ash

S.No	Name of the chemical	Range of %
1	SiO_2	61 to 64.29
2	Al_2O_3	21.6 to 27.04
3	Fe_2O_3	3.09 to 3.86
4	TiO_2	1.25 to 1.69
5	MnO	Up to 0.05
6	CaO	1.02 to 3.39
7	MgO	0.5 to 1.58
8	P	0.02 to 0.14
9	SO_3	Up to 0.07
10	K_2O	0.08 to 1.83
11	Na_2O	0.26 to 0.48
12		0.20 to 0.85

Vitrified Polish Waste (VPW)

For the present study, the Vitrified Polish Waste (VPW) was brought from RAK Ceramics Industry at Samalkota of E.G District; A.P. Chemical Properties of VPW were shown in below table.

Table 3.2 Chemical Composition of VPW

S.No	Name of the chemical	Range of %
1	CaO	30-50%
2	SiO_2	28-38%
3	Al_2O_3	8-24%
4	MgO	1-18%
5	MnO	0.68%
6	TiO_2	0.58%

Waste plastic Fibers

Waste Plastic Fibres are collected from dumping yards in form of PET water bottles. The manufacture of plastic bottles takes place in stages. Typically, the plastic bottles, used to hold potable water and other drinks are made from Poly-Ethylene Terephthalate (PET), because the material is both strong and light.

List of Laboratory Tests

- Specific Gravity

- Compressive Strength of Cement
- Split Tensile Strength Test
- UPV
- Workability Test on Concrete Using Slump Cone

IV. RESULTS AND DISCUSSIONS

Introduction

Details of the laboratory experimentation carried-out with different combinations of materials have been discussed in the previous chapter. In this chapter a detailed discussion on the results obtained from various laboratory tests done on concrete.

Variation of various Properties of Concrete with % Replacement Flyash for M30 & M40:

Fig 4.1 and Fig 4.2 Shows the Slump Values for M30 & M40 Grades respectively and for the two grades of concrete slump value is improves up to 40% of replacement of Flyash to the cement. Improvements in Slump values at 40% replacement compare to virgin mix are 12.12%, 15.38% for M30, M40 respectively. Here we can observe that the % improvement is also increase with grade of concrete increase. At higher grade of concrete the workability also increase with replacement of Flyash to 40%. This is due to improvement in fluidity in the mix when mixed with flyash combined with cement. Hence we can say that up to 40% of replacement of flyash in the cement is improves the workability of the concrete.

Fig 4.4 and 4.5 shows the results of compressive strength for M30, M40 Grades respectively at 7, 14 and 28 Days. At 28 days curing the compressive strength for two grades at 30% replacement of flyash as an industrial waste to cement improvement is 2.2%, 1.34% for M30, M40 grade concretes respectively. This is due to decrease in voids and that leads to increase in density. With increase in grade of concrete % improvement of compressive strength also increasing.

Fig 4.5, Fig 4.6 shows the results of split tensile strength for M30, M40 Grades respectively at 14 and 28 Days. At 28 days curing the tensile strength for two grades at 30% replacement of flyash to cement improvement is 11.48%, 9.9% for M30, M40 grade concretes respectively. This is due to decrease in voids and that leads to increase in density. For each grade individually tensile strength is improved at 30% replacement but there is no improvement for increase in grade of concrete.

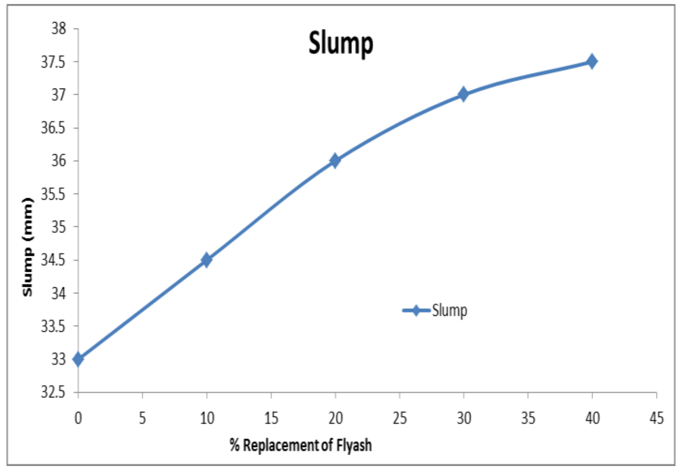

Fig 4.1 Shows Variation of Slump Values with % Replacement of Flyash for M30

Fig 4.7, Fig 4.8 shows the results of UPV for M30, M40 Grades respectively at 7, 14 and 28 Days. There is no considerable change in UPV with age for each grade individually. At 28 days curing the UPV for two grades at 30% replacement of Flyash to cement improvement is 5.3%, 6.1% for M30, M40 grade concretes respectively. UPV is one of the non-destructive tests to determine homogeneity in mix and to get density. Increase in UPV due to increase in density will shows that decrease in voids due to usage of flyash which can cover the voids formed due to size aggregate.

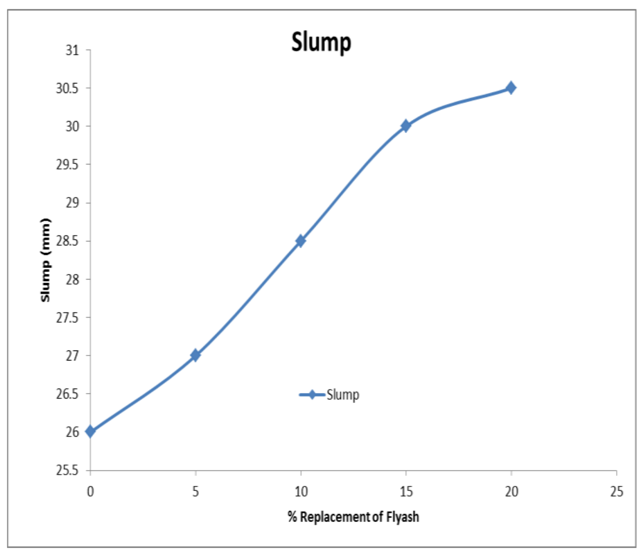

Fig 4.2 Shows Variation of Slump Values with % Replacement of Flyash for M40

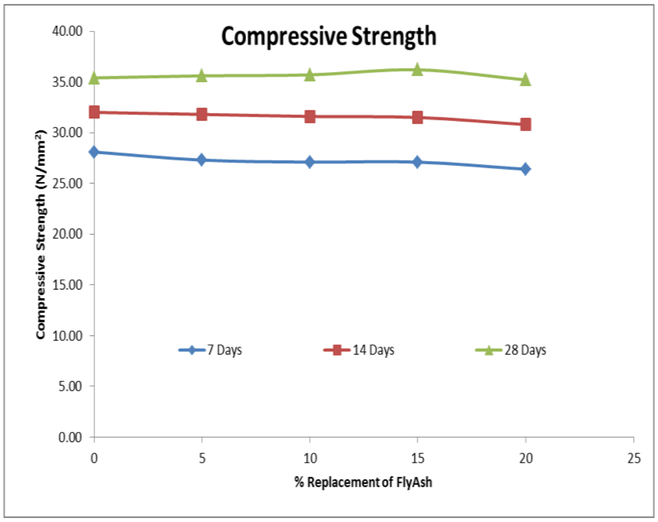

Fig 4.3 Shows Variation of Compressive Strength with % Replacement of Flyash for M30

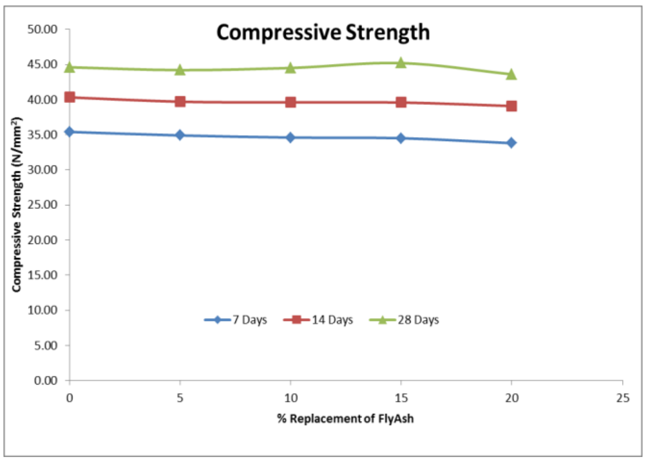

Fig 4.4 Shows Variation of Compressive Strength with % Replacement of Flyash for M40

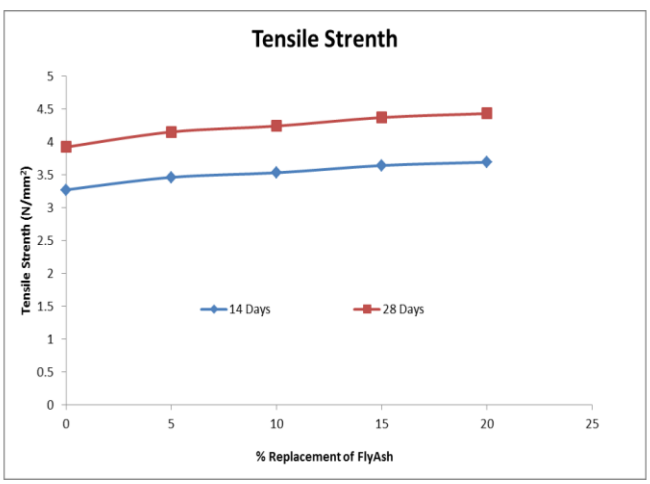

Fig 4.5 Shows Variation of Split Tensile Strength with % Replacement of Flyash for M30

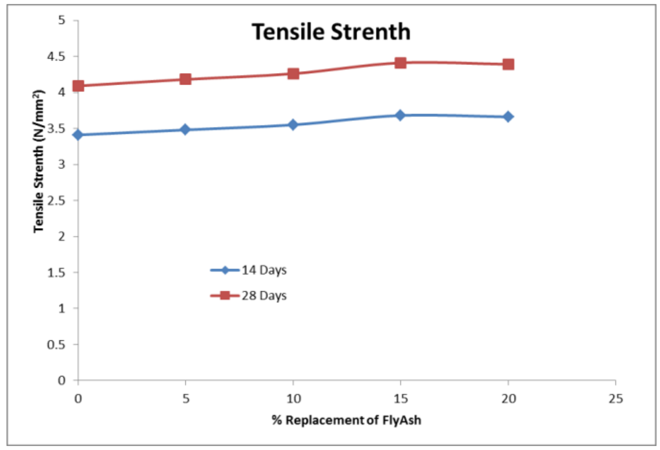

Fig 4.6 Shows Variation of Split Tensile Strength with % Replacement of Flyash for M40

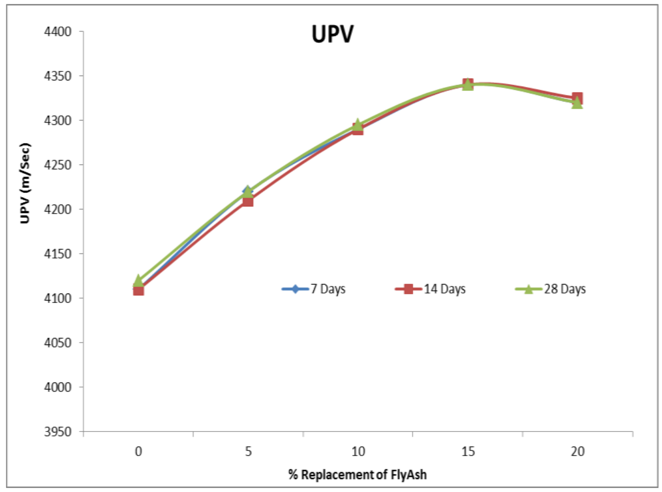

Fig 4.7 Shows Variation of UPV Values with % Replacement of Flyash for M30

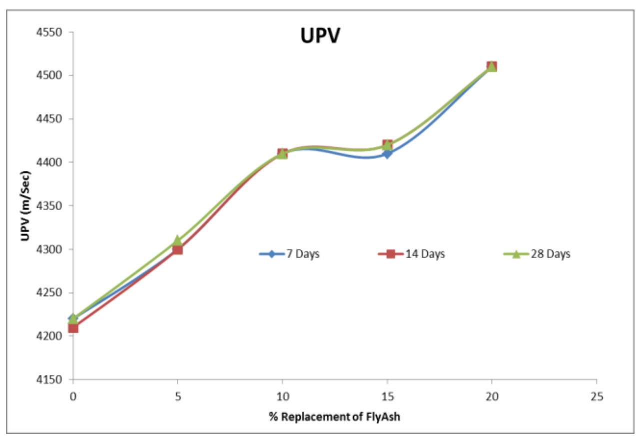

Fig 4.8 Shows Variation of UPV Values with % Replacement of Flyash for M40

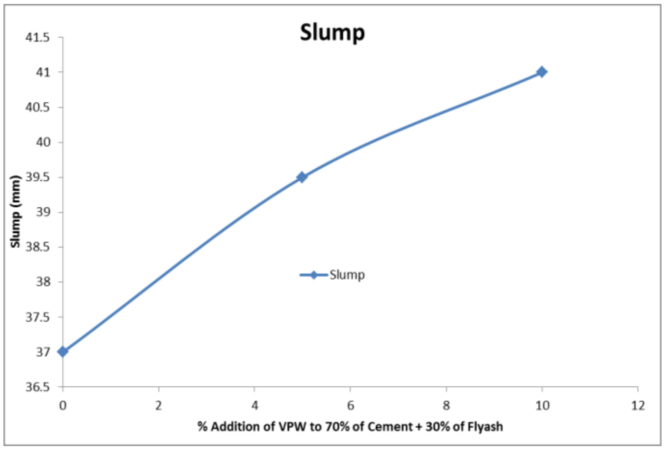

Fig 4.9 Shows Variation of Slump Values with % Addition of VPW for M30

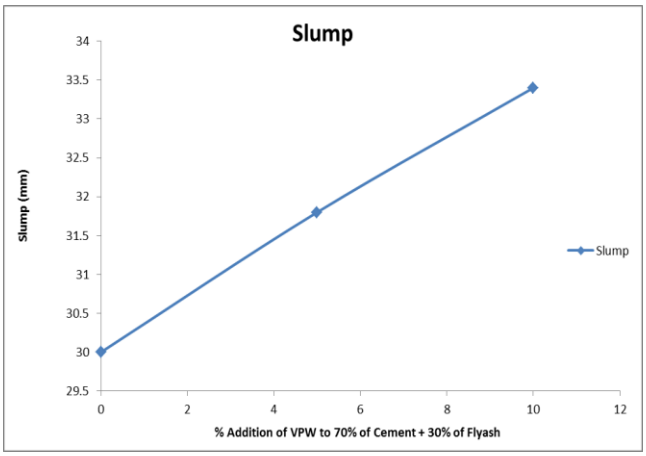

Fig 4.10 Shows Variation of Slump Values with % Addition of VPW for M40

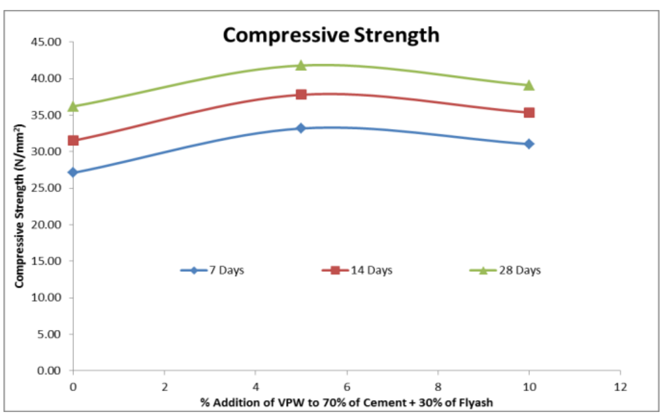

Fig 4.11 Shows Variation of Compressive Strength with % Addition of VPW for M30

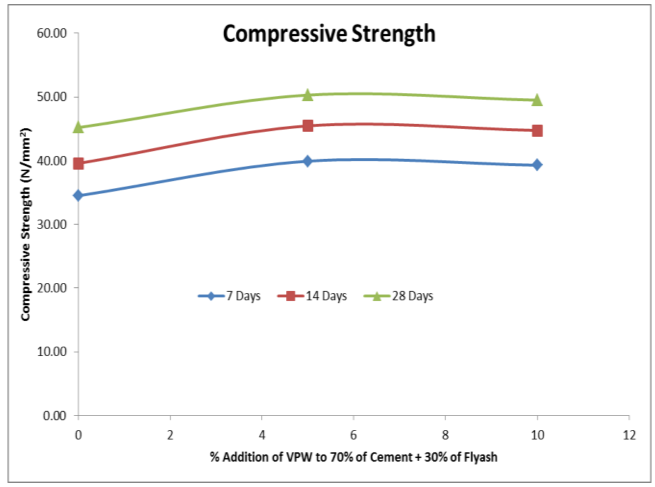

Fig 4.9 Shows Variation of Slump Values with % Addition of VPW for M40

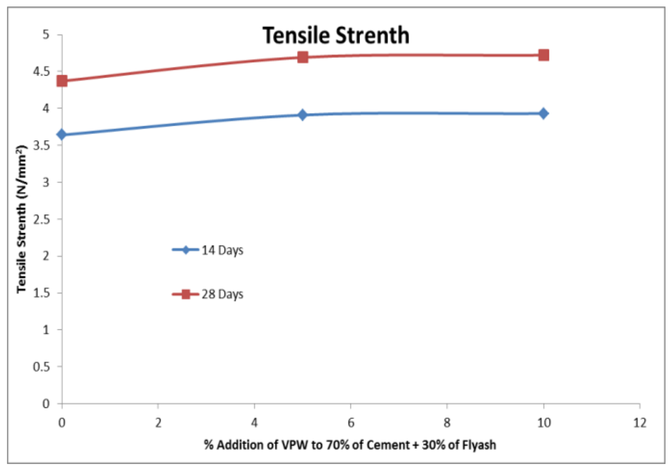

Fig 4.13 Shows Variation of Tensile Strength with % Addition of VPW for M30

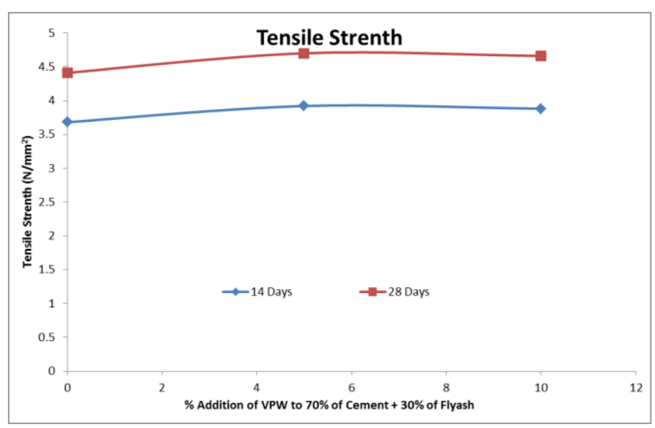

Fig 4.14 Shows Variation of Tensile Strength with % Addition of VPW for M40

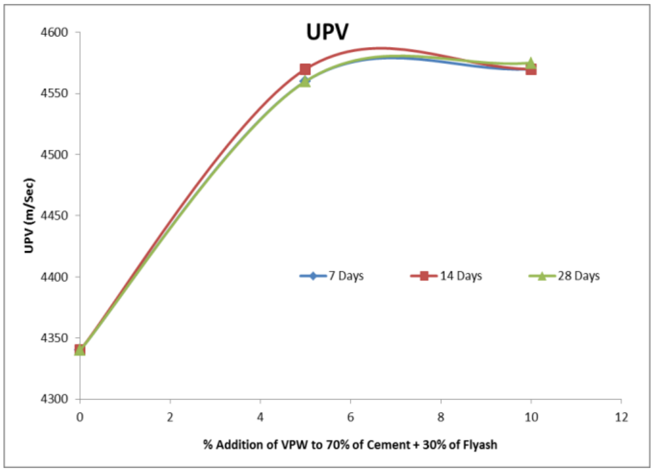

Fig 4.15 Shows Variation of UPV Values with % Addition of VPW for M30

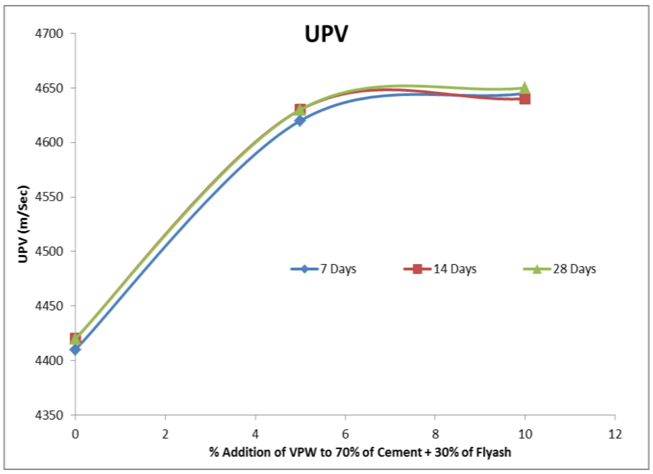

Fig 4.16 Shows Variation of UPV Values with % Addition of VPW for M40

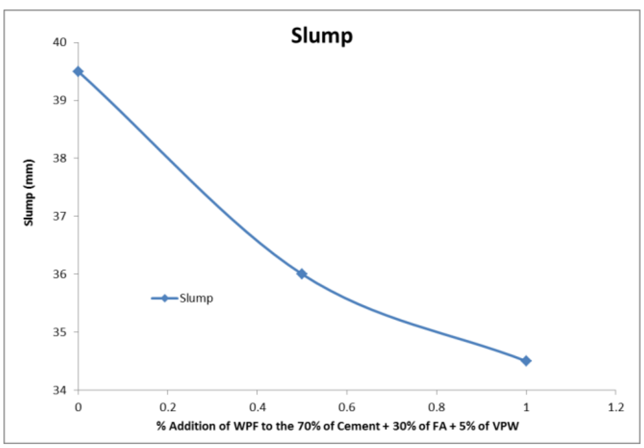

Fig 4.17 Shows Variation of Slump Values with % Addition of WPF for M30

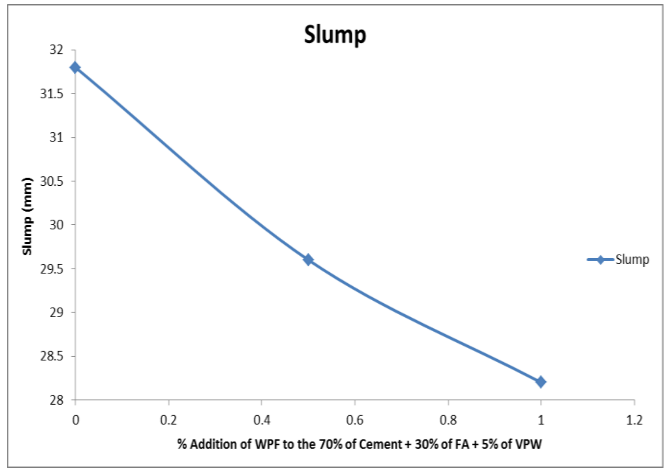

Fig 4.18 Shows Variation of Slump Values with % Addition of WPF for M40

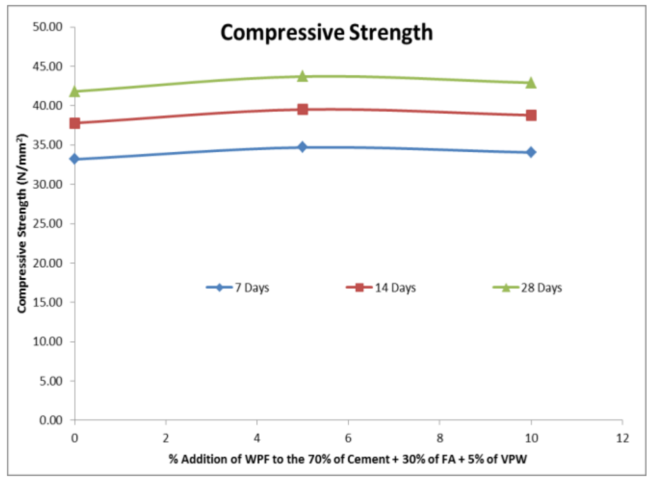

Fig 4.19 Shows Variation of Compressive Strength with % Addition of WPF for M30

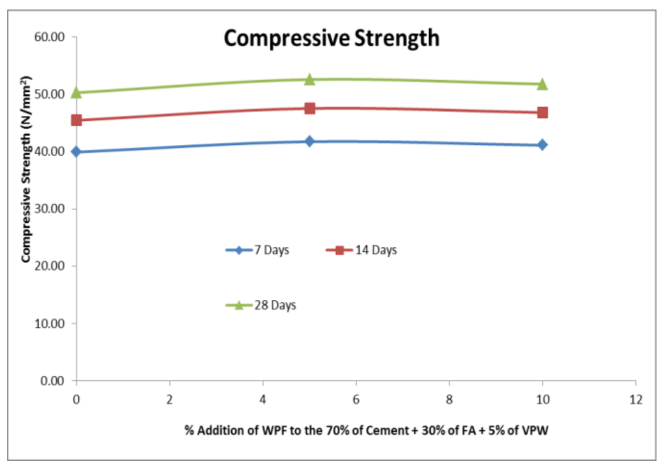

Fig 4.20 Shows Variation of Compressive Strength with % Addition of WPF for M40

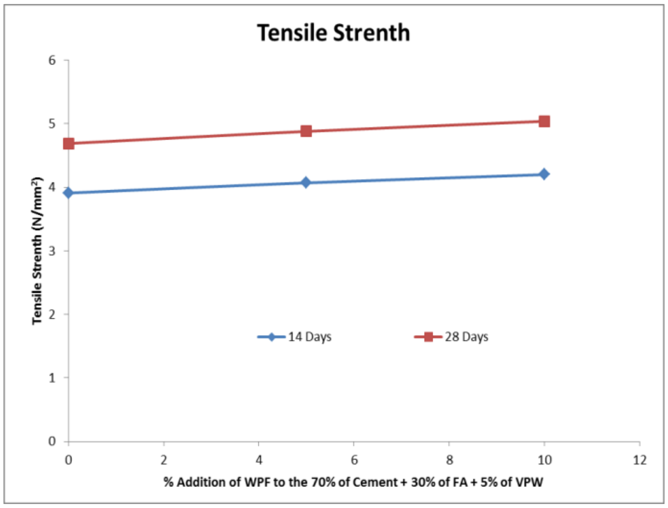

Fig 4.21 Shows Variation of Tensile Strength with % Addition of WPF for M30

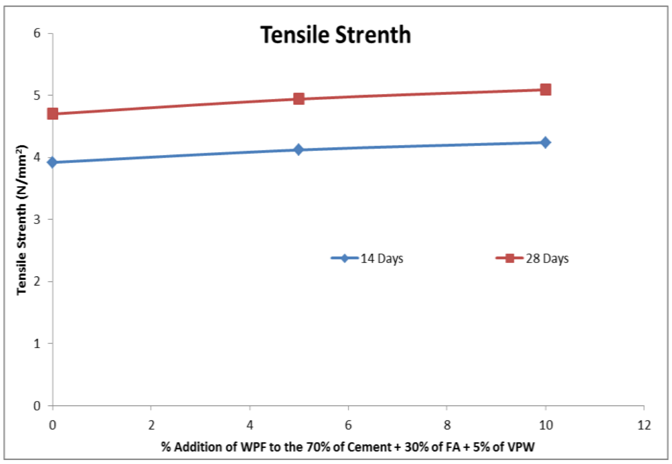

Fig 4.22 Shows Variation of Tensile Strength with % Addition of WPF for M40

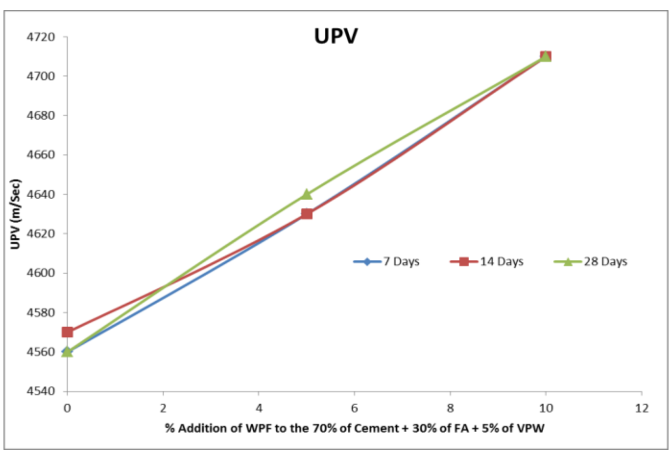

Fig 4.23 Shows Variation of UPV with % Addition of WPF for M30

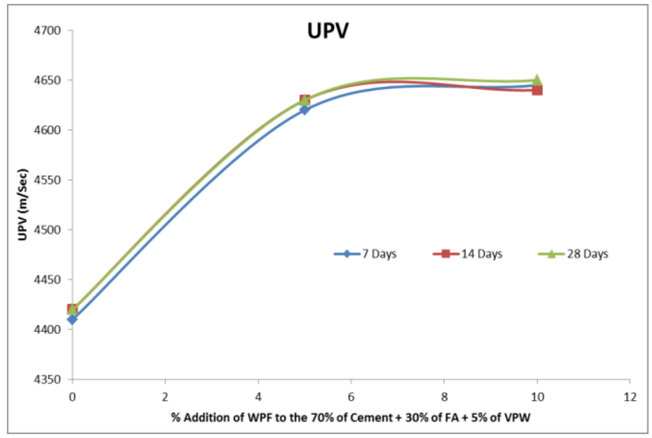

Fig 4.24 Shows Variation of UPV with % Addition of WPF for M40

Variation of various Properties of Concrete with % Addition of Vitrified Polish Waste for M30 & M40:

It is evident that the replacement of 30% of Flyash to the cement is optimum value to the virgin mix. Finally 70% of Cement + 30% of Flyash is optimum. For that optimum mix again Vitrified Polish Waste is added at different proportion of 0%, 5% and 10%.

Fig 4.9, Fig 4.10 Shows the Slump Values for M30, M40 Grades respectively and for the two grades of concrete slump value is improves up to 10% Addition of Vitrified Polish Waste for M30 & M40 to 70% of Cement + 30% of Flyash by an amount of 6.75 & 6% respectively. Fig 4.11, Fig 4.12 shows the results of compressive strength for M30, M40 Grades respectively at 7, 14 and 28 Days. At 28 days curing the compressive strength for two grades at 5% addition of VPW by 15.47% and 11.283% respectively for M30 and M40 Grads. Fig 4.13, Fig 4.14 shows the results of split tensile strength for M30, M40 Grades respectively at 14 and 28 Days. At 28 days curing the tensile strength for three grades at 5% addition of VPW by 7.32% and 6.57% respectively for M30 and M40 Grads. Fig 4.15, Fig 4.16 shows the results of UPV for M30, M40 Grades respectively at 7, 14 and 28 Days. There is no considerable change in UPV with age for each grade individually. However the UPV results are improved threw out the addition due to decrease in void ratio.

Variation of various Properties of Concrete with % Addition of Waste Plastic Fibers (WPI) to optimum mix of Cement + Flyash + VPW for M30, M40:

From the discussion of 4.2 however the workability and UPV results are increased for every addition of Vitrified Polish Waste to the optimum mix of Cement and Flyash, but based on strength criteria it is clear that 5% addition of VPW is optimum. Now for that optimum mix we discuss what is the effect of % addition of Waste Plastic Fibers (WPF).

Fig 4.17, Fig 4.18 Shows the Slump Values for M30, M40 Grades respectively and for the two grades of concrete slump value is observed that getting decrease with increase in WPF Content. It may be fibers will control the flowbility of concrete. Fig 4.19, Fig 4.20 shows the results of compressive strength for M30, M40 Grades respectively at 7, 14 and 28 Days. At 28 days curing the compressive strength for two grades at 0.5% addition of WPI is almost same i.e by an amount of 4.5% was observed when compared with optimum mix of Cement, Flyash and VPW.

Fig 4.21, Fig 4.22 shows the results of split tensile strength for M30, M40 Grades respectively at 14 and 28 Days. At 28 days curing the tensile strength for three grades at 0.5% addition of WPI by 4.01% and 5.1% respectively for M30 and M40 Grads when compared with optimum mix of Cement, Flyash and VPW. Fig 4.23, Fig 4.24 shows the results of UPV for M30, M40 Grades respectively at 7, 14 and 28 Days. There is no considerable change in UPV with age for each grade individually. However the UPV results are improved threw out the addition due to decrease in void ratio.

V. CONCLUSIONS

The following are the conclusions made based on the laboratory experiments carried out in this investigation for various tests with various % replacements of Flyash, VPW and addition of Fiber.

1. It is clear that the Improvement in Slump values is increase with increase in grade of concrete for replacement of 12.5mm Aggregate to 20mm Aggregate. Improvement in the slump for M50 compared to M30 is 96% where it is 26.23% when compared with M40.
2. Compressive Strength also improved for each grade at 15% replacement and also increases with increase in grade of concrete. Compared to M30 improvement in compressive strength for M40 and M50 are 17.27% and 41.27% respectively.
3. Split Tensile strength is improved for all grades for every type of replacement at optimum conditions and for addition of PPF the improvement is high compare to remaining mix proportions.
4. Poly Propylene Fiber is very effectively work for arrest the micro cracking and it improves the tensile strength as well as UPV results i.e we can said that cracks were minimized due to this fiber.

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