Study on Strength Behavior of High Performance Concrete using Industrial Waste and Plastic fibers

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Abstract- **Due to rapid industrialization energy demand increases day by day. Energy generation through thermal power plants produce large quantity of coal ashes in which only 40% of that is being utilized in construction field and balance ashes are disposed over lands. Coal ash consists of different ashes, namely, class-F fly ash, class-C fly ash and pond ash. In this research, a study is carried out on concrete using class-f fly ash and pond ash as a partial replacement for cement and fine aggregate, respectively. In addition waste plastic bottles are made into fibers and are used in concrete in volume fraction as 0.5%, 1%, 1.5% and 2%. The specimens are prepared with partial replacements of cement by 30% of class-f fly ash and 10% of silica fume and partial replacement of sand by 20% of pond ash for all specimens. Super plasticizer is added to improve the workability of concrete. The sample specimens consist of concrete cubes, cylinders and prisms. The compressive strength, split tensile strength and flexural strength tests are carried out and the test results are compared with that of conventional concrete.**

Keywords- Class-f fly ash, pond ash, silica fume, waste plastic fibers, compressive strength, split tensile strength, flexural strength

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I.INTRODUCTION

The ashes are used in concrete for the purpose of economy, eco friendly and most importantly reduction in cement content and sand content. Cement is a water-based binder used to bind other building materials together. The reason cement is one of the most common construction ingredients among other is its ability to hold the structure together. Sand is a major component of concrete and without the sand, concrete will not function as intended. The properties of a specific concrete mix will be determined by the proportion and type of sand used to formulate the concrete. Sand is a larger component of the mix than cement. Accumulation of ash disposed over lands is dangerous to the environment, and many environmental issues. This is one of the major environmental challenges that the world is facing because of ashes disposed over lands. And most commonly used fine aggregate is river sand in many parts of the world. On one side extraction of river sand in excess leads to environmental impacts and on other side disposal of coal ashes from thermal power plants, leading to many environmental problems. The cement production consumes huge amounts of limestone and clay and production of cement releases large amount of CO_2 into the atmosphere. CO_2 gas is a major contributor to greenhouse effect. The carbon dioxide emission and green house emission are some challenge to the human society. To eliminate such kind of environmental problem and excess extraction of river sand and for the purpose of eco-friendly, economy most importantly reduction in cement content and sand content the disposed coal ashes are used effectively in the partial replacement for cement and fine aggregate.

Among different waste fractions, plastic bottles (PET) are non-biodegradable which create lots of environmental issues. These waste PET bottles are used as a fiber in the concrete for durability and serviceability.

A review of literature state that several investigations are previously performed on fly ash concrete. Haldive [1] mentioned that at present India produces around 112 million ton of fly ash annually. Disposal of fly ash and bottom ash is a growing difficulty in India. Huge amount of water is also required for fly ash and bottom ash disposal in slurry form. In this study they found out that at 28^{th} day compressive strength decreased as the fly ash and pond ash content increased. And same for tensile strength when fly ash and pond ash content increased the strength decreased. But for 45^{th} day strength of concrete shows higher strength when compare to 28^{th} day results.

Gaurav [2] mentioned that specimens are prepared with the partial replacement of alcoofine, fly ash and pond ash for cement and fine aggregate, respectively. They found higher compressive strength when 4% alcoofine and 26% of fly ash is replaced for cement and 10% pond ash for sand. Similarly higher split tensile strength is achieved when 6% alcoofine and 24% of fly ash is replaced for cement and 10% pond ash for sand.

Amudhavalli and Jeena [3] mentioned in their study that the M35 grade concrete specimens of cubes, cylinder and prism are casted with percentage replacement of cement by silica fume by 0, 5, 10, 15 and 20 %. And the results indicate that use of silica fume in concrete has improved the performance of concrete in strength and durability aspects.

Ghugal [4] replaced sand with pond ash to the extent of 25% and 50% and the results showed that when 25% of pond ash with sand content gives consistently high compressive strength, flexural strength and split tensile strength.

Today the construction industries are in need of finding the cost effective material for the concrete structures [5]. The possibility of using waste plastic bottles fibers with 1, 2, 4 and 6% as a partial replacement for fine aggregate are produced and compared with normal mix. And the results indicate that 2% replacement give reasonable with high compressive and split tensile strength.

II. OBJECTIVE

The dispose of coal ash and waste plastic bottles over landfill is one of the major pollutants to the environment, so it is better to utilize it effectively in the field of construction. The cost of concrete production also can be cut down using fly ash and pond ash. The objective of this research work is to study the compressive strength, split tensile strength and flexural strength of blended concrete with coal ashes and plastic fibers for the structural applications.

III. METHODOLOGY

A. *Materials*

The main composite material for the concrete is cement and aggregates. Class-f fly ash, pond ash, silica fumes and waste plastic bottles are used.

Class-f fly ash normally is produced by burning bituminous coal. Class-f fly ash is pozzolanic in nature. And this fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrate lime mixed with water to react and produce cementitious compounds.

Pond ash is a waste material and being in contrast to fly ash, having much lower pozzolanic property and it is not suitable for replacement of cement but because of its particle size distribution it can be used as a sand replacement material.

Silica fumes are added to concrete to improve its properties, in particular its compressive strength, bond strength and abrasion resistance.

Waste plastic PET bottles are collected and cut into small fibers. The length of the fiber is 20mm and width is 2mm.

B. *Mix Proportion*

M35 grade of concrete is used and mix design is done as per IS 10262:2009 and mix proportion is carried out by percentage replacement of cement by 30% of class-f fly ash, 10% of silica fume and fine aggregate(river sand) by 20 % of pond ash for all specimens. And waste plastic fiber by 0.5, 1, 1.5 and 2% by volume of concrete. The various mix proportion are shown in Table.1.

Table.1 Mix Proportion

S.no	Coarse aggregate %	Cement %	Fly ash %	Silica fume %	Fine aggregate %	Pond ash %	Plastic fibers %
mix-1	100	100	-	-	100	-	-
mix-2	100	60	30	10	80	20	0.5
mix-3	100	60	30	10	80	20	1.0
mix-4	100	60	30	10	80	20	1.5
mix-5	100	60	30	10	80	20	2.0

C. *Specimen Preparation, Casting and Testing*

In this study totally 5 mixes are prepared. Totally 30 cubes, 30 cylinders and 30 prisms are casted. After the specimens are casted they are kept in curing tanks.

After 7days and 28days curing cubes are tested for compressive strength and cylinders are tested for split tensile strength. And after 14days and 28days curing prisms are tested for flexural strength. The slump value for all the five mixes are shown in Table.2.

Table.2 slump value results

Specimen	Slump value(mm)
mix-1	40
mix-2	100
mix-3	95
mix-4	90
mix-5	80

IV. RESULTS AND DISCUSSION

A. Compressive strength

The cubes of size 150x150x150mm are tested for compressive strength at the age of 7 and 28 days and the results are shown in Figure1. It can be seen that the average strength at 7^{th} and 28^{th} day for mix-2, mix-3, mix-4 and mix-5 specimens show high strength when compare to normal mix.

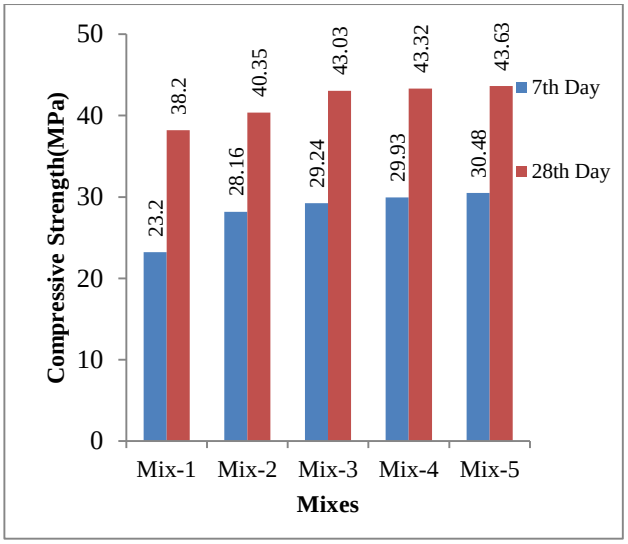

Figure.1 Compressive strength of concrete

B. Split tensile strength

The cylinders of size 150 mm diameter and length of 300 mm are tested for split tensile strength at the age of 7 and 28 days and the results are shown in Figure.2. It is observed in the 7th and 28th day results that as the percentage of fiber increases the spilt tensile strength increases.

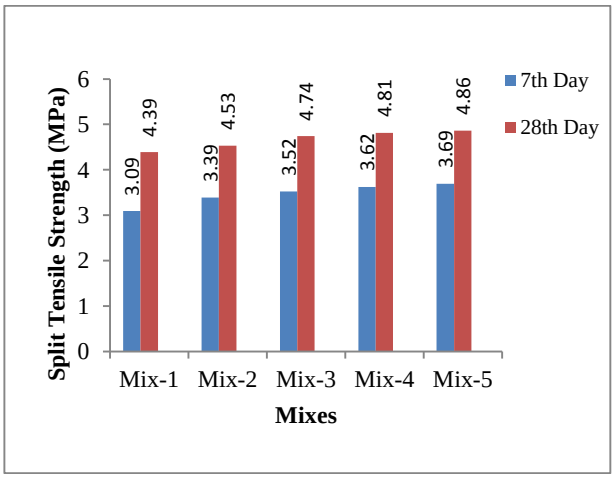

Figure.2 Split tensile strength of concrete mixes

C. Flexural strength

The prisms of size 100x100x500 mm are tested for flexural strength at the age of 14 and 28 days and the results are shown in Figure.3. And the flexural strength results of concrete with fibers shows high strength when compare to normal conventional concrete.

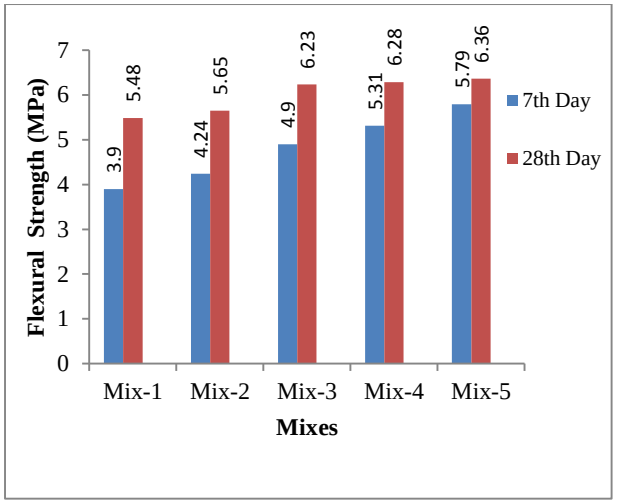

Figure.3 Flexural strength of concrete

V. CONCLUSION

- From this study the result indicates that higher the volume of fiber content there is a low consistency.
- For mix-2, 3, 4 and 5 the compressive strength increases approximately 5.3%, 11.2%, 11.8% and 12.3% respectively when compared to conventional concrete.
- Split tensile strength of concrete for mix-2, 3, 4 and 5 shows increase in strength approximately up to 3%, 7.3%, 8.7% and 10.5% respectively.
- Flexural strength of concrete for all fiber mixes shows good results when compare to conventional concrete.
- Reduces the environmental pollution due to disposal of coal ash by using the waste fly ash and pond ash in construction and it is an alternative source for mineral aggregate.
- Reduces the environmental pollution and solid wastes due to disposal of waste plastic bottles by using them in the concrete effectively.

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