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Use of Flyash and Plastic Waste as a Constituent in Concrete

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ABSTRACT- Cement production gives rise to CO_2 emissions generated by calculations of CaCO3 and by fossil, being responsible for about 5% of the CO2 emissions in the world. This can be substantially reduced if cement replacement materials, either partial or complete such as fly ash are used. Presently large amounts of fly ash are generated in thermal industries with an important impact on the environment and humans. In recent years many researchers have established the use of supplementary cementitious materials (SCM) like flyash (FA) not only improves the various properties of concrete both in its fresh and hardened states but also can contribute to economic construction costs. Plastic bags which are commonly used for packing, carrying vegetables, etc create a serious environmental problem. The safe disposal of plastic bags in the environment is the most challenging issue for solid waste management across the globe. These are non-biodegradable and toxic. Every year at least 15% of total plastic waste remains untreated. Concrete is one of the best choices for construction in many countries today. Waste plastic is being tried in the field of construction as a spatial replacement in fine aggregate, coarse aggregate, or as an additive the concrete. In the present study fly ash (FA) is taken as the partial replacement in cement and low-density polyethylene (LDPE) is used as an additive in the concrete. FA was partially replaced in cement at percentages of 10, 20, and 30. Along with the variation of FA, LDPE was also added from 0.2% to 1% in the concrete by volume. Ample number of samples in M20 grade was prepared with a w/c ratio of 0.55 It was found from the result that the optimum compressive strength for 7 days and 28 days were 28.44 N/mm2 and 33.77N/mm2 obtained at 20% percent replacement of FA with 0.4% addition of LDPE Similarly the optimum split tensile strength for 28 days was 2.49 N/mm2 obtained at 20% replacement of FA with 0.8% addition of LDPE. Thus 20% FA with up to 0.4% LDPE can be adopted so that the disposal of waste plastic and fly ash can be done well as well and the efficiency of the concrete can be managed effectively.

KEYWORDS- Fly Ash, Waste Plastic, LDPE, M20 Grade Concrete, Compressive Strength, Split Tensile Strength.

I. INTRODUCTION

The rapid growth of industrialization gave birth to numerous kinds of waste byproducts which are environmentally hazard and creates problems of storage. Leaving the waste materials to the environment directly can cause environmental problem. Hence there use of waste material has been emphasized. Waste can be used to produce new products or can be used as admixtures so that natural resources are used more efficiently and the environment is protected from waste deposits. These industrial wastes are dumped in the nearby land and the natural fertility of the soil is spoiled. Any country‘s economic and industrial growth depends on the availability of power. In a country like India electricity is the key for its development and thermal power plant are the major source of electricity in our country. India has 211 billion tons of coal reserves. Indian coals used in thermal power plants is of low grade quality and has an ash content of 40 to 50% [1]. The power generation in India was about 200,000 MW in 2012 and it is expected to increase up to 300,000MW by 2017. The present fly ash generation rate is about 131.09 million tonnes per year and the utilization rate of coal is 73.13 million tons per year (Singh and Gupta 2014). The coal reserve of India is about 200 billion tones and its annual production reaches 250 million tones (MT) approximately. About 70% of this is used I the power sector. In India, unlike in most of the developed countries, ashcontent in the coal used for power generation is 30-40%. About 60% of thesepower plants use coal as the major source of fuel. Fly ash is difficult to decompose so using fly ash is a major step towards sustainable development. Fly ash is a byproduct of the combustion of pulverized coal in thermal power plants. Fly ash is one of the residues generated in the combustion of coal. Fly ash is generally captured from the chimneys of power generation facility, whereas bottom ash is, as the name suggests, removed from the bottom of the furnace. In the view of global warming efforts are on to reduce the emission of CO2 to the environment. The major problem of the whole process of production of fly ash is their safe disposal and management [2]. The waste generated from industries are complex characteristics and composition, hence it is necessary to safely dispose the wastes otherwise it will have a negative impact on environment and social life, which will ultimately disturbthe ecological system.

Plastics are normally stable and not biodegradable. So, their disposal is a problem. Research works are going on in making use of plastics wastes effectively as additives in plain and reinforced concrete mixes for variety of purposes. Different forms and types of wastes are utilized to check the feasibility of them in concrete. The use of domestic waste plastic waste in concrete will not only be its safe disposal method but may also improve the concrete properties like tensile strength, chemical resistance, drying shrinkage and creep on short and long term basis. The effective use of domestic wastes plastics in concrete contributes in order to prevent the environmental strains caused by them, also to limit the consumption of high amounts of natural resources[7]. The re-formation of natural sources is beyond the proportion of mankind. Hence the increased demand of concrete has raised a serious question on the quickly vanishing valuable natural sources. It is therefore has become a necessity to find an alternate material could be used along with the conventional materials and try to reduce the quick and huge usage of valuable sources[3].

A. Objectives

The objective of the present work is to examine the mechanical properties of the concrete mix in which there is percentage replacement of cement by flyash and addition of waste domestic plastics as an additive. This will be achieved by experimental designs and methods. With the above mentioned objectives, the following study plan was made:

- To characterize the properties of Ordinary Portland Cement
- To study the properties of the fly ash collected from the field source.
- Collection of the domestic waste plastic and analization of its properties.
- To study the workability of concrete with natural aggregates without any addition of flyash and waste plastic and concrete with different proportion of flyash and waste domestic plastic.
- To investigate the properties of fresh and hardened concrete, properties of natural aggregate concrete and concrete with different proportion of fly ash and waste domestic plastic.
- To carry out validation experiments to compare the predicted and experimental results.

B. Fly Ash

Fly ash is generally captured by precipitators or other particle filtration equipment before the flue gases reach the chimneys of coal-fired power plants.

C. Flyash in Concrete Advantages

One of the major effects that the fly ash has on concrete is improving its workability, as the percentage of fine particles in fly ash is greater than in cement [4]. Using fly ash in concrete reduces the water demand.

D. Plastic

Inaccurate statistics have been seriously made on the total number of plastic bags produced so far, but today about a trillion plastic bags are being nonchalantly used worldwide every year .These bags are very popular with both retailers and consumers, because they are very cheap, strong, lightweight, functional, and as a hygienic means of carrying food and other goods. A material which contains one or more organic polymers of large molecular weight, which shows solid form in its finished state and while manufacturing or processing into finished articles, can be shaped by its flow, is termed as "Plastics"[5]. Plastic is one of the most abundant materials in the world today. It is an organic amorphous solid, and is favoured for its cheap production costs, mechanical and thermal abilities, stability and its durability. Plastic can be sorted into two different categories when considering thermal properties: thermoplastics and thermoset plastics. Thermoset plastics are formed by step-growth polymerization under proper conditions, allowing the condensation of bi-functional molecules. When thermoset plastics are exposed to adequate heat, they undergo chemical changes that are irreversible [6].

E. Types of Plastic

It shows a list of some common types of plastic and their everyday uses. Different chemical formulae give the material different mechanical, chemical or thermal properties.

F. Use of Waste Plastic in Concrete

- It is Durable and corrosive resistant.
- It is more economical and has a longer life.
- Free Maintenance (such as painting is minimized).
- Very Hygienic and clean.
- Ease processing / installation.
- Light weight material.
- To reduce the extraction of raw materials.
- To reduce the transportation cost.
- To reduce the environmental impact and improved profits.

II. MATERIALS AND METHODS

Materials

A. Cement

Ordinary Portland cement (OPC) 43 grade conforming to the requirements of BIS (IS: 8112-1989) manufactured by Ramco has been used in the entire experimental study. To avoid the long storage times and to avoid the loss of strength, cement was procured according to the phase wise requirements. The cement was stored in bags in air tight room to have minimum exposure to the humidity.

B. Aggregates

Aggregate properties greatly influence the behaviour of concrete, since they occupy about 80% of the total volume of concrete. The aggregate are classified as

- Fine aggregate
- Coarse aggregate

C. Water

Portable drinking water free from impurities and salt having pH value of 7 and conforming to IS 456 -2000 was used for mixing of concrete. Tap water available at the lab was stored in the curing tank for the curing of specimens.

D. Preparation of Concrete Mixture

Concrete containing both fly ash and waste plastic were prepared by mixing cement, fly ash and waste plastic in different proportion in a controlled manner. Mix design was done for M20 grade concrete as per IS 10262:2009[6].

Design mix for M20 concrete

Grade of Concrete — M20
Using 0% fly ash as partial replacement of cement

E. Casting and Testing of Concrete

Concrete mixture was designed and test for the fresh and hardened relevant characteristics. The concrete cubes prepared for the test were of M20 grade of concrete. Compressive strength of 150mm X 150mm X 150mm size cubes and split tensile strength of 300mm X150mm cylinder were tested. The proportion of coarse aggregate, fine aggregate and cement was found to be 1:1.51:3.18 for conventional aggregate concrete and 1:1.61:2.7 from the mix design. Different percentage of fly ash and waste plastic concrete and ordinary concrete was obtained to conduct compression test on BIS standards. The curing period for the BIS specimen are 7 and 28 days respectively. Four concrete mixes has been prepared with 0%, 10%, 20% and 30% fly ash replacement in cement by weight. Each concrete mix with four different percentage of plastic i.e. 0%, 0.4%, 0.8%, 1.2% has been added by volume.

F. Mixing Procedure

Uniform mixing of concrete should be ensured to get correct test results of the specimen. A manually loaded laboratory mixer operated by electricity was used for all the mixes. Required amount of aggregate, cement, fly ash and shredded plastic were weighed according to the design mix for different mix.

G. Casting, Compaction and Curing of Moulds

The steel cube moulds of size 150mmx 150nunx150mm and cylinder moulds of 300 x 150mm were coated with oil as a greasing material on the inner surfaces and were placed on a plane platform. Then the amount of fine aggregates, coarse aggregates, cement, fly ash and waste plastic were weighed according to the design mix. Then the materials were mixed with water. Thereafter slump test has been conducted to measure the degree of workability of the mix. Concrete was then poured in to the moulds in three layers: each layer was uniformly tamped by the tampering rod with 25 numbers of blows. Then the mould was placed on a vibrating table to release air voids. The top surface of the moulds were finished using a trowel.

After 24 hour of casting moulds were then safely demoulded causing no damage to the specimen. The specimens are then coded for easy reference and were immersed immediately in a curing tank with normal water at room temperature.

III. METHODS

A. Workability of Concrete

The property of fresh concrete is assessed by workability in terms of slump value. To check the consistency and slump value of fresh concrete, the slump cone test has been conducted on all concrete mixes immediate after mixing of the concrete. The slump cone specified by BIS (IS: 7320-1974) was used to measure the slump of the fresh concrete. The slump cone was placed on a smooth surface (metal base plate) and filled with concrete in three layers, each layer was compacted uniformly by 25 blows with a standard 16 mm diameter tamping rod, and the top surface was struck off by means of sawing and rolling motion of the tamping rod. The mould was then lifted slowly without shaking and the unsupported concrete is the slump. Height of slump has been measured by the measuring rod.

B. Compressive Strength of Concrete

The compression test was conducted on 150 mm cubes at 7 and 28 days adopting wet process. At curing period of 7 days, 48 cubes have been tested.

C. Split Tensile Strength

Test has been carried out on three samples for each concrete mix and the average results have been reported. A total of 32 samples were prepared.

IV. RESULT AND DISCUSSION

The physical and mechanical characteristics of fine aggregate and coarse aggregate and compared with relevant standards. Since approximately 70 to 80% of the volume of concrete is occupied by the aggregates, it is important to understand the influence of the various properties of aggregates on both fresh and hardened properties of concrete. Thereafter the properties of the fresh and hardened concrete, prepared with different percentages (0, 10, 20, 30) of fly ash and (0, 0.4, 0.8, 1.2) of waste plastic (LDPE) are discussed. All mixes are designed for M20 grade of concrete in accordance with the Bureau of Indian Standard (BIS) [6].

A. Fresh Concrete

The properties of hardened concrete are seriously affected by its degree of compaction. It is absolutely necessary that the fresh concrete should be workable such that the concrete can be properly compacted and can be transported, placed and finished easily without any segregation.

B. Workability

The workability of the concrete of M20 grade at constant w/c ratio of 0.55 for different percentage of LDPE. It is observed that at 0% of LDPE the workability of concrete mix is 120, 100, 90 and 60 mm for 0%, 10%, 20%, and 30% of FA respectively. For 0.4% of LDPE the slump value is 120 mm. For 0% FA and 100 mm and 100 mm for

10% FA. At 0.8% LDPE the slump value are 115 mm, 95 mm, 70 mm and 50 mm for 0%, 10%, 20% and 30% FA respectively. The slump values at 0.8% LDPE for 0%, 10%, 20% and 30% FA decreases with respect to the slump values at 0.4% LDPE for 0%, 10%, 20% and 30% FA. The slump values at 0.8% LDPE for 0%, 10%, 20% and 30% are 115 mm, 95 mm, 70 mm and 50mm respectively remains same for slump values at 1.2% LDPE for 0%, 10%, 20% and 30%.

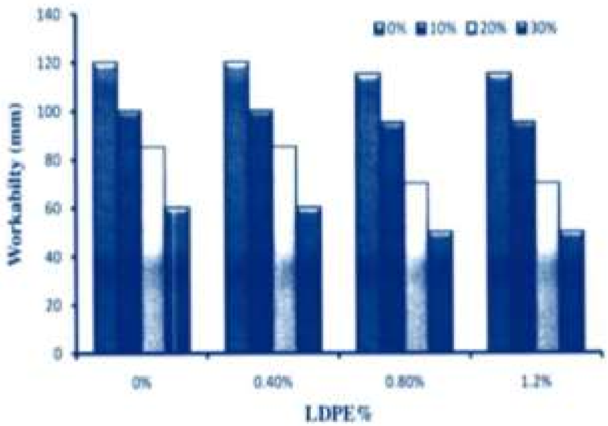

Figure 1: Compressive strength of the concrete of M20 grade tested at 7 days at constant

C. *Hardened Concrete*

For the use of concrete in any particular application, the characteristic compressive strength of concrete at 28 days important.

Compressive strength of concrete prepared with 0, 10, 20, 30% FA replacement of cement and 0, 0.4, 0.8, 1.2% shredded LDPE addition has been tested for 150 mm cube with curing age of 7 and 28 days.

Figure 1 represents the compressive strength of the concrete of M20 grade tested at 7 days at constant w/c ratio of 0.55 for different percentage of LDPE. The study show that at 0% LDPE the compressive strength are 24.133, 26.37, 27.56 and 21.96 N/mm2 for 0%, 10%, 20% and 30% FA respectively. The compressive strength at 1.2% LDPE for 0%, 10%, 20% and 30% FA shows the minimal result i.e. 23.15, 24.14, 24.81 and 20.66 N/mm2 respectively.

At 1.2% LDPE the compressive strength of concrete mix for all percentage of FA is lowest as compared to other percentage addition of LDPE.

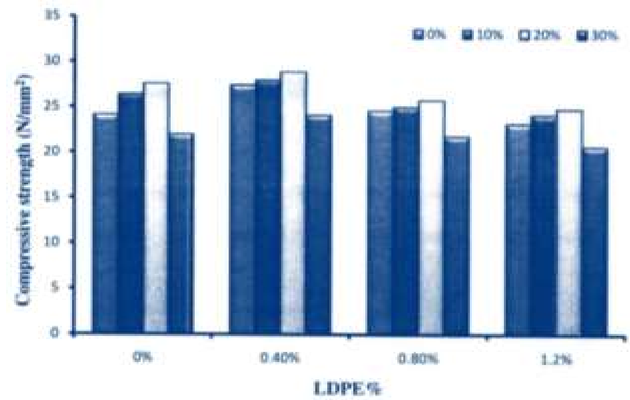

Figure 2: LDPE compressive strength

The study shows that at 0% **LDPE** the compressive strength are 31.70, 32.14, 33.33 and 27.37 for 0%, 10%, 20% and 30% FA respectively. The compressive strength at 1.2% LDPE for 0%, 10%, 20% and 30% FA shows the minimal result i.e. 26.96, 28.88, 29.18 and 23.96 N/mm2 respectively. At 1.2% LDPE the compressive strength of concrete mix for all percentage of FA is lowest as compared to other percentage addition of LDPE.

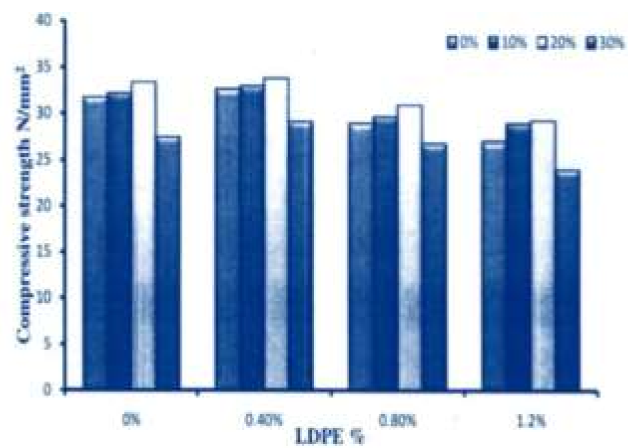

Figure 3: Split tensile strength of the cylinder specimen of M20 grade

D. *Development of Split Tensile Strength with Age*

Split tensile strength of concrete prepared with 0%, 10%, 20%, 30% FA replaced in cement and 0%, 0.4%, 0.8%, 1.2% addition of LDPE was casted using150 X 300 mm cylinder mould and experimental tests were done on the cylinder specimens with curing age of 28 days.

Figure 3 represents the split tensile strength of the cylinder specimen of M20 grade at constant w/c of 0.55 for different percentage of LDPE. At control mix i.e. 0% LDPE and 0% FA the split tensile strength was 2.21 N/mm2. At 0% LDPE the split tensile strength for 10% and 20% FA has been found to be 2.27 and 2.38 N/mm2 respectively which is 2.7% and 7.69% more than the control mixes. The split tensile strength for the same at 30% FA is 1.65% which is 25.33% less than the split tensile strength of the control mix. At 0.4% LDPE the split tensile strength for 0%, 10%, 20% and 30% FA the split tensile strength were found to be 2.28, 2.35, 2.4 and 1.9 N/mm2 respectively. At 0.8% addition of LDPE to the concrete mix for 0%, 10%, 20% and 30% FA the strength were 2.35, 2.42, 2.49 and 1.96 N/mm2 respectively. it was observed that for 0%, 10%, 20% and 30% FA at 1.2% LDPE, the split tensile strength increased up to 20% FA and then decreased. The strength at 20% FA for 1.2% LDPE was found to be 2.41 N/mm2 which is the optimum strength for 1.2% LDPE.

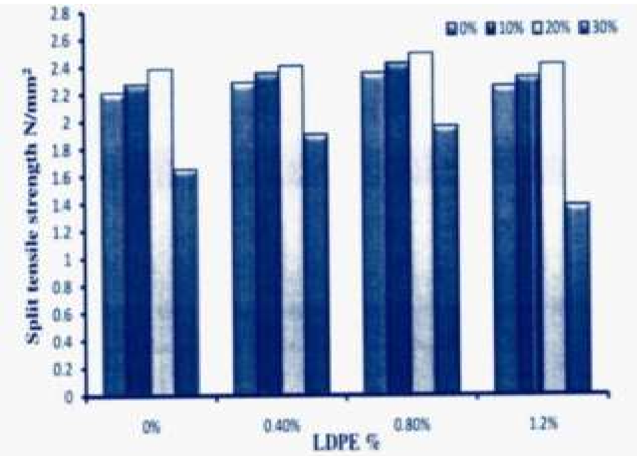

Figure 4: Split tensile strength of the cylinder

Figure 4 represents the split tensile strength of the cylinder specimen of M20 grade at constant w/c of 0.55 for different percentages of FA. The split tensile strength of the control mix was found to be 2.21 N/mm2. With the addition of 0.4% and 0.8 % LDPE at 0% FA the tensile strength were 2.28 and 2.35 N/mm2 with an increase of 3.16% and 6.33 % respectively. With the addition of 1% LDPE the strength decrease to 2.25 N/mm2. With the addition of 0.4 and 0.8 % LDPE at 10% FA the strength were found to be 2.35 and 2.42 N/mm2 with an increase in strength of 3.15% and 6.6% respectively. With the addition of 1.2% LDPE the strength decrease to 2.32 N/mm2. With 20% FA, the tensile strengths were found to be increasing up to 0.8% LDPE addition and then the strength is decreased. At 0.8% LDPE the strength was found to be 2.49 N/mm2 which is the optimum value. At 30% FA the strength of the concrete mix was decreasing with respect to other percentage of FA. The strength at 30% FA for 0%, 0.4%, 0.8% and 1.2% were found to be L.65, 1.9, 1.96 and 1.38 N/mm2 respectively and 1.96 N/mm2 being the optimum value. It was observed that for every percentage of FA, the strength increases up to 0.8% LDPE addition and then there was a sudden decrease in the strength.

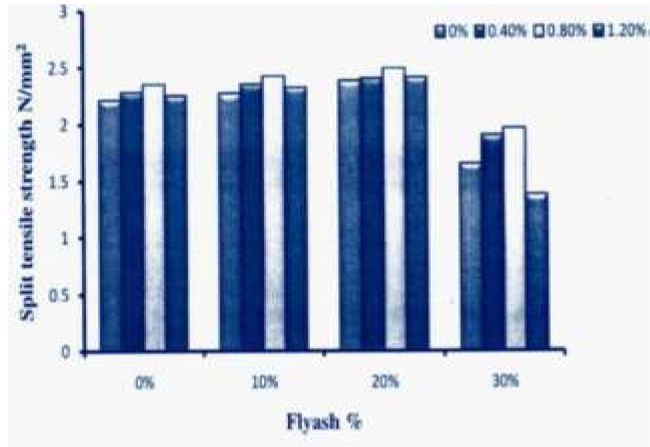

Figure 5: Split tensile strength of the cylinder

V. CONCLUSION

Casting of cube and cylinder specimens of M20 grade of concrete was done. These specimens were then cured for desired 7 and 28 days. Test for properties of fresh concrete and hardened concrete were carried out in the laboratory. The experiments showed that replacing 20% of fly ash in cement by weight with addition of 0.4% of waste plastic (LDPE) by volume gives compressive strength of 28.44 N/mm2 for 7 days test and 33.77 N/mm2 for 28 days. Tensile strength was found to be 2.493 1\l/mm' for 20% fly ash in cement and 0.8% waste plastic (LDPE) addition.

Based on the experimental data received after a wide range of samples with different proportions of fly ash and shredded LDPE plastics, following conclusions are made.

- The plastic bags could be used in shredded form to avoid difficulty in workability.
- Plastic fibres along with fly ash showed good combination as far as strength gain is concerned.
- Best and optimum results for compressive strength were noticed in replacing 20% fly ash in cement by weight with addition of 0.4% LDPE fibres by volume of the concrete.
- The splitting tensile strength observations show the improving of tensile strength of concrete. Up to 0.8% of plastic improvement of strength was recorded after that addition of strength of concrete decreases with addition of plastic.
- To increase the durability aspects of the concrete the concept of using LDPE fibers and fly ash could be very good environmental friendly option as far as waste disposal is concerned.
- As the fly ash content increases there is reduction in the strength of concrete. This reduction is more at earlier ages as compared to later ages.
- This is expected, as the secondary hydration due to pozzolanic action is slower at initial stage for fly ash concrete.
- Rate of strength development at various ages is related to the w/c and percentage of fly ash in concrete mix.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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