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STUDY ON PROPERTIES OF CONCRETE WITH COLOUR ADSORBED FLY ASH, RICE HUSK ASH, STEEL SLAG AND POLYPROPYLENE FIBRES

SANKAR JEGADESH J. S[1] & S. JAYALEKSHMI[2]

[1]Research Scholar, National Institute of Technology, Tiruchirappalli, Tamil Nadu, India

[2]Associate Professor, National Institute of Technology, Tiruchirappalli, Tamil Nadu, India

ABSTRACT

The main objective of the project is to solve the waste management of Textile Industries, Thermal Power plants and Steel Manufacturing Industries. The solution for current environmental problems of disposal of steel slag and fly ash has been dealt by use of Fly ash as an adsorbent and using Colour Adsorbed Flyash as partial replacement for cement, use of steel slag as partial replacement for coarse aggregate and use of Rice Husk ash as partial replacement for cement in concrete. The key importance is to use the waste materials and combining the advantages of Fiber Composites (Polypropylene fibers) in concrete. In this experimental investigation an attempt is made to study the effect of partial replacement (30%) of coarse aggregate by the waste materials (steel slag) obtained from Steel Industry and Cement by (30%) Colour Adsorbed fly ash and (20%) Rice husk Ash on properties of Concrete. Also a detailed investigation is made to study the effect on the addition of fiber composites (organic polymers-POLYPROPYLENE FIBRES) on the properties of concrete.

KEYWORDS: Colour Adsorbed Flyash, Rice Husk Ash, Steel Slag, Water Management, Polypropylene Fibers

INTRODUCTION

Concrete is the largest produced construction material. Aggregates and cement are the important constituents in concrete. They give body to the concrete and affect the economy. Requirement of aggregate is also increasing proportionally as all the materials required for producing cement and concrete. They are obtained from the earth's crust only. Hence, we are exploiting the natural resulting in depletion of the resources. Resources could be saved and preserved by finding an alternative and substitute materials. Thus, partial replacement of ingredients of concrete with CAF, RHA and steel slag are used to reach sustainability.

LITERATURE REVIEW

Seyoon Yoon, Paulo J.M. Monteiro, Donald E. Macphee, Fredrik P. Glasser and Mohammed Salah-Eldin Imbabi from the measured values of compressive strength and Young's modulus in HVFA concretes CEB–FIP models, which were designed for ordinary concretes, could be applied to HVFA concretes using different empirical coefficients, the values of which were reported in the present study. **Mahdi Arezoumandi and Jeffery S. Volz** investigated on the effect of fly ash replacement level on the shear strength of high-volume fly ash concrete beams. **Shi-Cong Kou and Chi-Sun Poon** presented the findings of a long-term study on the mechanical and durability properties of concrete prepared with 0%, 50% and 100% recycled concrete aggregate that were cured in water or outdoor exposure conditions for 10 years. **Tarun R. Naik, Shiw S. Singh, Mathew P. Tharaniyil, and Robert B. Wendorf** had undertaken research to evaluate the performance of Blast Furnace by-products in concrete and masonry products. Test results indicated that masonry blocks made with 35 percent used furnace slag passed the ASTM requirements for compressive strength, absorption, and bulk density. Wang **Qiang, Yan Peiyu, Yang Jianwei and Zhang Bo** investigated the **i**nfluence of steel slag on mechanical properties and durability of concrete. **Liu Chunlin, Zha Kunpeng and Chen Depeng** experimentally investigated the Volume deformation, compressive and flexural strength of concrete containing EAF slag and (or) scrap tire particles as aggregate by strength test according to the specification of GB/T 50081-2002 and unrestrained specimens volume deformation test. **Dinesh Mohan, Kunwar P. Singh, Gurdeep Singh, and Kundan Kumar** investigated the use of low-cost adsorbent as a replacement for the current expensive methods of removing dyes from wastewater.

As such, fly ash generated in National Thermal Power plant was collected and converted into a low-cost adsorbent. The prepared adsorbent was characterized and used for the removal of dyes from wastewater. Adsorption studies were carried out for different temperatures, particle sizes, pH, and adsorbent doses. In comparison to other low-cost adsorbents, the sorption capacity of the material under investigation is found to be comparable to that of other commercially available adsorbents used for the removal of cationic dyes from wastewater. **J.L. Alonso and K. Wesche** noted that the finely divided glass phase, the predominant phase in fly ash, reacts as a pozzolona, a siliceous and aluminous material that in itself possesses little or no cementations value but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementations properties. **E. B. Oyetola and M. Abdullahi,** found that The compressive strength of the OPC/RHA sandcrete blocks increases with age at curing and decreases as the percentage of RHA content increases. The study arrived at an optimum replacement level of 20%. **Zerbino R., G. Giaccio, O.R. Batic and G.C. Isaia** proposed that the RHA can inhibit or promote ASR depending on their particle size.

MATERIALS REQUIRED

Among the various types of cement, ordinary Portland cement (OPC) is by far the most important type of cement. The OPC was classified in to three grades, namely 33 grade, 43 grade and 53 grade depending upon the strength of the cement at 28 days when tested as per IS 4031-1988. If the 28 days strength is not less than 33 N/mm^2, it is called as 33-grade cement. Getting good sand free from organic impurities and salts is very difficult in now a day. While adding the sand to the mix, it should be free from organic and inorganic matters. And the sand should be in uniform size i.e., all the sand particles should be fine. So a sieve analysis has to be done and the sand, which is passing through 1.8mm, is to be collected and used in the project. The maximum size of the aggregates depends on the particular application and is usually limited to 20 mm. The moisture content should be closely monitored and must be taken into account in order to produce concrete of constant quality. Consistency of grading is of vital importance.

COLOUR ADSORBED FLYASH (CAF)

The textile industry and the thermal power plants are producing huge amount of wastes that pollutes the environment in different ways. These waste should be disposed in a safe manner or be utilized for any other purpose to save our environment. It will be handier if one waste is used to minimize the effect of the other waste. The fly ash can be used as colour adsorbent in various waste water treatment plants. The fly ash which acts as colour adsorbent has to be suitably disposed to avoid environmental problems. This project aims to provide a solution to the prevailing environmental problems particularly due to Dye stuffs from the textile processing industries and dumping of fly ash by the thermal power plants. In this study, flyash which is produced as waste from the thermal power plant is used as adsorbent for the wastewater. So, as an attempt to find out a solution through low cost treatment methodology the Colour Adsorbed Fly (CAF) ash is reused in construction industries. In this view, the fly ash from the thermal power plant and effluents from Textile industries are collected. Properties of untreated effluents are studied. Effluent is experimentally treated by two methods namely Packed column set-up and sedimentation method. Packed column set-up is made by using single layer fly ash and then effluent is treated with this packed column set-up. In the other method, fly ash is mixed with the effluent directly, stirred well, allowed to settle and then outlet ie. Treated effluent is collected. The parameters and the characteristics of the effluent before and after the treatment are studied and compared. The Sludge ie Colour Adsorbed Flyash (CAF) from the settling tank and Packed column set-up is removed. The CAF ash is used in different proportions in the cement in concrete. The strength and durability properties of concrete are studied and the results are compared with conventional concrete respectively.

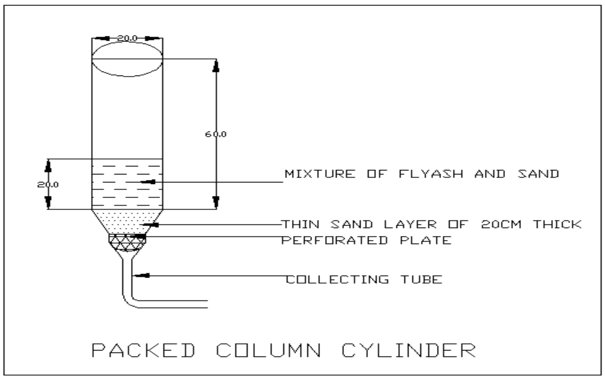

Figure 1: Packed Column Set - Up

The packed column setup is shown in **figure 1**. The column of 20 cm diameter and 60 cm height is to be adopted. The column is of non-porous, non-reactive and inert. PVC pipe has to be used as a column. The column is packed with adsorbent materials in plain manner or in alternate layers of adsorbent and inert materials. The column of short size is tested. For large industries, the column of large size can be adopted. The experimentation is done by using single layered fly ash. In the single layered fly ash column, the bottom of the column is filled with sand for 10 cm thickness and above which mixer of fly ash and sand of 40cm thickness is provided. The fly ash and sand are mixed with proportions of 3:1. Filter is provided at bottom most using 1 micron (1µ) perforated cloth to avoid the washout of the fly ash. The treatment process is carried out and the removal of dyes by adsorption on column composed of fly ash and sand mixtures reaches an equilibrium condition when the adsorbent mixture stops adsorbing the solute dyes. The adsorbent equilibrium point is indicated by the concentration of dye in the effluent which becomes equal to the initial concentration.

RICE HUSK ASH (RHA)

Rice husk is burnt approximately for 48 hours under uncontrolled combustion process. The burning temperature is within the range of 600 to 8500˚C.According to the chemical characteristics, the RHA has high levels of silicon dioxide, approximately 93%, and the specific gravity is 2.16. The result shows a very distinct peak corresponding to crystalline silica. The reason for this behavior is the long time combustion process and high temperature of burning. The average particle size distribution is 13.34µm. Thus the RHA is finer than cement and should be expected to work not only a pozzolanic role, but also a micro filler effect.

STEEL SLAG

Steel slag aggregates are highly angular in shape and have rough surface texture. They have high bulk specific gravity and moderate water absorption (less than 3 percent).The specific gravity is 3.85 ad unit weight is found to be 1600 – 1920 kg/m^3**.** The water absorption capacity is 3%.

POLYPROPYLENE FIBRES

The polypropylene fibers are hydrophobic, which do not absorb the water, and are non-corrosive. Moreover, the polypropylene fibers have excellent resistance against alkali, chemicals and chloride and have low heat conductivity. By these characteristics polypropylene fibers have therefore no significant effect on the water demand of the fresh concrete. They do not intervene the hydration of cement and hence do not influence unfavorably the effects of all constituents in the concrete mixture. Polypropylene is the lightest synthetic polymer. Hence the count of fiber for a given weight is high in case of polypropylene. It is 52% lighter than polyester and 26% lighter than nylon and acrylic. Hence polypropylene fibers are ideal for reinforcement. Unlike other fibers available, they are available in triangular cross section. By simple calculation, one can see that a triangular fiber has 29% more surface area than circular fiber. Higher surface area results in better reinforcement and is easy to use and they can disperse easily. The length of fibers varies from 24mm to 42 mm. The long length of fiber holds together different components of concrete together, while shorter length fibers (which have lower diameter) increases the number of fibers, thereby providing better reinforcement, crack prevention and increase in strength of concrete. It has been used in floorings, roads; slabs and other load bearing structure. These polypropylene fibers are suitable for structural works. It can be used to decrease or replace the steel in concrete, particularly in floors and certain precast. Due to the long length, it gives better anchorage and reinforcement and also increases the number of fibers in a given dosage, preventing crack formation. It is recommended for heavy structural concrete/load bearing structures. It is the most popular among the macro fibers and gives better result.

SPECIFICATION OF POLYPROPYLENE FIBRES (CPPST FIBRE)

Table 1

Material	100% virgin polypropylene
Length	24-42 mm
Absorption	It does not absorb any moisture
Melt Point	162°C
Specific Gravity	0.91
Ignition Point	570°C
Thermal Conductivity	Low
Electrical Conductivity	Low
Alkali Resistance	100% Alkali Proof
Acid & Salt Resistance	High

WORK PLAN

Test Specimens

The experimental program is designed to study the mechanical properties of concrete with partial replacement of cement by colour adsorbed flyash and Rice husk Ash and replacement of coarse aggregate by steel slag for M_{20} grade of concrete. The compressive strength of the specimens was studied after 28 days. For the test specimens, 53 grade pozzolonic Portland cement, Natural River sand and coarse aggregate, steel slag from steel plants have to be used.

The maximum size of the coarse aggregate is limited to 20mm. A sieve analysis conforming to IS 383 – 1970 is to be carried out for both fine and coarse aggregates. The concrete mix proportions of M_{20} (1:1.81:3.85) with the water cement ratio of 0.55 is to be used. The concrete mix design is proposed to achieve the compressive strength of 20MPa after 28 days curing, in case of cubes. The flexural strength and the split tensile strength of the specimens are also tested. The concrete cubes (150mmx150mmx150mm) and Concrete Cylinders (150mmx300mm) for conventional as well as other mixes are to be casted. Each layer is compacted with 25 blows using 16mm diameter rod.

EXPERIMENTAL SETUP

This experimental program consists of casting and testing of 3 cubes, 6 cylinders and 2 Reinforced Concrete beam. The optimum percentage of each waste material has been chosen from the literatures. The designations for each specimen have been given as

- Conventional concrete
- Concrete + Polypropylene fibers (1%)
- Concrete + Polypropylene fibers (2%)
- Concrete + Colour Adsorbed Fly Ash (30%)
- Concrete + Colour Adsorbed Fly Ash (30%) + Polypropylene fibers (1%)
- Concrete + Colour Adsorbed Fly Ash (30%) + Polypropylene fibers (2%)
- Concrete + Rice husk ash (20%)
- Concrete + Rice husk ash (20%) + Polypropylene fibers (1%)
- Concrete + Rice husk ash (20%) + Polypropylene fibers (2%)
- Concrete + Steel slag (30%)
- Concrete + Steel slag (30%) + Polypropylene fibers (1%)
- Concrete + Steel slag (30%) + Polypropylene fibers (2%)

Specimens Casting

All the cube and steel specimens are to be casted in steel moulds. To avoid balling effect of fibers, the following procedure is to be followed in casting. First, aggregates and cement are put and allowed to mix for one minute and water is added within two minutes. Then, fibers are uniformly dispersed throughout the mass with slow increment. Finally, concrete is allowed to mix for three minutes in the concrete mixer.

All the specimens is well compacted by using steel rods. For compaction, each layer is vibrated by means of a suitable vibrator until the specified condition is obtained. After the top layer has been compacted the surface of the concrete is brought to the finished level with the top of the mould, using a trowel. The process is carried out considering IS 10080 – 1982. The specimens are remoulded after one day and then placed in a curing tank for 28 days of curing. The curing process is carried out considering IS 516 – 1959.

EXPERIMENTAL PROCEDURE FOR TESTING THE PROPERTIES OF THE CONCRETE

The procedure is executed considering IS 516 – 1959. The concrete cube specimens are placed over the Compression Testing Machine and the load is gradually applied till the failure of the specimen. The ultimate load is noted down as collapse load and compressive strength is to be calculated. Thus, the specimens have to be tested and the optimum replacement of polypropylene fiber has to be determined.

Determination of Compressive Strength of the Concrete

The compressive strength tests were carried out on 150mm x 150mm x 150 mm cubes as specified by IS 516-1959 (1989). This test was carried out by using the AIMIL compression testing machine of 2000 kN capacity at a uniform stress of 149 kg/cm^2/minute after the specimen had been centered in the testing machine. The ultimate load (P) was noted down. The compressive strength was calculated by using the relationship

$$\text{Compressive strength} = \left(\frac{P}{A}\right) \text{Mpa}$$

Where P is ultimate load (load of failure) in Newton

A is area of cube in mm^2.

Determination of Tensile Strength of the Concrete

The tensile strength tests were carried out on the concrete specimen of size 150 mm in diameter and 300 mm in length conforming to the specifications IS 5816-1970 (1985). This test was carried out by using the AIMIL compression testing machine of 2000 kN capacity by placing the cylindrical specimen horizontally between the loading surfaces of a compression testing machine and the load was applied until the failure of the cylinder, along the vertical diameter. The splitting tensile strength of the specimen was estimated by using the relationship

$$f_t = \left(\frac{2P}{\pi DL}\right)$$

where f_t is Splitting tensile strength of concrete in M Pa

P is load applied in kN

D is diameter of cylinder in mm

L is length of cylinder in mm.

RESULTS AND DISCUSSIONS

Figure 2, 3 and 4 shows the results of compressive strength results of cubes and cylinders and split tensile strength of the concrete. From the test results, it was known that with addition of 2% Polypropylene fiber with conventional concrete provides the best results in Split tensile strength of concrete. With the replacement of cement partiality with CAF and addition 2% Polypropylene fiber provides strength value of 34.26 MPa and 4.1 MPa in compressive and split tensile strength. They provide an optimum replacement and gives strength more than the target mean strength and the conventional concrete. With the partial replacement of coarse aggregate with Steel Slag and addition of

2% Polypropylene fiber provides best optimum results with 33.68 MPa and 3.44 MPa in compression and tension respectively. With partial replacement of cement by RHA and addition of 2% Polypropylene fiber provides optimum results with 29.96 MPa compressive strength and 4.58 MPa in Split Tensile Strength tests.

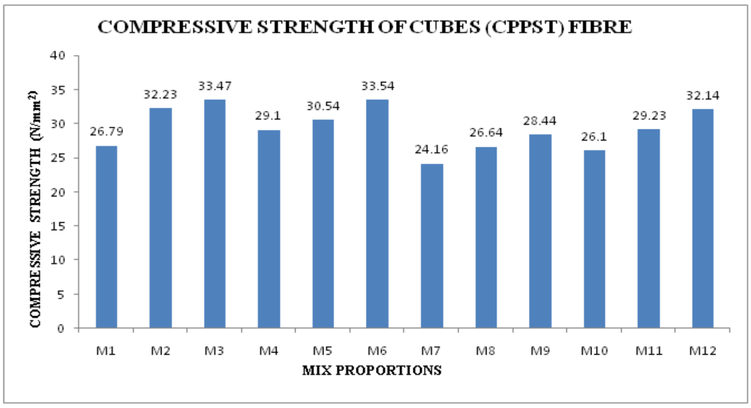

Figure 2: Compressive Strength of Cubes CPPST Fiber

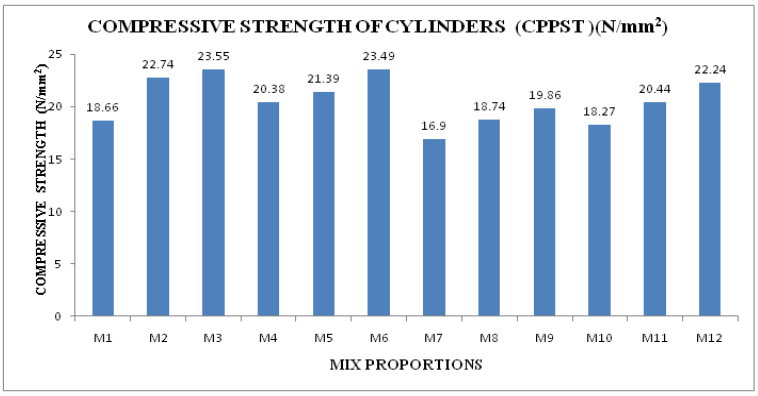

Figure 3: Compressive Strength of Cubes CPPST Fiber

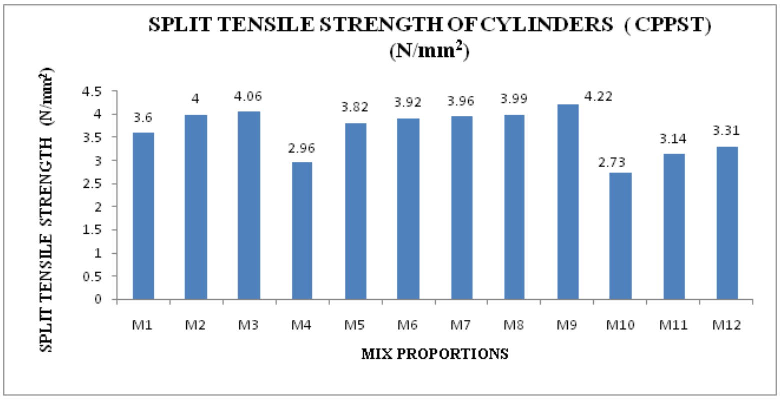

Figure 4: Split Tensile Strength of Cylinders CPPST Fiber

CONCLUSIONS

The paper concludes the following vivid results:

- The experiment deduces the 2% addition of CPP40 Polypropylene Fiber is the optimum addition percentage in concrete by volume.

- With the waste material optimum replacement in concrete and 2% addition of CPP40 Polypropylene Fiber provides better results than the conventional concrete and is economical.
- The environmental problem of slag and fly ash disposal finds a fruitful solution and an Eco friendly remedy is obtained

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