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Study of Mechanical Properties of Polymer Concrete by Manufactured Sand and Orthophthalic Polyester Resins

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Abstract – Recently, a number of researches have involved improving the concrete technology requirements through advanced research. These studies involved high strength concrete HSC, were highly dependent on the quality of ingredient– materials. HSC production potentially involves several trial mixes and uses high quantities of fine materials thus making it very costly and time consuming. The objectives of this study were to reduce the production cost, time required and to improve HSC properties by providing control mixes and using Orthophthalic polyester resin. This was done by experimentally investigating the HSC production using 100% replacement of cement and water by Orthophthalic polyester resin and selecting the optimum replacement content. All concrete mixes were homogeneous in fresh concrete state, did not show any sign of segregation. Orthophthalic polyester resin additions further improved the workability. At the age 7 days, all concrete mixes achieved the cube compressive strength between 60 to 70MPa. Tensile and flexural strength were increased using Orthophthalic polyester resin using Orthophthalic polyester resin. Higher strength concrete showed low ductility because the ultimate strain was found less than 0.35%, there was In General 10% Orthophthalic polyester resin content was found the optimum.

Keyword: Orthophthalic polyester resin, optimum, compressive strength and flexural strength, Split tensile strength.

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I. INTRODUCTION

This paper presents the effect of different polymers on structural and mechanical properties of concrete. The aim of this study is to investigate the mechanical and Flexural properties of polymer modified concrete. Thermosetting polymers are used at different dosages to modify the concrete matrix. Besides, a series of tests without modification was also carried out. By means of four point loading method, the flexural strength and flexural properties of polymer modified concrete are measured. The influence of different polymers and its optimum dosage in respect of flow and strength characteristics are found. A comparative study has been carried out to highlight the effect of two different polymers on fresh and hardened properties of polymer modified concrete. Based on these results, recommendations are made in respect of its dosage, chemical characteristics and suitability.

For the past few decades, active research has taken place in polymer modified concrete, polymer concrete and polymer impregnated concrete. Currently the same is used as popular construction materials because of comparative high performance, multi functionality and sustainability compared to conventional cement concrete. Concrete polymer composites are environment conscious and confirm to concerns of saving of natural resources, the longevity of infrastructures and the environmental protection. Adding aqueous polymer emulsions or dispersible polymer powders in the fresh concrete mix makes polymer modification of concrete. The polymer emulsion is stabilized by surfactants, and each polymer has its own film forming properties within the applicable temperature range and the physico-chemical conditions during hardening and curing. The surfactants and the low film forming ability of most Emulsions are generally hindering the building of highly performing and durable microstructures in PCC.

The process allows building up of composite polymer cement microstructures on a nano- scale, which can avoid the negative influences of the polymer admixtures cement interactions on the shape and distribution of the cement hydrate crystals, and on the transition zones between cementitious binder matrix and aggregates. This modified cement concrete contains two types of binder: the system based on hydraulic cement and the polymer system. An interpenetrating network of polymer and cement hydrates is generated in which the aggregates are embedded. Polymer modification is a frequently used technique to overcome some of the shortcomings of conventional concretes such as poor tensile and impact strength limited resistance to corrosion, poor behavior under severe conditions and poor adhesion of fresh mortar or concrete to old concrete. Some polymers are soluble in water and their low solubility causes difficulties in respect to the application concrete modifier. For water soluble polymers, one of the major advantages is the absence of surfactants to keep the polymers in solution. The polymer molecules are supplied on a molecular scale, improving the approach of the relative large cement grains (up till 80 µm) by the polymers. In the absence of surface active agents, the film formation on the hydrate crystals may proceed more easily and uniformly and the material properties can be better tuned and modeled.

There are various classes of water-soluble polymers that can be used for the modification of cement mortars and concrete. The first class consists of non-ionic polymers with an oxygen or nitrogen in the backbone of the polymer. Examples are polyethylene oxide (PEO) and polyethylene imine (PEI). These polymers can be synthesized with molecular weights up to the millions. Secondly, there are water soluble non-ionic polymers containing an acrylic group, e.g. polyacrylic acid (PAA) and polyacrylamide (PAAm). The water-soluble polymer polyvinyl alcohol (PVA), frequently used for the modification of concrete, belongs to the class of the water-soluble non-ionic polymers containing a vinyl group. The workability of the fresh mixture is markedly improved over that of ordinary concrete, because of plasticizing and air-entraining effects of the polymers. The modified systems show higher water retention than the ordinary systems. This may contribute to an improvement in the workability and the prevention of dry-out, and it also leads to superior adhesion to porous substrates such as ceramic tiles, mortars and concrete. In such cases, this type of polymers hardly contributes to an improvement in the strength of the modified system.

As a part of this study, a detailed literature survey is conducted and it reveals that, byvarying the nature and concentration of polymer materials, concrete property can be varied across a wide range that makes polymer modified concrete versatile in its applications. Then the results of the primary tests conducted in the laboratory reported that the use of PMC is rich in Specific applications. However, with the increasing demand being made on concrete technology to serve the needs of society, experts are responding positively by proposing new formulations using other materials.

Hence it is understood that, incorporating polymer materials into the concrete has, to some extent, contributed to this demand.

In this paper presents a comparative performance of two different polymers on conventional concrete. The selected polymers are from two different groups. The modification is brought by adding different dosages of polymers (by cement) to the conventional concrete. The behavior of concrete is studied with respect to its mechanical and structural properties by varying the two polymer dosages. The optimum dosage of the individual polymer is found from the experimental details. Finally recommendations are made based on the experimental investigations.

II. LITERATURE REVIEW

Polymers with different kinds of fillers are used as construction materials. They have good binding properties and good adhesion with aggregates. They have long-chain structure, which helps in developing long-range network structure of bonding. In contrast, cement materials provide short-range structure of bonding. As a result, polymer materials usually provide superior compressive, tensile and flexural strength to the concrete compared to Portland cement. Some polymer materials may provide good adhesion to other materials as well as resistance to physical damage (abrasion, erosion, and impact) and chemical attack. The choice of polymer mainly depends on the application.

Conventional concrete materials combined with polymers could yield composites with excellent mechanical and physical properties. Polymer materials with wide variations in properties could provide complex properties to polymer-modified concretes, and thus, present an opportunity to design structural materials with tailored properties.

Mandel and Said (Mandel, 1990)[1], conducted research on the effect of an acrylic polymer on the mechanical properties of mortar and found that the mechanical properties of mortar and the adhesion between mortar and a steel fiber improved with the addition of an acrylic polymer into the system.

Kim et al. (Kim, 1995)[2], studied the properties of polyvinyl alcohol (PVA) modified mortar and concrete with up to 2% polymer by weight based on cement and compared the structure and properties of polymer-modified concrete with those without polyvinyl alcohol. The interfacial transition zone and fractured surface were examined with both polarizing optical microscopy and scanning electron microscopy. They concluded that poly vinyl alcohol modified

Mortar showed slower absorption of water as compared to the unmodified mortar, which was an indication of lower permeability of the polymer modified mortar.

Muthukumar and Mohan (Muthukumar, 2005)[4], studied the mechanical properties and chemical resistance of Furan-based polymer concretes and concluded that they were cost- effective materials for construction in civil engineering applications.

Aggarwal et al. (Aggarwal, 2007)[3], studied the properties of polymer-modified mortars using epoxy and acrylic emulsion, and found that these materials had superior strength properties and better resistance to the penetration of chloride ions and carbon dioxide than PMCs based on vinyl acetate, copolymers of vinyl acetate–ethylene, styrene– butadiene, styrene–acrylic, and acrylic-styrene-butadiene rubber emulsions.

Ohama et al. (Ohama, 1994)[6], investigated the effect of the monomer ratio on the typical properties of polymer-modified mortars with styrene-butyl acrylate latexes. They found that the properties (pore-size distribution, flexural and compressive strengths, water absorption, and drying shrinkage) were affected largely by both monomer ratio and polymer-cement ratio.

Hence in this study an attempt is made to compare the effect of different polymer dosages on mechanical and structural properties of concrete in fresh and hardened state. Based on the experimental results,the optimum dosages are also reported.

III. TESTS

1. Compression Test

The compressive strength was obtained on cubes of 150 x 150mm x 150 mm size according to IS: 516-1959. Specimens were demolded 1 day after casting and then cured in open air until testing was carried out at 1, 3 and 7 days' age. Three specimens of each mixture were tested and the mean value was reported.

2. Flexure Test

The flexural strength was determined at 7 days on beams of size 150 x 150 x 700 mm are cured in air until the date of test according the IS:516-1959. Three specimens of each mixture were tested and the mean value was reported. The performance of the polymer concrete increases as the polymer dosage increase from 8% to 12%

3. Split Tensile Test

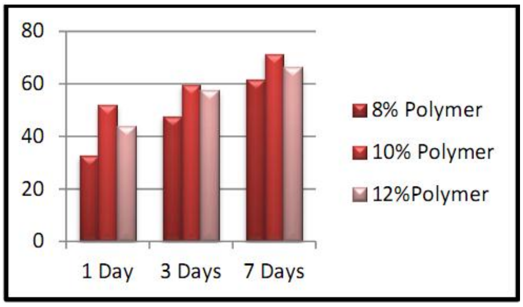
The splitting tensile strength of polymer concrete is determined at 1 ,3 and 7 days on cylinders measuring 150-mm diameter and 300-mm height, these are cured in air until the date of test according the IS: 5816-1999. Three specimens of each mixture were tested and the Mean value was reported. The results shown the similar trend as that of above, tending increase in tensile strength values as the polymer dosage increases later it slows down.

IV. RESULTS AND DISCUSSION.

1. COMPFRESSION TEST

Table No 4.1 – Compression Test

Age in Days	Compressive Strength in (N/mm^2)		
	8% Polymer	10% Polymer	12% Polymer
1	32.45	51.85	43.75
3	47.52	59.32	57.41
7	61.47	71.16	66.34



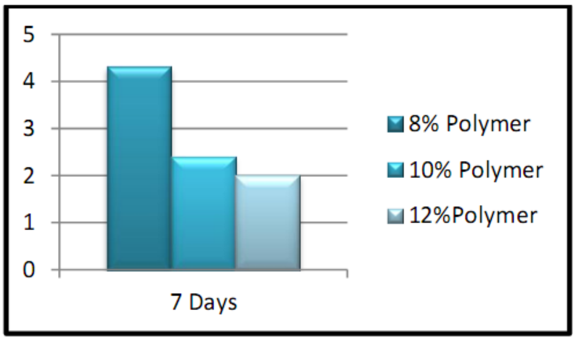
Compressive strength of conventional concrete in 28 days is achieved in 1day by polymer concrete.

Strength of polymer concrete is doubled in 7 days.

2. FLEXURAL STRENGTH

Table No 4.2 – Flexural Strength

Age in Days	Flexural Strength in (N/mm^2)		
	8% Polymer	10% Polymer	12% Polymer
7 Days	4.25	6.75	5.49

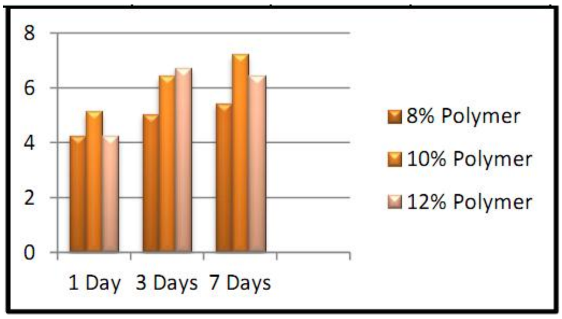


Flexure strength of conventional concrete in 28 days is achieved in 1day by polymer concrete.

3. SPLIT TENSILE STRENGTH

Table No 4.3 – Split Tensile Strength

Age in Days	Split Tensile Strength (N/mm^2)		
	8% Polymer	10% Polymer	12% Polymer
1	4.25	5.12	4.25
3	5.04	6.41	6.72
7	5.42	7.21	6.41



Split tensile strength of conventional concrete in 28 days is achieved in 1day by polymer concrete.

CONCLUSIONS

- From the results it is evident that the performance and structural characteristics of polymer concrete is superior to conventional concrete. It is observed that not only in hardened state but also in its fresh state. Compressive strength results envisage that the modification at optimum dosages is well advantageous and attaining superior results in early age. A dosage of 10% polymer is observed to be the optimum dosage to achieve complete polymerization and subsequent improvement in performance.
- Apparent density of Orthophthalic-based polymer concrete was about 2250 kg/m^3.
- The fully-developed compressive strength of Orthophthalic-based polymer concrete was

About 50 MPa and 60 MPa, respectively, when sufficient crosslinking of polymer binder had been formed.

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