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Study on Effect of Polymer on Fibre Reinforced Repair Concrete

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Abstract

The R.C.C structures are subjected to various durability problems such as spalling, erosion, wear, cracking, corrosion etc. years after its construction. In the case of hydraulic structures, the mains causes of degradation are due to abrasive processes and cavitation damages. The hydraulic structures mostly affected by abrasive processes are surfaces of spillways, stilling basins, walls of upstream reservoir and hydraulic tunnels. The major characteristics a hydraulic repair material should possess is abrasion resistance, low permeability and high bond strength. This paper aims to determine the best suitable polymer and its optimum dosage for repair of hydraulic structures. The polymers used for the study are Acrylic polymer and SBR latex. The fibres used were Polypropylene.

Keywords: Acrylic Polymer, SBR latex, Polypropylene fibre, Repair, Spillway

I. INTRODUCTION

The durability of a concrete structure is affected by the physical and chemical effects of where it operates. An adequate repair improves the function and performance of the structure, restores and increases the strength and stiffness, improves the appearance of the concrete surfaces, provides impermeability to water, prevents penetration of aggressive species at the interface of concrete and steel and improves its durability. Maintenance of structures on surfaces of concrete dams should be done by combining the characteristics of coast, feasibility, performance, durability, usage, time of application of materials and compatibility between them.

Abrasion is caused by the impact of elements transported by water in the hydraulic structures of concrete. The main factors affecting abrasion resistance of concrete are environmental conditions, surface finish, curing conditions, dosing of aggregates, mix ratio, use of special elements such as adding fibre and fly ash. No matter how carefully the spillway surface is finished, the waviness creeps in resulting in cavitation pitting.

Maintenance done using normal concrete will not be economically as well as structurally be feasible as the recovery services of hydraulic structures are usually expensive. Repair done using fibre reinforced concrete improves abrasion resistance but does not possess adequate bond strength and permeability characteristics. Previous studies conducted by introducing polymers into fibre reinforced concrete have shown that it enhances the abrasion and permeability characteristics of concrete. When the polymers are added to the concrete, the pores get reduced or sealed by the formation of a cement-polymer matrix.

The concept of polymer modification to concrete was introduced by Cresson. The first patent with present concept of polymer modification was published by Lefebure in 1924. Since then, considerable research and development of polymer modification for concrete have been conducted in various countries. A previous study conducted on SBR latex revealed the optimum usage is 5 percent by weight and the overall porosity and pore size distribution of the composites vary with the SBR content[1]. A study on the effect of polymer on the paste-aggregate interface showed that thin polymer coatings on aggregate have significant effect on the micro-cracking behavior of concrete[2]. A study on the abrasive resistance of concrete micro-reinforced with polypropylene fibres showed that the abrasive resistance is an inverse function of water-cement ratio[3] . Experimental study on the effect of polymer modified cementitous coatings suggested that they can highly reduce the water content of concrete under wet conditions and slow down the chloride penetration in concrete[4]. A study using cellulose fibres for polymer concrete with fly ash as filler revealed that the mechanical strength of polymer concrete with cellulose fibres were less than that without fibres[5]. A study with acrylic polymer concrete with methacrylic acid as additive revealed that the addition of methacrylic acid ensured the working life at low temperature and it also improved the mechanical properties of the acrylic polymer concrete[6]. Experimental study conducted by using recycled coarse aggregate of latex modified concrete showed that the addition of SBR latex improved the overall mechanical properties of concrete[7]. Experimental study conducted by using steel fibres in latex modified concrete showed that the fibre dosage enhanced the early compressive strength of concrete but reduced the 28 day compressive strength. A modified slant shear test was developed to determine the adhesion between concrete layers casted at different times, since the failures obtained from the previous tests were cohesive. The modified slant shear test was developed to enforce only adhesive failure.

II. MATERIALS, SPECIMEN PREPARATIONS AND TEST VARIABLES

A. Material Characterization

Acrylic and SBR latex with density of 1.03kg/l and 1kg/l are used for the study. Locally available fine and coarse aggregates are used for the study. Specific gravity of coarse and fine aggregates are in the range of 2.78 and 2.58 respectively. The aspect ratio of polypropylene fibres used for the study is 300.

B. Mix Design

Mix proportion were selected based on the previous studies conducted on polymer modified fibre reinforced concrete[] and the recommendations from the polymer manufacturer. Like the conventional concrete mix design, aggregates composed 75-80 percent of the total mass. M 30 mix was adopted for the entire experimental work. Polypropylene dosage was selected based on the test results conducted with various fibre dosages (0.5% , 1%, 1.5% and 2%). Polypropylene dosage of 1 percent by volume of cement was kept as the fibre dosage throughout the experiment since it yielded better results. Both Acrylic and SBR latex were added at 5%, 10% and 15% dosages. The effect of polymers on fibre reinforced concrete however depends on the monomer ratio of the polymers. On increasing the dosage of polymer, there was an increase in the workability in concrete. The mix proportion details are given in table I.

Table - 1
Mix design of Polymer modified fibre reinforced concrete

Designation	*Cement (kg)*	*Fine aggregate (kg)*	*Coarse aggregate (kg)*	*Water*	*Polypropylene fibre(kg)*	*Polymer (kg)*
ACP 1 & SB 1	*438.78*	*692.957*	*1221.15*	*157.6*	*1.306*	*21.939*
ACP 2 & SB 2	*438.78*	*692.957*	*1221.15*	*157.6*	*1.306*	*43.878*
ACP 3 & SB 3	*438.78*	*692.957*	*1221.15*	*157.6*	*1.306*	*65.817*

C. Specimen Preparation

The specimens for compressive strength, flexure and split tensile strength were casted at various polymer dosages and were cured for 28 days. The parent concrete for Slant shear strength and Cylinder splitting specimens (bond strength) were casted with M 30 concrete. The overlay concrete was casted over the parent concrete after 28 days of curing of the parent concrete. The slant shear test was done in accordance to ASTM standards C882/C882M-13a. The size of the slant shear specimens were 100 mm × 100mm × 300 mm. The sizes of the cylinder splitting specimens were 150 mm × 300 mm. The specimens for abrasion test were casted with a size of 68 mm × 68 mm × 30mm. The specimens used for permeability test were of size 100 mm × 100 mm × 100 mm.

III. TEST RESULTS AND DISCUSSIONS

A. Compressive Strength

With the increase of polymer dosages, there was a slight increase in the compressive strength of SBR modified fibre reinforced concrete while there was a slight decrease in the Acrylic modified fibre reinforced concrete. The main factors which affect the strength are water-cement ratio, nature of materials, testing and curing methods. All the mechanical properties are compared with controlled mix properties (MC2- 1% Polypropylene fibre dosage)

B. Flexural Strength

The flexural strength increased for SBR modified fibre reinforced concrete while there was a decrease in the Acrylic modified fibre reinforced concrete.

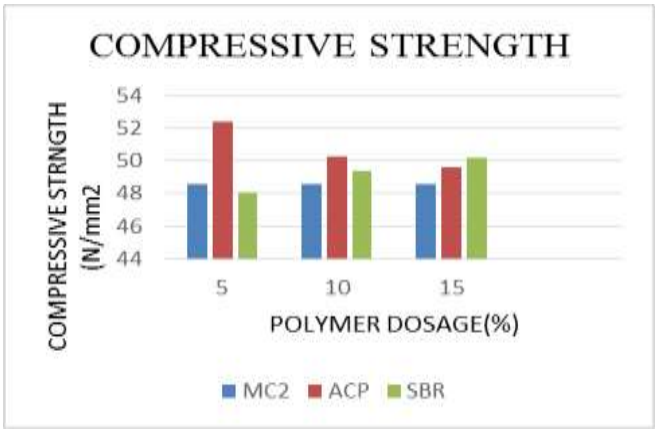

Fig. 1: Compressive strength

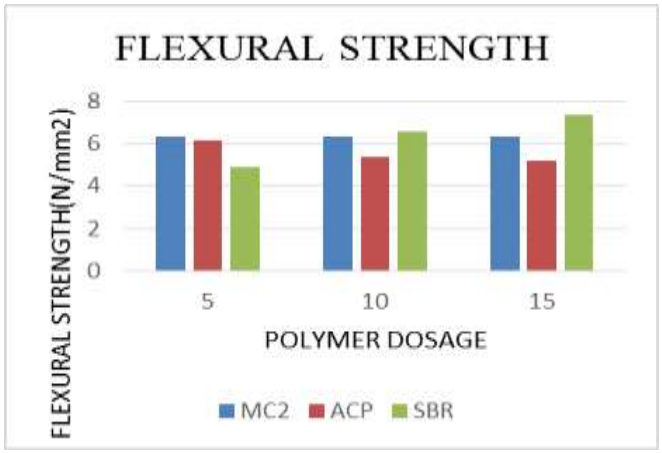

Fig. 2: Flexural strength

C. Split Tensile Strength

SBR modified fibre reinforced concrete showed higher strength at 15 % polymer dosage whereas a decline in strength was observed for the respective Acrylic polymer dosage.

D. Bond Strength

The bond strength was higher for 10% polymer dosages of both SBR and Acrylic polymers. The bond strength is affected by the effect of compressive stresses and combined shear and their relaxation by the polymer films formed on the bonding joints. The cylinder splitting strength showed that with an increase in polymer content, there is an increase in the bond strength of concrete.

E. Abrasion

The abrasion resistance depends upon the type of polymers, polymer-cement ratio, abrasion and wear conditions. The abrasion resistance improved by 30% for Acrylic polymer dosage and 25% for SBR polymer dosage.

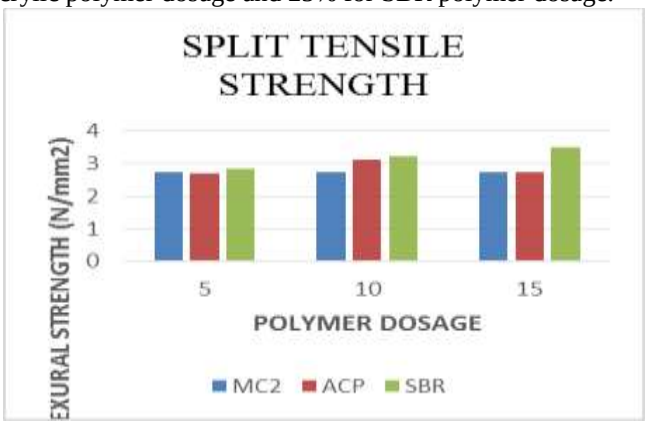

Fig. 3: Split tensile strength

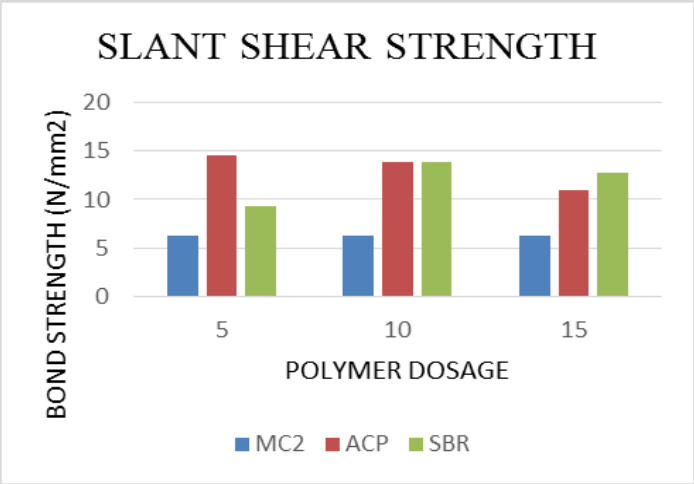

Fig. 4: Slant shear strength

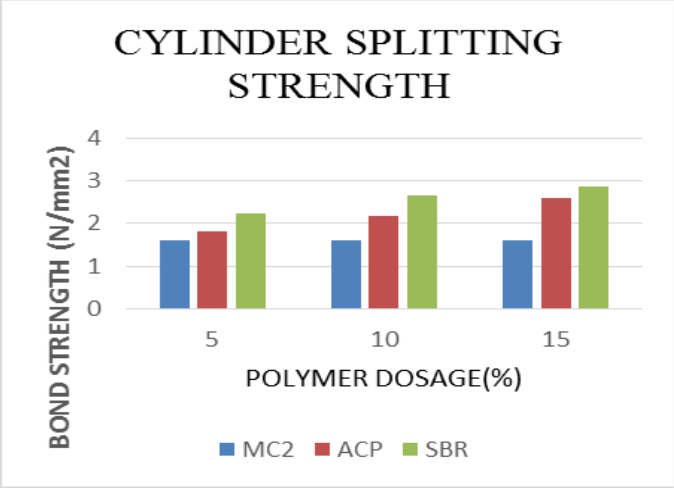

Fig. 5: Cylinder splitting strength

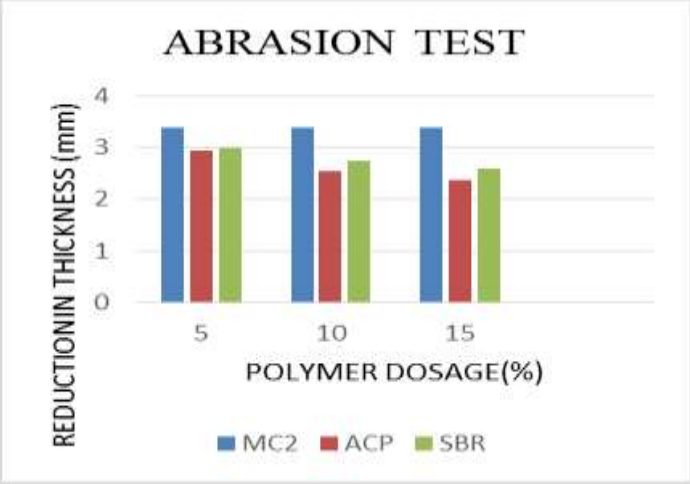

Fig. 6: Abrasion strength

F. Permeability

Polymer modified fibre reinforced concrete have a structure where the larger pores can be filled with polymers or sealed with continuous polymer films. The effect of filling or sealing increases with increase in polymer-cement ratio. Acrylic modified fibre reinforced concrete showed a decrease in 60% permeability whereas SBR modified fibre reinforced concrete showed a 58.6 % decrease in permeability at 15% polymer dosage.

IV. CONCLUSION

The repair works of hydraulic structures are extremely expensive and the material used for the repair work should be structurally and economically feasible. The polymer modified concrete should not only provide resistance to abrasion and permeability but it should also posses adequate bond strength. The addition of polymers improves the structure of the concrete by filling up the pores and forms a polymer-cement matrix throughout. Even though, large varieties of polymers are available in the market, polymers with maximum immersion ratio improves the mechanical , bond strength, abrasion and permeability properties of concrete. Based on the experiments conducted, the following conclusions were drawn.

1) There is an inverse relation between Polymer-cement ratio and water-cement ratio.
2) The addition of polymers improves the workability and mechanical properties of concrete.
3) The bond strength depends upon the polymer content in the concrete. Optimum Polymer content for bond strength was found to be at 10%.
4) Abrasion resistance increases with increase in polymer dosage. The addition of Polypropylene fibres also aids in improving the abrasion resistance.
5) Polymer addition improves the microstructure of concrete by filling up the pores and thereby reduces the permeability of concrete.
6) Optimum dosage of Acrylic polymer is 5% and SBR latex is 10% for M30 fibre reinforced concrete which is economically and structurally feasible for repair work of spillways.

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