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# Polymers: The Futuristic Materials of the Cement Concrete Industry

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## ABSTRACT

*Cement concrete is less effective in direct tension and flexural strength than compression. So there are minor and major crack due to tensile load, temperature variation and shrinkage etc. Due to presence of voids and micro cracks it is easily affected by chemical attack, and permits water inside and the reinforcement in RCC corrode. Minor cracks have always been problem for the life of cement concrete.Due to cracks and weaken by chemicals the life of concrete is very long.Various types of polymers when added to cement concrete, the engineering properties of cement mortar, concrete enhanced and it becomes more durable with more load bearing capacity. This review paper analyses a comparative study for polymers additives to cement mortarand concrete with respect to enhancement of engineering properties.And investigate the present scenario in the cement mortar industry, and analyses the different options available with the use of polymers.*

***KEY WORDS**: Epoxy resin, acrylic resin, flexural strength*

## INTRODUCTION

Polymers are playing key role in manufacturing the variety of cement and concrete containing desirable specific properties. Now new cement can have such property which can repair its cracks itself, concrete can resist high temperature, retrofitting and repair can be done by more durable polymer cement mortar. The introduction of polymer concrete has changed the many concept of traditional concrete. The new polymer concrete can have more flexural strength, more impact resistant, moreenvironments friendly, more weather resistant. Especially when some cement concrete structures subjected to sever climatic conditions of high or low temperatures, salty or acidic water, high impact loading, then special repairing materials mortars are required.Cement is brittle material and Shrinkage cracks are common problem in it. Due to minor and major cracks the water permeability increases, which deteriorate the bonds between aggregates and corrosion of RCC steel starts. So many researches are going on to improve the flexural, tensile durabilityand compressive strength of cement concrete and mortar. Adding small quantity of polymers give desired enhanced properties in cement mortars and concretes.Some polymers are very helpful in this regard. Polymers may be used in emulsion form, powder form. Some of the literatures have been studied and discussed here to understand the current situation in this regard.

**1. Self Healing Effect of Polymers in Polymer Concrete.** Researcher found that when epoxy resin used with concrete , it has self repairing capacity due to delayed hardening. In Carbonation, the $Ca(OH)_2$

present in the hardened concrete reacts in presence of $CO_2$ and moisture produces $CaCO_3$ .the volume of produced product are more than the initial $Ca(OH)_2$.hence fill the cracks. When epoxy resin is used without hardener. The degree of self repair is found up to 30% (1).

**2 ( i ) Study of different Polymers in Cement Concrete with Aggressive Thermal and Acidic Exposure.** Concrete and cement mortar (repair material) may deteriorate due to many reasons such as loads, temperature variation,moisture, chemical attack etc. Plain cement mortar do not have capacity to bear it for long-time. Polymer concrete can be the solution of these problems. Polymer concrete may have good adhesion and low shrinkage. Polymers can be added in cement concrete mix (polymer modified mortar or concrete) or polymers can be directly mixed with aggregate without cement also (polymer concrete). The choice of polymers depends upon the requirement of the function to be performed. Mortar or repair material not always subjected to room temperature. There may be high rise in temperature or very high temperature continuously, like in chimney, thermal power plants etc. In this experimental research, five different samples have been studied, control mix of plain cement concrete of cement and sand in ratio 1:3, with w/c ratio 0.4, other specimen prepared with polymer and sand (1:5 ratio), Acrylic, SBR, Epoxy emulsion, Epoxy resin. Special investigation done for aggressive environment, effect of thermal cycles, influence of high temperature, effect of acidic exposure have been studied. In thermal cycles samples are kept at high temperature of 85° for 8 hours a day then cooled at room temperature. Such 30, 60, 90, 120 cycles are applied. Then samples are tested for the strength. And sample are tested for acidic exposure, in which samples are kept in acid solution (of 5% sulphuric acid) for 180 days, and found that polymer concrete has best resistance to the acidic exposure and thermal cycles, but poor resistance for high temperate .Change in compressive strength is least in epoxy resin against acidic exposure, and epoxy emulsion shows best results against higher temperature. Epoxy resin showing best resistance against thermal cycles (2).

**2. ( ii ) Study of different Polymers in Cement Concrete with Aggressive Thermal and Acidic Exposure.** Cement concrete and mortar always face the chemical attacks, cement concrete contains voids and micro cracks. Through the voids and cracks the chemicals easily enters inside and weaken the structure so the life of the structure reduced. In this experimental research work, Four types of mixes prepared with fillers: fly ash, and three types of silica powder (fine medium and coarse). The specimen selected on the basis of highest density and lowest water permeability. Specimen size 5x5x5 cm are prepared and kept in the aggressive medium (acidic and alkali) for seven days and dried for seven days. Specimens are weight before and after immersion. Then characterization is done on the basis of colour change of moulds, surface appearance, and Colour change of medium. Test was performed for, 7, 14, 28, 56, days of immersion cycles, alkali medium taken NaOH (15%, 30%, 60%), and acidic medium were citric acid, sulphuric acid, hydrochloric acid, acetic acid. The compressive strength and weight loss is measured after chemical exposure. It was found that epoxy 15% and silica 200 % was the best composition. The loss of compressive strength is more when expose to acetic acid. Four polymers are tested here; these polymers are Acrylic Ester, Styrene Acrylic Ester polymer, Styrene Butadiene polymer, and vinyl co-polymer. Styrene butadiene polymer posses lowest resistance and styrene acrylic ester polymer shown the highest resistance against aggressive exposure (3).

**3. Comparative Study of Acrylic Emulsion and Epoxy Emulsion on Properties of Polymer Concrete.** This study present the comparative study of two types of polymer admixtures of cement concrete, epoxy and acrylic emulsions and found that epoxy emulsion is found better than acrylic. Here it is found that when polymers are added then initially compressive and flexural strength decreases, but at higher level of percentage the flexural strength are better than control mix. But at the same time by adding polymers the other properties like chloride ion penetration, depth of carbonation, and water absorption decreases. this experiment depict that the durability of polymer concrete is better than conventional cement concrete. All the experimental results can be summarized as under.

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**Summery of Experimental Results**

| | Polymer % | w/c ratio | Comp strength 28 days Mpa | Compr strength 90 days Mpa | Flexural strength Mpa 28 days | Carbonation depth mm | Chloride ion penetration, mm | Water absorption, % |
|---|---|---|---|---|---|---|---|---|
| Control mix | 0 | 0.5 | 40 | 45 | 8 | 11.5 | 11 | 6.5 |
| | | | | | | | | |
| Acrylic mix | 5 | | | | | 9.2 | 10 | |
| | 10 | 0.43 | 30 | 40 | 6 | 8.0 | 8.8 | 5.5 |
| | 15 | | | | 7 | 6,2 | 7.5 | |
| | 20 | 0.4 | 35 | 47 | 7.5 | 4.0 | 6.2 | 3.8 |
| | 25 | | | | | | | |
| | 30 | 0.38 | 40 | 50 | 8 | | | 3.0 |
| | Polymer % | w/c ratio | Comp strength 28 days Mpa | Compr strength 90 days Mpa | Flexural strength Mpa 28 days | Carbonation depth mm | Chloride ion penetration, mm | Water absorption, % |
| Control mix | 0 | 0.5 | 40 | 45 | 8 | 11.5 | 11 | 6.5 |
| | | | | | | | | |
| Epoxy mix | 5 | | | | | 9.0 | 8 | |
| | 10 | 0.48 | 32 | 42 | 6.5 | 6.2 | 6.8 | 5 |
| | 15 | | | | 7.5 | 5.0 | 5.8 | |
| | 20 | 0.45 | 38 | 50 | 8.0 | 3.0 | 4.8 | 3 |
| | 25 | | | | | | | |
| | 30 | 0.42 | 42 | 55 | 9.0 | | | 2.0 |

Following conclusion can be drawn from the summery of the experiments.

1. Water cement ratio required for getting fixed flow value is less in acrylic than epoxy mixed concrete.
2. Compressive strength at 28 days curing, less than the control mix when mix percentage content of acrylic is up to 20% and equal to control mix when acrylic percentage content is 30%. But in case of epoxy the comp strength is slightly more than the control mix at 30 percentage content.
3. But compressive strength after 90 days curing the is more than the control mix for both acrylic and epoxy polymer even at 20% loading.
4. Flexural strength of acrylic mix up to 20% loading is less than the control mix. But equal to control mix at 30% mixing. in case of epoxy polymer flexural strength is equal at 20% loading and more than control mix at 30% loading.
5. Depth of carbonation is less in epoxy than acrylic polymer.
6. From Chloride ion penetration result, it is clear form table that chloride ion penetration is less in epoxy resin than acrylic resin.
7. Water absorption is also less in epoxy resin (4).

**4. Effect of Very High Temperature on Strength of Polymer Concrete.** This paper present the effect of high temperature on polymer concrete when Epoxy resin polymer percentage 5%, 7%,10%, 15% of cement is used. Temperature raised 200°C, 400°C, 700°C for half hour, and one hour exposure, after 28 days of curing. After Temperature exposure cement concrete is tested for compressive strength and split tensile strength. The result shows that when the best temperature resistant result are on 7% resin mixed in cement concrete.( Variation in strength is least on 7%) (5).

**5. Effect of Cement Replacement by Epoxy Resin on Strength of Polymer Concrete.** Polymer modified Portland polymer concrete posses good ductility, compressive strength over conventional concrete. In this paper epoxy polymer is used. For flexural test mould of 150x150x600 mm was prepared, for compressive test mould of 150x150x150 mm is prepared, and split tensile cylindrical of diameter 150 a height 300 mm is prepared. The strength of cement concrete has been examined by replacing the cement 0, 20, 40, 60, 100 percent by epoxy resin. To examine the mix concrete after addition of polymers following test were performed; compressive strength , split tensile strength, four point flexural test, and direct shear test. It has been found that improvement in the strength were as following: compressive strength increased 75%, tensile strength increased 98%, the increment in shear strength was 148%, and the increase in flexural strength was 51%. This experiment showed that suitable polymer can replace cement binder. The fact established that polymer concrete is stronger cement concrete than conventional cement concrete (6).

**6. Effect of addition of FlyAsh on Strength of Polymer Concrete.** In this experimental analysis, cement concrete with different polymers such as Polyester, vinyl-ester, and epoxy resin were prepared with use of Fly Ash. Modulus of elasticity, tensile strength, and compressive strength were examined. It is shown that increasing fly ash the value of flexural and tensile strength decreases. This polymer concrete is very useful in repair of concrete structures beams, columns, slabs etc, resin used as binding materials. Cylinders of 50 mm diameter and 100 mm height were prepared and tested. Fine sand with density 1494 kg/m$^3$, water absorption 8%, and particle size less than 425 µm was taken. Low calcium fly Ash as been used in this experiment. The chemical constituents of used fly ash was

| component | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $Na_2O$ | $K_2O$ | $SO_3$ |
|---|---|---|---|---|---|---|---|---|
| Percentage | 51.8 | 24.4 | 9.62 | 4.37 | 1.5 | o.34 | 1.41 | 0.26 |

Concrete-mix was prepared with sand, resin, and fly ash. Every Mix was coded according to percentage of constituent. In sample named S60R40, means sand is 60% and resin is 40%, in sample S60R30F10, sand 60%, resin 30%, and flyash 10%,and in the third sample the S60R20F20, sand was 60%, resin 20% and fly ash 20%. Again in place of Resin the different type of resin places these were Polyester, Vinyl ester, and Epoxy Resin are the binder here .The catalyst of resin is mixed as per manufacturer's suggestion. Resin and catalyst is mixed separately and sand and fly ash mixed separately and then both mix to get uniform mixture. After cast the curing of sample is done for seven days at room temperature at 24°C. From the experiment it is found that for vinyl ester resin and polyester resin addition up to 10 % fly ash the strength increases then start decreasing. But for epoxy resin the compressive strength increases up to 20% of fly ash content, but flexural strength decreases after 10% of fly ash (7).

## CONCLUSION

This study shows that by adding polymers the properties of mortar can be enhanced of desired nature, and the defects of conventional cement mortar can be reduced. Form above analysis it is clear that polymers can be beneficially added up to 15-20%. By these admixtures the compressive strength can be increased up to a limited amount and flexural and tensile strength can be increased more than compressive strength.These days the more advance nature mortar can be prepared particular aggressive condition. Such as for higher temperature, chemical attack, for very low temperature. Addition of these polymers chloride ion penetration

can be reduce, to increase the life of RCC structure where life of structure is severely affected by corrosion of steel. Permeability of water in cement concrete is also reduced by polymers so the durability of the structure increased, impact resistance, abrasion resistance is also increased. There are so many types of polymers available which are added to cement mortar and concrete.There is tremendous future scope of polymer concrete, in different ways with different polymers.

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