Study on Properties of Polymer Modified Mortars used as Repair Materials

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Abstract

The aim of this thesis work is to study the properties of certain polymers available in the market used for repair works of concrete structures. One SBR and one Acrylic based polymer have been selected for study. These polymers are added to mortar and used as polymer modified mortars (PMMs) for various applications. Compressive strength, flexural strength, bond strength and water permeability of these PMMs were studied. Water cement ratio was kept constant at 50%. Two sand/cement ratios of (1:3 and 1:2) were adopted. Polymer /cement ratios were varied as 5%, 10% and 15%. From the test results it was found that flexural strength and bond strength of Acrylic and SBR modified mortar improved. Water permeability of Acrylic and SBR modified mortar was much lesser than plain mortar. Bond strength with 15% polymer addition was comparable to that of bond strength of an epoxy based polymer bonding agent.

Keywords: Polymer modified mortar(PMM), Styrene Butadiene Rubber(SBR), Acrylic polymer, Slant shear test, Split cylinder test, Epoxy bonding agent

I. INTRODUCTION

Concrete is the material which revolutionized the construction field than any other materials. It is the most commonly used construction material on earth. Man consumes no other material except water in such huge quantities. Concrete has been in use as a building material for more than hundred and seventy years. Its popularity is due to relative economy and availability, mouldability, durability and high compressive strength.

However concrete has got several drawbacks like low tensile strength and brittleness, high thermal shrinkage, low chemical resistance and lesser long term durability. These deficiencies often manifest in the form of cracks, spalling, erosion and wear of concrete. This also lead to exposure of reinforcement to the environment resulting in possible corrosion. All these will lead to progressive deterioration of structure and reduce the durability of structures. Hence repair is necessary to enhance the durability of such structures.

In the past cement mortar was used for any kind of repair and was a universal repair material. But cement mortar is not the right material for repair as it has several drawbacks like high shrinkage, low bond strength, high permeability etc. Polymer modified mortars are now widely being used instead of cement mortar owing to the superior properties of the latter.

Polymer modified mortar is a composite material obtained by adding polymers to cement mortar. A polymer is a large molecule, composed of many repeated subunits called monomers. Examples of polymers are natural rubber latex, styrene butadiene rubber latex, polyacrylic ester latex, neoprene etc. When polymers are added to conventional cement mortar several properties of conventional cement mortar are improved.

II. LITERATURE SURVEY

S Ahmad et al. (2011), [1] proposed a technique consisting of applying locally available polymer modified mortar in cracked beams to increase the load carrying capacity. Total of six full scale RC beams were constructed with the same material using the same mix and w/c ratio. Initially, beams were tested until the development of cracks with width reached a limiting value of 1 mm. The beams were then repaired with the application of polymer modified mortar technique. After 3 days of water curing the beams were tested again and loaded till the failure. An improvement in the load carrying capacity was observed in the beams after the retrofitting.

M.V. Diamanti et al. (2013), [2] studied the permeability of concrete, coated with commercial polymer-modified mortars with two different polymer-to-cement ratios, to water and chlorides as a function of water absorption, chloride penetration rate and coating adhesion properties. Tests were performed on coated concrete specimens as well as on coating layers. The effect of physical barrier to chloride penetration and the ability to decrease water content into concrete were discussed, as well as the influence on the service life of RC structures.

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L.K. Aggarwal et al. (2007), [3] Developed, an epoxy emulsion based polymer and studied properties of the cement mortar modified with this newly developed epoxy emulsion and compared with those of the acrylic- modified mortar. The results showed that the mortars with the newly developed system have superior strength properties and better resistance to the penetration of chloride ions and carbon dioxide.

Joao Feiteira et al. (2013), [4] studied, polymer–cement mortars by subjecting to accelerated alkali reactivity tests and their performance compared to that of an unmodified cement mortar. Expansion of PCMs was overall higher, but SEM observations revealed apparent lower micro cracking intensity of the cement paste, compared to the unmodified CM. Subsequent stiffness damage tests confirmed lower micro cracking intensity in PCMs.

Mahyuddin Ramli et al. (2012), [5] evaluated the oxygen permeability over different stages of aging for three commercial polymer-modified mortars; styrene–butadiene rubber, polyacrylic esters and vinyl acetate–ethylene as well as unmodified conventional mortar exposed to different curing conditions. The results indicated that the presence of polymer latex in the mortars greatly enhanced the pore structure of the paste and resulted in increasing the waterproofness and hence, impermeability of the polymer cements system.

III. EXPERIMENTAL PROGRAMME

A. Materials Used

The cement used was JSW portland slag cement with specific gravity 3.09, standard consistency 32%, and initial setting time 120 minutes. The fine aggregate used was M sand with specific gravity 2.65, fineness modulus 2.99, and falling in grading zone II. The fine aggregate used had specific gravity 2.79. The two polymers used in this study are SBR latex with specific gravity 1.02 and Acrylic polymer with specific gravity 1.03. The water used was tap water. The substrate concrete used in bond test had average 28 day cube compressive strength 44.83 N/mm^2.

B. Casting of Specimens

The cube for testing compressive strength has size 70.7mm. Mortar beams are of size 100×100×500mm was used for testing flexure. Slant shear test and split cylinder test were used for testing bond strength. A 100×100×300mm prism was used for slant shear test and a 150×300mm cylinder for split cylinder test. 100mm cubes was used for permeability test. Three specimens were casted for each mix. Water/cement ratio is kept constant at 50%. Two cement/sand ratios 1:2 and 1:3 were adopted. Three Polymer percentages were adopted. Plain cement mortar is used as control mix. Details of mixes are given in Table I. The substrate concrete use in slant shear test and split cylinder test had a 28 day compressive strength of 44.83N/mm^2. Details of slant shear specimen and split cylinder specimen are given in Fig 1. to Fig 4.

Table - 1
Nomenclature

Mix	*Designation*	*Polymer/cement ratio (%)*	*Water/cement ratio (%)*	*Sand/cement ratio*
Control mix	*CM*	*0*	*50*	*1:2 and 1:3*
Acrylic 5%	*A5*	*5*	*50*	*1:2 and 1:3*
Acrylic 10%	*A10*	*10*	*50*	*1:2 and 1:3*
Acrylic 15%	*A15*	*15*	*50*	*1:2 and 1:3*
SBR 5%	*S5*	*5*	*50*	*1:2 and 1:3*
SBR 10%	*S10*	*10*	*50*	*1:2 and 1:3*
SBR 15%	*S15*	*15*	*50*	*1:2 and 1:3*

Fig. 1: Slant shear test substrate portion

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Fig. 2: Slant shear test full specimen

Fig. 3: Split cylinder test substrate portion

Fig. 4: Split cylinder test full specimen

C. Testing Of Specimens

The 28 day tests on specimens include compressive strength test, flexural strength test, slant shear test, split cylinder test and water permeability test.

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IV. RESULTS AND DISCUSSIONS

Graphical representation of compressive strength for various mixes is given in Fig 5. As the polymer/cement ratio increases there is a slight increase in compressive strength for Acrylic and SBR mortar. At a polymer /cement ratio of 5%, the compressive strength is lesser than control mix. But for 15% addition of SBR polymer, the compressive strength is 5% higher than control mix. SBR polymer is having better strength than Acrylic polymer for all percentage additions.

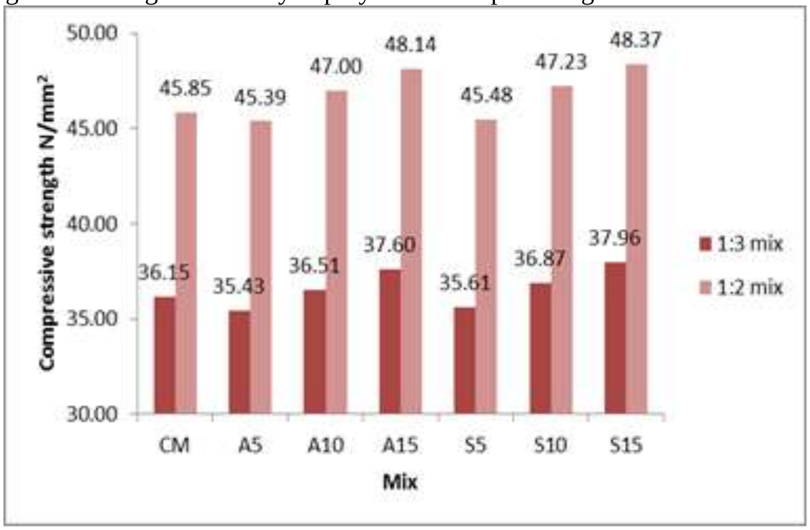

Fig. 5: Compressive strength

Graphical representation of flexural strength for various mixes is given in Fig 6. As the polymer/cement ratio increases the flexural strength goes on increasing. When the polymer/cement ratio is 15% the improvement in flexural strength is 39% compared to control mix, for SBR mortar. SBR polymer has got better strength than Acrylic polymer.

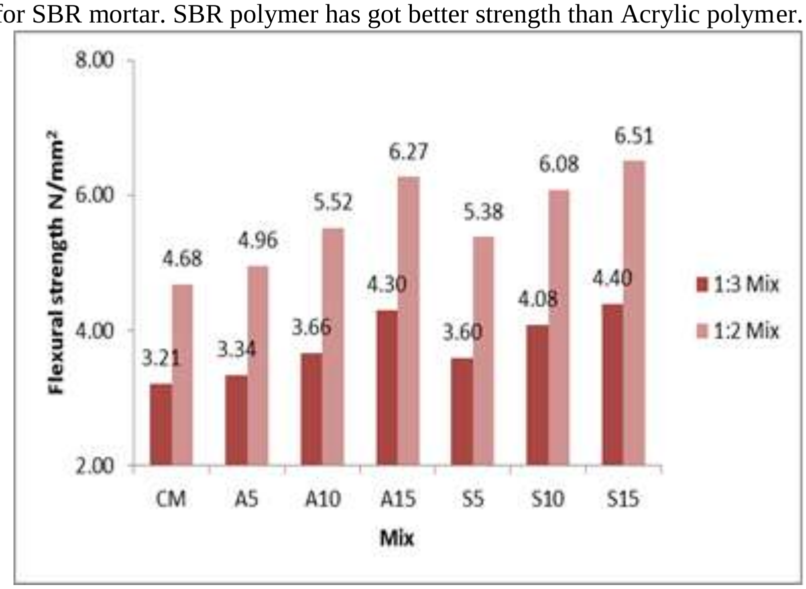

Fig. 6: Flexural strength

Graphical representation of bond strength in slant shear test for various mixes is given in Fig 7. As the polymer/cement ratio increases the bond strength increases rapidly. When the polymer/cement ratio is 15% the bond strength is 49% higher than control mix for SBR mortar. SBR polymer has got better strength than acrylic polymer. Bond strength of control mix and substrate concrete was also tested using an epoxy bonding agent. This value is comparable to that of Acrylic and SBR mortar with 15% polymer addition.

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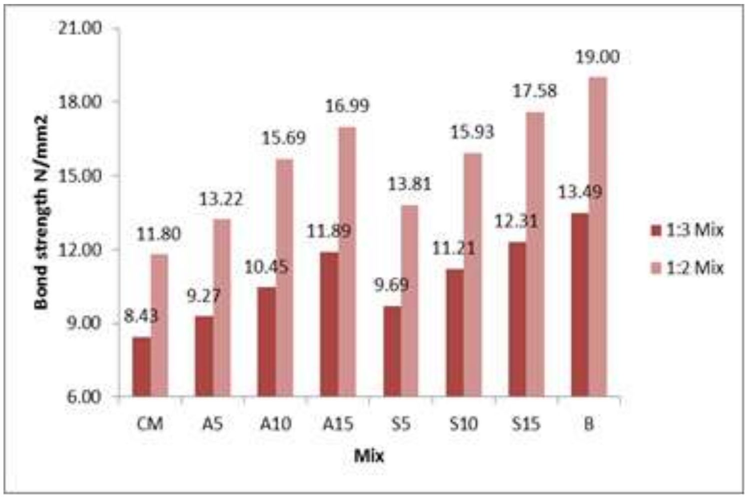

Fig. 7: Bond strength in slant shear test

Graphical representation of bond strength in split cylinder test for various mixes is given in Fig 8. As the polymer/cement ratio increases the bond strength increases rapidly. When the polymer/cement ratio is 15% the bond strength is 43% higher than control mix for SBR mortar. SBR polymer has got better strength than Acrylic polymer. Bond strength of control mix and substrate concrete was also tested using an epoxy bonding agent. This value is comparable to that of Acrylic and SBR mortar with 15% polymer addition.

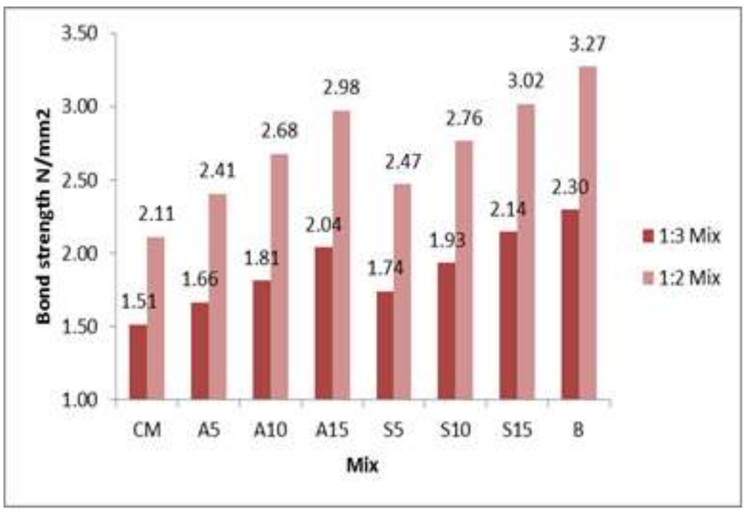

Fig. 8: Bond strength in split cylinder test

Graphical representation of coefficient of permeability values for various mixes is given in Fig 9. Permeability for Acrylic and SBR mortars is much lesser than that of normal mortar. The reason for this can be attributed to the cover formed by polymer films. Lower permeability values indicate that polymer modified mortars have better durability and chemical resistance.

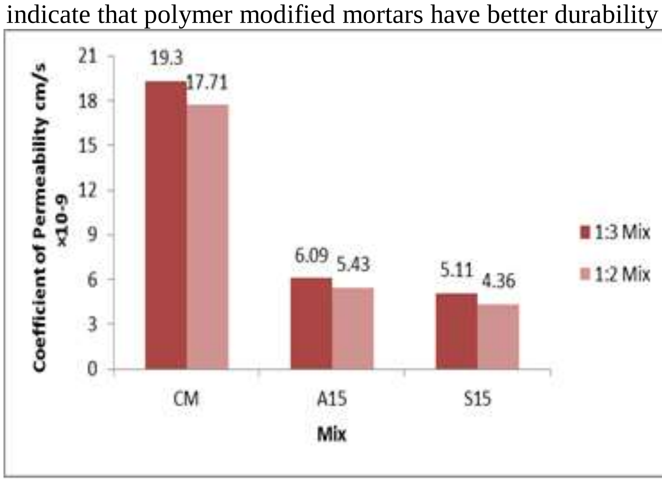

Fig. 9: Coefficient of permeability

V. CONCLUSIONS

SBR polymer has got better properties than Acrylic polymer. Both has got better properties than unmodified cement mortar. The flexural strength and bond strength of Acrylic and SBR mortars are much higher than that of plain cement mortar. Acrylic and SBR mortars are more impermeable than plain cement mortar. Polymer modified mortars are having higher values for flexural strength and bond strength. Bond strength of Acrylic and SBR mortars are comparable to that of an epoxy based bonding agent. Compared to plain cement mortar, Acrylic and SBR mortars showed only a slight increase in compressive strength. Properties of Acrylic and SBR modified mortar improves as polymer percentage increases and cement content increases. When the polymers are added the workability of mortar mix improves. Hence by reducing water/cement ratio properties may be further improved. Because of better flexural strength, bond strength and permeability the selected SBR and Acrylic based polymers are good for repair works.

REFERENCES

[1] S. Ahmad, A. Elahi, S.A. Barbhuiya, Y. Farid, 2012,"Use of polymer modified mortar in controlling cracks in reinforced concrete beams", Construction and Building Materials 27 (2012) 91–96
[2] Cheng Yan, Julian, Ajith Thamboo, Manicka Dhanasekar, 2013, "Flexural and shear bond characteristics of thin layer polymer cement mortared concrete masonry", Construction and Building Materials 46 (2013) 104–113
[3] L.K. Aggarwal, P.C. Thapliyal, S.R. Karade, 2007 "Properties of polymer-modified mortars using epoxy and acrylic emulsions", Construction and Building Materials 21 (2007) 379–383
[4] Joao Feiteira, Maria S. Ribeiro, 2013 "Polymer action on alkali–silica reaction in cement mortar", Cement and Concrete Research 44 (2013) 97–105
[5] Mahyuddin Ramli, Amin Akhavan Tabassi, 2012 "Effects of polymer modification on the permeability of cement mortars under different curing conditions: A correlational study that includes pore distributions, water absorption and compressive strength", Cement & Construction and Building Materials 28 (2012) 561–570
[6] A. Momayez, M.R. Ehsanb, A.A. Ramezanianpour, H. Rajaie, 2005,"Comparison of methods for evaluating bond strength between concrete substrate and repair materials", Cement and Concrete Research 35 (2005) 748–757
[7] Hongyan Ma, Zongjin Li, 2013 "Microstructures and mechanical properties of polymer modified mortars under distinct mechanisms", Construction and Building Materials 47 (2013) 579-587
[8] Shetty M.S, Concrete Technology - Theory and Practice, S. Chand and Company Ltd, New Delhi

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