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Technical Note

APPLICATION OF POLYMER ADMIXTURES TO MODIFY CONCRETE PROPERTIES: EFFECTS OF POLYMER TYPE AND CONTENT

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ABSTRACT

The present work described the influence of polymer admixture (i.e. polymer latexes) contents on the physical/mechanical properties of latex modified concretes (LMCs). At the first step, the optimum water to cement ratio was determined for a LMC concrete according to the results of compressive strength. Afterwards, six latexes were investigated as admixture for LMCs at 10% of latex content. Their physical and mechanical properties including compressive strength, flexural strength, splitting tensile strength and capillary water absorption was evaluated. Finally, two latexes which were better in LMCs general properties (i.e. Acrylic and Co-polymer Acrylic) were incorporated at 5 and 15% of latex contents to concrete. The result have shown that the increase in the amount of latex content decreased the compressive strength, but the other properties including flexural strength and split tensile strength were improved. Also, an improvement in barrier efficiency for water absorption of LMC concrete with increment of latex content was observed.

Keywords: Latex modified concrete (LMC); polymer admixture; Concrete; Mechanical properties.

1. INTRODUCTION

Portland cement based concretes are the most widely used structural materials in the world. They have most advantages such as high stiffness and compressive strength, low cost and ease of fabrication. Nevertheless, they encountered with serious problems including low tensile and flexural strength, low strain capacity, brittleness, permeability and long term

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durability, which need to be improved [1].

Polymeric latexes are widely used to modify physical/mechanical properties of cement based concretes [2, 3]. Latex is an aqueous dispersion of spherical polymer particles which is generally incorporated to cement mixture by a mixture-proportioning method as an admixture. It is compatible with traditional concretes due to its water based nature.

The researches have shown that latexes involve their properties including flexibility, damping ability, chemical resistance and/or barrier effect to the concretes [4-7]. The film formation of latex which is resulted from the coalescence of latex particles when water is consumed by cement hydration and evaporation, it is known as the reason for decreasing in water permeability of latex modified concretes (LMCs) [3]. The durability of concrete is directly related to its permeability. The different gases and chemical substances can penetrate from pores and cracked area and attack the concrete and reinforcement elements. Incorporation of latexes improves the chloride penetration resistance of the concrete and reduces the general ionic permeability [8].

Polymer latexes affect the mechanical properties of concretes by formation of latex films and membranes on the concretes capillary pores [9]. The latexes reducing the concrete water content due to presence of high range supper plasticizing agent in latex constituents, consequently produces a concrete with improved mechanical properties [10].

The latexes have to meet certain requirements to be compatible for use as a cement additive. The latexes characterizations which affect the LMC properties are including particle size and distribution, glass transition temperature (Tg), minimum film formation temperature (MFFT), mechanical stability towards mixing and chemical stability towards active cations produced during hydration process, which have been investigated by researchers [2, 11].

In this Research, six polymeric latexes (acrylic copolymer, polyvinyl acetate and two kind of acrylic and styrene-butadiene-rubber), were used as admixture in concrete mix design. The better latexes in performance for LMCs concrete properties were investigated. The effect of latex content on the mechanical and physical properties of LMCs including (i.e. compressive strength, flexural strength and water absorption) was studied.

2. EXPERIMENTAL

2.1Materials

- *cement*

Ordinary Portland cement type I-425 form Tehran Cement Co. was used in this research.

- *latexes*

The Latexes used in this study and their usual usage in the industries are shown in Table 1.

2.2 Methods

- LMC preparation

The LMC samples were prepared using a traditional laboratory concrete mixer. At the first the mixture prepared with w/c ratio of 0.35 and 0.45.

The mix design of control concrete and LMC's are given in Table 2. After LMC preparation they were left for 2 days in moulds under wet conditions. Then specimens removed from moulds and cured in humidity chamber (at 95±5% relative humidity and 25 °C) for 5 days, and then air cured for 21 days in laboratory conditions was performed.

Table 1: Latex types and their usual usage

No.	Latex code	Latex Type	Usual usage
1	BA	Acrylic: type I	Water based paints
2	CA	Acrylic: type Π	Water based paints
3	CCA	Acrylic copolymer	Water based paints
4	BS	Styrene Butadiene Rubber (SBR): type I	Concrete binding agent
5	CS	Styrene Butadiene Rubber (SBR): type Π	Concrete binding agent
6	FP	Polyvinyl acetate	Water based paints

Table 2: Mix design of LMC's

Concrete Type	Cement (kg/m^3)	Water(kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)	Dry Latex (kg/m^3)
Control	400	- *	1000	680	0
LMC	400	-*	1000	680	-**

*The water content is based on w/c ratio of 0.35 or 0.45.
******The latexes dry (solid) content was evaluated and then they were used at 5%, 10% and 15% weight fraction of cement content.

Characterization

- Compressive strength

The compressive strength was tested in accordance with the ASTM C39 testing procedures. The compressive strength test was measured using a Universal testing machine on cubic specimens with dimensions of 100 mm×100 mm×100 mm.

- Flexural strength

The flexural strength was conducted on specimens with 500mm×100 mm×100mm in dimensions, using the Universal testing machine in accordance with the ASTM C1609 testing procedures.

- Splitting tensile strength

The splitting tensile test was done on cylindrical specimens of 100mm diameter and 150 mm height. The test was performed using an MTS loading frame in accordance with the requirements of ASTM C 496/C 496 M.

3. RESULTS AND DISCUSSION

3.1 Effect of water to cement (W/C) ratio

For determination of best water to cement ratio for LMC samples, the LMC's with one type of latex in w/c ratio of 0.45 and 0.35 was prepared. The LMC's experimented by flexural test and compressive test which results are depicted on Fig. 1. The results exhibited that the mechanical properties of the LMC reduced by increase in the water content. Therefore, the water to cement ratio of 0.5 was selected to study the effect of latex type and its content.

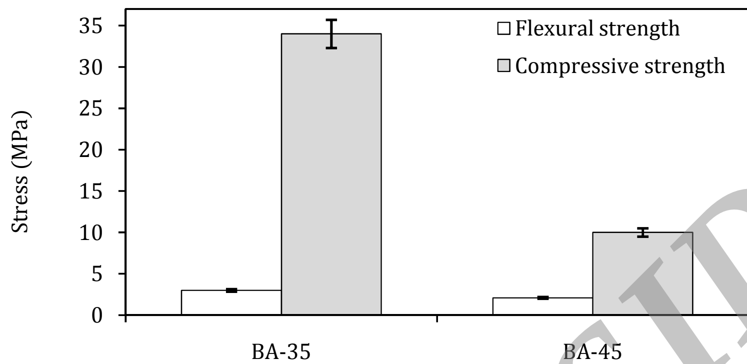

Figure 1. Effect of water to cement ratio on the LMC properties

3.2 Effect of latex type

The effect of different latex types on the mechanical properties of LMC based on the selected water to cement ratio was investigated. To select the best latexes according to the mechanical properties of LMCs, samples with latex to cement ratio of 10% was produced. The compressive test, flexural test and tensile test were conducted on the LMCs and better latexes are determined.

To study the effect of latex content the LMCs with different latex to cement ratio of 5%, 10% and 15% in weight were prepared using selected latexes.

- Compressive strength test

The results of compressive test of LMCs with different type of latex are presented in the Fig. 2. The incorporation of latexes to the mixtures reduced the compressive strength of all samples. According to the results acrylic latex (CA) and copolymer (CCA) have shown the best performance among the studied latex. The SBR-type Π (CA) latex and polyvinyl acetate (FP) latex exhibited the higher reduction in the compressive strength of the LMCs.

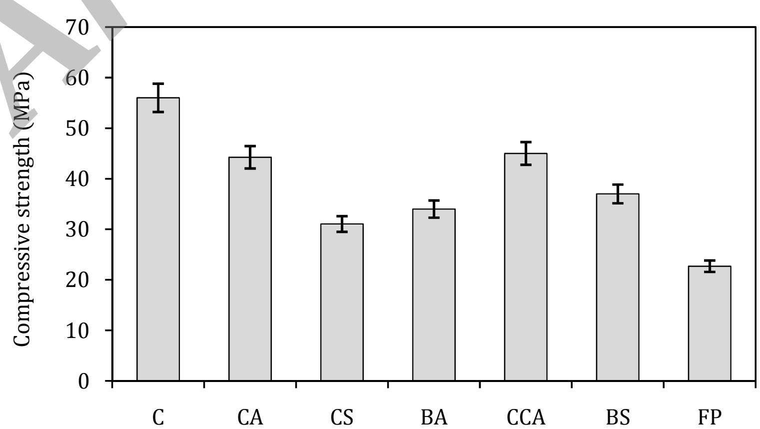

Figure 2. Effect of latex type on compressive strength of LMC

The compressive strength results of the LMCs with different amount of incorporated Acrylic and Co-polymer acrylic at 28 days and 90 days of curing are presented in Fig. 3. The results indicated that the compressive strength of LMCs in slightly lower compared to control specimen, and decreases with increment of latex CA and CCA content.

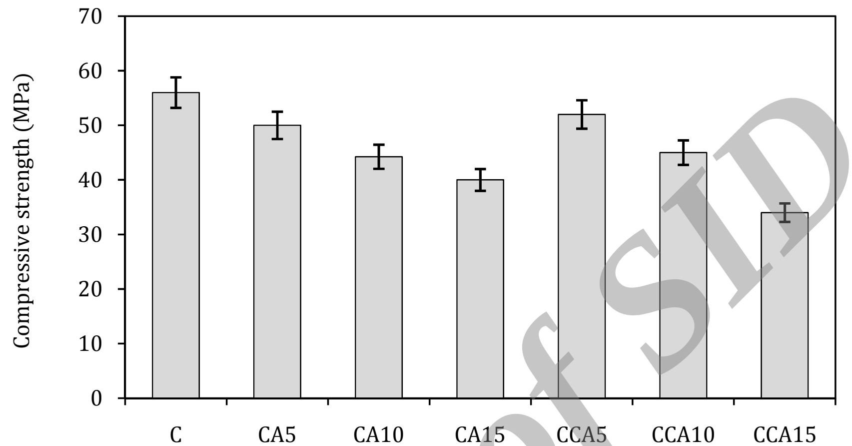

Figure 3. Compressive strength of concrete mixtures containing different amounts of latex of CA and CCA

3.3 Flexural strength

The Flexural strength of the LMCs prepared with different types of latexes is demonstrated in Fig. 4. The results have shown that the two latex types of CA and CCA have the better performance among the studied latexes. The CCA latex exhibited an improvement in the flexural strength of concrete by incorporation of 10% in weight of cement.

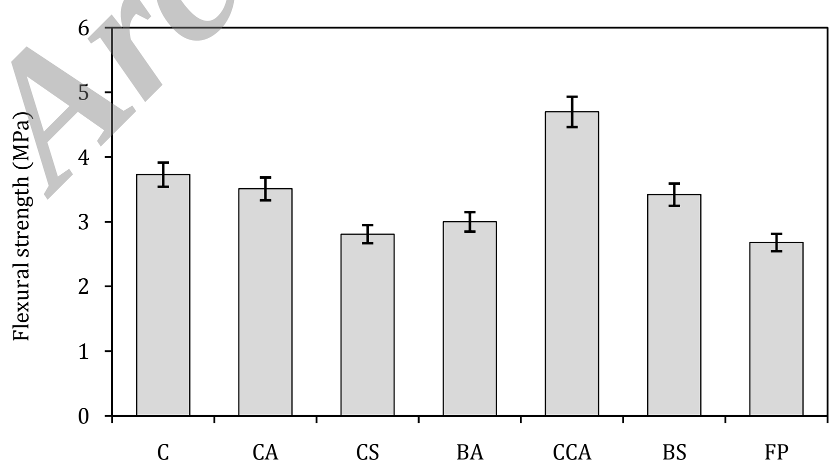

Figure 4. Effect of latex type on flexural strength of LMC

The results of flexural strength of LMCs samples with different amount of CA and CCA latexes are shown in Fig.5. As seen from the results, the CCA latex shows better performances in comparison with the CA latex in same incorporated weight fraction of concrete. With incorporation of higher amount of both latexes, the flexural strength of concrete was improved. A remarkable increase in the flexural strength of all concrete samples with latex to cement ratio of 15% in weight was observed.

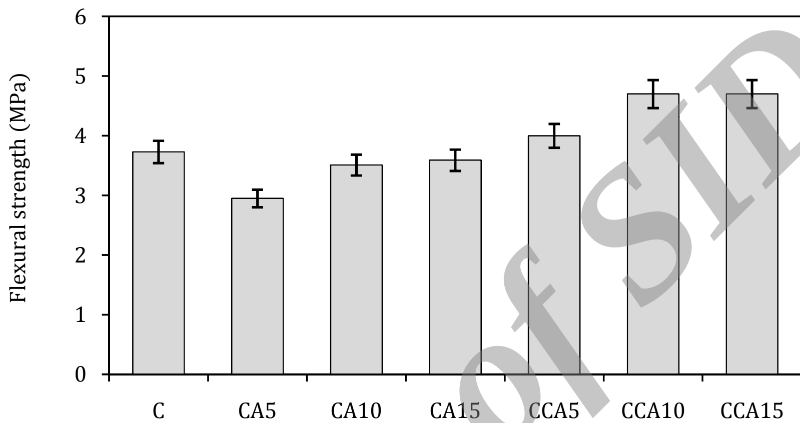

Figure 5. Flexural strength of concrete mixes containing different amounts of latex of CA and CCA

3.4 Tensile strength

The result of tensile strength of LMCs with different types of latexes is presented in Fi. 6. Similar to the results obtained in the flexural strength, the CA and CCA latexes have better performance in among the other latex types. An improvement on the tensile strength of concrete was observed by using CCA latex. The CCA latex has greater strength compared to other latex types. The FP latex has shown a higher decrease in the tensile strength of LMC.

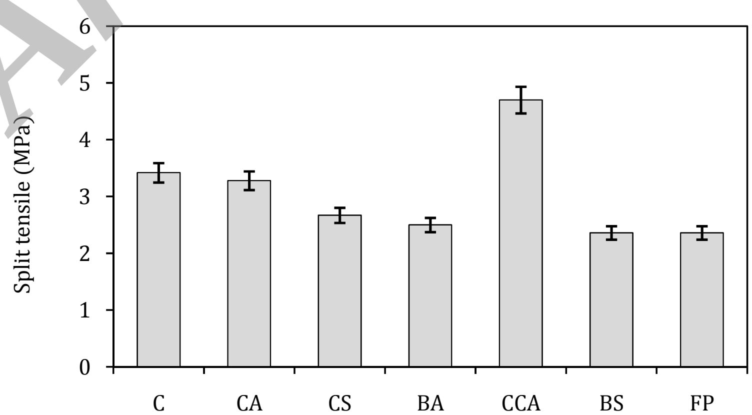

Figure 6. Effect of latex type on tensile strength of LMC

The Tensile strength results of LMCs are presented in Fig. 7. The results showed the similar trend to the observed results in flexural strength. The LMC containing CCA latex shown greater tensile strength compared to the sample with CA latex. The tensile strength of concrete is increased by increment of latex content especially in 15% of incorporated weight fraction. An improvement up to 45% in tensile strength of concrete was observed for LMC with 10% and 15% weight fraction of CCA latex. Improvement in tensile strength of concrete by incorporating 15% weight fraction of CA latex was not more than 22%.

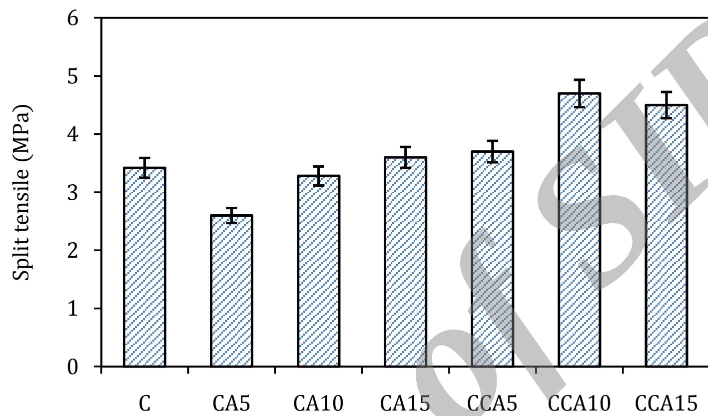

Figure 7. Tensile strength of concrete mixes containing different amounts of latex of CA and CCA

3.6 Modulus of elasticity

Modulus of Elasticity results of concrete samples containing different amounts of latexes of CA and CCA are presented in Fig. 8. The results indicated that the addition of latex to the concrete mix reduced the modulus of elasticity. By increase in latex content higher reduction in modulus elasticity was observed. The CA latex shows better performance compared to the CCA latex in the higher latex content. Loss of modulus of elasticity in samples containing polymer latex modified concrete is associated with increased flexibility as observed in flexural strength.

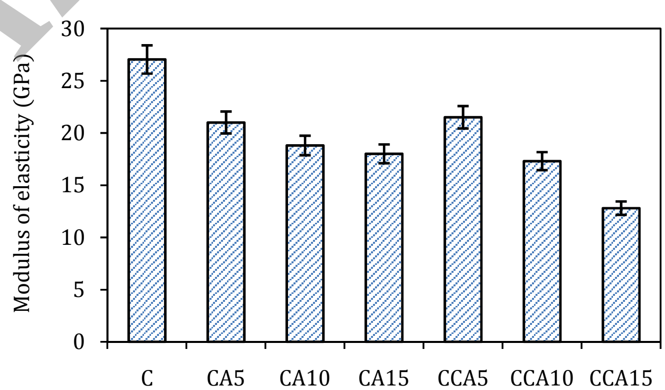

Figure 8. Modulus of elasticity of concrete mixes containing different amounts of latex of CA

and CCA

3.5 Capillary water absorption

Capillary water absorption of latex modified concrete with CA latex and CCA latex in different weight fraction content is presented in Figure 9. By increase in the latex content from 5% to 10% the capillary water absorption decreased but an increase with increment of latex content from 10% to 15% was observed. It may be attributed to the increase in the porosity of the concrete.

According the results latex to cement ratio of 10% in weight is considered as optimum value. The CA latex shown better performances in capillary water absorption compared to the CCA latex.

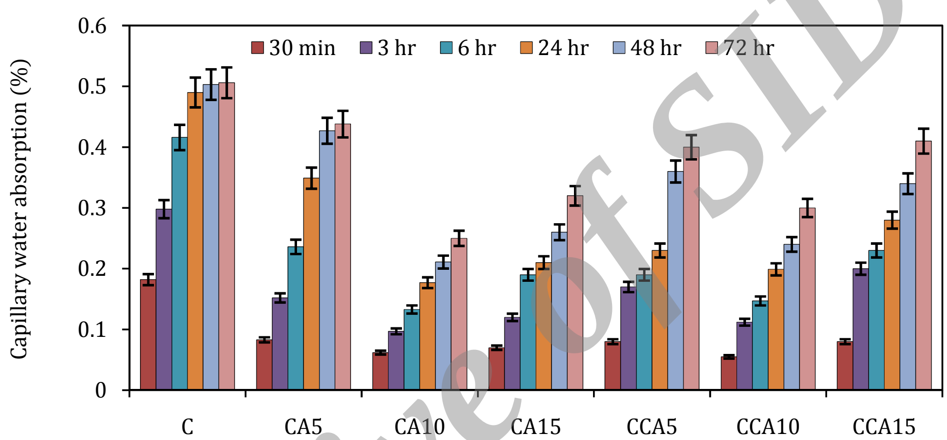

Figure 9. Capillary water absorption of concrete mixes containing different amounts of latex of CA and CCA

4. CONCLUSION

In this work, the effect of some homemade latex type and latex content on the physical/mechanical properties of latex modified concrete was investigated. The following conclusion can be drawn from the present study:

□ All polymer admixtures caused decease in water permeability of the concretes. In the case of using 10% of acrylic latex (i.e. type CA) the permeability decreased up to 50%.

□ Using polymer admixtures in all types caused decrease in the compressive strength and modulus of elasticity of the specimens but this fall was acceptable in the case of acrylic and co-polymer acrylic polymer usage (i.e. CA and CCA types). Increasing polymer content caused also decrease in compressive strength due to lubricant effect of the polymer particles in the cement matrix.

In contrast with previous researches addition of polymers to concrete mix design caused decrease in flexural and tensile properties except in the case of addition of acrylic co-polymer latex, but the properties increased by increase in the latex content.

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