Construction and Building Materials 191 (2018) 145–154

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Investigation on mechanical and durability properties of polymer and latex-modified concretes

Faramarz Moodi [a], Amin Kashi [b,*], Ali Akbar Ramezanianpour [b], Mohammadreza Pourebrahimi [b]

[a] Concrete Technology and Durability Research Center (CTDRc), Department of Civil & Environmental Engineering, Amirkabir University of Technology, Tehran, Iran
[b] Department of Civil & Environmental Engineering, Amirkabir University of Technology, Tehran, Iran

HIGHLIGHTS

- Selecting appropriate types and optimum percentages of polymeric materials are two crucial parameters in PCs and LMCs.
- Durability and strength can be improved by using polymeric materials in concrete.
- Significant linear relationship was found between compressive and tensile strength in PCs and LMCs.

ARTICLE INFO

Article history:
Received 2 June 2018
Received in revised form 8 September 2018
Accepted 29 September 2018

Keywords:
Polymer concrete
Latex-modified concrete
Durability
Mechanical properties
Distance based approach (DBA)

ABSTRACT

This study investigated the performance of polymer concrete (PC) containing polyester and epoxy resins, and latex-modified concrete (LMC) containing SBR and epoxy latexes in terms of strength and durability at various ages. In PC, the percentages of polyester were 10% and 20% and the percentage of epoxy was 10% of the weight of the aggregate. In LMC, 15% and 25% SBR, and 25% epoxy by weight of cement were used. Results showed that selecting appropriate types and optimum percentages of polymeric materials leads to higher compressive, tensile and flexural strengths in PCs and LMCs compared to ordinary concrete. Their freezing/thawing and abrasion resistance were also enhanced, and both their shrinkage and permeability were reduced by adding appropriate polymeric materials in optimum percentages. A significant linear relationship was found between the compressive and tensile strength of PC and LMC which was more evident than that of ordinary concrete. The paper is concluded with a comparison of different types of concrete using a distance based approach (DBA).

© 2018 Elsevier Ltd. All rights reserved.

1. Introduction

In recent years, polymeric materials have been motivated to use in concretes due to the improving in mechanical and durability properties. Polymers can be used in order to produce three different types of concrete consisting of: polymer-impregnated concrete (PIC), polymer concrete (PC) and latex-modified concrete (LMC), which can be used to repair and rehabilitation of ordinary concrete [1–7]. A number of studies on the mechanical and durability characteristics of PCs and LMCs are represented in the following:

In a study conducted by Rahman et al. it was revealed that latex-modified mortars had higher durability in different environmental conditions such as brine, acidic and alkaline environments [8]. In terms of permeability, Ramli et al. showed polymer-modified mortars had lower chloride penetration than cement mortar, and vinyl acetate ethylene performed better than both SBR and poly acrylic ester [9]. Wu et al. found that latex improved the abrasion resistance of concretes [10]. Generally, the performance of latex-modified mortar against chloride and sulfate attack was better than ordinary mortar [11,12]. Ukrainczyk and Rogina recommended that in order to improve the strength of SBR-modified mortar, the optimum percentage of latex should be considered [13]. In a study which was conducted by Hwang et al. SBR-modified mortar showed lower compressive strength and also higher flexural strength than ordinary mortar [14]. Investigation of the effect of filler on the compressive strength of polymer concretes revealed that adding filler to the PC caused a higher compressive strength [15]. Study on the effect of polymeric materials in light weight concretes showed that both flexural and tensile strength could be improved by adding SBR to concretes [16]. In a study which was carried out by Li et al. a significant increase in the flexural strength was observed by adding 5% SBR by weight of cement [17]. Results of mid-point load flexural tests showed that regardless of the optimum percentage of latex, adding more

* Corresponding author.
E-mail addresses: kashi_1365@yahoo.com, akashi@aut.ac.ir (A. Kashi).

https://doi.org/10.1016/j.conbuildmat.2018.09.198
0950-0618/© 2018 Elsevier Ltd. All rights reserved.

percentage of SBR decreased both flexural strength and ductility of LMCs [18]. Barluengaa et al. found that in LMCs when water/cement ratio was a constant value, compressive strength decreased by adding more SBR [19]. During an investigation of the compressive strength of PC, it was found that by increasing the amount of epoxy resin, the compressive strength increased, while the tensile strength was relatively constant. Also, a higher resin content yielded a higher ultimate stress and modulus of elasticity [20].

These studies indicated that the use of polymeric materials in mortar and concrete mostly resulted in higher strength and durability when compared to the ordinary ones. The objective of the present work was to study the effect of different resins and latexes on the strength and durability enhancement of PCs and LMCs at various ages. Also, different percentages of polymeric materials were studied. Furthermore, the relationship between the different types of mechanical strength was investigated. Finally, a distance based approach (DBA) has been used in order to compare the performance of different types of concrete.

2. Experimental program

2.1. Materials

Type I portland cement was used for LMC and ordinary concretes. Table 1 shows physical and chemical characteristics of the cement. The aggregate types were crushed granite stone and naturally river-washed quartz sand for coarse and fine aggregates, respectively, from a local quarry which were suitable for preparing ordinary concrete according to ASTMC33 [21]. The grading of the aggregates used in this research is presented in Table 2. The coarse aggregate had water absorption and a specific gravity of 2.5% and 2.56 gr/cm^3, respectively, and the fine aggregate had water absorption of 5.21% and a specific gravity of 2.54 gr/cm^3. Potable water was used for preparing the specimens.

Different types of polymeric materials consisting of SBR latex, epoxy latex, polyester and epoxy resins were used in this study. The latexes' properties are presented in Table 3. The polyester used in this research was unsaturated orthophthalic polyester diluted in 33% styrene. For preparing the polyester resin, cobalt and methyl ethyl ketone peroxide were added in terms of promoter and initiator, respectively. The epoxy resin was based on diglycidyl ether of bisphenol A and an aliphatic amine hardener. Different properties of the resins used in this research are summarized in Table 4. The preparation of the polymer mixtures was carried out according to the manufacturer's instructions.

2.2. Specimen preparation

The properties of the mixtures of different specimens are presented in Table 5. Generally, three series of concretes were prepared in this study. The first group was ordinary concrete at 0.56 water/cement ratio and having a 50-mm slump. It was used as control specimen without any polymeric materials. For preparing the ordinary concrete, the two types of aggregates were first mixed, and then, water and cement were added to the concrete. A vibration table was used in order to compact the specimens. In Table 5, the ordinary concrete is denominated with CC. In the second group, epoxy and SBR latexes were added to prepare latex-modified concrete (LMC). The SBR solids added to the ordinary concretes were 15% and 25%, and epoxy was 25% by the weight of cement. In this group, the cement and aggregate content was similar to the ordinary concrete and slumps were kept constant at 50 mm. Preparation of the specimens was similar to the ordinary concrete. Latex was thoroughly dispersed into the mixing water by stirring prior to being discharged into the mixer. LMCs with 15% SBR, 25% SBR and 25% epoxy are denominated with SBR-15, SBR-25 and EPX-25, respectively, in Table 5. The third group was polymer concrete (PC) prepared by mixing polymeric materials and aggregates. Polyester resin was added by 10% and 20%, and also epoxy resin was added by 10% by the mass of aggregates. In PCs, aggregates' content was similar to that in the ordinary concrete. In these concretes, fine and coarse aggregates were first mixed, following which, the aggregate mix was placed into moulds and the moulds were then filled with resin. A vibration table was used in order to the compact the mixes.

Batching and mixing were conducted in a control condition (20 °C and 40% RH). After casting, both ordinary concretes and LMCs were kept in the control condition for 24 h and then demolded and stored in a curing room (25 °C and 90% RH) for 4 days. After that, the specimens were kept in the control condition

Table 3
Properties for latexes.*

	SBR	Epoxy
Physical state	Milky white liquid	Milky white liquid
Total solids (by weight of polymer)	47%	60%
Specific gravity (gr/cm3)	1.01	1.05
pH	10.5	–**
Mean particle size (µm)	0.16	1.7

* According to the manufacturer's data sheet.
** It was not reported.

Table 4
Properties for resins.*

	Epoxy	Polyester
Tear strength (MPa)	30	60
Flexural strength (MPa)	50	120
Glass transition temperature (°C)	75	100
Heat distortion temperature (°C)	65	50

* According to the manufacturer's data sheet.

Table 1
Physical and chemical characteristics of cement.

Physical tests		Chemical analysis (%)							
Specific gravity (gr/cm^3)	Blaine (m^2/gr)	CaO	SiO_2	Al_2O_3	Na_2O	SO_3	Fe_2O_3	MgO	K_2O
3.2	0.4	57.5	23	4.8	5	3.7	2.5	2.3	1.2

Table 2
Grading of fine and coarse aggregates.

	19 mm*	9.5 mm	4.75 mm	2.36 mm	1.18 mm	0.6 mm	0.3 mm	0.15 mm
Fine aggregate	–	–	100**	79.6	59.2	35.3	12	2
Coarse aggregate	100	38.2	6.8	3.5	–	–	–	–

* Sieves (nominal size).
** Percent passing.

Download English Version:

https://daneshyari.com/en/article/11012616

Download Persian Version:

https://daneshyari.com/article/11012616

Daneshyari.com