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Feasibility study of asphalt-modified mortars using asphalt emulsion

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Abstract

Asphalt emulsion is manufactured by emulsification of asphalt, and it is an energy-saving, ecologically safe material because it does not need any heating processes creating gas emission and fire hazard in its use. The purpose of this study is to evaluate the feasibility on the use of an asphalt emulsion as a polymeric admixture. Asphalt-modified mortars using an experimentally manufactured asphalt emulsion are prepared with various polymer–cement ratios, and tested for strengths, adhesion, water absorption, water permeation, carbonation and chloride ion penetration. As a result, it is found that waterproofness, carbonation resistance and chloride-ion penetration resistance of the asphalt-modified mortars are markedly improved with the increase in the polymer–cement ratio, while their compressive strength and adhesion to mortar substrates are reduced with the increase in polymer–cement ratio. Therefore, it is recommended to control their polymer–cement ratios to be less than 10% in practical applications. Further study to improve their compressive strength and adhesion is suggested.

Keywords: Durability; Polymers; Asphalt

1. Introduction

In general, asphalt which is widely used as paving and waterproofing materials in construction industries. The heating processes accompany the emission of gases with disagreeable odors from the asphalt and the danger of fire, and then the melted asphalt becomes a hazard to burn or scald the human body. The development of application methods of the asphalt, which do not need any heating processes, is strongly requested in Korea. Asphalt emulsion itself has been used as a waterproofing material due to its effectiveness in cost and in water repellency. Thus, active use of asphalt emulsion is in progress [1]. Additionally, there exist a few efforts to use asphalt emulsion as cement modifier in Korea. Soh [2] reported the modification effects of asphalt emulsion which was added to cement mortar. According to his results, asphalt-modified cement mortar shows the strength reduction due to the high porosity which the increase in the addition ratio of asphalt emulsion. Li et al. [3] conducted experiments to evaluate the mechanical properties of a three-phase cement–asphalt emulsion composite (CAEC). Through experimental investigation, they reported that CAEC possessed most of the characteristics of both cement and asphalt, namely the longer fatigue life and lower temperature susceptibility of cement concrete, and higher toughness and flexibility of asphalt concrete.

The asphalt emulsion is manufactured by emulsification of asphalt, and is an energy-saving and ecologically safe material, because it does not need any heating processes which may provide the chance of gas emission and the danger of fire in its use. The cost of the asphalt emulsion is much lower than those of ordinary polymeric admixtures such as styrene–butadiene rubber (SBR), polyethylene-vinyl acetate (EVA) and

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polyacrylic ester (PAE) emulsions for polymer-modified mortars and concretes [4]. If high-quality asphalt emulsion is developed as a polymeric admixture, its applications are expected to expand considerably in construction industries. The purpose of this study is to investigate basic properties of asphalt-modified mortars using an experimentally manufactured asphalt emulsion and to evaluate the feasibility of the use of the asphalt emulsion as a polymeric admixture.

Asphalt-modified mortars are prepared with various polymer–cement ratios, and tested on strengths, adhesion, water absorption, water permeation, carbonation and chloride ion penetration. The feasibility of its use as a polymeric admixture is discussed.

Table 2
Physical properties of ordinary Portland cement

Density (g/cm^3)	Blaine fineness (cm^2/g)	Setting time (h:min)		Compressive strength (MPa)		
		Initial set	Final set	3 days	7 days	28 days
3.14	3300	2:18	3:12	15.0	25.5	43.3

Table 3
Properties of asphalt emulsion

Color	Density (g/cm^3, 20 °C)	pH (20 °C)	Viscosity (MPa s, 20 °C)	Total solids (%)
Blown	1.02	9.02	479	58.0

2. Materials

Ordinary Portland cement as specified in KS 5201 (Specification for Portland cements) was used for the preparation of asphalt-modified mortars. Tables 1 and 2 list chemical compositions and physical properties of the cement. Standard sand graded to pass a No. 30 (600 μm) and to be retained on a No. 50 (300 μm) sieve, was used as fine aggregate.

An asphalt emulsion experimentally manufactured in Korea was used, of which properties are given in Table 3. A silicone emulsion-type antifoamer (AF) was added to the asphalt emulsion with 2.0% ratio to the total solids of the asphalt emulsion.

3. Testing procedures

3.1. Preparation of specimens

Fresh asphalt-modified mortars (AE) were mixed with mix proportions given in Table 4 in accordance with the method conforming to KS F 2476 (Making method of test sample of polymer-modified mortar in the laboratory). Beam specimens 40 × 40 × 160 mm were made for flexural and compressive strengths, water absorption, accelerated carbonation and chloride ion penetration. Disk specimens of 150 mm diameter and 40 mm thickness were molded for water permeation. Specimens were made of the fresh asphalt-modified mortars, and subjected to a 2d-20 °C–80% (RH)-moist followed by 5d-20 °C–water and then to 21 d-20 °C–50% (RH)-dry curing. Special-shaped specimens for an adhesion test were prepared by placing the fresh asphalt-modified mortars in size of 40 × 40 × 10 mm on cement mortar substrates, of which mixture proportion was cement:river sand = 1:3 (by mass).

The water–cement ratio of cement mortar substrates was 65.0% and was cured at 1d-20 °C-80% (RH)-moist followed by 27d-20 °C-50% (RH)-dry curing. The fresh asphalt-modified mortars were cured at 2d-20 °C-80% (RH)-moist followed by 5d-20 °C-water, which were placed at 20 °C-50% (RH)-dry curing until the adhesion test.

3.2. Flexural and compressive strength tests

Beam specimens were tested for flexural and compressive strengths in accordance with KS F 2477 (Method of test for strength of polymer-modified mortar).

3.3. Adhesion test in tension

Special-shaped specimens were tested for adhesion in tension by using a manually operated direct pull-gage machine as illustrated in Fig. 1. After the adhesion test, the specimens were observed to identify failure modes, which are classified into the following four types:

A: adhesive failure.
M: cohesive failure in asphalt-modified mortar.
S: cohesive failure in mortar substrate.
A:M:S: mixed failure.

Types of failure modes are also shown in Fig. 1, and the respective approximate ratios of A, M, S and A:M:S

Table 1
Chemical compositions of ordinary Portland cement

Chemical compositions (%)								
CaO	SiO_2	Al_2O_3	Fe_2O_3	MgO	SO_3	insol.	ig. loss	Total
65.3	22.2	5.1	3.2	1.3	1.9	0.3	0.6	99.9