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Performance of fiber reinforced asphalt concrete under environmental temperature and water effects

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ABSTRACT

This paper studies the reinforcing effects and mechanisms of fibers for asphalt concrete (AC) mixtures under the environment temperature and water effects. Four typical fiber types – polyester, polyacrylonitrile, lignin and asbestos – are studied. Laboratory tests were conduct on the fiber reinforced AC (FRAC) to measure its strength, strain and fatigue behavior. Results show that fibers have significantly improved AC's rutting resistance, fatigue life, and toughness. The flexural strength and ultimate flexural strain, and the split indirect tensile strength (SITS) at low temperature have also improved. The polymer fibers (polyester and polyacrylonitrile) have improved rutting resistance, fatigue life, and SITS more significantly than lignin and asbestos fibers, which may be primarily due to their greater networking function; while lignin and asbestos fibers result in greater flexural strength and ultimate flexural strain, which may be primarily due to their greater asphalt stabilization effect. However, fiber's effect under the water freezing–thaw effect does not seem promising, and the SITS of FRAC with lignin and asbestos fibers even reduces to some extent under this effect. It is also found that a fiber content of 0.35% by mass of mixture achieves the optimum performance outputs of rutting resistance and SITS for polyester fiber.

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1. Introduction

Asphalt concrete (AC) is a composite material consisting of aggregate, asphalt binder (mastic), and air void. AC has been primarily used as a material in constructing road and airport pavements. However, under the effects of repeated vehicle loading at high temperature, moisture cycling, and low-temperature contraction, AC mixture is susceptible to distresses of rutting (permanent deformation), stripping (separation of asphalts from aggregates), and cracking, etc. Accordingly, additives have been used to alter the engineering properties (e.g. strength) of asphalt binder and improve the performance of AC material for pavement use. These additives primarily include the organic polymers as illustrated in numerous literatures [1]. In comparison, not many fibers have been used in AC materials due to their high cost and limited research demonstrations. However, previous researches have identified fiber's effects on improving the engineering properties and performances of asphalt matrix. Fiber prevents asphalt leakage due to its function of asphalt absorption [2,3]. It increases the Marshall stability, reduces the voids in mineral aggregates (VMA) to improve adhesions between aggregates [4]. Fiber increases the viscosity and stiffness of asphalts [5] also improves AC's moisture susceptibility [6], wearing resistance [7], creep compliance and rutting resistance [8]. It reduces AC's reflective cracking [9,10], increases the low-temperature anti-cracking property, fatigue life [11–13], and durability [1,14,15]. It was also noted that fiber improves the toughness, tensile strength [16], fracture energy [17], and dynamic modulus [18] of AC mixtures. Researches have reported that fiber's absorption and stabilization of asphalt binders [19], and its three-dimensional networking function [16,19] have contributed to the performance improvement for the fiber-asphalt matrix.

2. Research significance and objectives

AC pavements are subjected to various temperature and environmental conditions like water freezing–thawing cycling effect. Therefore, it is essential to investigate effects of fibers on AC materials under various environmental conditions. Meanwhile, the reinforcing effects and mechanisms are dependent on fiber types and their geometry and physical properties. Thus, it would be essential to compare fibers' reinforcing effects and mechanisms toward a more appropriate election and use of fiber in engineering design.

While the advantages of fiber reinforced asphalt concrete (FRAC) have been identified, not many researches have focused on a comprehensive study of FRAC using different fiber types under various temperature and environmental conditions; specifically there are limited researches studying the water effect on FRAC.

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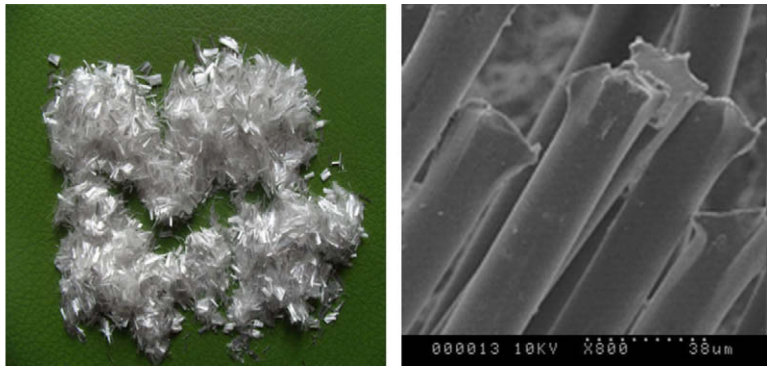
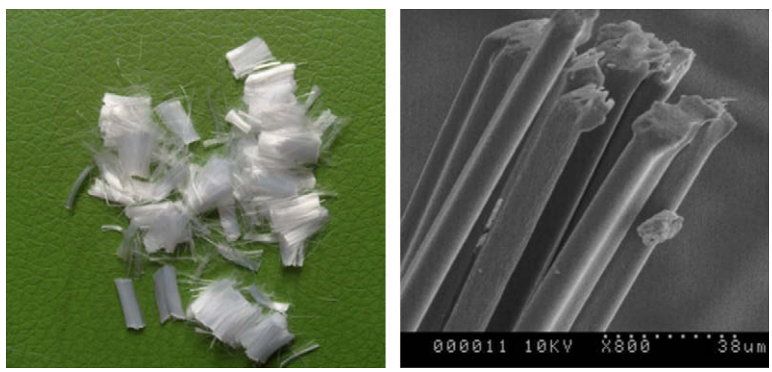
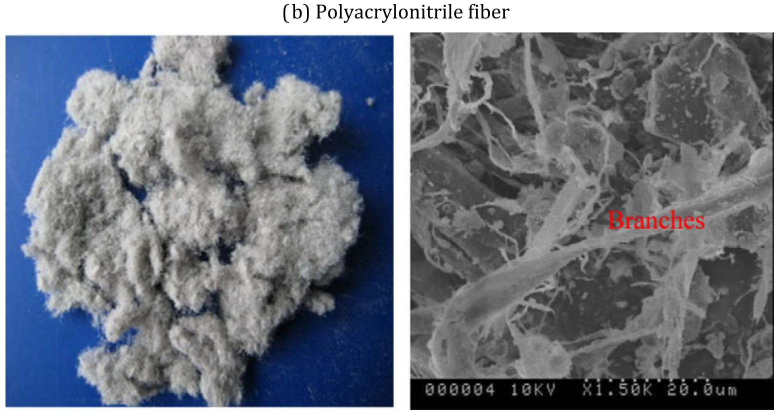
Accordingly, this investigation studies fiber's reinforcing effects and mechanisms on AC materials under various environmental conditions through experimental study. FRAC's performances at high, intermediate, and low temperatures are evaluated, using four typical fiber types (polyester, polyacrylonitrile, asbestos, and lignin). The effect of water freezing and thawing is also studied. The



(a) Polyester fiber



(b) Polyacrylonitrile fiber



(c) Lignin fiber

(c) Asbestos fiber

Fig. 1. Fibers and their microstructures.

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