Amirkabir Journal of Civil Engineering

Amirkabir J. Civil Eng., 52(5) (2020) 273-276
DOI: 10.22060/ceej.2018.15194.5850

Investigation of fracture resistance of roller-compacted concrete pavement modified with synthetic fibers

A. Yousefi, B. Golchin*
Department of Civil Engineering, University of Mohaghegh Ardabili, Ardabil, Iran

ABSTRACT: Roller compacted concrete pavements (RCCP) are considered as an adjunct of solid pavements. High strength at early age, faster construction, and relatively low cost, are benefits of such pavements to be mentioned. One obstacle of these types of pavements is that using steel bars as reinforcement is not possible. This disadvantage results in low ductility and strength. So far, researchers have presented numerous solutions to address these issues, such as implementing fibers. The aim of this study is the investigation of fracture resistance of RCCP modified with polyolefin-aramid fiber in different loading modes (pure mode I, pure mode II and mixed-mode I/II). For this purpose, liner elastic fracture mechanics (LEFM) was used for obtaining the fracture resistance of RCCP with polyolefin-aramid fibers with percentages of 0.1%, 0.3%, and 0.5% by weight and 20 mm length. The results showed that the minimum fracture toughness of RCCP occurs under pure mode II loading conditions, showing that both plain RCCP and polyolefin-aramid fiber-reinforced RCCP represent less resistance against fracture under pure II conditions. It is found that adding polyolefin-aramid fibers more than 0.3% by weight of the mixture does not lead to a significant improvement of the fracture resistance.

Review History:

Received: 2018-10-28
Revised: 2018-12-04
Accepted: 2018-12-05
Available Online: 2018-12-17

Keywords:

Liner Elastic Fracture Mechanics
Roller compacted concrete pavement
Polyolefin-aramid fiber
Fracture resistance.

1. INTRODUCTION

In our country, hundreds of billions of dollars annually pay to cover the cost of asphalt layers in the construction of road pavements, which after several years, will need rehabilitation. Due to the consumption of energy and rising prices caused by the removal of subsidies, the economic advantages of concrete versus asphalt pavements is undeniable. In last years, a large amount of the funding has been used for the price of the bitumen in the construction of new roads or the improvement of existing roads. Also, there are a lot of factories that produce a large amount of cement. Hence, the use of roller-compacted concrete pavements (RCCP) can be attractive in many main roads [1].

Fracture may occur under the mode I (opening or tension mode), mode II (sliding or shear mode), mode III (tearing or anti-plane shear mode), or a combination of them (Figure 1) [2].

In fracture mechanics, the stress intensity factors are known as the main fracture parameter for describing the crack tip stress filed and fracture behavior of the cracked component. The stress intensity factors can be explained by the following general Equation 1:

i = I, II, III (1)

Where is the applied stress, a is the crack length and Y_i is the geometry factor that is the function of geometry and loading condition of the cracked body.

The main objective of the current study is to evaluate the effect of polyolefin-aramid fiber (a kind of synthetic fibers) on the fracture resistance of RCCP in pure and mixed loading modes.

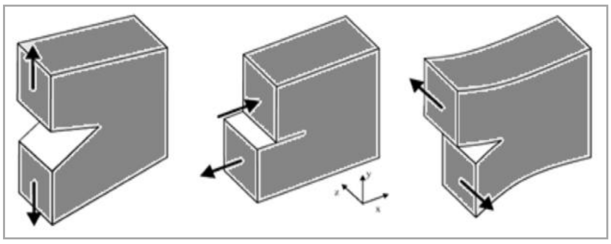

Fig. 1. Different fracture modes

2. TEST SPECIMEN

The cracked semi-circular bend (SCB) specimen is chosen for conducting the mixed-mode fracture tests. The SCB specimen is a semi-disk of radius R and thickness t containing an inclined edge crack of length a subjected to three-point bending. As shown in Figure 2, the combination of mode I and mode II loading can be easily controlled by changing the crack inclinations angle by increasing angle from zero, the loading conditions varies from pure mode I to pure mode II conditions. Pure mode I loading is achieved by setting the crack angle to zero [3].

*Corresponding author's email: b.golchin@uma.ac.ir

Copyrights for this article are retained by the author(s) with publishing rights granted to Amirkabir University Press. The content of this article is subject to the terms and conditions of the Creative Commons Attribution 4.0 International (CC-BY-NC 4.0) License. For more information, please visit https://www.creativecommons.org/licenses/by-nc/4.0/legalcode.

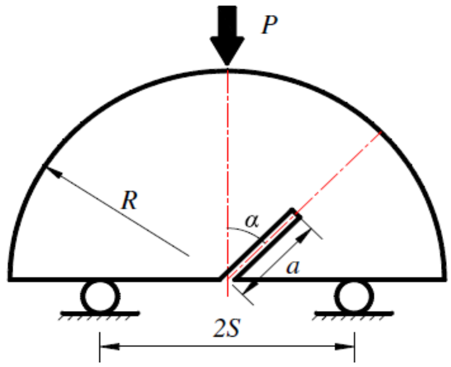

Fig. 2. General configuration of the SCB specimen

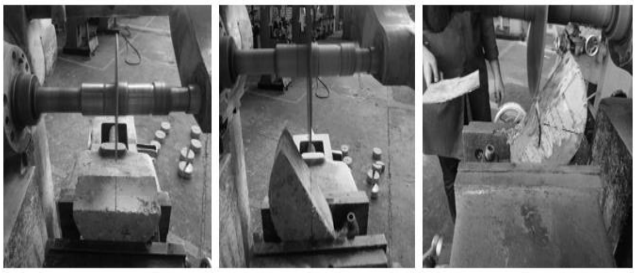

Fig. 3. Cracked SCB specimens

The preparation process for the cracked SCB specimens, made of RCCP, is illustrated in Figure 3.

3. FRACTURE TEST

The fracture tests were carried out using a universal testing machine and a three-point bend fixture (Figure 4). Each specimen was loaded at a constant rate until it was fractured. During the test, load versus displacement was recorded for each specimen.

4. RESULTS AND DISCUSSION

As seen from Figure 5, an average mixed-mode fracture toughness enhancement can be achieved by adding the polyolefin-aramid fiber to the mixture. According to this figure, the effect of adding polyolefin-aramid fiber is more considerable for the mixed-mode I/II conditions rather than pure mode I and pure mode II. It also can be found that adding polyolefin-aramid fibers more than 0.3% does not improve the mixed-mode fracture toughness of the RCCP significantly, pointing out that the optimum content of polyolefin-aramid fibers is around 0.3% by weight of the total RCCP mixture.

Figure 6 shows the variation of the effective fracture toughness (K_{eff}) of polyolefin-aramid fiber-reinforced RCCP versus loading mode (M^e), for different fiber contents. As seen from this Figure, for all cases, the K_{eff} has a minimum value at pure mode II, and decreases as the M^e approaches zero meaning that shear deformation negatively influences on the mixed mode fracture resistance.

5. CONCLUSIONS

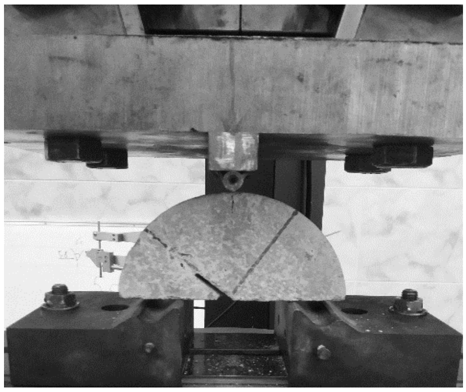

Fig. 4. SCB test set-up

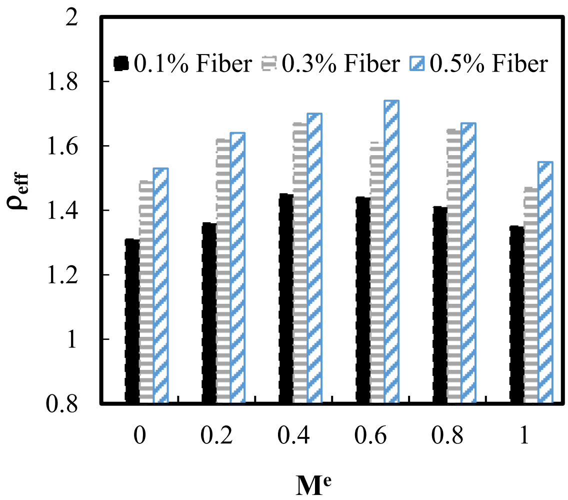

Fig. 5. Relative mixed-mode fracture toughness

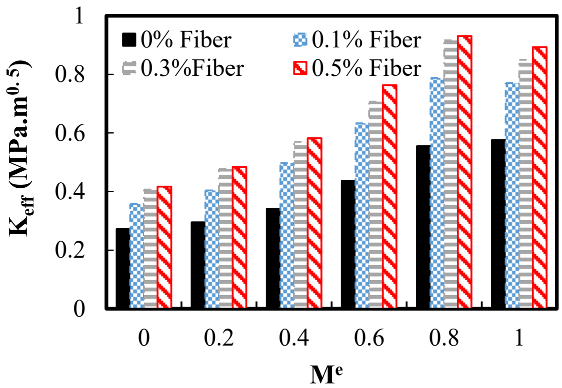

Fig. 6. K_{eff} versus M^e for different fiber contents

- The mixed-mode fracture resistance of polyolefin-aramid fiber-reinforced RCCP enhances as the fiber content increases. However, adding polyolefin-aramid fibers more than 0.3% by weight of the mixture does not lead to a significant improvement of the fracture resistance.
- The minimum fracture toughness of RCCP mixture occurs under pure mode II loading conditions, showing that both plain RCCP and polyolefin-aramid fiber-reinforced RCCP represent

less resistance against fracture under pure II conditions.

• Reinforcement of RCCP with fiber percentages of 0.1%, 0.3%, and 0.5% by weight, led to an increase in the compressive strength.

REFERENCES

[1] "Guide for Roller-Compacted Concrete Pavements", Portland Cement Association (PCA), August 2010.

[2] T.L. Anderson, Fracture mechanics: fundamentals and applications, CRC press (2005).

[3] M.R. Ayatollahi, M.R.M. Aliha, Wide range data for crack tip parameters in two disc-type specimens under mixed mode loading, Comput. Mater. Sci. 38 (2007) 660–670.

HOW TO CITE THIS ARTICLE

A. Yousefi, B. Golchin, Investigation of fracture resistance of roller-compacted concrete pavement modified with synthetic fibers, Amirkabir J. Civil Eng., 52(5) (2020) 273-276.

DOI: 10.22060/ceej.2018.15194.5850