Amirkabir Journal of Civil Engineering

Amirkabir J. Civil Eng., 55(3) (2023) 121-124
DOI: 10.22060/ceej.2023.20436.7441

Investigation on properties of cold recycled asphalt mixtures reinforced with polypropylene fibers

M. Sabouri*, M. Sadeghi

Civil Engineering Department, Sharif University of Technology, Tehran, Iran

ABSTRACT: Despite substantial environmental and economic benefits, cold recycling of asphalt pavements is not common due to some poor field performance reports. This study investigates the effect of fiber reinforcement on the performance of cold recycled mixtures. For this purpose, cold recycled mixtures were reinforced using polypropylene fibers at two different lengths and three different contents. Indirect tensile strength, IDEAL-CT, and semicircular bending tests were carried out to find the optimum length and content of the fiber. The effect of cement on the performance of fiber-reinforced mixtures was also evaluated. The results show that although the use of polypropylene fibers reduces the wet strength by up to 54%, it can increase the dry strength by up to 39%. The results also indicate a significant improvement in fracture indices obtained from IDEAL-CT and SCB tests in the presence of fiber. The crack tolerance index was 3.5 times and the flexibility index was 2.8 times higher at the optimum fiber content and length compared with the control mixture. It was also concluded that the addition of cement to fiber-reinforced mixture can eliminate the adverse effect of fiber on moisture sensitivity while maintaining fracture properties similar to the control mixture. The study results show that the combined use of fibers and cement can lead to an economical cold recycled mixture with reduced emulsified asphalt content and improved mechanical properties.

Review History:

Received: Sep. 02, 2021
Revised: Dec. 19, 2021
Accepted: Jan. 17, 2023
Available Online: Feb. 07, 2023

Keywords:

Cold recycling
Fibers
Emulsified asphalt
Polypropylene
Cement

1- Introduction

Cold recycling is one of the most promising technologies in the pavement industry in terms of environmental and economic impacts [1]. However, cold recycled mixtures generally suffer from high air void content, weak early life strength, relatively high moisture susceptibility, and long curing time [2, 3]. Fibers are expected to enhance the tensile strength, energy absorption capacity, and toughness of asphalt mixtures. Fiber properties such as type, content, length, diameter, and surface texture highly affect the mechanical performance of fiber-reinforced asphalt mixtures [4]. The addition of polypropylene fibers has shown the ability to improve the dry strength and stability of both emulsified asphalt and foamed asphalt cold recycled mixtures, although a significant change in wet strength was not observed [5-7]. The combined addition of fibers and cement to RAP aggregates has resulted in higher resilient modulus values compared to the use of cement [8]. Moreover, the combined addition of fibers and cement to foamed asphalt mixtures resulted in better mechanical properties than the addition of cement [9].

The current study evaluates the strength, moisture susceptibility, and fracture properties of fiber-reinforced emulsified asphalt cold recycled asphalt mixtures with and without cement.

2- Materials and methods

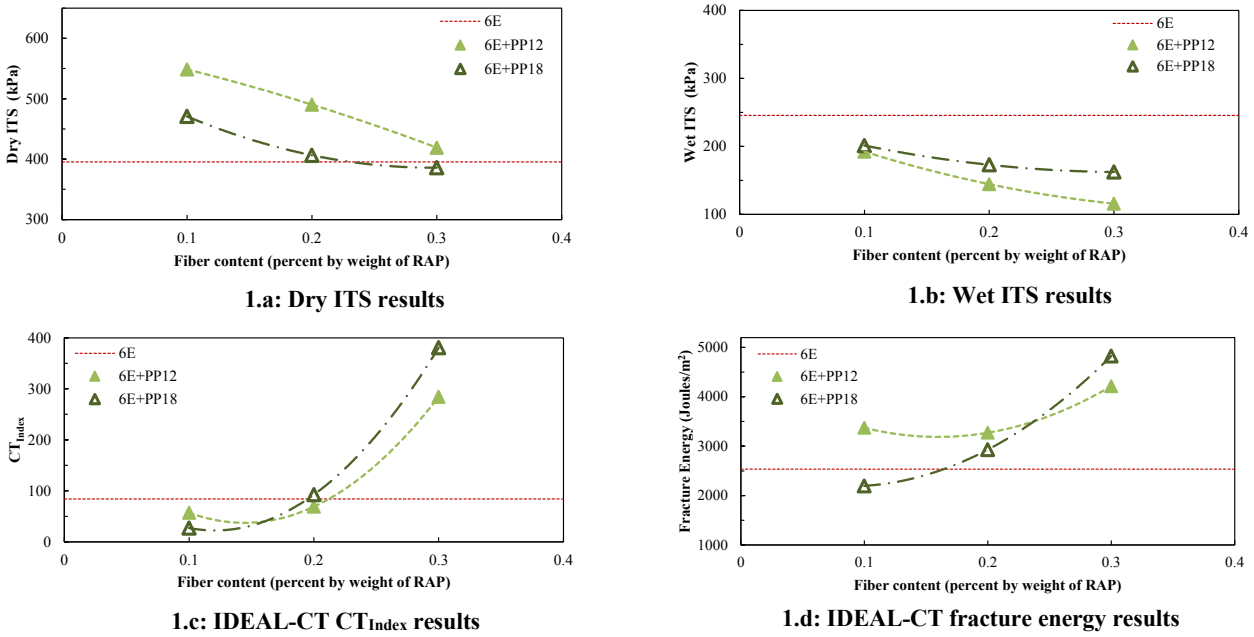
Cold recycled mixtures in this study comprised 100% RAP without virgin aggregates. RAP gradation met the medium gradation of AASHTO MP31-17. CSS-1h emulsified asphalt with 63% asphalt residue from a PG64-22 base binder was used as the stabilizing agent. Polypropylene fibers in two lengths (12 mm and 18 mm) and three contents (0.1, 0.2, and 0.3% by the weight of RAP) were used to reinforce the mixtures. A type III Portland cement (As per ASTM C150) with 2% content (By weight of RAP) was used for some of the mixtures. An SBR Latex is also used in all mixtures having cement.

3- Results and Discussion

3- 1- Effect of fiber-reinforcement

Figure 1 shows the results of ITS and IDEAL-CT tests for cold recycled samples reinforced by adding Polypropylene fibers. “6E” in Figure 1, as shown by the horizontal dotted line, represents the mixture with 6% emulsified asphalt (By weight of RAP) without any additives or the “control mixture” and provides a baseline to evaluate the effects of additives. Fiber contents are shown in the horizontal

*Corresponding author’s email: sabouri@sharif.edu



1.a: Dry ITS results

1.b: Wet ITS results

1.c: IDEAL-CT CT_{Index} results

1.d: IDEAL-CT fracture energy results

Fig. 1. IDT and IDEAL-CT results for cold recycled mixtures reinforced by Polypropylene fibers

axes, and fiber lengths in mm are shown in labels. Based on Figures 1.a and 1.b, the addition of PP fibers results in comparable or higher dry strength while reducing the wet strength. However, both dry and wet strengths decrease with an increase in fiber content. As shown in Figures 1.c and 1.d, IDEAL-CT results indicate an enhancement of both CT_{Index} and fracture energy with an increase in fiber content. While the best dry strength is observed for lower length and the lowest content, the best CT_{Index} and fracture energy were obtained for higher length and the highest content.

3- 2- Combined Effect of fibers and cement

As the optimum IDEAL-CT result was obtained for 18 mm fibers at 0.3%, these values were used to evaluate the combined effect of Polypropylene fibers and 2% cement. Figure 2 shows the results. "4.5ME2C" contained 4.5% modified emulsified asphalt and 2% cement compared to the weight of RAP and without fibers. The results show that the combined use of fibers and cement provides both dry and wet ITS results comparable to those obtained by adding cement; hence the detrimental effect of fibers on wet strength is compensated by the effect of cement. However, the combined use of fibers and cement resulted in considerably better CT_{Index} and Flexibility Index results than the mixtures having cement; hence the addition of Polypropylene fibers significantly enhances the fracture properties of cement-treated mixtures.

4- Conclusions

Given the results, it can be stated that:

- PP fibers are effective in enhancing the dry strength and fracture properties of cold recycled mixtures, but further increase the moisture susceptibility too.
- The combined use of PP fibers and cement, while maintaining the positive effects of cement on strength and moisture resistance, significantly improved their fracture properties.

References

[1] G. Thenoux, A. Gonzalez, R. Dowling, Energy consumption comparison for different asphalt pavements rehabilitation techniques used in Chile, Resources, Conservation and Recycling, 49(4) (2007) 325-339.

[2] C. Ling, A. Hanz, H. Bahia, Evaluating moisture susceptibility of cold-mix asphalt, Transportation Research Record, 2446(1) (2014) 60-69.

[3] I. Thanaya, S. Zoorob, J. Forth, A laboratory study on cold-mix, cold-lay emulsion mixtures, in: Proceedings of the Institution of Civil Engineers-Transport, Thomas Telford Ltd, 2009, pp. 47-55.

[4] G. Ferrotti, E. Pasquini, F. Canestrari, Experimental characterization of high-performance fiber-reinforced cold mix asphalt mixtures, Construction and Building Materials, 57 (2014) 117-125.

[5] B. de S. Bueno, W.R. Da Silva, D.C. de Lima, E. Minete, Engineering properties of fiber reinforced cold asphalt mixes, Journal of Environmental Engineering, 129(10) (2003) 952-955.

[6] Y. Kim, T.-S. Park, Reinforcement of recycled foamed asphalt using short polypropylene fibers, Advances in Materials Science and Engineering, 2013 (2013).

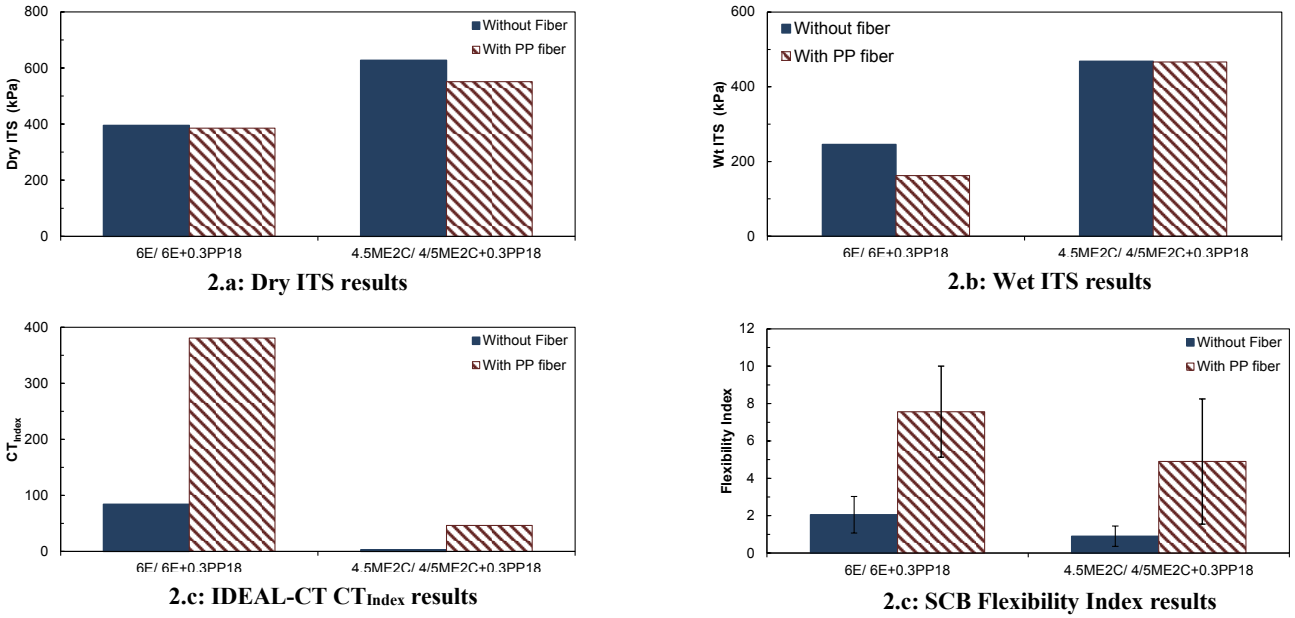


Fig. 2. IDT, IDEAL-CT, and SCB results for mixtures reinforced by PP fibers and combined use of fibers and cement

[7] G. Martinez-Arguelles, F. Giustozzi, M. Crispino, G.W. Flintsch, Laboratory investigation on mechanical performance of cold foamed bitumen mixes: bitumen source, foaming additive, fiber-reinforcement and cement effect, Construction and Building Materials, 93 (2015) 241-248.

[8] A.J. Puppala, S. Saride, A. Potturi, L.R. Hoyos, Resilient Behavior of Cement-Fiber Treated Reclaimed Asphalt Pavement Aggregates, in: Contemporary Topics in Ground Modification, Problem Soils, and Geo-Support, 2009, pp. 433-440.

[9] E.A. Taziani, E. Toraldo, F. Giustozzi, M. Crispino, Investigation on the combined effect of fibers and cement on the mechanical performance of foamed bitumen mixtures containing 100% RAP, Advances in Materials Science and Engineering, 2016 (2016).

HOW TO CITE THIS ARTICLE

M. R. Sabouri , M. Sadeghi, Investigation on properties of cold recycled asphalt mixtures reinforced with polypropylene fibers, Amirkabir J. Civil Eng., 55(3) (2023) 121-124.

DOI: 10.22060/ceej.2023.20436.7441