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Comparison of the effects of micro and macro polymer fiber on the mechanical and durability of roller-compacted concrete pavements

A. A. Ramezanianpour[1], J. Sobhani[2,*] , A. R. Pourkhorshidi[2] , M. Lotfi[1]

[1] Department of Civil and Environmental Engineering, Amirkabir University of Technology, Tehran, Iran.
[2] Department of concrete Technology, Road, Housing and Urban Development Research Center

ABSTRACT: A laboratory study was performed to determine the benefits of micro and macro fibers in roller-compacted concrete (RCC) for pavements by measuring the RCCs mechanical and durability properties. To this aim, three RCC mixtures with use of micro and macro polyolefin-based fibers in two volumetric content (1 and 2 kg/m3) were prepared and the mechanical properties (compressive strength and flexures strengths (modulus of rupture and toughness)) and durability properties (salt scaling under freeze-thaw and water permeability) were evaluated. The results emphasized that the macro fibers could be efficiently enhanced the toughness in comparison with the microfibers. Moreover, the water permeability of fiber-concrete decreased up to 20% in comparison with the reference concrete. Furthermore, it was found that the application of microfibers in comparison with macro fibers significantly improved the salt-scaling resistance of concrete.

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1. INTRODUCTION

Roller-compacted concrete for pavement (RCCP) can be considered as an evolution of the RCC technology used for dam construction. RCCP is made with smaller maximum size aggregates and contains a high-quality cement paste having a relatively low water cementitious material ratio (w/cm) [1].

Interest in roller compacted concrete (RCC) as a paving material has increased in recent years because of its economic benefit relative to other stabilized construction materials, construction expediency high-density paver technology, and ability to open early to traffic. From a materials perspective, RCC has reduced cementitious contents compared to typical Portland cement concrete (PCC) pavements as a result of increased aggregate content, a more continuous aggregate gradation [1-2], and increased construction compaction energy.

Fibers may provide improved shear load transfer and residual strength in RCC, as noted for conventional PCC pavement. Macro-fibers have been added to PCC pavement to reduce slab thickness, control crack width and decrease crack deterioration rates, increase joint spacing, and increase fracture properties. By reducing the crack width at a joint, the shear mechanism of aggregate interlock is enhanced, thereby increasing load transfer and potentially reducing the slab's critical tensile stresses [3-7].

2. EXPERIMENTAL DETAILS

Locally available ordinary Portland cement type I conforming to ASTM C150 was used. Fine and coarse crushed aggregate was obtained from local sources in southern Tehran province. The coarse aggregates had a saturated surface dry density of 2620 kg/m^3, the maximum size of 19 mm and water absorption of 2.65%. Two synthetic macro and microfibers were utilized in this study and their properties shown in Table 1.

In Table 1, the mix proportion of fiber roller compacted concrete is shown.

Water= 132.7 kg/m^3, Cement= 350 kg/m^3, aggregate=1903 kg/m^3

In this research, compressive and flexural strength, salt-scaling durability, water penetration under pressure, were tested.

3. RESULTS AND DISCUSSION

Compressive and flexural strength, salt-scaling durability, water penetration under pressure, were shown in Fig. 1.

As seen in Fig. 1, minor changes could be seen for compressive strength with the use of both fiber types.

As seen in Fig. 2, microfibers could not improve the flexural strength due to short length and low modulus of elasticity. Moreover, macro fibers showed better performance in comparison with the micro-fiber specimens.

In general, the permeability of specimens with the use of fibers decreased as seen in Fig. 3.

As demonstrated in Fig. 4, specimens with microfibers showed better performance in salt-scaling tests due to the improved transition zone between fibers and cement paste in compassion with the macro fiber included mixtures.

*Corresponding author's email: sobhani@bhrc.ac.ir

Table 1. Properties of utilized fibers

Item	Macro fiber	Microfiber
Type	Modified olefin	Polypropylene
Diameter (mμ)	0.3	20
Density (g/cm^3)	0.91	0.91
Modulus of elasticity (GPa)	7	3.7
Tensile strength (MPa)	620	360
Length (mm)	58	12
L/d	193	600

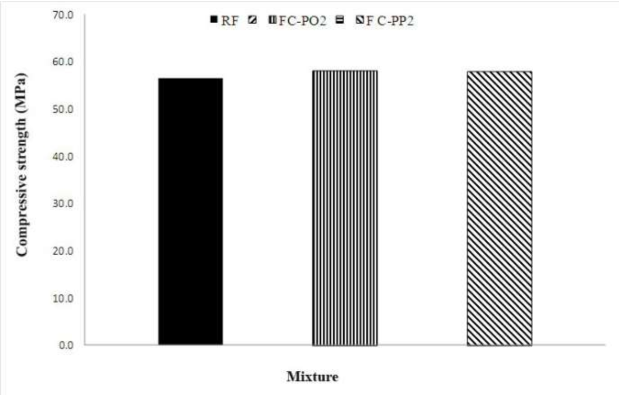

Fig. 1. Compressive strength of mixtures

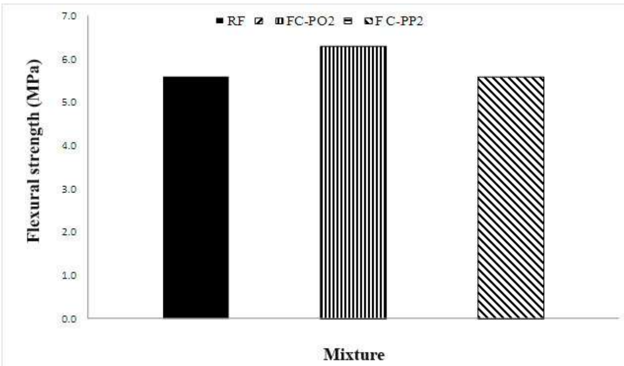

Fig. 2. Flexural strength of mixtures

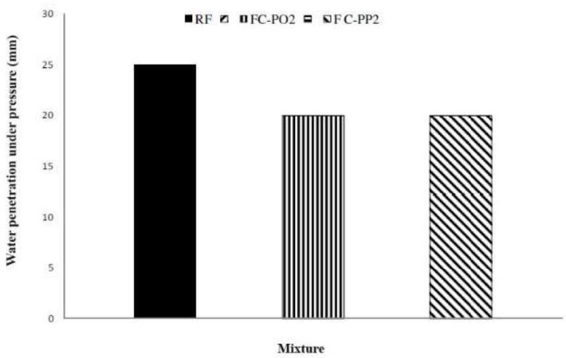

Fig. 3. Water penetration under pressure

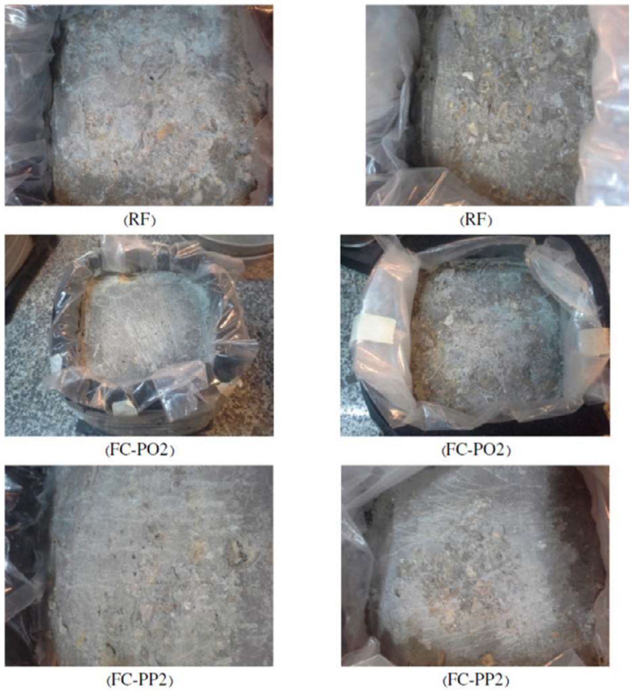

Fig. 4. Visual inspection of specimens after salt-scaling test

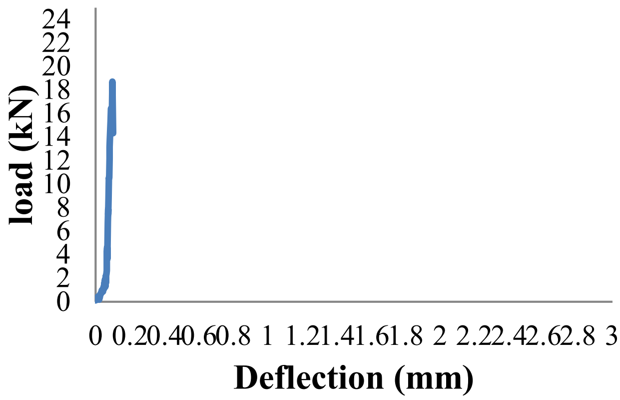

Fig. 5. Load-deflection curve for reference mixture

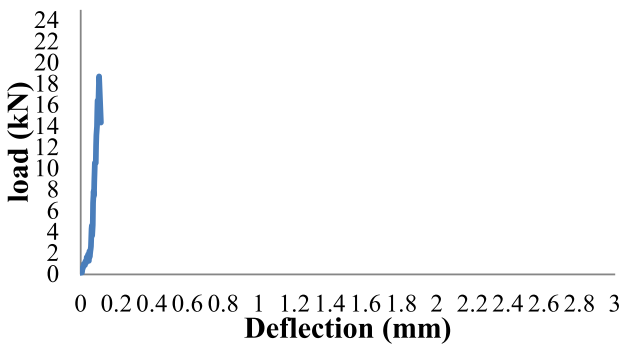

Fig. 6. Load-deflection curve for mixture FC-PO2

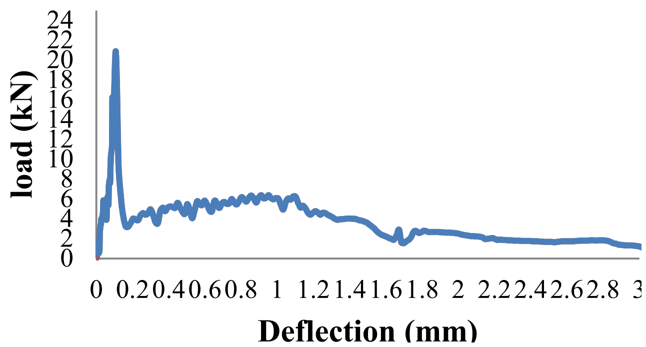

Fig. 6. Load-deflection curve for mixture FC-PP2

Table 2. Mix proportion of fiber roller compacted concrete

Mix code	Fiber type	Fiber (kg/m^3)
RF	Reference	0
FC-PO2	Modified olefin	2
FC-PP2	Polypropylene	2

As seen in Fig.s 5 and 6 and Table 3, the failure mode of the specimen is of brittle type; however, the mixtures with macro fibers do not fail in a brittle, catastrophic manner at the formation of the first crack under an identifiable maximum load.

4. CONCLUSIONS

The following conclusion could be drawn:

.Minor changes could be seen for compressive strength with the use of both fiber types.

· Microfibers could not improve the flexural strength due to the short length and low modulus of elasticity. Moreover, macro fibers showed better performance in comparison with the micro-fiber specimens.

· Specimens with microfibers showed better performance in salt-scaling tests due to the improved transition zone between fibers and cement paste in compassion with the macro fiber included mixtures.

· Mixtures with macro fibers do not fail in a brittle, catastrophic manner at the formation of the first crack under a identifiable maximum load.

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