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Abstract

Effects of Polypropylene Macro Fibers on the Structural Requirements, Cost and Environmental Impact of Concrete Pavements †

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With an increasing interest in environmental issues, a variety of studies have been carried out to improve the sustainability of concrete pavements [1]. Use of structural fibers in pavement applications is one of the methods proposed to reducethe carbon footprint of concrete pavements. As the fibers allow the production of concrete pavements with lower thickness and without conventional rebars [2] (which means lower use of materials), by increasing the cracking resistance, and flexural performance of concrete. However, the number of studies that numerically present the benefit that could be obtained from macro fibers is still limited. This study has been carried out to examine how the use of polypropylene (embossed, 40 mm) fibers in varying amounts (0.25–0.50–0.75–1.00%vol.) change the required thickness, cost, and environmental impact (CO_2 emission) of concrete pavements. Selection of polypropylene fiber among its alternatives (steel, glass, carbon, etc.) was done by considering their common usage in slab-on-ground applications, which is due to their various advantages, such as ease of handling, competitive cost, and corrosion free nature.

To achieve the aim of the study, first an experimental study was conducted to determine the mechanical performance (compressive strength, modulus of elasticity, and flexural performance) of concrete mixtures with and without fibers. Then, thickness design for a sample road was done (according to IRC 58 [3]) by using the experimentally obtained material parameters, and specified thickness values were used to determine the amount of material (aggregate, cement, water, super-plasticizer, fiber) required to produce 1 m^2 pavement. In the last part, by using the amount of required materials and cost/CO_2 emission of unit products, cost and CO_2 emission values were determined for each of the considered mixtures (for 1 m^2 pavement construction).

Based on the mechanical test results, used fibers did not considerably change the compressive strength, modulus of elasticity, and flexural strength of concrete mixtures. However, considerable improvements in the post-cracking flexural performance were obtained for the fiber reinforced concrete (FRC) mixtures depending on the amount of fiber used. Despite the increasing cost (13.9–51.3–85.5–111.5% increase for 0.25–0.50–0.75–1.00%vol., respectively), decreased thickness requirements (5.2–9.6–14.0–19.7% reduction for 0.25–0.50–0.75–1.00%vol., respectively) and CO_2 emissions (8.3–9.9–11.6–15.1% reduction for 0.25–0.50–0.75–1.00%vol., respectively) were found for FRC mixtures compared to the plain one. Based on the results, despite the decrease in thickness requirement and CO_2 emission, material cost increases with increasing polypropylene fiber amount. It is worth noting here that the presented results are valid for the fibers used in this study, and use of

different fiber types (with different raw materials (e.g., recycled fibers), surface properties, lengths, aspect ratios, etc.) might alter the results in varying amounts.

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