R&T UPDATE
Concrete Pavement Research & Technology

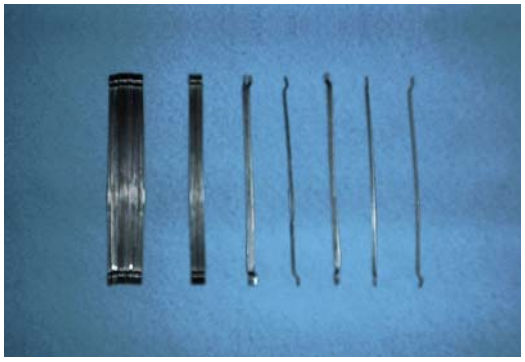
FIBER REINFORCED CONCRETE PAVEMENTS

The use of fiber reinforcement in concrete pavements is continuing to see more attention. Various fiber types are currently being specified in bridge decks, ultra-thin whitetopping pavements, thin unbonded overlays, and concrete bus pads. These types of concrete pavement projects are increasingly being used and are exhibiting excellent performance. Many in the concrete construction industry are familiar with the design, construction, performance, and benefits of both steel and synthetic fiber reinforcement, but new technologies and research are showing surprising results.

Fibers used in concrete pavements are typically made from steel or plastic and are available in a variety of lengths, shapes, sizes, and thicknesses. They are added to fresh concrete during the batching and mixing process. The primary differences between conventional steel reinforcement and fibers are location, length, and area of cross section. Fibers are equally distributed throughout the concrete instead of placed at specific pavement locations, are much shorter than continuous steel bars, and take up a much smaller cross-sectional area of the pavement than conventional steel reinforcement.

Steel Fibers

Early research on steel fiber reinforcement in concrete was performed in the 1950s and 60s. The first commercial steel fiber reinforced concrete pavement in the US was placed in August 1971 at a truck weigh station near Ashland, Ohio. This was followed by two bridge deck overlays in Pennsylvania in 1972 that are still in service. Following those successful installations, steel fibers were used on a number of experimental concrete pavement projects in the 1970s and 80s, and have since been used primarily in industrial floors, heavy-use pavements, airfields, parking structures, and bridge decks.



Some steel fibers have hooked ends and are collected in bundles that break apart during mixing (above) while others may be crimped in shape and unattached (below).

Steel fibers are generally 0.5 - 2.5 in. (12.7 - 63.5 mm) long, and 0.017 - 0.04 in. (0.45 - 1.0 mm) in diameter. The usual amount of steel fibers ranges from 0.25% to 2% by volume, or 33 - 265 lb/yd^3 (20 - 157 kg/m^3). The benefits of steel fibers include up to 150% increase in flexural strength, reduced potential for cracking during concrete shrinkage, and increased fatigue strength. Significant research, testing, and application of steel fibers in concrete has occurred since the 1970s and has led to the primary use of steel fibers for increased strength and even thinner pavement designs.

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Synthetic Fibers

Synthetic fibers are manufactured from materials such as acrylic, aramid, carbon, nylon, polyester, polyethylene, or polypropylene. The use of synthetic fibers has been increasing at a steady rate in the past couple of decades. Their primary use in concrete pavements to date has been in ultra-thin whitetopping, where 2 to 4 inches of concrete is bonded to an existing asphalt pavement to form a composite pavement.

Synthetic fibers come in a variety of shapes, sizes, and properties.

The most commonly used synthetic fibers in concrete pavements are made of fibrillated polypropylene. They are normally used in concrete at a rate of at least 0.1% by volume. Ultra-thin whitetopping typically utilizes 3 lb/yd^3 (1.8 kg/m^3) of polypropylene (or polyolefin) fibers. The benefits of polypropylene fibers included reduced plastic shrinkage and subsidence cracking, as well as increased toughness or post-crack integrity. In fresh concrete, polypropylene fibers also reduce the settlement of aggregate particles from the pavement surface, resulting in a less permeable and more durable, skid resistant pavement.

New Developments in Fiber Reinforcing

Most of the research to date on fibrous concrete has involved either steel fibers for structural enhancement, or synthetic fibers for enhanced pavement performance, by decreasing permeability and giving the concrete residual strength after cracking occurs. However, recent research and development initiatives in the fiber industry have resulted in improvements and technology enhancements. Two of these improvements are structural synthetic fibers, and steel/synthetic blends.

Structural synthetic fibers are high strength, high modulus fiber reinforcement that is designed to structurally reinforce a concrete slab in place of steel rebar or steel fibers. To achieve the structural enhancement, addition rates are typically greater than standard polypropylene fibers, often up to 10 lb/yd^3. The benefits of synthetic structural fibers include tight crack control, easy use and handling, scheduling advances, and no corrosion. Residual strengths after cracking are generally in the range of 100 - 275 psi flexural, while most synthetic fibers demonstrate 80 - 100 psi residual strength.

Steel/synthetic fiber blends combine the benefits of both types of fibers. The steel fibers give the concrete increased strength, and the synthetic fibers give the concrete increased durability and toughness. Typical dosage rates of blended fibers are 24 lb/yd^3, with the majority of the weight coming from the steel fibers. Test results have shown increased residual strength (after cracking) of up to 90 psi flexural, compared to 25 lb/yd^3 of straight steel fibers.

Resources

The Use and State-of-the-Practice of Fiber Reinforced Concrete, AASHTO Task Force 36 report, August 2001.

For additional information, please consult ACPA's fiber manufacturer members:

Euclid Chemical Co.
19218 Redwood Road
Cleveland, OH 44110
(800) 321-7628
www.euclidchemical.com

Nycon, Inc.
101 Cross Street
Westerly, RI 02891-2407
(800) 456-9266
www.nycon.com

SI Concrete Systems
4019 Industry Drive
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(423) 892-8080
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W.R. Grace & Co. – Conn.
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