Concrete in Practice
What, why & how?
NRMCA

CIP 24—Synthetic Fibers for Concrete

WHAT are Synthetic Fibers

Synthetic fibers engineered for use in concrete can withstand the long-term alkaline environment of concrete. These fibers are manufactured polymer-based materials such as polypropylene, nylon, or polyethylene. Synthetic fibers are added to concrete before or during the mixing operation. The use of synthetic fibers at typical addition rates of 1 to 2 lbs per cubic yard does not require any modification to concrete mixtures. At higher addition rates, workability may be reduced and water reducing admixtures may be required to retain slump.

WHY Use Synthetic Fibers

Synthetic fibers benefit the concrete in both the plastic and hardened state. Benefits include:

- reduced plastic settlement cracks
- reduced plastic shrinkage cracks
- increased toughness and impact resistance
- provides energy absorption

Macro-synthetic fibers, typically at a higher dosage rate, can be used for crack control in hardened concrete or temperature/shrinkage reinforcement in some applications. Documentation on the use of fibers for these applications should be available.

HOW do Synthetic Fibers Work in Early-Age Concrete

Early-age volume changes in concrete cause weakened planes and cracks to form due to stresses that exceed the strength of the concrete at a specific time. This is beneficial to minimize plastic shrinkage cracking. The growth of these micro shrinkage cracks is inhibited by mechanical blocking action of the synthetic fibers. The internal support system of the synthetic fibers inhibits the formation of plastic settlement cracks. The uniform distribution of fibers throughout the concrete discourages the development of large capillary channels caused by bleed water migration to the surface. These bleed water capillaries can provide locations for later age cracking.

Synthetic Fibers—Micro (top); Macro (bottom)

HOW do Synthetic Fibers Work in Hardened Concrete

Benefits seen to early-age performance of concrete continue to contribute to the performance of hardened concrete. Prevention of early age cracking in the freshly mixed stage reduces the potential for increased cracking in the hardened state. Hardened concrete attributes provided by synthetic fibers are improved toughness for energy absorption and resistance to impact forces.

The ability to resist tensile forces can be enhanced with the use of synthetic fibers to the concrete. When plain concrete develops tensile stresses that exceeds its tensile strength, due to bending or changes in temperature and shrinkage, cracking occurs. Synthetic fibers can prevent the effect of excessive tensile stresses by bridging and dispersing cracks and holds concrete tightly together. These benefits are enhanced with the use of a higher dosage than typically used for control of plastic shrinkage cracking.

Macro-synthetic fibers reduce the amount of plastic (early age) and post-hardening crack formation. Macro-synthetic fibers are thicker fibers and are used at a higher dosage rate of around 5 lbs/cubic

yard. In these uses and with the higher modulus of these fibers improves toughness, resistance to cracking and crack tightness.

Synthetic fibers help concrete develop its optimum long-term integrity by the reduction of plastic and drying shrinkage crack formation, increased energy absorption and resistance to impact forces. Synthetic fibers are compatible with chemical admixtures, pozzolans, slag cement, silica fume, metakaolin, and cement chemistries.

HOW are Synthetic Fibers Used as Secondary Reinforcement

Synthetic fibers which meet certain hardened concrete criteria can be used as non-structural temperature/shrinkage or post-crack control reinforcement. These fibers should have documentation, including ASTM C1609 test results of residual flexural strength confirming their ability to hold concrete together after cracking. The uniform distribution of synthetic fibers throughout the concrete ensures the critical positioning of its use as secondary reinforcement.

Fibers used to control plastic shrinkage cracks, reducing shrinkage and temperature cracking, and in composite steel deck construction should meet the criteria of ICC Evaluation Service AC 32 (ref. 5).

References

1. ASTM C1116, *Specification Fiber Reinforced Concrete,* ASTM International, West Conshohocken, PA, www.astm.org.
2. ASTM C1609, *Test Method for Flexural Performance of Fiber-Reinforced Concrete (Using Beam with Third-Point Loading).* ASTM International, West Conshohocken, PA, www.astm.org.
3. ACI 544.1R, *Report on Fiber Reinforced Concrete*, American Concrete Institute, Farmington Hills, MI, www.concrete.org
4. *Non-structural Cracks in Concrete*, Concrete Society Technical Report No. 22.
5. ICC Evaluation Service, Inc., AC 32, *Acceptance Criteria for Concrete with Synthetic Fibers*, December 2010.

APPLICATION GUIDELINES

Use Synthetic Fibers For:

- Reduction of concrete cracking as a result of plastic shrinkage.
- An alternate system of nonstructural shrinkage/temperature reinforcement (with documentation).
- Greater toughness and resistance to impact.
- Internal support and cohesiveness; concrete for steep inclines, shotcrete, and slip-formed placements.
- Reduction of concrete cracking as a result of plastic settlement.
- Applications where nonmetallic materials are required.

***Do Not* Use Synthetic Fibers For:**

- Control of cracking as a result of external forces.
- Higher structural compressive or flexural strength development.
- Replacement of any moment-resisting or structural steel reinforcement.
- Decreasing the thickness of slabs on grade.
- The elimination or reduction of curling and/or creep.
- Increasing control joint spacing.
- Reduction in the size of the support columns.
- Reducing the thickness of bonded or unbonded overlay sections.

1994, 2014