THINGS TO CONSIDER ABOUT *Fiber-Reinforced Concrete*

FROM LEFT: MICRO FIBERS, MACRO FIBERS PHOTO CREDIT: FORTA CORPORATION

There are a variety of fibers that may be added to concrete in order to improve its fresh and hardened properties. Fibers provide a three -dimensional, or multidirectional reinforcement throughout the entire concrete matrix. ASTM C1116/C1116M "Standard Specification for Fiber-Reinforced Concrete" and ACI-544 "Report on Fiber-Reinforced Concrete" (FRC) list four categories for fibers, based on the type of material from which the fiber is produced.

- Type I – Steel Fiber-Reinforced Concrete
- Type II – Glass Fiber-Reinforced Concrete
- Type III – Synthetic Fiber-Reinforced Concrete
- Type IV – Natural Fiber Reinforced Concrete

Synthetic Fibers are the most widely used type of fiber and may be classified as microfibers or macrofibers.

Microfibers are used primarily to minimize cracking due to plastic shrinkage or plastic settlement in concrete. They provide much needed reinforcement when early age concrete has limited tensile strength and may be manufactured from polypropylene, polyethylene, polyester, nylon or other synthetic materials such as carbon, aramid and other acrylics.

Typically dosed between .5 – 3 lbs/yd3, microfibers are primarily used in concrete applications such as slab-on-grade, overlays/toppings, curbs, driveways, sidewalks, basement floors, garage floors, and colored concrete, where the objective is to control plastic shrinkage cracking while improving durability properties.

Macrofibers usually have lengths greater than 1.5 inches and increase the post-crack tensile strength and ductility of concrete. They are a proven cost-effective alternative to traditional welded-wire or rebar reinforcement where temperature and shrinkage reinforcement (secondary reinforcement) are a consideration. While macrofibers are typically used to replace traditional temperature and shrinkage steel reinforcement, in some applications they may be used in a hybrid system to enhance the performance of the concrete element. Examples of such applications include: septic tanks, burial vaults, manholes, and other precast products where the reduction of steel and placement labor has resulted in a sizable savings to the producer. They may also be incorporated into flatwork projects such as streets, bridge decks, and commercial floors.

Dosed at a rate of 3 – 20 lbs/yd3, this class of fiber has emerged over the past 15 years as a suitable alternate to steel fibers when dosed properly. They may be manufactured from polypropylene and other polymer blends having the same physical characteristics as steel fibers (length, shape, etc.).

The method used for the addition of fibers is crucial in delivering consistent and homogeneous FRC mixtures and to prevent or significantly minimize balling. Fibers should not be loaded in the batching sequence with the cement. Instead, they should be loaded at the same time as the coarse aggregates to take advantage of the shear that the aggregates provide. If that is not possible, they may be loaded up front with the head water, with the mixer turning at slow speeds. A final option would be introducing them after the batching cycle has been completed.

Mixing time will vary based on when the fibers are introduced into the mixture and normally ranges from 3 to 5 minutes, but not less than 70 mixing revolutions. It should be noted that longer mixing time is preferred when the fibers are added after all the standard ingredients have already been introduced and mixed. Additional attention must be given to concrete mixtures with low slump. Poor workability mixtures are generally not preferred in FRC as they may lead to non-homogeneous fiber distribution.

The use of fibers may alter the apparent slump of the concrete. This is especially true when fiber dosages exceed 1.5 lbs. per yard. In most cases this concrete is easily workable after it is placed and vibrated, even though it appears to be very stiff. Good jobsite quality control practices must be exercised so that water is not added to this concrete, thus lowering the compressive strength and durability.

FRC may be pumped, but it should be noted that the fiber type and dosage may affect the pumping process and require adjustments as compared to the requirements for conventional concrete. ACI 544.3R "Guide for Specifying, Proportioning, and Production of Fiber-Reinforced Concrete" provides guidelines for pumping FRC.

References:

- *Standard Specification for Fiber-Reinforced Concrete, ASTM C1116/C1116M*
- *Standard Test Method for Obtaining Average Residual-Strength of Fiber-Reinforced Concrete, ASTM C1399/C1399*
- *Standard Test Method for Evaluating Plastic Shrinkage Cracking of Restrained Fiber-Reinforced Concrete (Using a Steel Form Insert), ASTM C1579*
- *Standard Test Method for Flexural Performance of Fiber-Reinforced Concrete (Using Beam with Third-Point Loading), ASTM C1609/C1609M*
- *Specification for Ready-Mixed Concrete, ASTM C94/C94M*
- *Specification for Concrete Made by Volumetric Batching and Continuous Mixing, ASTM C685/C685M*
- *Report on Fiber-Reinforced Concrete, ACI 544*
- *Fiber Reinforced Concrete DMS-4550 Texas Department of Transportation*

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