Adding steel or synthetic fibers to concrete at low-volume dosage rates provides benefits not available in conventional concrete. Steel fiber benefits include increased impact strength and toughness, and enhanced fatigue and crack resistance. Synthetic fiber benefits include reduced plastic shrinkage and settlement cracking, and increased impact and shatter resistance. These benefits are typically obtained by using approximately 15 to 33 pounds of steel fibers or 1.5 to 3.0 pounds of synthetic fibers per cubic yard of concrete.

At these dosage rates, production and construction procedures don't differ greatly from those for conventional concrete. However, care is needed during mixing, placing, and finishing to prevent the development of fiber balls, the on-site addition of water to the concrete, and the possibility of visible fibers at the surface of the concrete.

Fibers come in an array of materials, lengths, diameters, and geometries. Steel fiber shapes include round, oval, rectangular, and crescent cross sections. Synthetic fibers, which are usually made of nylon or polypropylene, can be angular fibrillated fibers or smooth, round monofilament fibers. If you're not familiar with steel or synthetic fibers, consult the manufacturer before use. A manufacturer's representative knows best how the fiber's properties will affect the concrete you plan to place.

Mixing

**Synthetic fibers.** Synthetic fibers are packed loosely in degradable bags, which can be added to the mix at the batch plant or thrown into the truck mixer at the jobsite. Manufacturers, however, strongly recommend adding the fibers at a reliable batch plant for at least two reasons. First, it provides an added measure of control. And second, it's very important that synthetic fibers be mixed at least three to five minutes, a goal that's not always feasible on the jobsite. Proper mechanical agitation ensures separation of the fibers, virtually eliminating the formation of fiber balls in the concrete. It also distributes the fibers in a thorough, uniform manner throughout the mix.

**Steel fibers.** Packaged in boxes and bags, steel fibers are manually added to the concrete at either ready mix plants or job sites. At the ready mix plant, some fiber types may be preloaded into concrete trucks before the other mix materials are added. In many cases, fibers are added to the aggregate stream during normal batching procedures or tail loaded into the concrete truck after all the other concrete components have been added to the truck.

To expedite batching procedures, it is slightly advantageous to add steel fibers to the trucks prior to concrete batching or with the aggregate stream. If fibers are tail loaded or added at the jobsite, it will require approximately two minutes...
to introduce the fibers to the truck and four minutes of additional mixing time to distribute the fibers throughout the concrete.

To prevent the formation of fiber balls, at least one manufacturer uses a special adhesive to glue a number of steel fibers together; during mixing, the glue degrades, dispersing the fibers throughout the concrete. The mixing of some un-collated steel fibers may require care to prevent the development of fiber balls in the fresh concrete. Don’t add fibers to the mixer faster than the mixer can pull them into the mixing drum. Since these steel fibers are reportedly vulnerable to clumping if they fall on each other and stack up on the aggregate conveyor belt or mixer blades, ACI Committee 544 (Ref. 1) recommends precautions like the following:

- Allow the project engineer to review and accept the equipment and method used to add the fibers to the mix.
- Perform a full-scale trial at least eight days before the first placement.
- Don’t allow fibers to pile up or slide down the blades of a partially filled drum.
- Don’t use equipment with worn-out mixing blades.
- Don’t overmix, since this can cause wet fiber balls (composed of both fibers and the cement-paste matrix).

The information contained in Reference 1 is best used as a general reference. Be sure to consult the steel-fiber producers for state-of-the-art information.

Placing

Both synthetic- and steel-fiber-reinforced concrete can be placed using conventional equipment such as truck chutes, concrete buckets, conveyors, and pumps. The equipment should be clean and in good condition to ensure that the fiber-reinforced concrete flows easily.

Adding low volumes of steel or synthetic fibers reduces slump, making properly proportioned concrete appear stiffer and less workable. You should expect this and resist the temptation to add water, which increases water-cement ratio and weakens the hardened concrete.

Although fiber-reinforced concrete looks stiffer, it’s relatively easy to place and consolidate. If better workability is desired, adjust aggregate grading or add a mid- or high-range water reducer to the mix instead of water. As with conventional concrete, use flat shovels or special concrete hoes, and never use garden rakes (with five or six tines) to move the concrete.

Finishing

Though fiber-reinforced-concrete finishing operations are very similar to those for plain concrete, there are some differences. Use the following procedures to produce a satisfactory surface.

**Strikeoff operations.** One key to finishing fiber-reinforced concrete is using external vibration in the form of a vibratory truss screed, portable power screed, or laser-guided screed to strike off the concrete. On some jobs, this step may be essential. External vibration brings paste to the surface and buries fibers located at the slab surface, encapsulating them in concrete and minimizing exposed fibers. If external vibration is not practical for the application, be sure to leave a layer of mortar at the surface that’s thick enough to encompass the fibers.

**Bull-floating and restraightening operations.** As with air-entrained concrete, don’t use wood floats or other wooden tools, because they can tear the concrete surface. Use magnesium floats instead. Magnesium floats do an especially good job of establishing a high-quality surface and closing up any tears or open areas caused by the screed. Be careful not to overwork the surface, since this will bring excessive fines to the surface and may result in crazing. If bleedwater or excessive fines are at the surface, the material should be screeded off and discarded.

**Waiting period.** The millions of synthetic fibers in the concrete can block or delay the appearance of bleedwater at the surface. Therefore, be sure all bleedwater has evaporated before getting on the concrete. Since fiber-reinforced concrete doesn’t look any different from plain concrete, it’s simply a matter of waiting a little longer than usual. But if inexperienced finishers misinterpret the scarcity of bleedwater as a sign that initial set has occurred, they may get on the concrete too early, increasing the likelihood of problems like exposed fibers and delamination.

Since there are fewer steel fibers (by volume) in the concrete, the appearance of bleedwater is not delayed. Therefore, timing the finishing of steel-fiber-reinforced concrete is the same as that for plain concrete, and finishing practices should not be significantly affected.

**Final floating operations.** For the final floating, use magnesium floats or power tools. Hold hand tools flat (not on edge) and move them with a sawing motion (short, quick, back-and-forth movements) as you draw them across the surface. Hand floats can be followed with a hard-steel troweling if a smooth surface is desired, but if you don’t keep the trowel flat, its edge will cause steel fibers to spring out of the surface.

During each power troweling pass, it is common to see steel fibers kicked out of the concrete surface by the finishing blades. These fibers should be removed from the surface of the slab be-
fore the next power troweling. Attaching magnets to power trowels helps pick up the surface fibers and prevents them from being pushed back into the wearing surface of the slab. After floating the surface, wait until final finishing can be done without damaging the concrete—usually about the time of the initial set.

**Final finishing operations.** Synthetic fibers are compatible with almost all concrete surface treatments and finishes, including pattern stamping, exposed aggregate, brooming, and hand or power troweling. Steel fibers, however, are not compatible with pattern stamping or exposed-aggregate finishes.

The use of burlap to texture concrete is generally not recommended on either steel- or synthetic-fiber-reinforced concrete, since a burlap drag is likely to lift up the fibers and tear the surface. Check with the fiber manufacturer before considering the use of a burlap finish.

If a textured surface is desired, you can use a stiff-bristled broom or a texturing rake (with about 60 tines), as long as it’s pulled in only one direction. If the rake or broom is pulled back and forth, it can disrupt the fibers. And to keep fibers from being pulled up, one steel-fiber manufacturer recommends holding the broom or rake at a very low angle to the surface of the concrete; the bristles or tines should be at an angle of less than 30 degrees.

**Sawcutting.** All forms of sawcutting equipment can be used with fiber-reinforced concrete. Low-volume fiber-reinforced concrete is sawcut in a similar fashion to nonreinforced concrete: A section should be cut and evaluated for surface spalling and raveling. If the sawcut ravel, delay the procedure for 30 to 60 minutes and then try again.

**Exposed fibers.** If there are exposed fibers at the slab surface, the relatively soft synthetic fibers generally wear off quickly under light traffic. Protruding carbon-steel fibers corrode at the surface. Under light traffic, the corroded fibers will brush off, but will leave small rust blemishes on the slab surface. In high-volume traffic areas, this is generally not a concern. If it is, use an embedded mineral or metallic hardener to ensure no steel fibers are visible. Steel fibers left exposed in hardened concrete can be clipped from the concrete with offset nippers or wire cutters.

**References**

1. ACI Committee 544, Guide for Specifying, Proportioning, Mixing, Placing, and Finishing Steel Fiber Reinforced Concrete, ACI 544.3R-93, American Concrete Institute, Farmington Hills, Mich., 1993.