Steel Fiber-Reinforced Concrete Design Considerations

1. ASTM A820 is the standard specification for steel fibers used as reinforcement in concrete. There are two principal physical delineations for the type of steel used, drawn wire and slit sheet. Drawn wire steel fibers fall within the Type I classification, whereas slit sheet products are listed as Type II.

2. Length, diameter, configuration, tensile strength and/or aspect ratio can be used to specify steel fiber.

3. The range in fiber length available is _" to 2". The 1" length provides both macro-micro crack reinforcement and hardened concrete benefits.

4. Aspect ratio is a pure number relating the diameter of the fiber to its length; it has two functions:

   - It provides a better understanding of the interfacial bond potential.
   - It determines the balling potential of fibers when introduced into the mixing system.

   When the aspect ratio exceeds 60, there is a potential of balling and fibers over 2" in length have this potential.

5. Configuration can be either straight, continuous-deformed, or end-deformed. Initially, straight fibers were the only configuration of steel fibers available. It was quickly learned that their bonding potential was limited which restricted their expected contribution to the engineering properties of concrete. New products were developed to increase the bond between the fiber and concrete and two configurations emerged as the two best configurations: A hooked-end, drawn-wire fiber and a continuously-deformed, slit-sheet steel fiber. It was determined that the continuous-deformed, slit-sheet fiber provided better micro-macro cracking performance, as well as flexural strength enhancement; whereas, the end-deformed, drawn-wire steel fibers performed best post-first-crack.

6. To provide optimum performance, steel fibers should be clean and free from rust, oil and deleterious materials. They should be introduced in a continuous stream to the mixing system which must be rotating at mixing speed.

7. Calcium chloride, and chlorides in general, should not be used with steel fibers. Although steel fibers do not exhibit the same rusting problems as continuous-steel reinforcement, it makes good engineering sense to avoid chlorides.

8. To improve consistency and mobility, low-, medium- and high-range water reducers are recommended for use with steel-fiber reinforced concrete. Typically, medium- and high-range water reducers are used as standard practice.

9. To measure concrete consistency, the standard slump cone ASTM C143 test can be used. There is also a specific test that for fiber reinforced concrete, ASTM C995, Inverted Slump Cone. When using this test, the optimum range for complete evacuation of the inverted slump cone is 10-30 seconds. If evacuation time is less than 10 seconds, the test is invalid, and the standard slump test should be used.

10. Two ASTM test methods apply to measuring the air content of fresh concrete: C231 is run with the pressure meter and C173 utilizes the roll-o-meter. The roll-o-meter is recommended with fiber-reinforced concrete, particularly for mixes with higher fiber dosage levels.

11. When fabricating specimens for hardened concrete tests, it is recommended the mold be externally vibrated vs. using the standard consolidation method of internal rodding, which may preferentially align the fibers.

12. Steel fibers are compatible with all standard admixtures and additives, such as air-entraining and water reducing admixtures, silica fume and fly ash. Since the proportions and consistency of a steel-fiber mix are important, it is recommended that trial mixes be fabricated to insure target strength values are achieved and that mix consistency/workability are acceptable.

13. When pumping steel fiber-reinforced concrete, use a 6” line and minimal flexible hose. Do not try to pump a steel-fiber mix that is too wet. Also, ensure the mix ingredients are properly proportioned. More mortar than coarse aggregate is appropriate and permitted within ACI 211’s mix design guidelines.

14. Steel fiber-reinforced concrete increases strain capacity and impact resistance, as well as energy absorption and tensile strength. Dosage level, fiber length and configuration are all factors in determining the increase achieved.

15. In marine structures, steel fibers have been proven to enhance resistance to abrasion, cavitation and erosion. Wetting and drying and elevated salt levels have not proven to be a problem with durability, this based on a number of reports on installations in Eastern Canada.

16. Nycon uses a computer-based version of the Westergaard analysis method to calculate the thickness of slabs-on-ground. The program looks at a large range of in-situ and design parameters—from axle loads to uniformly distributed loads to rack loading. Design factors, such as soil loading (k) and safety factors, can be adjusted to provide various potential cross-sections to meet the requirements of a specific application. When provided with design and project site information, Nycon engineers are available to assist in producing cross-section data for a range of steel fiber dosage levels. A Design Request Form (sample following) should be completed by project/consulting engineer(s) and submitted to Nycon for design assistance.