FIP 3 – PLACING, PUMPING & FINISHING FIBER-REINFORCED CONCRETE

Fibers of different materials, architecture and dimensions will act differently during the placement, pumping, and finishing of fiber-reinforced concrete (FRC). Therefore, it is important that fibers are properly added and mixed to allow for optimum placement, pumping and finishing (see FIP 2 – Batching Fiber-Reinforced Concrete). Recommendations from the specific fiber supplier will be the most valuable source of information. However, the following general suggestions may help the contractor avoid job-site fiber-related problems:

Placing Fiber-Reinforced Concrete

Typically, higher dosages and longer length fibers affect the rheology of plastic concrete more than lower dosages and shorter length fibers. Consequently, cellulose and synthetic microfibers rarely affect the rheology of plastic concrete to any major degree, due to their relatively short lengths and low dosages.

In general, most steel and synthetic macrofibers – especially at high dosages – will impact the visual slump or slump flow of fresh concrete as measured by the respective slump cone tests. It is important to note that the slump cone measurement is intended only as proof of consistency from one concrete truck to another, and is not an indication of the actual workability of the concrete mix. Though neither synthetic polyolefin nor steel fibers absorb mix water, they do act as a cohesive agent in plastic concrete and, in the static state, can cause the FRC to appear stiffer to those unaccustomed to working with the material. This may raise concern regarding the workability of the mixture.

However, these fibers affect the workability of concrete much less than would be perceived from the slump cone measurement. As such, it is important for the concrete producer and concrete contractor to be aware of this observation regarding FRC and not add water in excess of the design water-cementitious materials ratio (w/cm) to the mix to recover this perceived slump loss. FRC generally moves well during placement once vibration energy is applied to the plastic concrete. However, if additional slump or workability is required during placement, water-reducing admixtures – in particular, mid- or high-range water reducers – or a workability-retaining admixture should be used.

Pumping Fiber-Reinforced Concrete

The pumping of fiber-reinforced concrete is also related to the visual slump vs. true workability dynamic of the material. Though the three-dimensionally distributed fibers act as a cohesive agent in the plastic concrete, they allow for relatively easy movement of the FRC once the energy of pumping is applied. Properly dispersed fibers will typically not impede the pumping of FRC and sometimes may slightly lower and even out pump pressures. Higher dosages and higher modulus (stiffer) fibers, such as steel and some polyolefins, may affect pumpability. Therefore, proactive measures may be necessary to prevent line clogging or material stoppage in the pump lines. These measures include increasing the

mortar volume by 10% in accordance with the recommendations provided in ACI 211.1 or implementing adjustments based on prior experience with the specific fiber.

In all cases, pre-project trials using the exact pump mix with the specified dosage of the specified fiber are highly recommended to prevent potential pumping issues during a project. One area that should be addressed during project pre-construction meetings is the type of pump-hopper grate that will be used on the project. As fiber dosages increase and cohesiveness of the resulting concrete mix increases proportionately, FRC may tend to build up and bridge over the pump grate, rather than easily slip past and into the pump hopper. Round-bar grates are preferred as fiber dosages and fiber lengths increase, because they allow for easier flow of FRC compared to conventional slatted pump grates. Adequate grate and/or hopper vibration should also be maintained to help energize and move FRC past the grate and into the hopper pumping chamber. Fiber producer recommendations should be considered carefully regarding the optimum pump grate and pumping procedure for a given fiber and dosage.

Finishing Fiber-Reinforced Concrete

Fiber material type, architecture, dimension and dosage may each affect the surface finish of FRC, as well as the required surface-finishing methods used for a given project. For instance, stiff or rigid fibers may show more tendency to protrude up through the slab surface more than relatively flexible low-modulus fibers. Depending again on the fiber material type, architecture, dimension and dosage, the finished surface appearance may change depending on the distance to the observed surface (down on hands and knees, or standing). In some cases, a particular fiber may lay down better in short length, whereas a different fiber shape may actually lay-in to the concrete surface better in longer lengths.

Again, pre-project trials using the chosen fiber and dosage should be performed to qualify owner expectations and placement capabilities of the contractor. Fiber supplier recommendations should be observed for best surface finishing practices for a particular fiber type. It is important to note that fibers are three-dimensionally distributed within the entire concrete cross-section, and therefore fibers will be in the top, middle and bottom of the slabs and may require special operations to secure a suitable surface finish. Fibers that appear on a slab surface may not affect the overall performance of the concrete, but owner preference for aesthetics should be considered and approved prior to lay down. Finishing practices that disrupt the slab surface will naturally also affect the appearance of fibers that lie at or near the surface. For example, a textured or broomed exterior surface finish will have a tendency to reveal more surface fibers than a smooth, hard-troweled finish.

A variety of broom-finishing tips are available from fiber suppliers to help minimize surface appearance, such as brooming in one direction only and using a specific broom bristle to help align surface fibers. If necessary, a torch can be used to burn off synthetic fibers on the surface of the concrete. A laser screed or vibrating screed is recommended for finishing of industrial, commercial and warehouse floors where high dosage levels of synthetic macrofibers and steel fibers are used. This will ensure a more uniform consolidation of the concrete and the desired finish.

Pre-Project Trials

Fibers made of cellulose, steel or synthetics are distributed three-dimensionally throughout the entire concrete matrix and, therefore, may impact the placement, pumping or finishing of a FRC slab or project. Each fiber material type, architecture, dimension and dosage will affect these operations in different ways and to different degrees. Therefore, pre-project trials using the specific concrete mixture, fiber type and dosage, and pumping and finishing equipment are highly recommended to enable changes to be made prior to the official project start-up, as well as minimize fiber issues during the run of the project.

REFERENCES:

1. FIP 2 – Batching Fiber-Reinforced Concrete, Fiber Reinforced Concrete Association
2. ACI 544.1 R-96 – Report on Fiber Reinforced Concrete, American Concrete Institute
3. ASTM C 1116/C1116M – Standard Specification for Fiber Reinforced Concrete, ASTM International