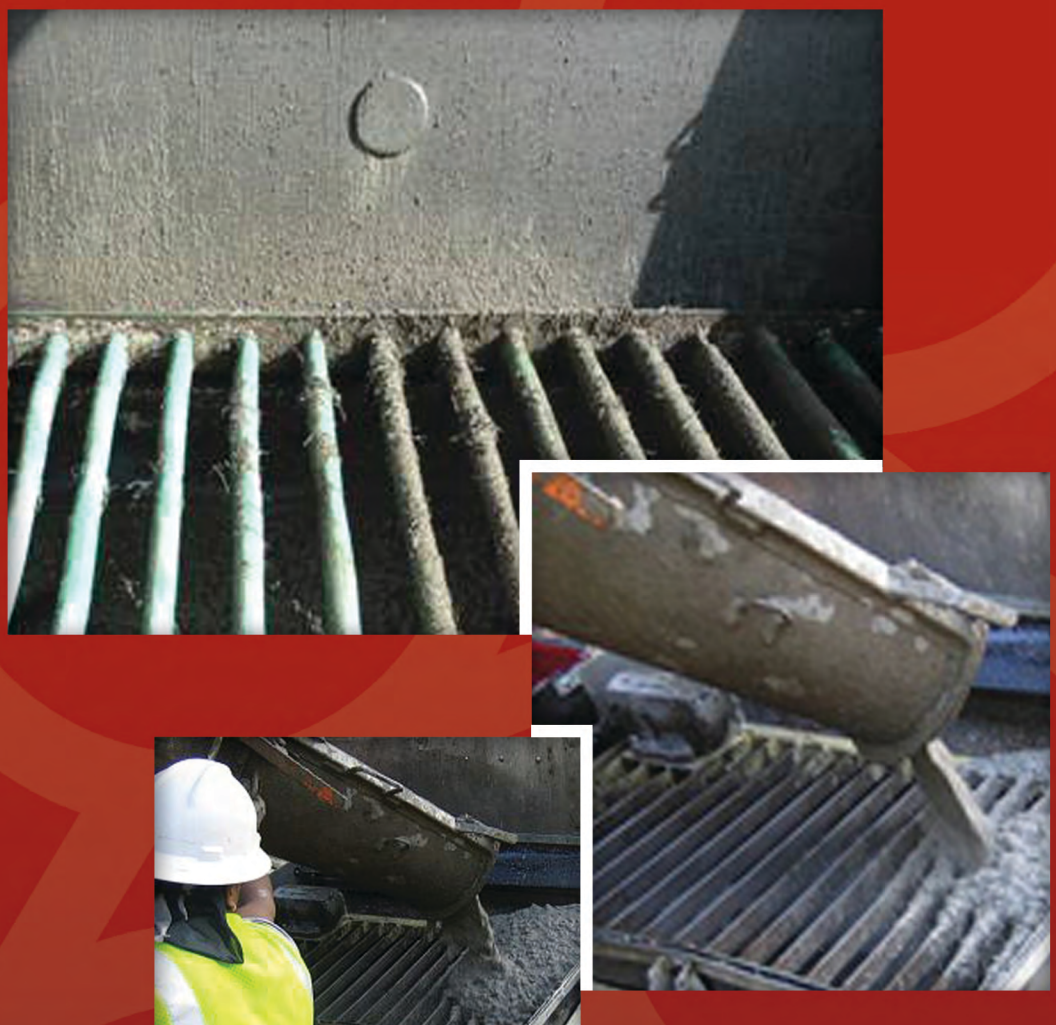
FORTA® Corporation



Pumping High-Volume Fibers

Technical Report

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FORTA Corporation
TECHNICAL REPORT

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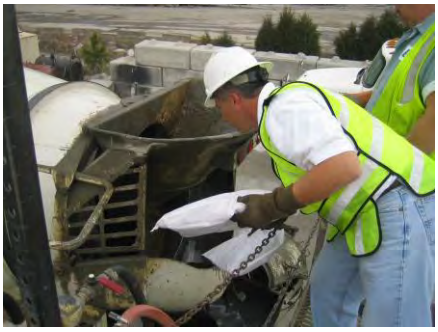
Introduction

In 1978, FORTA Corporation introduced the concept of three-dimensional synthetic fiber reinforcement to the construction market worldwide. At that time, typical fiber dosages were relatively low at approximately 0.1% by volume, in the range of 1.0 to 1.5 lbs. per cubic yard of concrete. These first-generation fibers at these low dosages were designed and used to control plastic shrinkage and temperature-related cracking in a wide variety of precast, shotcrete, and flatwork applications. In applications and projects where this low-dosage fiber-reinforced concrete was pumped, minimal effect was realized in the overall pumping process. Though a small amount of fiber buildup was noted on the pump-hopper grate, no major changes to the pumping operation were evident.

With the advent of High Volume Synthetic Fibers (HVSF) or macrosynthetic fibers such as FORTA-FERRO® in 1999, pumping issues became more noticeable and challenging. At fiber dosages of 4 to 5 times that of the first-generation fibers, it became important to adjust normal pumping practices to accommodate the higher volume of these macrosynthetic fibers, and to search for solutions that would ease the pumping dilemmas in the field.

General Pumping Pointers

For both low-volume and high-volume fiber projects, there are general pointers that will assist ready-mix producers and pumping contractors in minimizing project-site delays and problems. Concrete that includes synthetic fiber reinforcement has historically been very pumpable, however following the simple precautions noted below will help insure a successful project and a trouble-free jobsite.



Mixing

Avoid adding fibers as a first ingredient to central-batch mixing systems or ready-mix trucks. When fibers are added first, the odds for fiber mixing and balling problems increase dramatically. Add fibers with other ingredients or at the end of the batch cycle. When superplasticizers are used, it may be of advantage to add and mix the fibers prior to adding the admixture to allow for sufficient mixing friction.

Slump

When synthetic fibers are added to the mix, the visual slump (as measured by the slump cone) will be reduced, though actual flowability and workability will not be affected to the same degree. Naturally, low slump mixes (less than 3″) can be a challenge to pump – with or without fibers. Most synthetic fibers are hydrophobic – do not absorb water – and do not take free water out of the mix. Fibers do, however, tend to act as a cohesive agent and bind the mix together, though actual pumpability is rarely affected. In fact, in many cases, pumped fiber concrete projects have reported a more uniform resulting pump pressure and slightly less-than-normal pump pressure due to the reduced segregation in the fiber mixes.

Speed

It is important not to pile up the FRC (Fiber Reinforced Concrete) on the grate. The ready mix truck operator should discharge the fiber concrete into the pump hopper only as fast as the pump auger can take it away. The fiber-reinforced mix moves quite well, but is sometimes difficult to restart once it has become static.

Chute

The position and placement of the ready-mix truck chute is probably the most important aspect when pumping fiber-reinforced concrete. In normal situations, the chute is typically placed at the very bottom of the pump hopper, and most often rests directly on the grate surface. With fibers acting as a cohesive agent in the mix, this placement typically results in a FRC buildup that is difficult to move through the grate. With FRC mixes, especially with long-length and high fiber dosages, it is important to raise the chute much higher (i.e. 12″ from the grate surface) to allow for natural falling velocity to help the concrete pass through the grate. Depending on the landscape and position of the pump truck on the site, this may require a temporary ramp buildup in front of the pump hopper to allow for the chute to be elevated, yet still retain enough slope to allow for concrete discharge flow down the chute.

It is also beneficial to place the chute nearer the back or uppermost part of the pump grate instead of near the bottom seam. This higher position will give the FRC more opportunity and space to work its way down through the grate openings. Grates that are sloped are much better for FRC mixes than flat, horizontal grates.

Vibration

Though FRC often looks stiffer than plain concrete, it still moves quite well under vibration. A strong vibrator on the grate is important to minimize fiber buildup and maximize FRC flow. On some pump trucks, the grate vibrator is activated only when the pump is in actual operation, making it important not to pile up excess FRC on the grate during the non-pumping/non-vibration periods. Vibrators mounted directly on the grate surface will be much more effective in moving FRC mixes than those mounted only on the hopper shell.

High Volume Fibers

Macro or structural synthetic fibers – FORTA-FERRO® – entered the concrete market in 1999 as a next-generation alternative to a much higher level of conventional reinforcing steel in a wide variety of applications. The advent of this level of synthetic fiber brought with it longer lengths, heavier filaments, and much higher dosage levels than first-generation fibers, and therefore magnified pumping issues.

The unique patented twisted-bundle configuration of FORTA-FERRO® has proven to allow for very uniform distribution of the fibers, and virtually eliminate the clumping and balling issues that are typical of many other types and brands of macro fiber. This uniform mixing action has been an important benefit in pumped-concrete projects, however issues remained at the hopper grate – especially at the typical high-dosage levels required for these high-performance fibers. Following the previously mentioned general pumping pointers will minimize problems of buildup and flow-through at the pump grate at low fiber dosages of 3-4 pounds per cubic yard, however dosages above the 4-pound level typically require a modification to standard pump-grate equipment. Conventional pump grates consist of thin rectangular, metal slats, generally spaced 2-1/2″ apart, to prevent large rocks, cement balls, and other large objects from entering the pump hopper and risk causing damage or line blockages. High dosages of long-length, heavy-duty macro-fibers tend to drape over and build up on thin-slat grates, and concrete movement through the grate becomes almost impossible.

The ‘Round-Bar’ Grate Solution

After several years of trial-and-error exercises and in partnership with a major concrete pump manufacturer and several progressive pumping contractors, FORTA Corporation introduced a pump-grate solution that has eliminated those issues related to high-volume fiber mixes. Instead of the thin-slat grate design, pumping contractors have switched to a ‘round-bar’ grate configuration that minimizes fiber build-up and allows high-volume fiber mixes to flow easily into the hopper. Trial configurations of round-bar grates have ranged from 1″ diameter bars up to almost 3″, with 1-1/2″ to 2″ bars eventually becoming the most common, while preserving the same 2-1/2″ bar-to-bar space opening as conventional grates. The large diameter round grate bars tend to be self-cleansing and facilitate an easy roll-off and flow-through of the fiber-reinforced concrete, even at fiber dosages of 7.5 lbs./cubic yard and higher. As mentioned previously, the actual pumping portion of the process has never been a problem – pump pressures are typically more even and slightly less than might be expected – even at the higher dosages above 4 pounds.

Example of a trial grate using 1″ bars on the left, and larger 1-1/2″ bars on the right. In actual use, the larger bars tend to optimize flow-through and minimize buildup.

Working vibrators are critical to improving flow-through of high-volume fiber mixes.

Even if FRC buildup occurs, adequate vibration quickly moves the high-fiber mixes through the round-bar grate.

The round-bar grate is essentially self-cleansing, even at high fiber dosages.

Safety

Naturally, the temptation exists to simply lift or remove the grate from the pump hopper to avoid any potential flow issues with high-volume fiber mixes. Most concrete pumps are fitted with a safety shut-off switch to prevent the pump from operating if the pump grate is not in the closed position. FORTA Corporation does not recommend lifting or removal of the grate, due to the increased risk of pump damage from large articles and serious safety risks to operators or drivers from possible blow-back from the pump hopper.

Creating a Round-Bar Grate

Many pump manufacturers offer a variety of pump grate configurations to accommodate various pumping issues, and can be contacted regarding availability of a high-fiber, round-bar grate to fit most models. An alternative that has been performed by several U. S. pumping contractors is to simply recycle an old deteriorated slatted grate by removing the worn slats from the grate frame and replacing them with 1-1/2″ to 2-1/2″ round-bar stock. Many progressive pumping contractors have retrofitted discarded slat grates into round-bar grates, and now actively market their "first-in-the-area" ability to quickly and easily handle the rapidly-increasing number of high-fiber project.

A Pumping Pre-Con Alert

If in fact high-fiber dosed concrete is to be pumped on a project, it is important to alert the pumping contractor at an early pre-construction meeting to afford them time to accommodate and install a round-bar grate. As macrosynthetic fiber applications become more and more common, project specifiers have begun adding a round-bar grate stipulation to project specifications to help avoid any pumping issues on the job. This stipulation can be as simple as: "For application areas where the macrosynthetic fiber dosage exceeds 4.0 lbs./cubic yard, the concrete pumping contractor must provide a large-diameter round-bar pump grate to allow for the easy and rapid pass-through of the fiber-reinforced concrete into the pump hopper.

Last-Minute Quick-Fix Options

If, for whatever reason, the project specification for a constructed round-bar grate or the pre-con meeting forewarnings regarding a grate correction for a high-fiber project were ignored, there are two last-minute solution options that have been successfully used on past jobs – a large pipe layover and a small hose cover. Though not as efficient or effective as a true manufactured round-bar grate, both last-minute options are relatively inexpensive to prepare and quick to install.

A large diameter pipe layover has been used many times on high-fiber projects, and is the best performing alternative to a true pre-built round-bar grate. In essence, the process involves using large diameter pipes made of steel or PVC to rest in between every other slat opening in the grate, thereby creating a wide, round upper surface for the fiber concrete to slide over. Pipes should be slightly larger in diameter than the slat-opening space, which is typically 2 ½" wide on most grates. Pipe diameters of approximately 2 7/8" to 3" have worked well on previous project trials. The pipes can be pre-cut to length based on the hopper height – generally 25" to 27" long for total hopper span or shorter lengths if a grate vibrator is installed within the grate surface. Once cut to length, the layover pipes can be easily secured to the grate slats with long zip-ties placed at top and bottom, spinning the zip buckles to the bottom and clipping the ends to minimize potential fiber hang-up. The pipe install time requires just a few minutes, and allows the high-volume fiber mix to melt easily over and between the pipes and eliminate fiber drape-over the normal thin metal slats. Even though this process

essentially blocks half of the open-slat area, the overall flow-through process has not been significantly hampered in previous project experience.

Metal pipe lay-over method zip-tied in place.

PVC pipe lay-over being zip-tied into place between slats.

Conclusion

Over the past 10 years, second-generation macrosynthetic fibers have become a more and more popular method to replace higher levels of conventional steel reinforcement, reduce cracking, and offer substantial cost-savings to a wide variety of concrete project applications. And pumping of this concrete into difficult project locations has also become a more frequent occurrence. The round-bar grate solution to high-fiber mix flow issues has eliminated a cause for concern in that regard, and has proven to allow for trouble-free pumping job-sites. For additional information or to view examples of the FORTA®-designed round-bar grate in action, please visit www.forta-ferro.com and scroll onto the "Video" button to view "Pumping Round Bar Grate."

FORTA® personnel are available to assist with fiber selection and use, as well as the explanation of reasonable expectations of the fiber. FORTA® representatives do not engage in the practice of engineering or architecture as licensed by government agencies, nor are they licensed to act in a role of overall project supervision where FORTA® products are used. FORTA® personnel are available solely for the support of our customers - those that purchase and specify our products.

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