CONCRETE FIBER SOLUTIONS

DESIGNERS GUIDE: STEEL FIBER REINFORCEMENT FOR GROUND SUPPORTED SLABS

CFS 100-2 FIBERS

SUPERIOR CRACK CONTROL – COST SAVING – FASTER INSTALLATION

Meets ASTM A820

UL CERTIFIED

WWW.CONCRETEFIBERSOLUTIONS.COM

DESIGNERS GUIDE: STEEL FIBER REINFORCEMENT FOR GROUND SUPPORTED SLABS

CFS 100-2 FIBERS

Steel fibers can help control random cracks in ground-supported concrete floors. In ordinary jointed floors, steel fibers provide a safety net by limiting the width of any cracks that occur, by accident, between the joints. In floors with extended joints, steel fibers take on the primary role in preventing visible cracks while allowing monolithic slabs up to 110' long.

This guide offers information on using steel fibers in both kinds of floors. It does not cover the use of steel fibers in suspended floors, including composite steel deck-slabs and pile-supported structural slabs.

Jointed Floors with Steel Fibers

In these floors, closely-spaced sawcut joints form the main defense against random cracks. Most designs space the joints no more than 20 ft apart. ACI 360, *Guide to Design of Slabs-on-Ground* describes these floors as "slabs reinforced for crack-width control" and categorizes them as Type 2a slabs.

The purpose of the steel fibers is to limit the width of any cracks that occur between the joints and to enhance aggregate interlock at the joints. The steel fibers play a role similar to that of wire mesh or light rebar in other floor designs, but fibers offer two important advantages over those other reinforcing materials. First, steel fibers are always distributed throughout the floor. In contrast, wire mesh and rebar often ends up at the wrong elevation. Second, steel fibers don't get in the way when concrete is placed. In contrast, wire mesh and rebar interfere with concrete trucks and screeding machines, and they create a trip hazard.

To use steel fibers in an ordinary jointed floor, follow these rules:

1. Specify Type II fibers, 1 inch long, continuously deformed, with an aspect ratio of 43. CFS100-2 as manufactured by Concrete Fiber Solutions
2. Specify a fiber dosage of 15-25 lb/yd^3
3. Determine slab thickness and concrete strength as if the slab were unreinforced
4. Determine joint spacing as if the slab were unreinforced
5. Use dowels at construction joints, unless load transfer is not needed
6. Omit dowels at sawcut joints (but see discussion below)

WHY STEEL FIBERS?

CFS believes that steel fibers are the best means to control shrinkage cracking. We don't just claim this but we will prove it.

Our CFS 100-2 steel fiber:

- Meets requirements of ASTM A820
- Provides superior crack control
- Is easily placed and finished
- Saves time and money on the job

concretefibersolutions.com

704-571-1323

7. Saw joints to one fourth the slab depth
8. Consider adding short lengths of rebar at re-entrant corners and other potential crack inducers

Rules 3, 4, and 6 deserve extra discussion.

Rule 3 deals with the floor's basic structural design -- the process of determining what combination of sub-base, slab thickness, and concrete strength is needed to support the intended loads. Steel fibers at 25 lb/yd^3 have practically no effect on concrete's compressive and flexural strengths. For that reason, we at Concrete Fiber Solutions recommend that the fibers not be taken into account in the structural design. Some engineers disagree, recommending designs based on a property called residual strength or flexural toughness. We believe the science behind residual-strength designs has not been proven, and may never be proven.

Rule 4 deals with joint spacing -- a complicated, controversial subject, which will not be settled here. We make no recommendation on joint spacing beyond this: If your goal is to minimize visible cracks, do not expect steel fibers at 15-25 lb/yd3 to allow any increase in joint spacing over what you would feel comfortable specifying for an unreinforced floor. The fibers are there not to prevent cracks, but to limit their width.

Rule 6 deals with load transfer across sawcut joints. Steel fibers improve load transfer and have generally proven adequate in the absence of dowels. The risk exists, however, that some joints will open so wide that they lose the ability to transfer load. If the floor usage demands near-perfect load transfer no matter what, consider adding dowels under the sawcut joints. Alternatively, consider testing the joints later for differential movement and installing mechanical stabilizers where readings exceed 0.010 in. (for vehicles with hard tires) or 0.020 in. (for vehicles with cushion tires).

Extended Joint Floors with Steel Fibers

In these floors, steel fibers form the main defense against random cracks. Slabs are cast up to 110 ft long and 110 ft wide without intermediate joints. The purpose of the steel fibers is to prevent visible cracks by stopping microcracks from growing. While no design method or material can guarantee the total elimination of all visible cracks, steel fibers in high doses have proven highly effective at crack prevention.

Steel fibers are not the only way to achieve an extended-joint floor, but they offer one big advantage over the alternatives of shrinkage-compensating concrete, post-tensioning, and heavy continuous reinforcement. All those alternatives require that substantial amounts of steel be installed ahead of the concrete pour. In contrast, with a steel-fiber design all the reinforcement comes down the chute of the concrete truck.

To use steel fibers in an extended-joint floor, follow these rules:

1. Specify Type II fibers, 1 inch long, continuously deformed, with an aspect ratio of 43. CFS100-2 as manufactured by Concrete Fiber Solutions.
2. Specify a fiber dosage of 65 lb/yd^3.
3. Specify concrete with 28-day drying shrinkage of no more than 0.035%, when tested to ASTM C157 (air-storage method).
4. Determine slab thickness and concrete strength as if the slab were unreinforced.
5. Divide the floor into slabs no more than 110 ft by 110 ft.
6. Make the slabs square or rectangular, with an aspect ratio not to exceed 1.5.
7. Avoid changes in slab thickness within any slab.
8. Install a polyethylene slipsheet directly beneath the slabs.

9. Carefully isolate the slabs from columns, walls, and all other building elements with 1 in. of soft, compressible foam.
10. Do not tie the slabs to any other building elements.
11. Avoid re-entrant corners.
12. Make no sawcuts or other induced joints within the slabs.
13. Use dowels at the construction joints between slabs.
14. Expect the construction joints to open wider than in an ordinary jointed floor. Consider armoring the joints, or filling them late in the construction schedule.

Why Specify CFS 100-2 Fibers

COST

Time is money in construction. In the time it takes to set the mesh or rebar, concrete with steel fibers could have been placed and finished. And with a steel fiber reinforced slab the required number of sawcuts is greatly reduced saving even more time and expense.

SAFETY

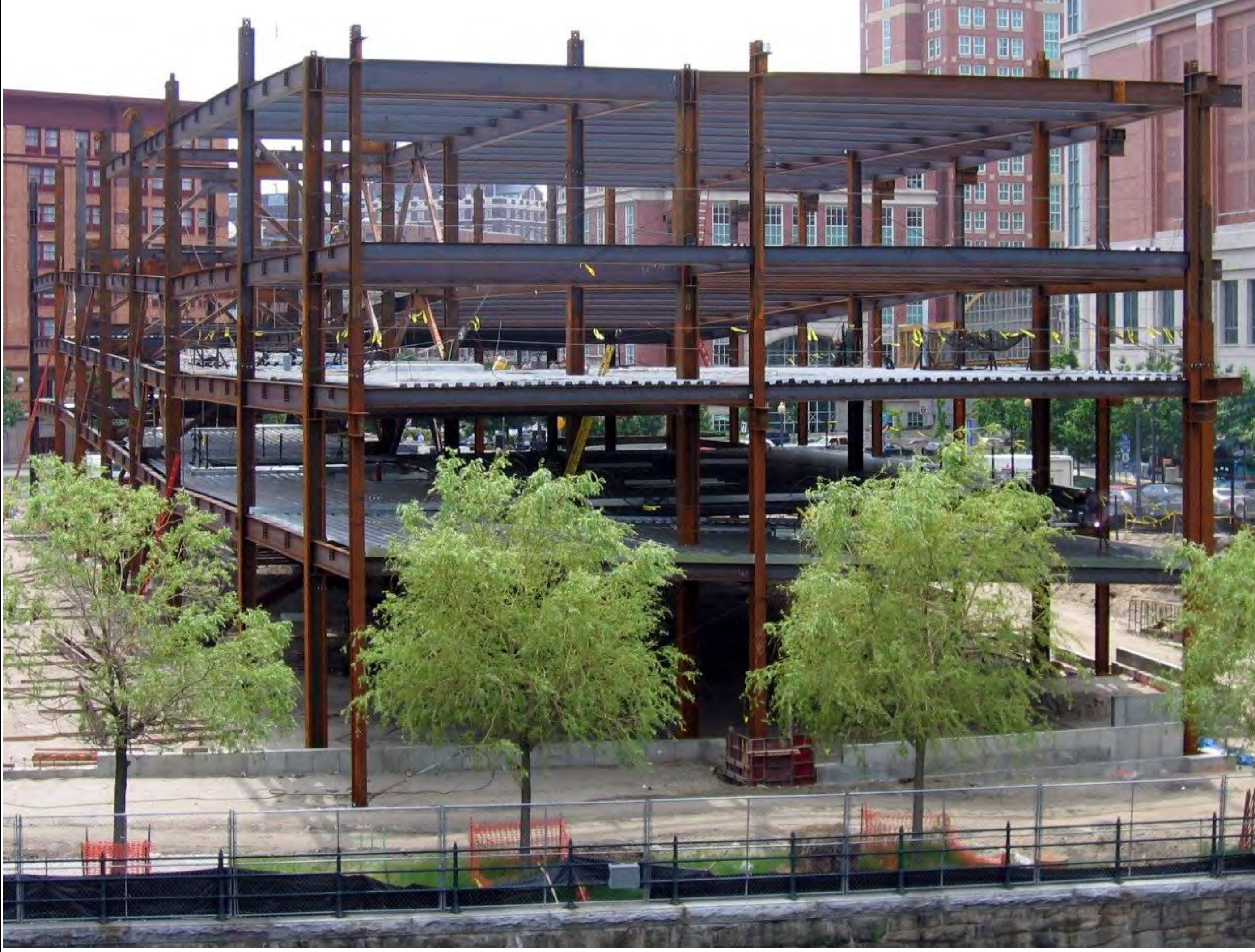
One of the leading tripping hazards on a jobsite is the mesh or rebar. This is completely eliminated with the use of steel fibers. This not only reduces the potential injuries and insurance claims for the concrete

When designing or constructing your next project using composite steel deck, specify Concrete Fiber Solutions CFS 100-2 steel fiber for the best results and lower costs.

CFS CONCRETE FIBER SOLUTIONS

750 West Lake Cook Rd.
Buffalo Grove, IL 60089
Tel: 704.571.1323
Email: Mike.McPhee@concretefibersolutions.com

CFS
CONCRETE FIBER
SOLUTIONS



COMPOSITE STEEL DECK

CFS 150-5 FIBERS

SUPERIOR CRACK CONTROL – COST SAVING – FASTER INSTALLATION

Meets ANSI / SDI C-2011

UL CERTIFIED

WWW.CONCRETEFIBERSOLUTIONS.COM

COMPOSITE STEEL DECK

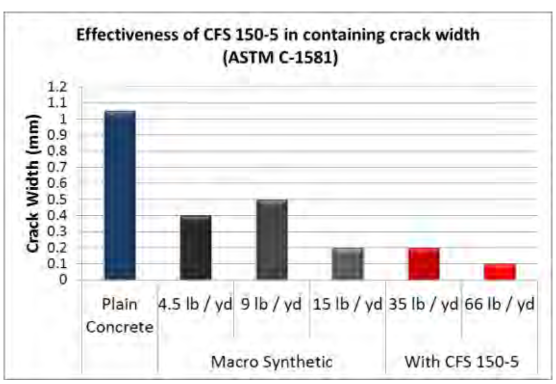
CFS 150-5 FIBERS

Steel fibers and composite steel decks have been a match for over 15 years. The Standard for Composite Steel Floor Deck-Slabs (ANSI/SDI C-2011) governs the materials, design and erection of composite slabs utilizing cold formed steel deck functioning as a permanent form and as reinforcement for positive moment in floor applications in buildings. Steel fibers are used for temperature/shrinkage reinforcement in these buildings. In these applications, any concrete floor cast on a metal frame and deck system is severely restrained from movement. When the concrete shrinks, the steel frame does not. This restraint causes tensile stress to develop in the concrete, which leads to shrinkage cracks. The SDI recommends three materials to control these cracks. Which is best?

Why Choose CFS 150-5 Fibers

CRACK CONTROL

To quote Dr. Tom Ryan: “It’s virtually impossible to keep the WWF near the top of the slab because it gets pushed down by the worker’s feet, pump lines, and the weight of the concrete. The fabrics final resting place is usually the top of the metal decking where it is of no value.”



Save time and money by using CFS 150-5 steel fibers in these applications. Nothing is better for shrinkage crack control than steel fibers since they eliminate the proper positioning of mesh and its associated costs.

WHY STEEL FIBERS?

CFS believes that steel fibers are the best means to control shrinkage cracking. We don’t just claim this but we will prove it.

Our CFS 150-5 steel fiber:

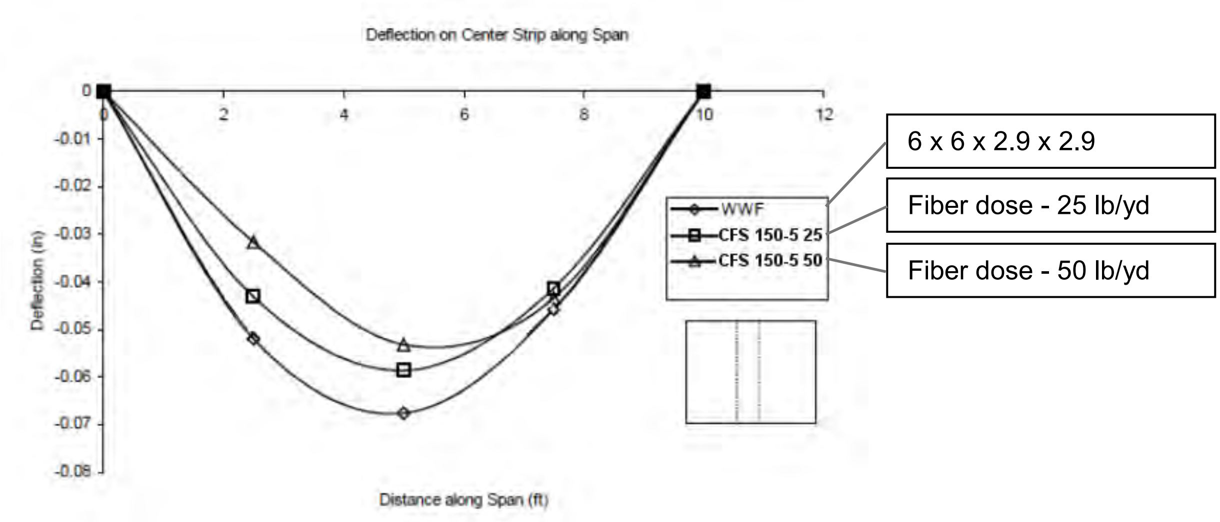
- Meets ANSI/SDI C-2011
- Provides superior crack control
- Is easily pumped and finished
- Saves time and money on the job

concretefibersolutions.com

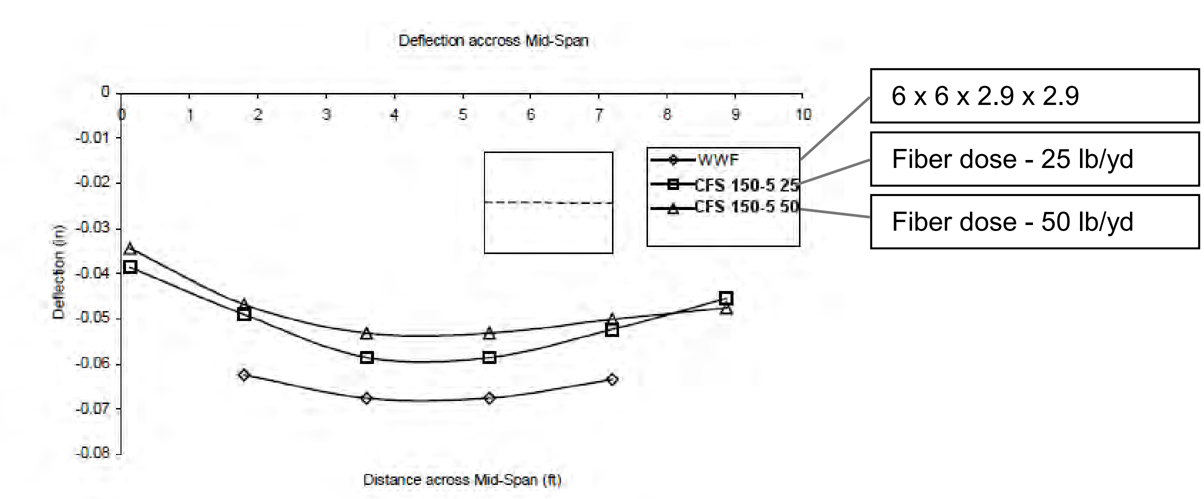
704-571-1323

DEFLECTION

Deflection on composite steel deck applications is always a concern. The more the slab deflects the larger the cracks. With this in mind test were conducted at Virginia Tech to compare the performance between steel fibers and mesh under load. The results: "Results showed that at the same load magnitude and location, the slabs reinforced with steel fibers had smaller deflections and strains than the slabs reinforced with WWF…"



DEFLECTION ALONG SPAN'S CENTER STRIP WITH 10 KIP CONCENTRATED LOAD AT MID-SPAN



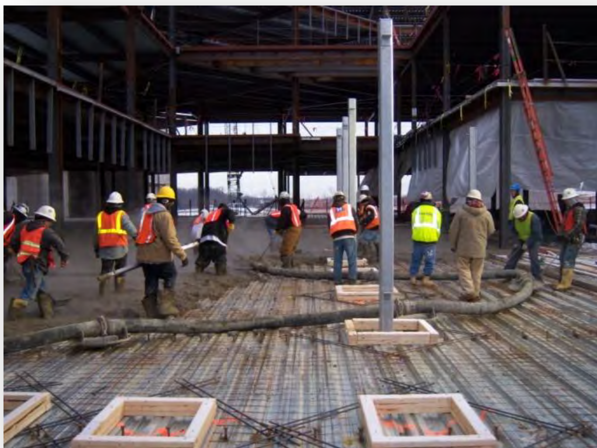
DEFLECTION ACROSS MID-SPAN STRIP WITH 10 KIP CONCENTRATED LOAD AT MID SPAN

COST

Time is money in construction. In the time it takes to set the mesh on the deck, concrete with steel fibers could have been placed and finished. There is no labor cost for installation, crane time to get the mesh on the deck or labor associated with keeping the mesh positioned properly.

SAFETY

One of the leading tripping hazards on deck is the mesh. This is completely eliminated with the use of steel fibers. This not only reduces the potential injuries and insurance claims for the concrete contractor but for all the trades working on the project.



WELDED WIRE FABRIC: CLUTTERED DECK WITH EXTENSIVE TRIP HAZARDS, MESH OUT OF POSITION RESTING ON TOP OF DECK

WITH CFS 150-5: A CLEAN DECK FREE FROM TRIP HAZARDS

LEED

CFS 150-5 is made from re-cycled material. The use of CFS 150-5 steel fibers will go to meeting LEEDS requirements on many projects while providing excellent results.

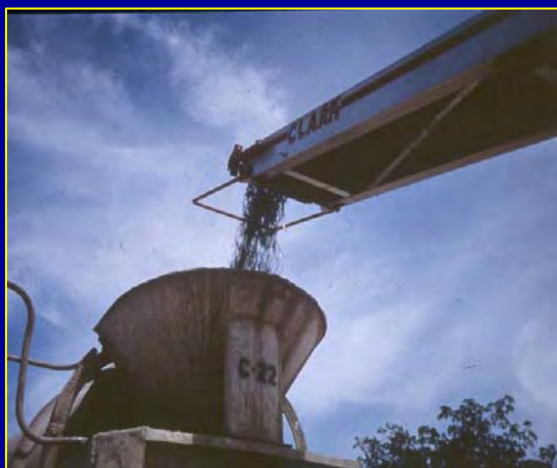
CFS150-5 is UL fire rated for D700, D800, and D900 series designs.

When designing or constructing your next project using composite steel deck, specify Concrete Fiber Solutions CFS 150-5 steel fiber for the best results and lower costs.

CONCRETE FIBER SOLUTIONS
750 West Lake Cook Rd.
Buffalo Grove, IL 60089
Tel: 704.571.1323
Email: Mike.McPhee@concretefibersolutions.com

Mixing, Placing, and Finishing

LOADING FIBERS WITH CONVEYOR



CONCRETE BEING TRUCK DUMPED

LOADING FIBERS ON PLATFORM

CONCRETE BEING PUMPED

Steel fibers can be added before during or after the concrete has been added to the truck. The fiber must mix for 3-4 minutes. Steel fibers are compatible with most admixtures. Calcium chloride should not be used with any steel product.

Steel fiber reinforced concrete can be handled by any means. Steel fiber reinforced concrete does not require any special procedures.

Mixing, Placing, and Finishing

LASERSCREED AND FIBERS THE PERFECT COMBINATION

SFRC BEING FINISHED WITH PANS

BROOM FINISH AND TOOLING JOINTS

SOFFCUT SAW

THE FINISHED JOINT

Mixing, Placing, and Finishing

FINISHED POLISHED FLOOR

FINISHED STEEL COIL FACILITY

FINISHED STEEL PROCESSING PLANT

FINISHED DISTRIBUTION FLOOR

FINISHED FLOOR AT THOMAS BUS

UltraFiber 302 Blend

If you think that Fiber Blends won't stand up to the competition then take a look at how each product fairs in a comparison.
Ultra-Fiber 302 meets and/or exceeds the others in every category.

Features	UltraFiber 302	Macro-Fibers	Welded Wire
Reinforcing always positioned properly	Yes - mixed throughout concrete matrix	Yes - mixed throughout concrete matrix	No - Requires support and labor intensive
Reduction in Plastic Shrinkage and temp. Cracks/Early Age Benefits	Yes	Yes	No
Crack Control in Hardened Concrete	Yes- very high tensile strength and high modulus of elasticity	No - low modulus of elasticity	Yes - if properly positioned in the upper third of the slab
Easy to place in the concrete mix	Yes - mixed into concrete	Yes - mixed into concrete	No - must be supported on chairs or slab bolsters in upper third of the slab
Provides three dimensional reinforcement	Yes	Yes	No - reinforcement is only on one plane in the concrete
Superior finish with no effect on workability of the mix	Yes	No - Common issue, fibers on surface and must use ad mixtures to maintain workability	No - slows the placing and finishing of the concrete
Cost effective, safe to use and no labor	Yes	Yes - but requires the additional cost of $8- $10 in admixtures per cubic yard to place and finish	No - very labor intensive and a safety hazard
Building code approved	Yes	Yes	Yes - only 4x4 4/4 welded wire mats on supports
Meets ACI 302-15 design guide lines for slab on ground	Yes	Yes	Yes - only 4x4 4/4 welded wire mats on supports
Renewable materials & environmentally friendly	Yes	No	No
Meets or exceeds ASTM specifications	Yes	Yes	Yes – only if certified
Impact and shatter resistance	Yes	Starting at 6 lb dosage some improvement	None
Corrosion resistant	Yes	Yes	No - corrodes when exposed to water and chemicals; aesthetics and possible disruption
Accepted Design Protocol - additional tensile capacity	Steel Component	No	Very limited and based on WWF size
Extend Joint Spacing	No	No	No
Higher Residual Strength Characteristics	Yes	Yes	No

SOLOMON COLORS, INC.

Ed McLean, Director of Fiber Products – (217) 527-1139
4050 Color Plant Road | Springfield, IL 62702
emclean@solomoncolors.com
www.solomoncolors.com

ULTRAFIBER 302 BLEND™

UltraFiber 500® Natural Cellulose Fiber blend with CFS Cold Drawn Steel Fibers

Advantages of UltraFiber 302 Fiber Blend

ACI 302 recognizes the benefits of using a natural cellulose micro fiber and steel fiber blend to reduce early age plastic shrinkage and provide long term crack control. Additionally, this fiber blend improves the tensile strength/capacity of the concrete. The UltraFiber 302 Blend can replace traditional continuous steel for temperature and shrinkage reinforcement. UltraFiber 500® is the fiber of choice for decorative concrete and a proven performer reducing plastic drying shrinkage in residential, light commercial, overlays and structurally reinforced concrete. CFS 150-5 steel fibers have long been a solution for longer term concrete crack control and added tensile capacity in the same applications. Combining these two fibers creates "peace of mind" in overlays and traditional 4" to 6" building slabs and pavement designs within ACI joint guidelines.

- Easy to Use 16.5 lbs. (7.48 kg) Water Soluble Bags
- One Bag Per Cubic Yard
- "Concrete Finishers First Choice"
- Renewable Materials & Environmentally Friendly

ACI 302-15 will be adopted by the building codes. New requirements of ACI 302-15 will include: all concrete building slab on grade construction to be placed on a vapor barrier, 4x4 – 4.0 – 4.0 properly supported welded wire fabric or steel fiber / micro fiber blends. UltraFiber 302 Blend is a cost effective alternative to WWF and light rebar installations.

Applications

- Slabs on Grade
- Office and Retail
- Schools Churches
- Parking Lots
- Selected Pavements & Overlays
- Concrete Overlays

UltraFiber 302 Blend

SOLOMON
UltraFiber 302 Blend®

Equipment | Products | Solomon

4050 Color Plant Road, Springfield, IL 62702, PH: 800-624-0261 • 360 S Lilac Ave, Rialto, CA 92376, PH: 866-747-2656
Email: sgs@solomoncolors.com • www.ultrafiber500.com

UltraFiber 500 and Type V Steel Fibers

Product Use

Sidewalks, drives, pavements, pervious, overlays and industrial slabs. Ideal for colored concrete, stamping and textures.
Mix Considerations and Addition: The UltraFiber 302 Blend requires mechanical mixing generally accomplished by incorporating into the mixer truck drum. UltraFiber 302 Blend generally does not require any special admixtures or additional water. UltraFiber 302 Blend comes in degradable bags that can be added prior to, during or after the batching of the concrete. Mixing time is suggested to be at least 5 minutes at a mixing speed as specified in ASTM C 94. Personnel handing the bags should wear gloves and eye protection.

Compatibility: UltraFiber 302 Blend is compatible with all commonly used concrete admixtures and traditional mix designs. No additional admixtures are required for workability.

Dosage: The standard dosage of the UltraFiber 302 Blend is one 16.5 lbs. (7.48 kg) bag per cubic yard of concrete.

Finishing: UltraFiber 302 Blend can be placed and finished using traditional tools, equipment and techniques. Ideal with pumping, vibrating screeds, laser screeds, troweling equipment and hand tools.

Guidelines

UltraFiber 302 Blend is considered a secondary reinforcement to reduce temperature and plastic shrinkage, reduction of drying shrinkage and crack retention. Will not replace structural or load bearing reinforcement. UltraFiber 302 Blend is not intended to be used to thin slab sections or extend joint spacing past that which is recommended by ACI industry standards.

Packaging

UltraFiber 302 Blend is available in 16.5 lbs. (7.48 kg) water soluble – degradable bags. The UltraFiber 302 Blend bags are palletized and shrink-wrapped for protection in shipping.

Technical Services

Solomon Colors, Inc. has a technical service staff available for guidance and application support. Solomon Colors, Inc. does not engage in the practice of engineering or supervision.

Reference Documents

ASTM A 820 Standard Specification for Steel Fibers for Reinforcing Concrete.
ACI 544 Fiber Reinforced Concrete
ACI 544-3R Guide for Specifying, proportioning, Mixing, Placing and Finishing Steel Fiber Concrete
ACI 302-15 Guide for Concrete Floor and Slab Construction
ACI 304 Guide for Measuring, Mixing, transporting and

Placing Concrete

ICC- ESR 1032
ASTM C 94/C 94M Standard Specification for Ready-Mixed Concrete.
ASTM C1116/C 1116M Standard Specification for Fiber

Reinforced Concrete

UL Test UltraFiber 500 for use as an alternate to the welded-wire fabric used in Floor-Ceiling D700, D800 and D900 series designs G256 & G514

UltraFiber 302 Blend incorporates a blend of the UltraFiber 500 natural cellulose fibers and ASTM C 820 cold drawn steel wire fibers. Intended use to address temperature and shrinkage protection of the concrete. Application dosage of the UltraFiber 302 Blend shall be a minimum of one 16.5 lbs. (7.48 kg) bag per cubic yard of concrete. Manufacture shall provide documentation as to history and compliance.

This publication should not be construed as engineering advice. The information included in this publication is accurate to the best knowledge of Solomon Colors, Inc. but Solomon Colors Inc. does not warrant its accuracy or completeness. The ultimate customer, designer and user of the UltraFiber 302 Blend and UltraFiber Deck Blend products assume full responsibility for final determination for its use and suitability for the intended application. The only warrantee made by Solomon Colors, Inc for its products is set forth in the product data sheets for the product itself. Solomon Colors, Inc specifically disclaims all other warranties, expressed or implied including without limitation, warranties of merchantability or fitness for the particular purpose, or arising from provision of samples, a course of dealing or usage of trade.

Vapor Barrier Slab-On-Grade Building Construction ACI 302 and ACI 360

ACI 302-15 Construction of Concrete Floors will be published later this year. In this document a revised flow chart showing when and where vapor barrier is to be used will become gospel. In addition ACI 360 already employees vapor barrier under build slab on grade and will adopt this same flow chart.

The chart is quite simple to use and understand. I suggest that you have this as a sales tool. This will also be something that you can used to justify the use the UltraFiber 302 Blend.

At the top there are several conditions that the slab may be exposed to. If the slab condition is not included you go straight down the left side and note no vapor barrier is required. Examples driveways, exterior sidewalks and parking lots. Interior – most slab applications will require vapor barrier.

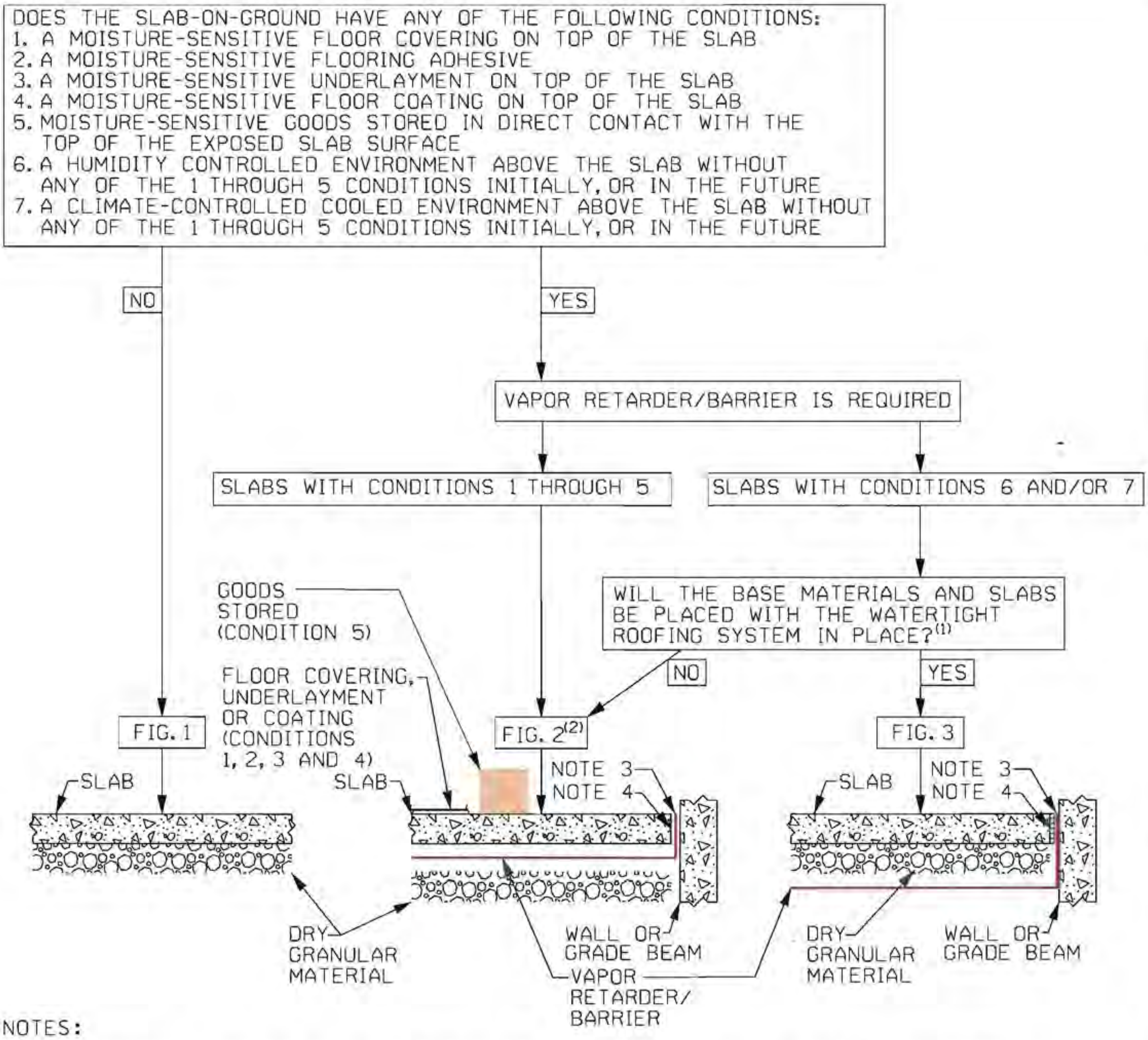
The yes column has two paths depending on the condition. The one in the middle has the vapor barrier above the granular base for conditions 1 thru 5. The one on the right has the vapor barrier below the granular base.

NOTE: the vapor barrier now is required to come up along the edges and be glued to the sides.

Notes below:

1) **warn about water ponding before concrete is placed, example rain or bad drainage or after placement with water coming down through the joints and having nowhere to go**
2) **Curling and that dominate joint issue plus others**
3) **Seal vapor barrier to wall**
4) **“foam plank” is typically ½” by thickness of slab – use of traditional black expansion board not acceptable. Note joints are to be sealed.**

Ed Mclean
Director of Fiber Products and Sales
4050 Color Plant Road Springfield, IL 62702
O/C (217) 331-4667
Fax 888-828-5250
emclean@solomoncolors.com



NOTES:

(1) IF GRANULAR MATERIAL IS SUBJECT TO FUTURE MOISTURE INFILTRATION FROM WET-CURING, WASH-DOWN AREAS SLOPED TO DRAINAGE, OR OTHER LIQUIDS THAT CAN POND ON TOP OF THE SLAB AND SEEP THROUGH JOINTS, CRACKS OR OTHER OPENINGS, USE FIG. 2.

(2) IF FIGURE 2 IS USED, MEASURES TO MINIMIZE SLAB CURLING, DOMINANT JOINTS, DELAMINATIONS, BLISTERING, CRUSTING, PLASTIC SHRINKAGE CRACKING, BAR SHADOWING AND SUBSIDENCE CRACKING LONGITUDINALLY OVER THE REINFORCEMENT, REDUCTION IN SURFACE FLATNESS, AND FINISHING TIME WILL LIKELY BE REQUIRED.

(3) VAPOR RETARDER/BARRIER SHOULD BE TURNED UP AND SEALED TO WALL, GRADE BEAM OR SLAB.

(4) FLEXIBLE CLOSED CELL FOAM PLANK FULL DEPTH OF SLAB (WHERE REQUIRED) WITH ELASTOMERIC JOINT SEALANT (WHERE REQUIRED) . (NOTE: FOAM PLANK IS NOT SHOWN IN FIG. 2 BUT CAN BE USED AS SHOWN IN FIG. 3)

ACI 360R-10 Fig. 4.7 - Decision flow chart to determine if a vapor retarder/barrier is required and where it is to be placed

ACI 302.1R-04 Fig. 3.1 - Decision flow chart to determine if a vapor retarder/barrier is required and where it is to be placed.

ACI 302.2R-06 Fig. 7.1 - Decision flow chart to determine if a vapor retarder/barrier is required and where it is to be placed (ACI 302.1R).

DRAFT 09APR15 - Proposed revisions to ACI 360R-10 Fig. 4.7, ACI 302.1R-04 Fig. 3.1 and ACI 302.2R-06 Fig. 7.1