Fiber Reinforced Concrete

To:
Foundation Performance Association

By: Patrick Greer

PROPEX®

Fibermesh – Novomesh - Novocon

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Global Footprint

★ Headquarters

○ Manufacturing Facilities

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1 Company . . . 4 Business Units

1 Geosynthetics

2 Performance Technologies

3 Concrete Solutions

4 Furnishing Solutions

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Concrete Solutions

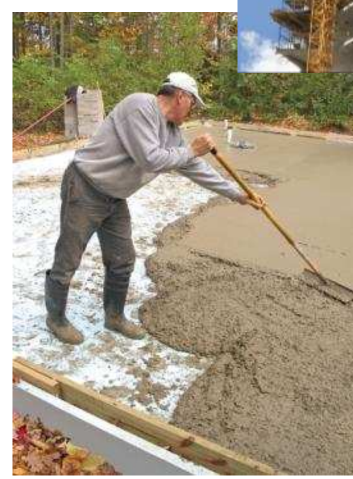
Making Good Concrete Better®

Markets

- Residential & Commercial Slabs-On-Ground
- Composite Metal Decks
- Industrial Flooring
- Transportation
- Walls
- Precast Concrete
- Shotcrete & Underground

Brands

- ENDURO®
- Fibermesh®
- Fibercast®
- Novomesh®
- Novocon®
- Fibreflor®
- SigmaJoint®
- Elemix®



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FRC - Seminar
Outline

I. **Micro Fiber applications in Concrete**

II. **Slab & Pavement: On Grade Construction**
- **Traditional Reinforcement Design**
- **FRC in ACI 360**

II. **FRC Solutions - Steel & Macro Fiber Applications**
- **Design Criteria**
- **Steel fibers**
- **Blended Solutions**
- **Macro-Synthetic Fibers**
- **Composite Metal Decking**

I. **Texas DOT Fiber Acceptance Criteria**
- **Testing Criteria**
- **Dosage Rates and Applications**

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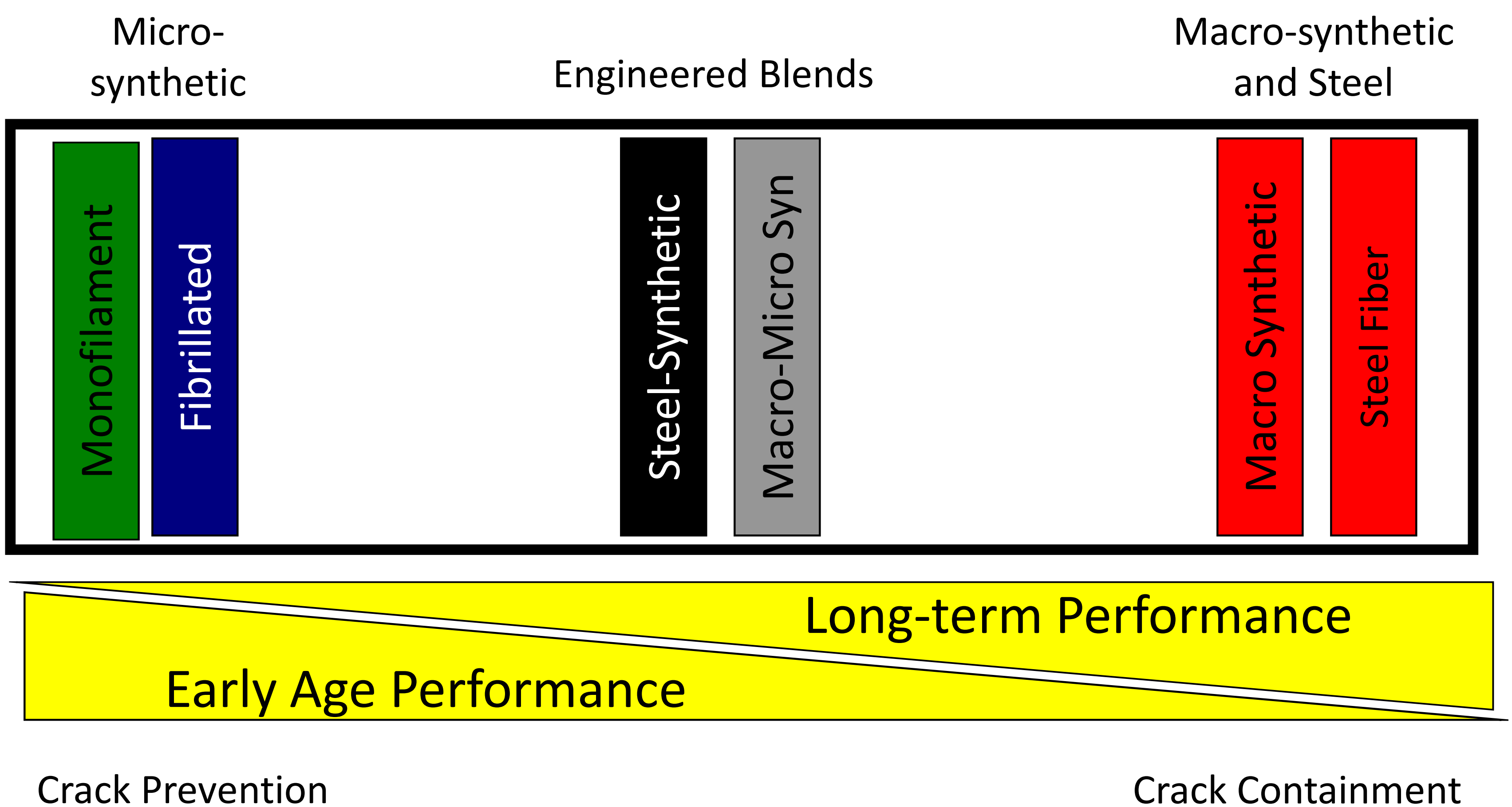
Fiber Reinforced Concrete Solutions



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The Correct Fiber Fit for your Project

- Any Cast in Place Concrete
- Microsynthetic Fibers : Monofilament or Fibrillated
- Slabs & Pavement: w/ Close Joint Spacing using Light Gage WWF
- Microsynthetic: Fibrillated
- Slabs & Pavements: Using Heavy WWF or Light Duty Rebar (> w2.9)
- Macrosynthetic – Steel – Engineered Blends
- Composite Metal Decking
- Macrosynthetic – Steel – Engineered Blends
- Heavy Commercial - Industrial Slabs & Pavements
- Steel Fibers – Engineered Blends

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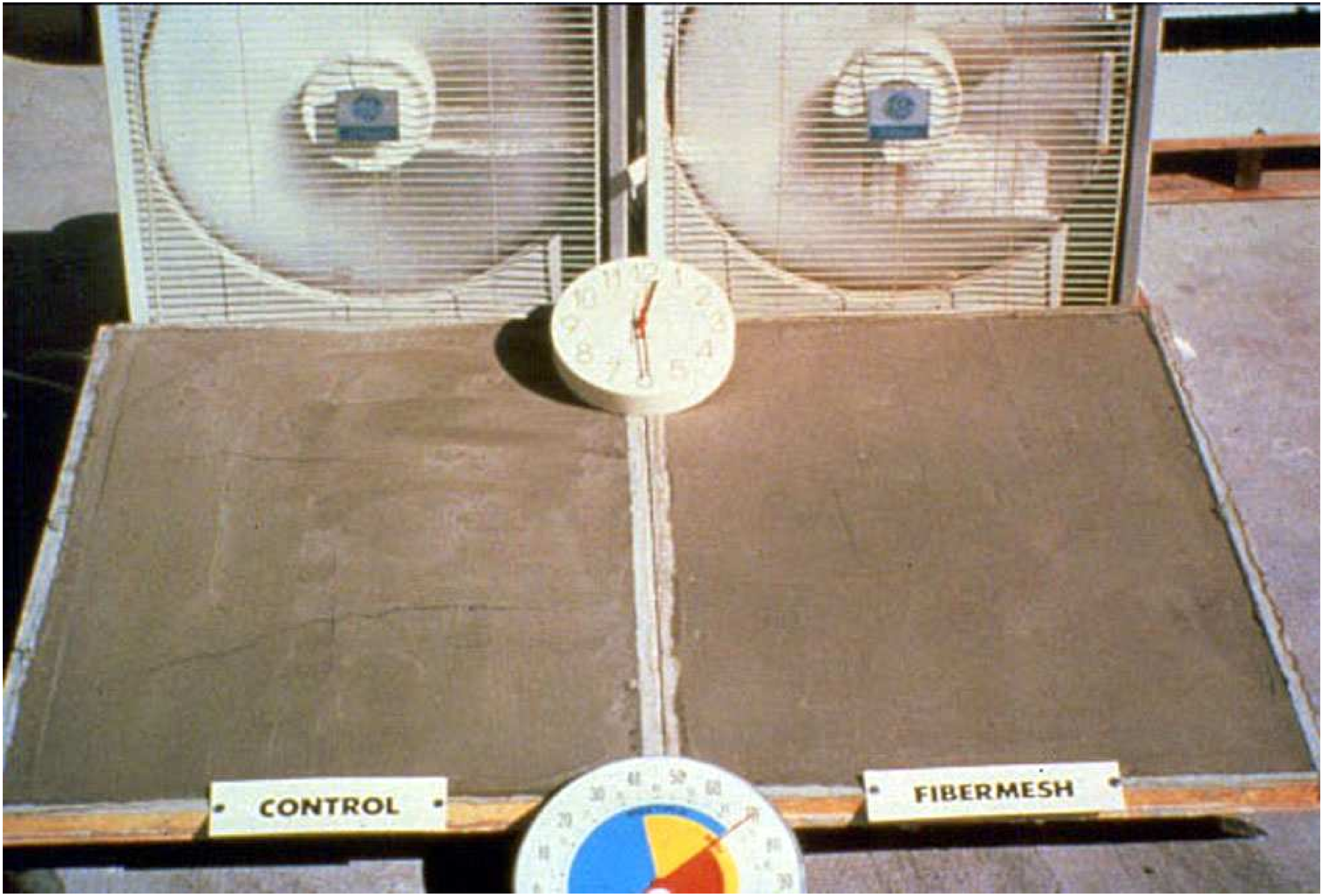
Family of Micro-Synthetic Polypropylene Fibers

Monofilament- Multifilament. Plastic concrete crack reduction. Excellent finishability.

Fibrillated - Fibrillated. Plastic concrete crack reduction, moderate toughness.



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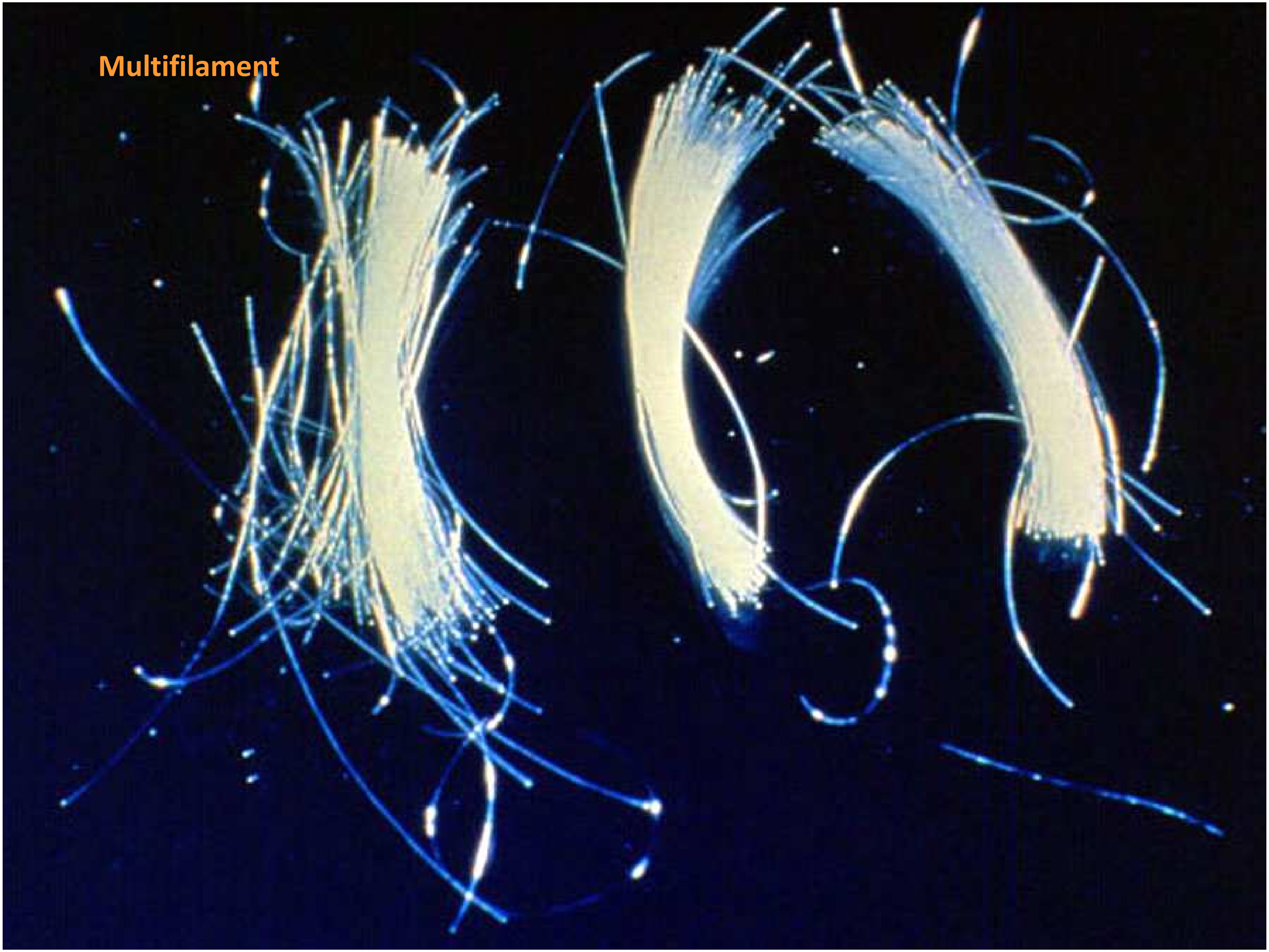
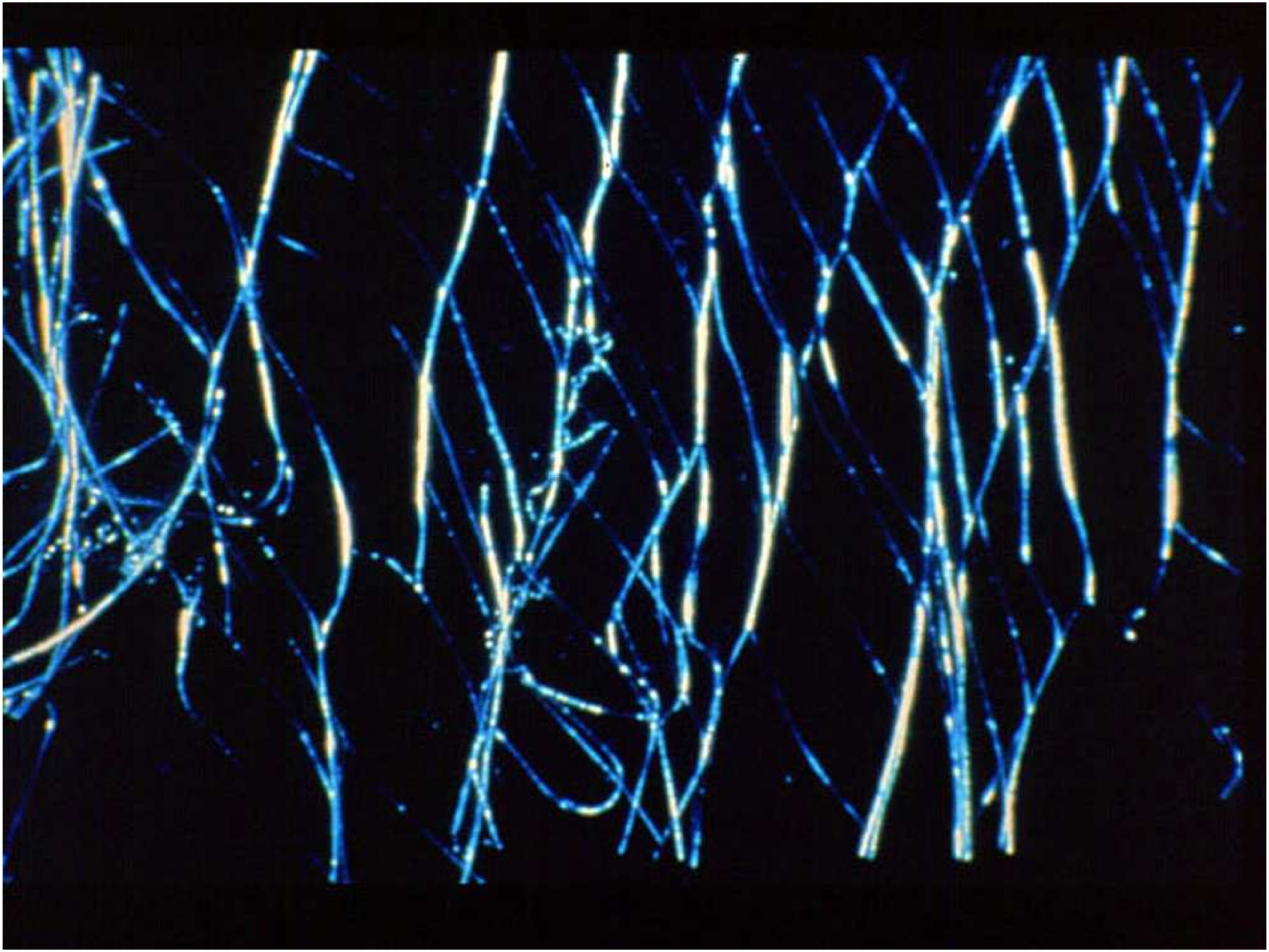
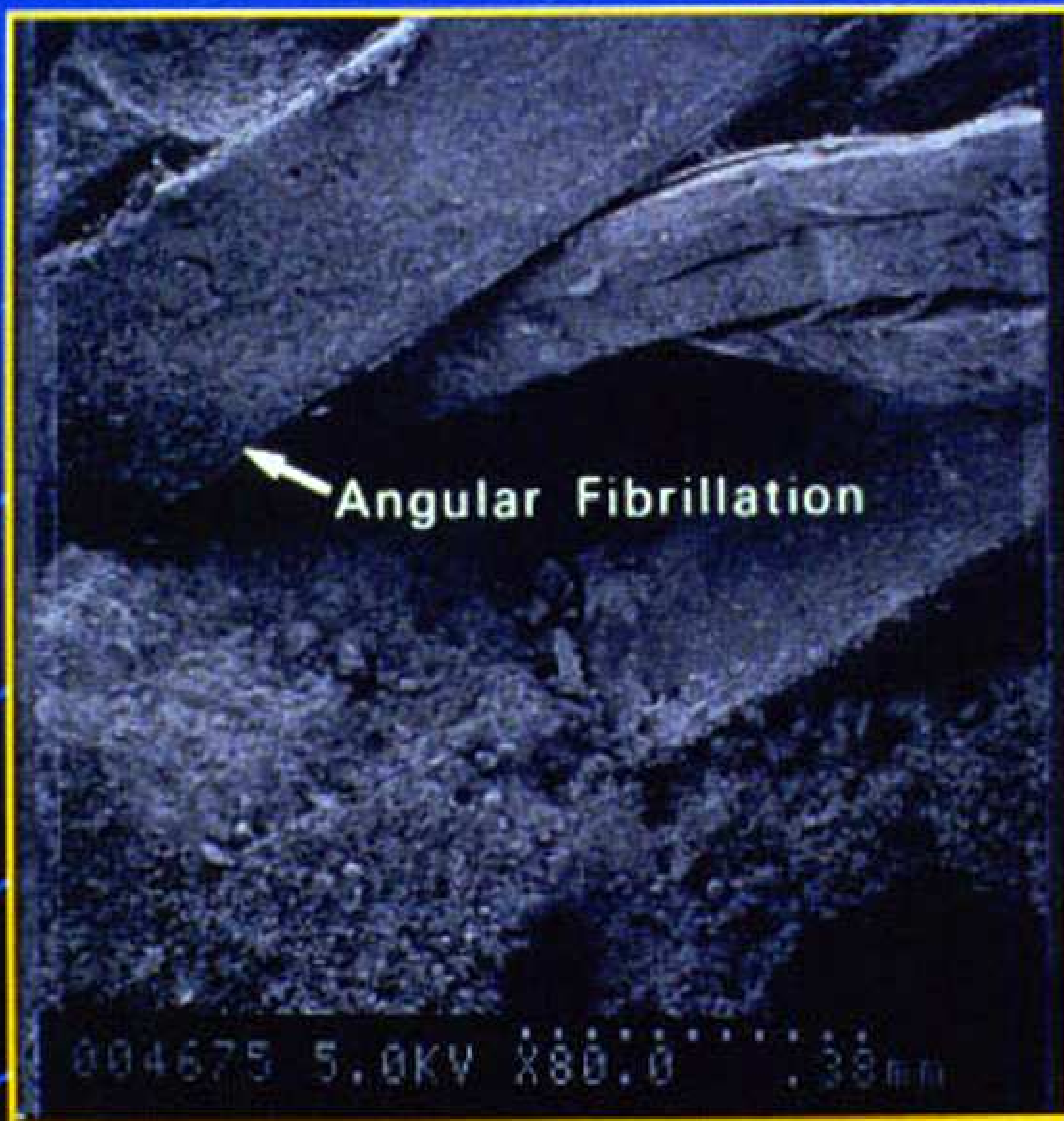

Multifilament



Micro-Crack's View - Inside of Fibermesh Concrete



Residential Slabs-On-Grade

Thousands of Successful Residential Applications Worldwide Since 1982

Monofilament Fibers Inhibit Plastic Shrinkage and Settlement Cracking

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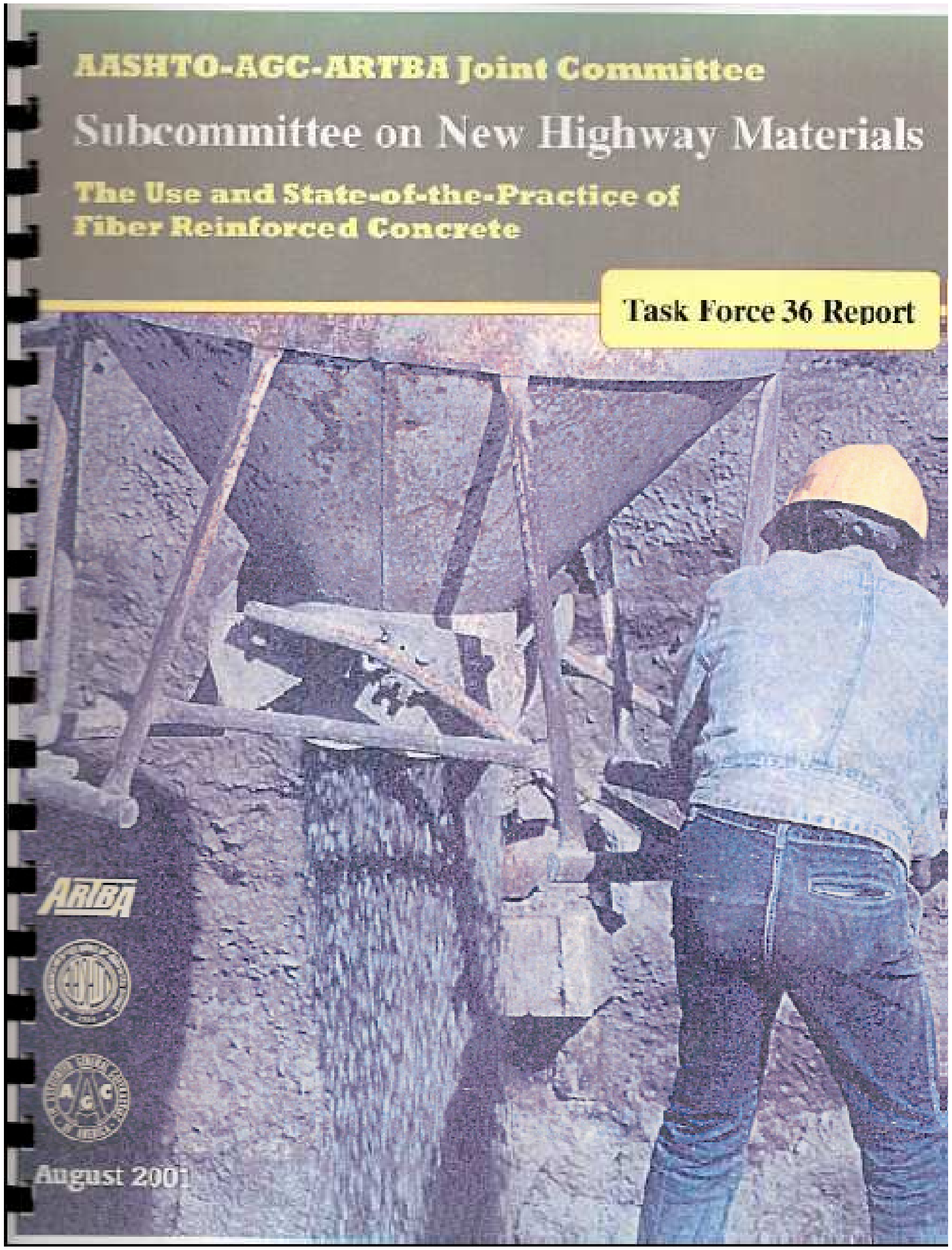
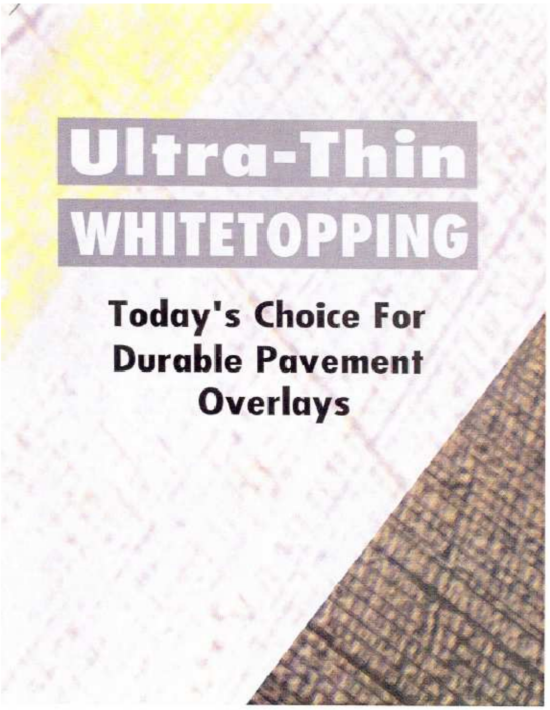


2 – 4’’ of high strength fiber reinforced concrete is placed over prepared, distressed asphalt.

FRC = 80 PSI - ARS



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Gonzales to Sealy, TX

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I-10 Mow Strip (length-80 miles)

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Microsynthetic FIBERS

- Inhibit Early Age Shrinkage Cracking
- Reduce Settlement Cracking
- Increases Impact Resistance
- Increases Shatter Resistance
- Reduces Water Migration
- Increases Abrasion Resistance
- Reduces Rate of Corrosion
- Increases Rebar Bond to Concrete
- Measurable Residual Strength
- Alternate System to Welded Wire Fabric (Slabs)
- Anti-Spalling

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APPLICATIONS of MICRO-SYNTHETIC FIBERS for RESISTANCE to EXPLOSIVE SPALLING in FIRES

NAT 2006

Chicago, Illinois

Trevor Atkinson

Director of Underground Concrete

SI Concrete Systems

Peter Tatnall

Principal

Performance Concrete Technologies

Tunnel Fires

- **Great Belt Tunnel (Denmark, 1994)**
- **Channel Tunnel (UK-France, 1996)**
- **Mont Blanc (Italy-France, 1999)**
- **Tauern (Austria, 1999)**
- **Kaprun (Austria, 2000)**
- **Gotthard (Italy-Switzerland, 2001)**
- **Baltimore Rail Tunnel (2002)**

Explosive Spalling

- Most DANGEROUS form of spalling
- Occurs during first 20 – 30 minutes when rapid heat rise is encountered.
- Characterised by forcible separation of pieces of concrete and accompanied by a loud bang.

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Non-Fibrous Concrete

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Non-Fibrous Concrete

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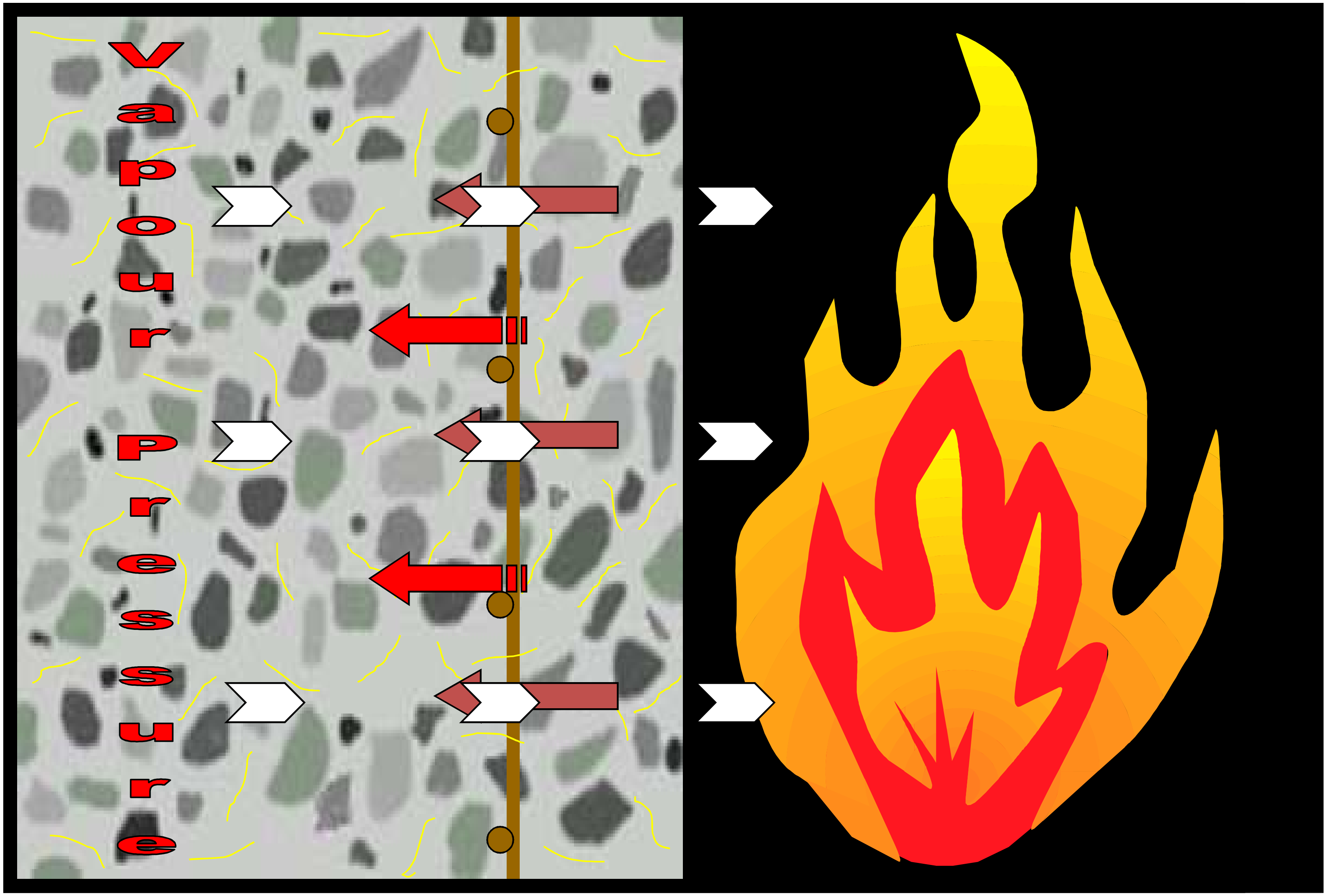
Polypropylene Fiber Reinforced Concrete



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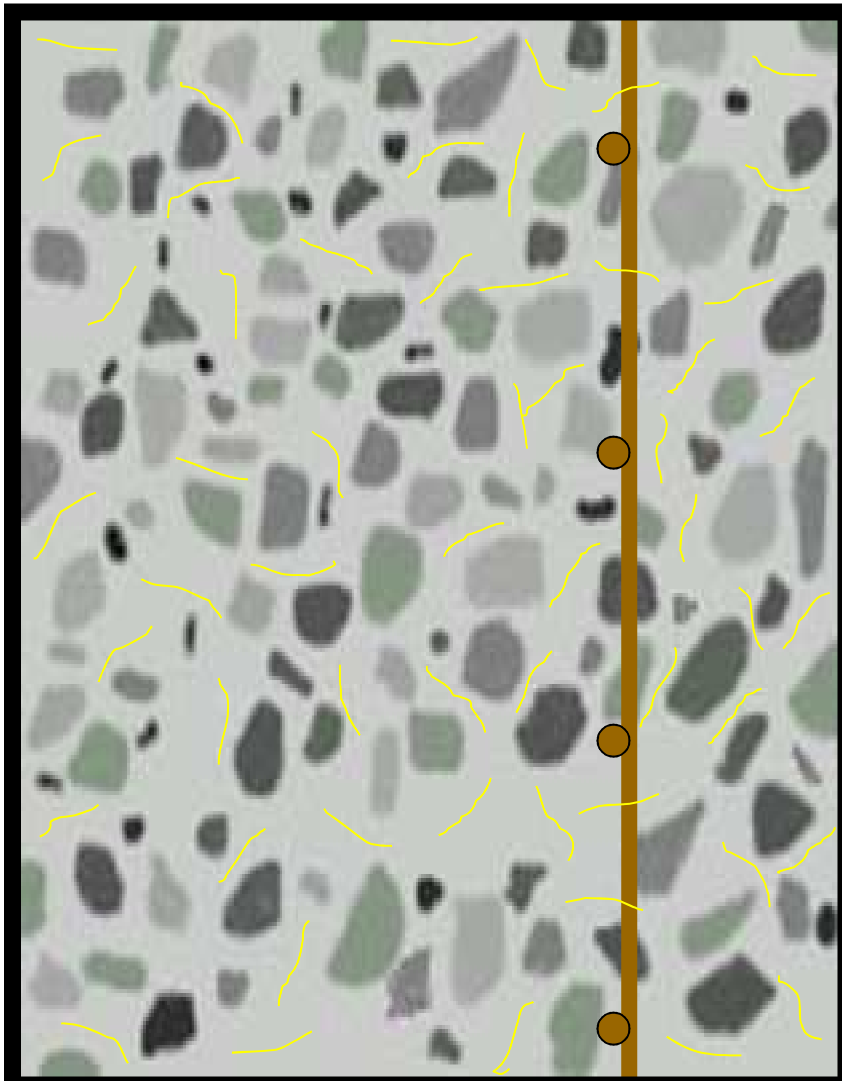
Polypropylene Fibre Reinforced Concrete



No Surface Spalling

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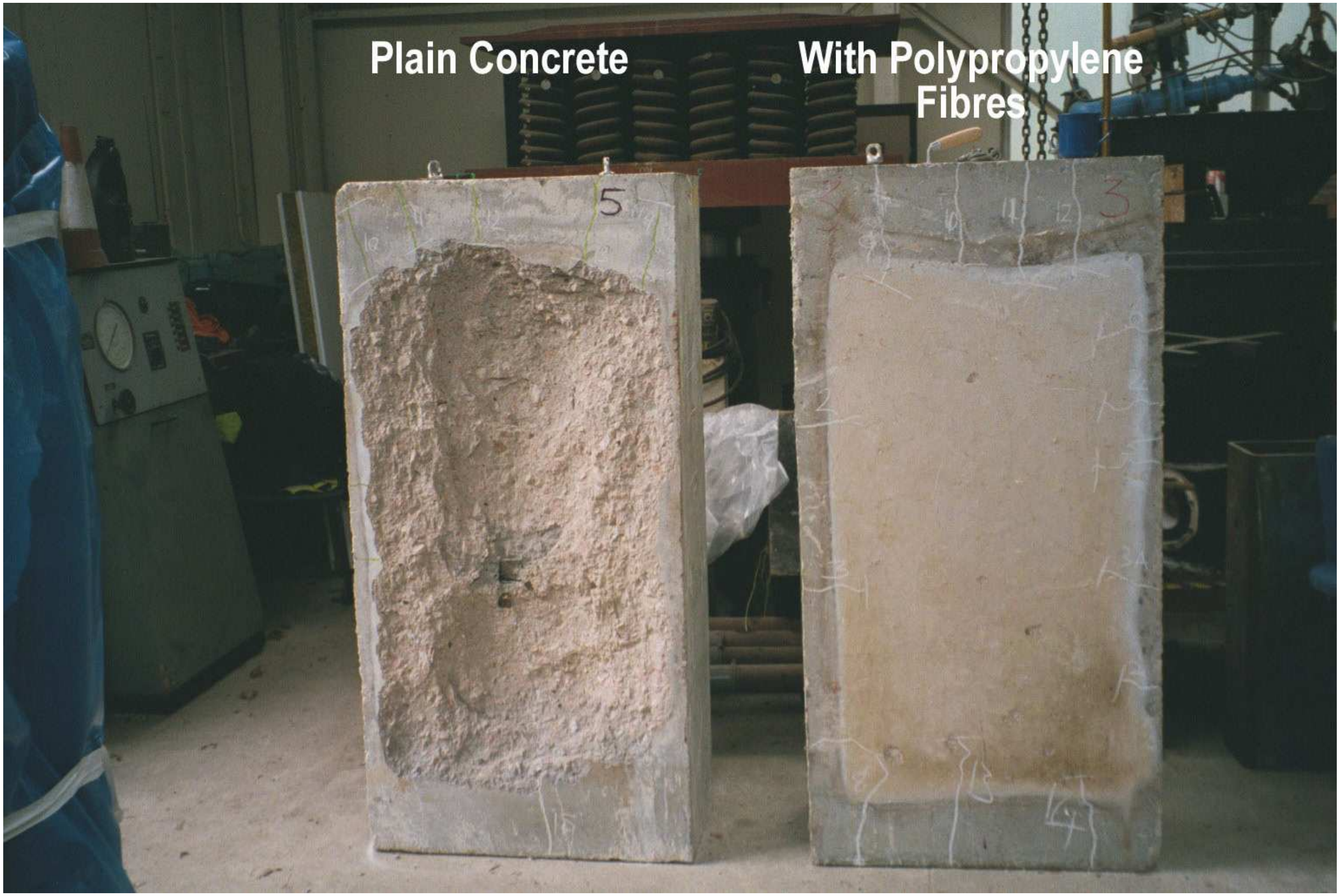
CTRL Tests
Intermediate Test Results



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Fire Explosive Spalling Protection

Test Results

With Steel Fibers – 15 minutes

With Micro-PP Fibers – 2 hours

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Conclusions:

Polypropylene micro- fibers are:

- **Internationally proven to limit the occurrence of explosive spalling.**
- **Recognized by designers, insurance companies and fire fighting authorities to:**
- **Protect the integrity of the concrete structure**
- **Mitigate damage and loss**
- **Protect lives of those trying to escape as well as those fighting the blaze**

Polypropylene Microsynthetics The most Proved and Tested Fibers for Concrete

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Microsynthetic Fibers Enhances all Concrete

Infrastructure Designed to last 50 to 100 Years

Water Treatment Plants

Concrete Bridge Decks

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Traditional Concrete Reinforcement

Concrete Slabs and Pavements On Grade

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Why Reinforce Slabs?

- Influence crack width and location
  - Insurance against crack deterioration
  - Insurance for extended joint spacing
  - **Not to prevent cracks**
- Maintain slab surface tolerance
- Poor soil conditions
- Impact and fatigue resistance
- Structural slabs on ground

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Proper Location of Concrete Reinforcing

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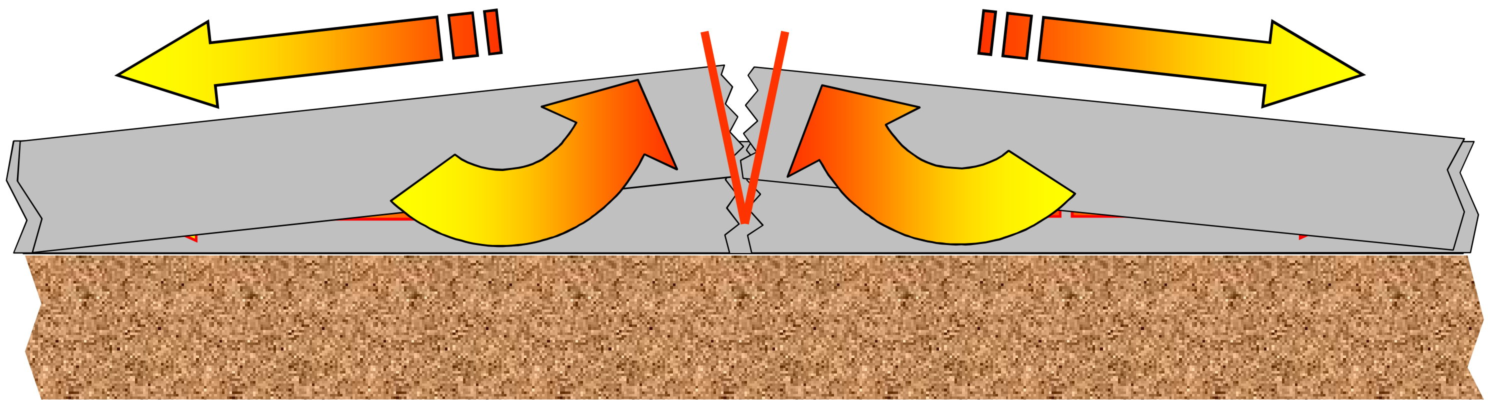
Crack Width Variance



- Differential drying causes curling
- Cracks (joints) form in “V” shape

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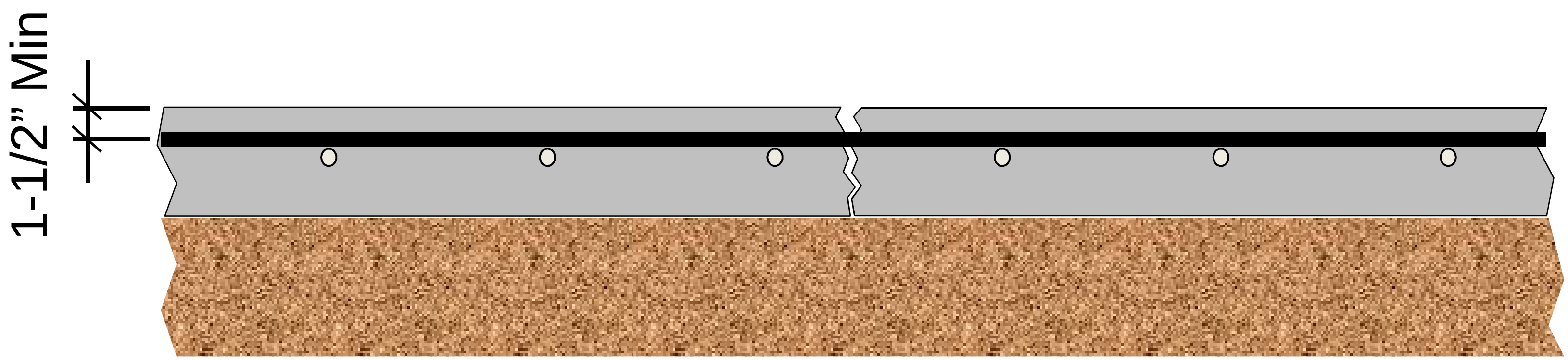
Restraint of Crack at Top



- Place reinforcing as high as possible
  - Top 1/3rd of slab thickness
- Minimum 1-1/2" cover
  - Avoid plastic settlement crack above bar

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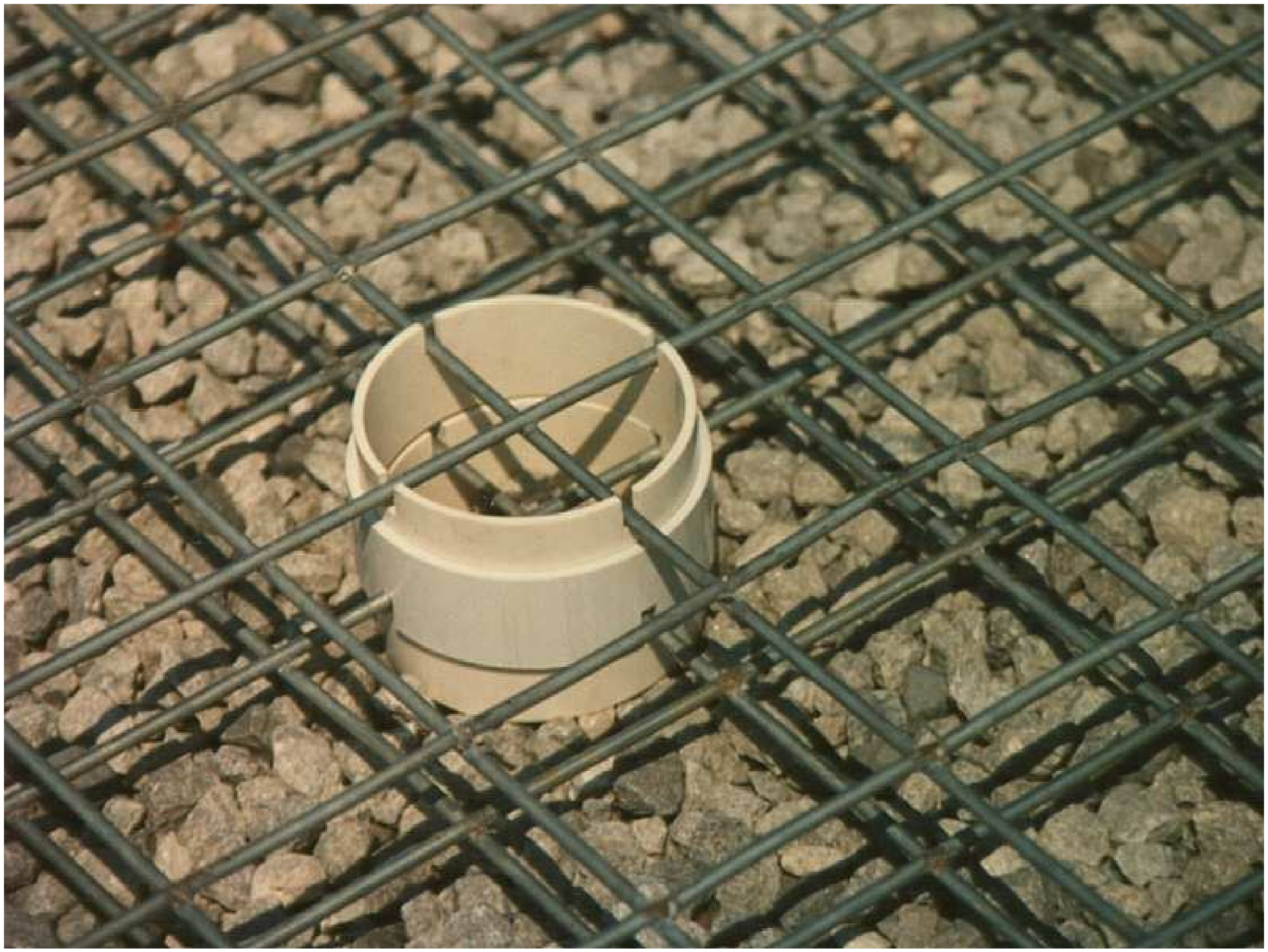
Wire Reinforcing Institute

- “Welded wire fabric keeps the cracked sections of a slab closely knit together so that the slab will act as a unit”
- “It has been emphasized that the primary purpose of welded wire fabric is to control cracking -- not to prevent it”
- Only works if WWF is positioned in the proper location

Can Proper Positioning Of Secondary Reinforcement Be Guaranteed?



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One Day We had a little Wind

Wire Reinforcing Institute

- “Fabric half buried in the subgrade, has little value”
- “It is impossible to “hook” fabric uniformly to the desired location after the concrete has been placed”

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CHALLENGE

Suggested Support Spacing

Welded Wire Reinforcement Range	Welded Wire Spacing	Suggested Support Spacing
W or D9 and larger	12” and greater	4-6 ft.
W or D5 to W or D8	12” and greater	3-4 ft.
W or D9 and larger	Less than 12”	3-4 ft.
W or D4 to W or D8	Less than 12”	2-3 ft.
Less than W or D4	Less than 12”	2-3 ft.

(Wire Reinforcing Institute, Inc. - Tech Facts 702-R, 1998)

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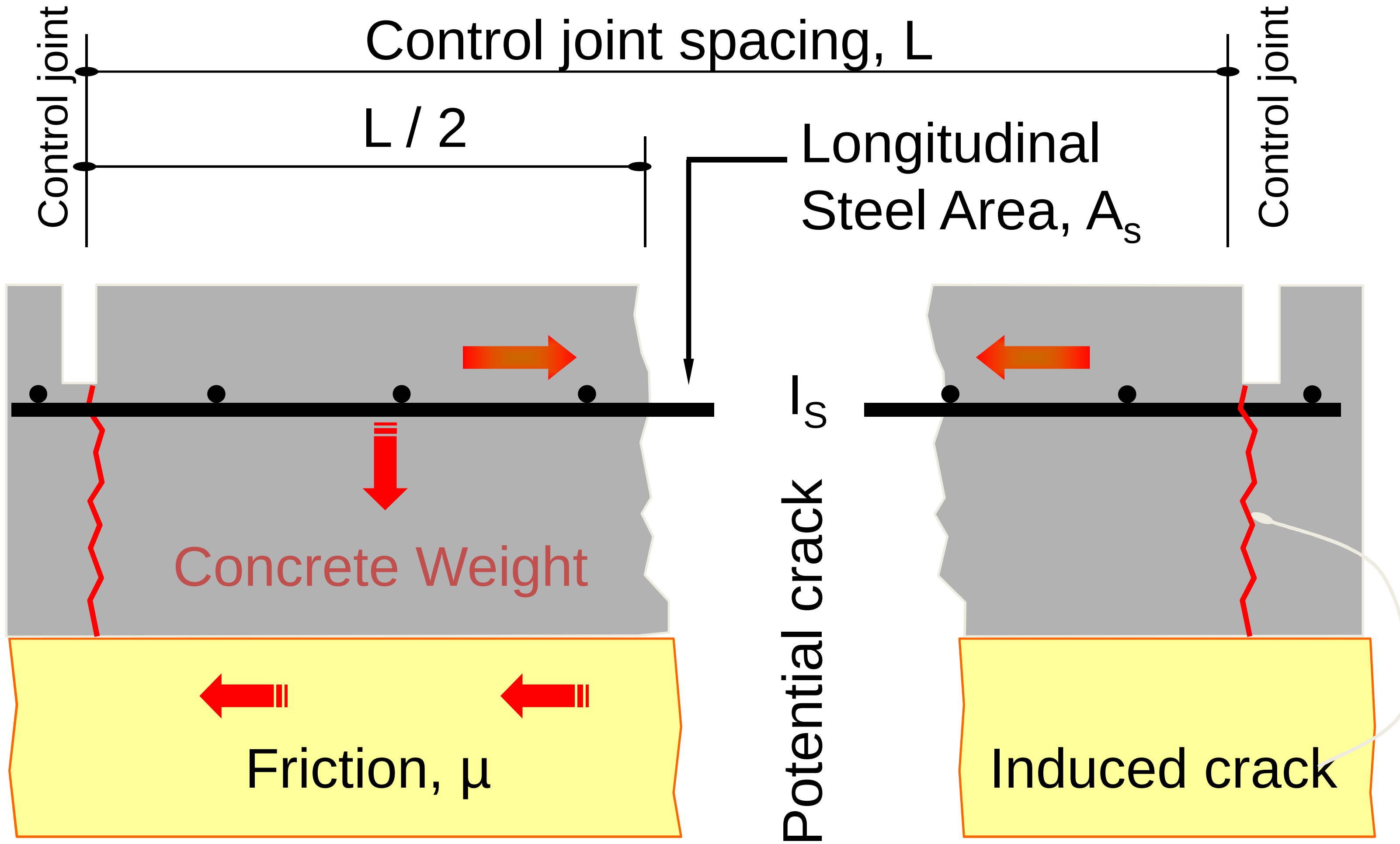
Subgrade Drag Formula



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Subgrade Drag Formula

$$A_s = \frac{F\,L\,W}{2\,f_s}$$

A_s = cross-sectional area of steel
F = subgrade friction coefficient
L = distance between joints
W = weight of concrete
f_s = reinforcing allowable stress (psi)

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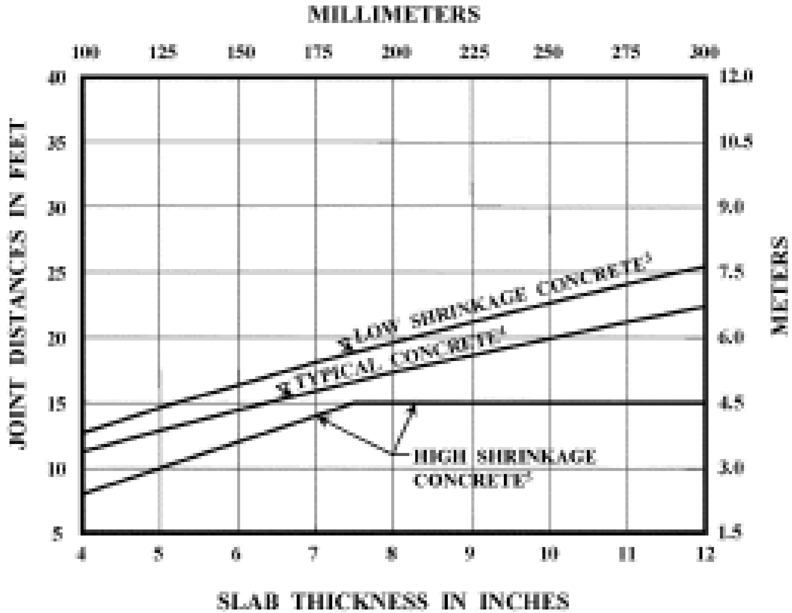
ACI 360R – 10 Recommended Control Joint Spacing for Unreinforced Concrete (Less than $\%A_s$ = 0.5%)



NOTES:

1. Joint spacing recommendations based on reducing the curling stresses to minimize mid- panel cracking (Walker-Holland 2001). See discussion in Section 6.2 for joint spacing for aggregate interlock.
2. Joint spacing criteria of 36 and 24 times the slab thickness has been utilized in the past.
3. Concrete with an ultimate dry shrinkage strain of less than 520 millionths placed on a dry base material.
4. Concrete with an ultimate dry shrinkage strain of 520 to 780 millionths placed on a dry base material.
5. Concrete with an ultimate dry shrinkage strain of 780 to 1100 millionths placed on a dry base material.

Fig. 6.6—Recommended joint spacing for unreinforced slabs.

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ACI 360R - 10

3.2—Slab types

- ***3.2.1 Unreinforced concrete slab***

- ***3.2.2 Slabs reinforced for crack width control***

- **3.2.3** *Slabs reinforced to prevent cracking*

  Shrinkage Comp. & Post Tension Slabs

- **3.2.4** *Structural slabs (ACI 318)*

  Structural Concrete

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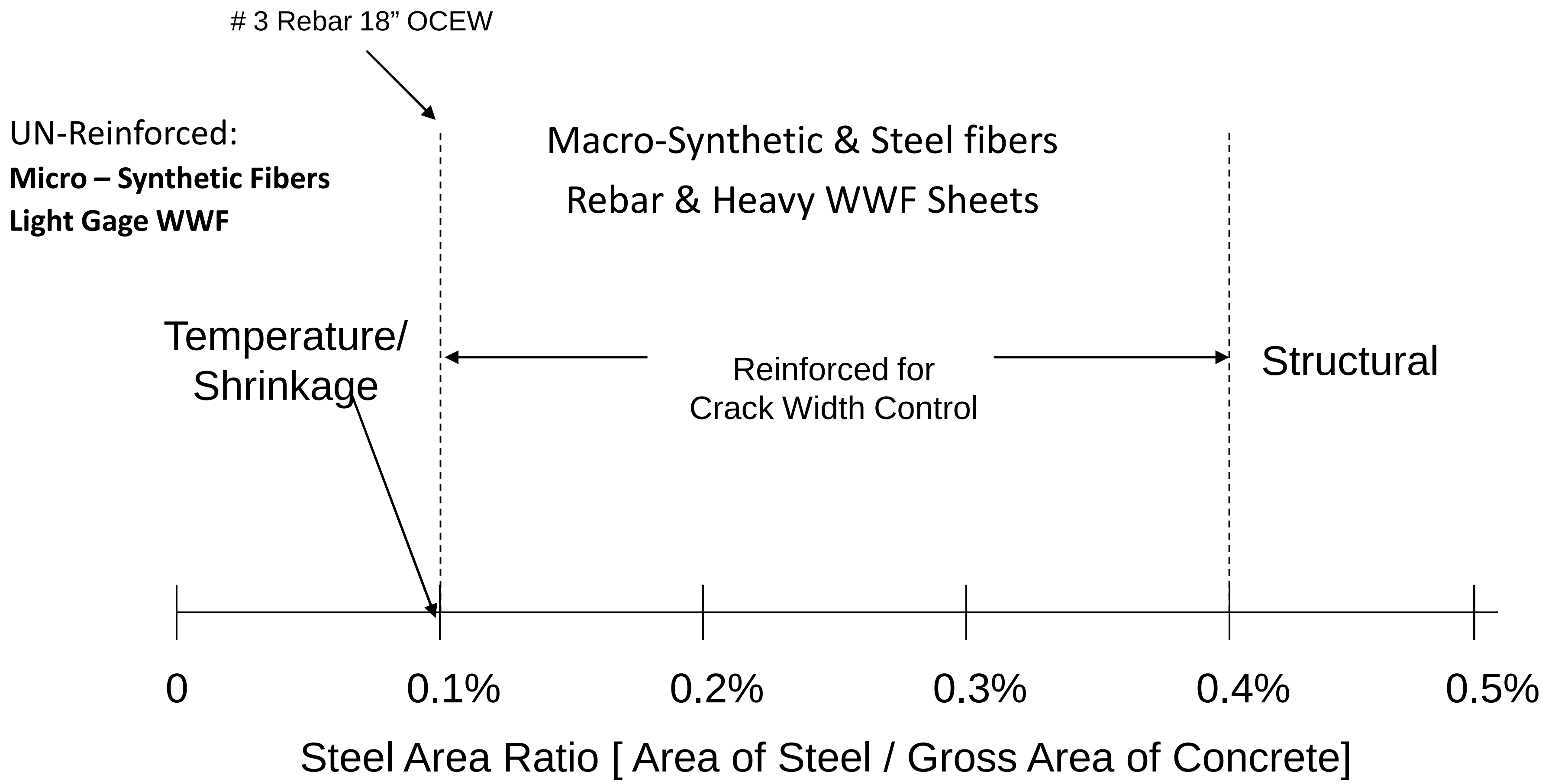
3.2.1 *Unreinforced concrete slab*

- *"It is designed to remain uncracked between joints due to loads on the slab surface and restraint to concrete volumetric changes."*

- Adequate thickness to support loads
- Control joint spacing to handle shrinkage

Concrete Reinforcement Spectrum



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3.2.2 *Slabs reinforced for crack width control*

- *"The primary purpose of the reinforcement is to limit the width of any cracks that may form at or between the joints. Bar or wire reinforcement should be stiff enough so that it can be accurately located in the upper 1/3 of the slab". ACI Recommends 0.1% steel*

- *"Slabs may be reinforced with reinforcing bars, welded wire reinforcement sheets, steel fibers, or Macro-polymeric fibers."*

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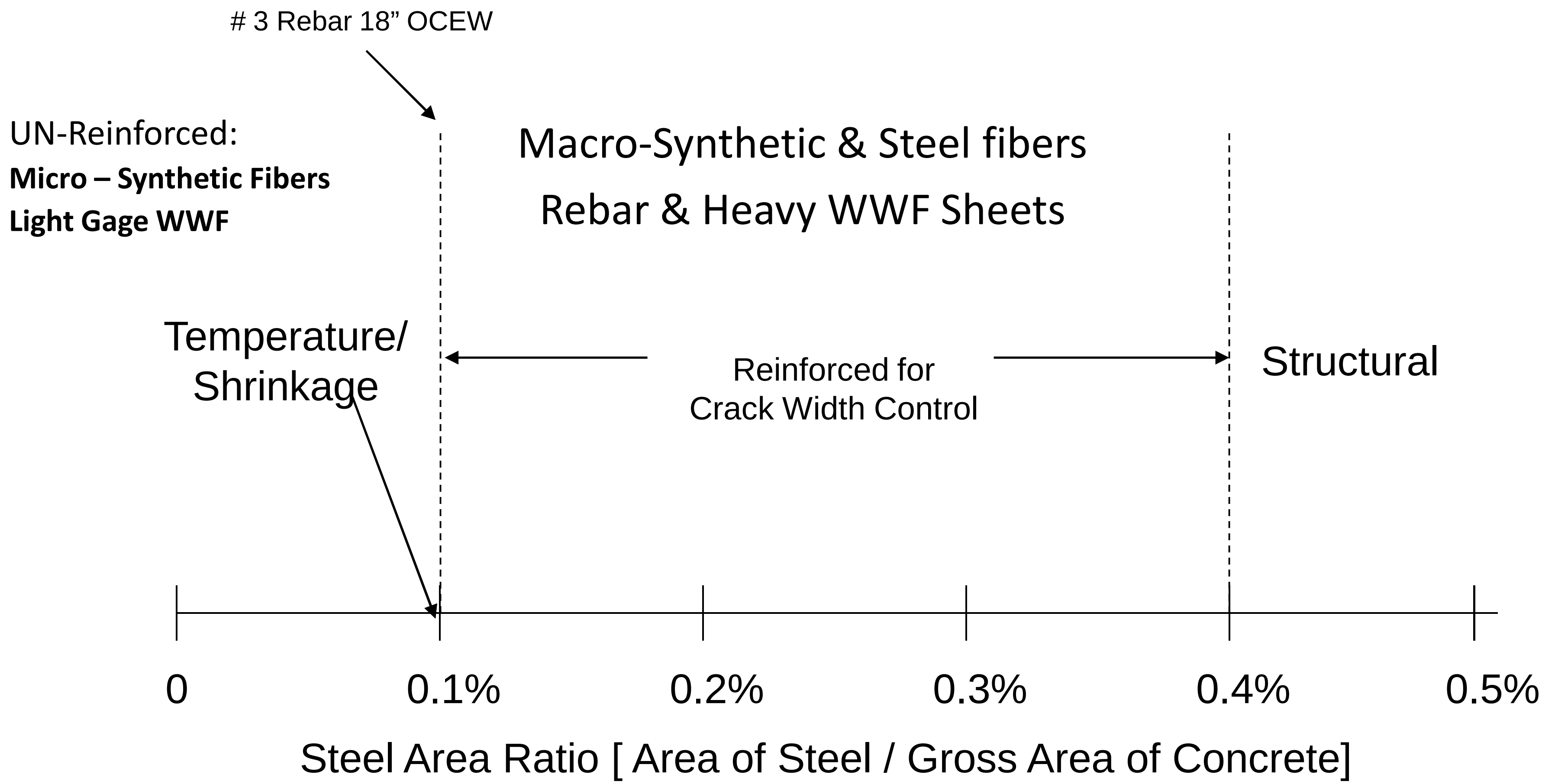
Concrete Reinforcement Spectrum



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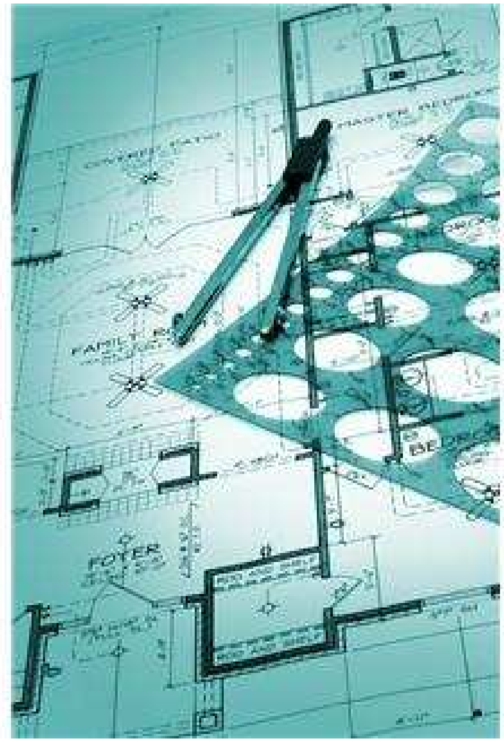

Design Criteria for

Fiber Reinforced Concrete Macro Synthetic & Steel Fiber

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Testing FRC

All typical test methods may be used with FRC; however, . . .

They may not show the effects of the fibers.

Therefore, test methods have been developed to show effects of fibers . . .

In the plastic and hardened states. . .

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Committee 544 & 506:

- 544.1R; 544.3R; *506.1R*

A 820 – Steel fiber spec.

C 1116; C 1399, C 1550;

C 1579; C 1609/M; New Syn.

JSCE /JCI: SF 4 Equiv. Flex. Strength

TR-34 $R_{e,3}$ - Eq. Flex Str. Ratio

YEILD LINE ANALYSIS DESIGN METHOD

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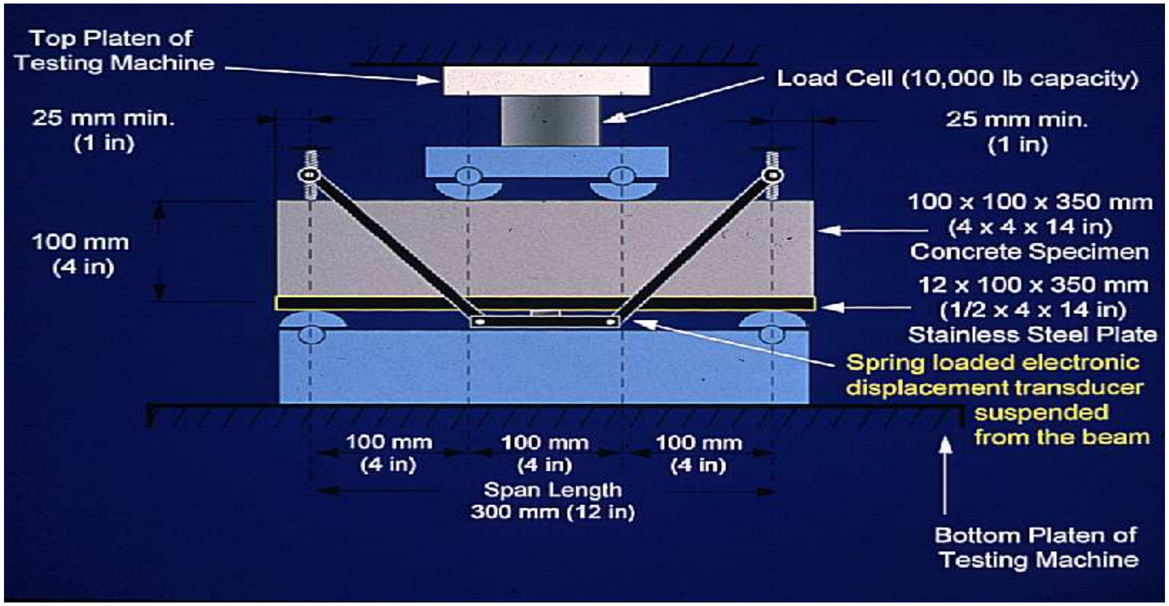
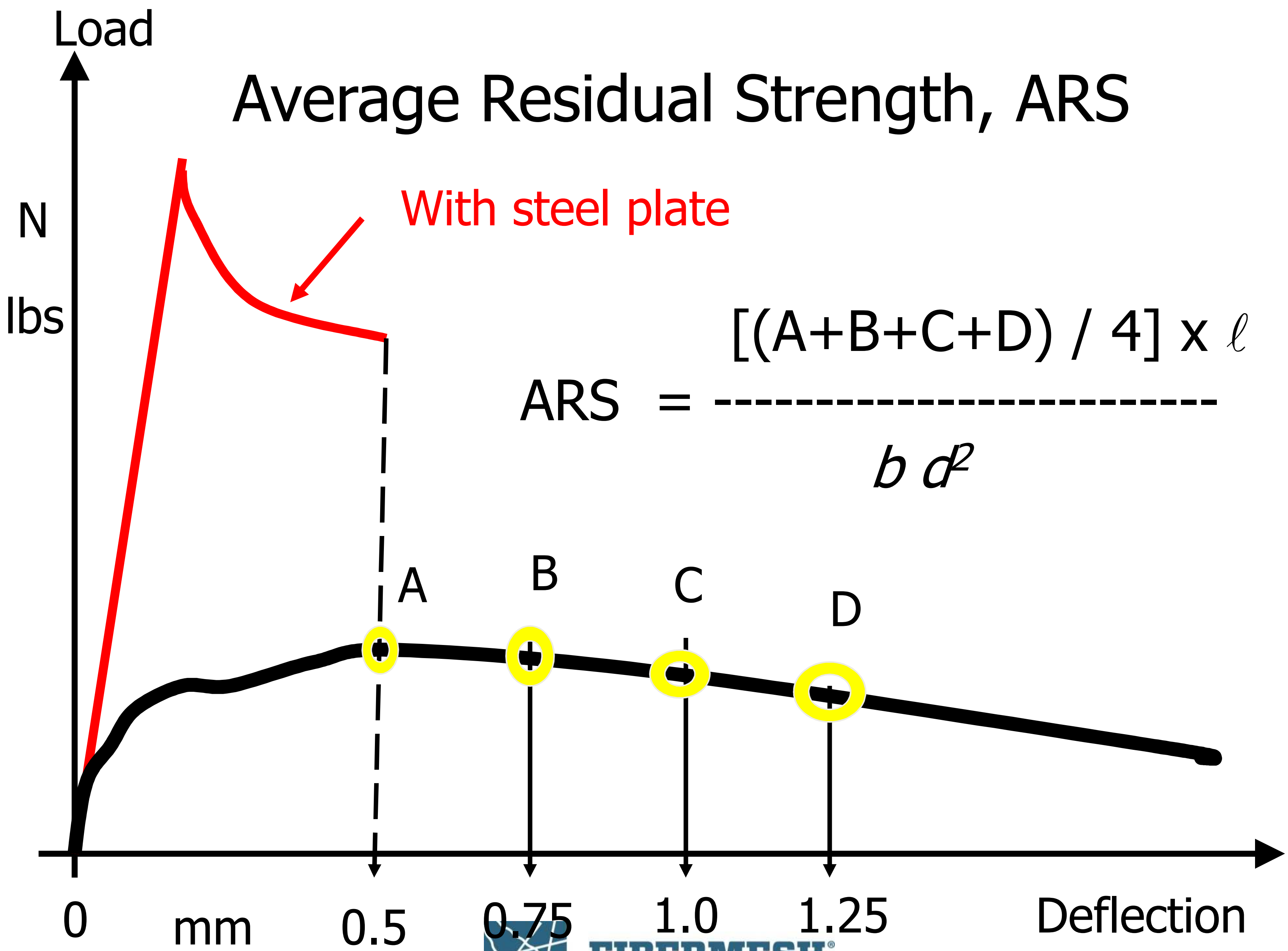
C 1399-04, "Test Method for Obtaining Average Residual-Strength of Fiber Reinforced Concrete"



ASTM C 1399

Average Residual Strength, ARS

$$ARS = \frac{[(A+B+C+D) / 4] \times \ell}{b\, d^2}$$



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Moment Capacity Calculations

The Ultimate-Strength Design Methodology, used since the early 1960's, can be used to evaluate fiber reinforced concrete to conventional reinforced concrete on the basis of the bending moments resisted by the contained tensile elements in a unit of concrete.

$$Mn = \phi As\, fy\, (d - a/2)$$

Step by Step process:

Step 1: Calculate depth of rectangular stress block, "a", using Equation 2.
a = Asfy/(0.85f'cb)
Step 2: Calculate the moment capacity of the continuously-reinforced section, "Mn", using Equation 3. $Mn = \phi As\, fy\, (d - a/2)$
Step 3: Based on the required moment capacity, Mn, of the continuously-reinforced section, calculate the required bending stress of the fiber-reinforced concrete section, "Fb" using Equation 4 *fb = Mn/S* This value also represents the required average residual strength (ARS) of the fiber reinforced concrete section f't. *f't = fb*
Step 4: This value can be found in the accompanying charts with the required fiber quantity
f't =Mn/S

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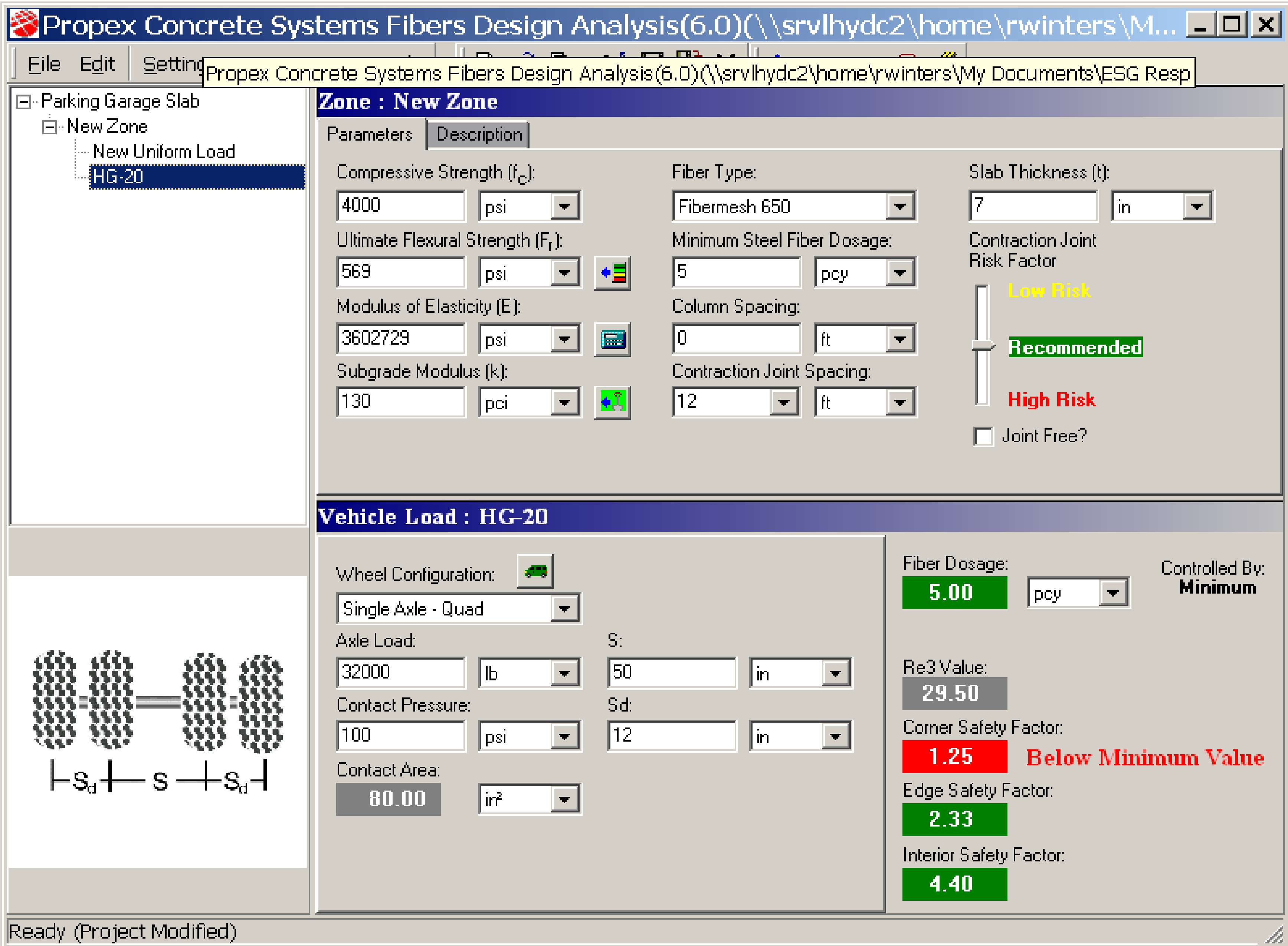
Yield Line Slab Analysis



ACI 360R 10: Chapter 11 – Fiber-Reinforced Concrete Slabs-on-Ground

11.3.2.3 ***Flexural toughness—Flexural toughness of*** steel FRC is determined by testing beams or panels in a laboratory using ASTM C1399, C1550, and C1609/1609M or JSCE SF4.

11.3.3.3 ***Yield line method—***

Yield line analysis accounts for the redistribution of moments and formation of plastic hinges in the slab. These plastic hinge regions develop at points of maximum moment and cause a shift in the elastic moment diagram. The use of plastic hinges permits the use of the full moment capacity of the slab and an accurate determination of its ultimate load capacity.

Provides Factors of Safety: on the basis of the location of the load with respect to the edges of the slab. "Interior – Free Edge – Corner" Factors of Safety

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SFRC

Steel Fiber Reinforced Concrete

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Steel Fibers Provide….

… Crack Width Control

…Positive Positioning of Reinforcing

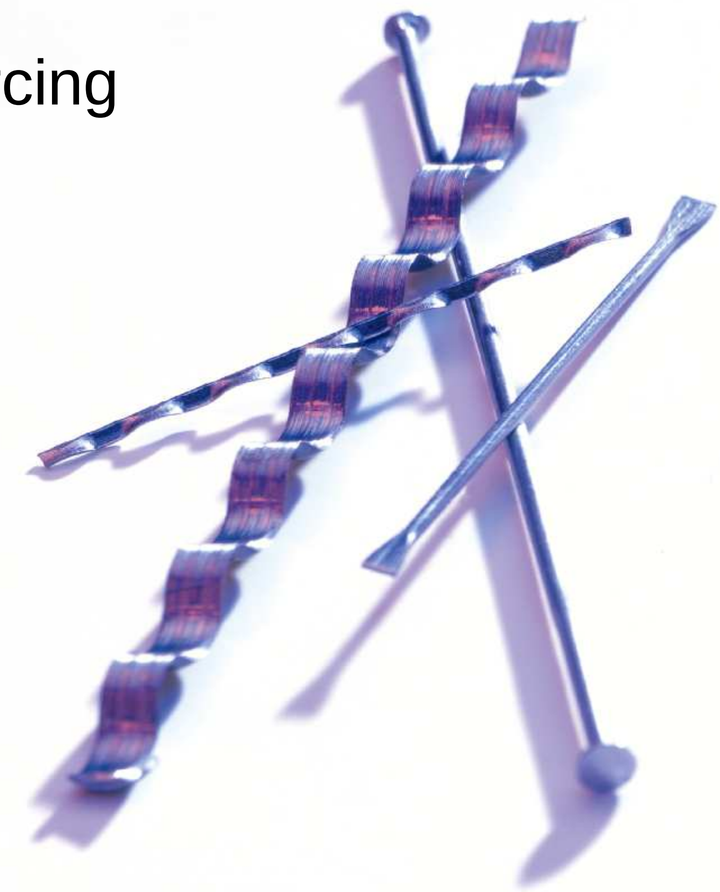
… Ductility

…Fatigue Endurance

…Impact Resistance

…Flexural Toughness

Re3 / ARS



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Tank reinforced with concrete & steel fibers
then subjected to same live fire

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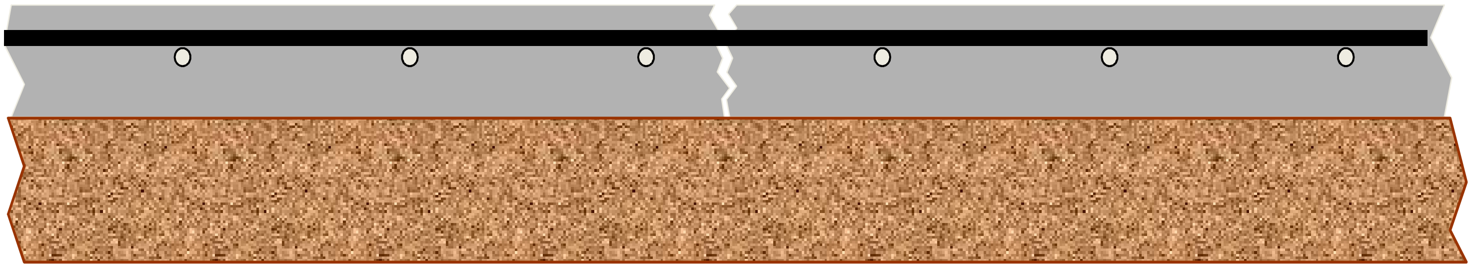
Conventional Reinforcement



- Provides single point crack restraint

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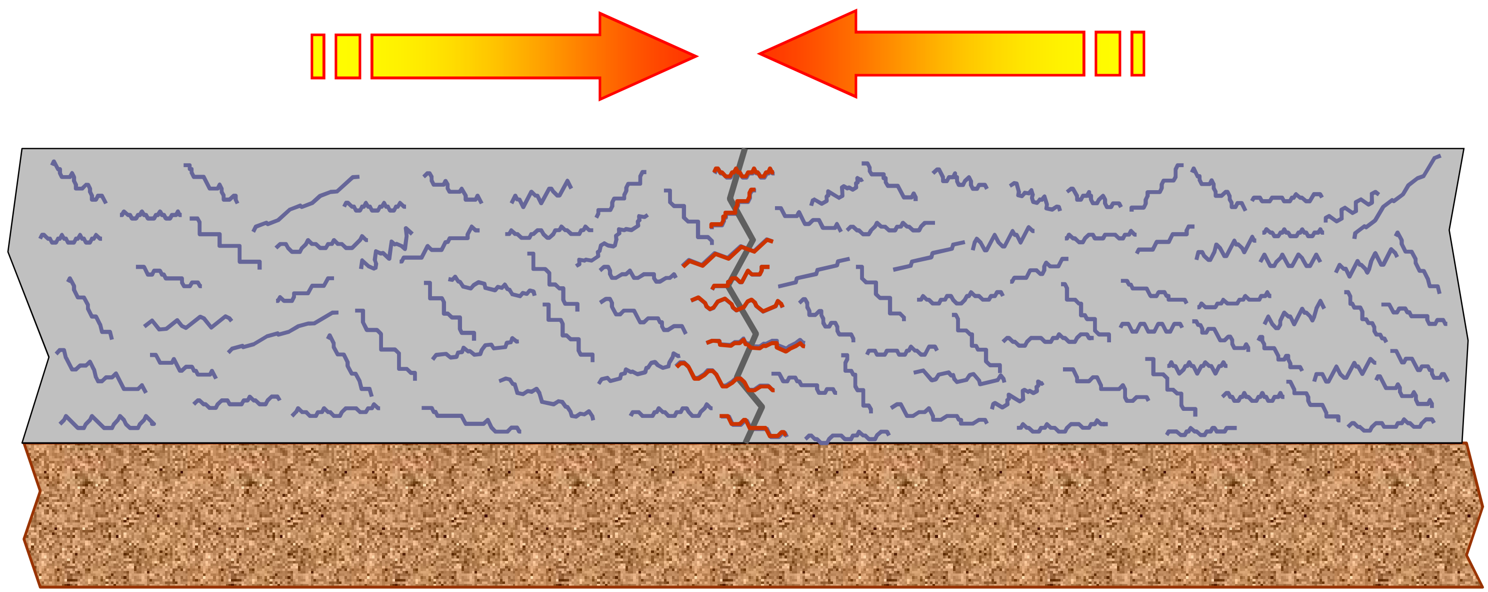
Steel Fibers



- Provide continuous crack restraint
  - From bottom of slab to just below surface

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Steel Fibers

- Restricts Joint Width
- Always Positioned Correctly
- Joint Filler Stays in Place
- Produce a More Stable Joint

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ACI 360 table 11.1
Steel fiber concentration & residual strength factors

Fiber concentration, lb/yd3	Application (typical residual strength factors) re[3]	Anticipated type of traffic
over 33	Random Crack width control (20 to 40%)	Commercial and light industrial with foot traffic or infrequent lift trucks with pneumatic tires
33 to 50	Light Dynamic loading (30 to 50%)	Industrial vehicular traffic with pneumatic wheels or moderately soft solid wheels
40 to 60	Medium Dynamic Loading (40 to 60%)	Heavy-duty industrial traffic with hard wheels or heavy wheel loads
60 to 120	Severe Dynamic Loading Joint spacing design (60% or higher)	Industrial and heavy-duty industrial traffic

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Steel Fibers

- Alternate System to Rebar in Slab On Grade Applications
- Alternate System to Conventional Reinforcement in Metal Decking.
- Uniform loaded slabs
- Projects Where Joint Stability and Crack Control are Critical
- Superflat & High Tolerance Floors
- Heavy Commercial - Industrial Floors

40 lbs. cubic yard of Novocon XR to replace #4's @ 12'' ocew
City of Sugarland, TX - August 2003

FIBERMESH®
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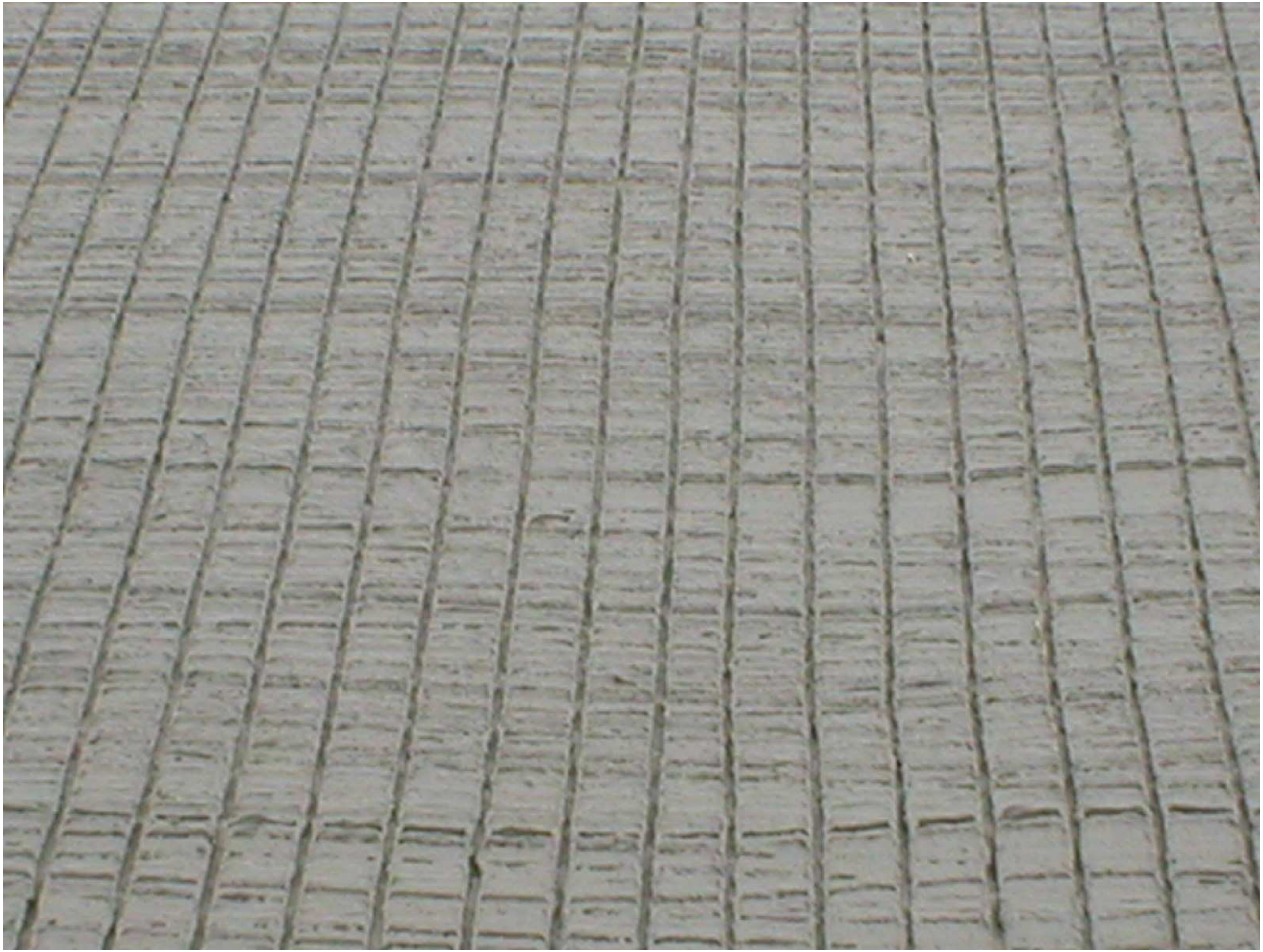
2’’ Steel fiber overlay. Novocon XR @ 75 lbs. cubic yard
City of Houston / I-610 frontage roads



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CONCRETE SYSTEMS

Blended Solutions

Novocon Steel Fibers or
Macro-Synthetic Fibers
+ Fibermesh Fibers
Novomesh System

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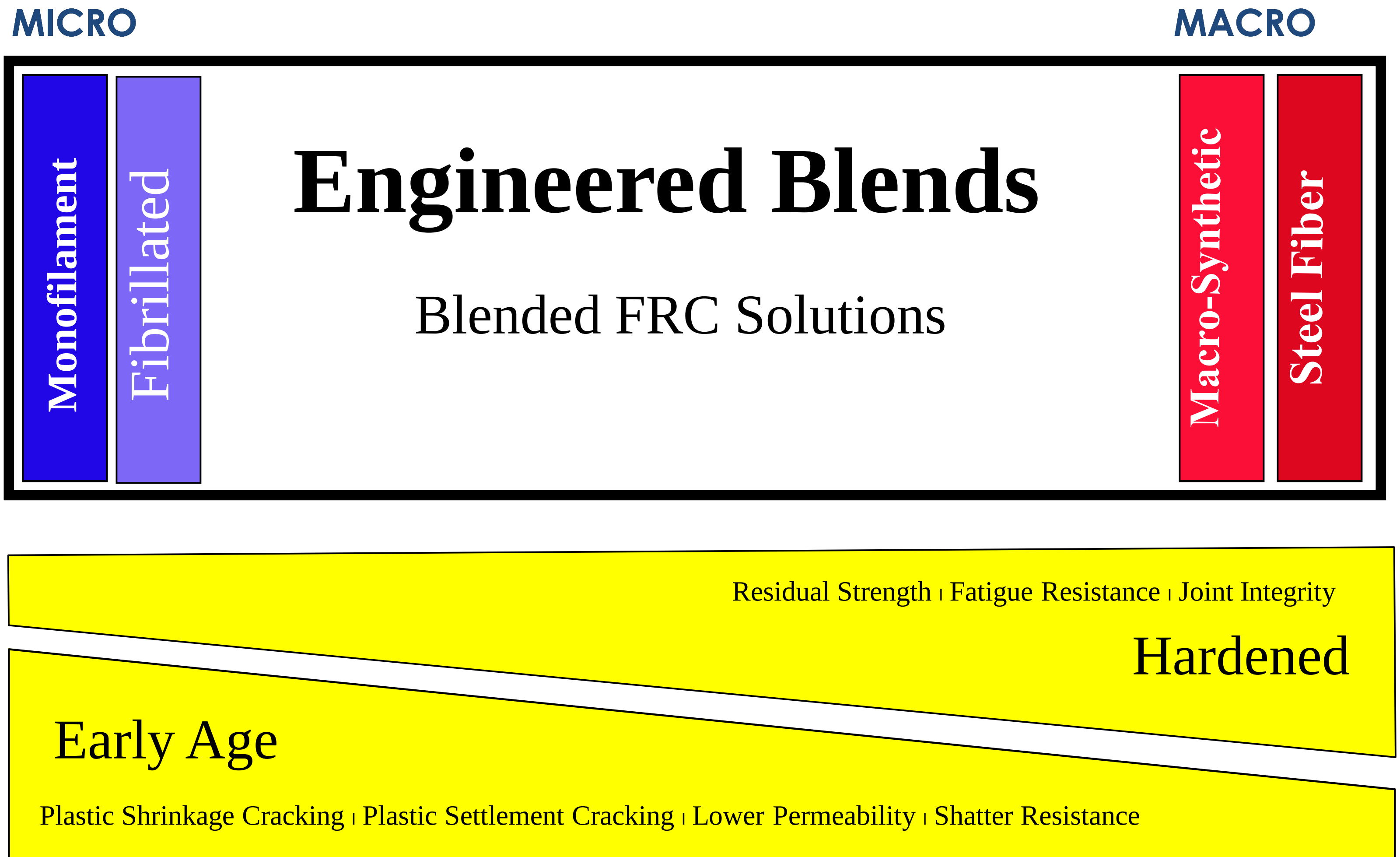
CONCRETE SYSTEMS

Fiber Reinforcement Product Positioning



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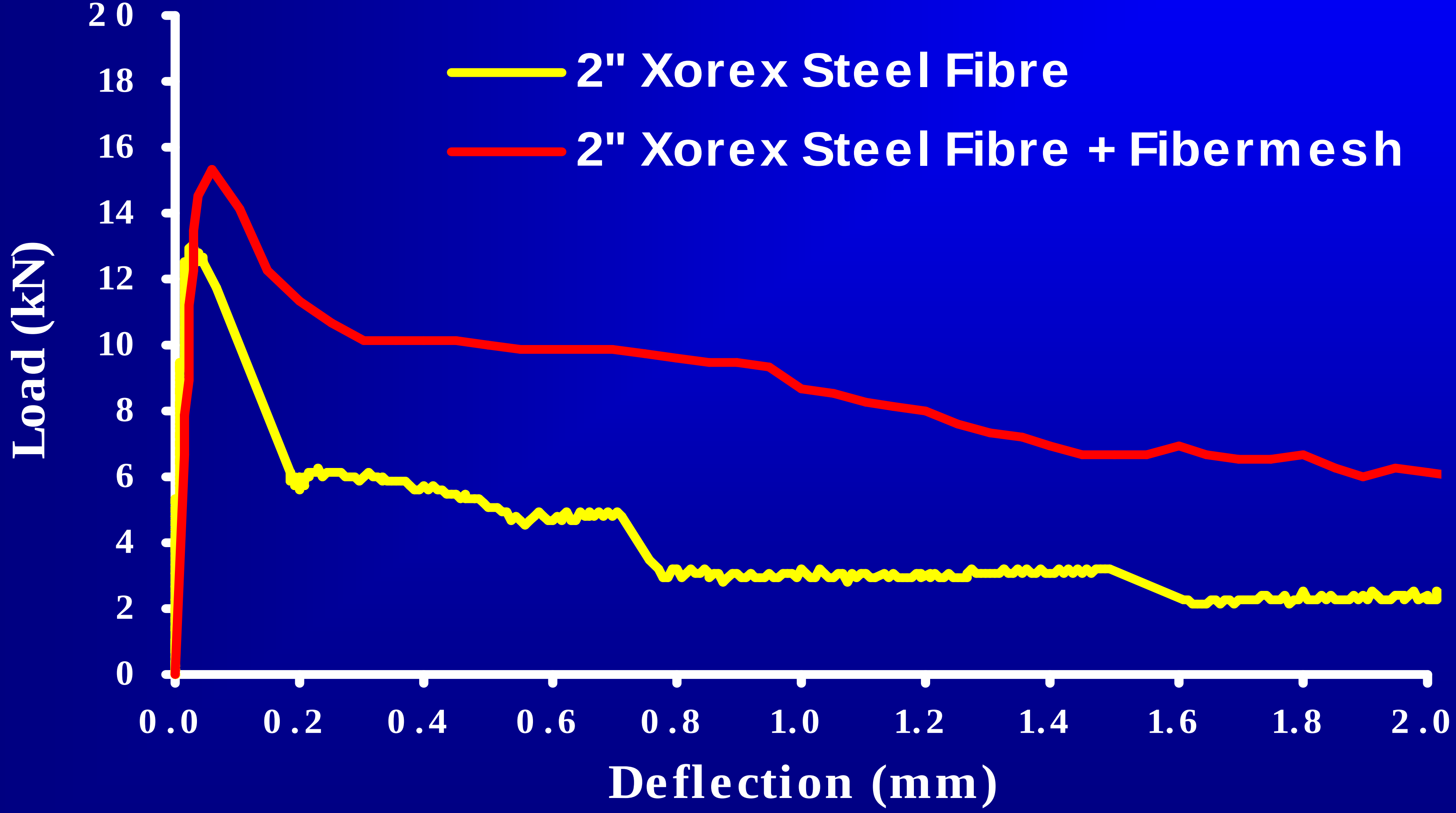
ASTM C-1018 Flexural Toughness

(Xorex: 20 lbs/yd^3, Fibermesh: 1.5 lbs/yd^3)



Steel & Micro Blend

A Blend of ASTM A820 Steel fiber

Microsynthetic - Monofilament

Commercial and Residential Markets

Providing Temperature and Shrinkage Reinforcement, not Structural

Not to be used to Extend Joint Spacing

24 pound bag (23 Steel + 1 PP)

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CONCRETE SOLUTIONS BY PROPEX

May 2003 - Galveston Conv. Ctr. – Specified 4’s @ 18’’. Used 36 lbs. Novomesh 850 cubic yard. Parking & Loading dock

Texas stores in 2007

Texarkana
Tyler
Longview
Mansfield
Conroe

Novomesh 850 blended steel fiber

Slab on ground – 24 lbs. cubic yard
Mezzanine CMD – 24 lbs. cubic yard
Loading dock – 36 lbs. cubic yard

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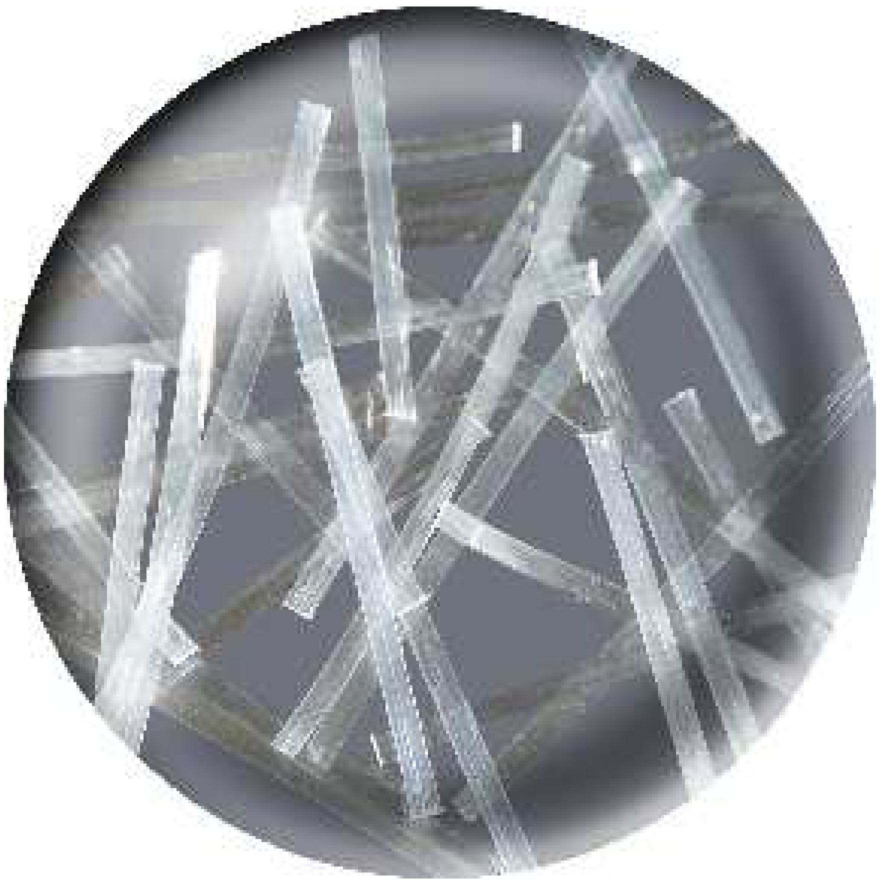
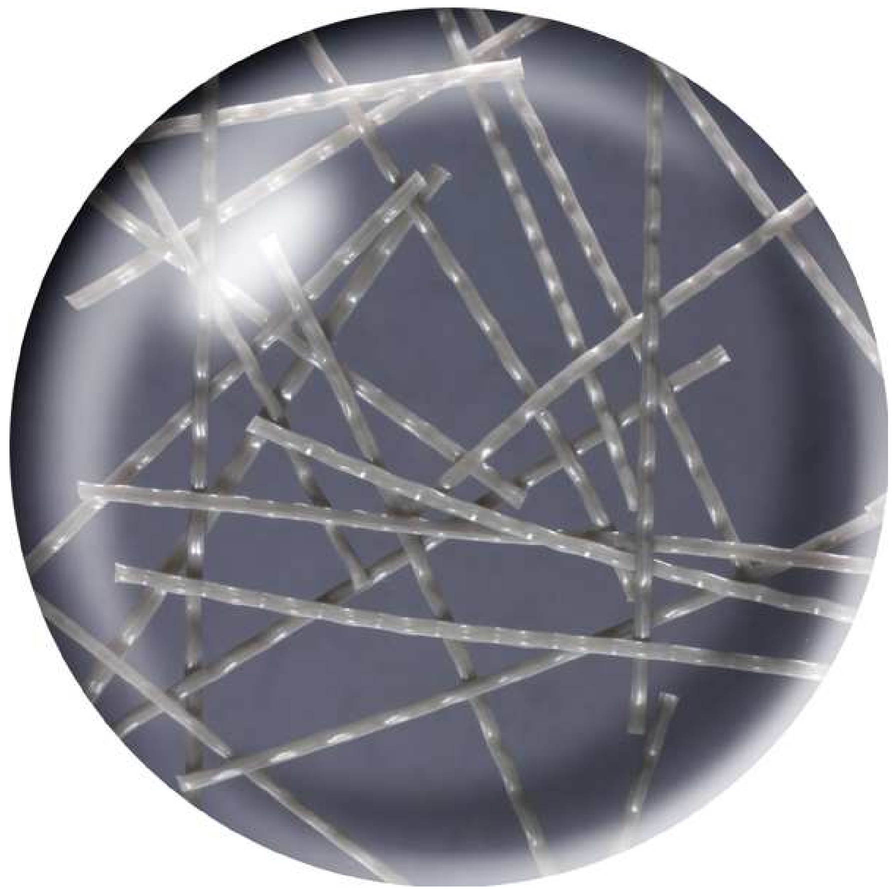
MACRO FIBER





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ACI 360R 10: Chapter 11 – Fiber-Reinforced Concrete Slabs-on-Ground

11.2 – Polymeric fiber reinforcement

11.2.2 - Design principals:

- **Micro-polymeric FRC design: same a unreinforced.**
- **Macro-polymeric FRC design : same as for Steel FRC**

11.2.3 - Joint details:

- **Micro's: same as for unreinforced s-o-g**
- **Macro's: At 0.2 to 1% - increases post-cracking strength – therefore:**

This material behavior permits wider sawcut contraction joint spacing; however, load transfer stability at sawn contraction joints should be considered carefully at wider joint spacing.

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Moment Capacity Calculations

The Ultimate-Strength Design Methodology, used since the early 1960's, can be used to evaluate fiber reinforced concrete to conventional reinforced concrete on the basis of the bending moments resisted by the contained tensile elements in a unit of concrete.

$$Mn = \phi As\, fy\, (d - a/2)$$

Step by Step process:

Step 1: Calculate depth of rectangular stress block, "a", using Equation 2.
a = Asfy/(0.85f'cb)
Step 2: Calculate the moment capacity of the continuously-reinforced section, "Mn", using Equation 3. $Mn = \phi As\, fy\, (d - a/2)$
Step 3: Based on the required moment capacity, Mn, of the continuously-reinforced section, calculate the required bending stress of the fiber-reinforced concrete section, "Fb" using Equation 4 *fb = Mn/S* This value also represents the required average residual strength (ARS) of the fiber reinforced concrete section f't. *f't = fb*
Step 4: This value can be found in the accompanying charts with the required fiber quantity
f't =Mn/S

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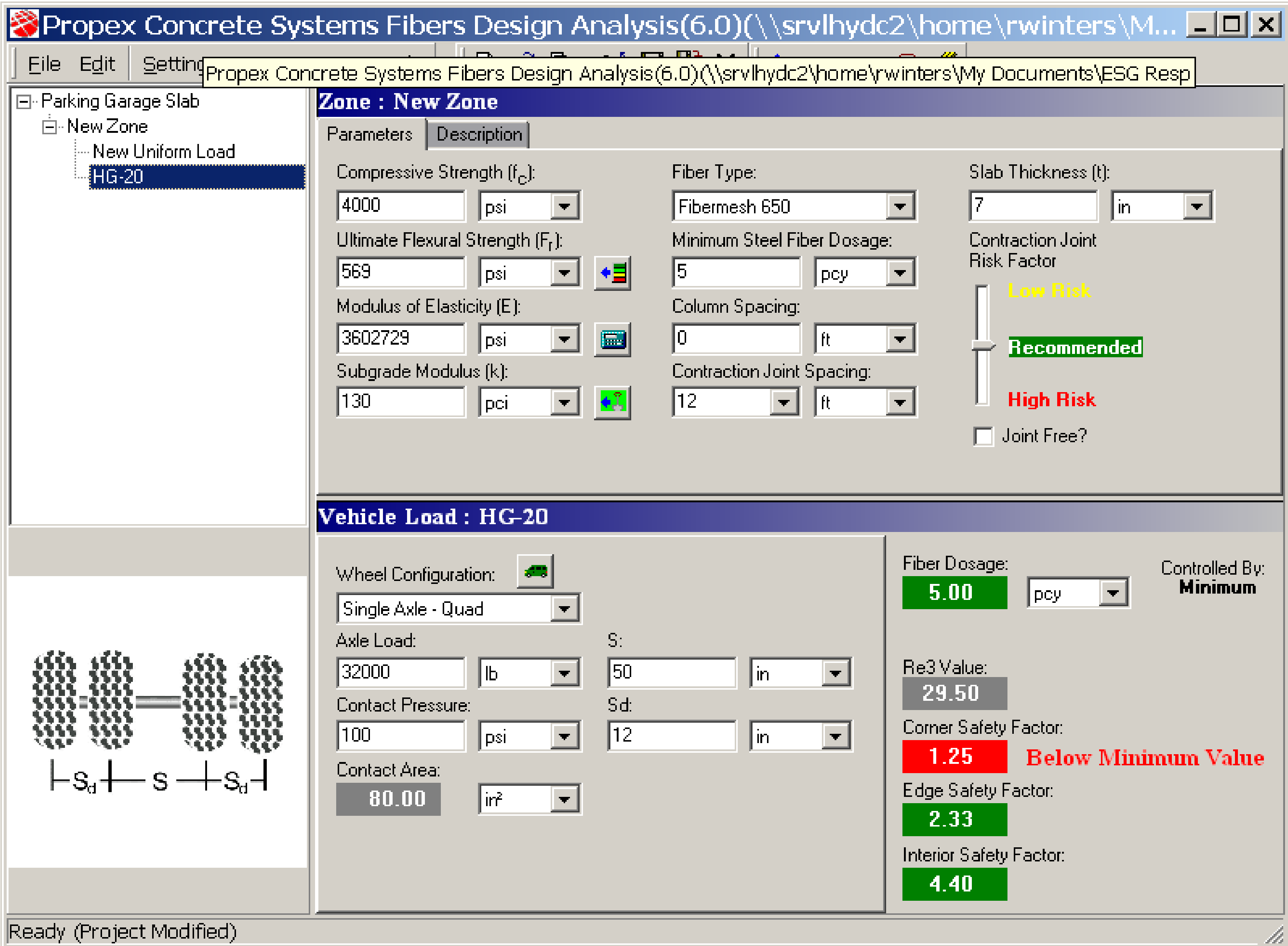
Yield Line Slab Analysis



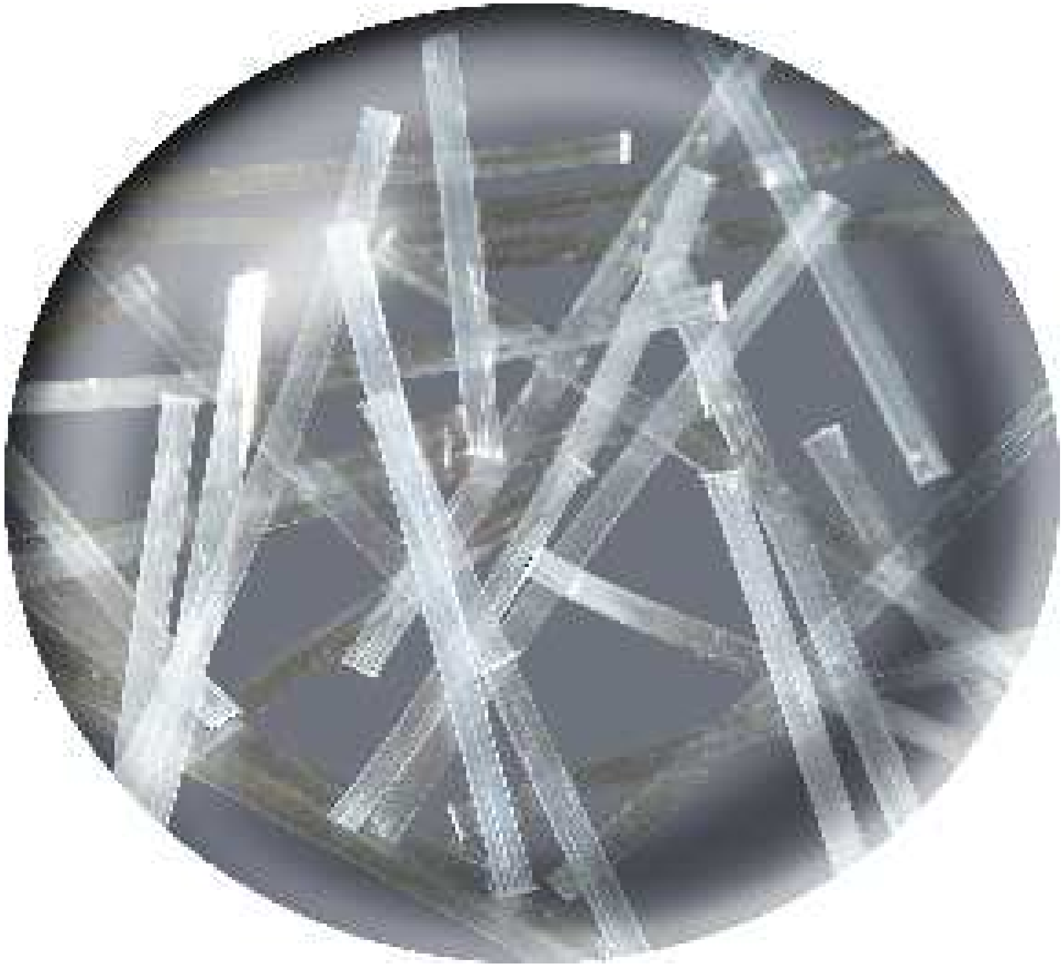
Macrosynthetic

Alloy Polymer Macro Synthetic Fiber

Alternate to 2.9 wire mesh and light duty rebar

Recognized By ACI 360R-06 Design of Slabs-on-Ground

Ideal for addition rates from 3 to 6#



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Fibermesh® 650 Conversion Chart - 3,000-psi Concrete
For Commerical and Light Industrial Slab On Ground Applications

Org.Design	6x6 W2.0/W2.0		6x6 W2.9/W2.9		6x6 W4.0/W4.0		4x4 W1.4/W1.4		4x4 W2.0/W2.0		4x4 W2.9/W2.9		4x4 W4.0/W4.0		# 3 Rebar @ 18" o.c.		# 3 Rebar @ 12" o.c.		# 4 Rebar @ 24" o.c.	
A_s , in^2/ft	0.040		0.058		0.080		0.042		0.060		0.087		0.120		0.073		0.110		0.100	
Thickness in inches	ARS	pcy	ARS	pcy	ARS	pcy	ARS	pcy	ARS	pcy	ARS	pcy	ARS	pcy	ARS	pcy	ARS	pcy	ARS	pcy
4	108	3.0	154	3.0	208	4.0	114	3.0	159	3.0	225	4.6	300	**	156	3.0	227	4.7	208	3.9
4-½	97	3.0	138	3.0	187	3.5	101	3.0	143	3.0	202	3.8	271	**	140	3.0	204	3.8	187	3.5
5	87	3.0	125	3.0	169	3.1	92	3.0	129	3.0	183	3.4	246	4.5	126	3.0	185	3.5	169	3.1
5-½	80	3.0	114	3.0	155	3.0	83	3.0	118	3.0	168	3.2	226	4.7	115	3.0	169	3.2	155	3.0
6	73	3.0	105	3.0	143	3.0	77	3.0	108	3.0	154	3.0	208	4.9	106	3.0	156	3.0	143	3.0
6-½	68	3.0	97	3.0	132	3.0	71	3.0	100	3.0	143	3.0	194	3.6	98	3.0	145	3.0	132	3.0
7	63	3.0	90	3.0	123	3.0	66	3.0	93	3.0	133	3.0	181	3.4	91	3.0	135	3.0	123	3.0
7-½	59	3.0	85	3.0	115	3.0	62	3.0	87	3.0	125	3.0	169	3.1	85	3.0	126	3.0	115	3.0
8	55	3.0	79	3.0	108	3.0	58	3.0	82	3.0	117	3.0	159	3.0	80	3.0	119	3.0	108	3.0

Notes:

- Represents fiber dosages based upon yield stress - fy where fy = 75,000 psi for WWF and 60,000 psi for
- Reinforcement assumed at mid-depth of slab
- Contraction Joint Spacing per ACI Guidelines - See ACI 302 & ACI 360
- Slab Thickness based on project requirements per ACI and PCA guidelines for slab on ground design
- Chart values based on ASTM C1399 ARS Values

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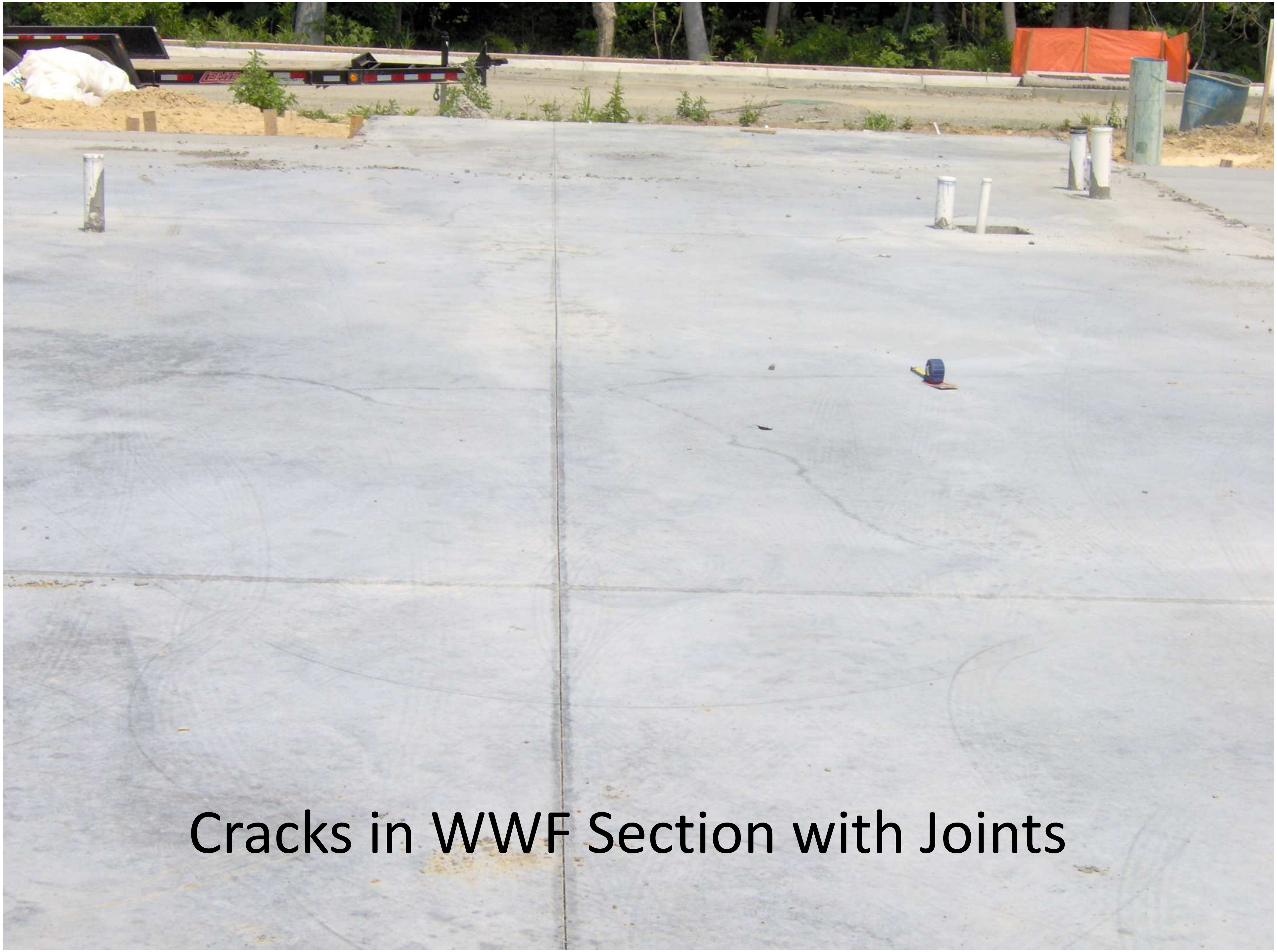
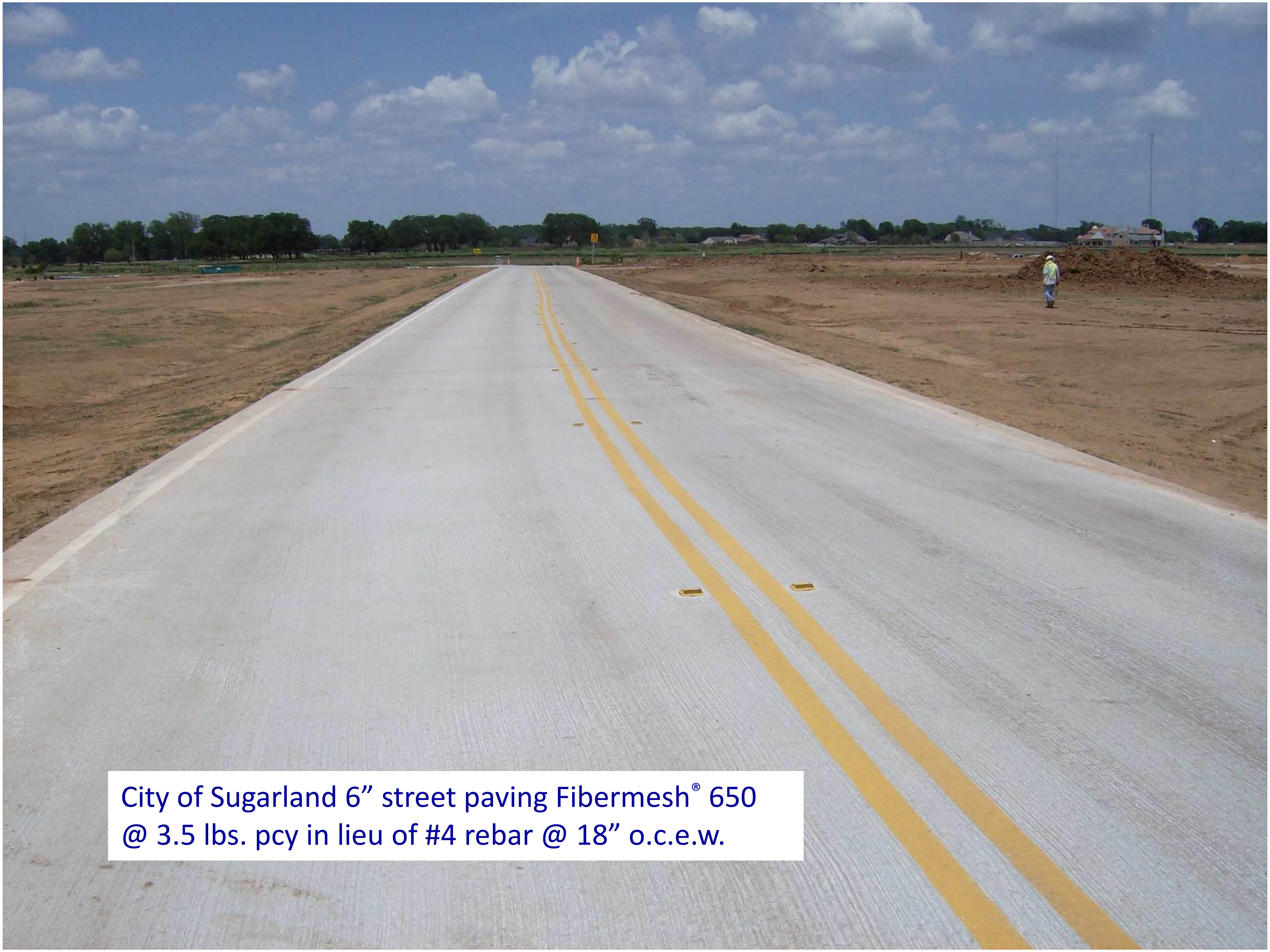


Cracks in WWF Section with Joints


1 2 3 4 5 6 7
FT & IN
INCHES
30FT
Crack Width in # 3 Rebar Section

Macrosynthetic Fiber: Crack Width



City of Sugarland 6” street paving Fibermesh® 650
@ 3.5 lbs. pcy in lieu of #4 rebar @ 18” o.c.e.w.

PROJECT SPOTLIGHT

Microsoft Underground Parking Structure
Redmond, WA

Fibermesh® 650 macro-synthetic fiber features e3® patented technology and is manufactured to an optimum gradation and highly oriented to allow greater surface area contact within the concrete resulting in increased interfacial bonding and flexural toughness efficiency.

A software developer in Redmond Washington was in the process of constructing the largest private underground parking structure in the United States. The slab-on-ground was originally designed by the structural engineer with #4 rebar at 18" on center. Working with the general contractor, Propex Concrete Systems submitted Fibermesh 650 at 3 lbs per cubic yard as an alternate design to the rebar. Being that the slab was only going to have passenger vehicular traffic the engineer approved the change. Fibermesh 650 is a macro-synthetic fiber engineered with patented e3 technology for optimum performance and workability. It is used as temperature and shrinkage reinforcement in concrete slabs-on-ground, pavements, and composite metal decks. Delivered in the ready mix truck, Fibermesh 650 can be easily pumped, placed and finished saving time and hassle.

The slab has been in service for over a year during construction. There is very little cracking in the slab even with some very large joint spacing of 20' by 40'. The use of Fibermesh 650 saved the owner a significant amount on the budget and allowed GLY to reduce several days on the construction schedule.

PROJECT DATA

Project: *Microsoft Underground Parking Structure*
Application type: *Slab-on-grade*
Fiber type: *Fibermesh 650*
General & concrete contractor: *GLY*
Concrete producer: *Cadman*
Total area: *850,000 sq. ft.*

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CONCRETE SYSTEMS

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Tel: 423 892 8080
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Propex House, 9 Royal Court, Basil Close
Chesterfield, Derbyshire, S41 7SL.UK
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www.fibermesh.com

Macro – Micro Blend

The all-synthetic
macro blend

Alternate to 2.9 wire mesh and light duty rebar

Recognized By ACI 360R-06 Design of Slabs-on-Ground

FIBERMESH®
CONCRETE SOLUTIONS BY PROPEX

Novomesh® 950 Conversion Chart {3,000-psi Concrete}
For Commerical and Light Industrial Slab On Ground Applications

Designation	6" x 6" W2.0 x W2.0		6" x 6" W2.9 x W2.9		6" x 6" W4.0 x W4.0		4" x 4" W1.4 x W1.4		4" x 4" W2.0 x W2.0		4" x 4" W2.9 x W2.9		4" x 4" W4.0 x W4.0		#3 rebar @ 12 in. x 12 in.		#3 rebar @ 18 in. x 18 in.		#4 rebar @ 24 in. x 24 in.	
A_s (in2/ft)	0.040		0.058		0.080		0.042		0.060		0.087		0.120		0.110		0.074		0.100	
Slab Thickness (in.)		pcy		pcy		pcy		pcy		pcy		pcy		pcy		pcy		pcy		pcy
4	164.6	5.0*	236.0	6.4	321.0		172.6	5.0*	243.8	6.9	347.5		469.0		351.2		240.7	6.7	321.0	
4 1/2	146.7	5.0*	210.6	5.0*	286.9	9.7	153.9	5.0*	217.6	5.2	310.8		420.6		314.2		214.8	5.0	286.9	9.7
5	132.4	5.0*	190.2	5.0*	259.4	7.9	138.8	5.0*	196.5	5.0*	281.1	9.4	381.2		284.2	9.6	194.0	5.0*	259.4	7.9
5 1/2	120.5	5.0*	173.4	5.0*	236.7	6.4	126.5	5.0*	179.2	5.0*	256.6	7.7	348.5		259.4	7.9	176.8	5.0*	236.7	6.4
6	110.7	5.0*	159.3	5.0*	217.6	5.2	116.1	5.0*	164.6	5.0*	236.0	5.0	321.0		238.6	6.6	162.5	5.0*	217.6	5.2
6 1/2	102.3	5.0*	147.3	5.0*	201.4	5.0*	107.3	5.0*	152.2	5.0*	218.5	5.0	297.4		220.9	5.4	150.3	5.0*	201.4	5.0*
7	95.1	5.0*	137.0	5.0*	187.5	5.0*	99.8	5.0*	141.6	5.0*	203.3	5.0*	277.1	9.1	205.6	5.0*	139.8	5.0*	187.5	5.0*
7 1/2	88.8	5.0*	128.0	5.0*	175.3	5.0*	93.2	5.0*	132.4	5.0*	190.2	5.0*	259.4	7.9	192.3	5.0*	130.6	5.0*	175.3	5.0*
8	83.3	5.0*	120.2	5.0*	164.6	5.0*	87.5	5.0*	124.2	5.0*	178.6	5.0*	243.8	6.9	180.6	5.0*	122.6	5.0*	164.6	5.0*

Comments:
- Represents fiber dosages based upon yield stress - fy where fy = 75,000 psi for WWF and 60,000 psi for rebar
- Reinforcement assumed at mid-depth of slab
- Contraction Joint Spacing per ACI Guidelines - See ACI 302 & ACI 360
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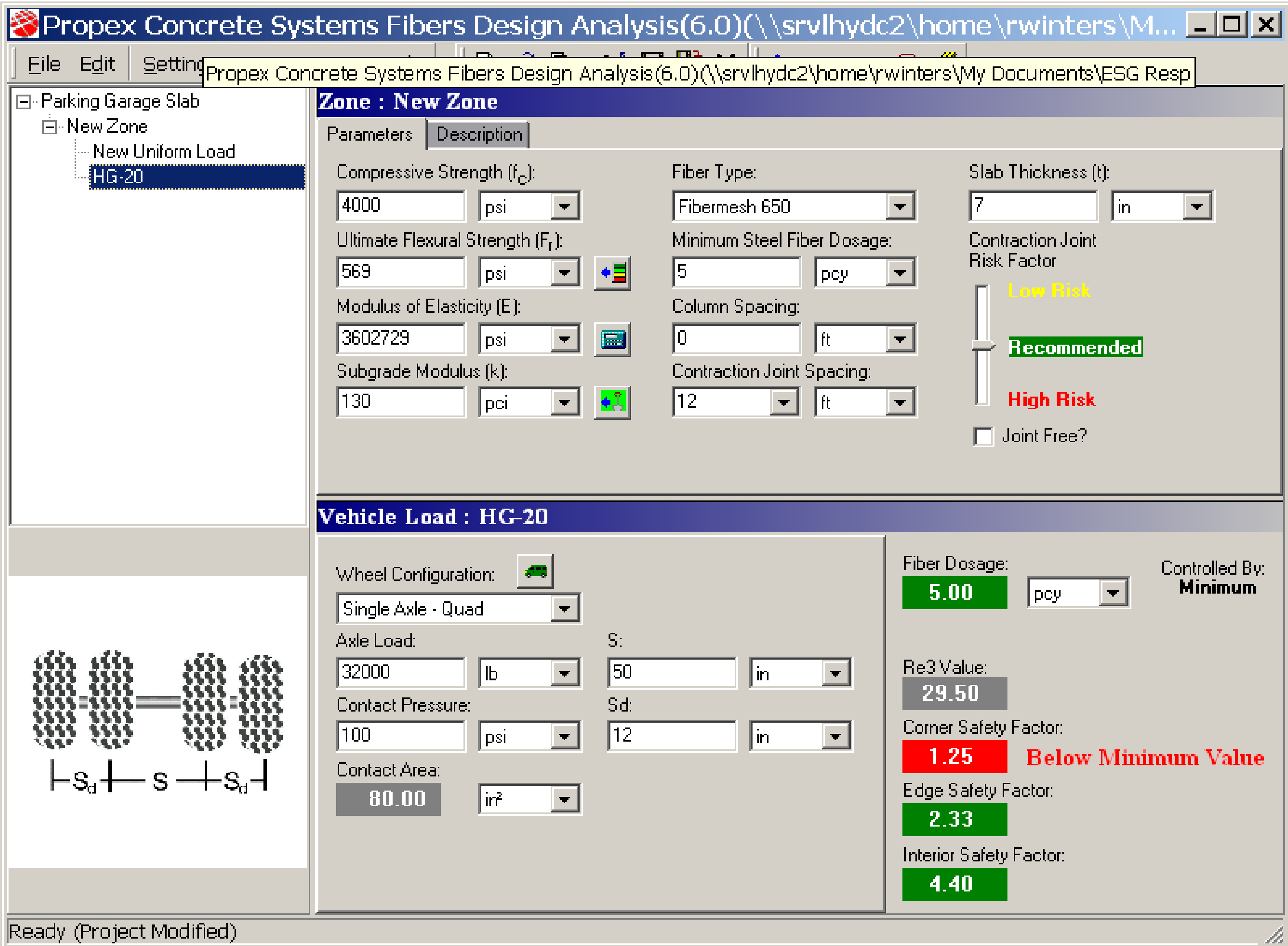
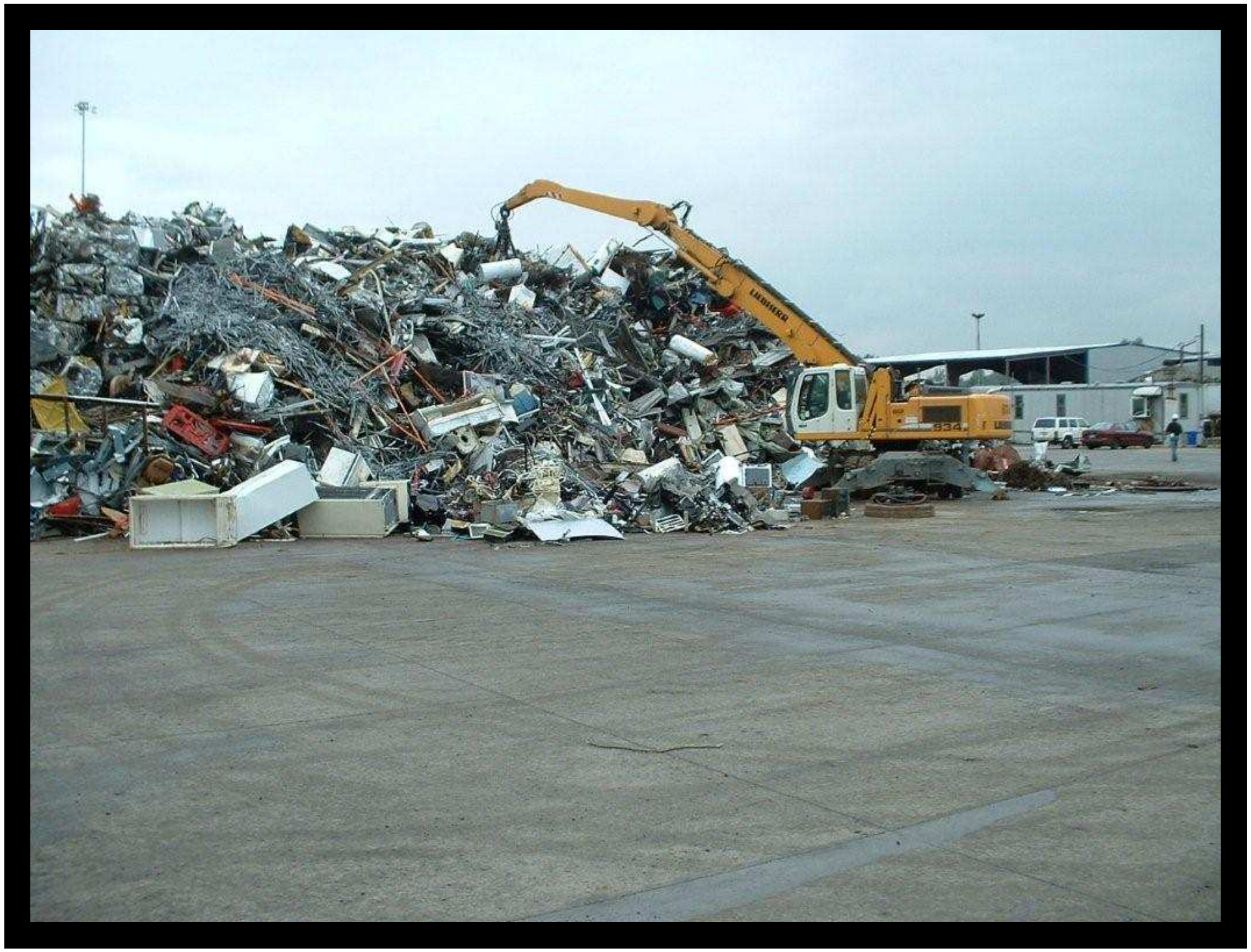
Yield Line Slab Analysis



Slidell, LA. Residential Streets – 5 lbs. 950. City of Slidell specifies 950 for streets

Volta Manufacturing Gears Rd. Houston, TX Novomesh 950 – 5 lbs pcy / 5,000 cyds.

Rivergate Scrap Metal
950@10lb/yd3



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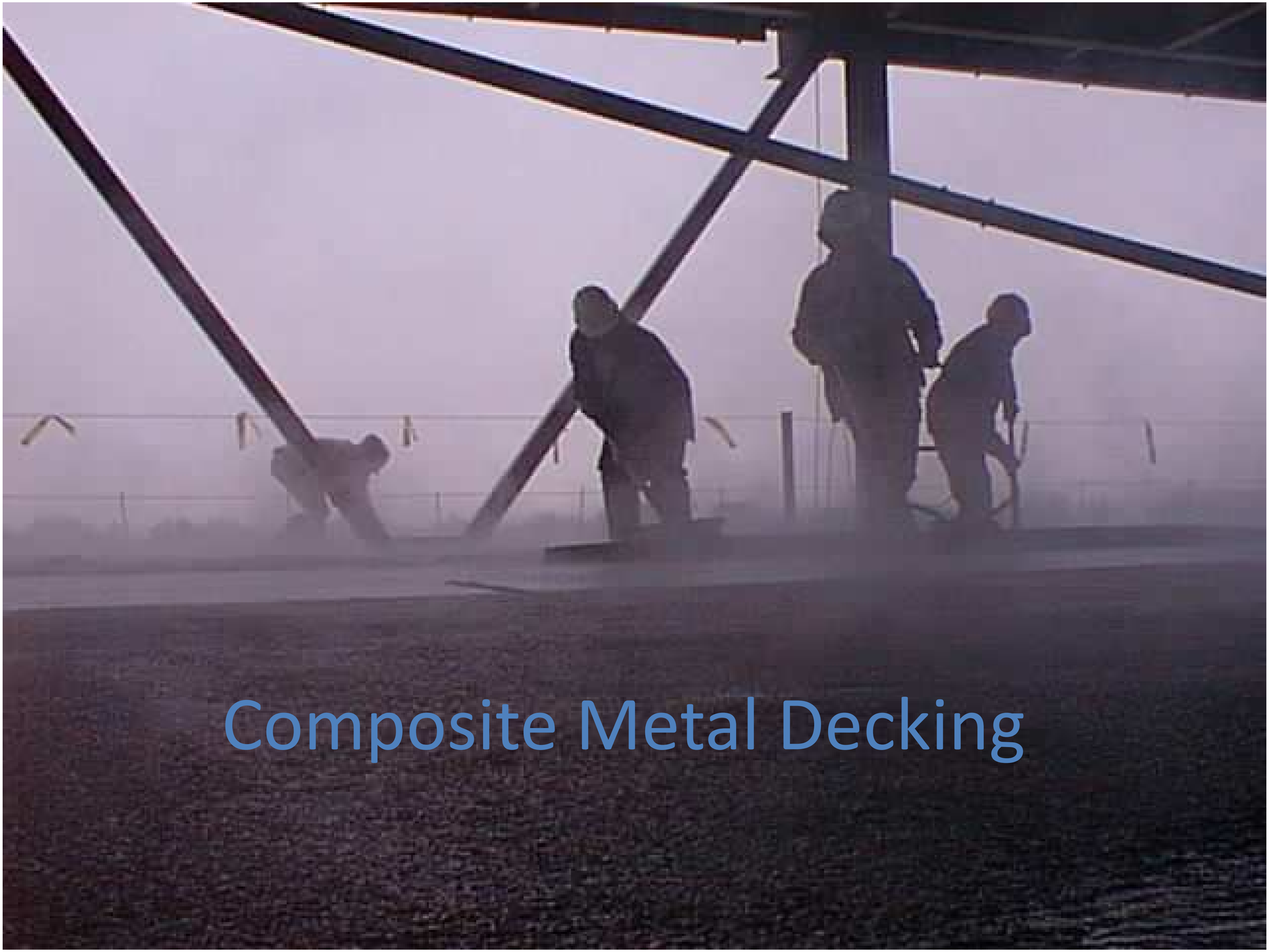

Composite Metal Decking

2007 ANSI - SDI C1.0 Standard for CMD

Reinforcement:

a. Temperature and shrinkage reinforcement, consisting of welded wire fabric or reinforcing bars, shall have a minimum area of 0.00075 times the area of the concrete above the deck (per foot or meter of width), but shall not be less that the area provided by 6 x 6 – W1.4 x W1.4 welded wire fabric.

   Fibers shall be permitted as a suitable alternative to the welded wire fabric specified for temperature and shrinkage reinforcement. Cold-drawn steel fibers meeting the criteria of ASTM A820, at a minimum addition rate of 25 lb/cu yd (14.8 kg/cu meter), or macro synthetic fibers "Coarse fibers" (per ASTM Subcommittee C09.42), made from virgin polyolefin, shall have an equivalent diameter between 0.4 mm (0.016 in.) and 1.25 mm (0.05 in.), having a minimum aspect ratio (length/equivalent diameter) of 50, at a minimum addition rate of 4 lb./cu yd (2.4 kg/m^3 are suitable to be used as minimum temperature and shrinkage reinforcement.

Texas Department of Transportation

DMS – 4550 FIBERS FOR CONCRETE
EFFECTIVE DATE: SEPTEMBER 2010

4550.1. Description. This Specification establishes requirements and specific test methods to determine the dosage of fibers for Class A and B concrete.

Pre-Qualified Fibers for Concrete – Synthetic
Modified ASTM C1399:

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Texas Department of Transportation

DMS – 4550 FIBERS FOR CONCRETE
EFFECTIVE DATE: SEPTEMBER 2010

1. Qualification. If approved for use by the Department, CST/M&P will add the material to the MPL.

2. Failure. Producers not qualified under this Specification may not furnish materials for Department projects and must show evidence of correction of all deficiencies before reconsideration for qualification.

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Texas Department of Transportation

DMS – 4550 FIBERS FOR CONCRETE
EFFECTIVE DATE: SEPTEMBER 2010

4550.6. Material Requirements. Provide fibers conforming to ASTM C 1116, including synthetic fibers, that are alkali-proof, non-absorptive, resistant to deterioration due to long-term exposure to moisture or substances present in admixtures, and do not contribute to nor interfere with the air entrainment of the concrete. Steel fibers for fiber reinforced concrete must conform to ASTM A 820, glass fibers must conform to ASTM C 1666, and cellulose fibers must conform to ASTM D 7357. In addition, the fibers and their dosage must meet the average residual strength requirements as listed in Table 1.

Texas Department of Transportation

DMS – 4550 FIBERS FOR CONCRETE
EFFECTIVE DATE: SEPTEMBER 2010

Table 1

Average Residual Strength (ARS) Requirements According to General Usage

Class of Concrete	Minimum Average Residual Strength (psi)[1]	General Usage[2]
A	115	Curb, gutter, curb & gutter, sidewalks
B	115	Riprap

1. When tested in accordance with ASTM C 1399 with the following modification: the initial deflection for the initial crack should be 0.02000 in. The sample tolerance of ARS should not fall below 10% of the specified required value.

2. For information only

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Texas Department of Transportation

Pre-Qualified Fibers for Concrete – Synthetic
Modified ASTM C1399:

Producer	Product	Length (in.)	Minimum Dosage (lb./cu. yd.)
Propex	Fibermesh 300	1.50	3.5
	Fibermesh 650	1.50	4.0
	Novomesh 950	1.80	10.0

Fibermesh – Novomesh - Novocon

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The Correct Fiber Fit for your Project

- Any Cast in Place Concrete
- Microsynthetic Fibers : Monofilament or Fibrillated
- Slabs & Pavement: w/ Close Joint Spacing using Light Gage WWF
- Microsynthetic: Fibrillated
- Slabs & Pavements: Using Heavy WWF or Light Duty Rebar (> w2.9)
- Macrosynthetic – Steel – Engineered Blends
- Composite Metal Decking
- Macrosynthetic – Steel – Engineered Blends
- Heavy Commercial - Industrial Slabs & Pavements
- Steel Fibers – Engineered Blends

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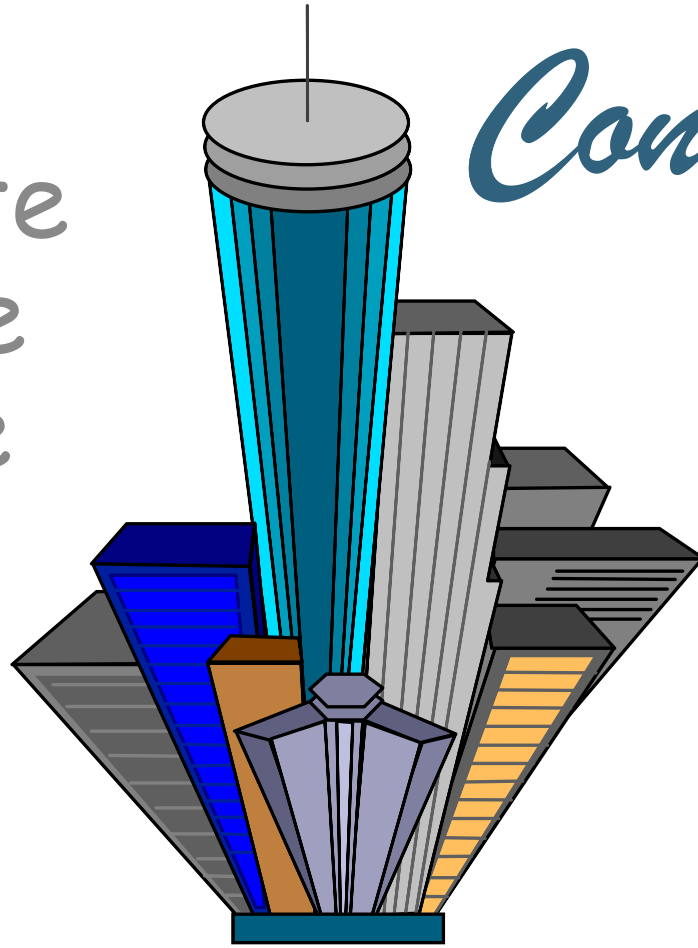
Fiber Reinforced Concrete

Concrete for the Future



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