Low Shrinkage Fiber-Reinforced Concrete for Improved Crack Control and Durability

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Concrete is cracked by …

- Low strength from improper curing
- Low strength from excess water
- Shrinkage cracking
- Freeze thaw cycles
- Chloride attack
- Alkali silica reaction
- Sulfate attack
- Acid attack
- Carbonation
- Fatigue and overloading (least)

Improving durability of concrete

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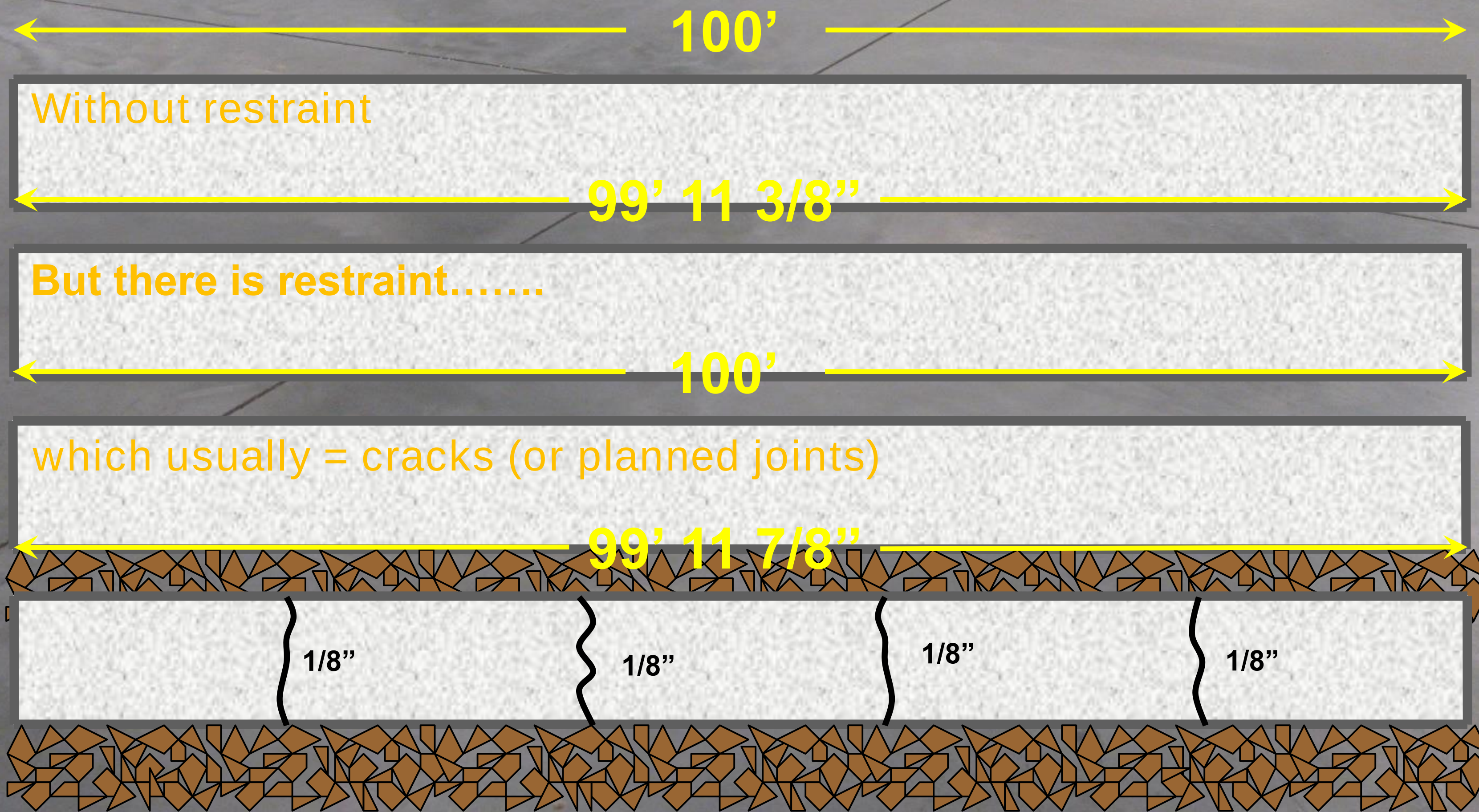
- Making the concrete denser and less permeable
  - Lower w/c, use SCM, proper gradation, curing …
- Minimizing cracking potential
  - …low shrinkage concrete
- Controlling the cracks / crack widths
  - … fiber reinforcement

Concrete shrinkage

Typical Concrete Drying Shrinkage is 0.05% = 5/8” in 100’



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Minimizing Shrinkage

Approaches to minimize cracking and curling due to shrinkage

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1. Mix design approach
2. Shrinkage reducing admixtures
3. Shrinkage compensation

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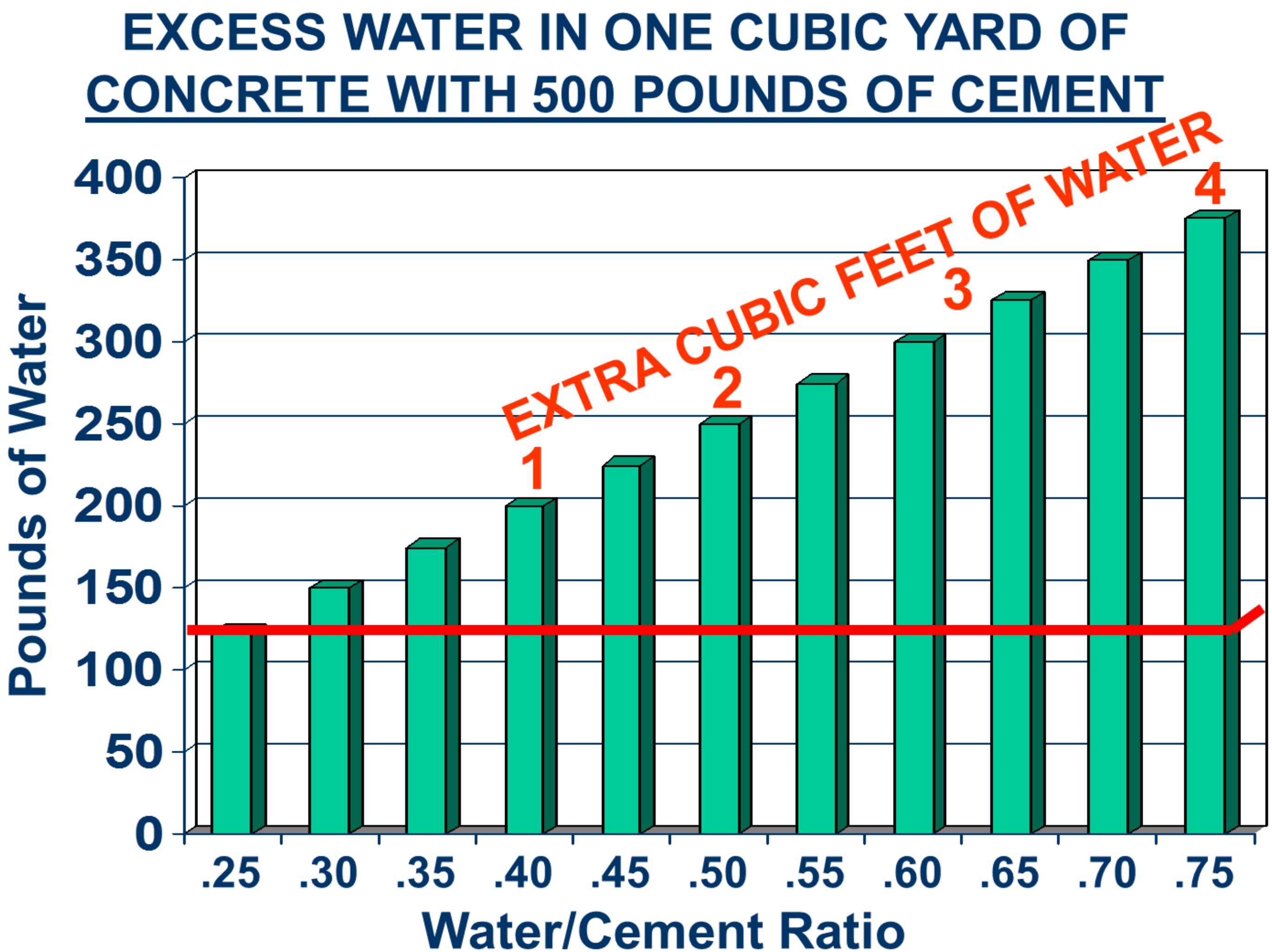
Less joints and less cracking

Water in concrete



Water reducing / plasticizing admixtures

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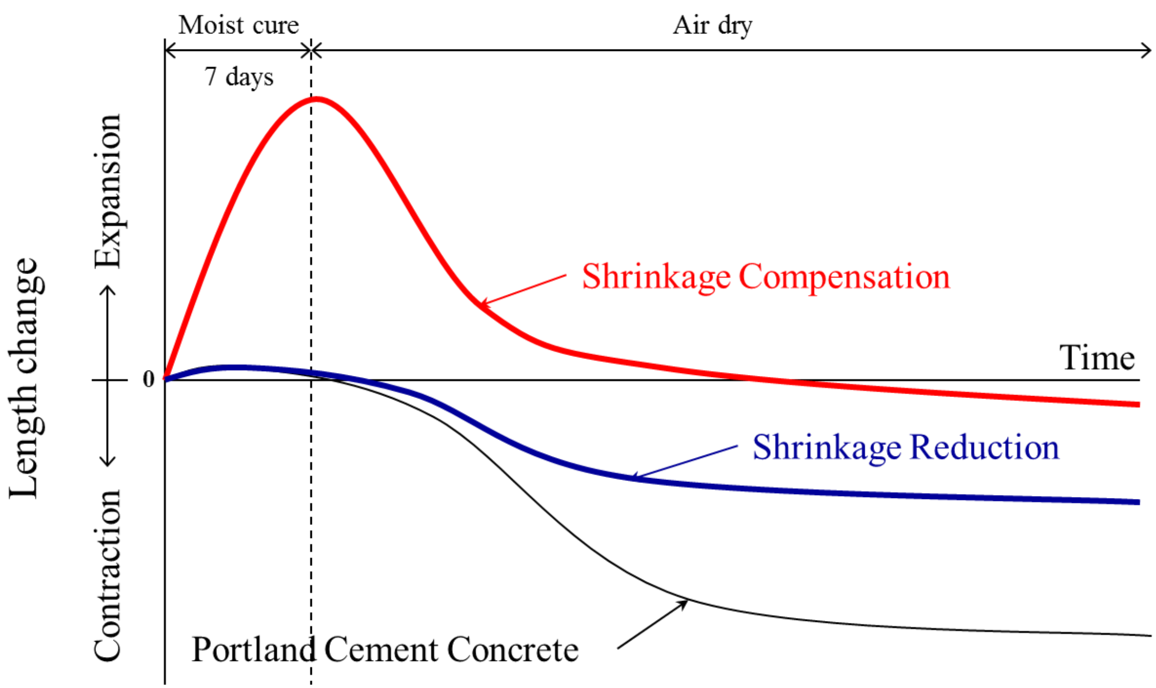
Aggregate size

MORE AND LARGER COARSE AGGREGATES

MEANS:	**LESS SURFACE AREA AND LESS SPACE TO FILL**
WHICH MEANS	**LESS PASTE**
WHICH MEANS	**LESS CEMENT**
WHICH MEANS	**LESS WATER**
WHICH MEANS	**LESS EXCESS WATER**
WHICH MEANS	**LESS SHRINKAGE**
WHICH MEANS	**LESS CRACKING & CURLING**

Theories of Shrinkage



- ACI 223 graphic
- curves dependent on many factors
- no influence from fibers
- importance of curing illustrated
- mix design can influence
- testing diligence is very important

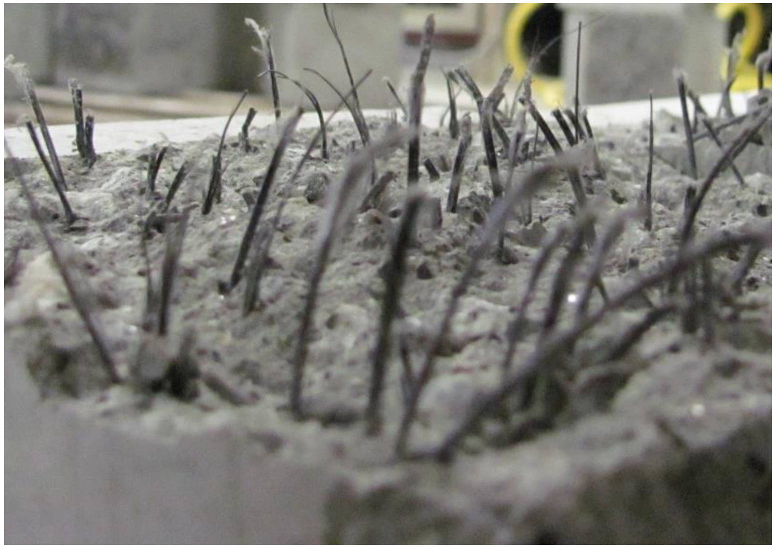
Summary of Mix design goals

- High quality paste but not too much
- Maximize well graded coarse aggregates
- Enough water for hydration and finishing; use plasticizers
- Use SRA / SCA to lower the concrete shrinkage

Fiber reinforcement

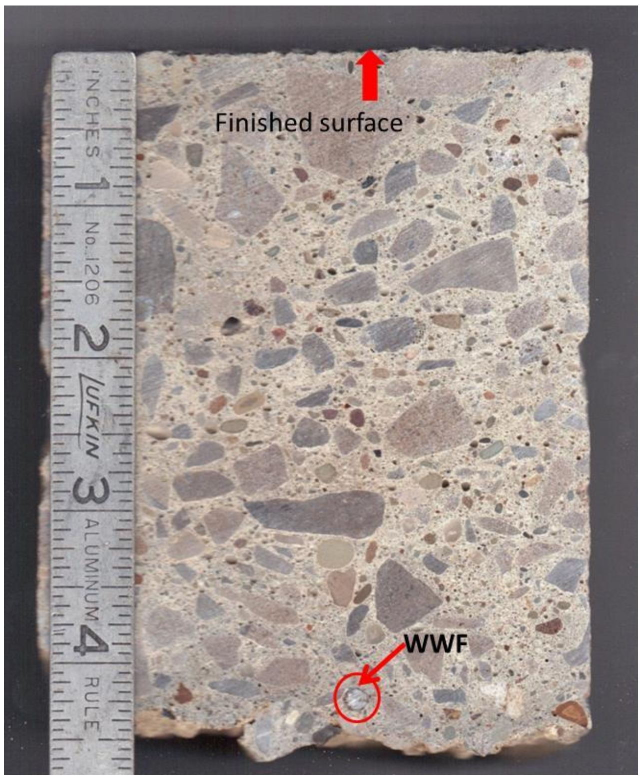
- Fibers are used in concrete for the same reason that straws were used in mud bricks thousands of years ago: **post-crack strength**.

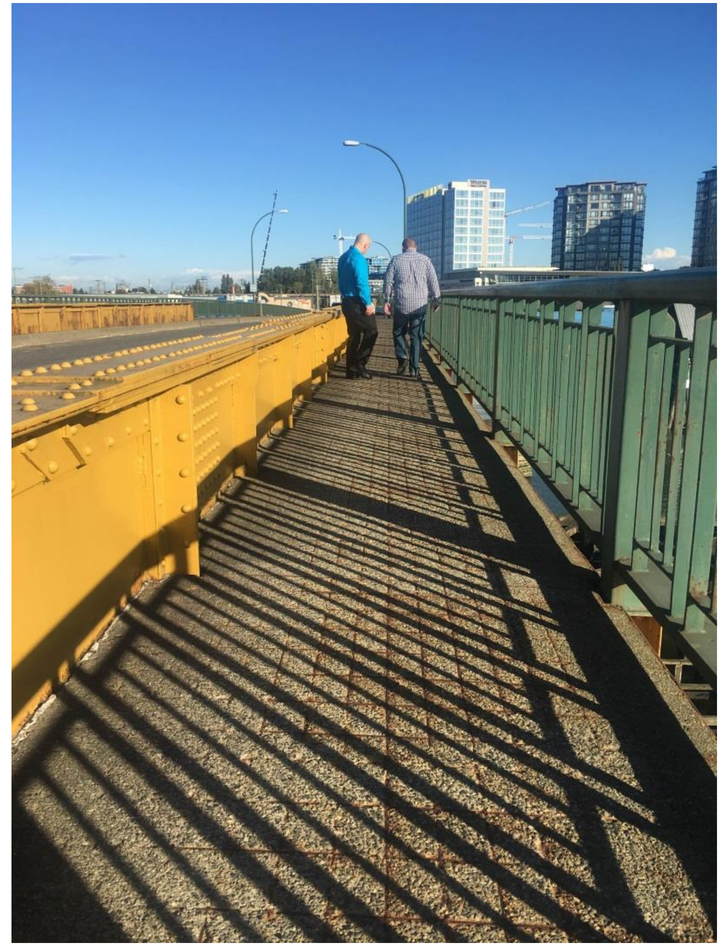
- Structural fibers provide additional tensile and flexural capacity.



Why not mesh or bars?

- If placed too low, it doesn't work!
- If placed too high, it will be exposed!
- Always corrosion issue (deicing salts)!





Types of Fibers

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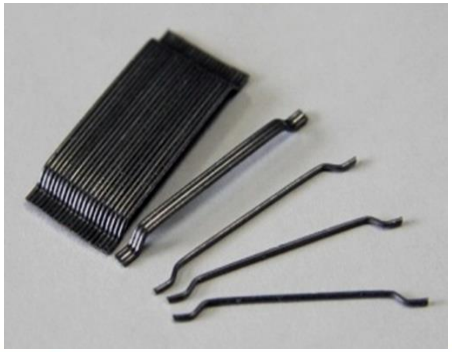
- **Synthetic microfibers**: “secondary” reinforcement; shorter and finer strands, plastic shrinkage crack control only. They can be monofilament or fibrillated (0.5-1.5 pcy)

- **Synthetic macrofibers**: longer and coarser strands, shrinkage crack control and limited structural applications. Dosage rates should be calculated by engineering requirements and equations (3-20 pcy)

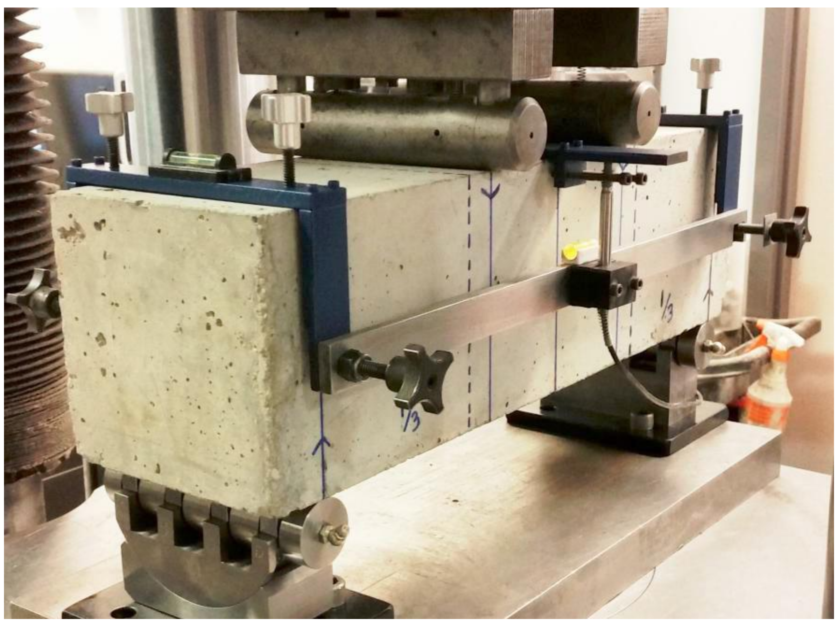
- **Steel fibers**: longer and coarser pieces, extended structural applications. Dosage rates should be calculated by engineering requirements and equations (15-100 pcy)

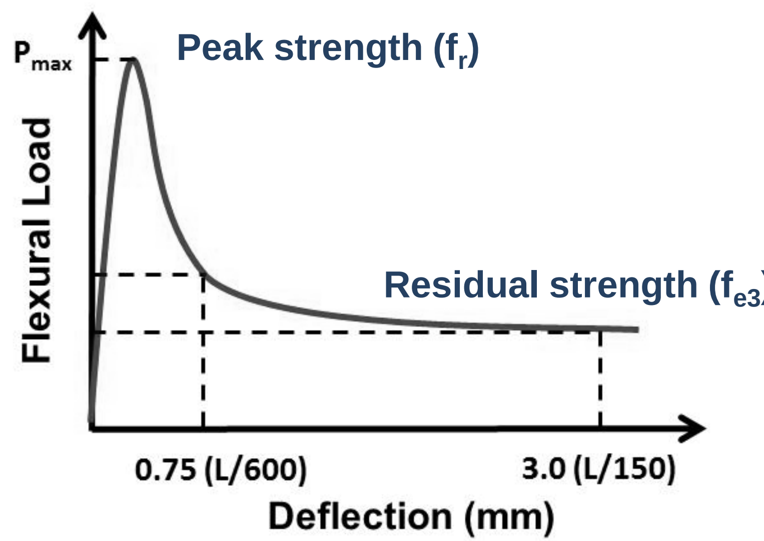


Testing FRC

Designation: C1609/C1609M – 12

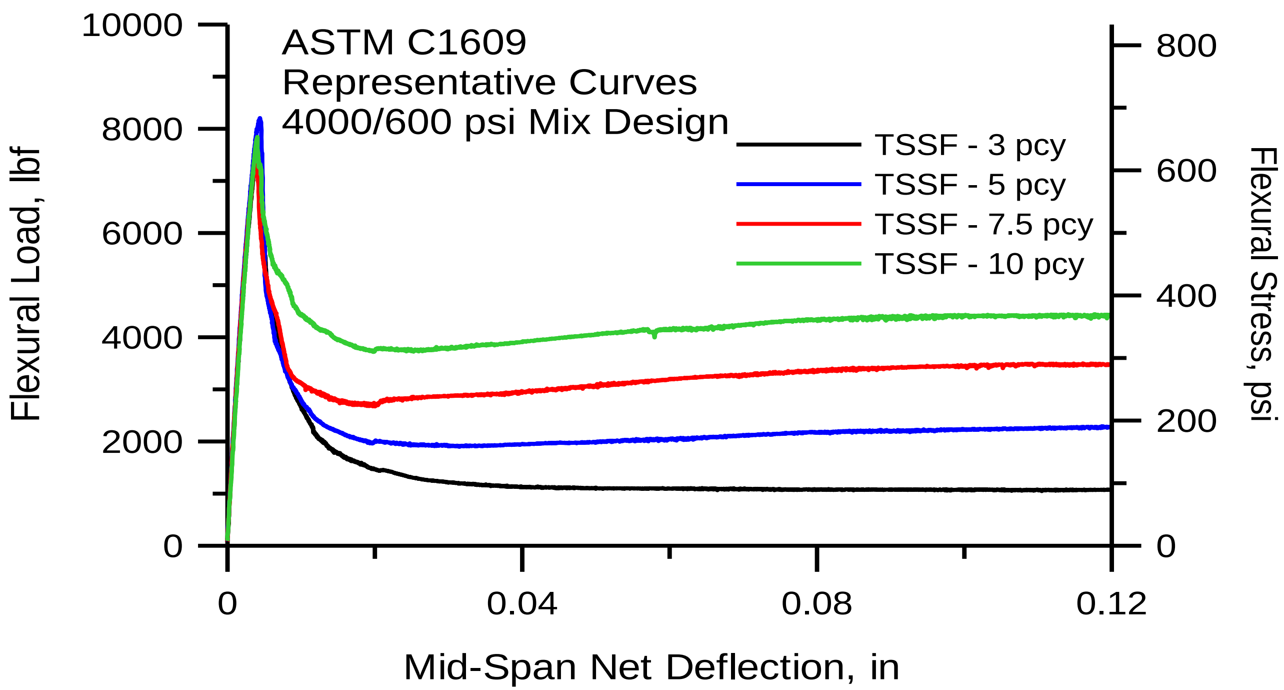
Standard Test Method for
Flexural Performance of Fiber-Reinforced Concrete (Using Beam With Third-Point Loading)[1]





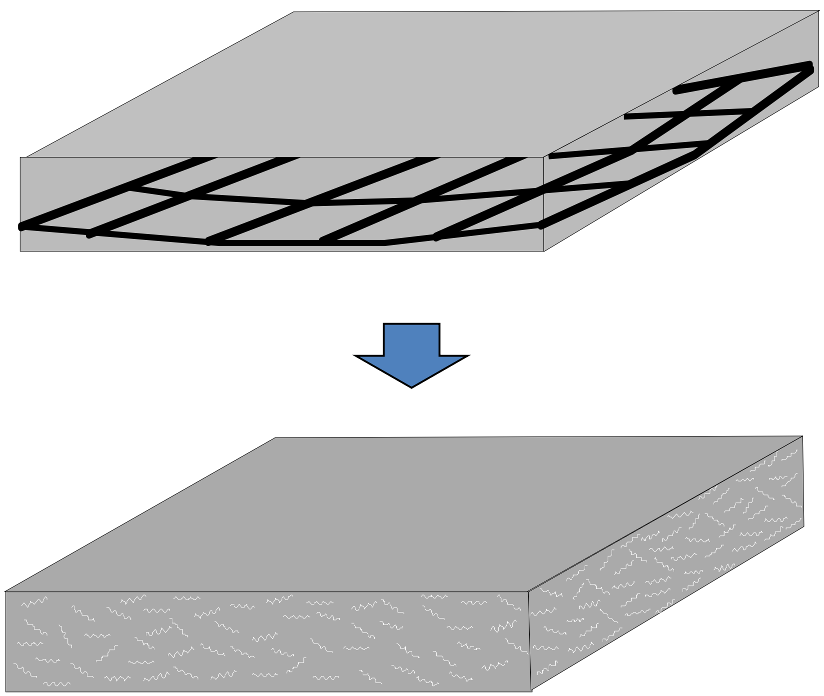
$R_{e3} = f_{e3} / f_r$

Effect of Fiber Dosage



TSSF	f_r (psi)	f_{e3} (psi)	R_{e3} (%)
3 pcy	597±43	133±9	22±3
5 py	669±9	209±15	31±2
7.5 pcy	651±25	293±29	45±4
10 pcy	662±8	372±39	56±6

FRC benefits

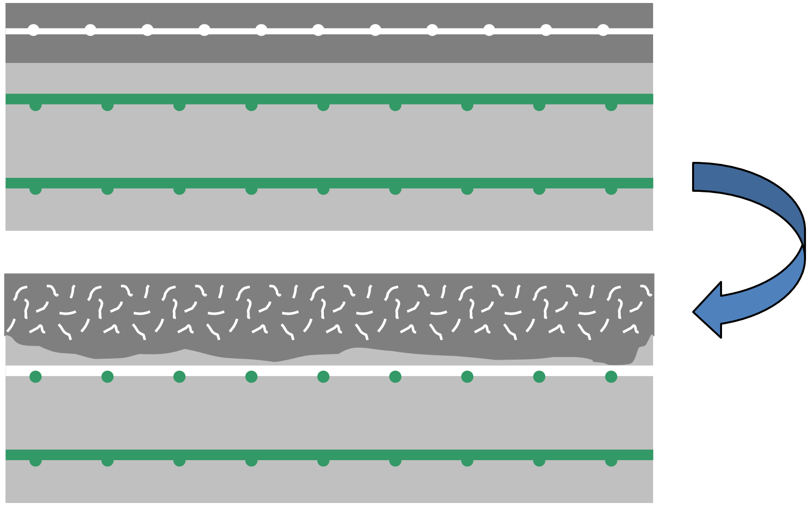


During the construction
- Reduced labor and costs
- Reduced construction time
- Increased safety
- Potential reduction in thickness
- Added value for RM

After the construction (in service)
- Three dimensional reinforcement
- Shorter and thinner cracks (in any)
- Less spalling and chipping
- Increase in long-term durability
- Lower maintenance costs

Salmon River Jeddore Bridge repair
Nova Scotia, Canada

3” thick topping
(high dosage synthetic macrofiber)



Mud Creek Bridge, Iowa.
122 feet length, 47 feet largest span, 30 feet width.

1.5” **overlay** with UHPC (high strength, high dosage steel fiber, SCC mix.)


Brand new bride deck without fibers or low shrinkage concrete

ABC's of CRACK-Less Bridge Decks

With Applications in

ACCELERATED

BRIDGE CONSTRUCTION

Sonny Fereira, PE California Department of Transportation
March 21, 2014
Bridge Contractors / Caltrans Liaison Committee Meeting

Formula for the CRACK-Less Bridge Deck

A. Shrinkage Reducing Admixture*

B. Water Reducing Admixture*

C. Fibers*

*add to concrete mix

The Current Cost Of Doing Business v. CRACK-Less Deck

$50 MILLION TO SEAL CRACKS

$2 MILLION FOR CRACK-Less DECKS

Desert Center, CA

1 lb/yd^3 micro and 3 lb/yd^3 macro fibers plus ¾ gal SRA

Thank you for your time and interest today!

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