

# AT 32 STORIES, IT'S ALL ABOUT THE BOND!



# Scott Hemphill



# Micro Structure of Cement

- ▣ Chemical composition of cement clinker
  - Tricalcium aluminate,  $C_3A$ 
    - ▣ Liberates heat during the early stages of hydration
  - Tricalcium silicate,  $C_3S$ 
    - ▣ Largely responsible for Portland cement's initial set and early strength gain
  - Dicalcium silicate,  $C_2S$ 
    - ▣ Responsible for strength gain after one week

**WARNING!**



**BRAIN EXPLOSION  
ZONE**

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After a day and a half of excellent presentations and only 30 minutes from “Happy Hour” I think we have all reached technical saturation.



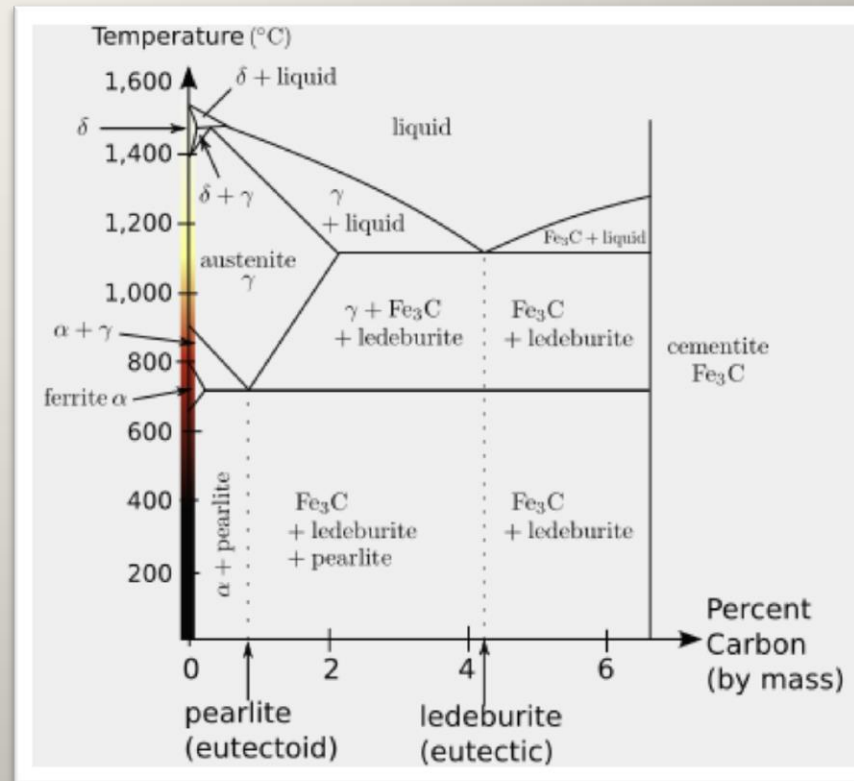
# Steel



# We thought we knew why steel was so strong.....

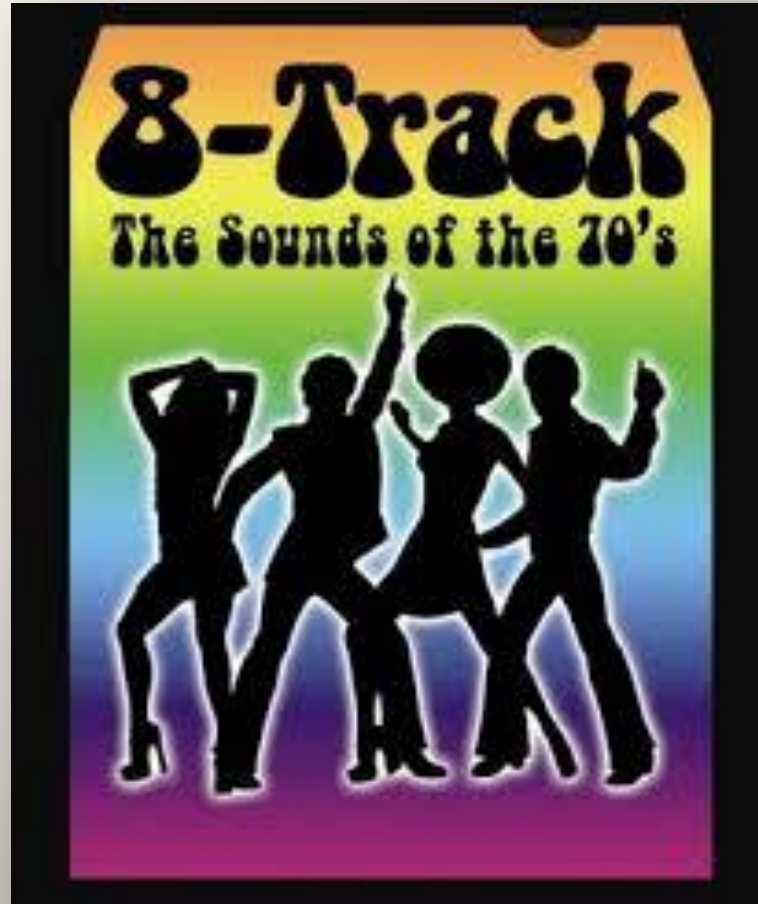


# .....We now understand where steel gets its strength





# In Concrete Restorations “dark Ages” we thought we understood Bonding.....

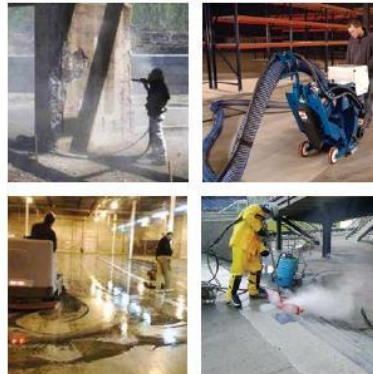


# .....We now understand how the repair gets its strength



## TECHNICAL GUIDELINES

Prepared by the International Concrete Repair Institute October 2013

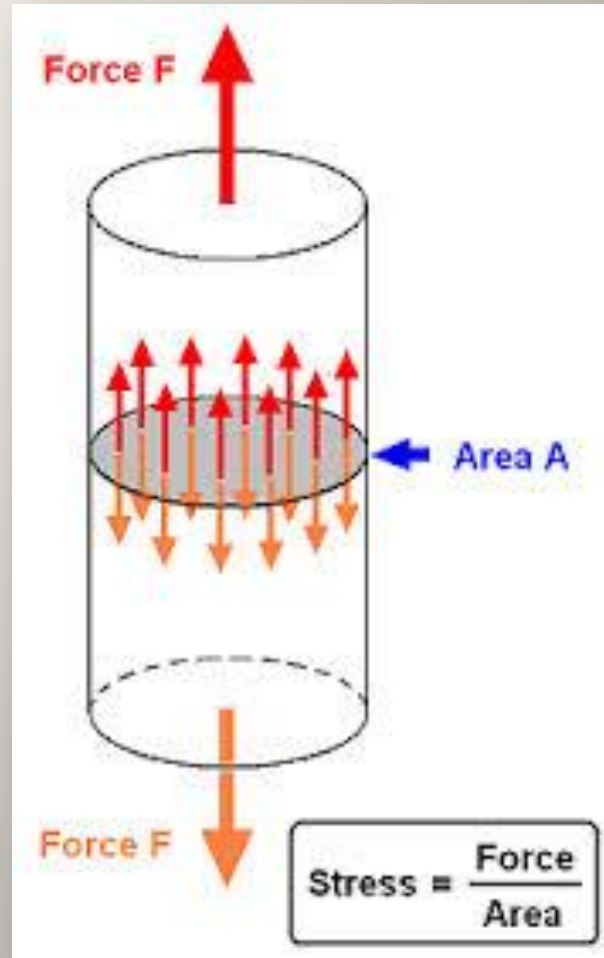


### Guideline No. 310.2R-2013

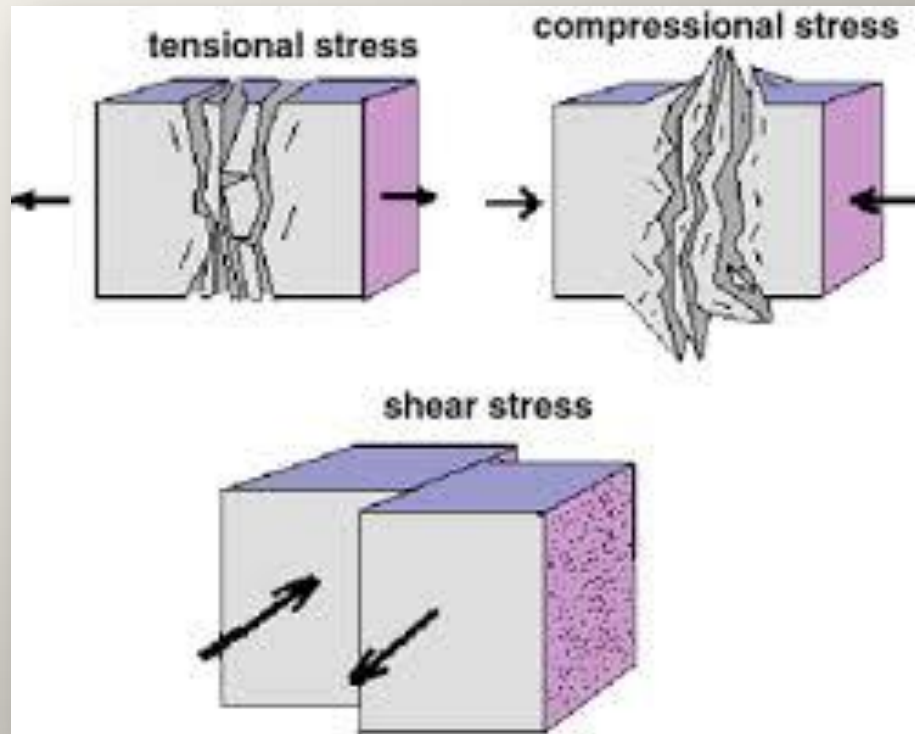
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**Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair**

# Simple Engineering



# Three Types of Stresses



# The Real Strength of Concrete

Compressive strength =  $F_c'$

Standard concrete = 2,500- 7,500 psi

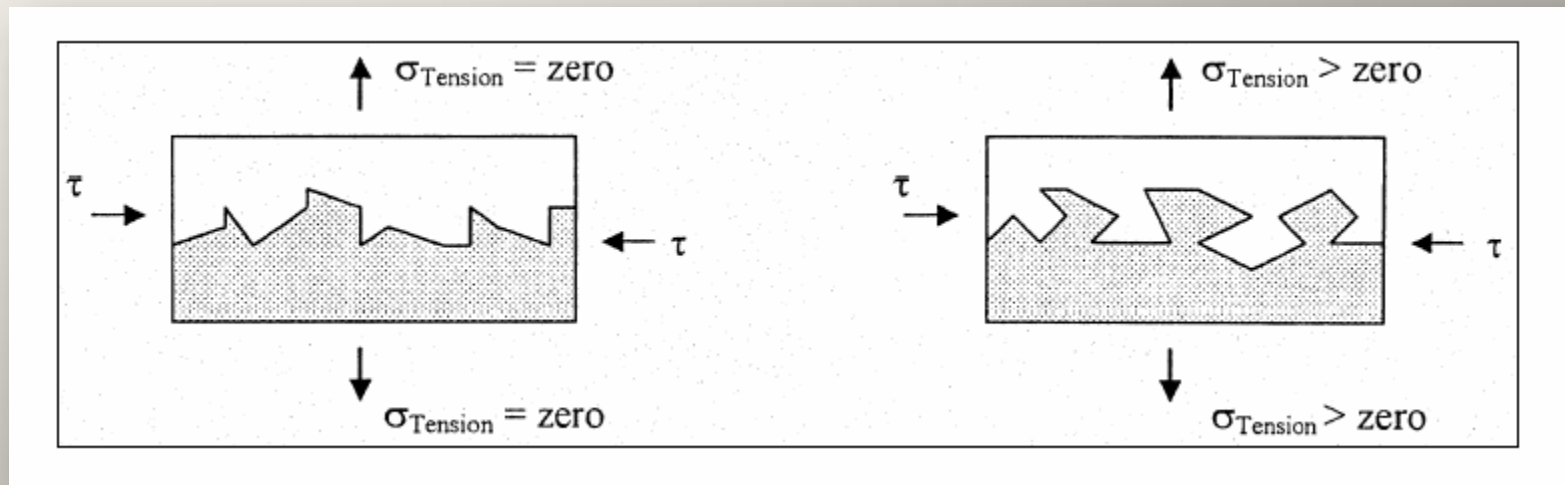
Repair mortars = 5,000- 12,000 psi

Tensile / Shear strength of concrete/ mortars

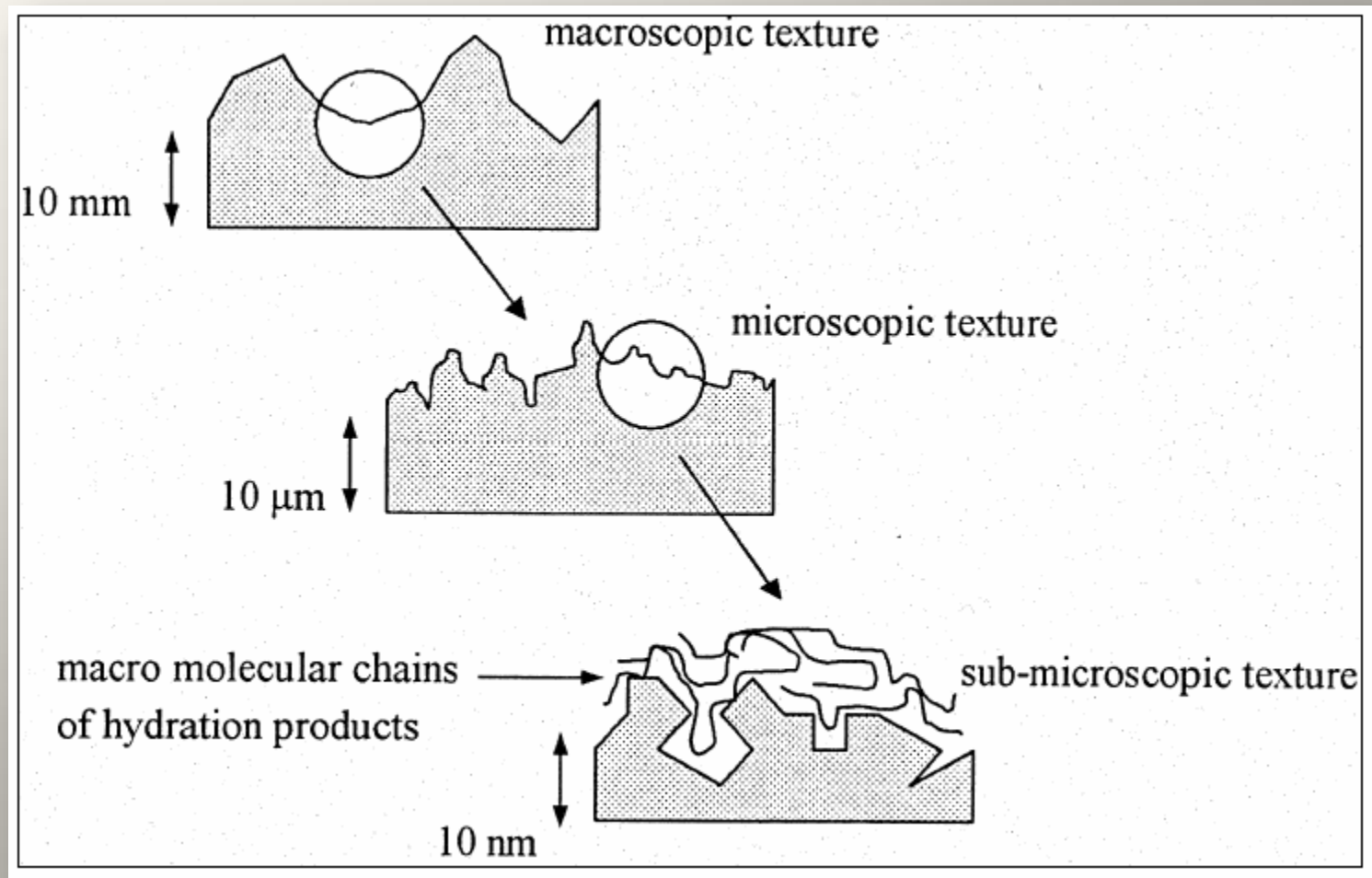
Only 10-15% of  $F_c'$

Accepted minimal bond strength = 200 psi!

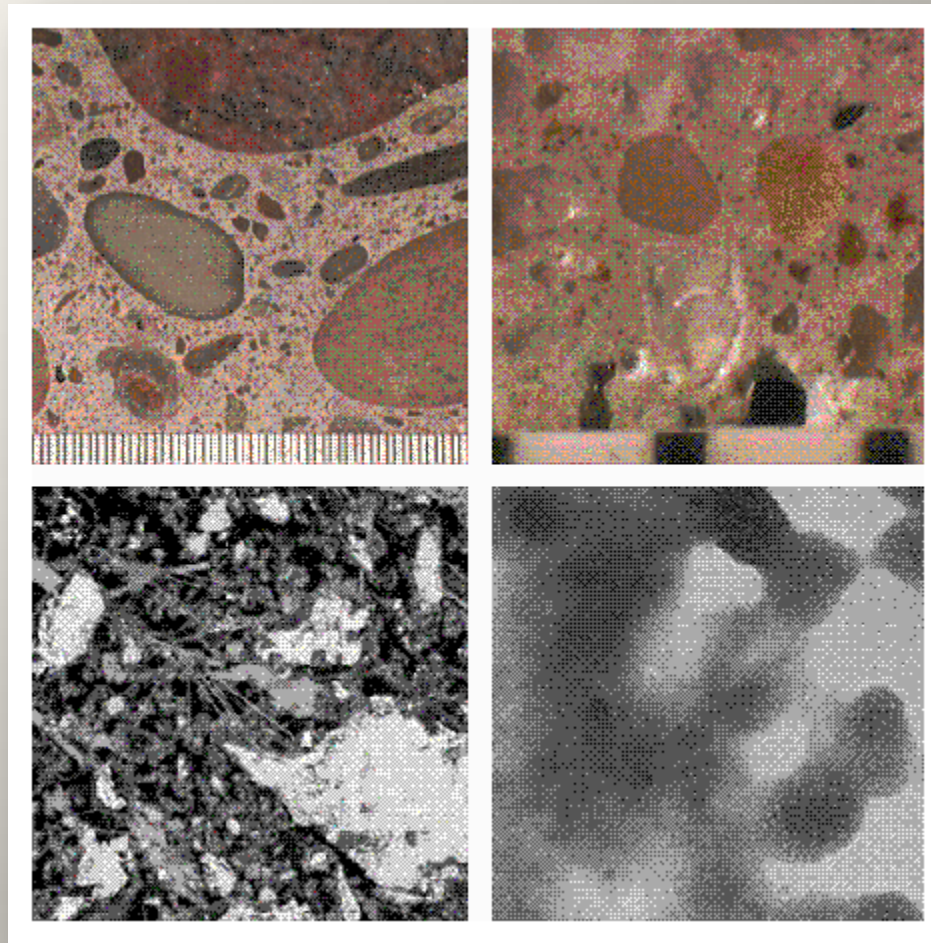
# Forces acting on discrete areas!



# The actual reaction area is not as much as you think!



# Macro-Micro Structure of Concrete

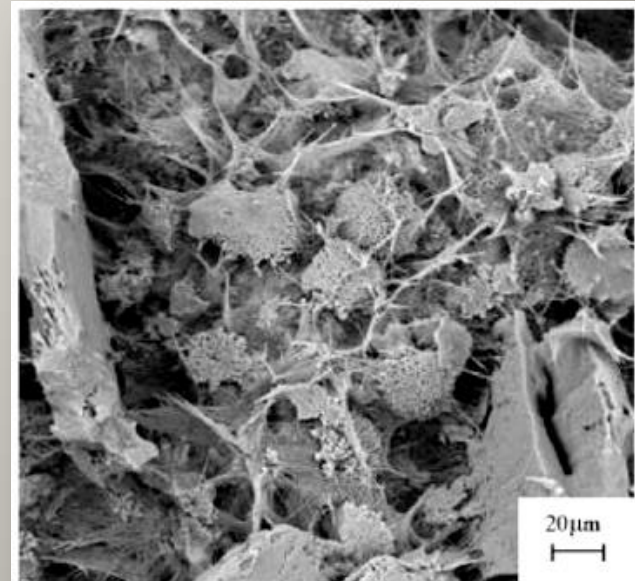
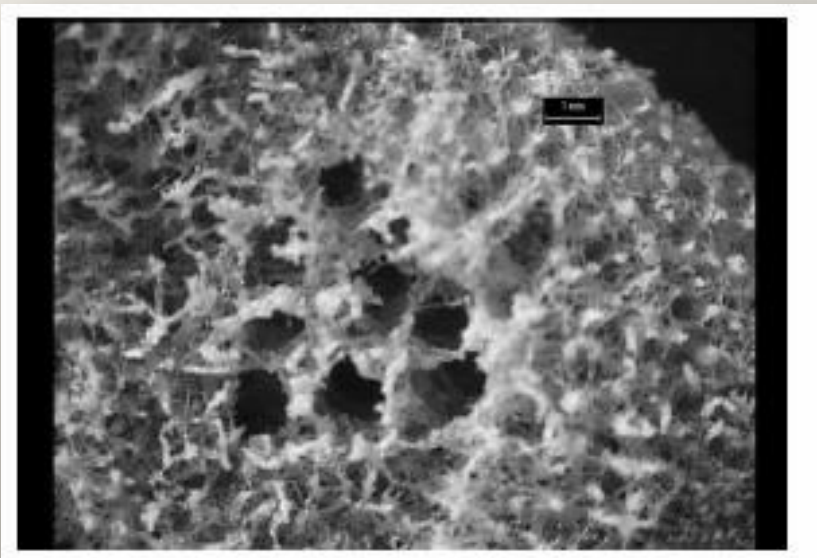




# Concrete Tensile Strength Put Into Perspective

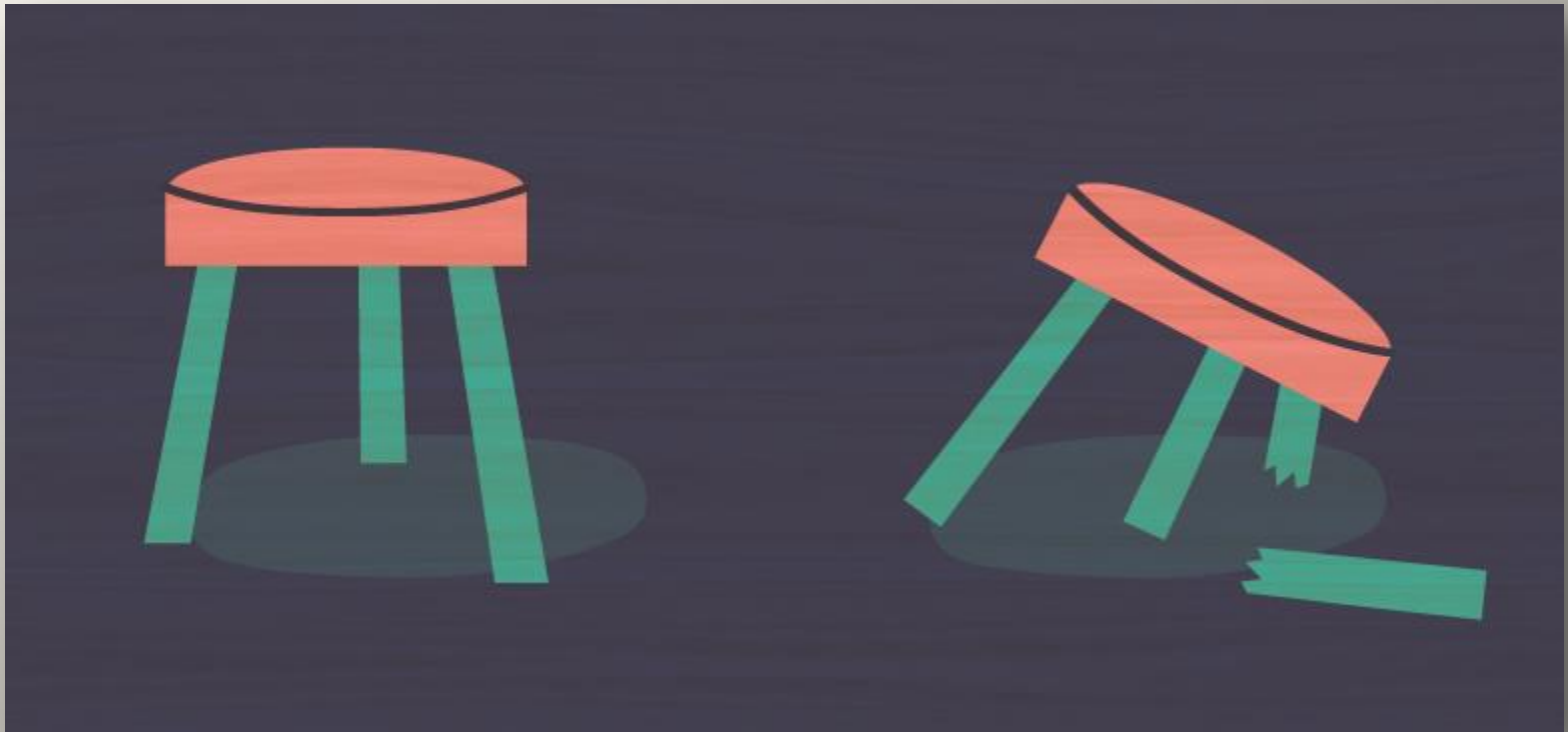
SEA SPONGE = +/- 100PSI

4,000 PSI CONCRETE = +/- 450PSI



**Figure 13.** SEM micrograph of the aggregate/paste interface in the (J) samples (CPI-S-32 cement/5% bottom ash/sand) after 28 days of aging.

# Simple Concept



# Preparation Triad for a Quality Bond

1. Surface preparation
2. Cleaning of the substrate/surface
3. Application of the repair material or product

# Surface Preparation

The goal is to provide a sound horizontal and vertical macro surface for the loads to react against.

- ▣ Removal of unsound or damaged material
- ▣ Saw cutting and detail chipping
- ▣ Profiling and leveling for coatings

# Surface Preparation

Determine the level of preparation needed and the most efficient and practical methodology

**TABLE 7.2: PREPARATION METHODS**

Surface preparation method	Concrete Surface Profile									
	CSP 1	CSP 2	CSP 3	CSP 4	CSP 5	CSP 6	CSP 7	CSP 8	CSP 9	CSP 10
Detergent scrubbing	■									
Low-pressure water cleaning	■									
Grinding	■	■								
Acid etching	■	■	■							
Needle scaling		■	■	■						
Abrasive blasting		■	■	■	■	■	■			
Shotblasting		■	■	■	■	■	■	■	■	
High- and ultra-high-pressure water jetting		■	■	■	■	■	■	■	■	■
Scarifying			■	■	■	■	■	■		
Surface retarder (1)				■	■	■	■	■	■	■
Rotomilling					■	■	■	■	■	■
Scabbling						■	■	■	■	■
Handheld concrete breaker						■	■	■	■	■

(1) Only suitable for freshly placed cementitious materials

# Surface Preparation

Verify that the level of surface preparation has been achieved.

Utilize Concrete Surface Profile (CSP) chips for clarity and accuracy.



# Cleaning of the substrate/surface

- ▣ Removal of damaged or “bruised” material left from surface preparation work
  - Abrasive Blasting
  - High pressure water blasting
  - Needle scaling

# Cleaning of the substrate/surface

- ▣ Micro surface preparation to open “pores” in the concrete
  - Abrasive blasting
  - Acid etching



# Cleaning of the substrate/surface

- ▣ Removal of contaminates
  - Detergent scrubbing
  - Power washing
  - Oil free compressed air

# Application of the repair material

- ▣ Explicitly follow manufacturers directions
  - Storage and handling
  - Mixing instructions
  - Application procedures
  - Curing

# Remember the stool!

Cutting corners or neglecting one of operations does not mean a third less bond capacity..... It more than likely means no bond capacity!

# Simple Math

$$\frac{1}{3} + \frac{1}{3} + \frac{1}{3} = 1 \quad \frac{1}{3} + \frac{1}{3} + 0 \neq 1$$



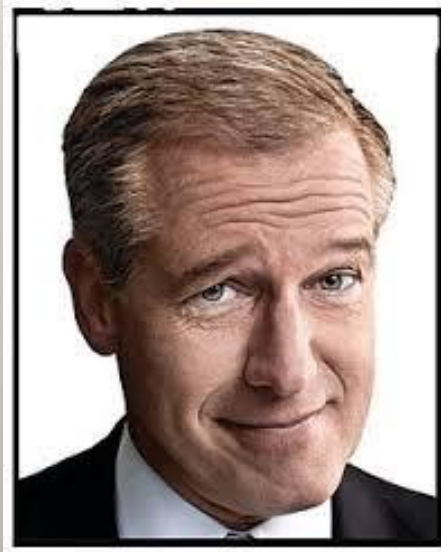
# What is the real cost of a High-Rise bond failure?

RE-MOBILIZING FOR ONE PATCH?



# What is the real cost of a High-Rise bond failure?

A TARNISHED PROFESSIONAL REPUTATION?



# What is the real cost of a High-Rise bond failure?

PUBLIC SAFETY?



# A MINOR BOND FAILURE?!

Lets examine the consequence of “minor”  
High-Rise bond failure

- ▣ 4” x 8” x 1.5” piece of polymer repair mortar
  - 43 in<sup>3</sup> in volume
    - ▣ About the size of a prime rib
  - At 150 lbs/ft<sup>3</sup> it weighs 3.75 lbs
    - ▣ About the weight of a bag of sugar



# A MINOR BOND FAILURE?!

STANDARD GARAGE  
REPAIR



32 STORY HIGH-RISE  
REPAIR



# A MINOR BOND FAILURE?!

## STANDARD GARAGE REPAIR

- ▣ Height = 10.0 ft
- ▣ Speed at impact = 17 mph
- ▣ Energy at impact = 36.9 ft-lb

## 32 STORY HIGH-RISE REPAIR

- ▣ Height = 320.0 ft
- ▣ Speed at impact = 97.5 mph
- ▣ Energy at impact = 1,624 ft-lb

# A MINOR BOND FAILURE?!

## STANDARD GARAGE REPAIR

Professional tennis serve  
+/- 45 ft-lbs of energy



## 32 STORY HIGH-RISE REPAIR

.44 Magnum handgun  
+/- 1,100 ft-lbs of energy

SHOOTING RESULTS (50 YDS.)					
.44 MAG. CARTRIDGE	VEL. @ 15' (FPS.)	ENERGY (FT.-LBS.)	GROUP SIZE IN INCHES		
			SMALLEST	LARGEST	AVERAGE
FEDERAL PREMIUM 240-GR. HYDRA-SHOK JHP	1461 Avg. 10 Sd	1,137	1.51	2.26	1.95
HORNADY CUSTOM 300-GR. XTP	1234 Avg. 8 Sd	1,014	1.76	2.26	2.01
WINCHESTER RAZORBACK XT 225-GR. BPHP	1366 Avg. 18 Sd	932	1.45	1.95	1.88
AVERAGE EXTREME SPREAD					1.95
<small>NOTES: MEASURED AVERAGE VELOCITY FOR 10 ROUNDS FIRED OVER A CED M2 CHRONOGRAPH 15 FT. FROM THE MUZZLE. HANDGUN ACCURACY WAS MEASURED FOR FIVE CONSECUTIVE, FIVE-SHOT GROUPS FIRED FROM A BENCH REST. RANGE TEMPERATURE: 68° F. HUMIDITY: 20%. ABBREVIATIONS: BPHP (BEVELED PROFILE HOLLOW POINT), JHP (JACKETED HOLLOW POINT), SD (STANDARD DEVIATION), XTP (XTREME TERMINAL PERFORMANCE).</small>					

# A MINOR BOND FAILURE?!

STANDARD GARAGE  
REPAIR

32 STORY HIGH-RISE  
REPAIR



# Take the extra time to do it correctly!



# Just how important is a good Bond to your success and bottom line?



# Remember, Its all about the Bond!



**Thank You for your time and  
attention!**