

# CONCRETE FIREPROOFING ANALYSIS, EVALUATION AND REPAIR STRATEGIES

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Picture Courtesy of Refinery Terminal Fire Company (RTFC)

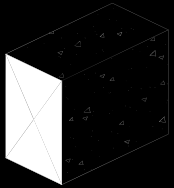
# Fireproofing Purpose

- ◆ Maintaining structural stability and integrity of steel members and vessel/pipe supports for a defined period of time when exposed to a fire



Picture Courtesy of Refinery Terminal Fire Company (RTFC)

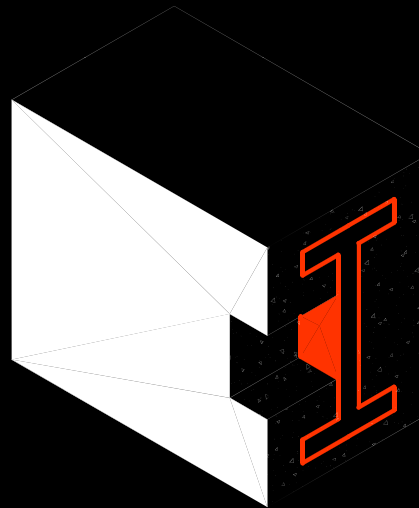
# Fireproofing Basics



**Material  
minimum  
thickness**



**Restrict heat  
transfer rate**

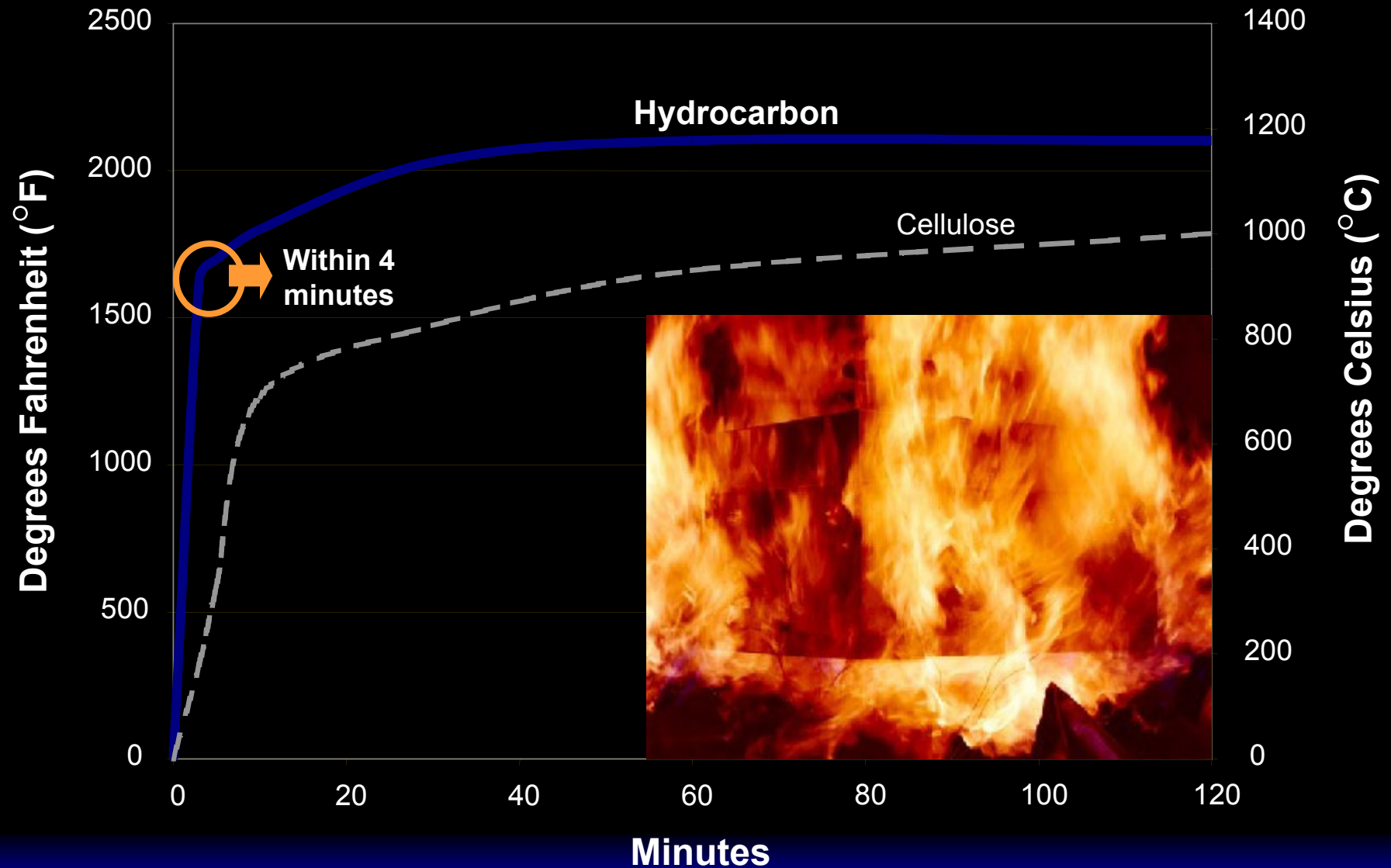


**Protected  
element**

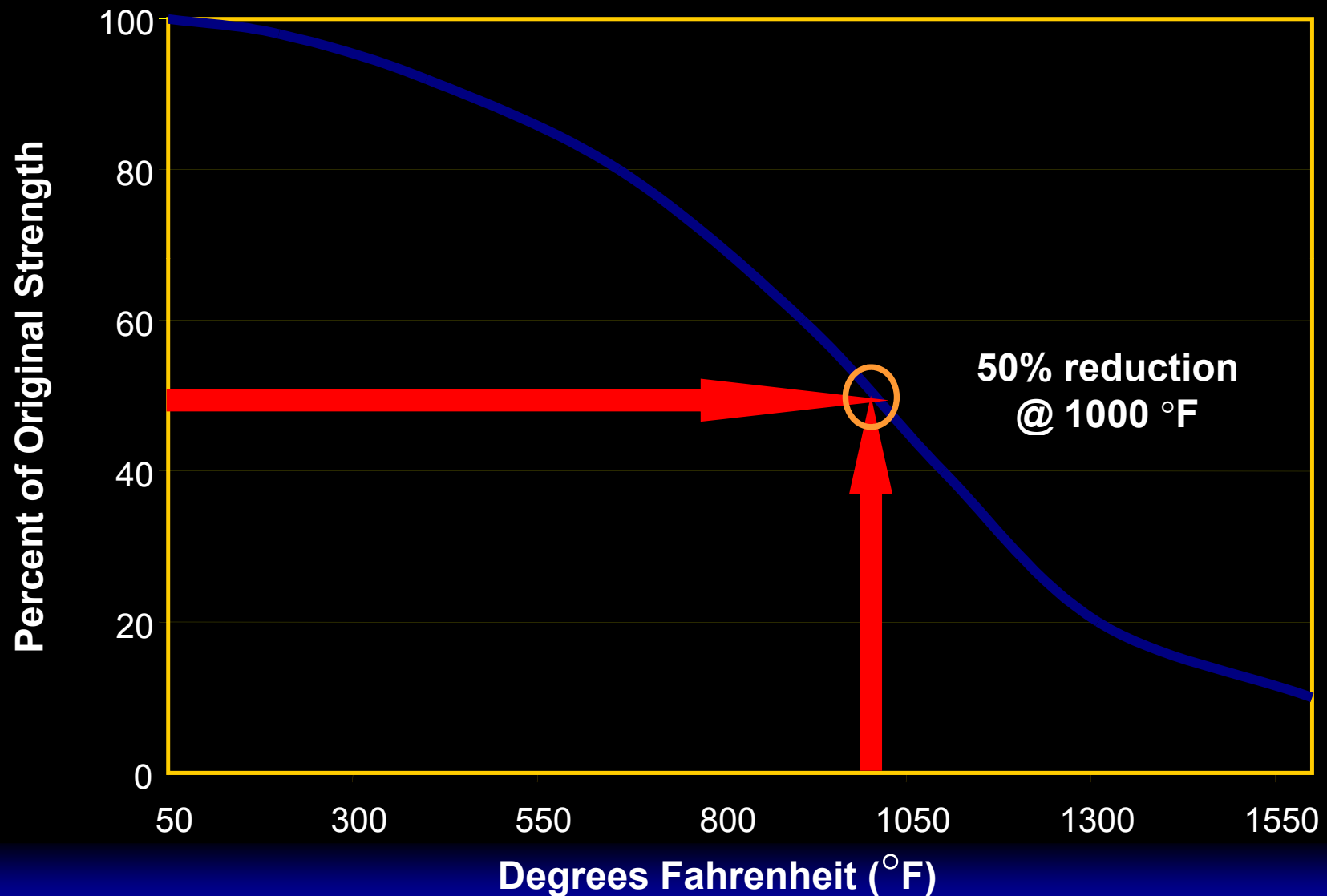


**Acceptable steel  
core temperature at  
the end of fire  
exposure to avoid  
collapse/buckling**

# Comparison of Typical 'Hydrocarbon' and 'Cellulose' Time-Temperature Curves



# Effect Of Temperature On Strength Of Structural Steel



# Fire And Explosion Behavior

- ◆ Resistance to thermal and erosive forces
- ◆ Surface temperature of substrate
- ◆ Non-combustible
- ◆ Withstand effects of explosion and subsequent drag pressures



Picture Courtesy of Refinery Terminal Fire Company (RTFC)

# Pre-Fire Durability

- ◆ Weather cycling and chemical tolerance
- ◆ Vapor permeability and low porosity
- ◆ Vibration resistance - compressive, tensile and flexural strength
- ◆ Hardness value and impact resistance
- ◆ Abrasion and erosion resistance
- ◆ Bonding strength
- ◆ Wash-down resistance

# Passive Fireproofing Materials

## CEMENTITIOUS

Lightweight

Dense

- Heat absorbers
- Hard and durable
- Economic
- Easy to install and repair

## INTUMESCENT

Epoxy  
based

- React under fire and emit gases
- Form a low density carbonaceous char

## FIBROUS

Boards

Blankets

- Can provide thermal insulation
- Absorb water
- Indoor applications

## COMPOSITES

Composite  
Panels

- Sandwich of metallic cladding, cementitious board, and mineral or ceramic fibers
- Not economically feasible



# Cementitious Concrete Materials

- ◆ Made with Portland cement or modified fire-resistant cements
- ◆ Specific weights
  - Dense concrete - 140 to 150 lb./ft<sup>3</sup>
  - Lightweight concrete - 25 to 80 lb./ft<sup>3</sup>
- ◆ Thermal conductivity tends to be inversely proportional to specific weight
- ◆ Capable of withstanding direct flame impingement up to 2000° F (1100° C)
- ◆ Alkaline passive film protects the embedded steel

# Intumescent Epoxy Coatings

- ◆ Intumescent coatings react to flame or heat at around 300° Fahrenheit (149° C) by expanding into a thick multicellular insulating blanket. This intumescent carbonaceous foam sharply limits the spread of flame and insulates the steel.
- ◆ Washable, aesthetically pleasing, mark resistant surface like traditional paint
- ◆ Provide protection from corrosion
- ◆ Require expertise in application and controlled conditions
- ◆ Comparatively higher cost to cementitious materials

# Fireproofing Rating

## A function of:

- ◆ Time and ease of evacuation
- ◆ Fire hazard posed by substance
- ◆ Fire suppression capabilities

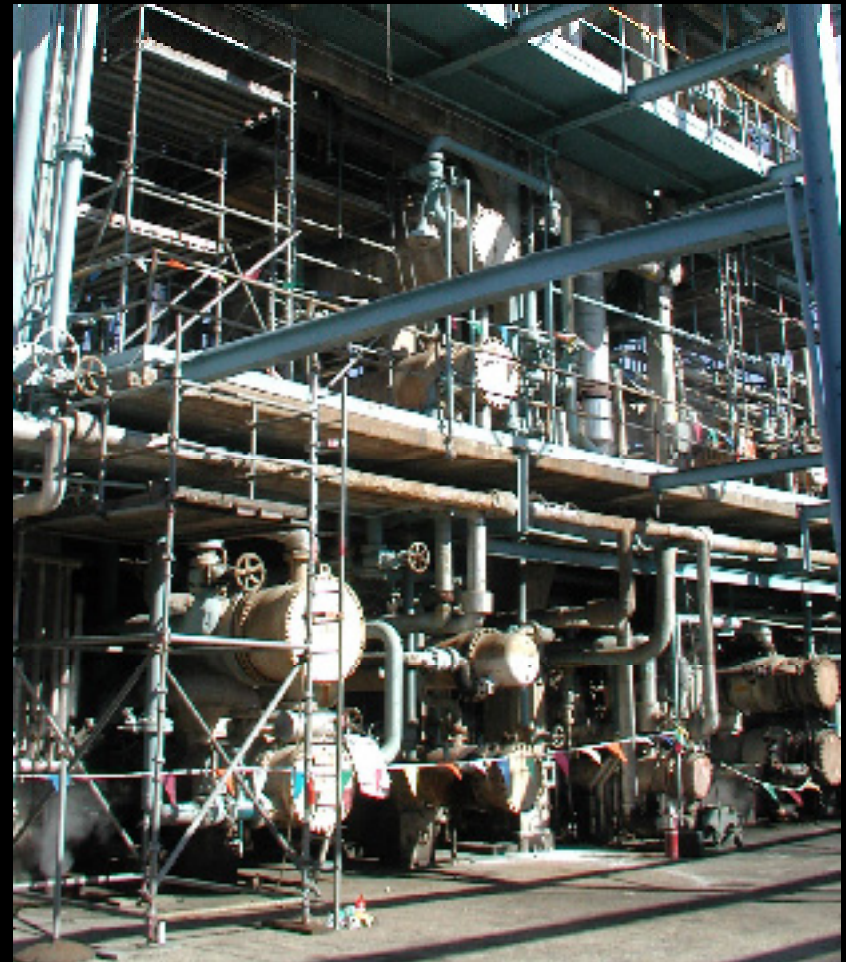
2 inches (50 mm) of  
cementitious products will  
provide a 2-hour rating  
(BS476 & ASTM E-119)



# Concrete Fireproofing In Processing Units

**Multilevel Equipment  
Structures**

**Pipe Racks**



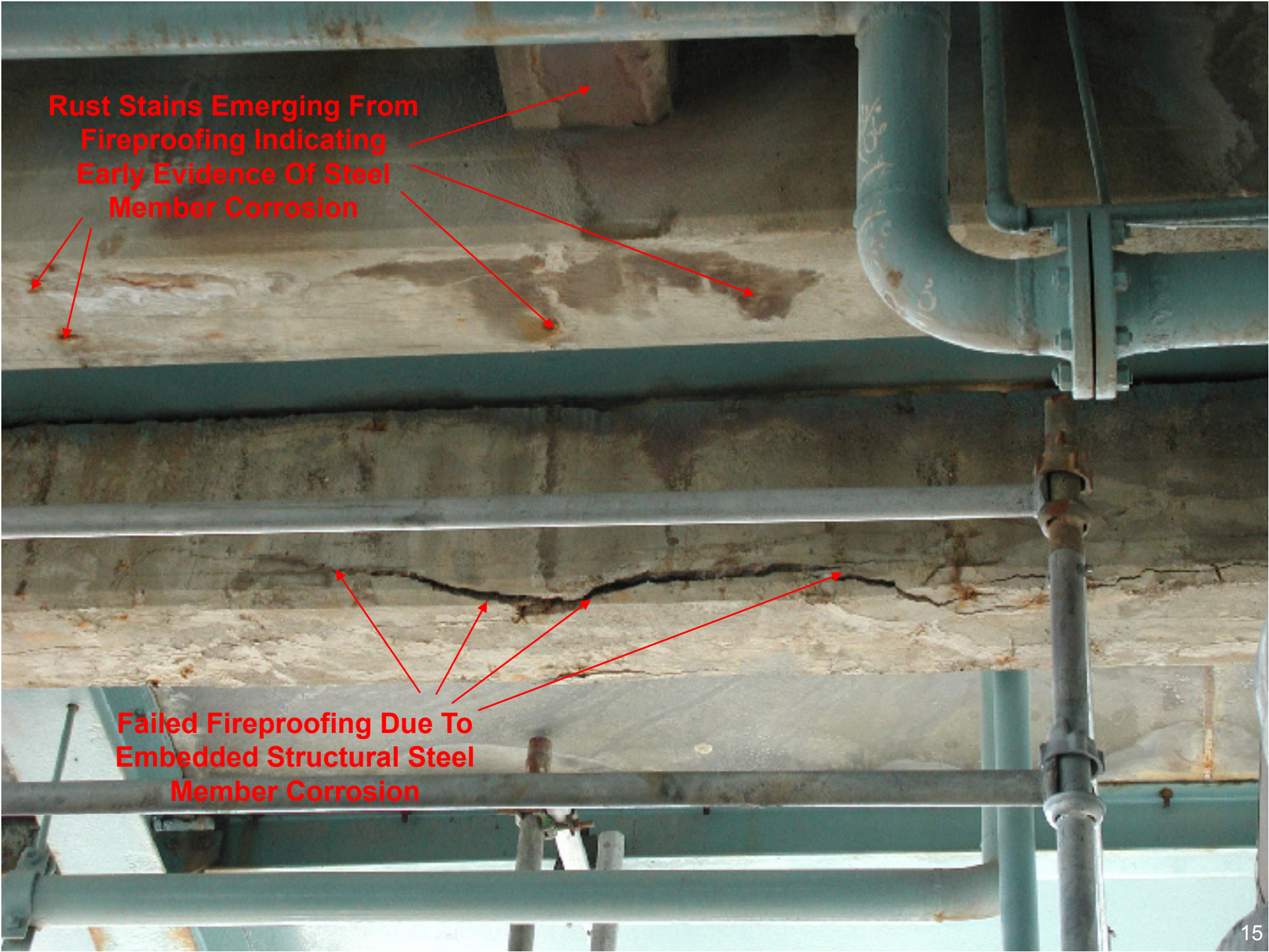
# Fireproofing Deterioration





**Embedded Structural Steel  
Corrosion Exposed During  
Fireproofing Inspection  
Process**



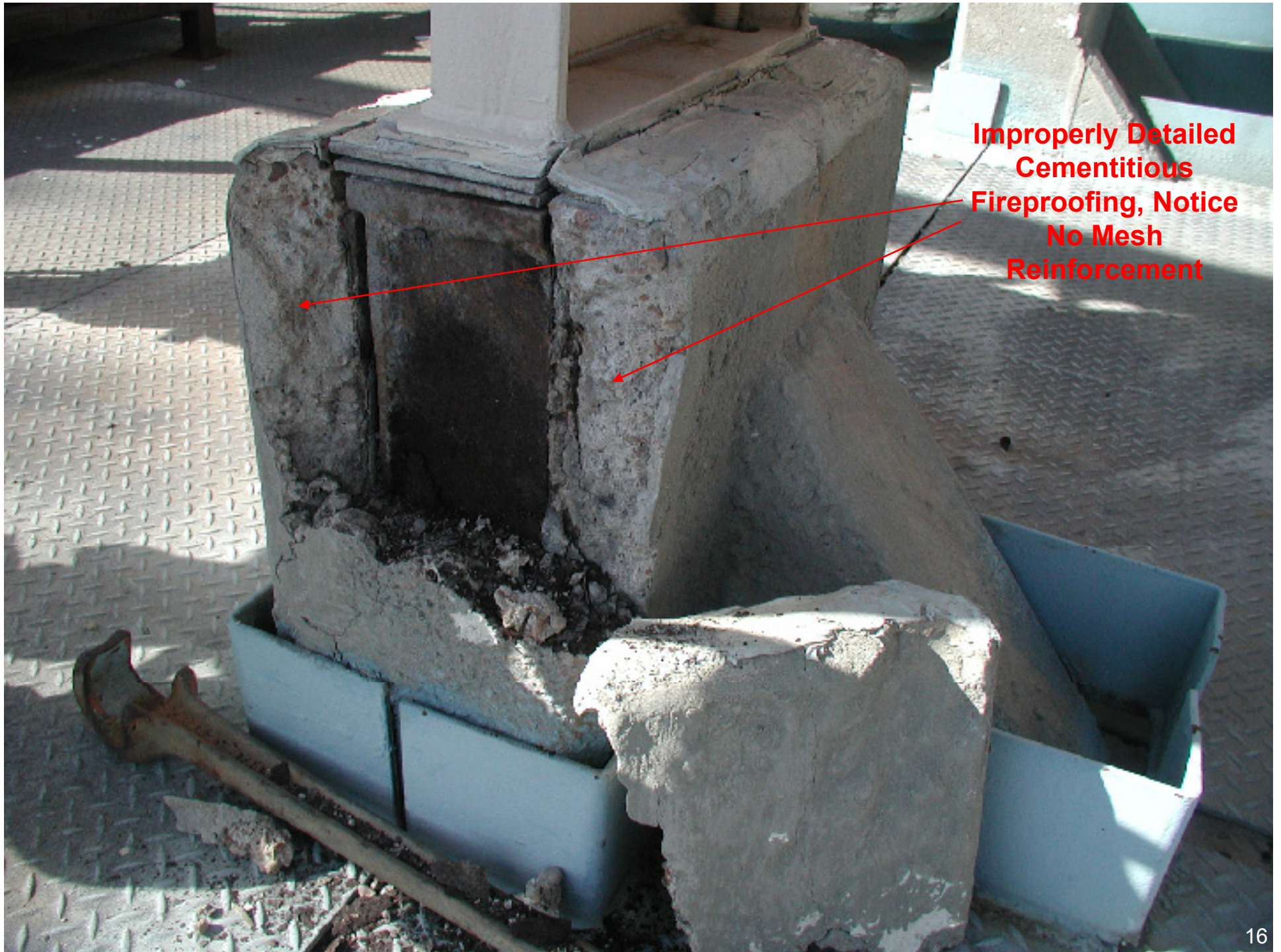


**Rust Stains Emerging From  
Fireproofing Indicating  
Early Evidence Of Steel  
Member Corrosion**

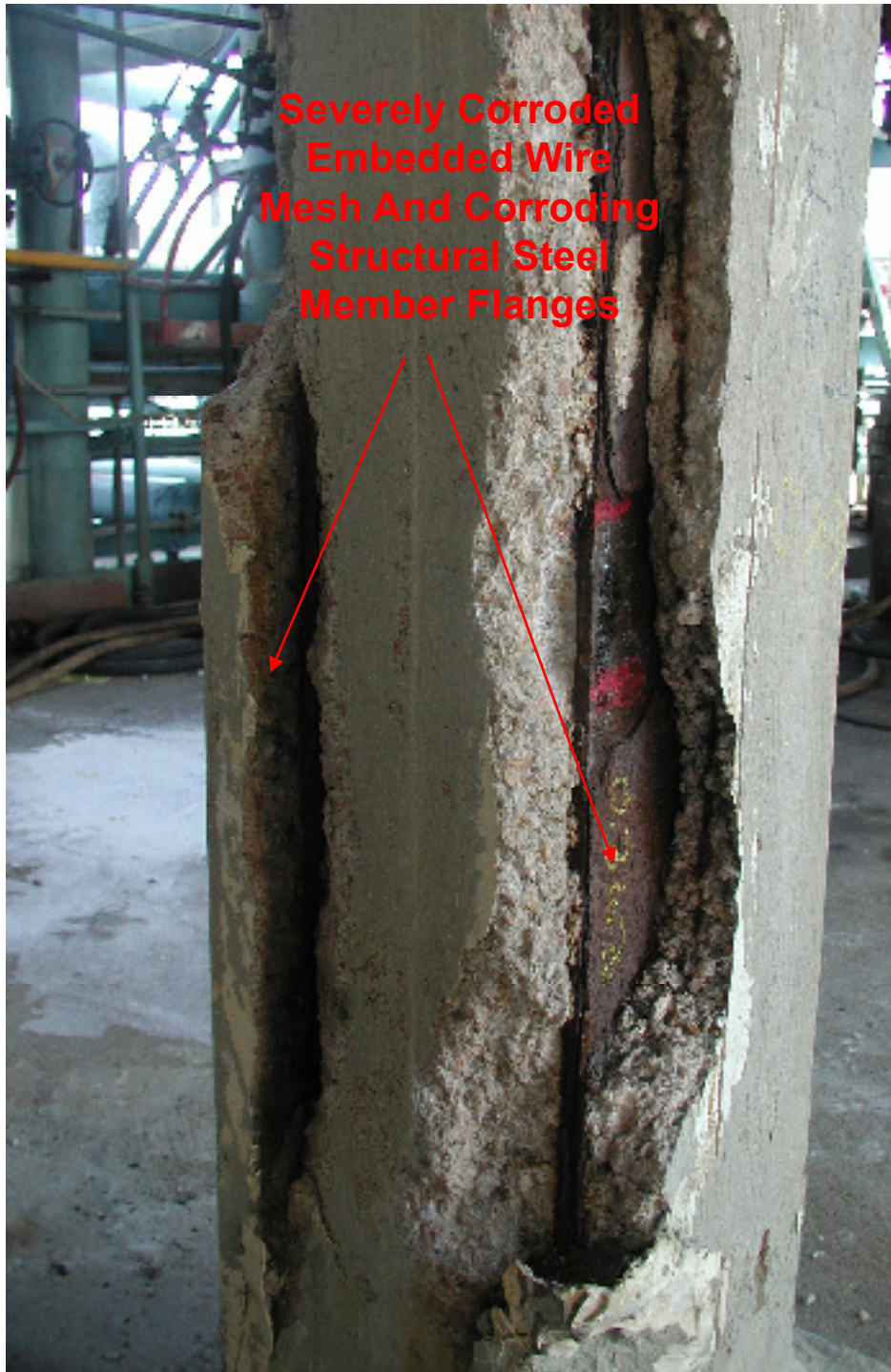
This photograph shows a horizontal structural steel beam. The beam is partially covered with a light-colored, textured fireproofing material. Several dark brown, irregular rust stains are visible on the fireproofing surface. Red arrows point from the text label to these stains. A large, dark, jagged crack runs horizontally across the middle of the beam, exposing the underlying steel. Another red arrow points from the text label to this crack. To the right of the beam, there is a vertical pipe with a 90-degree elbow, and another vertical pipe runs parallel to the beam on the far right. The background is a plain, light-colored wall.

**Failed Fireproofing Due To  
Embedded Structural Steel  
Member Corrosion**

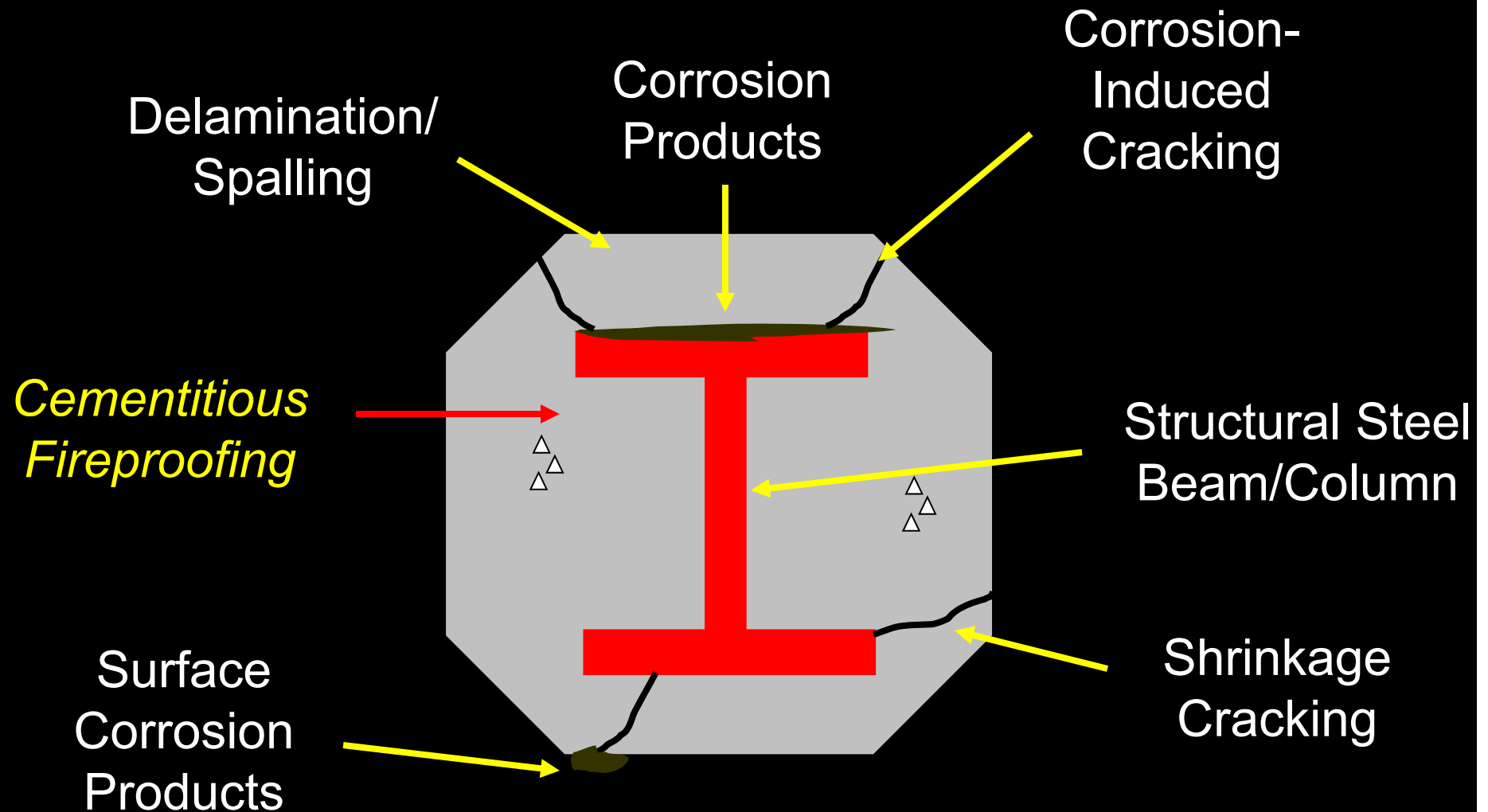




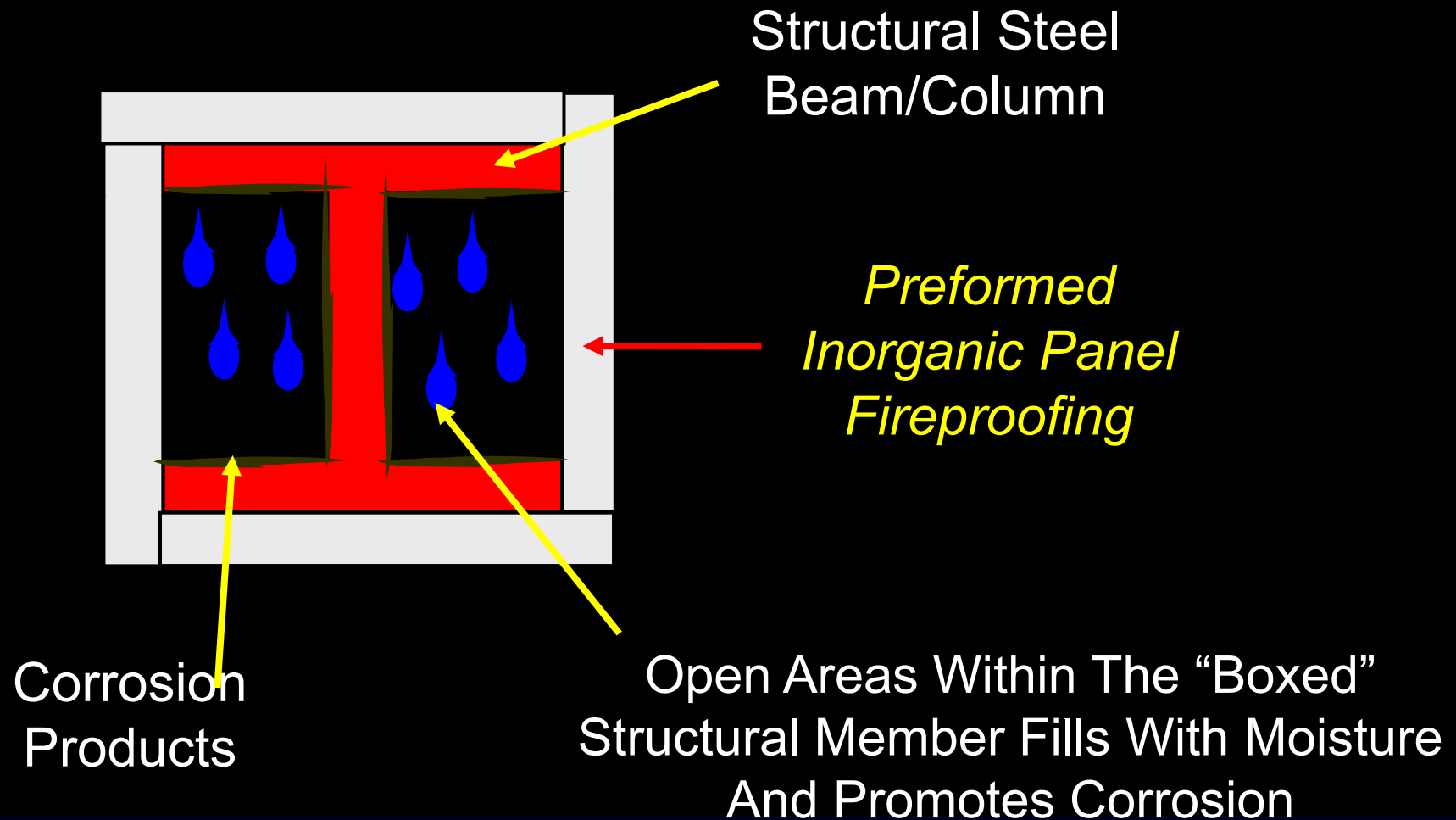




# Fireproofing Deterioration Mechanism



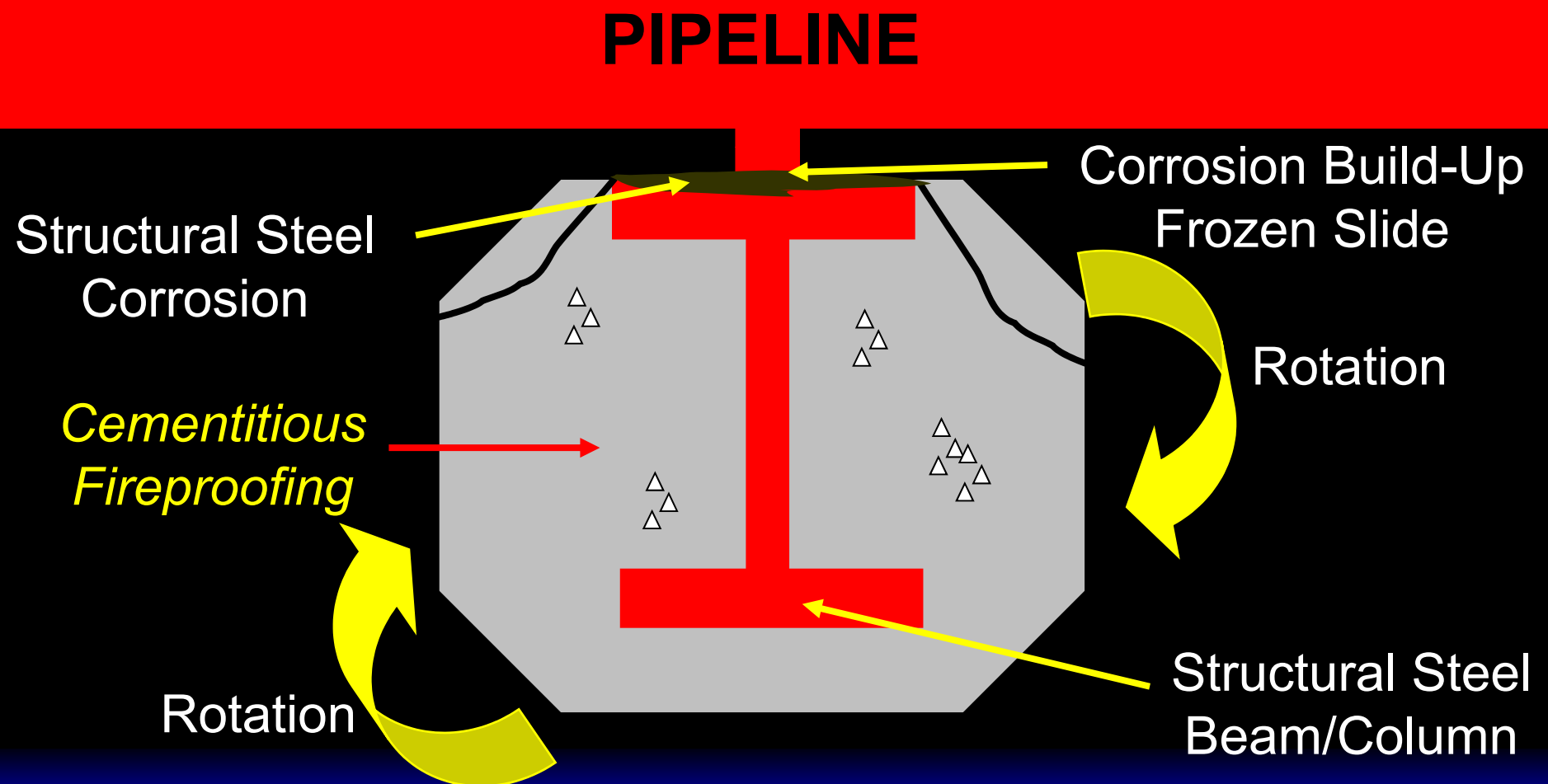
# Fireproofing Deterioration Mechanism (cont.)







# Fireproofing Deterioration Mechanism (cont.)



# Condition Survey And Evaluation

- ◆ **Assess the condition of concrete fireproofing**
- ◆ **Evaluate causes of concrete/steel distress**
- ◆ **Provide conceptual repair recommendations**

# Need For Fireproofing Restoration

## ◆ Safety

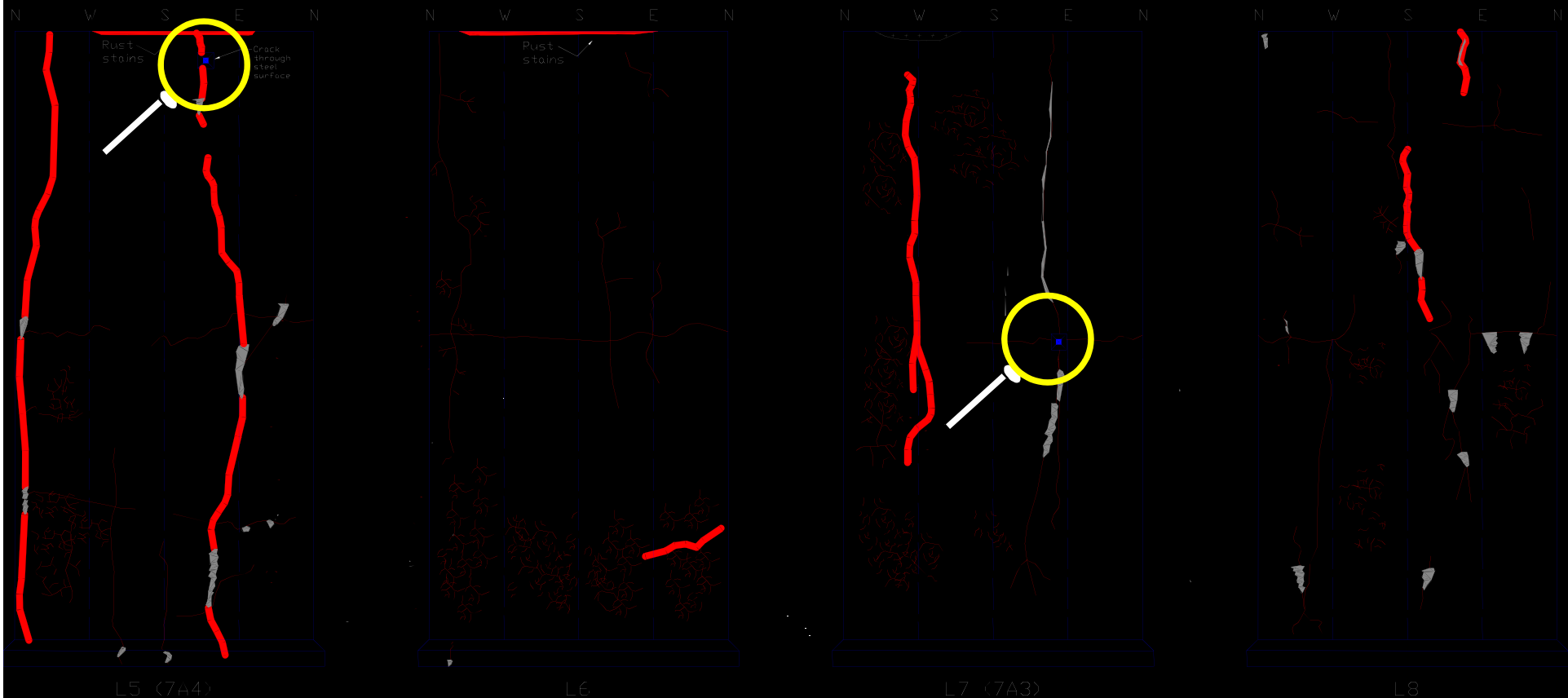
- Possible structural collapse
- Reduced fire protection/lower expected performance
- Personnel at risk due to falling debris

## ◆ Insurance costs

## ◆ Aesthetics of damaged/falling fireproofing



# Visual Inspection And Mapping



## NOMENCLATURE



CRACKS



EFFLORESCENCE



OPEN  
SPALL



EXCAVATION  
AND POWDER  
SAMPLE



COATING  
FAILURE



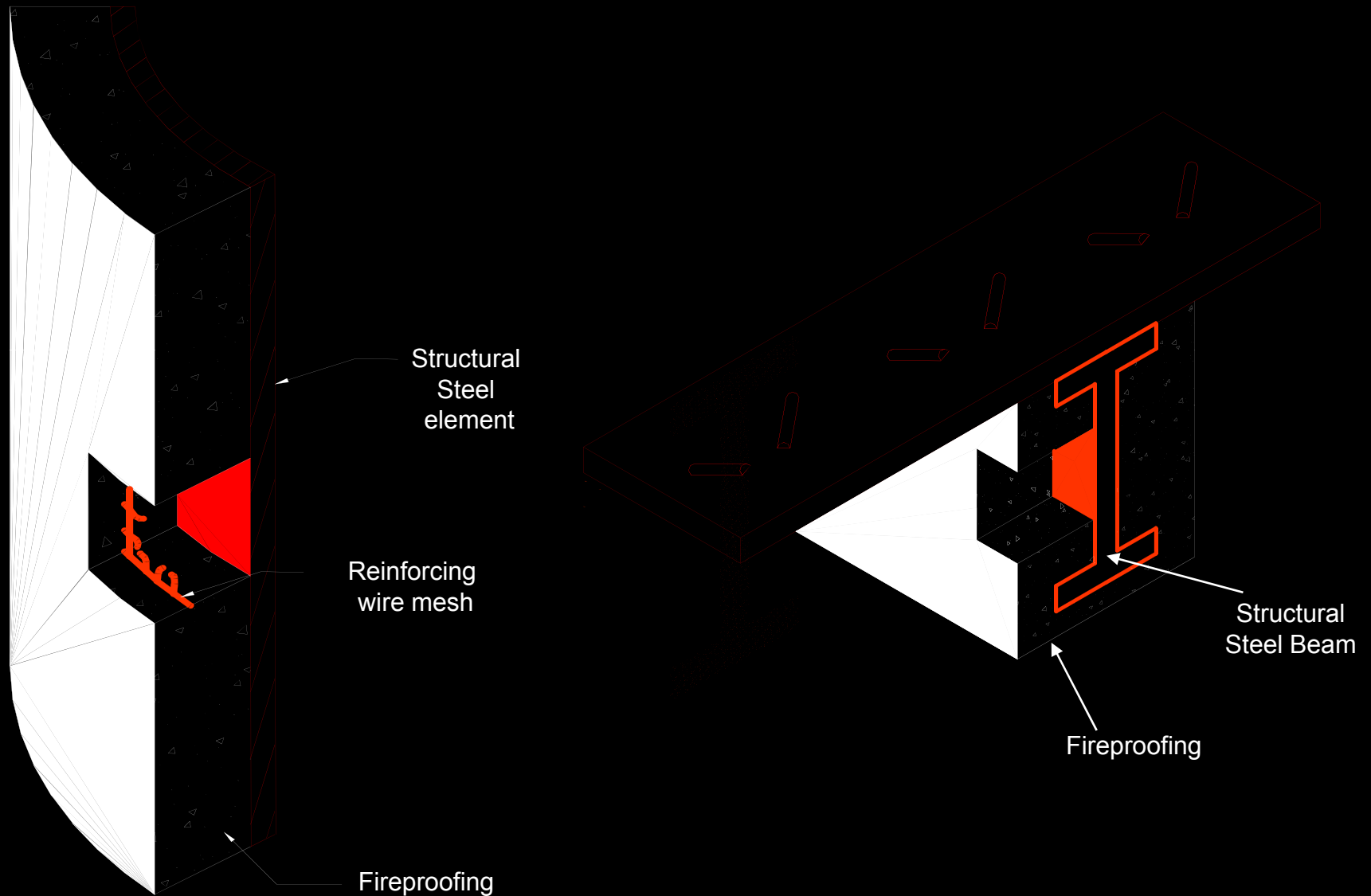
PREVIOUS  
REPAIR



**Note: Excavation at crack location**



# Excavation Geometry



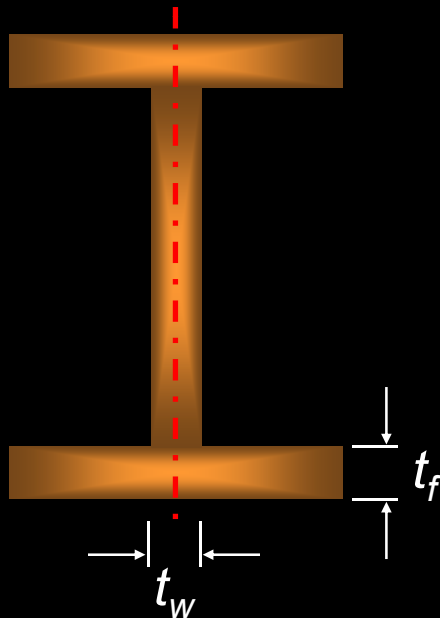
# Ultrasonic Thickness Measurements

- ◆ Ultrasonic Thickness Meter
- ◆ Structural steel pipes, webs and beams flanges
- ◆ Access one side of steel member



# Measurement Analysis

Wide Flange  
Shape



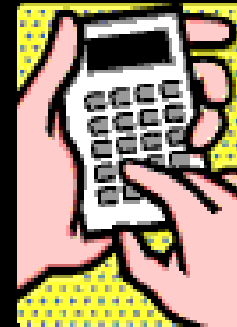
Flange  
Thickness  $t_f$

Theoretical

vs

Measured

Section  
Loss (%)



If critical,  
remedial actions  
needed *before...*

# Conceptual Fireproofing Repair

- ◆ Assemble scaffolding for elevated regions of distressed fireproofing
- ◆ Remove deteriorated concrete fireproofing and wire mesh avoiding damage to structural steel members
- ◆ Clean exposed embedded structural steel members of corrosion products
- ◆ Inspect members and connections for structural integrity
- ◆ Coat exposed structural steel section

# Fireproofing Repair (Cont.)

- ◆ **Install wire mesh**
- ◆ **Assemble mortar-tight cavity formwork**
- ◆ **Re-establish the cementitious fireproofing section by using “form and pour” placement techniques**
- ◆ **Remove formwork after curing period and surface grind cementitious repairs to match original fireproofing surface contours**

# Valuable Repair Aspects

- ◆ Turnkey investigation
- ◆ Attention to details
- ◆ Budgeting capabilities
- ◆ Corrosion protection to steel
- ◆ Production rates
- ◆ Adjustable crew size with qualified personnel
- ◆ High quality repair materials
- ◆ Observe standard industry practices