BOMA Georgia
MEMBER

Structural Inspection and Repair

Part I: Inspection

BOMA Georgia

Tuesday July 20, 2021

Learning Objectives

- **Building Structural Inspection**
  - Laws & Standards
  - Structural Engineering 101
  - Failure Mechanisms
  - Concrete, Masonry, Steel, & Wood
  - How to Purchase a Condition Assessment

AIA Continuing Education Provider

Innovative Engineering, Inc.

- **Scott L. Weiland PE SE**
  - **BSCE University of Michigan**
  - **Graduate Studies:**
    - San Jose State University
    - Georgia Institute of Technology
  - **Level I sUAS Thermographer**
  - **BESI Building Envelope Certified Level 2**
  - **Haag Certified Inspector – Commercial Roofs**
  - Articles:
    - **IFMA FMJ Magazine** – Legionnaires' Disease: COVID-19 for Buildings?
    - Structure Magazine – Building Façade Inspection Part I & II
    - Georgia Engineer – Building Façade Inspection Part I & II
    - AIA Design Equilibrium – Building Façade Inspection
    - BOMA Georgia Insight Magazine - Falling Building Façade Closes Atlanta Streets

Innovative Engineering, Inc.

- Trey Thomas PE
  - BSCET, Southern Polytechnic State University
  - 15 Years in Design and Restoration Engineering
    - Co-author of Forensic articles
  - OSHA Qualified Fall Protection Engineer
  - SPRAT Level 2 Rope Access Technician
  - FAA Part 107 Remote Pilot Certificate
  - FAA Part 107 Daylight Waiver
  - Level I Thermographer
  - Lead, Asbestos, & Mold Surveyor
  - Expert estimator (within 5% of actual)

Structural Condition Assessment - Why

- Legal
- Deterioration
- Transfer of Ownership
- Change of Occupancy
- Renovation, Rehabilitation, and Restoration
- Strengthening or Hardening
- Damage
- Signs of Distress

International Property Maintenance Code (IPMC)

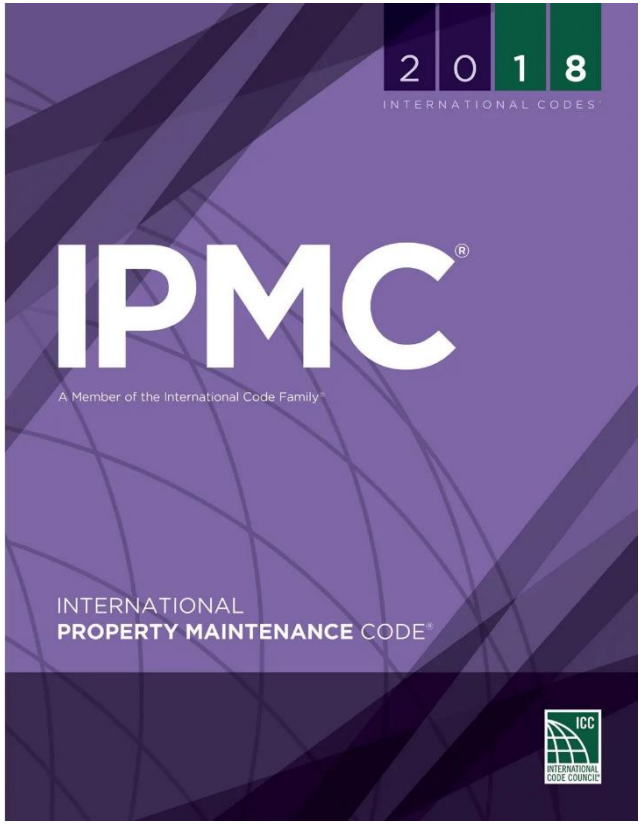
SECTION 304
EXTERIOR STRUCTURE

304.1 General. The exterior of a structure shall be maintained in good repair, structurally sound and sanitary so as not to pose a threat to the public health, safety or welfare.

SECTION 305
INTERIOR STRUCTURE

305.1 General. The interior of a structure and equipment therein shall be maintained in good repair, structurally sound and in a sanitary condition. *Occupants* shall keep that part of the structure which they occupy or control in a clean and sanitary condition. Every *owner* of a structure containing a *rooming house*, *housekeeping units*, a hotel, a dormitory, two or more *dwelling units* or two or more nonresidential occupancies, shall maintain, in a clean and sanitary condition, the shared or public areas of the structure and *exterior property*.

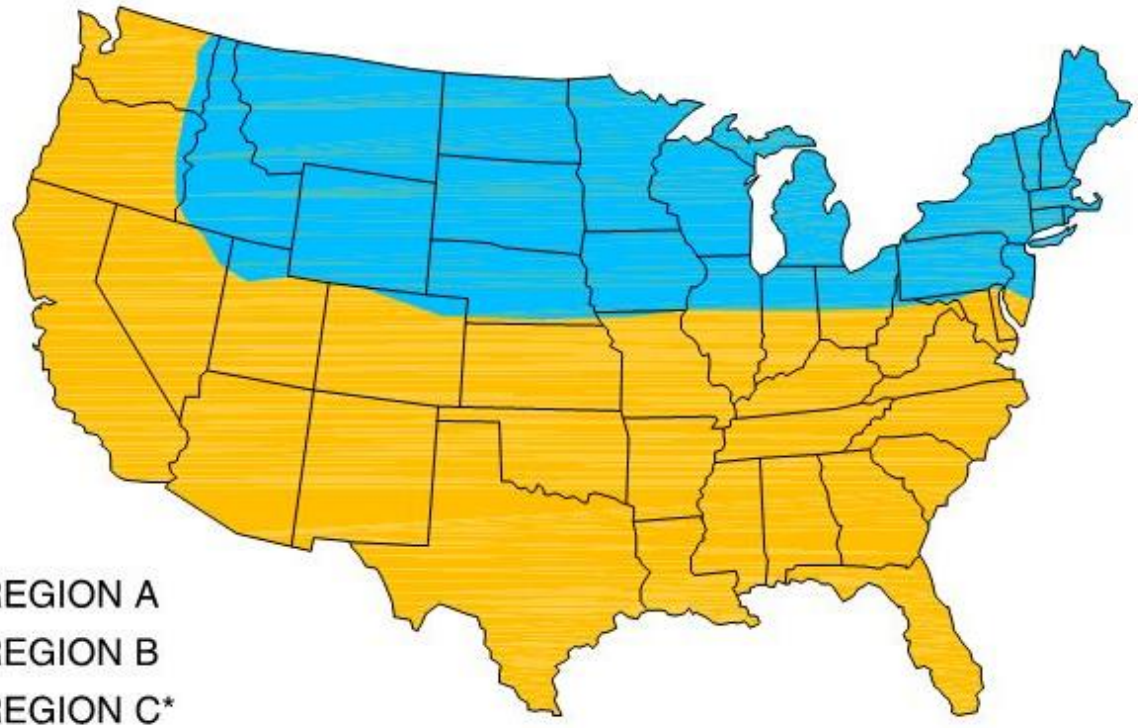
It's the Law!



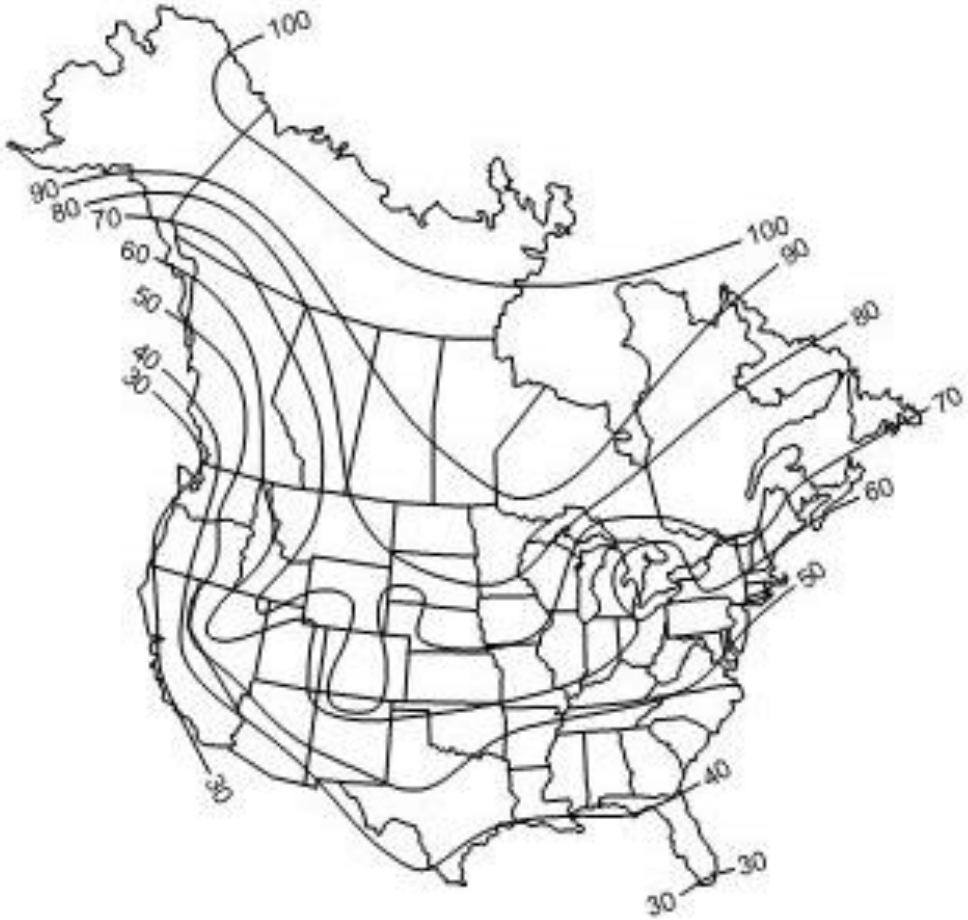
Façade Ordinances

- New York, NY
- Columbus, OH
- Boston, MA
- Chicago, IL
- Milwaukee, WI
- Detroit, MI
- Pittsburg, PA
- St. Louis, MO
- Philadelphia, PA
- Cleveland, OH
- Cincinnati, OH
- San Francisco, CA

Façade Ordinances – Rust Belt Exposure

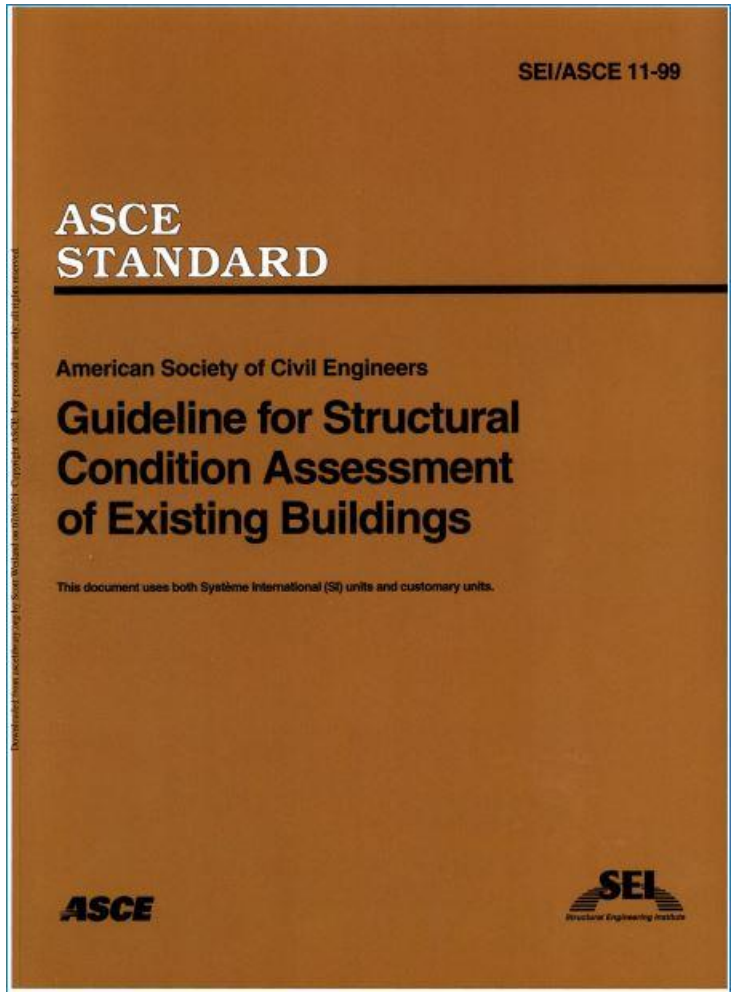


*Region C is defined as any site within ½ mile of a salt water body



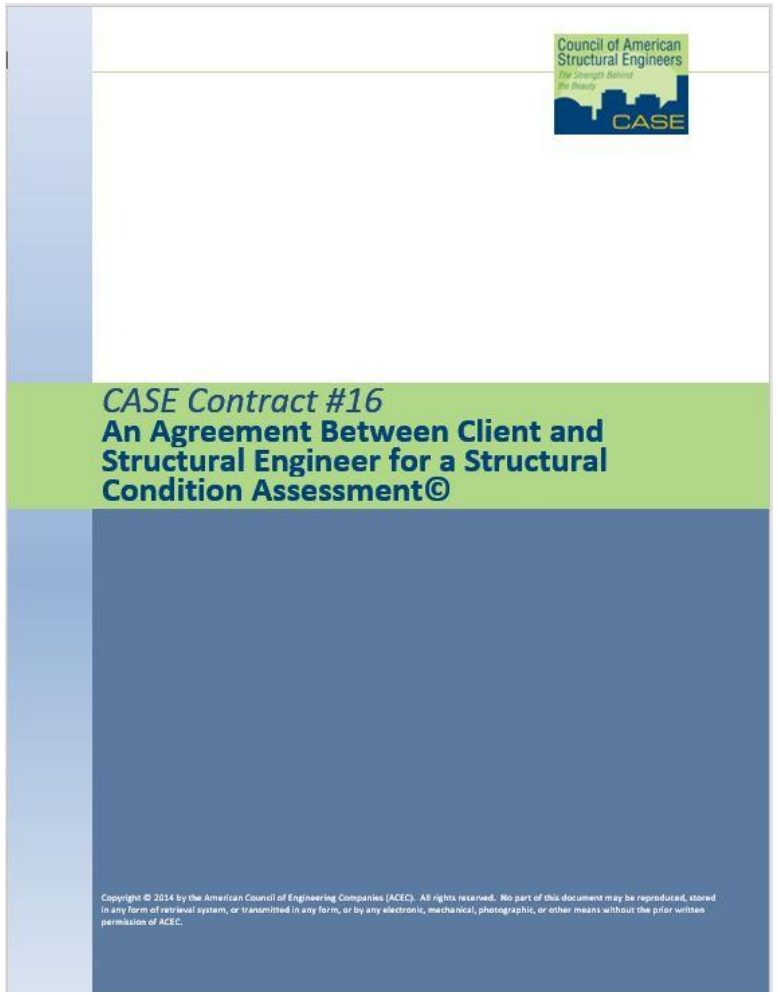
MAXIMUM SEASONAL CLIMATIC TEMPERATURE CHANGE, °F

ASCE Standard SEI/ASCE 11-99



- **Assessment**
  - Preliminary
  - Detailed
- **Materials**
  - Concrete
  - Masonry
  - Metals
  - Wood
- **Procedures**
- **Reporting**

CASE Contract #16 – Structural Condition Assessment

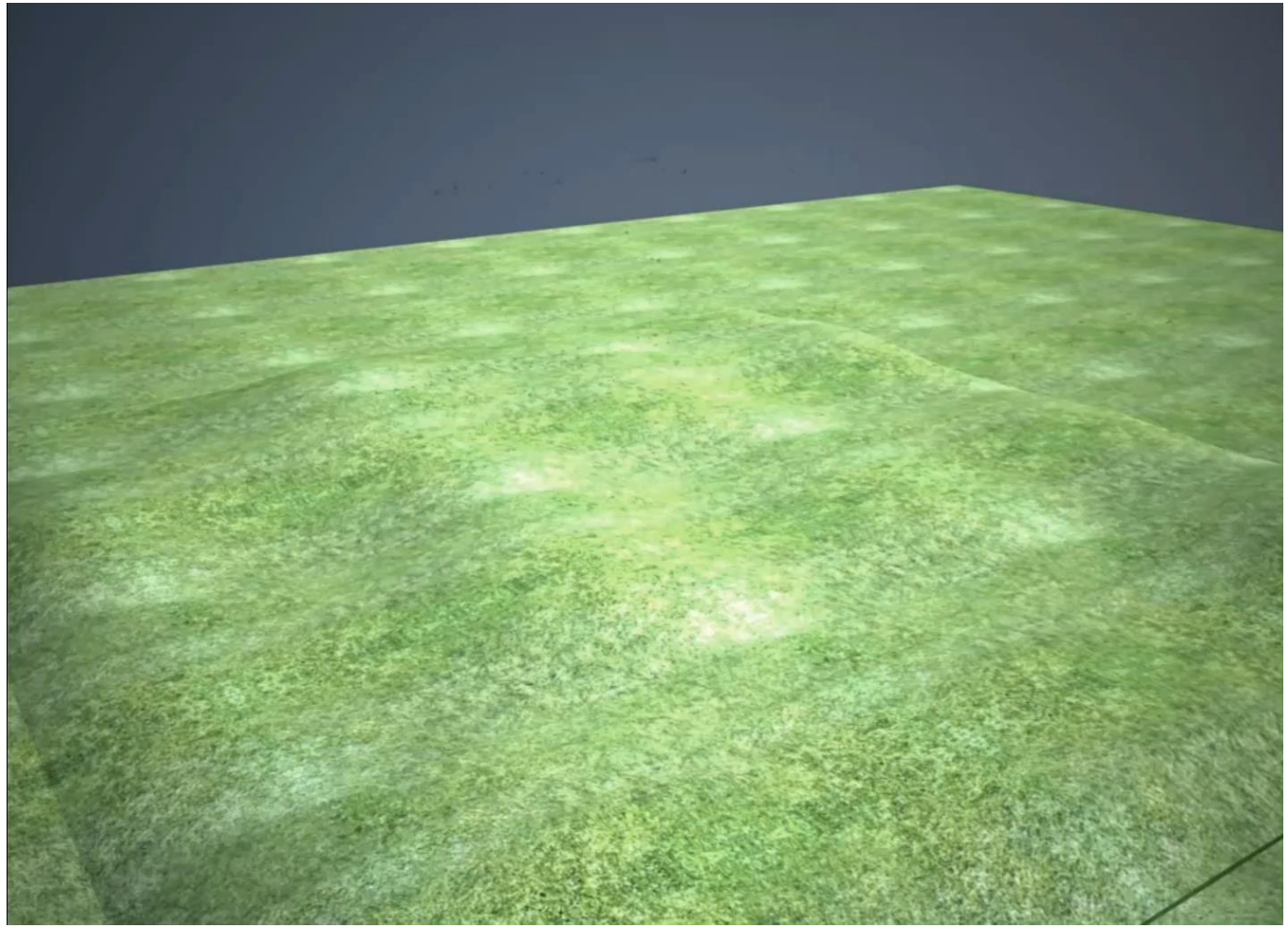


- **Document Review**
- **Visual Inspection**
  - Gravity Load path
  - Lateral Load path
- **Roof & Below Grade for Water Infiltration**
- **Façade Inspection**
- **Report**

Inspection Checklist

- Sitework
- Safety
- Foundations
- Basement
- Superstructures
- Exterior Closure
- Roofing
- Partitions & Doors
- Walls, Floors, Ceilings & Finishes
- Conveying
- Plumbing
- HVAC
- Electrical

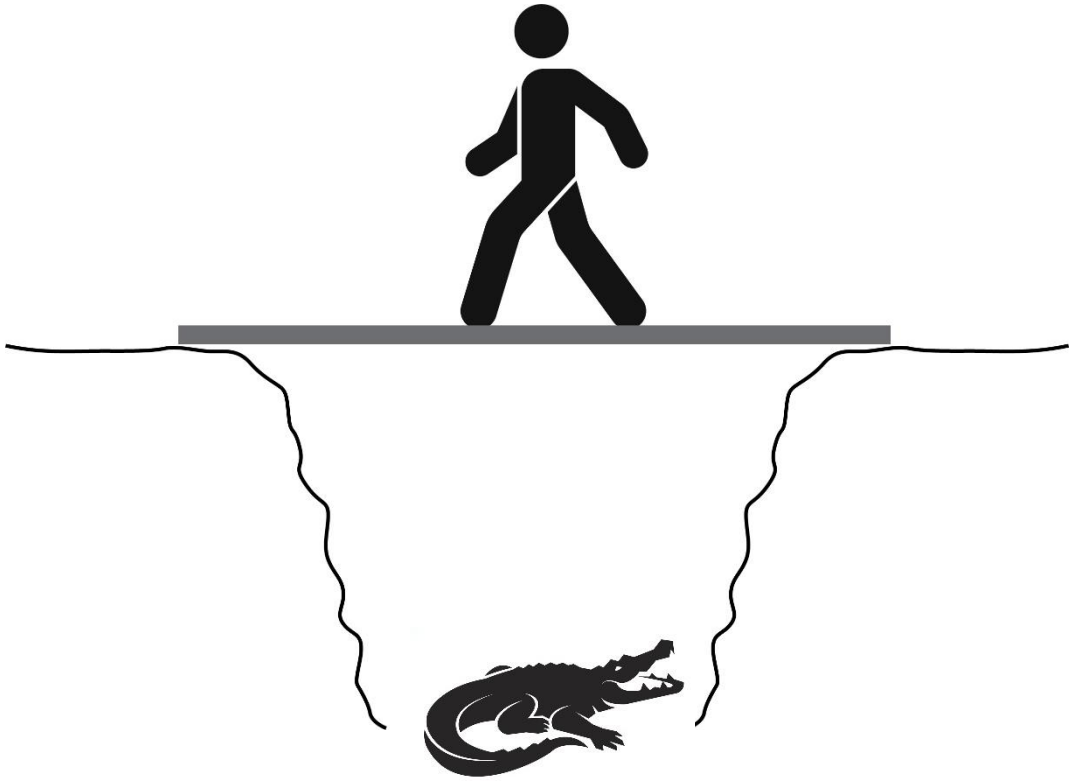
Building Structure - Definitions

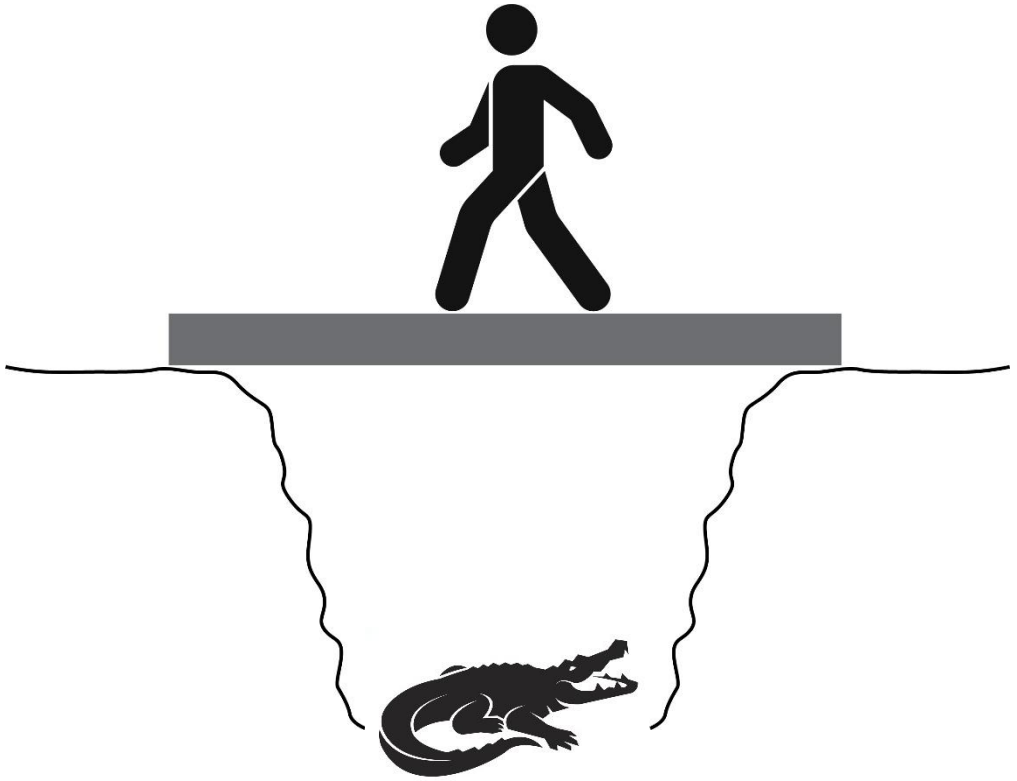


Credit: James Burke

- Foundations
- Columns
- Beams
- Slabs

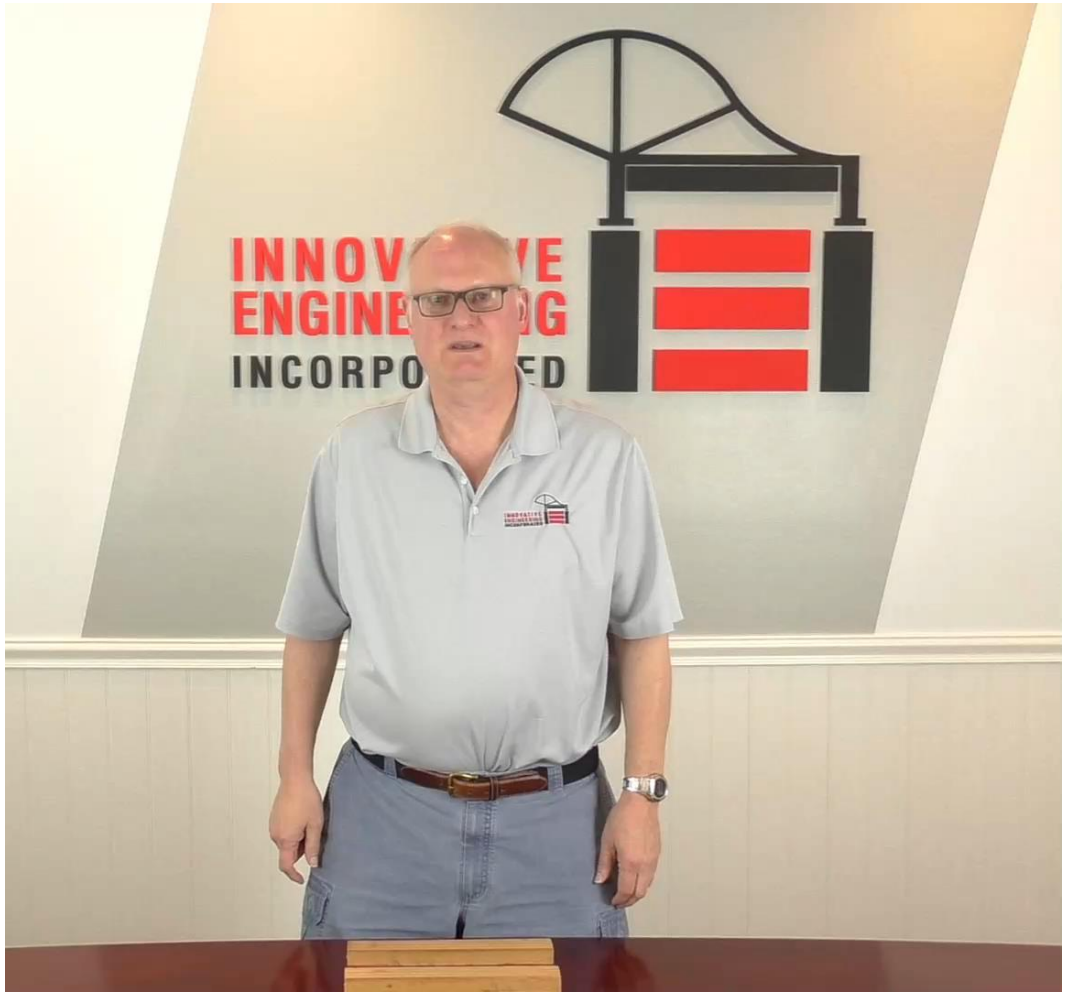
Building Structure – Beams and Slabs





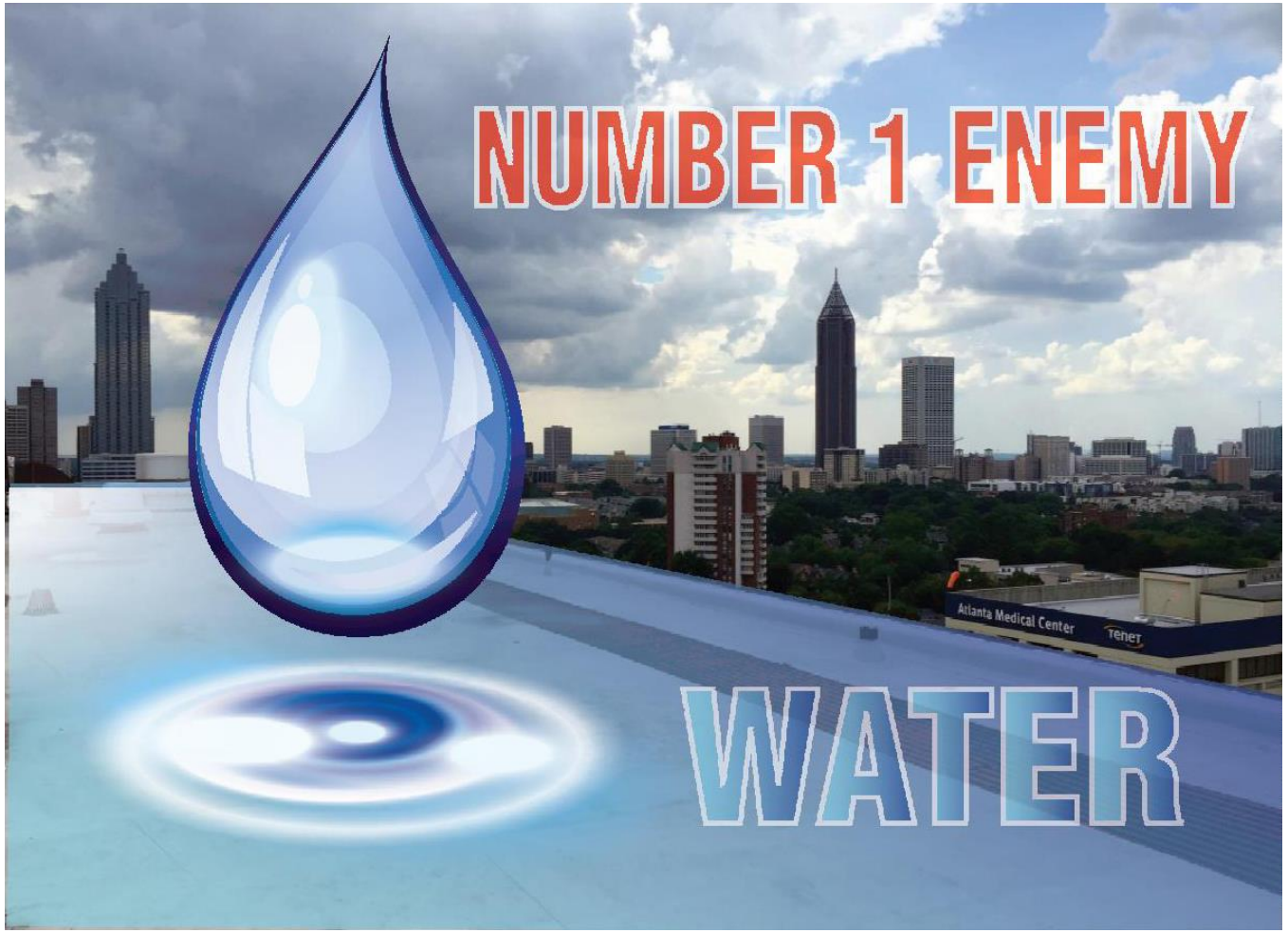
Building Structure - Columns

- **Failure Modes**
  - Stress
    - Pure Compression
    - Combined Stresses
    - Shear
    - Lack of Confinement
    - Torsion
  - Buckling



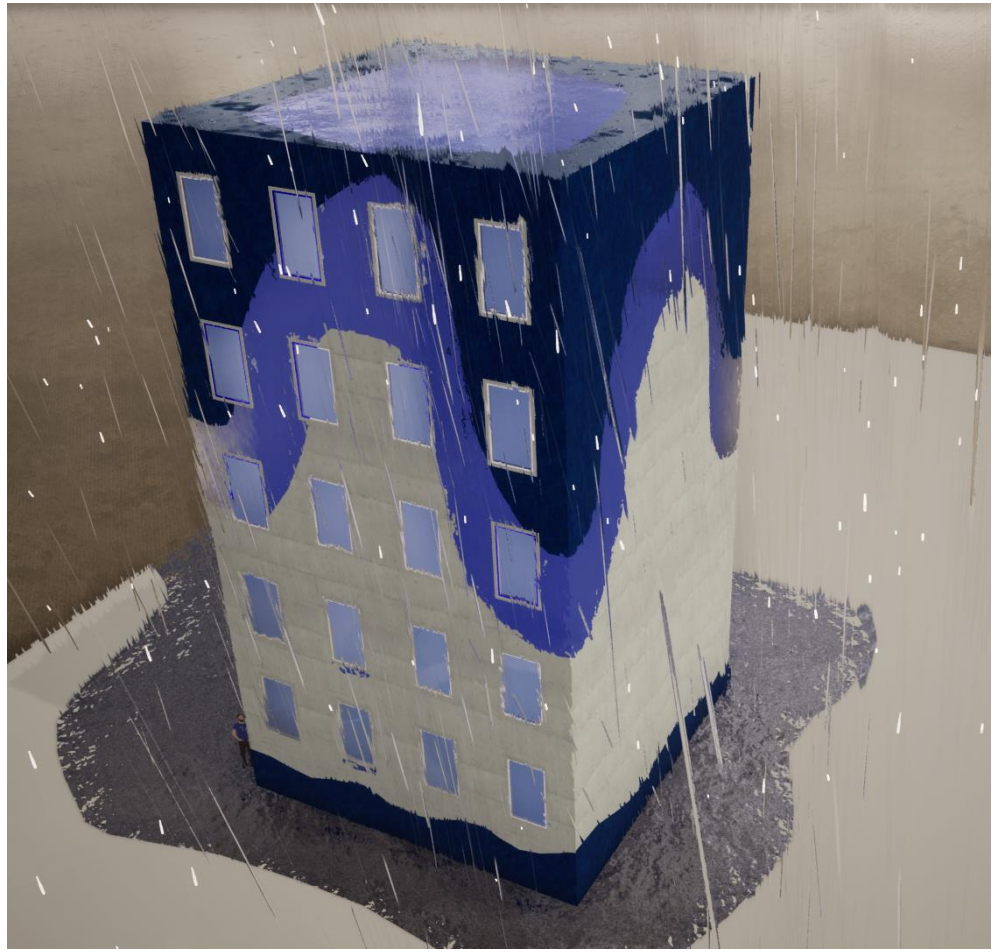
Building Science – Sources of Deterioration

- **Water Damage**
  - Mold
  - Corrosion
  - Rot
  - Termites & Insects
- **Movement of Materials**
  - Thermal
  - Moisture
  - Elastic Deformation
  - Creep
- **Other**
  - Impact Damage
  - Lightning Strike
  - Overload
  - Wind, Earthquake, Flood



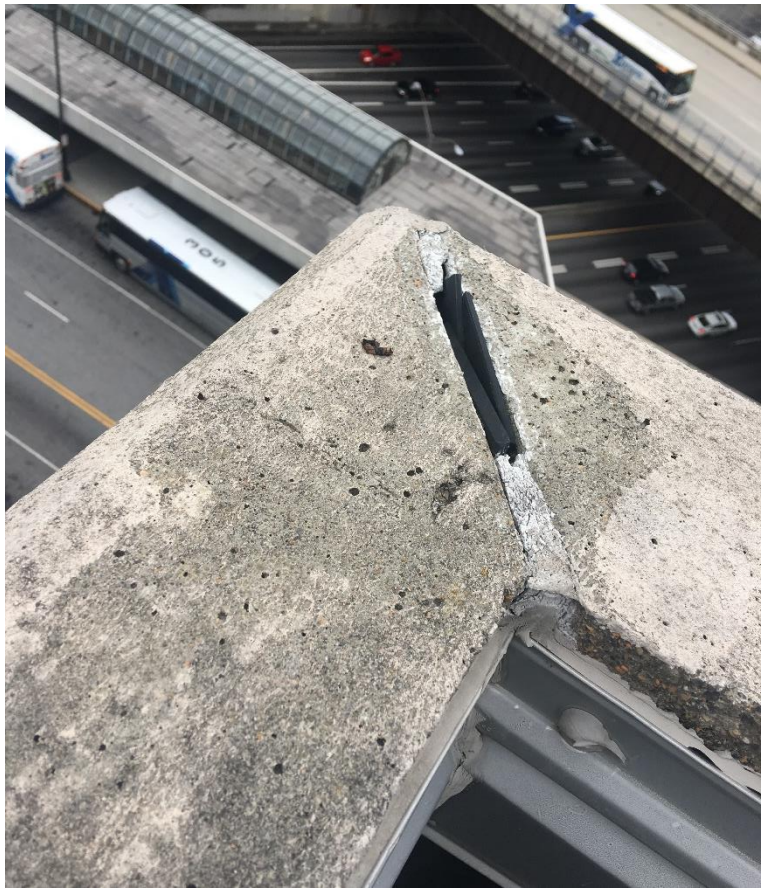
Building Science – Bulk Water Exposure

- **Water Intrusion: 70% of construction litigation**
- **Damage Functions**
  - Water
  - Heat
  - Ultra-Violet Radiation



Building Science – Water Shedding

Building Science - Natural Aging



Sealants

Roofing/Flashing

Building Science - Ponding

Ponding > 48 Hours

- **Ponding:** Most common factor in roofing & plaza slab failure
- **Water Shedding:** Can make up for shortcomings in design, construction, durability, & maintenance.
- **Degradation:** Asphalt & Polymeric materials
- **Freezing:** Erodes surface aggerate
- **Voids:** Manufacturer's warranty

Building Science - Roof Inspection

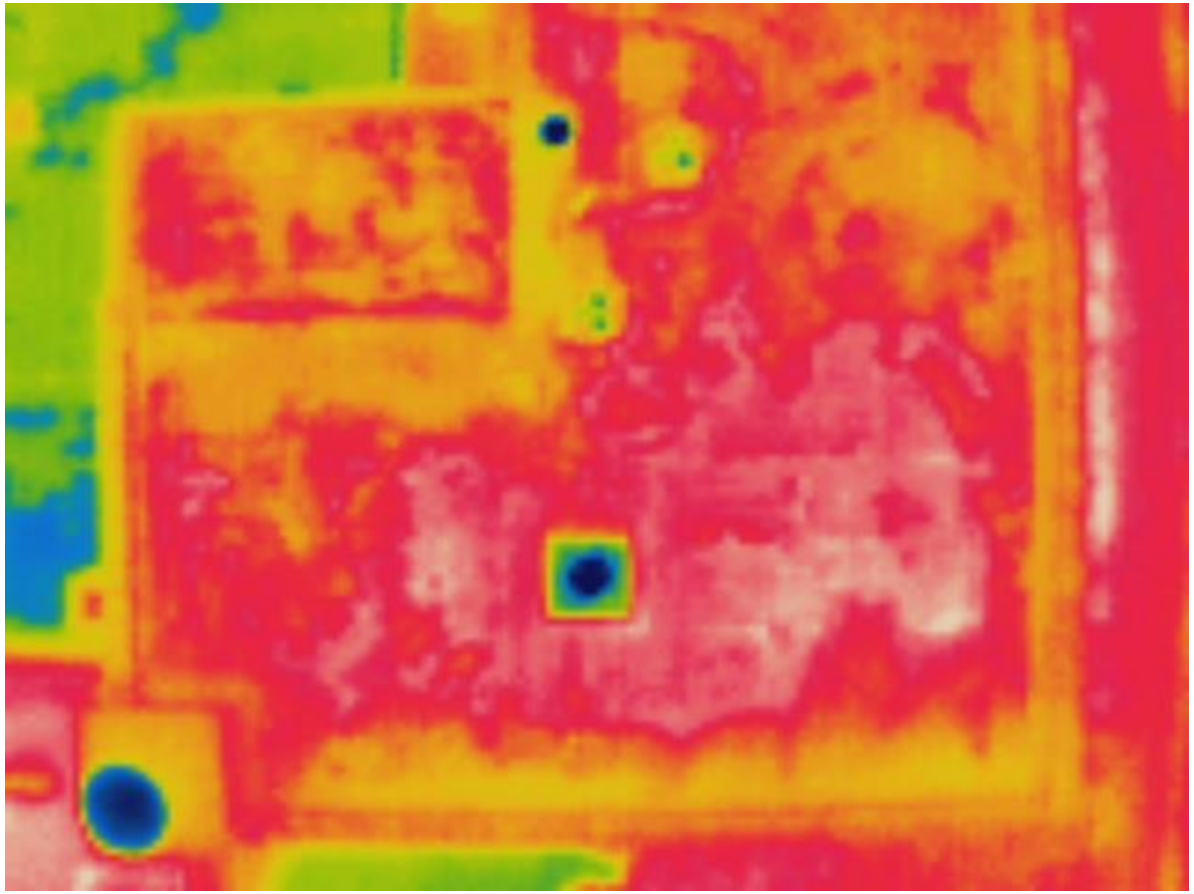
- **Attic/Plenum Space**
  - Water Stains
  - Rust
  - Pipe leaks
  - Condensation

Building Science - Drone Infrared Roof Inspection

- **Infrared Camera (IR)**
- **Best After Dusk**
  - Insulation and Moisture Heats Up During the Day
  - Dry Insulation cools off faster than Wet Insulation
- **Daylight Waiver Required**
- **Height to See Major Portions of Roof**
- **Safer and More Accurate than Handheld**

Building Science - Thermal Imaging

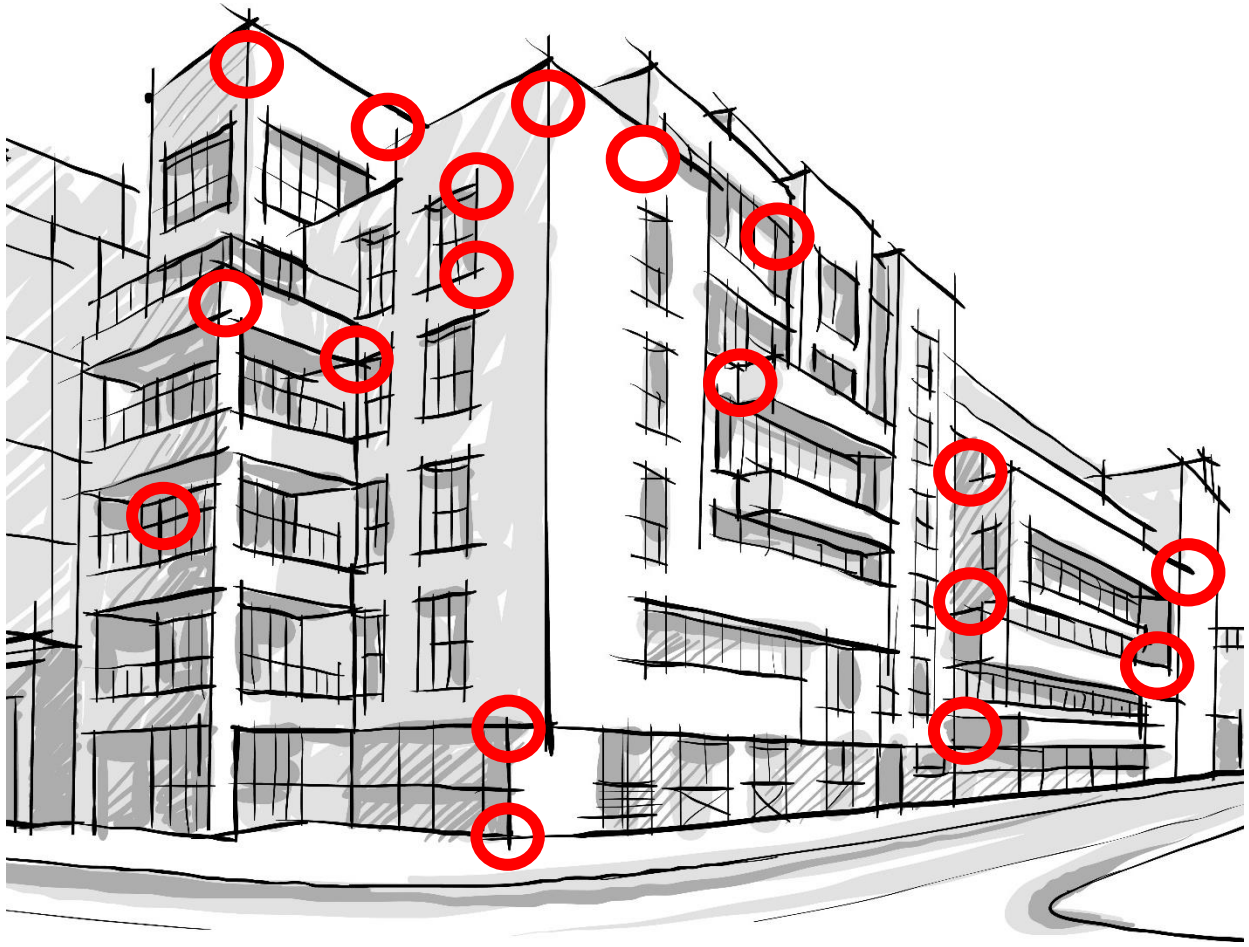
Visual Red-Green-Blue (RGB)



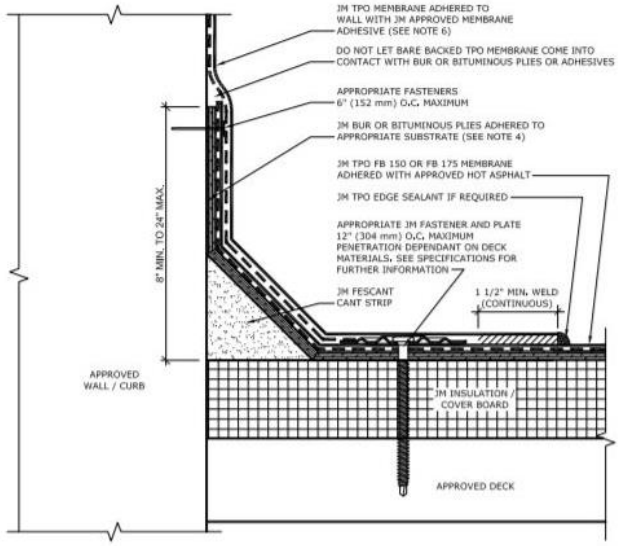
Infrared (IR)

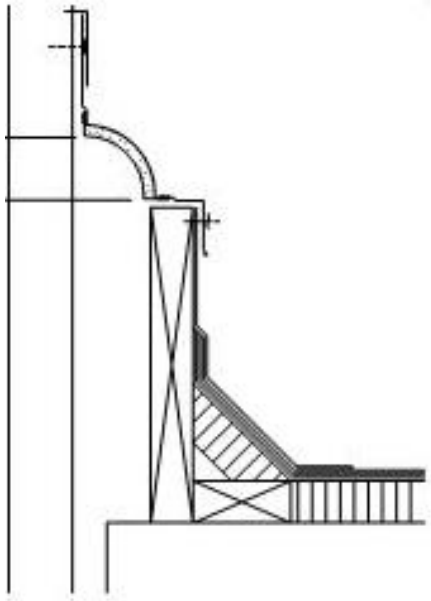
Building Science - Principles

- **90%/1%**
  - 90% of the water intrusion problems occur within 1% of the total building exterior. Usually at terminations and transitions
- **99%**
  - 99% of water intrusion problems are attributable to human error including detailing, specifications, or installation. Not material or system failures.

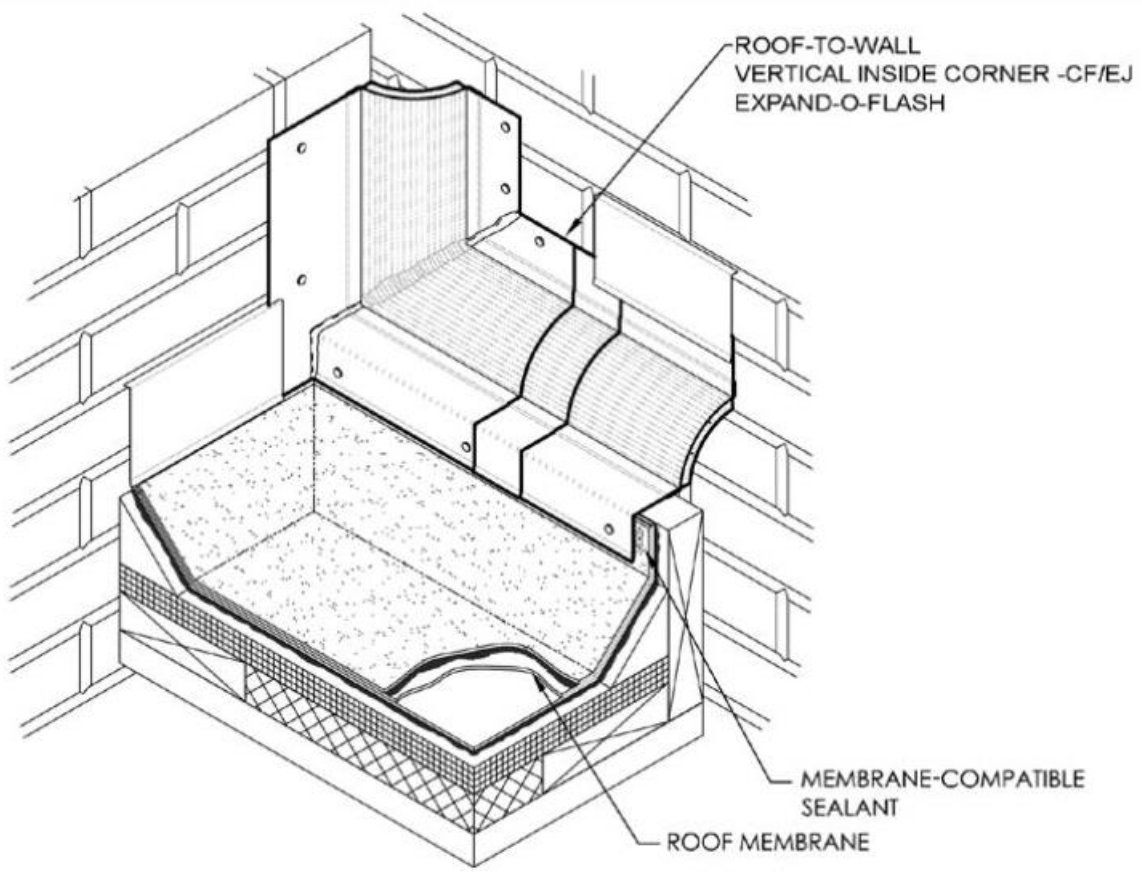


Building Science - Transition Details





2 D



3 D

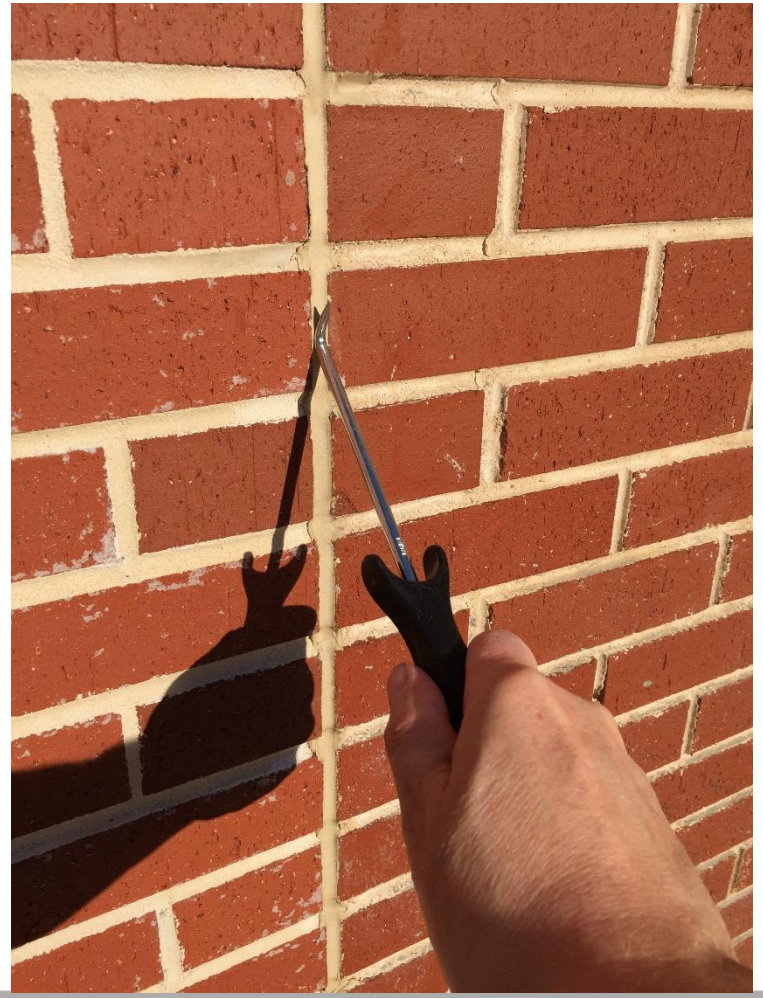
Building Science - Sealant

Building Science - Failed Joint Sealant

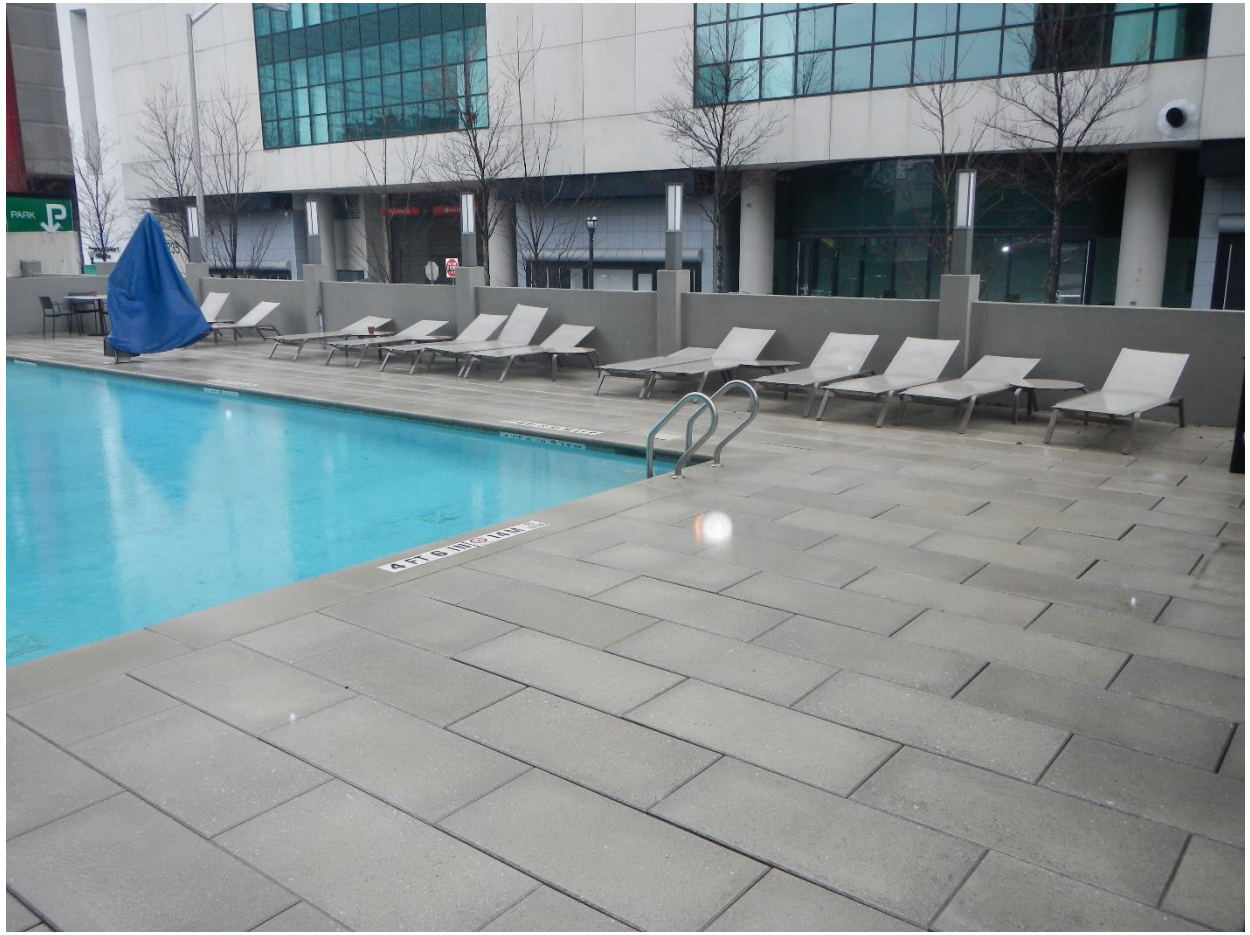
Cohesive Failure/Aged & Weathered

Adhesive Failure

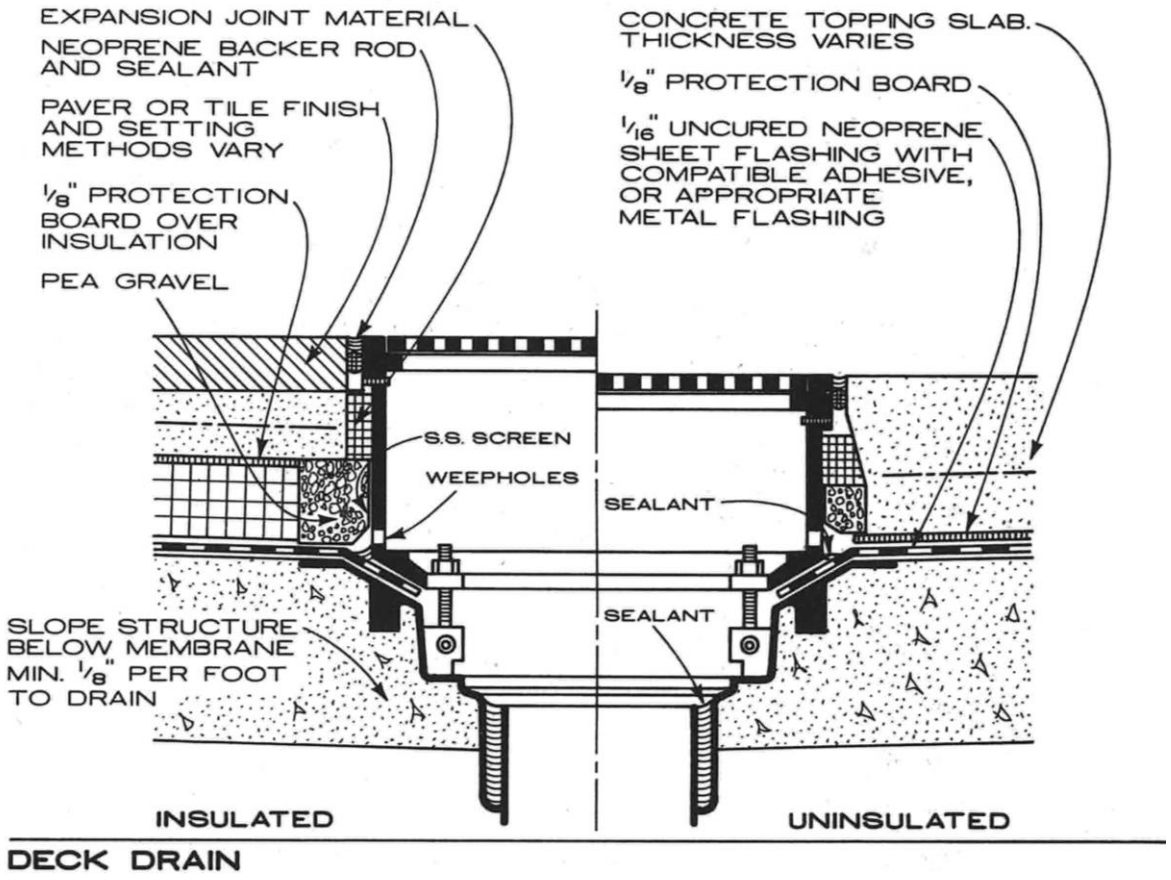
Building Science – Joint Sealant Testing



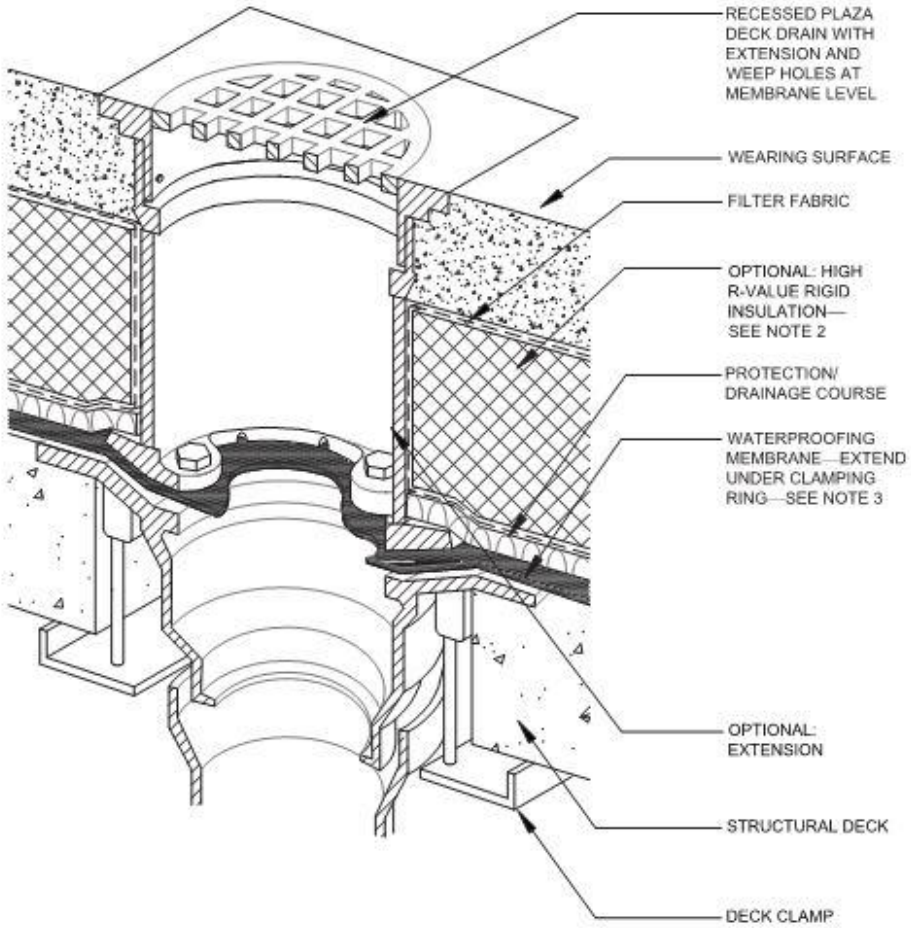
Building Science – Plaza Slabs



Building Science – Protected Membranes



Ref.: 1981 Architectural Graphics Standards



Ref.: NRCA Detail WP-24

Below Grade Waterproofing

- **One chance to get it right**
- **Three things required for a Leak**
  - Water
  - Hole(s)
  - Pressure
- **Difficult to diagnose**

Below Grade Waterproofing - Membrane

- **External Membranes**
  - Fluid-Applied
  - Sheet Applied
- **System Requirements**
  - Embedded Waterstop at Joints
  - Wrap Entire Foundation
  - Protection Board
  - Drainage System
- **Integral Waterproofing Admixture**

Building Science – Condensation

Matt Leech

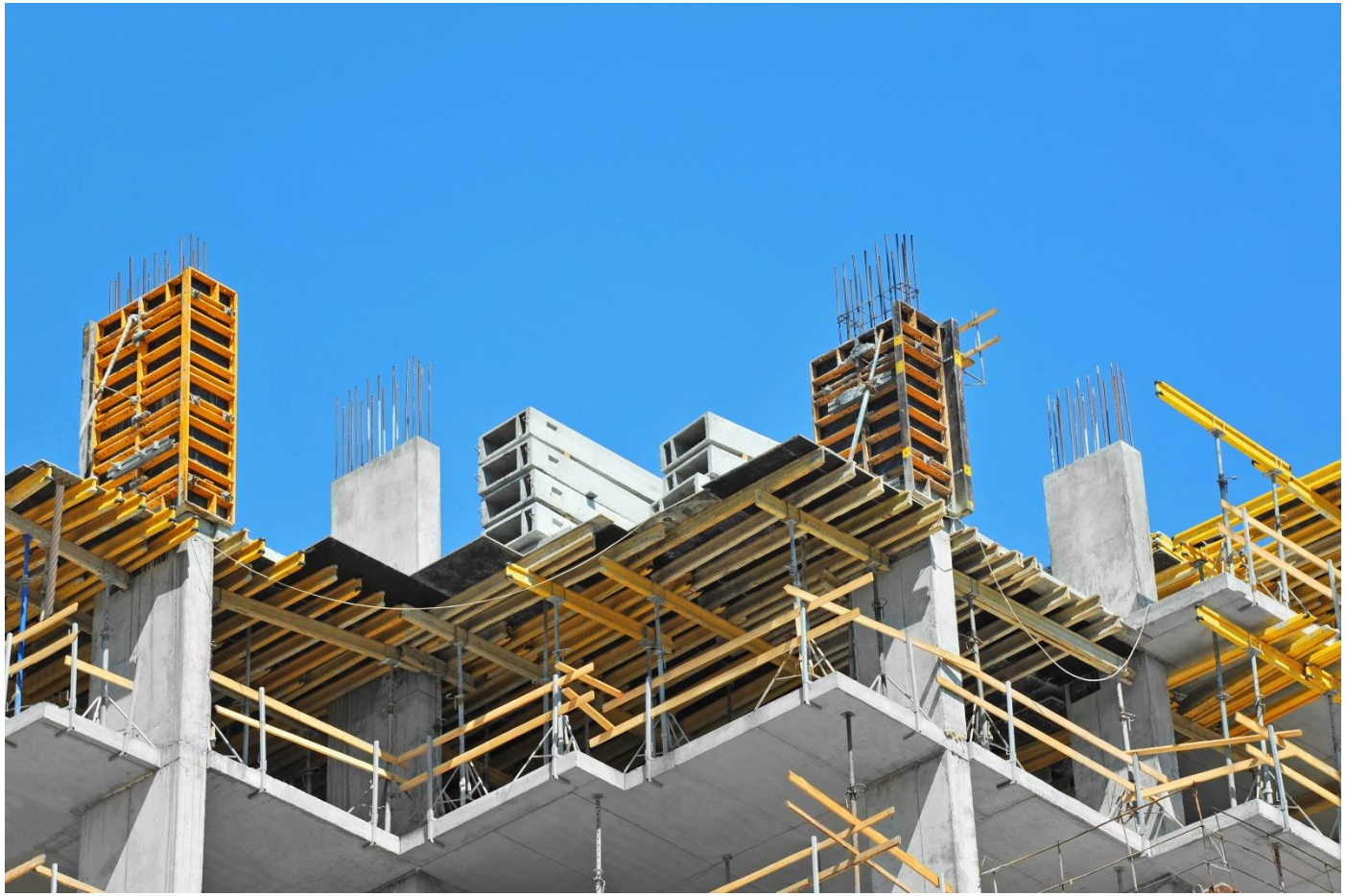
James Building

Building Structure Inspection

Intermission
&
Questions

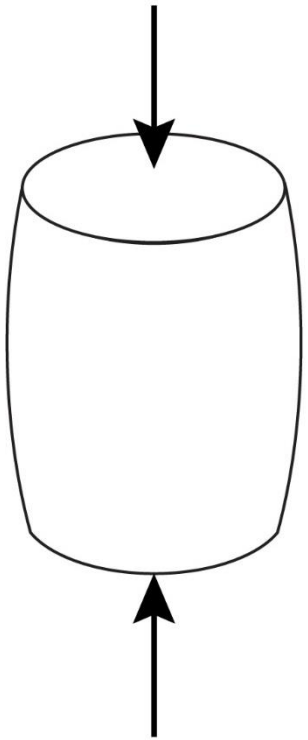
Reinforced Concrete

- **Moisture**
  - Corrosion
  - Freeze-Thaw
  - Osmosis
- **Cracking**



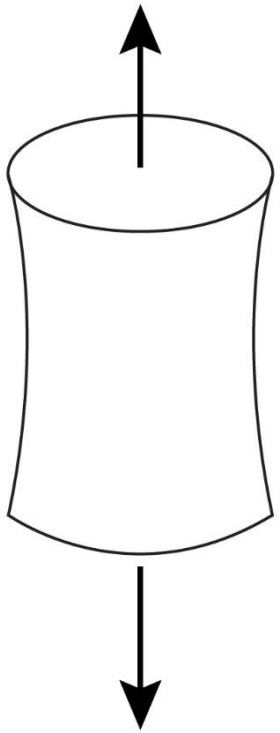
Reinforced Concrete - Strength

Compression



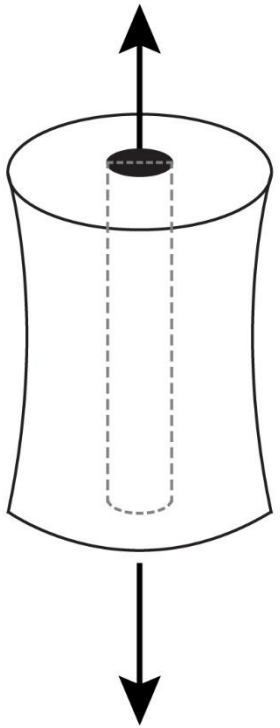
10 % of Compression

Tension

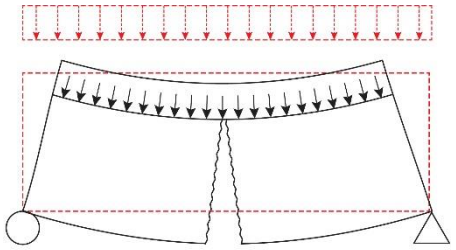


Add Reinforcing

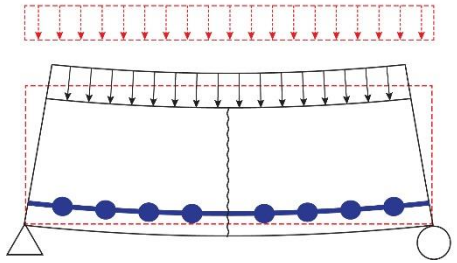
Tension



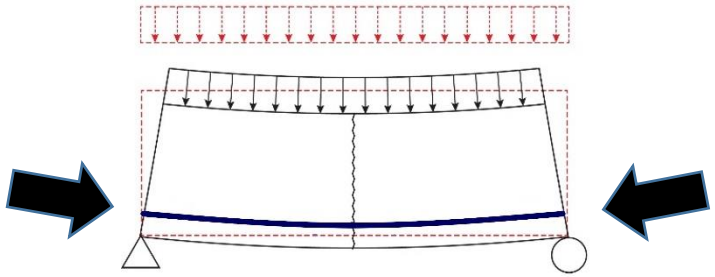
Reinforced Concrete – Simple Span Beam



Plain Concrete

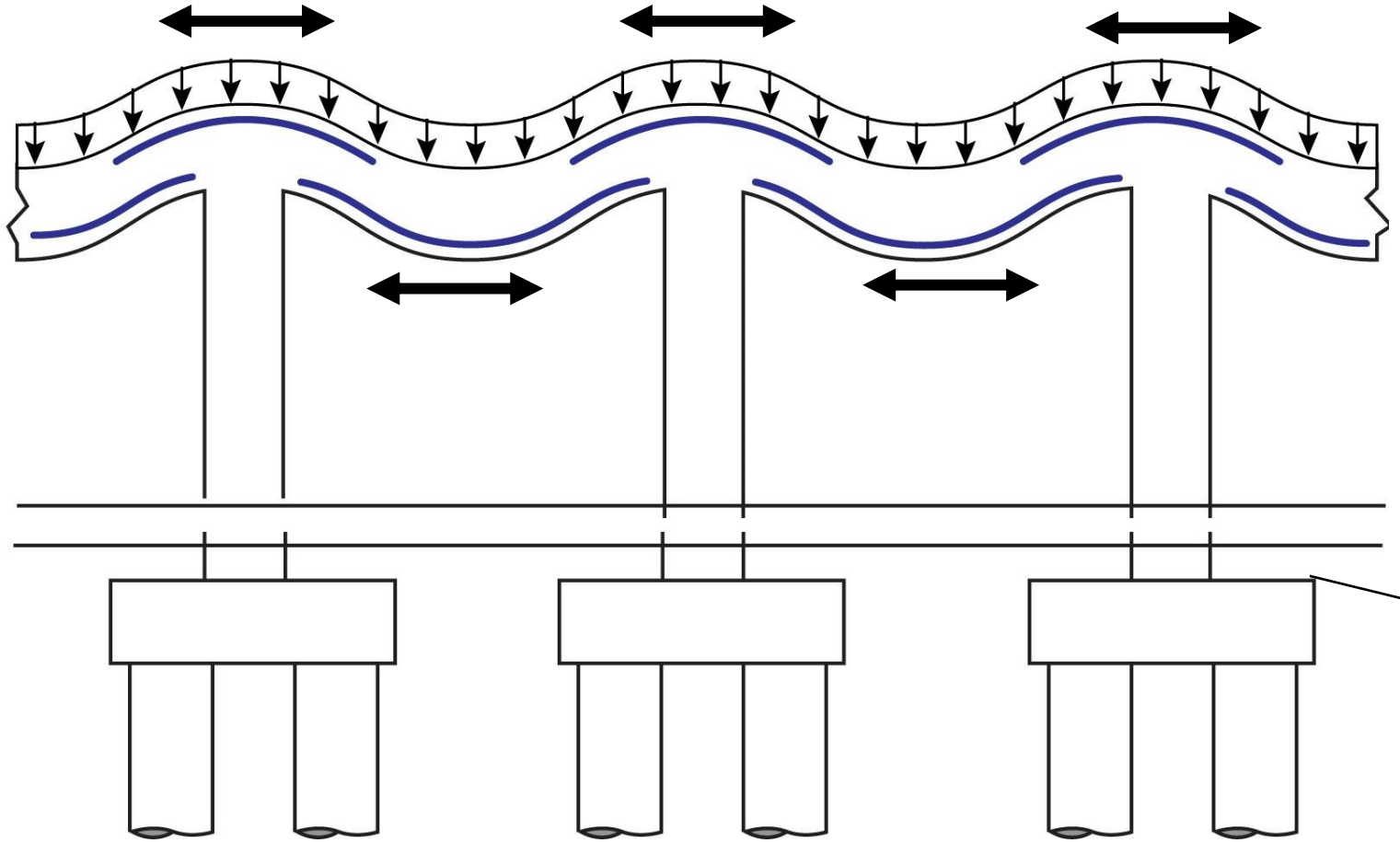


Reinforced Concrete



Prestressed Concrete

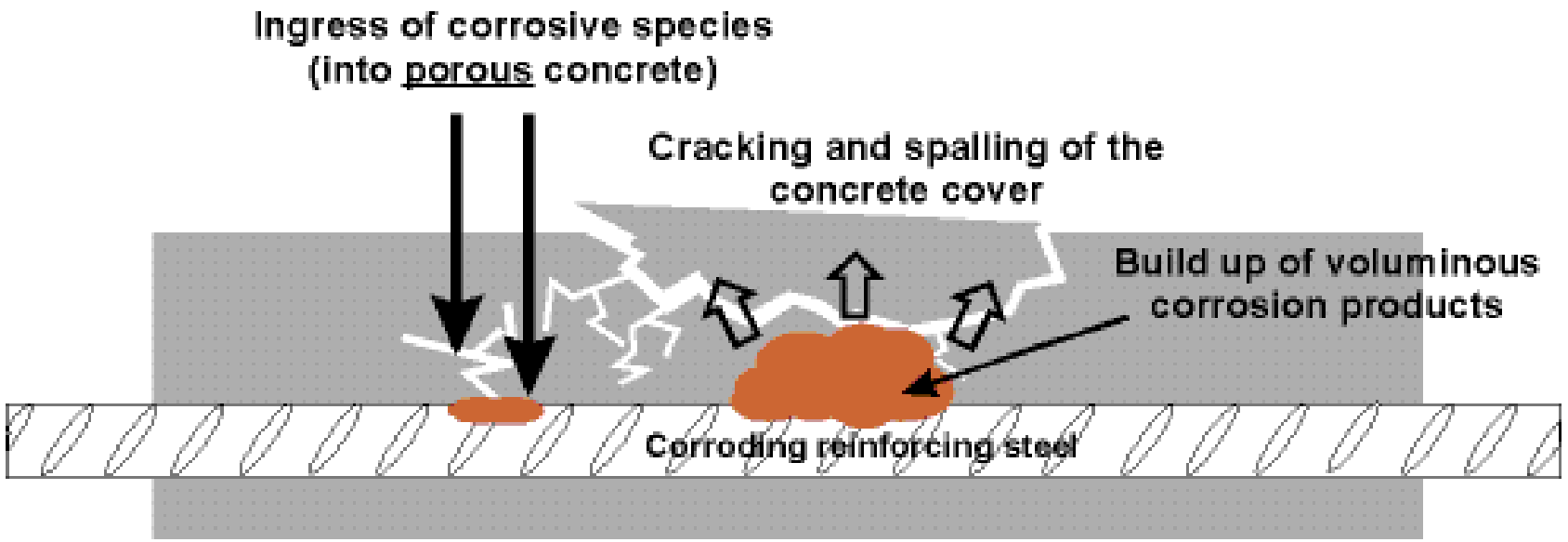
Reinforced Concrete – Multi-Span Beam/Slab

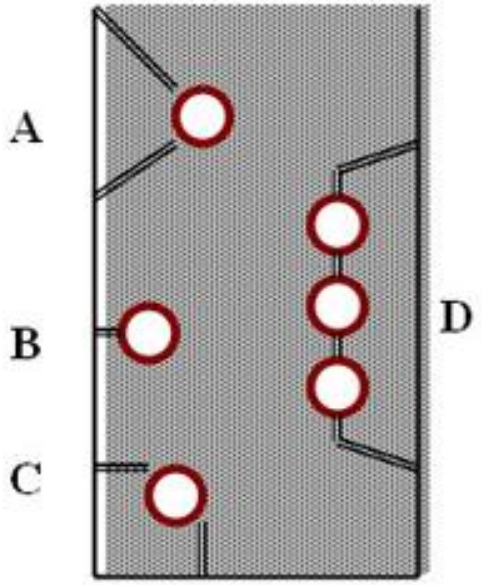


- **Tension in Top over Columns**
- **Tension in Bottom between Columns**

Foundation

Reinforced Concrete - Corrosion





A: Spall
B: Crack
C: Corner Spall
D: Delamination

Reinforced Concrete - Spall & Delamination

Spall

Delamination

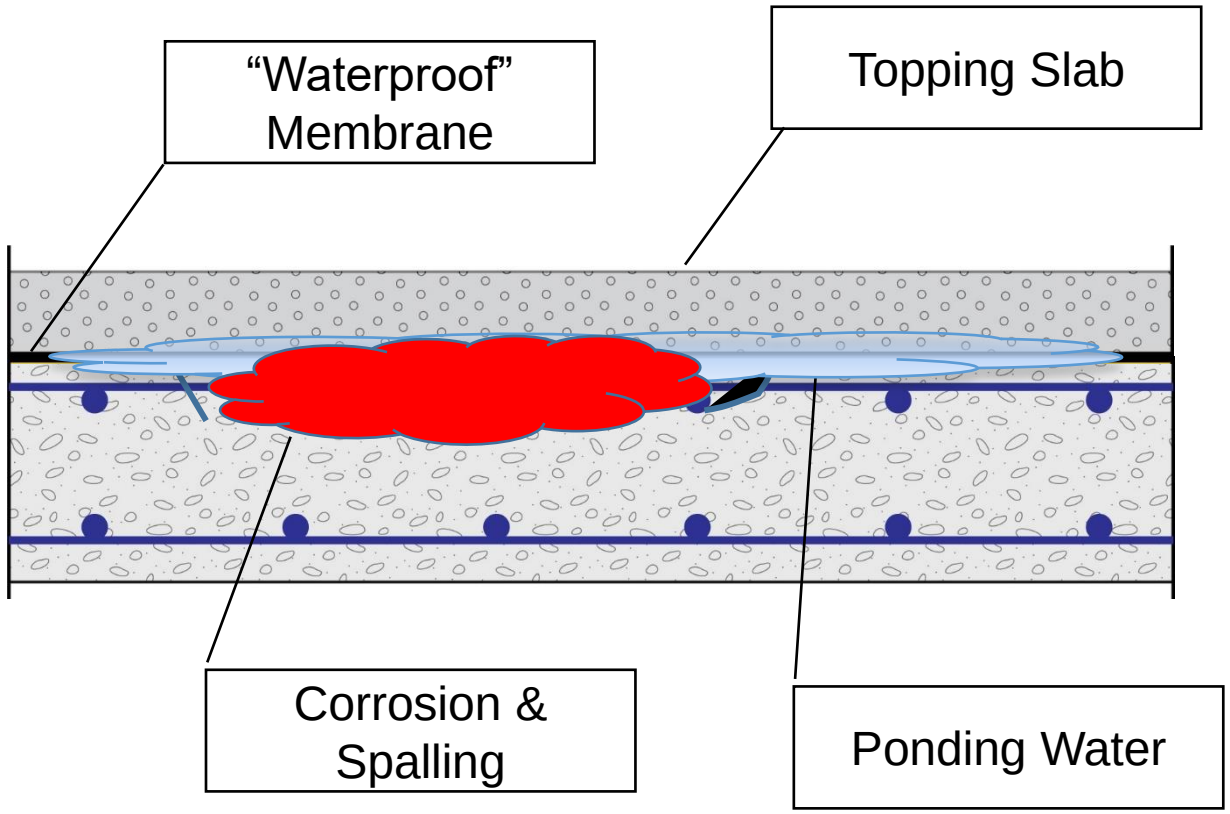
Section Loss

Reinforced Concrete - Sounding

Sounding Technology Inc.

Reinforced Concrete – Impulse Echo

Plaza Slab



Reinforced Concrete – Minimally Invasive Inspection

- **Multiple Water Control Layers**
  - Water Shedding
  - Water Drainage
  - Waterproofing
- **Can’t be afraid to dismantle small portion of Plaza Slab.**

Reinforced Concrete - Chloride Ion Testing

Dust at Various Depths

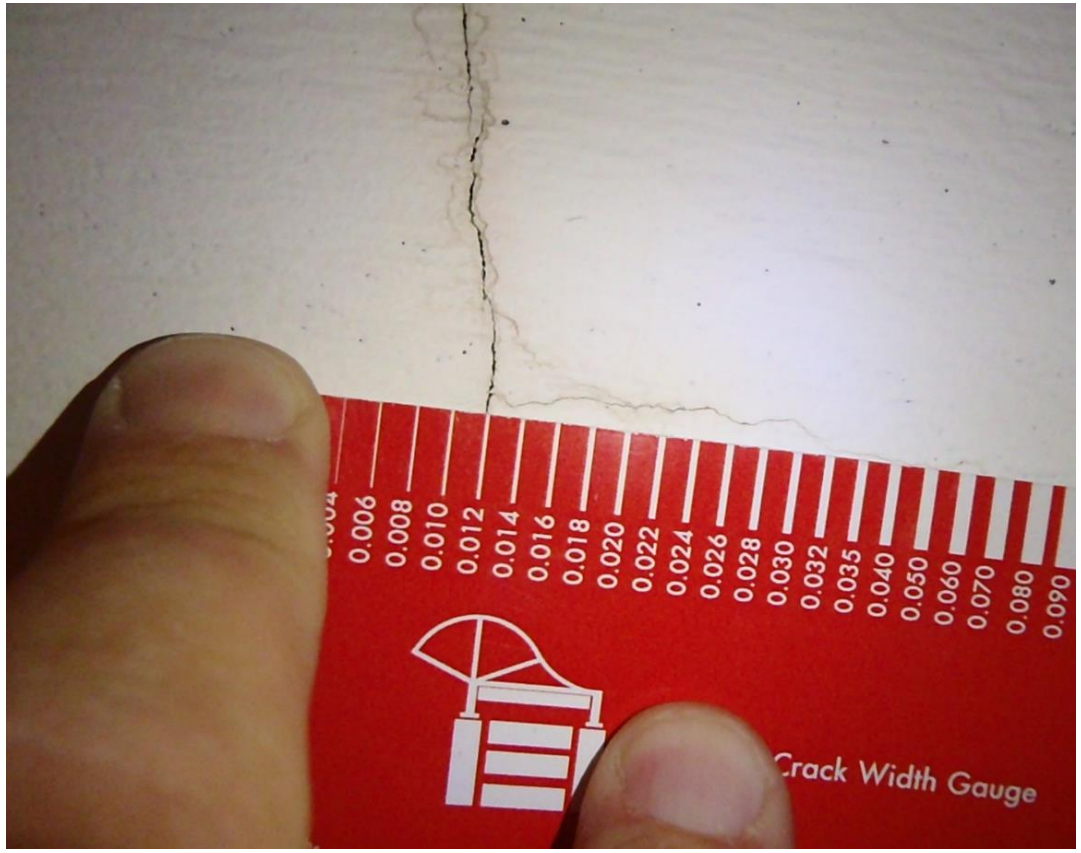
Chloride Ion Concentration

Reinforced Concrete - Carbonation Testing

Coring Slab

Depth of Carbonation

Reinforced Concrete - Cracks



.013” ≤ Cracks < .035”

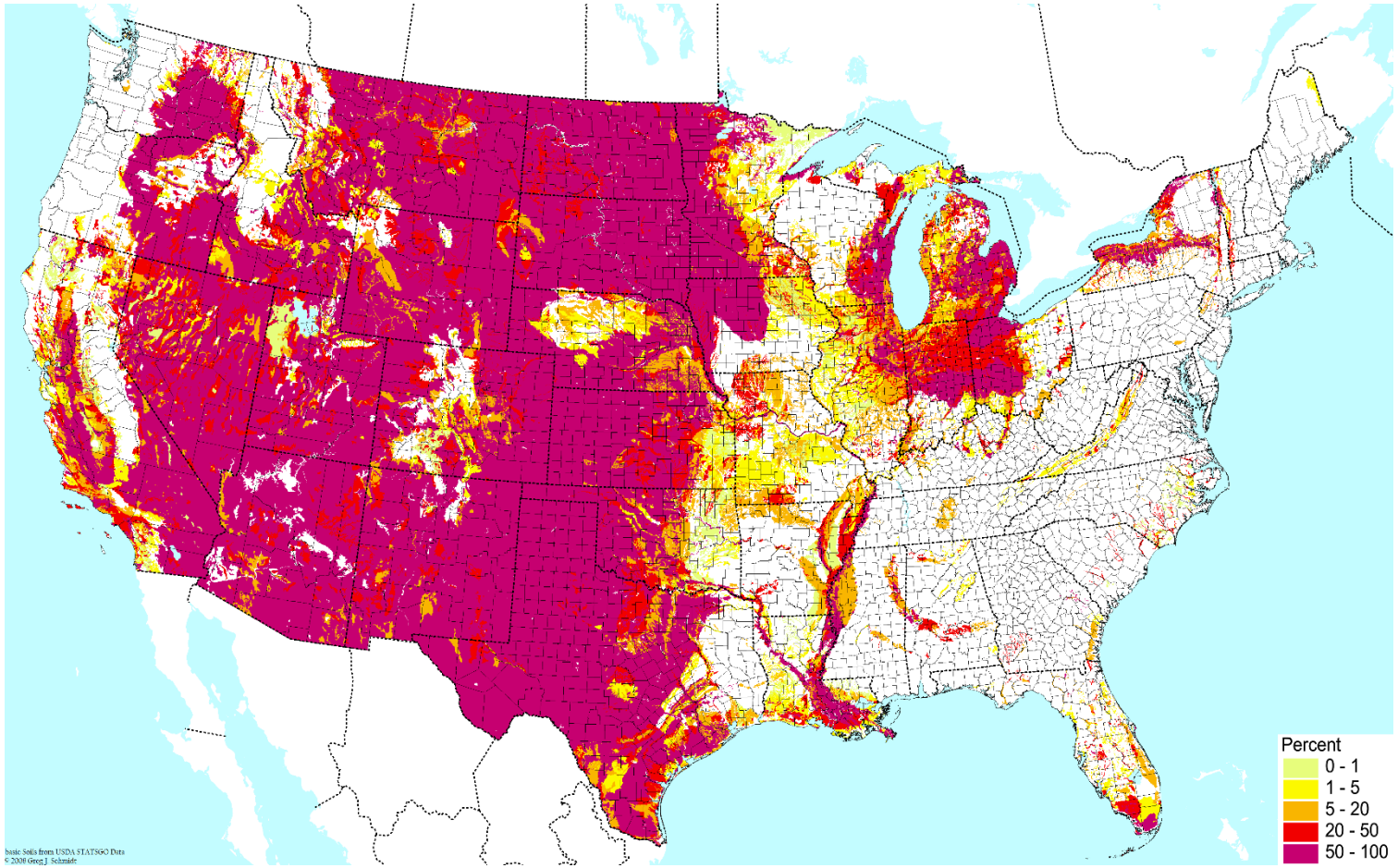
Cracks that Leak < .035”

Reinforced Concrete – Moving Cracks

- **Widening Crack**
  - Potential Failure
- **Expanding & Shrinking**
  - Thermal/Moisture Expansion & Contraction
  - Changing Loads

Reinforced Concrete – Slab Cracks

Reinforced Concrete – Sulfate Attack

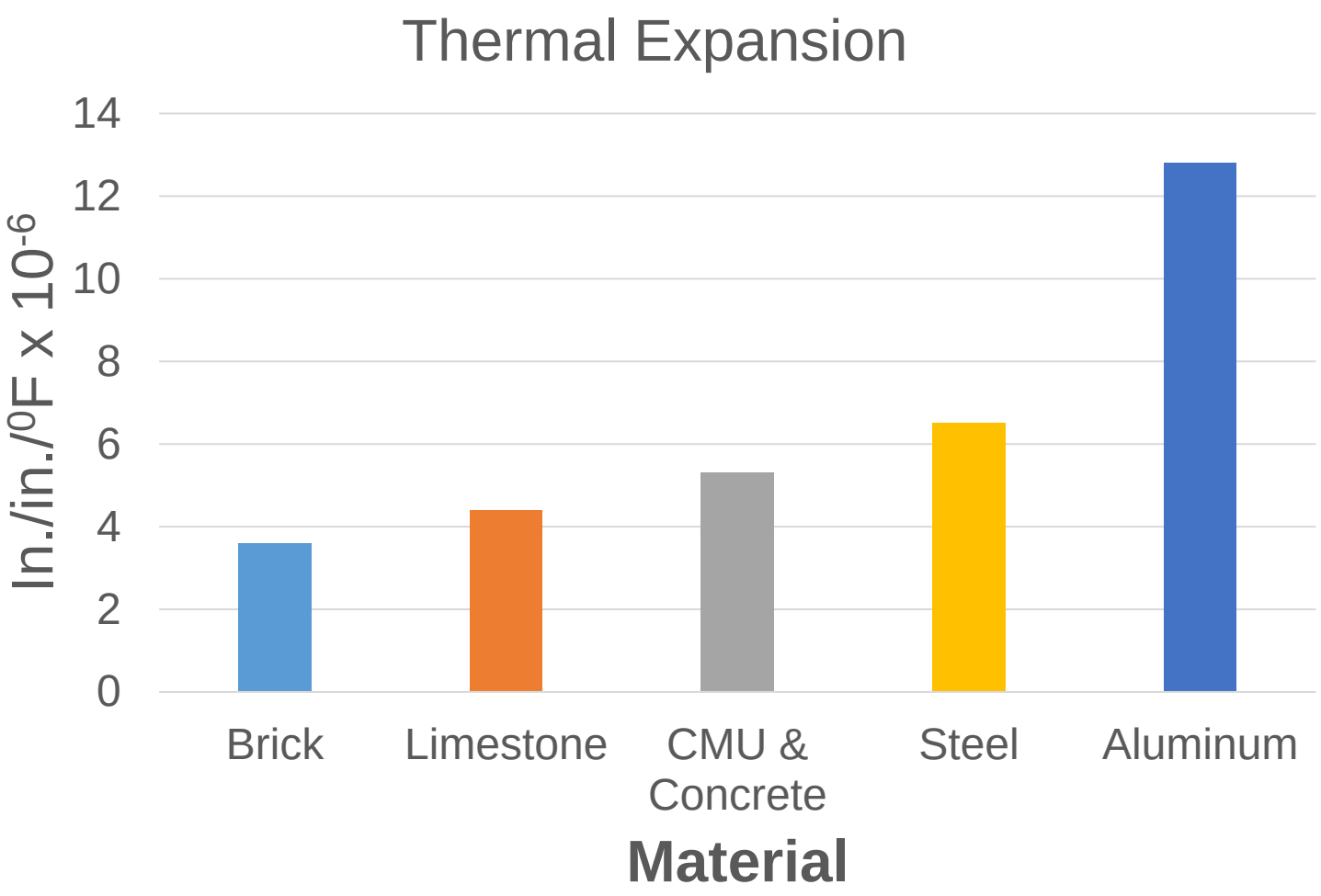


- High Alkalinity (Basic) = Alkali Sulphates
- Common in northern Great Plains and parts of the western U.S.
- Chemical Reaction with Cement Expands Destroying Concrete
- Test with Impulse Echo

Masonry

- **Thermal Expansion/Contraction**
- **Moisture**
  - Expansion/Contraction
  - Corrosion
  - Freeze-Thaw
  - Osmosis
- **Cracking**

Facade - Thermal Expansion



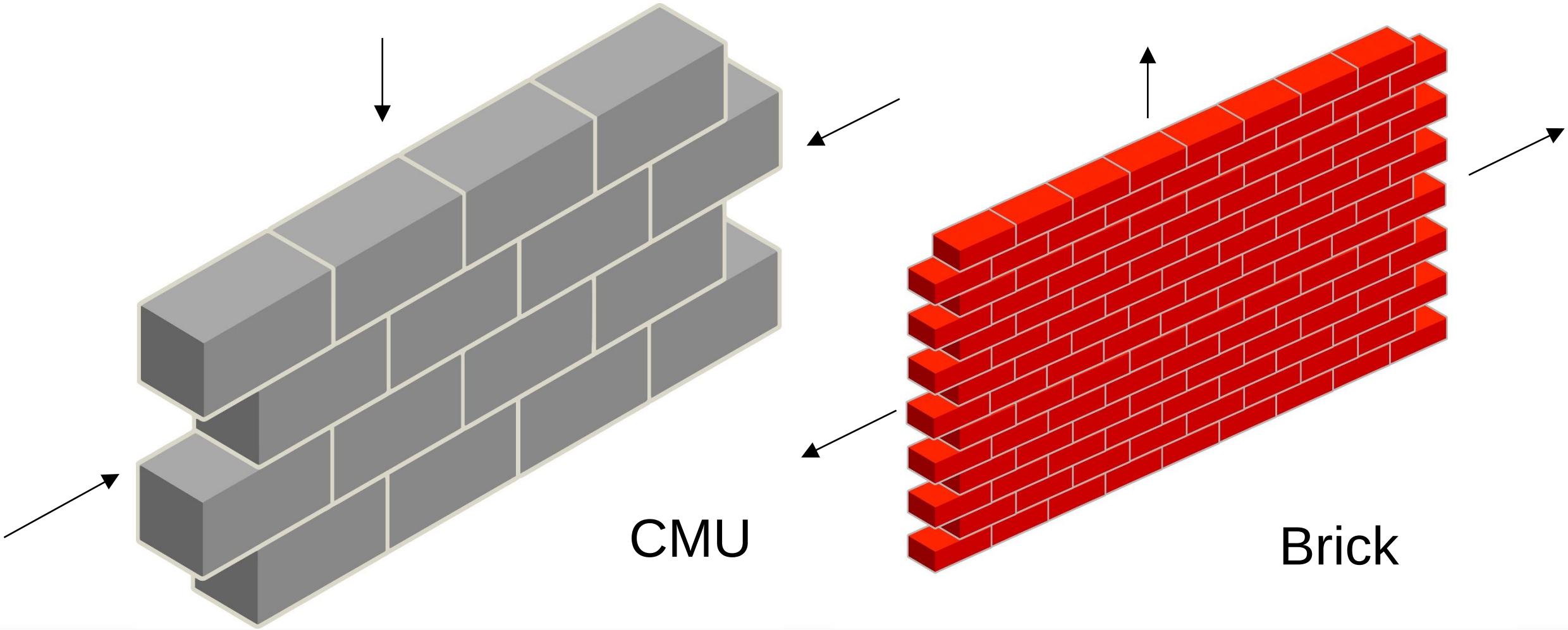
Coefficients of Thermal Expansion	
Material	in./in./^{0}F x 10^{-6}
Wood	
Pine (parellel to grain)	3.0
Pine (perpendicular to grain)	19.0
Masonry	
Brick	3.6
Limestone	4.4
Granite	4.7
Concrete Masonry Unit (CMU)	5.2
Marble	7.3
Concrete	
Concrete (Normal Weight)	5.5
Metals	
Steel	6.5
Copper	9.3
Aluminum	12.8
Finishes	
Glass	5.0
Gypsum Plaster, Sand	7.0
Gypsum Board	9.0

Façade – Thermal Expansion

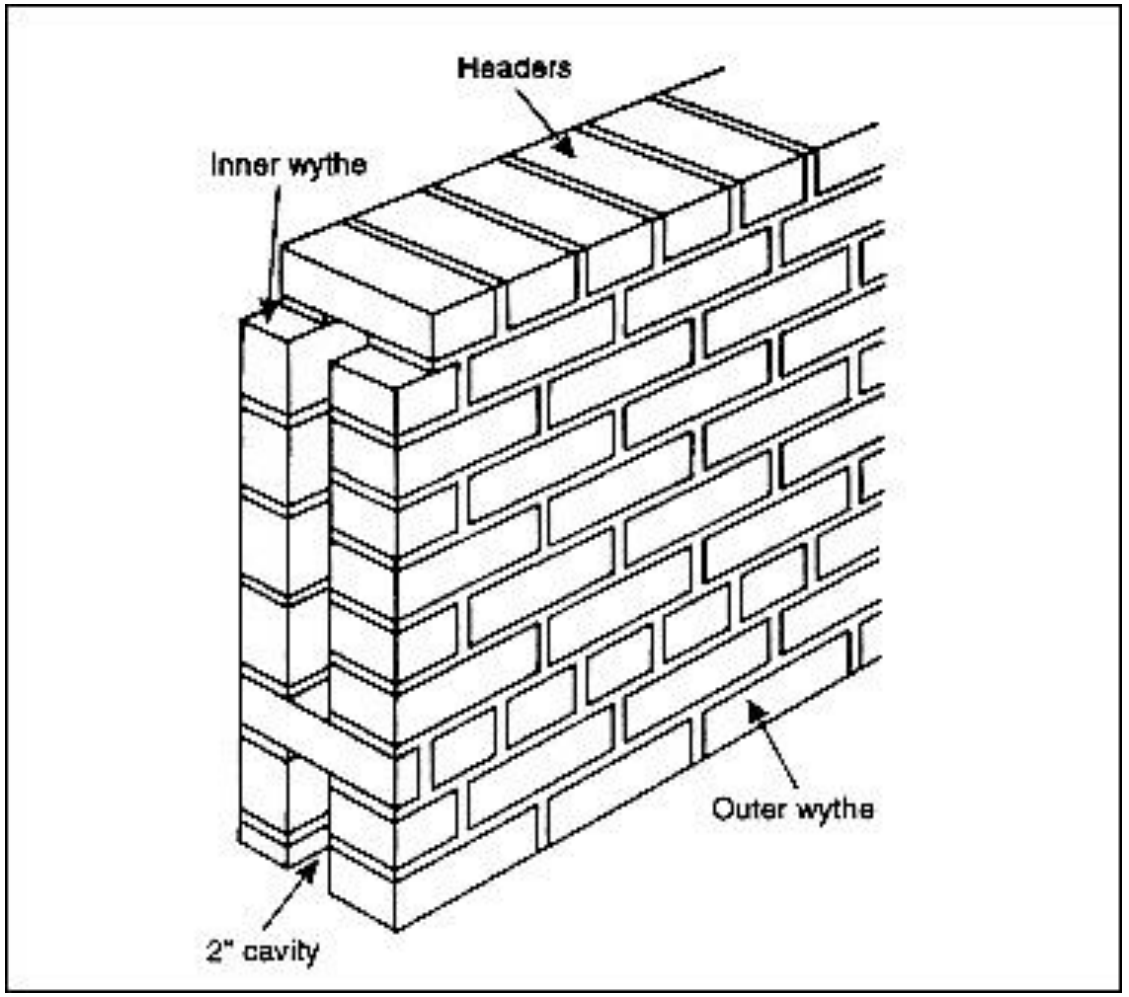
No Expansion Joints

Creates Hinge at Corner

Facade - Moisture Expansion/Shrinkage



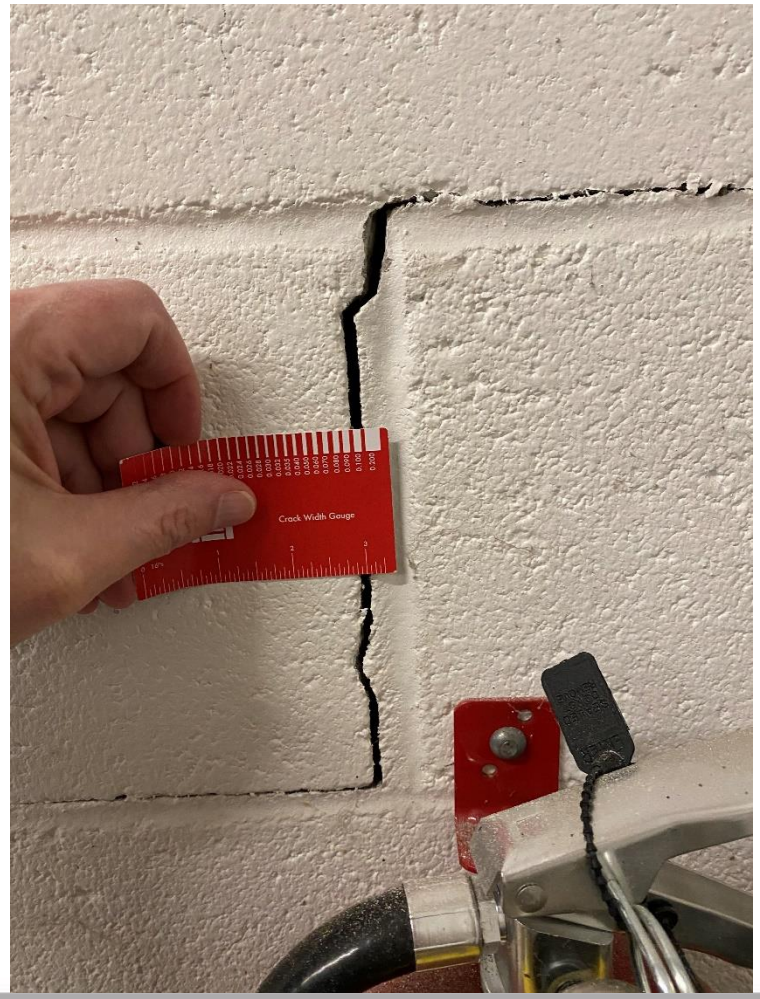
Façade – Moisture/Thermal Expansion/Contraction



Façade – Moisture & Thermal Expansion/Contraction

Façade – Moisture Damage

Masonry – Creep & Settlement



Façade Inspection - Tactile Close-Up

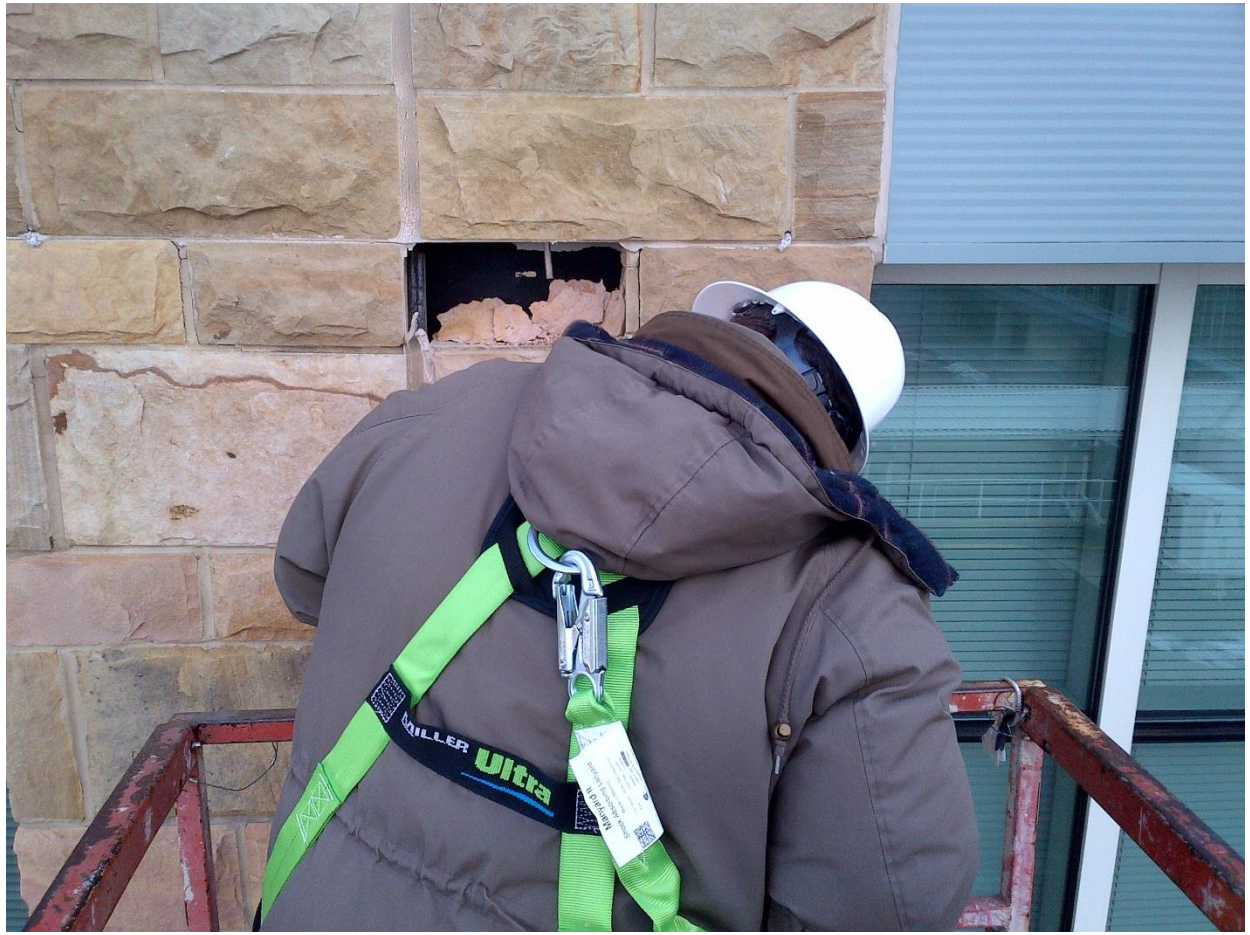
Boom Lift

Rope Access

Façade Inspection - Bore Scope (Brick Veneer)

Façade Inspection – Minimally Invasive Inspection

- **Multiple Water Control Layers**
  - Water Shedding
  - Water Drainage
  - Waterproofing
- **Can’t be afraid to dismantle small portion of wall.**



Masonry – Unauthorized Openings

- **Penetrations Through Load Bearing Walls**

Steel Framing - Deterioration

- **Moisture**
  - Rust
- **Fatigue**
- **Modified or Damaged Members**

Steel Framing Corrosion

- **Surface Rust**
- **Section Loss**
  - Flange
  - Web

Steel Framing - Corrosion

- Rust Expands 5 to 6 Times Original Volume
- Often Looks Worse Than It Is
- Scrape Rust
- Measure with Caliper

Steel Framing - Fatigue

Steel Framing – Altered or Damaged Members

Wood Framing - Deterioration

- **Moisture**
  - Rot
  - Insect Infestation
- **Checks & Splits**
- **Missing or Modified Members**

Wood Framing – Visual Inspection

Wood Framing - Probing

Wood Framing - Coring

Wood Framing – Moisture Meter

Moisture Content > 30% =
Serious Decay

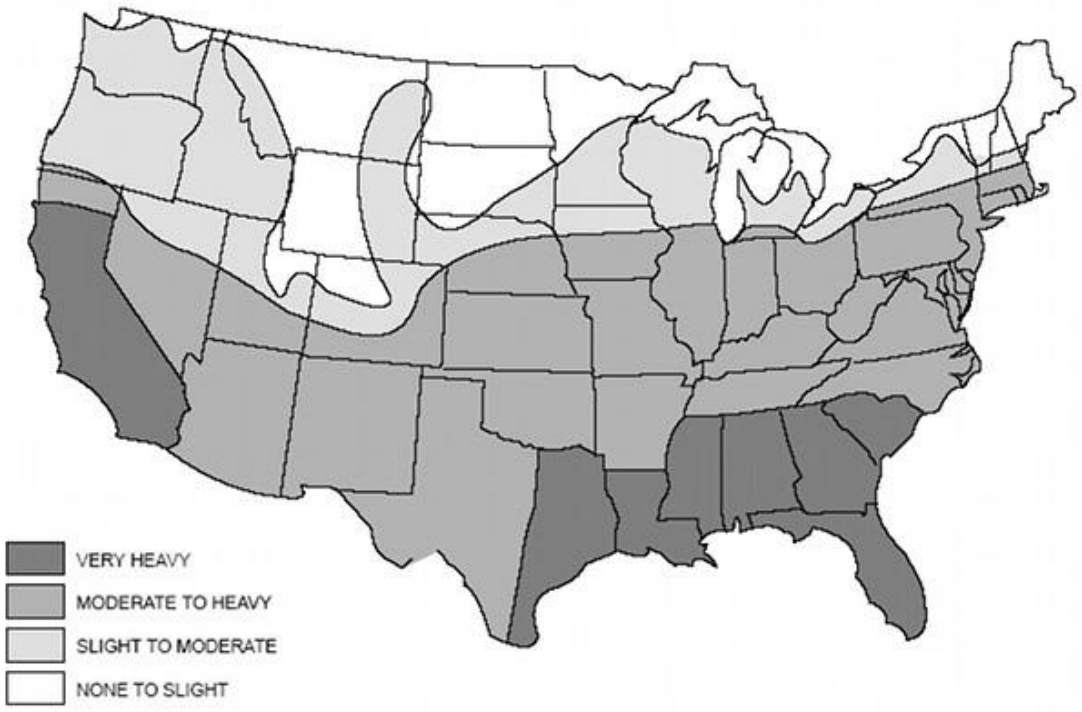
Wood Framing – Termite Infestation

Mud Tubes

Wood Framing – Termite Infestation

- **Galleries**
- **Parallel to Growth Rings**
- **May not be visible**
  - Thick lumber
  - Pressure Treated lumber

Wood Framing – Termite Infestation Probability



Note: Lines defining areas are approximate only. Local conditions may be more or less severe than indicated by the region classification.

FIGURE R301.2(6)
TERMITE INFESTATION PROBABILITY MAP

2000 INTERNATIONAL RESIDENTIAL CODE™

- Exist in all states except Alaska
- Live in a Colony (nest) in the Ground below the Frost Line
- Dark, Damp Environment
- Soldiers are ¼” Long and Whitish Crème in Color
- Can Penetrate 1/32” Openings.
- Travel in Shelter (Mud) Tubes to Shelter from Light

Wood Framing – Checks & Splits

Wood Framing – Modified Members

Russ LaBlanc

Buying Services - Scope of Work

Inspection Protocol

- Diagnose
- Prescribe
- Treat

Learning Objectives

- **Building Structure Inspection**
  - Laws & Standards
  - Structural Engineering 101
  - Failure Mechanisms
  - Concrete, Masonry, Steel, & Wood
  - How to Purchase a Condition Assessment

Questions?

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