BOMA Georgia

MEMBER

Structural Inspection and Safety for Building Operations

PENTA

ENGINEERING GROUP, LLC

INNOVATIVE ENGINEERING INCORPORATED

Agenda

- Building Structure Condition Assessment
  - Scott L. Weiland PE SE, Innovative Engineering Inc.
- Parking Deck Awareness
  - Mark E. Lester PE, Penta Engineering Group, LLC
- Parking Deck Walk-Through
  - Mark E. Lester PE, Penta Engineering Group, LLC

Building Structure Condition Assessment

How to Avoid Catastrophe

BOMA BTO Safety Seminar
Thursday, August 11, 2022, 8:30-11:30 PM
Atlanta, GA

Learning Objectives

- **Building Structure Condition Assessment**
  - Champlain Towers Collapse
  - Structural Engineering 101
  - Failure Mechanisms
    - Concrete, Masonry, Steel, & Wood
  - Laws & Standards

AIA Continuing Education Provider

Disclaimer

Presentations today provide general information.

For specific advice, consult a professional.

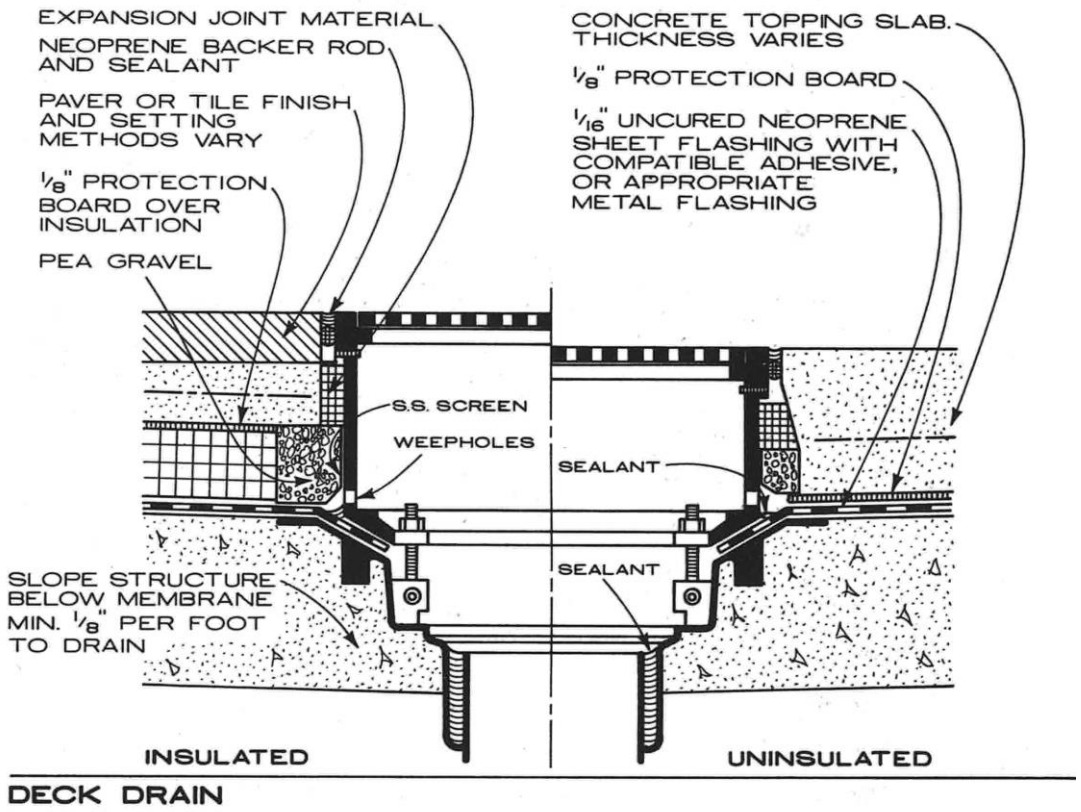
Innovative Engineering, Inc.

- **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**
  - **Author, Presenter, Educator**

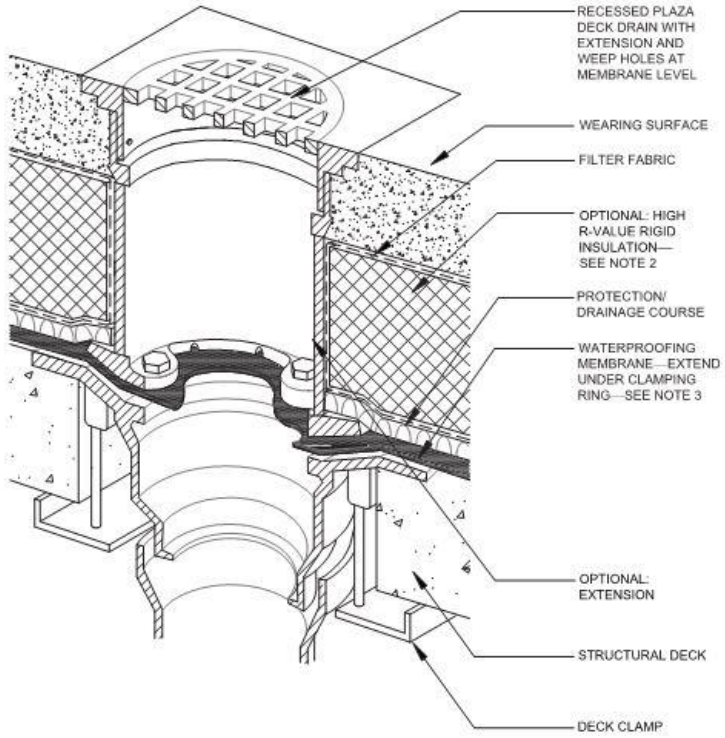
Champlain Towers Collapse

- Built 1981
- 12 Story, 136 Units
- Cast-In-Place Concrete
- Plaza Slab
- Below Grade Level Parking Garage
- 2018 Report
- 40 Year Recertification Underway

Plaza Slabs – Protected Membranes

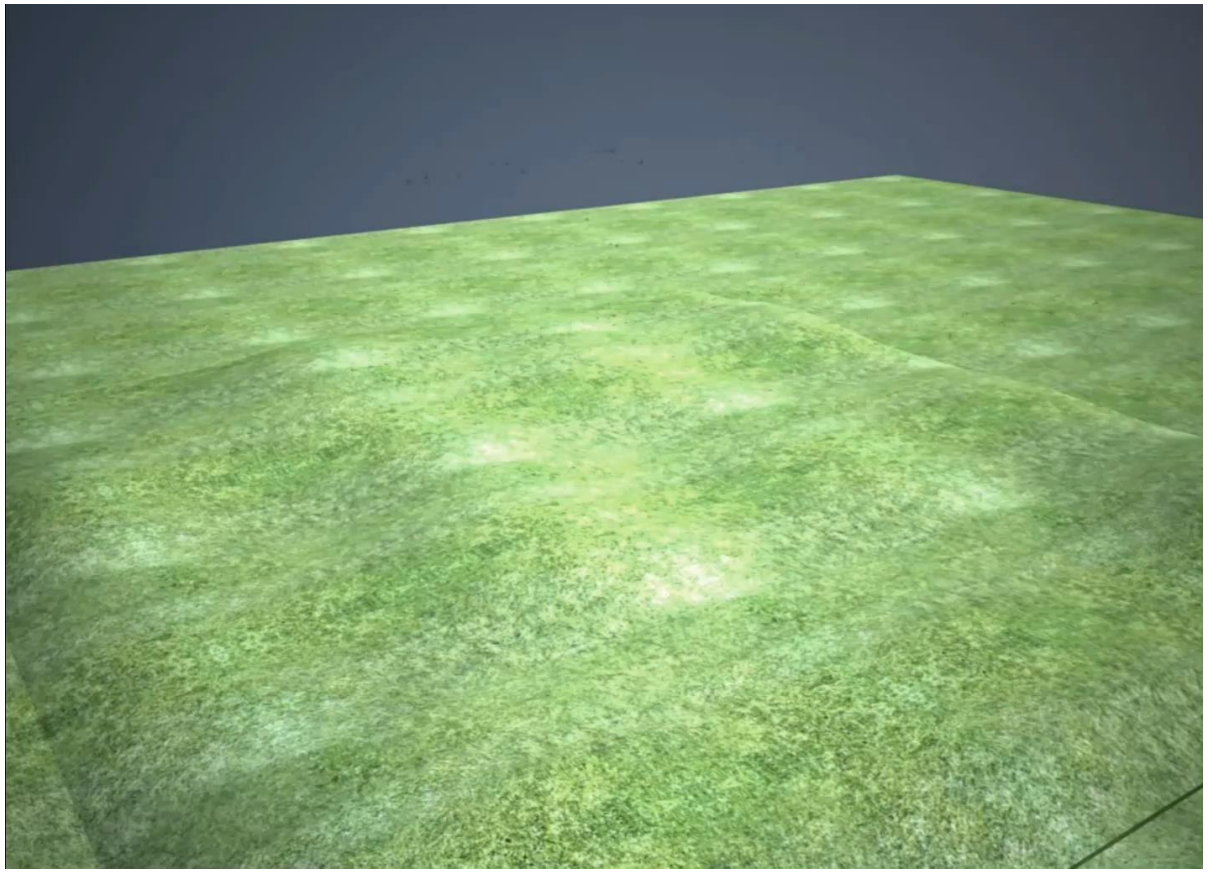


Ref.: 1981 Architectural Graphics Standards



Ref.: NRCA Detail WP-24

Building Structure - Definitions



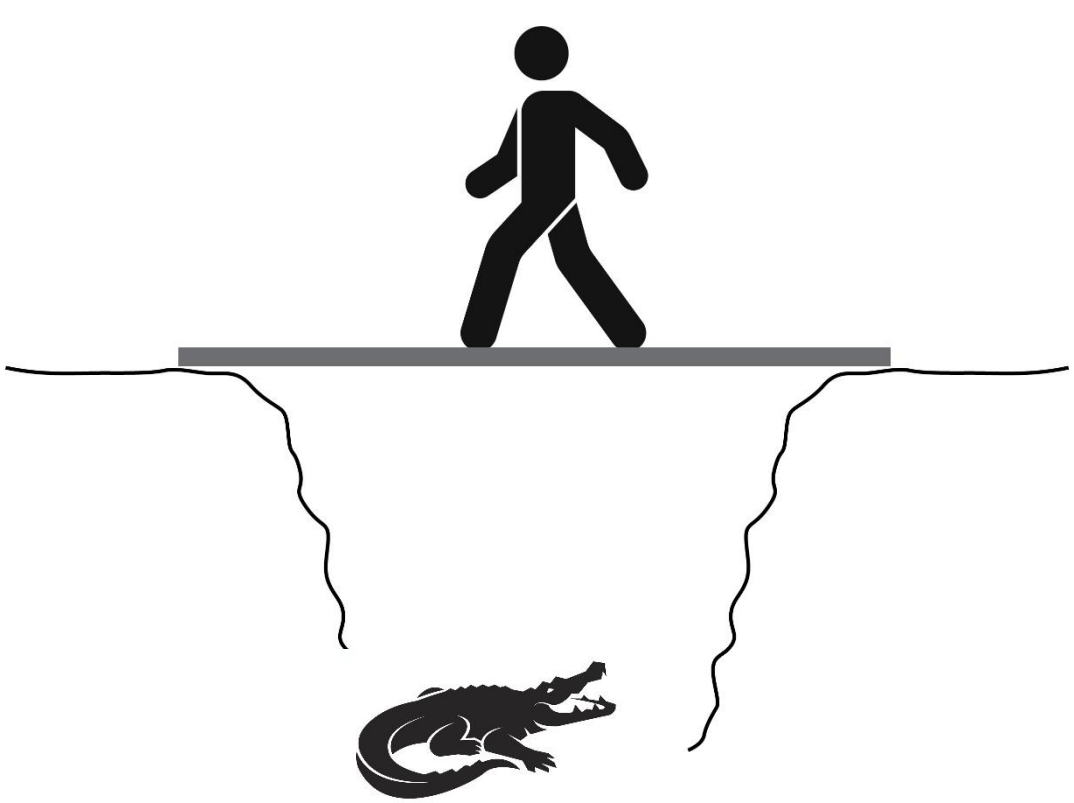
Credit: James Burke

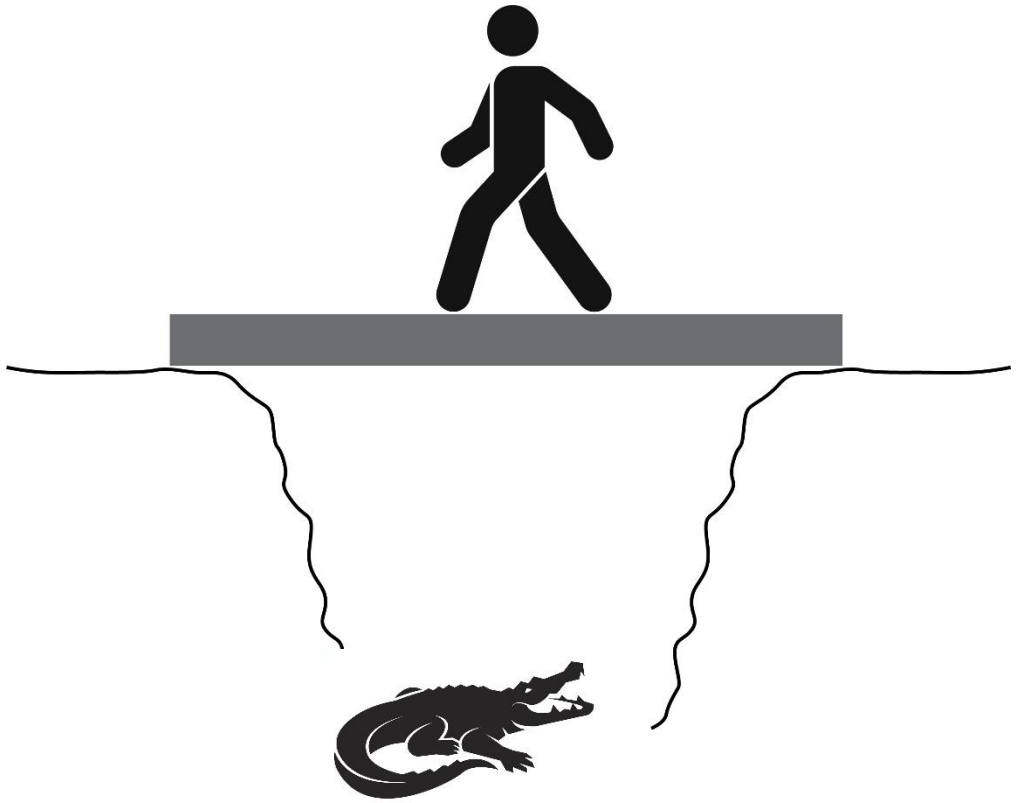
- **Foundations**
- **Columns**
- **Beams**
- **Slabs**

Building Structure - Columns

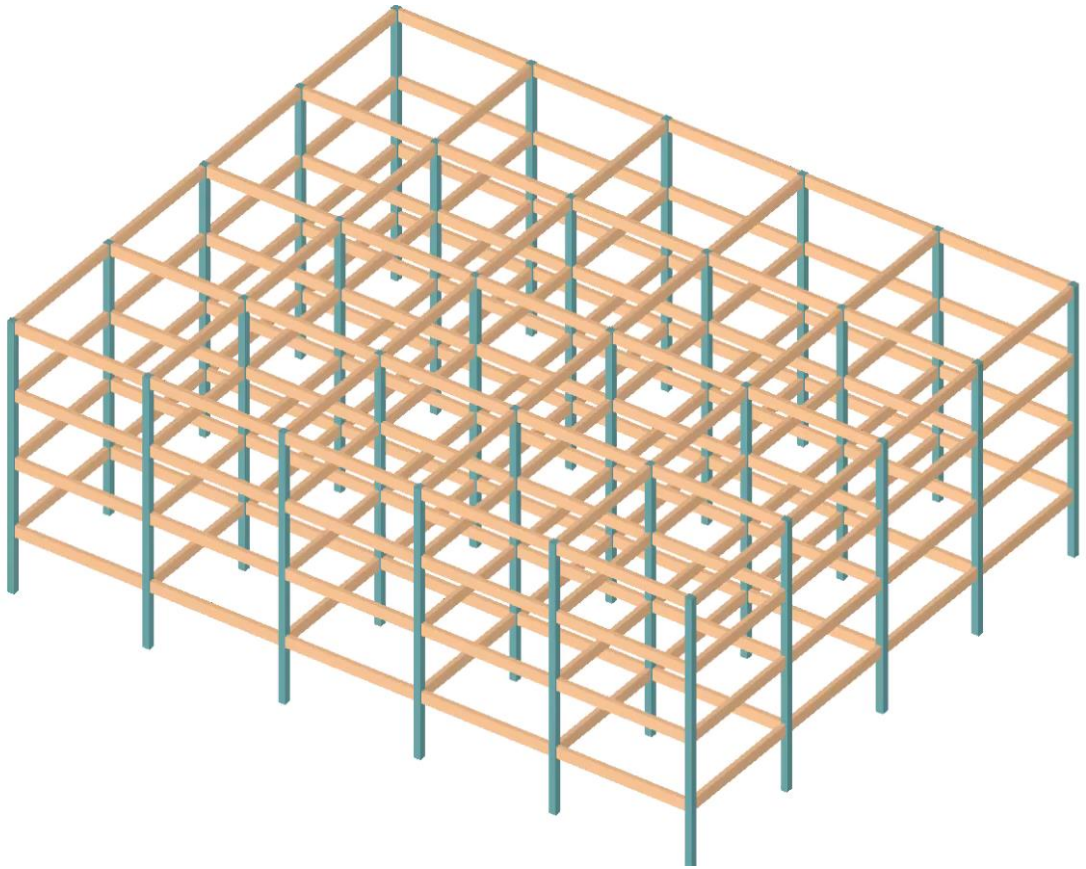
- **Failure Modes**
  - Stress
    - Pure Compression
    - Combined Stresses
    - Shear
    - Lack of Confinement
    - Torsion
  - Buckling

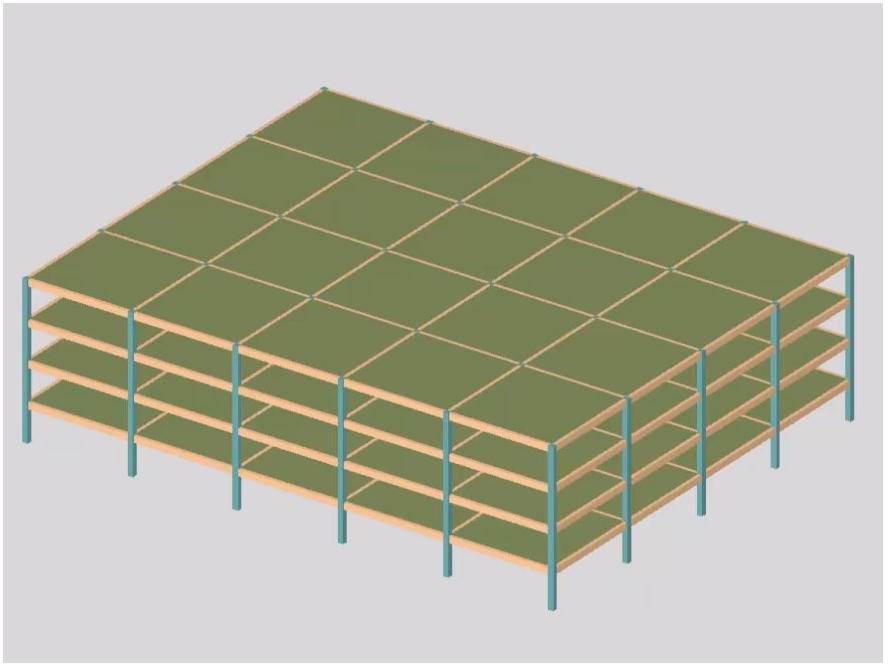
Building Structure – Beams and Slabs





Building Structure – Progressive Collapse

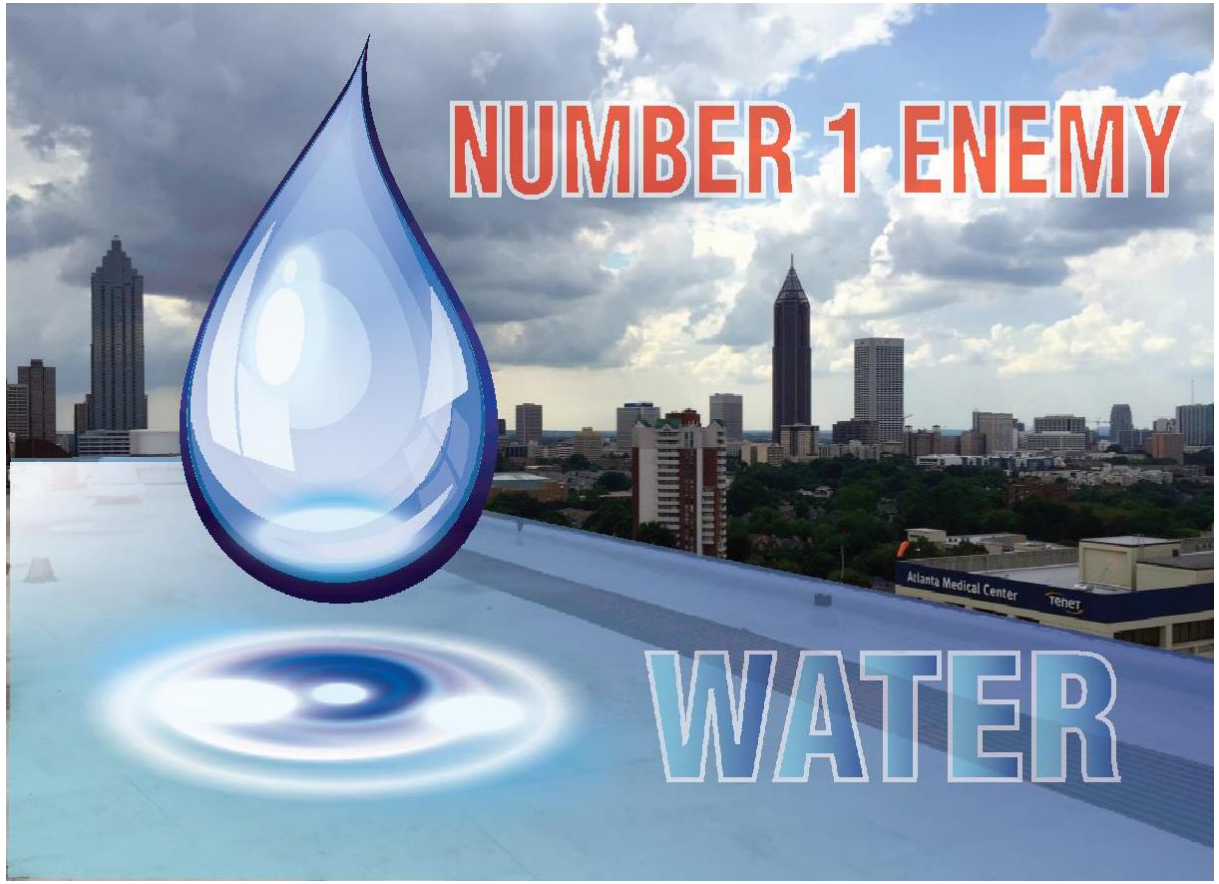




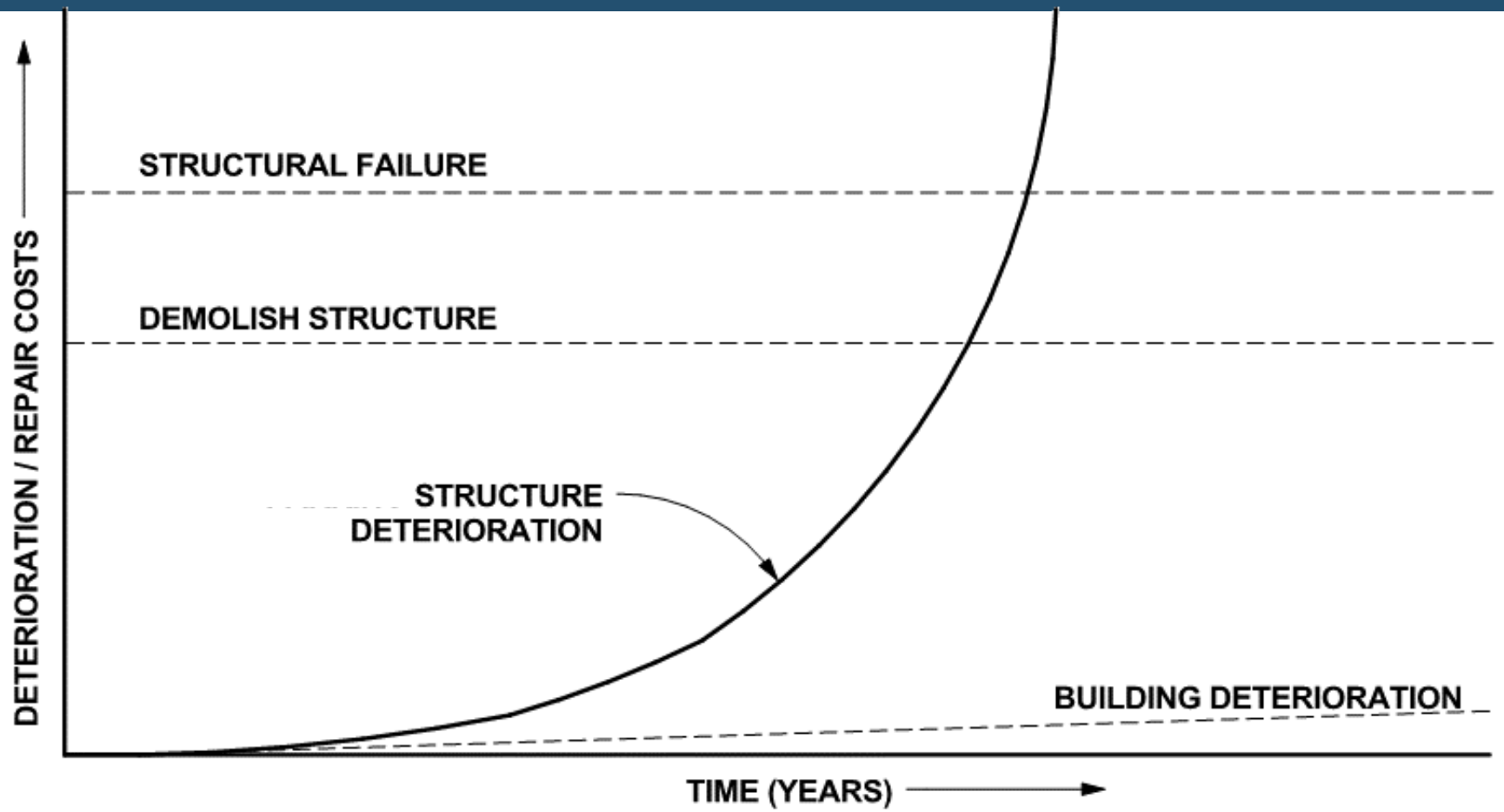
ASI Extreme Loading

Building Science – Sources of Deterioration

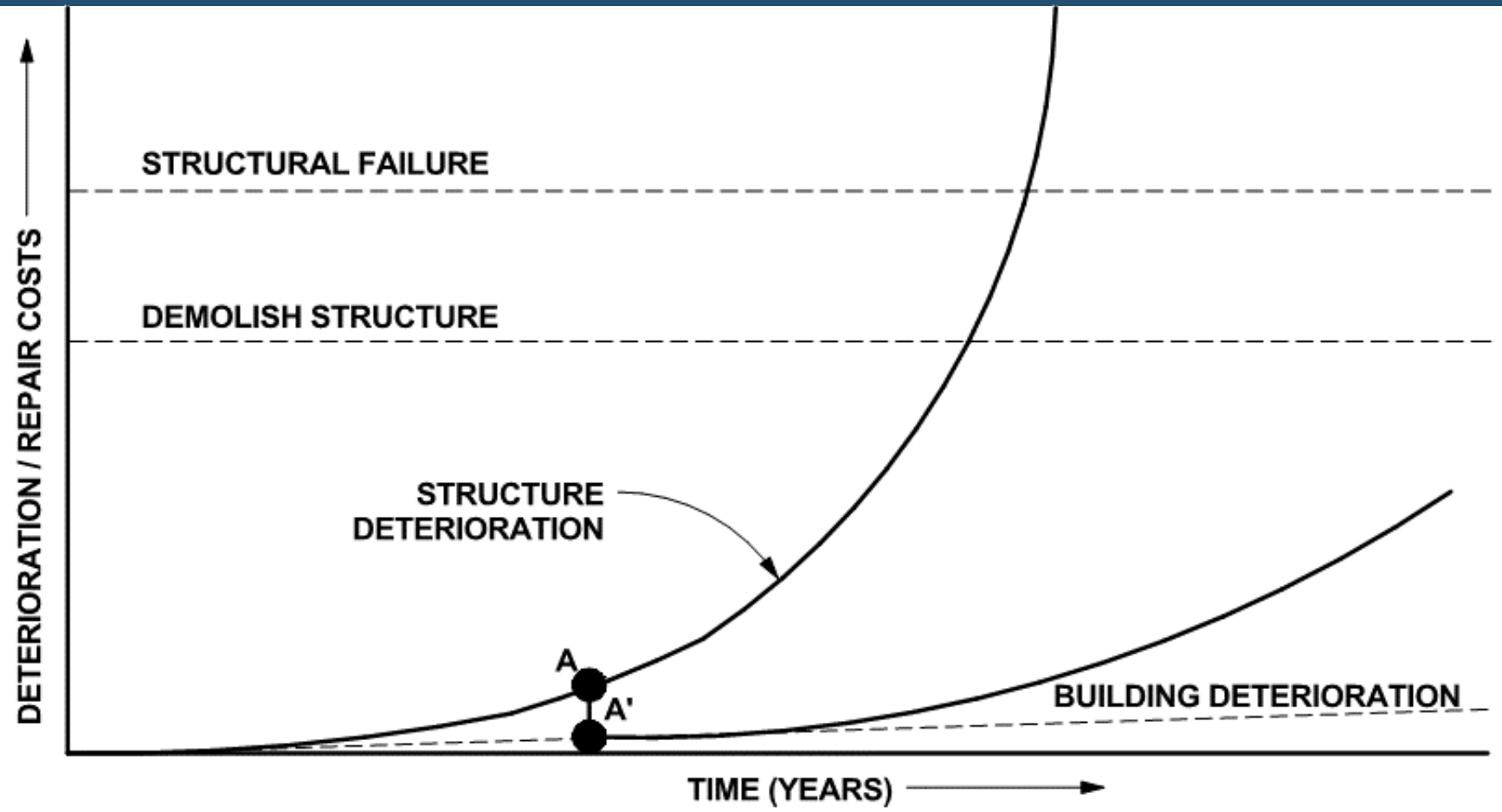
- Water Damage
  - Mold
  - Corrosion
  - Rot
  - Termites & Insects
- Movement of Materials
  - Thermal
  - Moisture
  - Elastic Deformation
  - Creep
- Other
  - Impact Damage
  - Lightning Strike
  - Overload
  - Wind, Earthquake, Flood



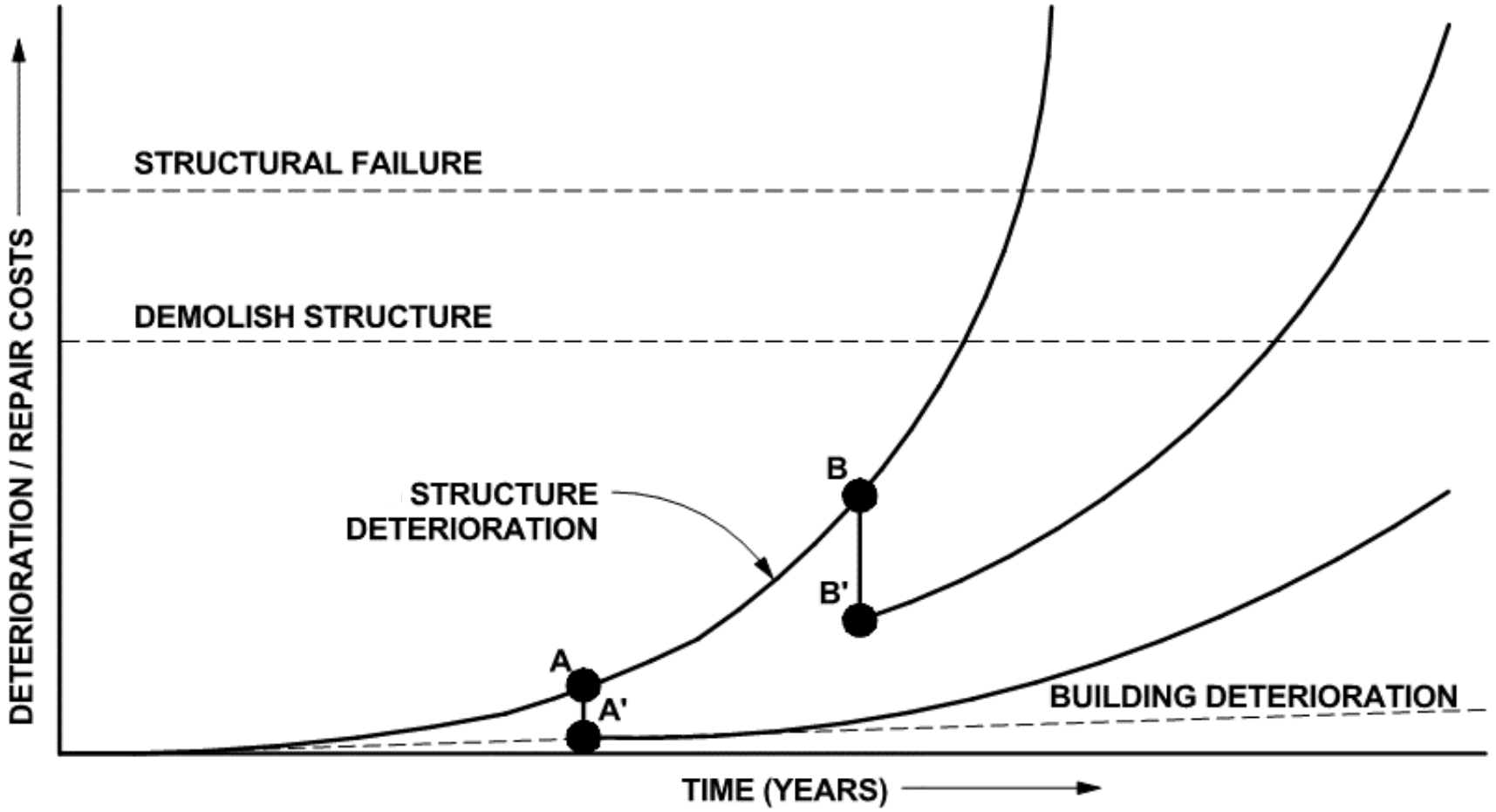
Deferred Maintenance Cost Curve



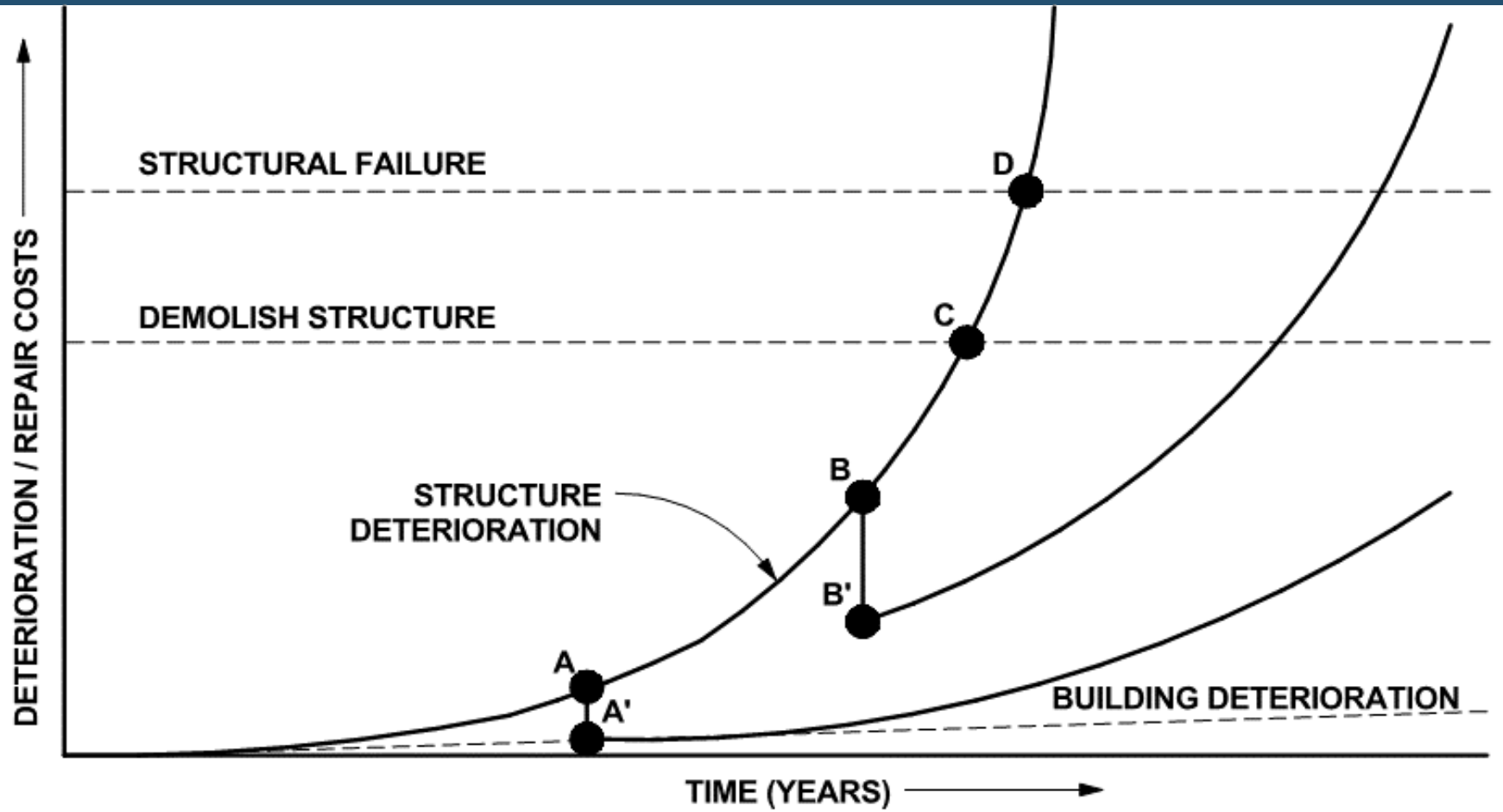
Deferred Maintenance Cost Curve



Deferred Maintenance Cost Curve

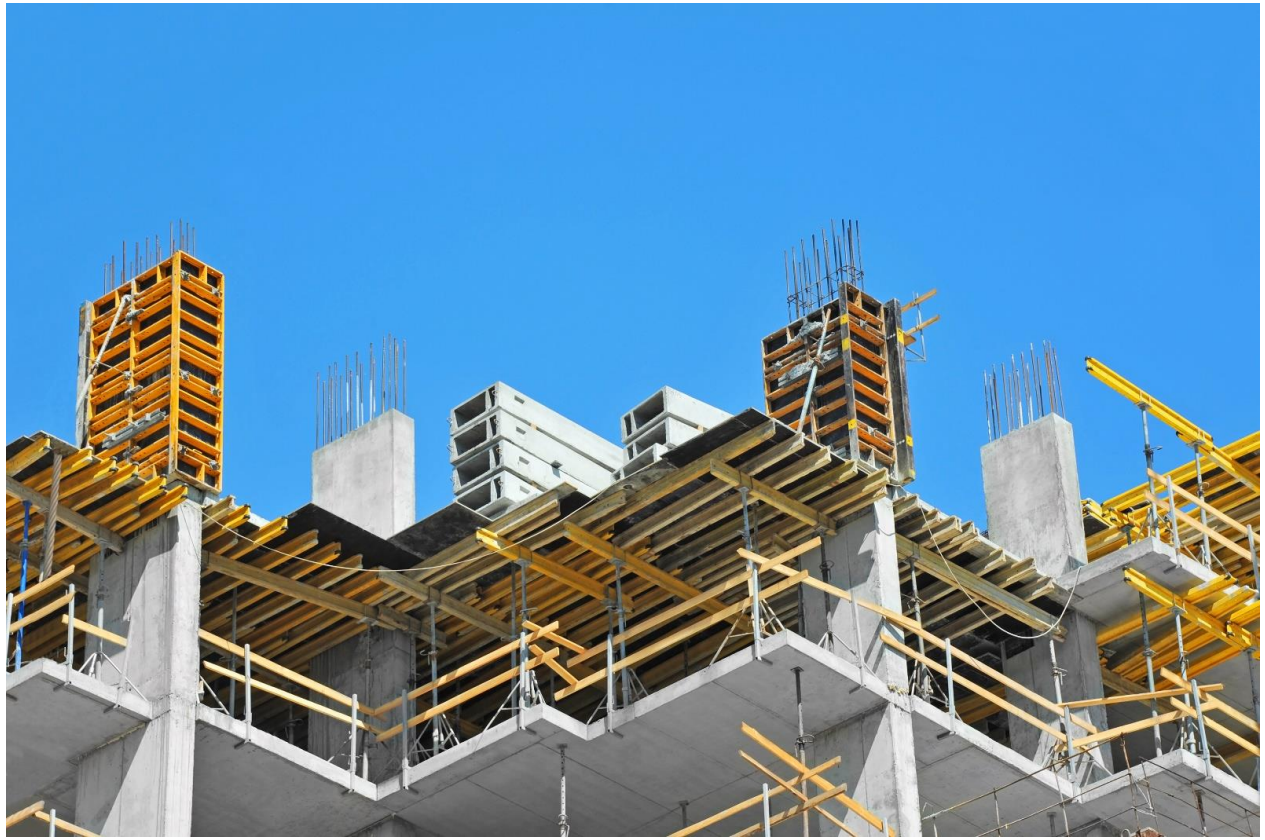


Deferred Maintenance Cost Curve



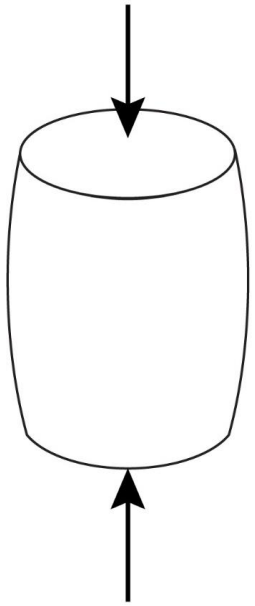
Reinforced Concrete

- Moisture
  - Corrosion
  - Freeze-Thaw
  - Sub-Efflorescence
- Cracking



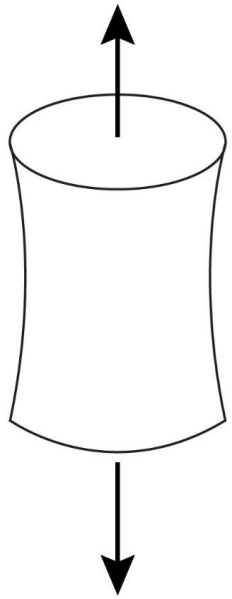
Reinforced Concrete - Strength

Compression



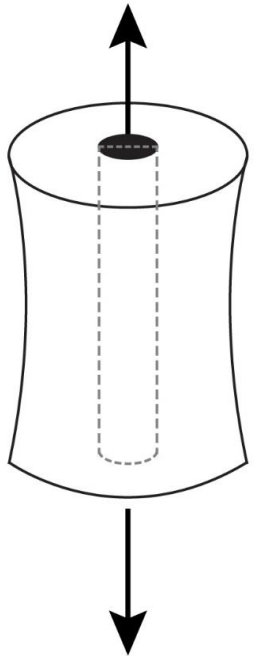
10 % of Compression

Tension

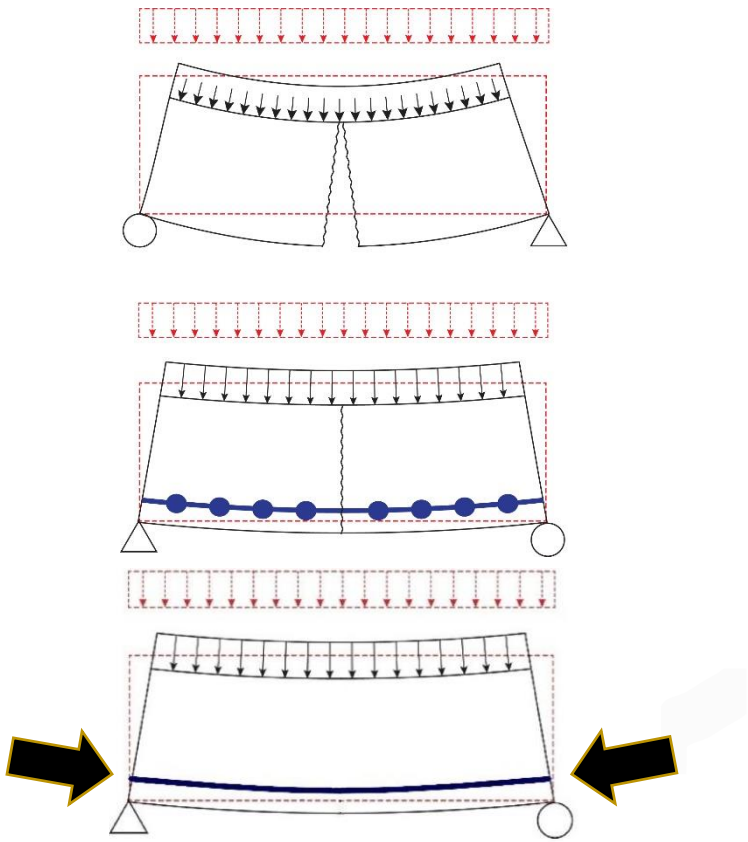


Add Reinforcing

Tension



Reinforced Concrete – Simple Span Beam

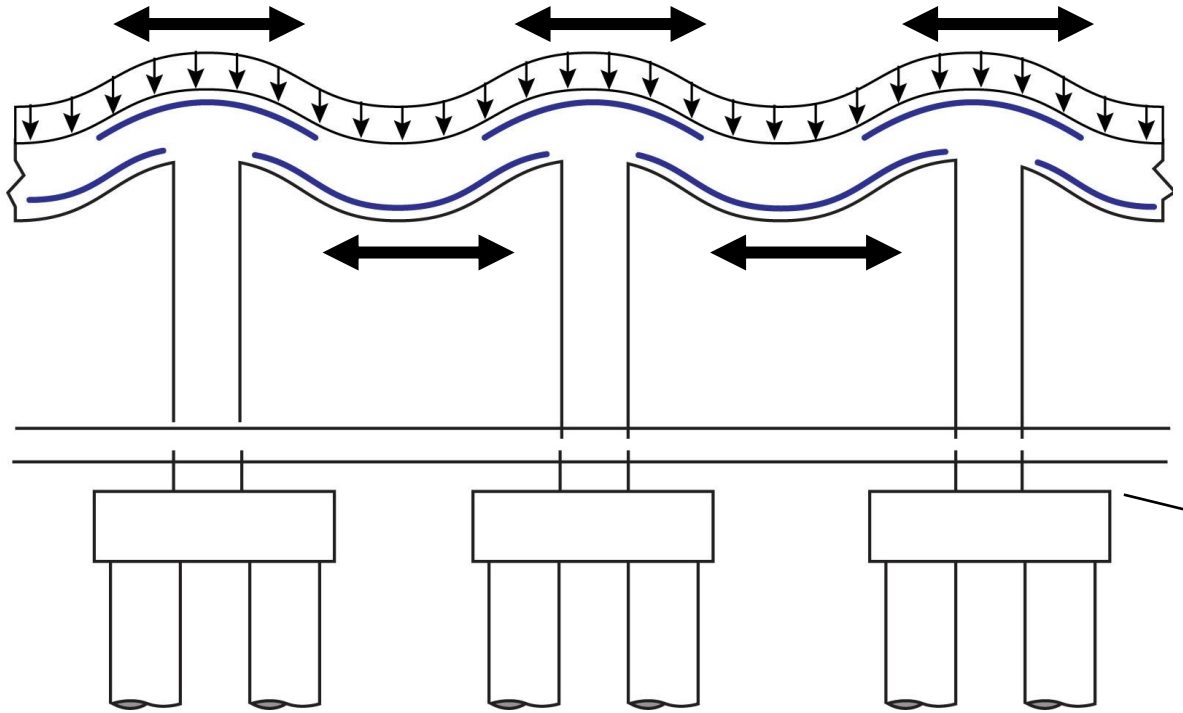


Plain Concrete

Reinforced Concrete

Prestressed Concrete

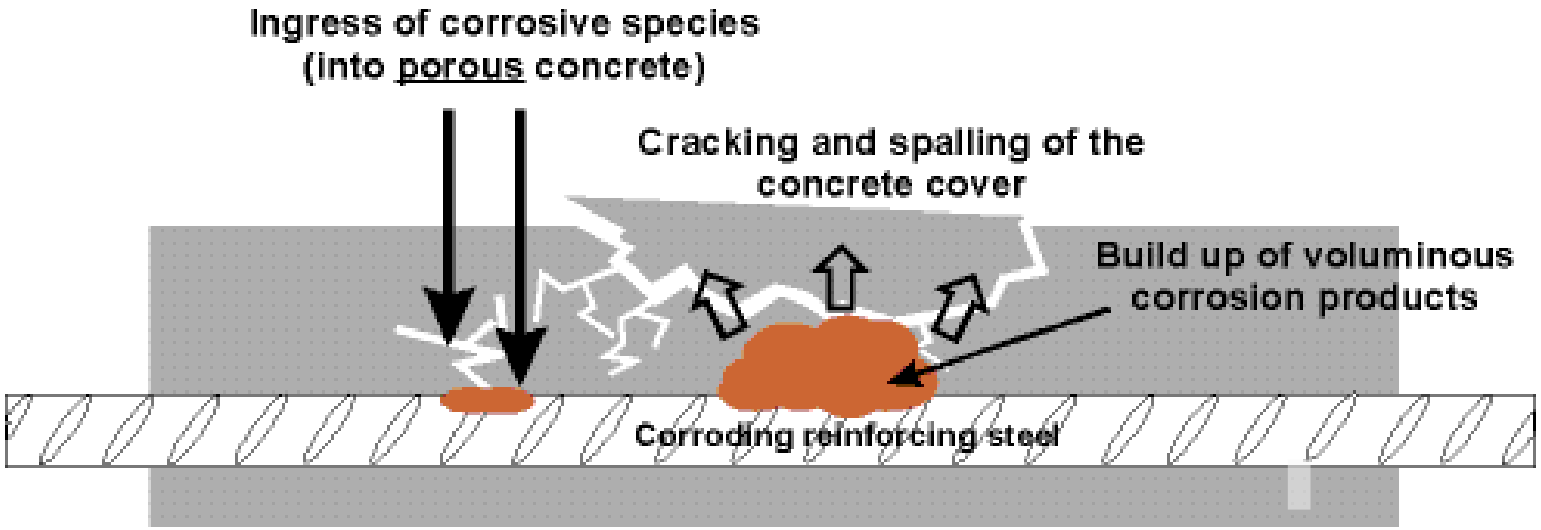
Reinforced Concrete – Multi-Span Beam/Slab

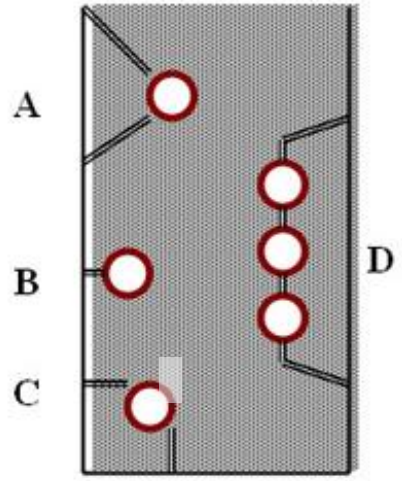


- Tension
  - Top over Columns
  - Bottom between Columns

Foundation

Reinforced Concrete - Corrosion





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

Reinforced Concrete - Spall & Delamination

Spall

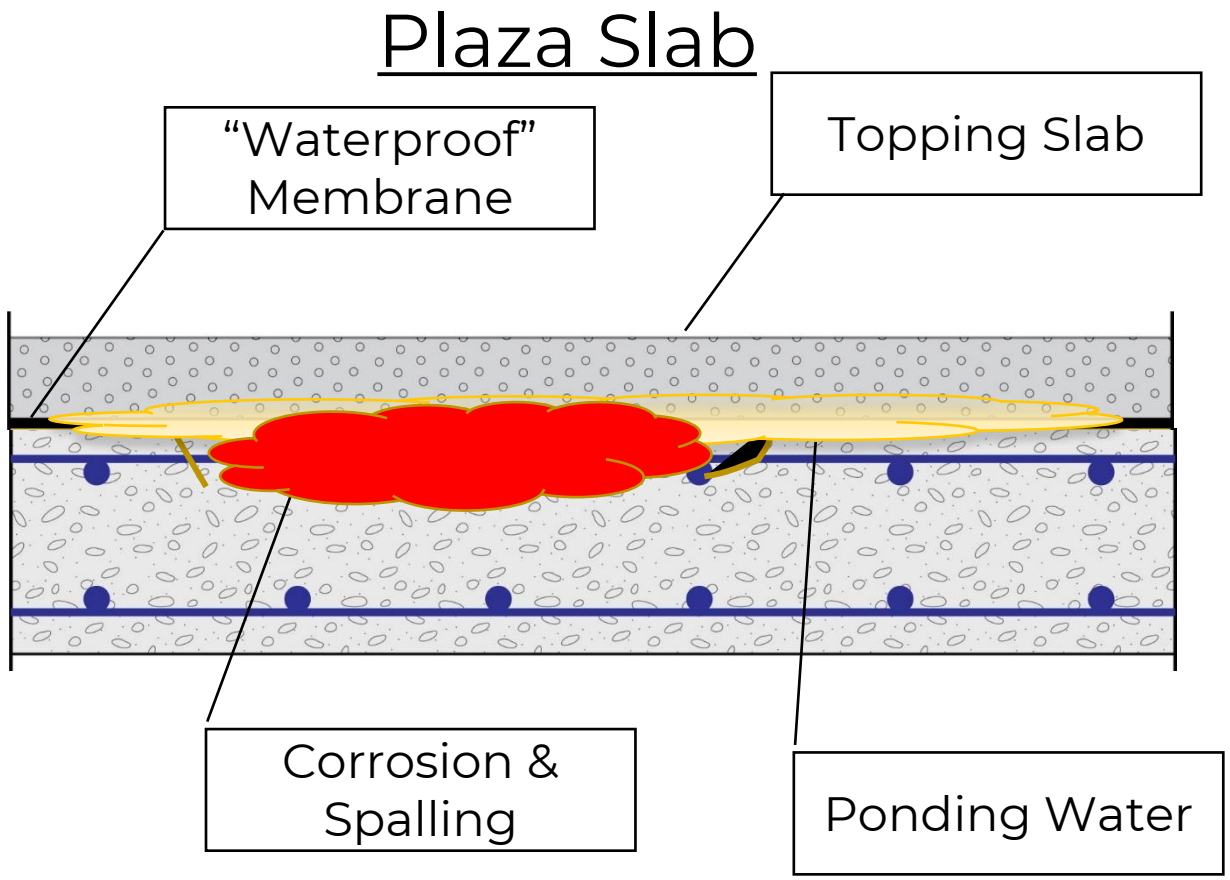
Delamination

Section Loss

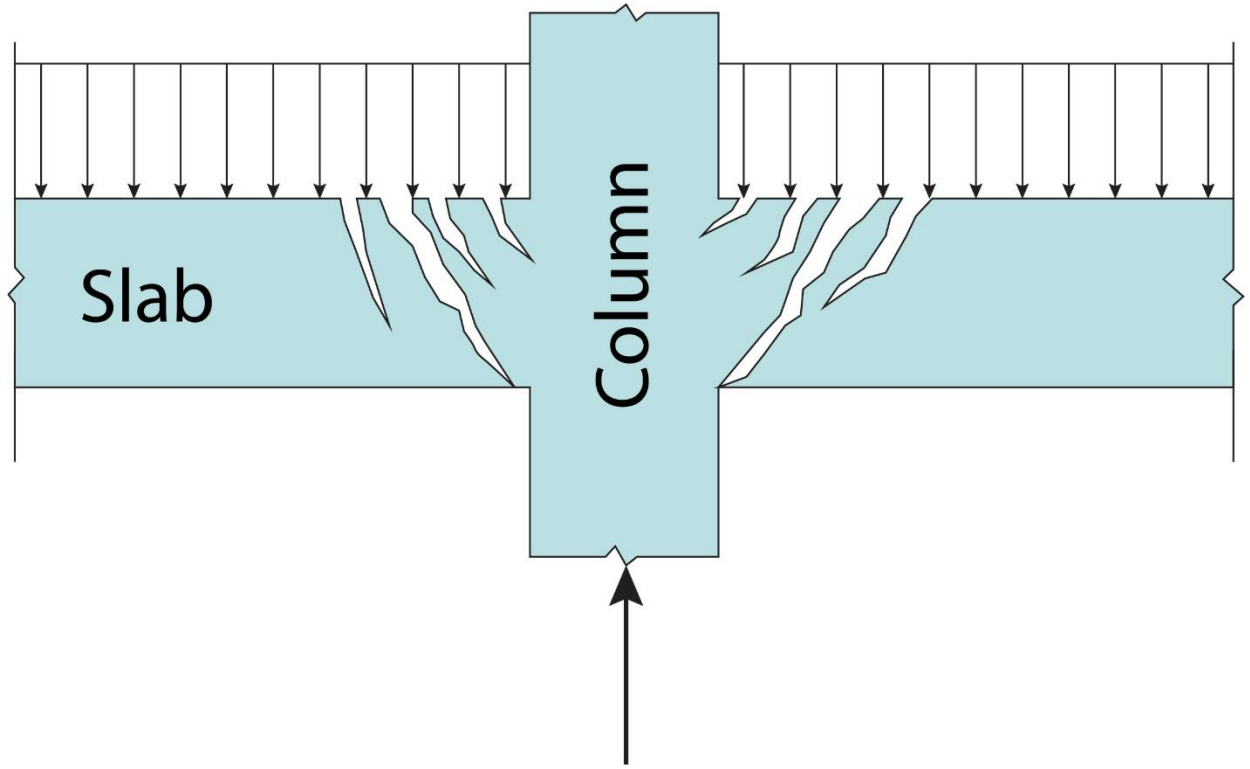
Reinforced Concrete - Sounding

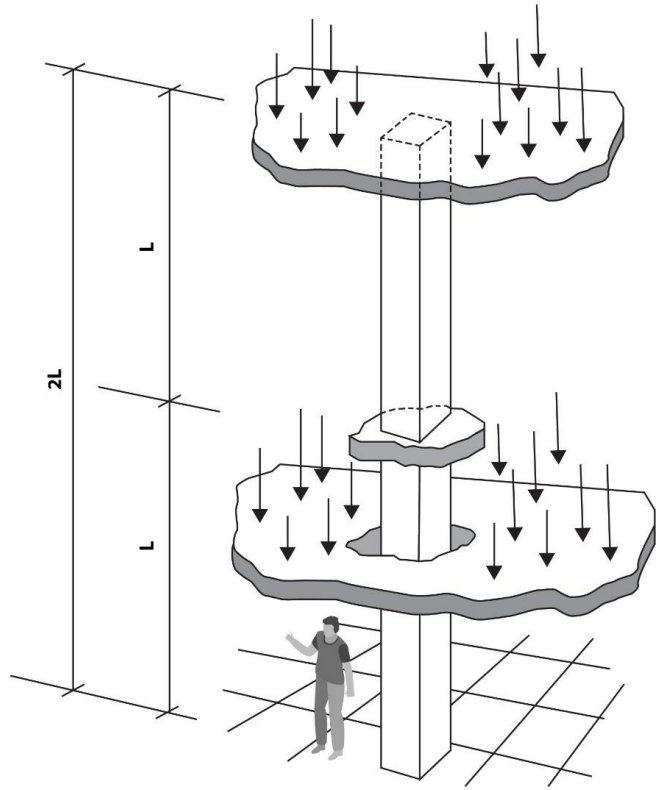
Sounding Technology Inc.

Reinforced Concrete – Impulse Echo

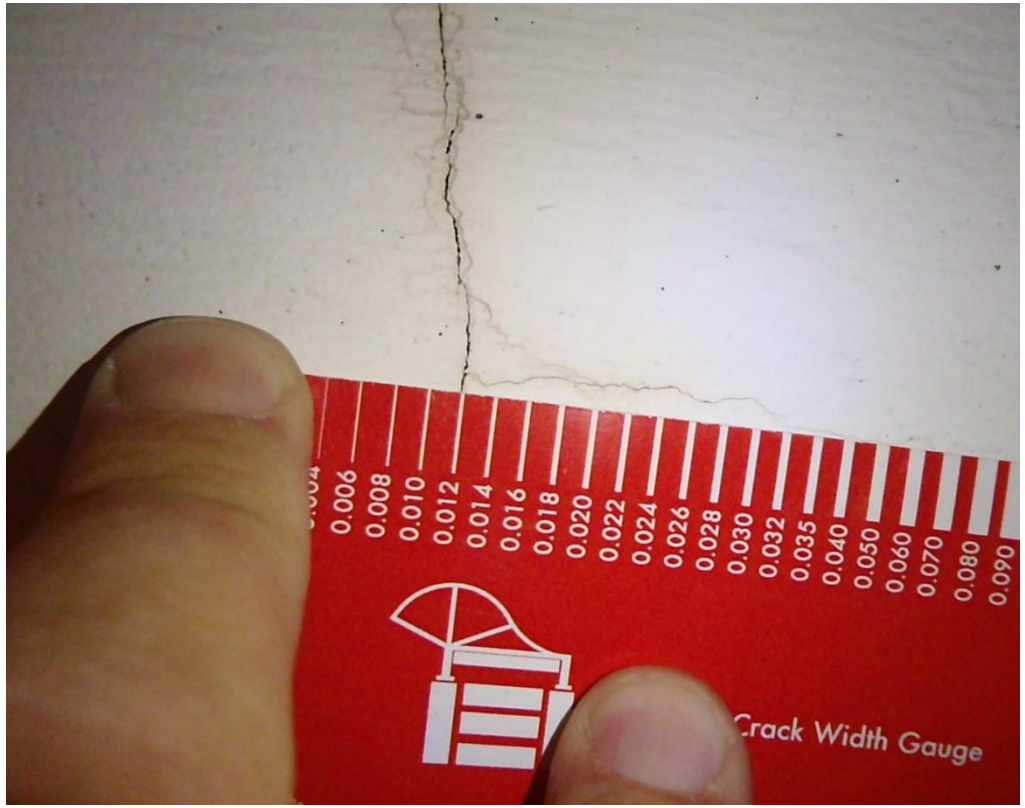


Champlain Towers Collapse – Punching Shear





Reinforced Concrete - Cracks



.013” ≤ Cracks < .035”

Cracks that Leak < .035”

Reinforced Concrete – Crack Repair (Route & Seal)

Crack Chasing

Crack Sealant

Reinforced Concrete – Crack Repair (Epoxy Injection)

Cracks ≥ .035”

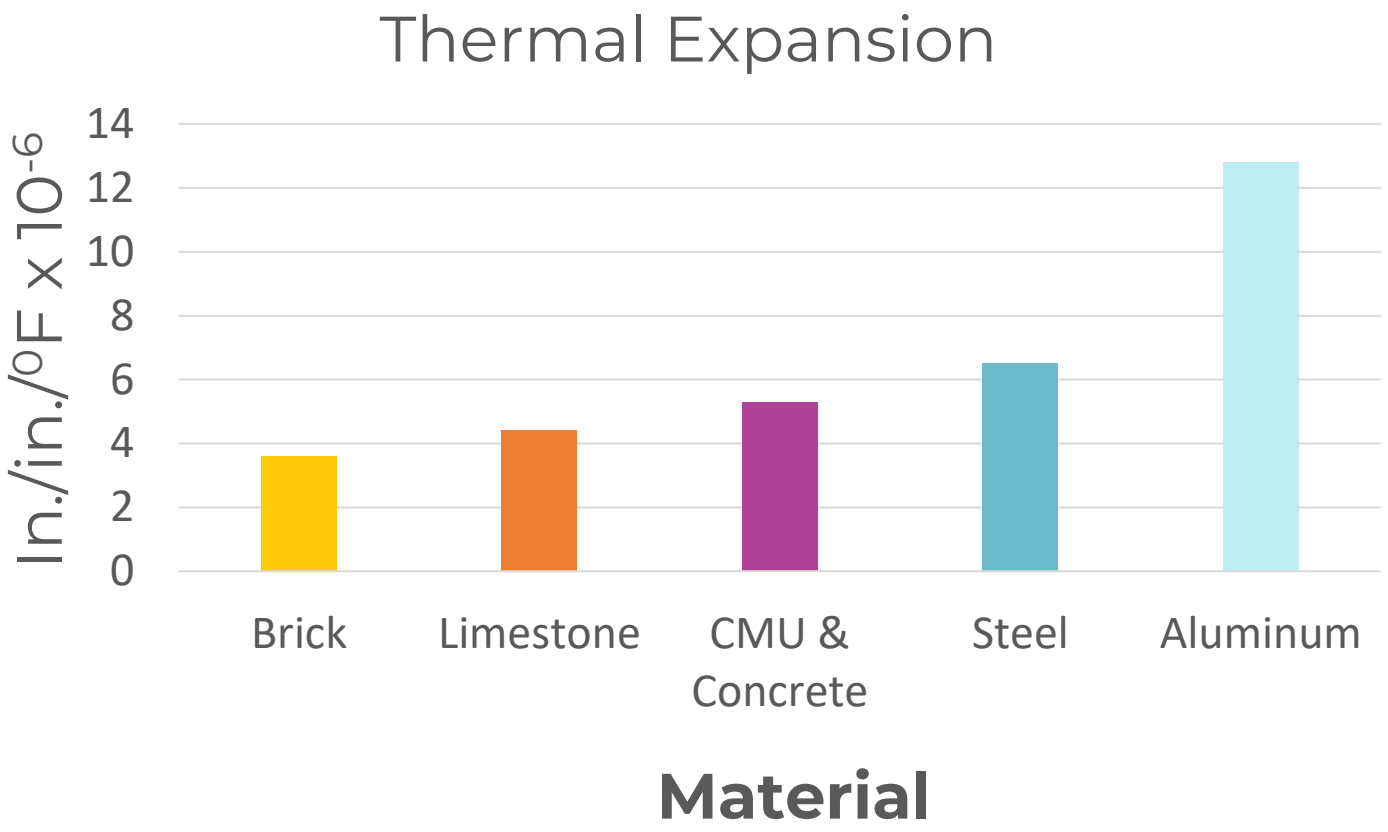
Inflatable Injection Port

Photos by Engineered Restorations Inc.

Masonry

- Thermal Expansion/Contraction
- Moisture
  - Expansion/Contraction
  - Corrosion
  - Freeze-Thaw
  - Subefflorescence
- Cracking

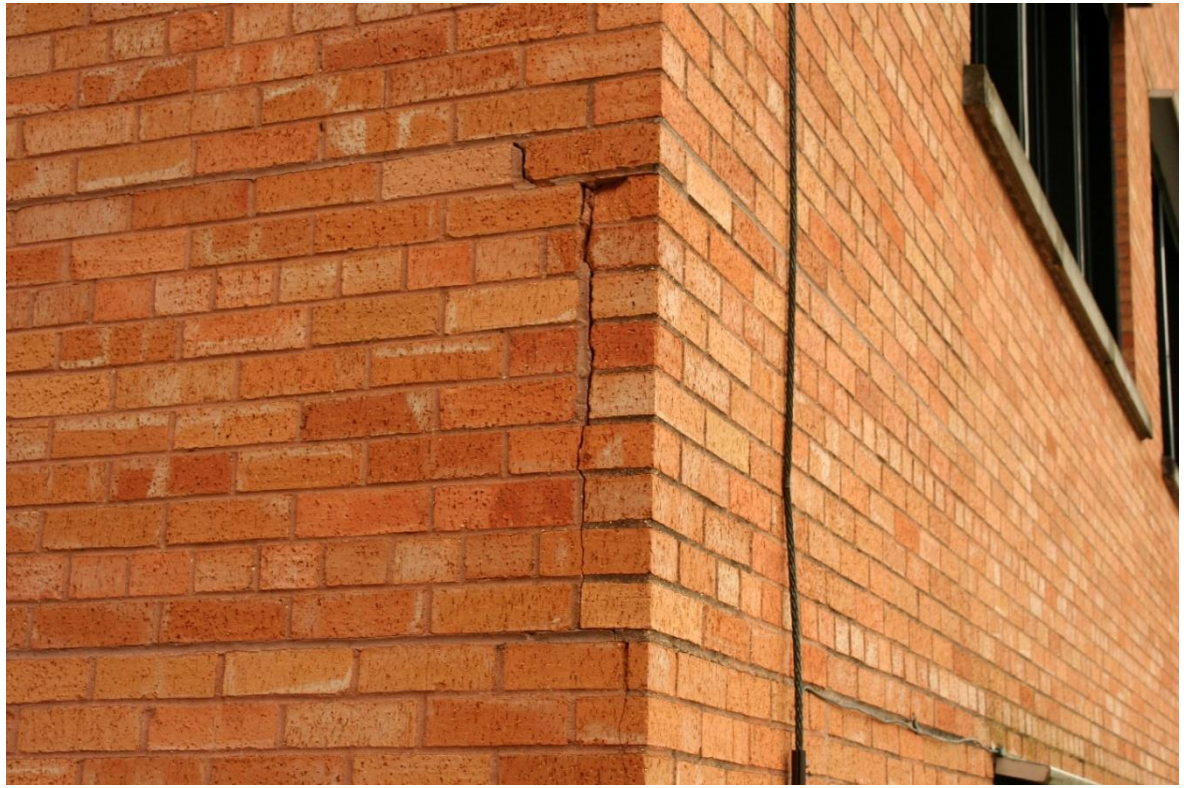
Facade - Thermal Expansion



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

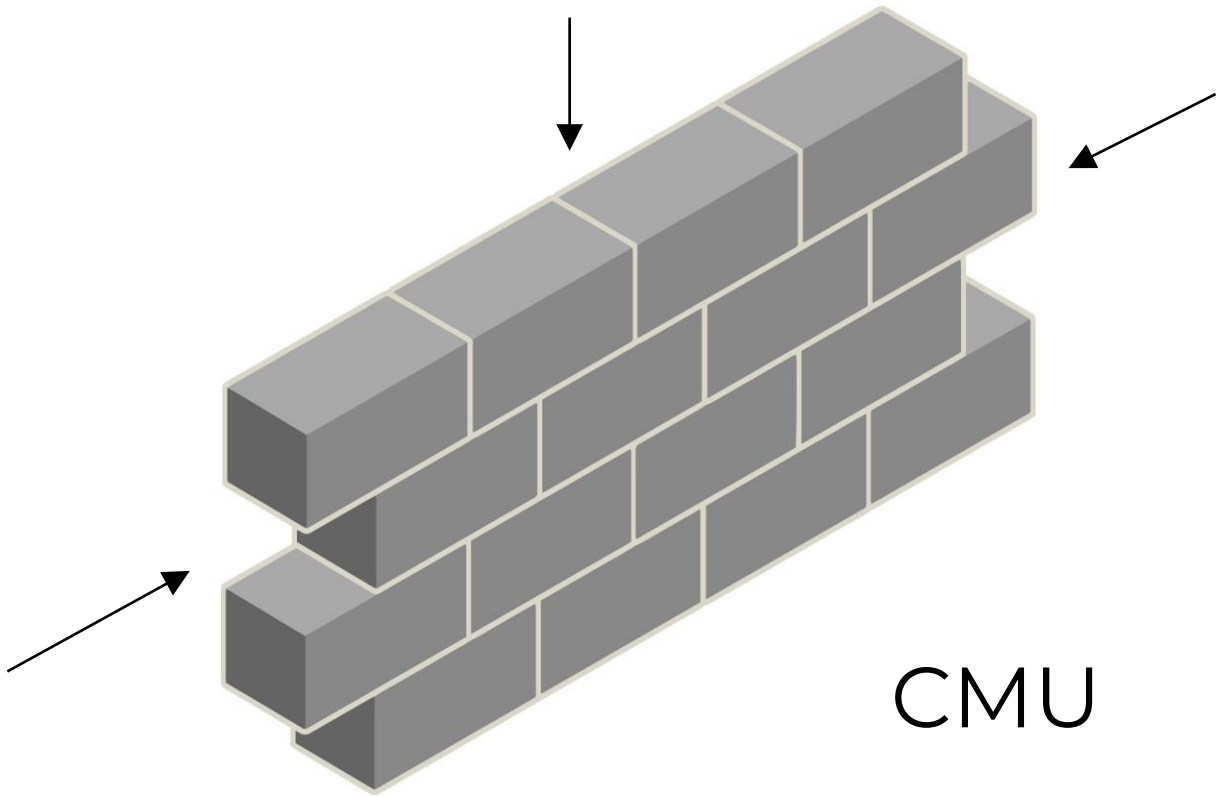
Façade – Thermal Expansion

No Expansion Joints

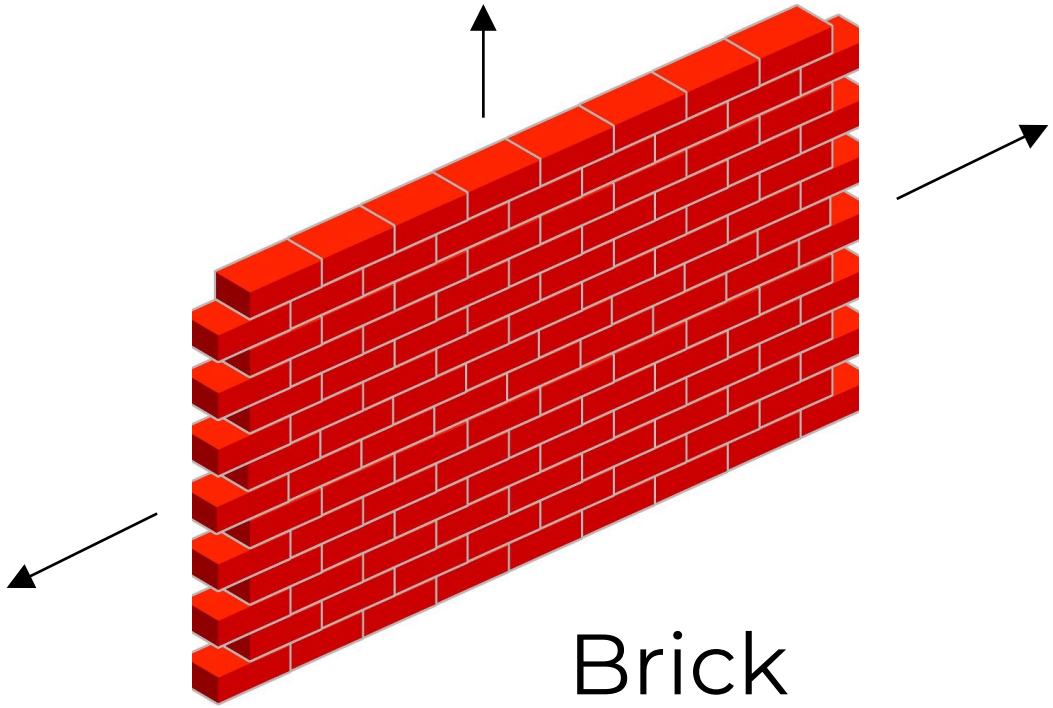


Creates Hinge at Corner

Facade - Moisture Expansion/Shrinkage

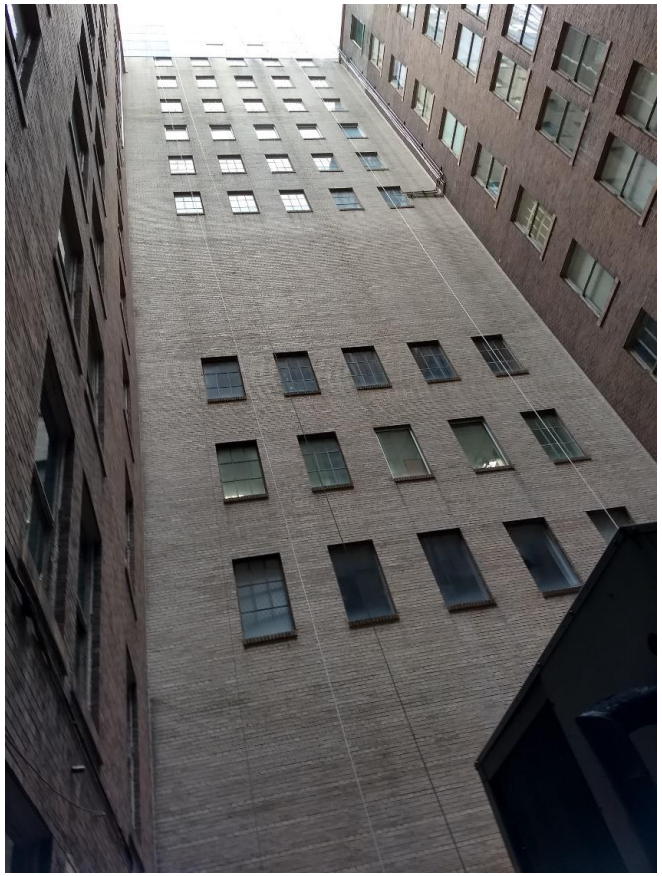


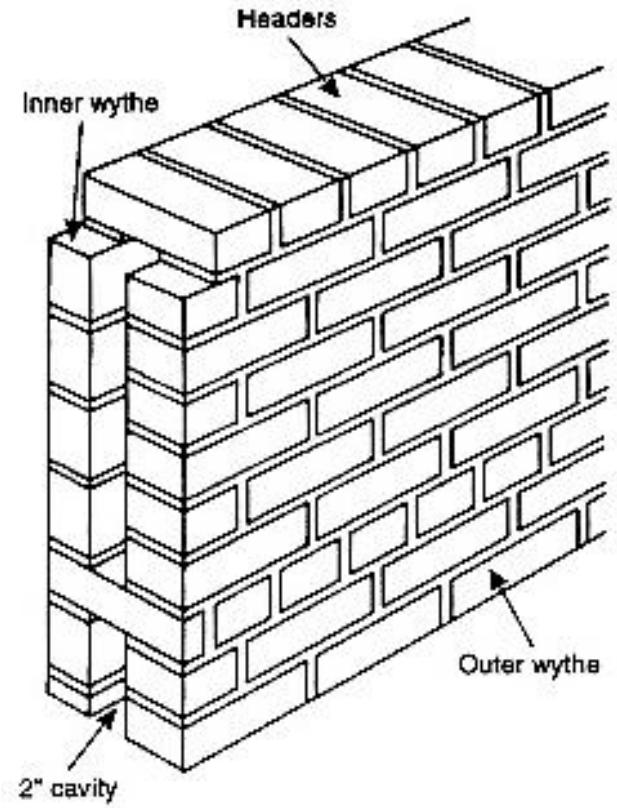
CMU



Brick

Façade – Moisture/Thermal Expansion/Contraction



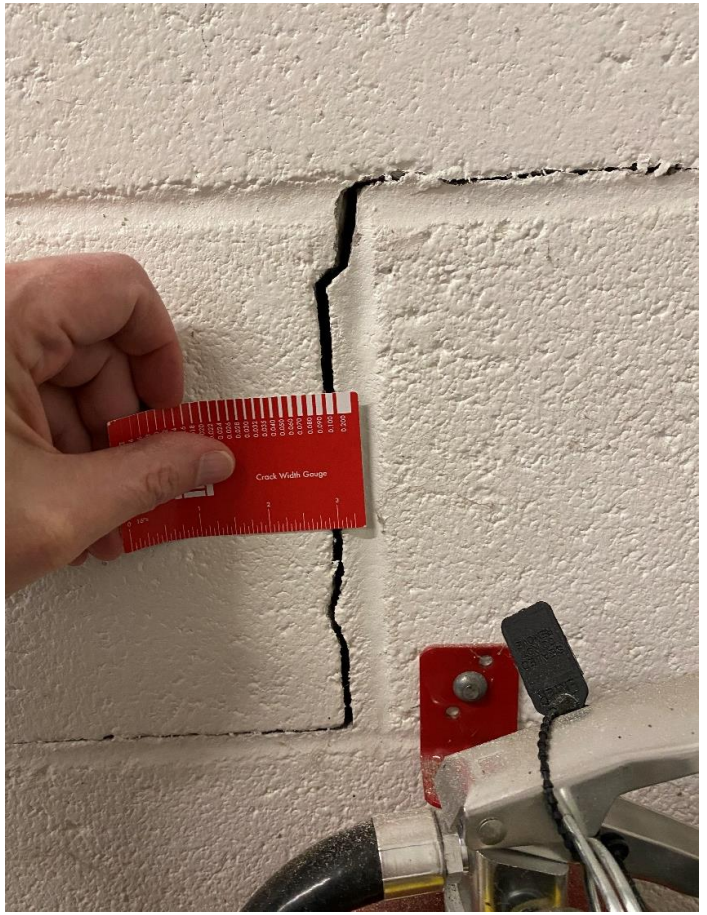


Façade – Moisture & Thermal Expansion/Contraction

Façade – Corrosion Expansion

Façade – Moisture Damage

Masonry – Creep & Settlement



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

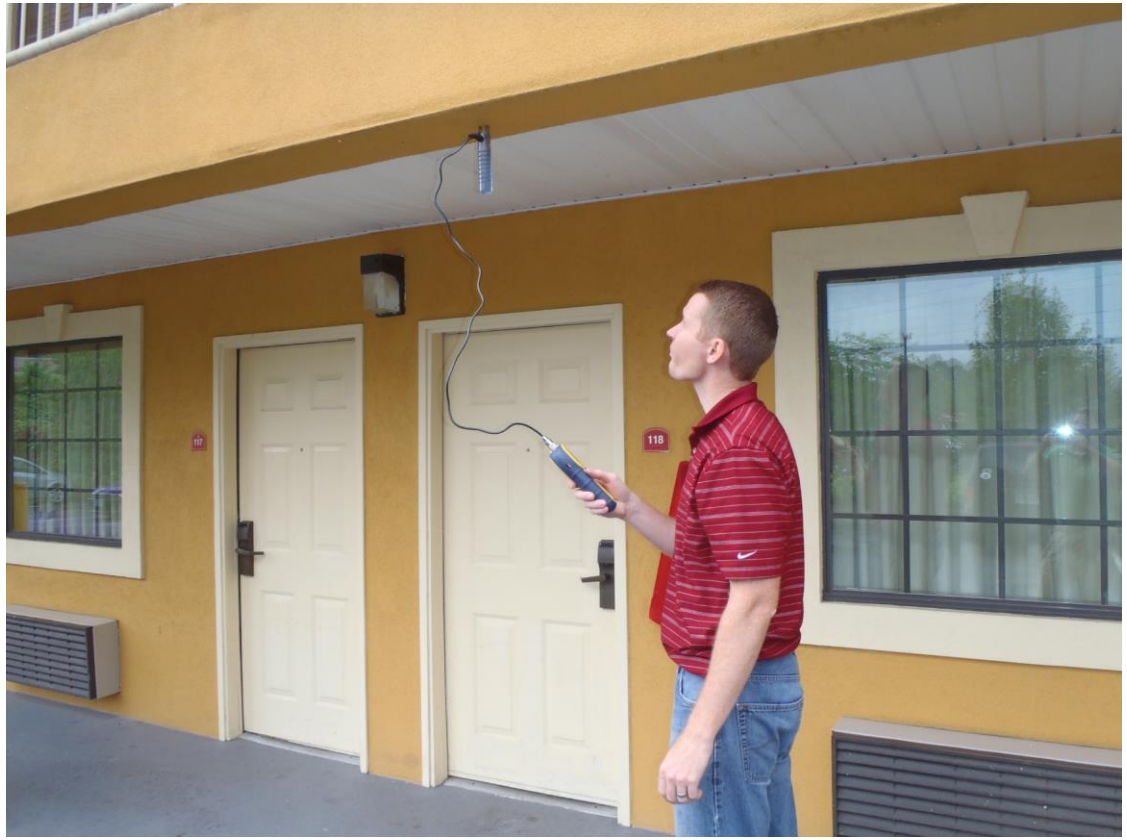
Steel Framing - Fatigue

Steel Framing – Altered or Damaged Members

Wood Framing - Deterioration

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

Wood Framing – Moisture Meter



Moisture Content > 30% = Serious Decay

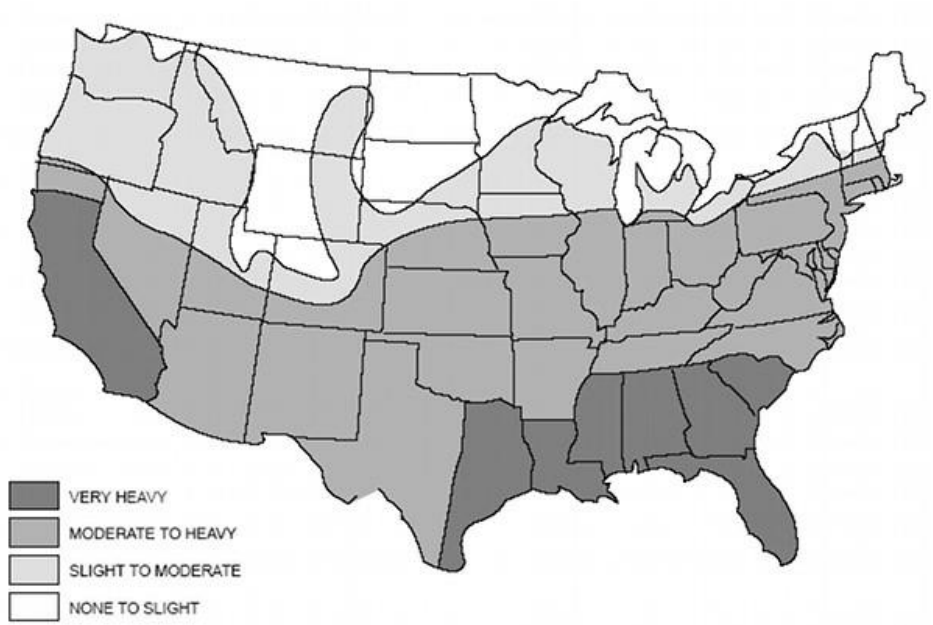
Wood Framing – Termite Infestation

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 – Modified Members

Image: Russ LaBlanc

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)

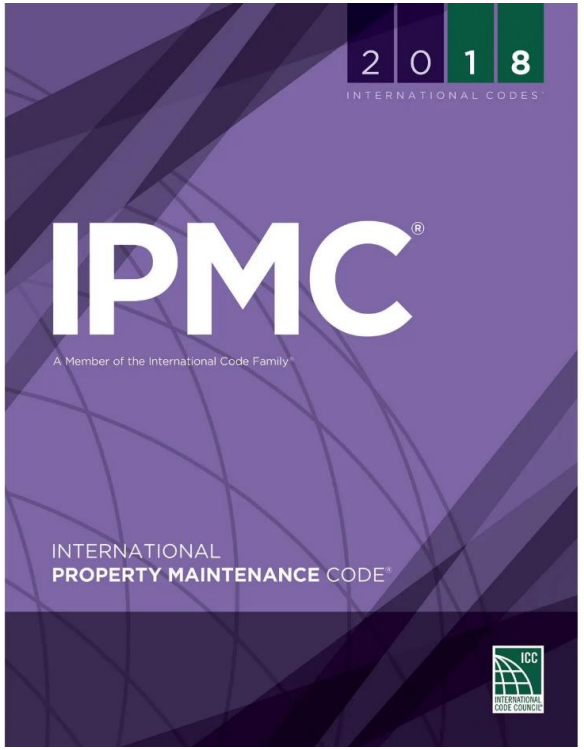
SECTION 304
EXTERIOR STRUCTURE

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.

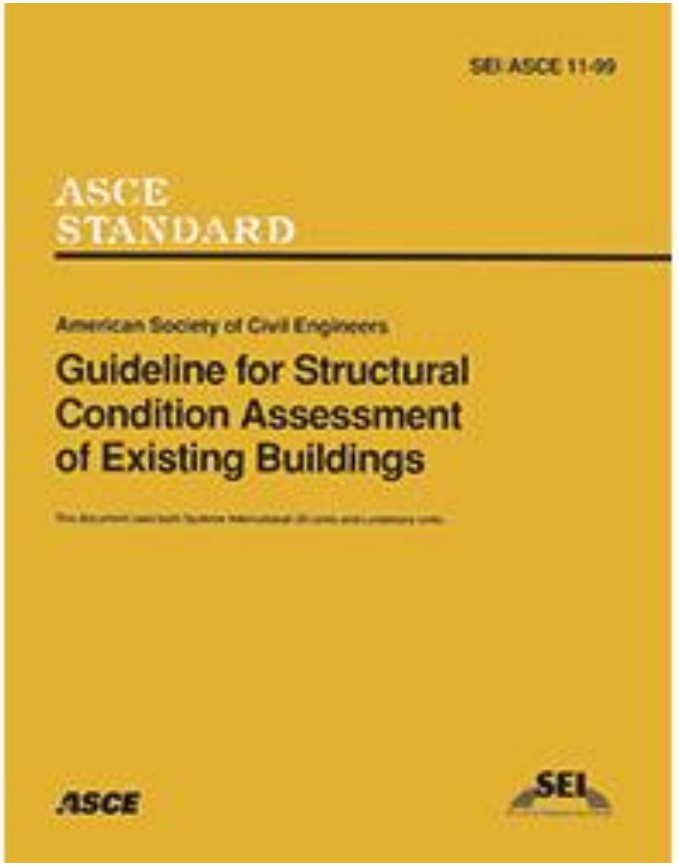
SECTION 305
INTERIOR STRUCTURE

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!

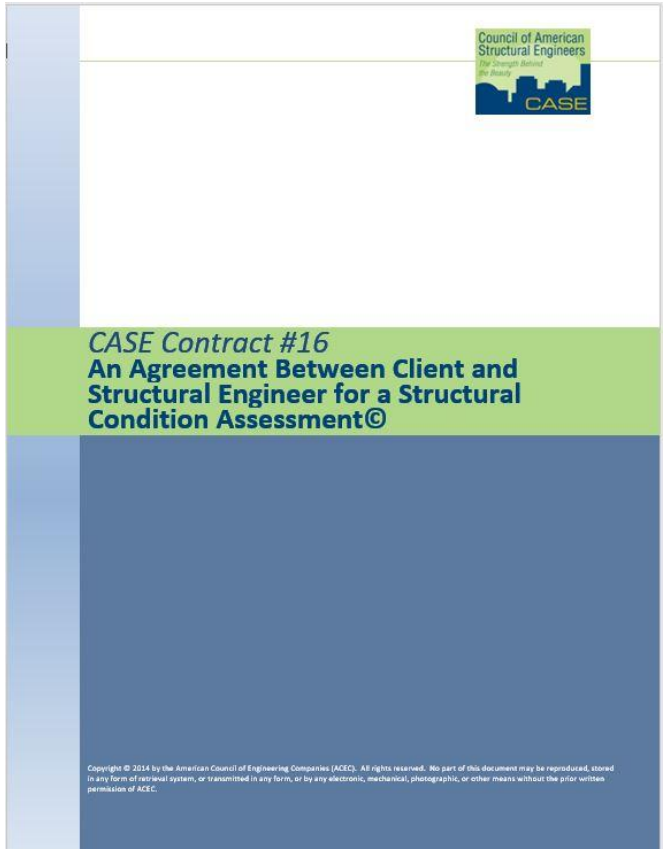


ASCE Standard SEI/ASCE 11-99



- **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**

Suggested Frequency of Inspection

- **Roof, Plaza & Below Grade Waterproofing**
  - Biannual
    - Fall Before Winter
    - Spring After Winter
    - After Storm
    - After Work on Roof
- **Façade & Structural Systems**
  - Self Inspection: Annual
  - Professional Inspection: Every 5 Years
- **Other Systems**
  - Annual Organized Self Inspection

Life Expectancy – Dependent on Install & Exposure

- **Building – 50 Years**
- **Roofing**
  - Metal – 25 Years
  - BUR & SBS Mod-Bit – 17 Years
  - APP Mod-Bit, EPDM, PVC – 14 Years
  - TPO – 13 Years
  - Polyurethane Foam – 12 Years
- **Sealants – 10 to 20 Years**
  - Silicone
  - Polyurethane
- **Traffic Bearing Membrane:**
  - **5 to 20 years**
- **Below Grade Waterproofing:**
  - **50 Years (Modern)**
- **Protected Waterproof Membrane:**
  - **50 Years (Modern)**

Learning Objectives

- **Building Structure Inspection**
  - Champlain Towers Collapse
  - Structural Engineering 101
  - Failure Mechanisms
    - Concrete, Masonry, Steel, & Wood
  - Laws & Standards

Questions?

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