ARCON
FORENSIC ENGINEERS

ENGINEERING EXCELLENCE 60 SINCE 1965

Building Envelope Failures

Investigating & Diagnosing Water-Related Damage Claims

July 2025

Overview

- The Building Envelope
  - What is it?
  - What is its purpose?
  - What is it comprised of?
- Typical Construction Sequence
- Sources & Examples of Failure

ARCON
FORENSIC ENGINEERS

The Building Envelope

In simple terms it is…

- That part of any building, above or below grade, that physically separates the outside (exterior) environment from the inside (interior) environment
- The key functions of the building envelope are to:
  - Prevent water penetration and enable;
    - Air Quality Control,
    - Temperature Control &
    - Vapour Control

ARCON
FORENSIC ENGINEERS

Components

The building envelope is comprised of the following physical components:

- Foundation System (below grade environment)
- Exterior Wall System (above grade environment)
- Doors & Windows (fenestrations)
- Roof System

ARCON
FORENSIC ENGINEERS

Construction Overview

The Typical Construction Sequence of a Residential Home

- Footing & Foundation Wall (Below grade)
- Exterior Wall & Floor Framing (Above grade)
- Roof Framing & Coverings
- Exterior Wall Finishes
- Site Grading

The age of the building provides context for the construction methods & materials

ARCON
FORENSIC ENGINEERS

Foundation System

In most of Ontario, foundations are constructed of poured concrete and comprise the footing and basement wall.

A weeping tile system will be laid around the perimeter of the footing typically with a fabric ‘sock’ to keep debris out and covered in granular stone to facilitate the dispersal of water that may collect at the outside of the footing & wall surface.

ARCON
FORENSIC ENGINEERS

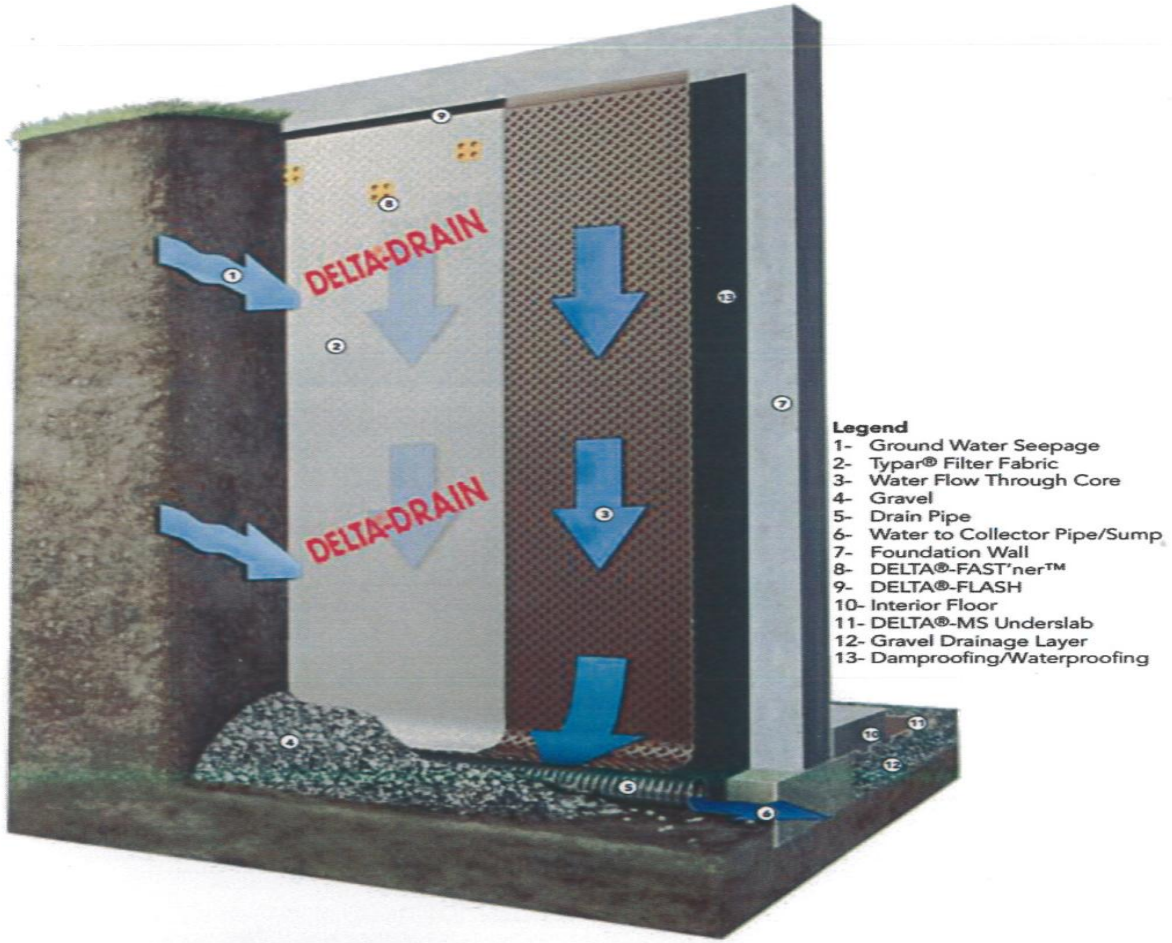
Foundation System

Waterproofing is applied to the exterior surface of the foundation to aid in repelling water.

ARCON
FORENSIC ENGINEERS

Foundation System

Foundation Drainage System



ARCON
FORENSIC ENGINEERS

Exterior Wall System

ARCON
FORENSIC ENGINEERS

Exterior Wall System

Exterior Wrap

- Covers Sheathing
- Tyvek or Similar
- All Joints Tape Sealed
- OBC Requirement

ARCON
FORENSIC ENGINEERS

Exterior Wall System

Exterior Cladding

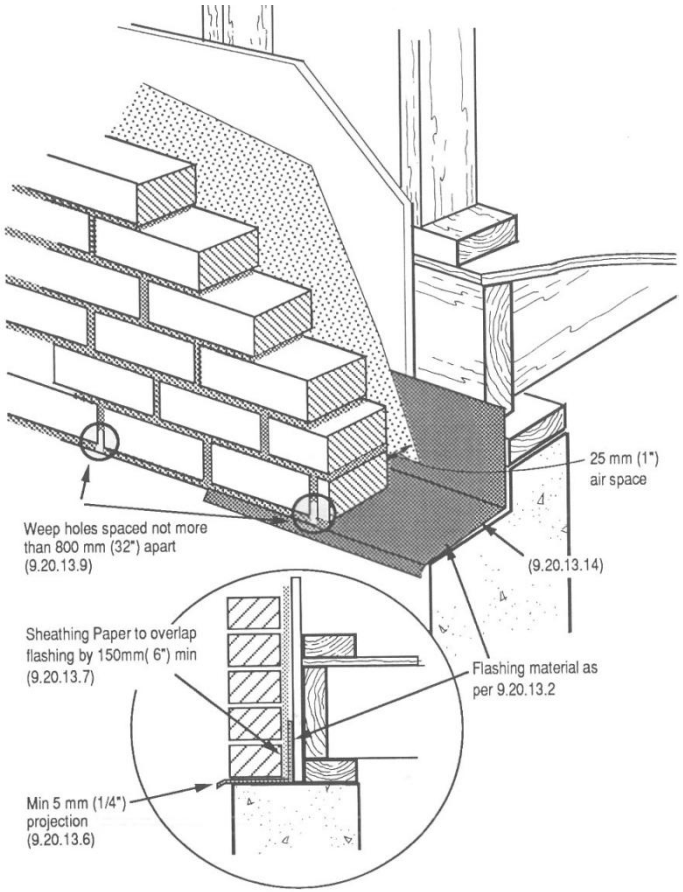
- Layer directly in contact with weather elements – first ‘line of defense’ against infiltration of weather
- Enables conditioning of the air inside the structure – temperature, humidity & purification

Types of Cladding

- Brick or Stone
- EIFS (Stucco Wall System)
- Siding (Cedar, Vinyl, Composites)

ARCON
FORENSIC ENGINEERS

Exterior Wall System



Typical Rain Screen Wall

Key Components:

- Drainage Cavity
- Weep Holes
- Flashing
- Clear Air Space

ARCON
FORENSIC ENGINEERS

Exterior Wall System

ARCON
FORENSIC ENGINEERS

Roofing System

Roof Framing

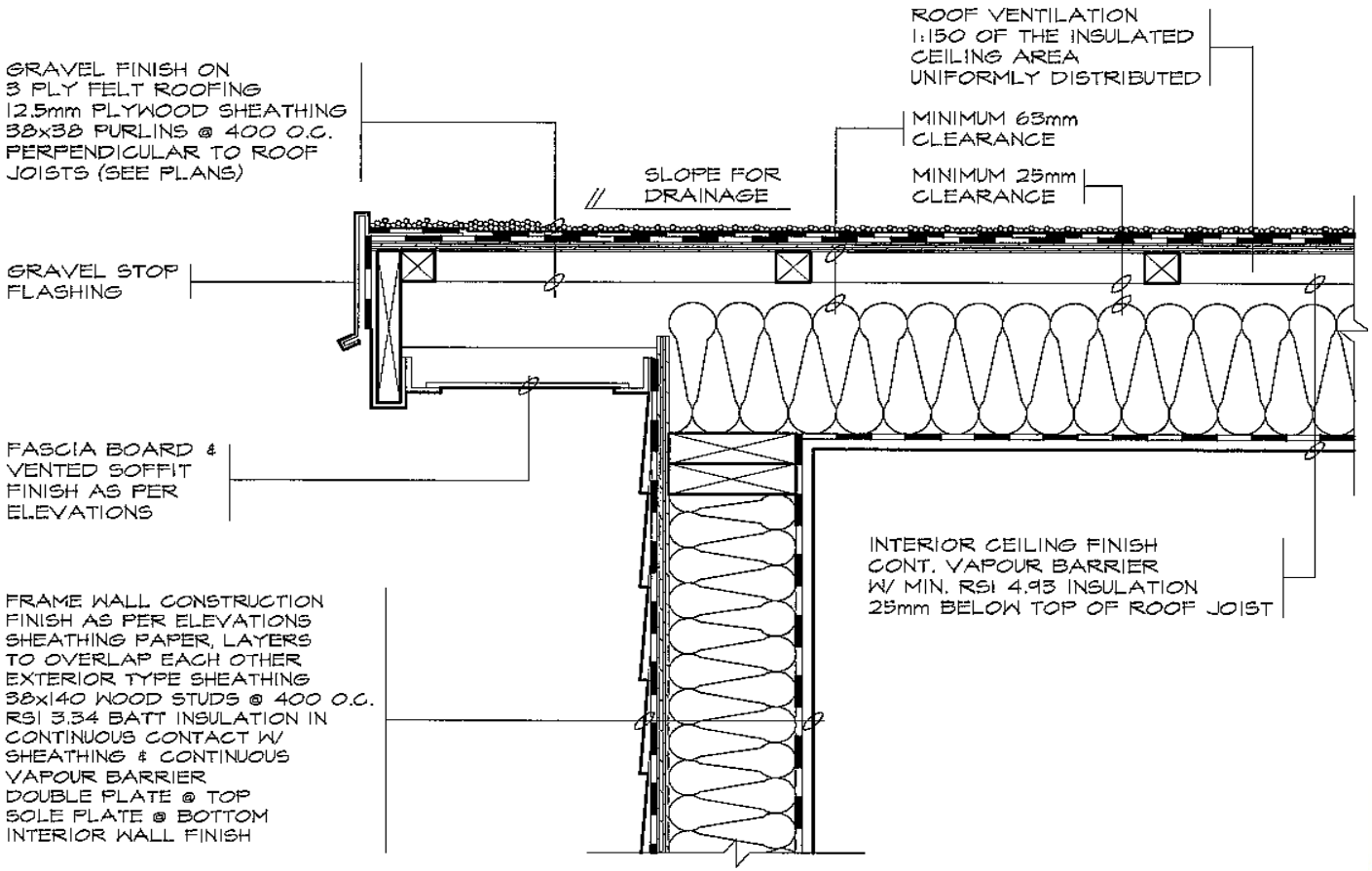
Sloped Roof

Flat Roof

ARCON
FORENSIC ENGINEERS

Roofing System

Flat Roof Cross Section



ARCON
FORENSIC ENGINEERS

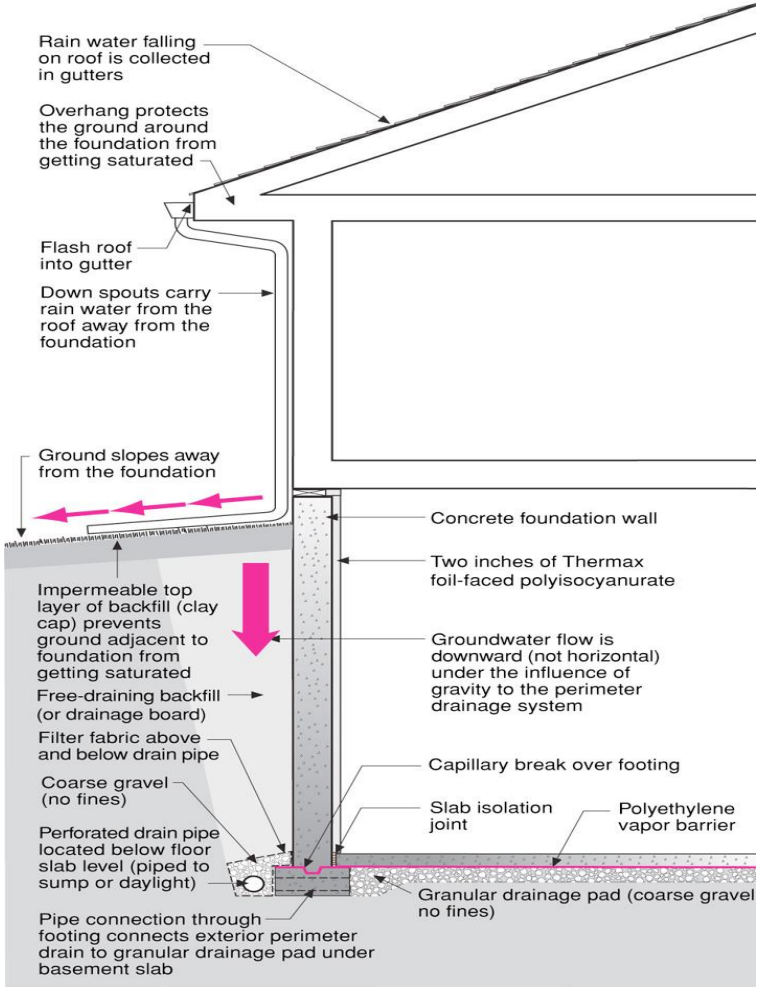
Ground Water Control

Two Key Principles:

- Keep rain-water away from foundation perimeter
  - Positive Exterior Grade
  - Rain-Water Leaders
  - Drainage aprons
  - Drainage swale
- Drain ground water collected at footings
  - Weeping Tile System
  - Free Draining Soil at Foundation
  - Damp-proofing System at Foundation

ARCON
FORENSIC ENGINEERS

Ground Water Control



ARCON
FORENSIC ENGINEERS

Ground Water Control

Site Grading

- Positive Slope Away from Foundation
- Grade Clearance to Exterior Wall Cladding
- Drainage Swale to Channel Water Away From Foundation

ARCON
FORENSIC ENGINEERS

Ground Water Control

Rain-Water Leaders

- Confirm if Above or Below Grade
- Discharge Outlet Location

ARCON
FORENSIC ENGINEERS

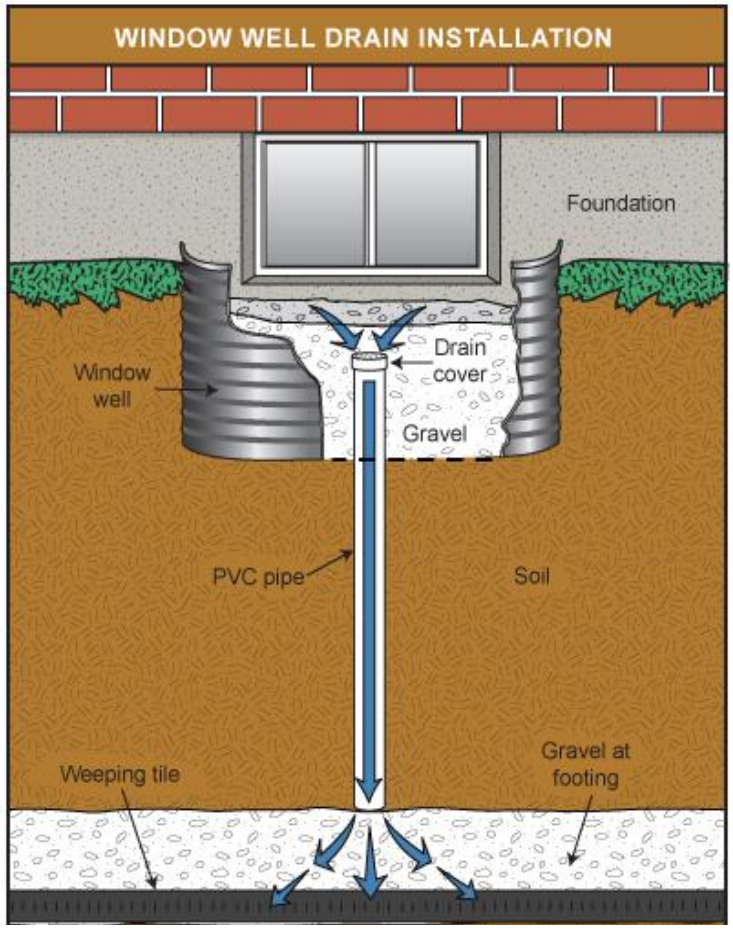
Ground Water Control

Window Wells

- Drains Blocked or Missing
- Clearances Between Windowsill and Grade
- Preventative Maintenance Practices

ARCON
FORENSIC ENGINEERS

Ground Water Control



ARCON
FORENSIC ENGINEERS

Ground Water Control

ARCON
FORENSIC ENGINEERS

Foundation System Failures

Causes of Foundation Moisture Entry

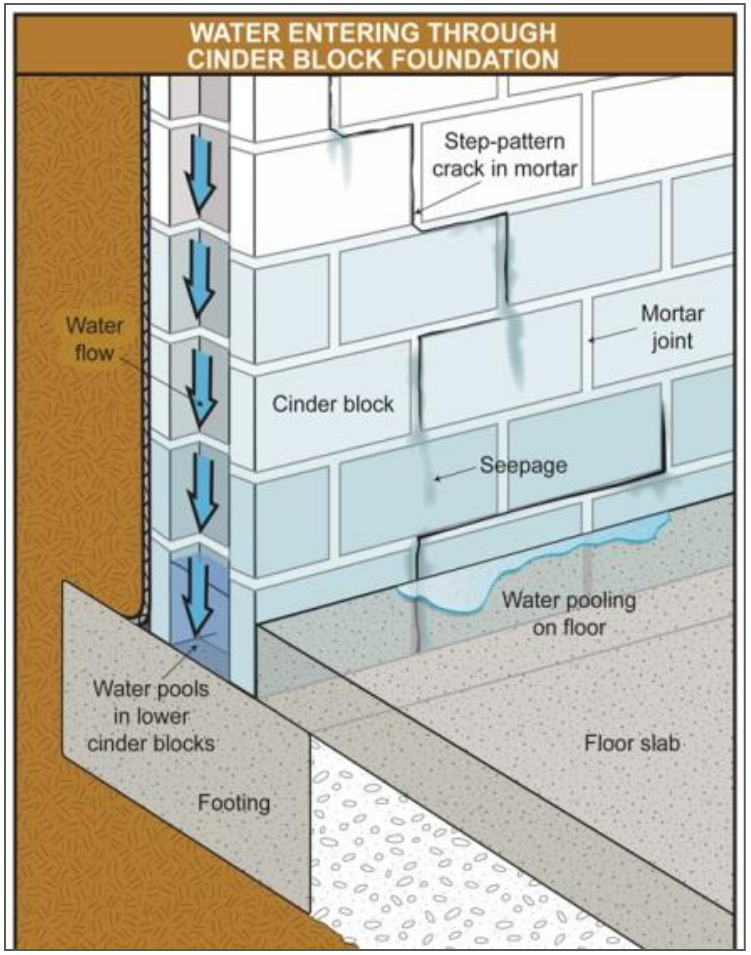
- Concrete Cracks In Foundation
- Hydrostatic Pressure on Walls/Slabs
- Capillary Action
- Condensation
- Poor Concrete Application and Materials
- Weeping Tile Failure

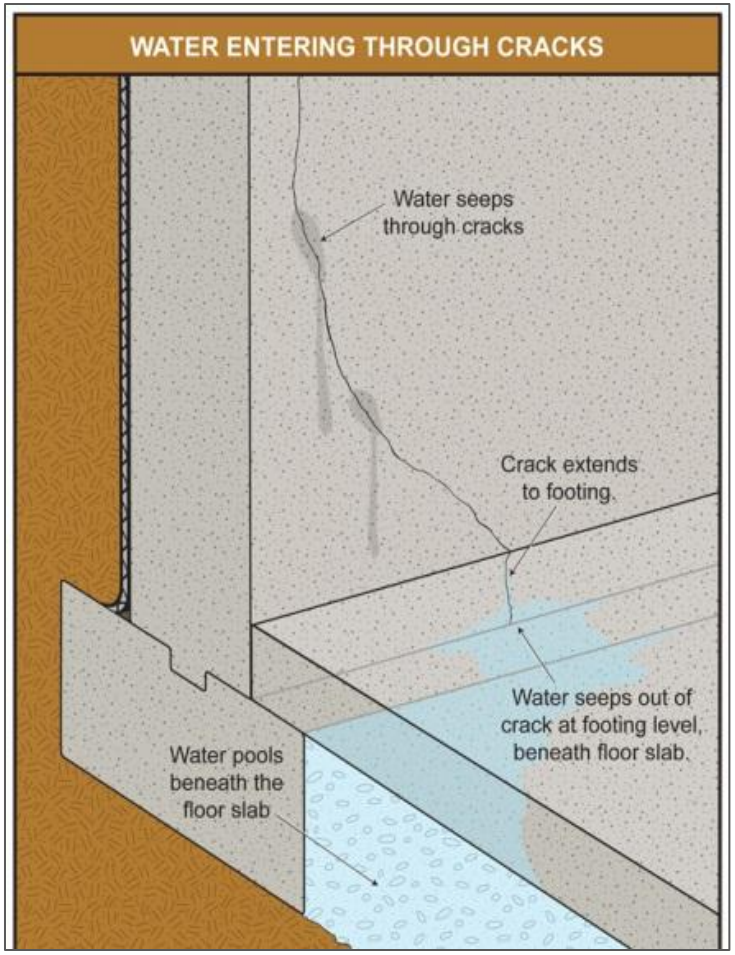
Sources of Water

- Ground Water
- Municipal Water (Water Line Leak)

ARCON
FORENSIC ENGINEERS

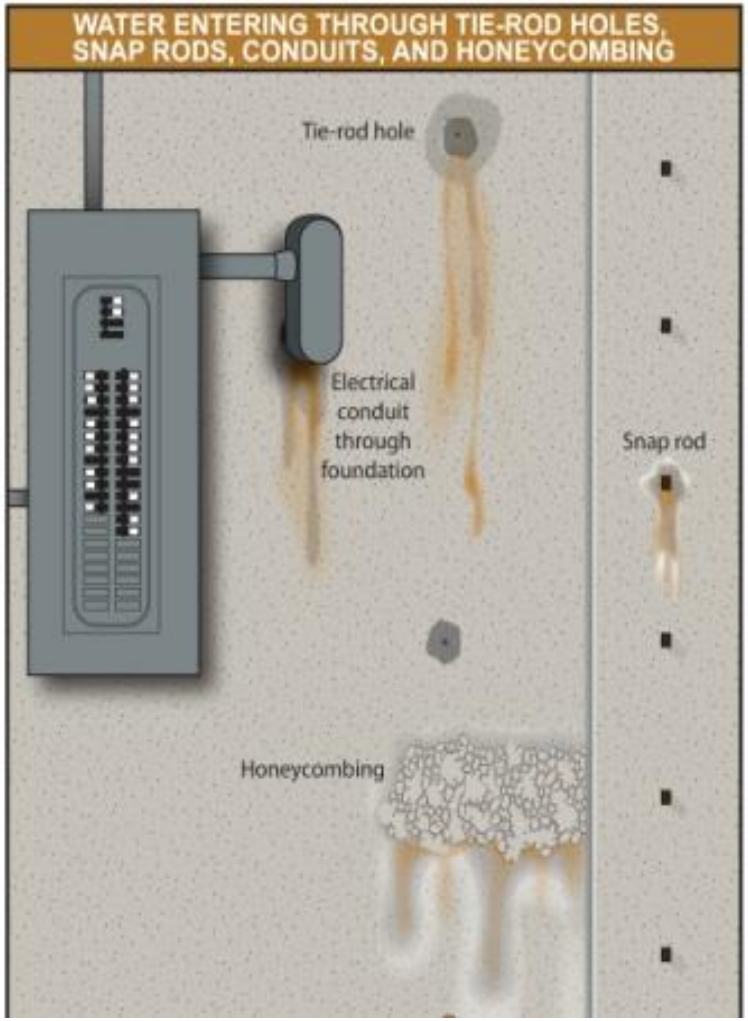
Foundation System Failures





ARCON
FORENSIC ENGINEERS

Foundation System Failures



Sources For Water Entry

- Wall Penetrations
  - Electrical Service
  - Tie-Rod Hole
  - Honeycombing
- Key Indicator
  - Efflorescence Staining

ARCON
FORENSIC ENGINEERS

Foundation System Failures

Sources For Water Entry

- Failure of Weeping Tile
- Failure of Damp-proofing
  - Slab/Foundation Wall Interface

ARCON
FORENSIC ENGINEERS

Foundation Case Study

Basement Water Entry Case Study

- Symptoms
  - Wet Carpet Finish Along Perimeter of Floor

- Verification:
  - Exterior Site Examination – Grading, Downspout
  - Partial Removal of Floor Finish by Contractor
  - Use of Thermographic Imaging

ARCON
FORENSIC ENGINEERS

Foundation Case Study

Exterior Verification

- Exterior Site Review
  - Rain-Water Leaders Discharge Point
  - Exterior Grading
  - Consider Age of Dwelling and Construction Practices

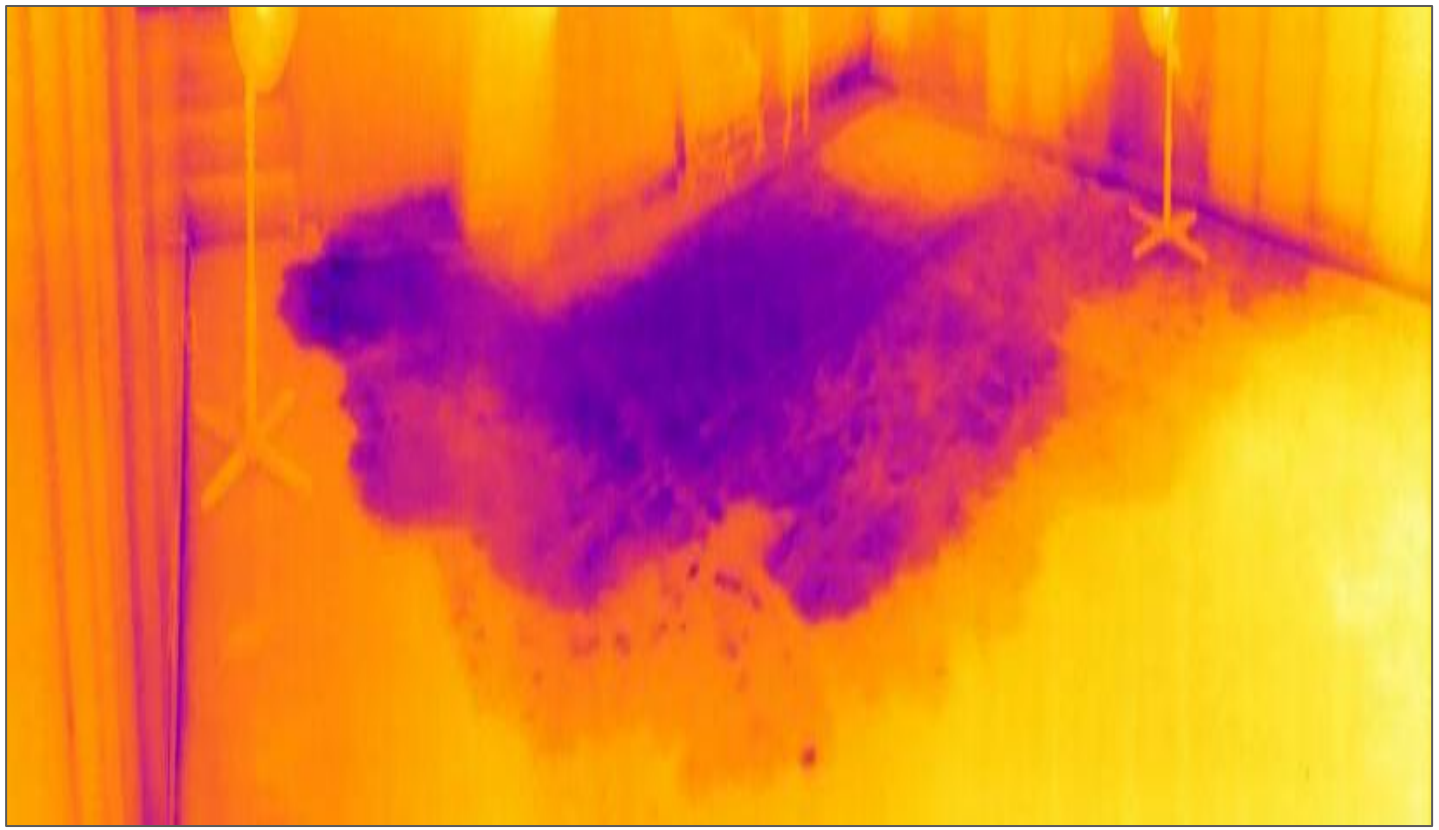
ARCON
FORENSIC ENGINEERS

Foundation Case Study

ARCON
FORENSIC ENGINEERS

Foundation Case Study

Thermographic Image of Basement



ARCON
FORENSIC ENGINEERS

Cladding System Failures

Causes of Water Entry

- Cavity Wall Drainage System Blocked or Lacks Weep Holes
- Open Joints in Wall System
- Integrity of Air Barrier System
- Flashing at Window and Wall Terminations
- Window Caulking – Missing or Cracked
- Lack of General Maintenance and Repair

ARCON
FORENSIC ENGINEERS

Cladding System Failures

Sources

- Primarily Weather-Related
- Can be Man-Made Such as From a Sprinkler
- Roofing System Failure

Symptoms of Cladding failure:

- Floor Finish Damage at Base of Wall (Water Stains, Cupping of Hardwood Floor)
- Damage to Interior Window Framing (Wood Rot)
- Damage to Wall/Ceiling Finish

ARCON
FORENSIC ENGINEERS

Cladding Case Study

Cladding System Failure Scenario

- EIFS Wall System

ARCON
FORENSIC ENGINEERS

Cladding Case Study

Wall Cladding System Case Study

- Symptoms
  - Water Pooling at Window-Sill (sporadic)
  - Staining of Carpet Floor at Window/Wall
  - Water Staining at Wall/Ceiling Finish
- Verification
  - Exterior Examination of Wall System & Windows
  - Removal of Interior Finishes Exposing Framing
  - Thermographic Imaging of Wall System

ARCON
FORENSIC ENGINEERS

Cladding Case Study

Cracks in EIFS Wall System

Caulking Missing or Cracked

Direct Moisture Entry into Wall Cavity

Cladding Case Study

Structural Decay and Rotting of Wood Framing

Exterior Sheathing Deteriorated

Wood Window Frame Deteriorated Due to Lack of Maintenance and Repair

Roofing System Failures

Causes of Water Infiltration

- External Barrier Breakdown or Damage
  - Weather-related: sun & wind
  - Sudden impact: tree or hail
  - Human or animal activity
  - Installation of solar panels or antennae
  - Lack of maintenance
- Improper design or installation

ARCON
FORENSIC ENGINEERS

Roofing System Failures

Symptoms of Water Intrusion

- Staining to Ceiling Finishes Around Light Fixtures or at the Corner of the Wall and Ceiling
- Direct Water Entry During Rain Event
- Condensation Forming in Attic Causing Water Damage
- Ice Damming Conditions

ARCON
FORENSIC ENGINEERS

Roofing System Failures

Verification of the Failure

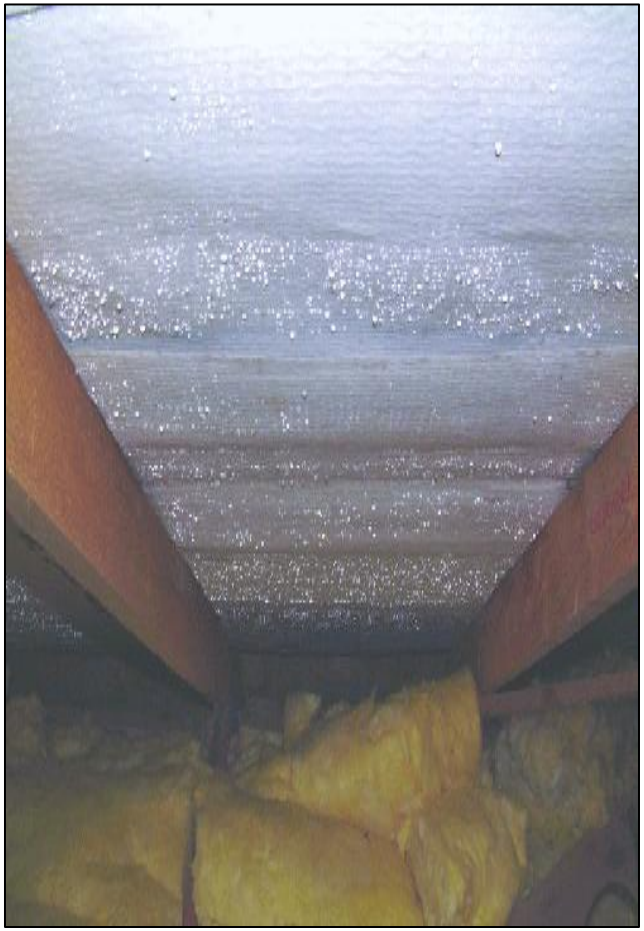
- Confirm Roof Membrane Leak or Condensation in Roof Attic (External vs Internal)
- Complete Thermograph of Roof
- Access Attic Area for Visual Inspection
- Confirm if Active Ducting Runs Through the Attic Space (Heat Loss)

ARCON
FORENSIC ENGINEERS

Roofing System Failures

Roof Attic Space

- Causes For Moisture Entry
  - Frost Build-up on Underside of Roof Sheathing
  - Melting of Ice – Source of Water Damage to Interior
  - Lack of Natural Air Ventilation
  - Heat Loss to Attic Space



ARCON
FORENSIC ENGINEERS

Roofing System Failures

VENTILATION REQUIREMENTS

- Flat Roof System
  - Cross Strapping for air movement
  - Clearance Requirements between insulation and underside of deck
  - Vent Roof Area
- Sloped Roof
  - Air Flow at Soffits
  - Vent Roof Area

ARCON
FORENSIC ENGINEERS

Roofing System Failures

Ice Damming Conditions

- Lack of Ventilation in Attic
- Heat Loss in Attic

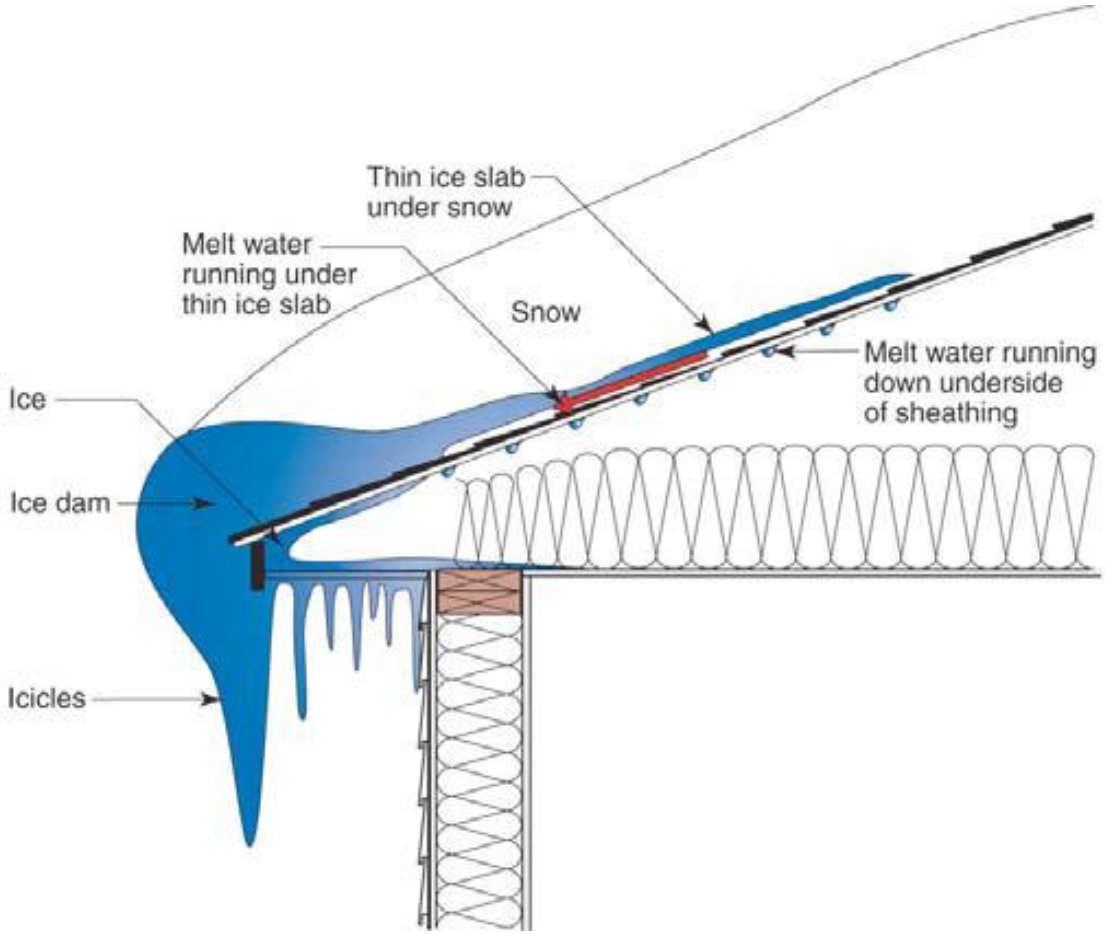
Result

- Build-up of Ice + Snow at Soffit
- Melt Water Enters Attic Area
- Damage to Interior Finishes

ARCON
FORENSIC ENGINEERS

Roofing System Failures

Ice Dam Formation on Roof



ARCON
FORENSIC ENGINEERS

Diagnostic Tools

Thermographic Scan

- Non-Destructive Test
- Identify Thermal Variance in Walls/Roofs
- Evaluate In-Floor Radiant Heating System
- Evaluate Parking Garage Heated Ramps

Blower Door Test

- Non-Destructive Test
- Identifies Air Leakage in Room – Negative Pressure
- Simulate Wind Driven Rain if Combined with Water Test on Exterior Walls/Windows

ARCON
FORENSIC ENGINEERS

Summary

Investigating & diagnosing structural water damage claims arising from a building envelope failure requires an extensive array of knowledge, tools and practical experience:

- Ontario Building Code
- Civil & Structural Engineering
- Building Science
- Construction
- Mechanical Systems
- Diagnostic Tools

ARCON
FORENSIC ENGINEERS

Summary

A well designed, constructed and maintained building envelope is critical to keeping external sources of water from damaging the building structure and its contents. However, exterior sources are not the only cause of damage.

Structural water damage claims can also arise as a result of the failure of, or lack of, a structure's mechanical systems.

ARCON
FORENSIC ENGINEERS