

# ANATOMY OF A BUILDING ENVELOPE FAILURE

Presented by Ray Ramos | July 2021  
*BE105-1, 1 LU / HSW*

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# Course

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This course will underscore the importance of preventing water infiltration into buildings (weatherproofing) to ensure the facilities remain safe and structurally sound while promoting health and safety for occupants and facility users. This course will review a case study of a medical facility that involves the deterioration of its structure and defects to its interior environment (mold, occupant comfort, air quality) resulting from poor building design and detailing (weatherproofing). The case study reviews how the effective use of testing, invasive investigation and leak location enabled implementation of correct repair designs that improved the building's interior environment and prevented interior mold growth.



# Learning Objectives

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At the end of this course, participants will be able to:

- **Learning Objective 1:** Learn what the building envelope is and how poor weatherproofing design and detailing will result in hazards to occupant comfort and indoor air quality (mold growth). Understanding how the importance of correct building envelope design and detailing (weatherproofing will ensure long term structural soundness of a building).
- **Learning Objectives 2:** Learn how corrective measures to restore the design and detailing of the facilities weather barrier can restore a building envelope and ensure the health of building occupants after a building envelope failure is detected.
- **Learning Objectives 3:** Review and learn of various methods, AAMA and ASTM standards for detection of interior environmental failure (water leaks that result in mold) and the location of defects in facility weather barriers which contribute to water leaks into the building interior environment.
- **Learning Objectives 4:** Review a case study in which testing and selective invasive investigation were utilized to recommend retroactive building design and detailing improvements to the weatherproofing, while at the same time maximizing the longevity of building integrity, the safety and health of building occupants following implementation of the design improvements.

# Presentation Introduction – Neurology Clinic, *Greenville, NC*

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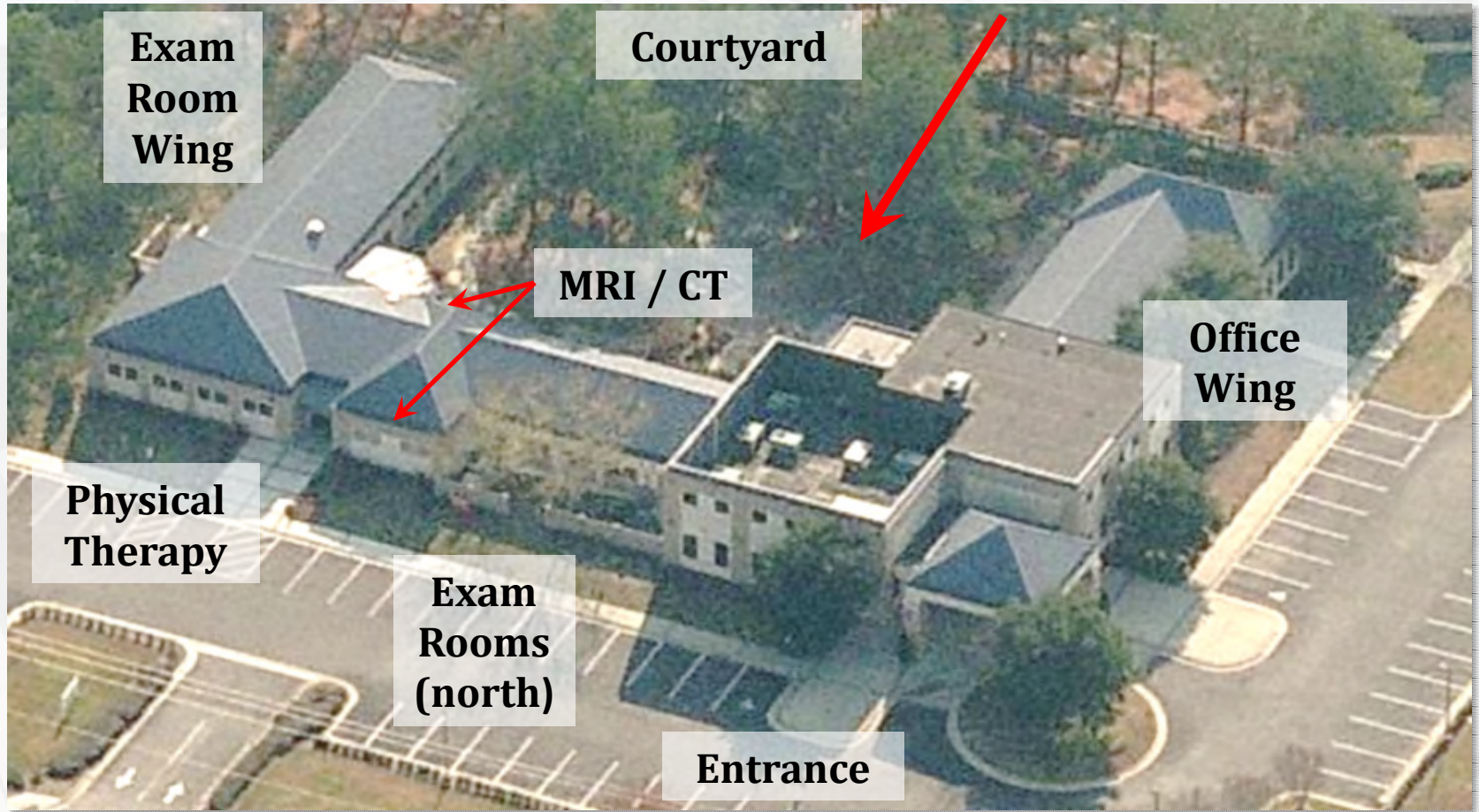
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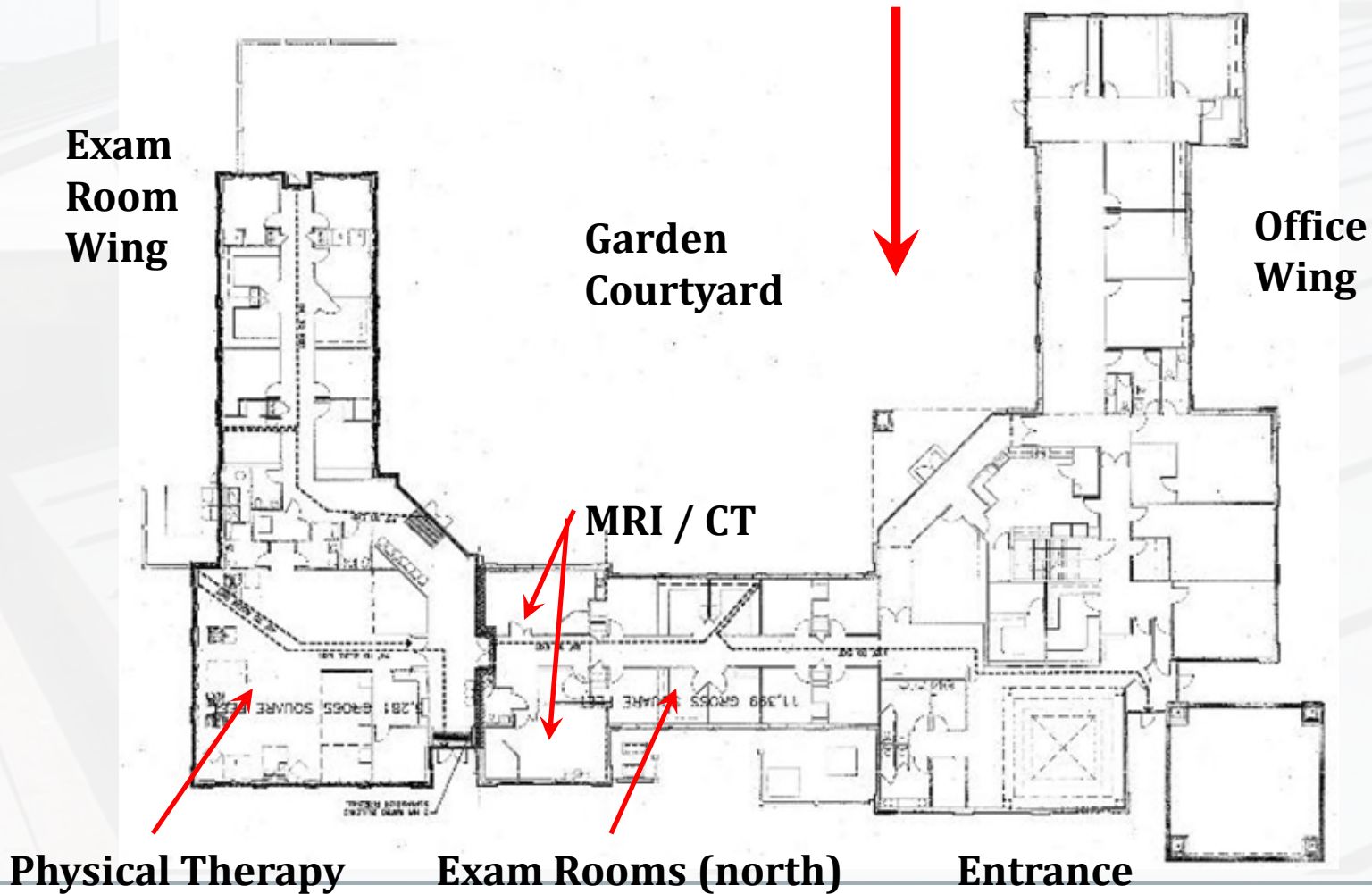
## 2. Building Overview

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## 2. Building Overview – Floor Plan

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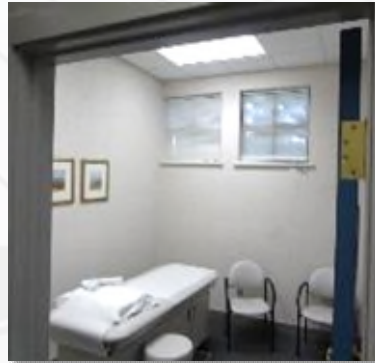
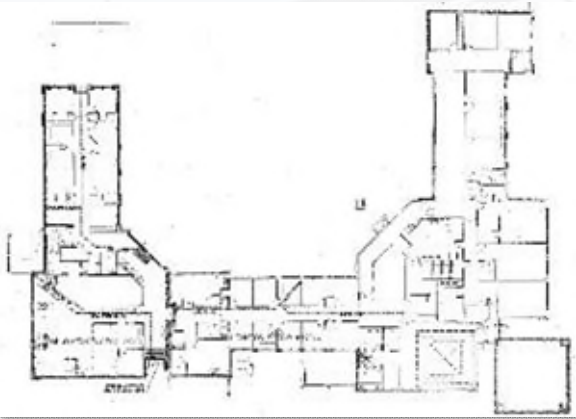


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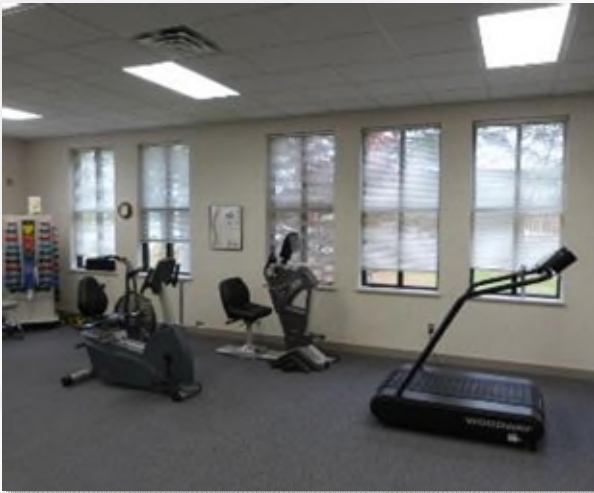


## 2. Building Overview - Interior

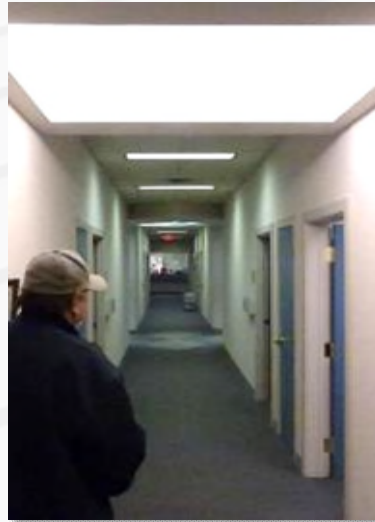
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**Exam Room  
(typical)**



**Physical Therapy**



**Corridor @ Exam Rooms**



**Office Wing**

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## 2. Building Overview – Test Methods & Owner Complaints

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### Test & Observation Methods

#### 1. Roofs:

- **Visual**
- Invasive
- Infrared
- Capacitance
- EFVM – Electronic Field  
Vector Mapping
- Nuclear

#### 2. Walls & Windows:

- **Visual**
- **Invasive**
- Borescope
- Infrared
- Blower Door
- **Water Testing**



**Owner complains of peeling wall paper at windows, water leaks and mold. Unsure if they should replace the roof or if they should replace windows?**

## 2. Building Overview – Definition

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**Building Envelope** - The Envelope has to respond both to natural forces and human values. The natural forces include rain, snow, wind and sun. The envelope provides protection by enclosure and by balancing internal and external environmental forces. To achieve protection it allows for careful control of penetrations. A symbol of the envelope might be a large bubble that would keep the weather out and the interior climate in.

– National Institute of Building Sciences, Whole Building Design Guide



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## 2. Building Overview - Elevation View (North)

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## 2. Building Overview – Exterior Walls & Windows

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## 2. Building Overview – Roof & Gutter Construction

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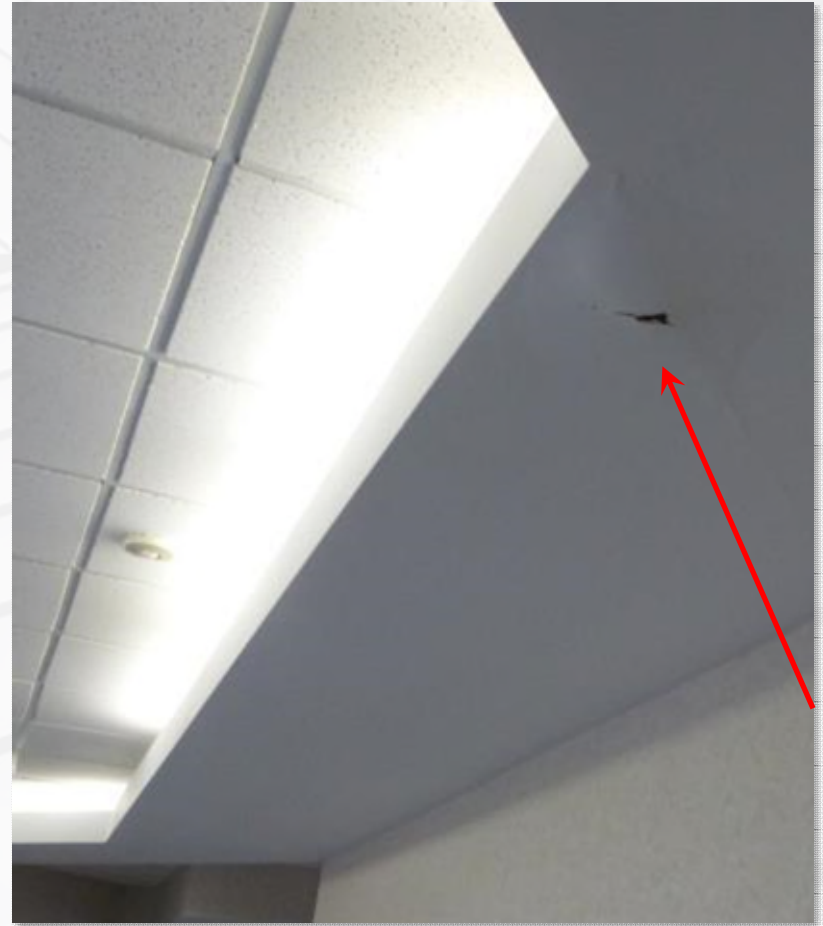
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### 3. Conditions / Symptoms – Entrance / Hallways

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### 3. Conditions / Symptoms – Physical Therapy

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### 3. Conditions / Symptoms – Office / Exam Rooms

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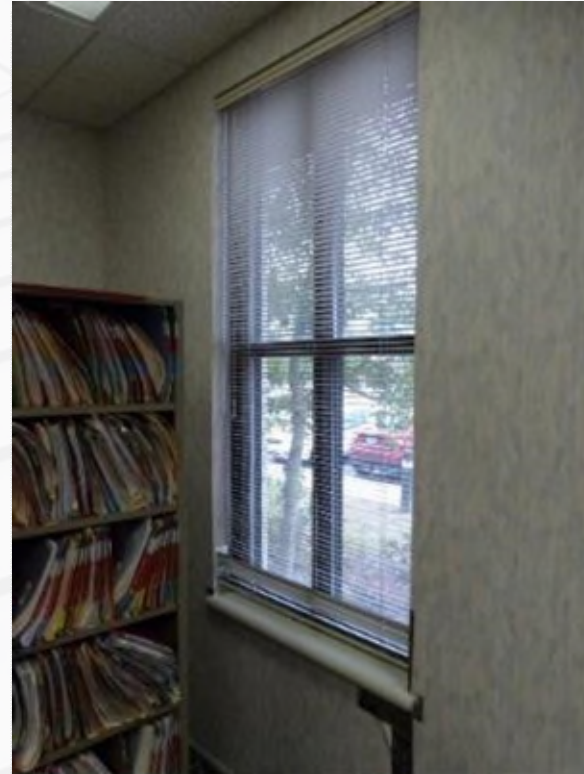
### 3. Conditions / Symptoms – First & Second Floor Windows

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**First Floor  
Directly Below**



**Second Floor**



### 3. Conditions / Symptoms – Concern for Mold

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- No wallpaper on exterior walls of buildings in southern climate
- Eliminate liquid water, Reduce Indoor Rh to 30% - 60%
- More on Mold: <https://www.epa.gov/mold/how-use-mold-course>

# 3. Conditions / Symptoms – Roof

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### 3. Conditions / Symptoms –Walls & Windows (Exterior)

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**Office Wing**



**Exam Room Wing**

### 3. Conditions / Symptoms – Brick Wall (Exterior)

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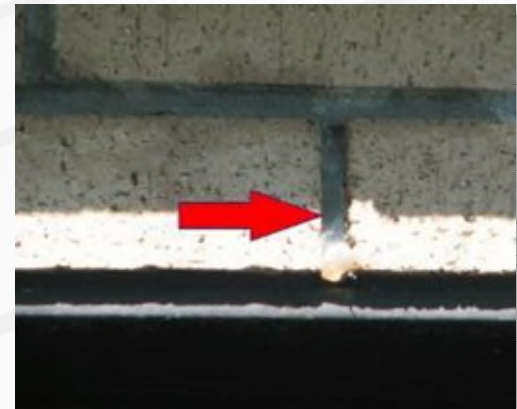


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### 3. Conditions / Symptoms – Brick Wall (Exterior)

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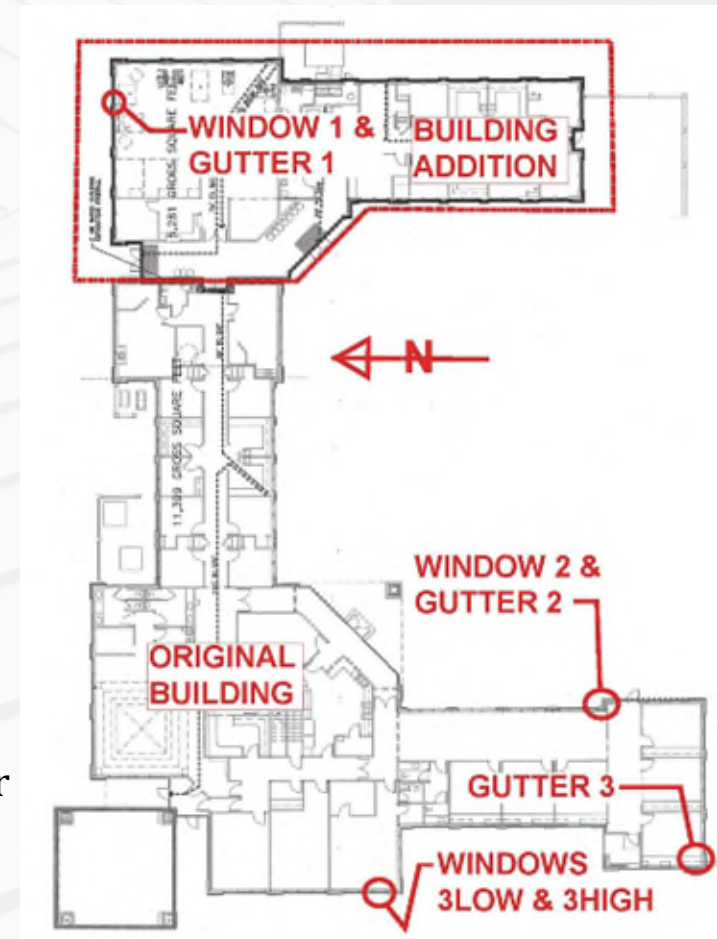
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## 4. Investigation Protocol – Reference ASTM E2128 & AAMA 511

- Visual Roof & Walls
- Review Existing Drawings
- Water Testing
  - w/Interior Walls Open
  - Test Windows
  - Test Gutter
- Open Windows
- Open Masonry

**ASTM E2128** – Standard Guide for Evaluating Water Leakage of Building **Walls** (*including fenestrations*)

**AAMA 511** – Voluntary Guidelines for **Forensic** Water Penetration Testing of **Fenestration Products**





# 4. Investigation Protocol – Water Testing:

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## Established Performance Criteria

- **AAMA 501.2** – Quality Assurance and Diagnostic Water Leakage Field check of **Installed** Storefronts, Curtain Walls and Sloped Glazing Systems.
- **AAMA 503** – Voluntary Specification for Field Testing of **Newly Installed** Storefronts, Curtain Walls and Sloped Glazing Systems.
- **ASTM E 1105** – Field Determination of Water Penetration of **Installed** Exterior Windows, Skylights, Doors and Curtain Walls, by Uniform or Cyclic Static Air Pressure Difference.

**These Standards have limitations both testing protocol and what is considered water leakage**

- **AAMA** – American Architectural Manufacturers Association
- **ASTM** International (American Society for Testing and Materials)

# 4. Investigation Protocol – Water Testing:

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## Testing Elements from AAMA 501.2, 503 & ASTM E1105:

- 12 Nozzle Spray Rack with Calibrated Nozzles – 8”/sq.ft./hr. (ASTM E1105).
- No air pressure chamber.
- No Time Limit – Test until leaks observed.
- Interior Walls Opened.
- Document test protocol before, during and after testing.
- Leak will mean any observable water entry.

## Why Alter Standards:

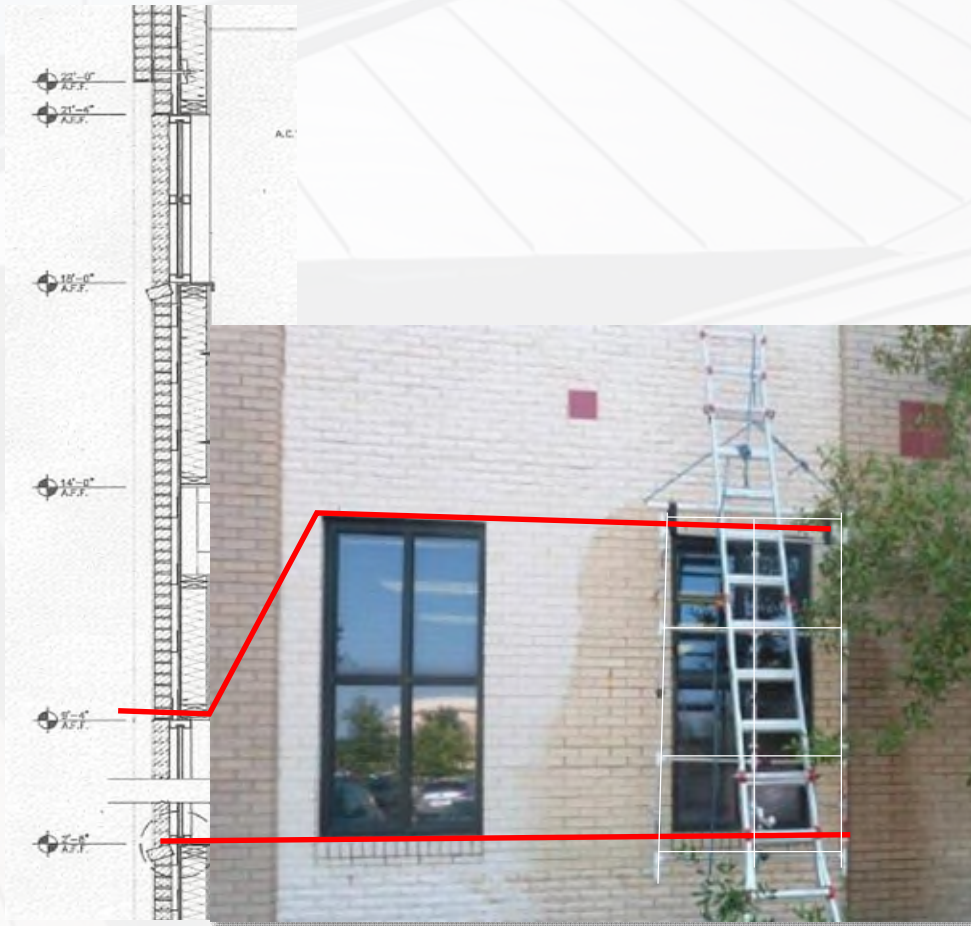
**ASTM E2128 & AAMA 511** – Primary Goal – Recreate leaks which are known to occur.

*The primary goal of building envelope leakage investigations are to trace the sources of building leaks. National testing standards are used to certify new fenestration products but must be adapted to detect the source of building envelope leaks. Their adaptation is based on physical evidence, the building conditions, an engineer’s experience, and engineering judgment.*

- Francesco Spagna, Simpson Gumpertz & Heger

## 4. Investigation Protocol - Water Testing (Windows)

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## 4. Investigation Protocol - Water Testing (Windows)

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## 4. Investigation Protocol - Water Testing (Windows)

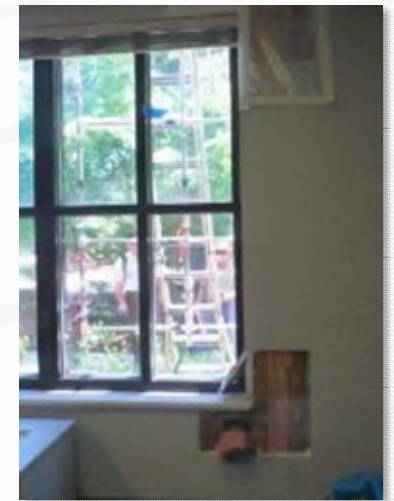
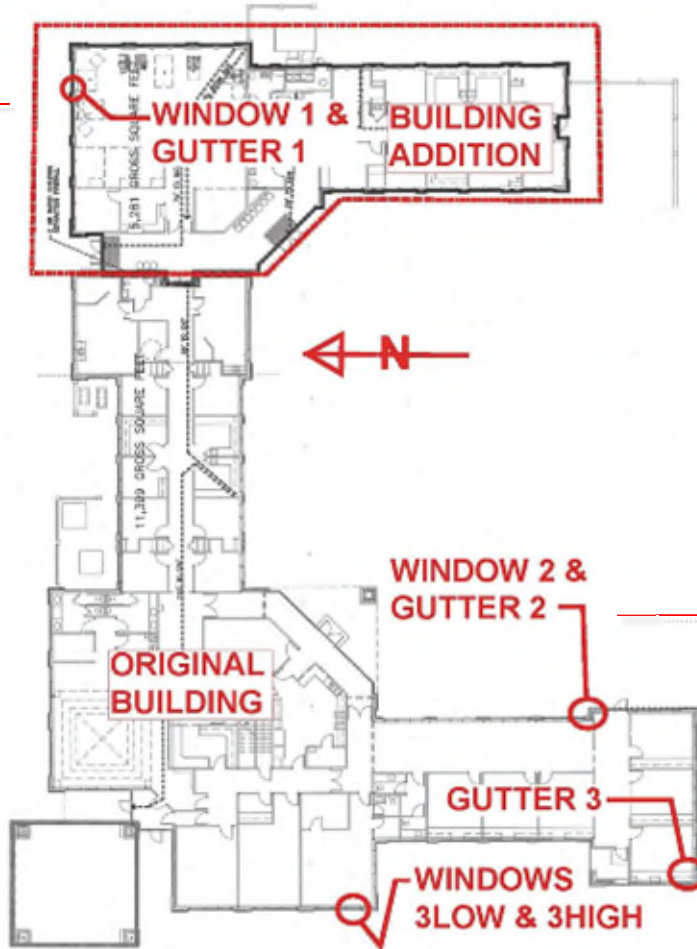
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## 4. Investigation Protocol - Water Testing (Windows)



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## 4. Investigation Protocol - Water Testing (Gutters)

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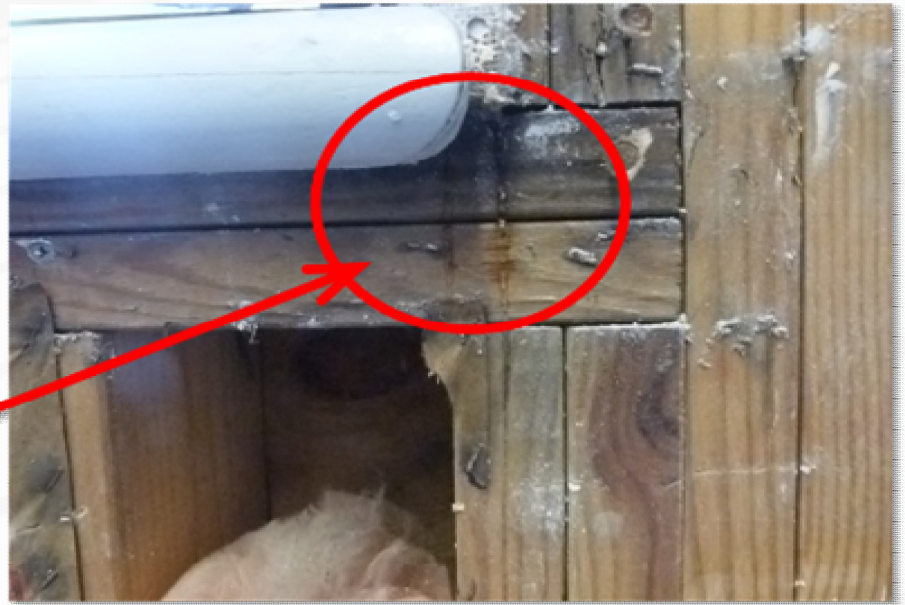


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## 4. Investigation Protocol - Water Testing (Gutters)

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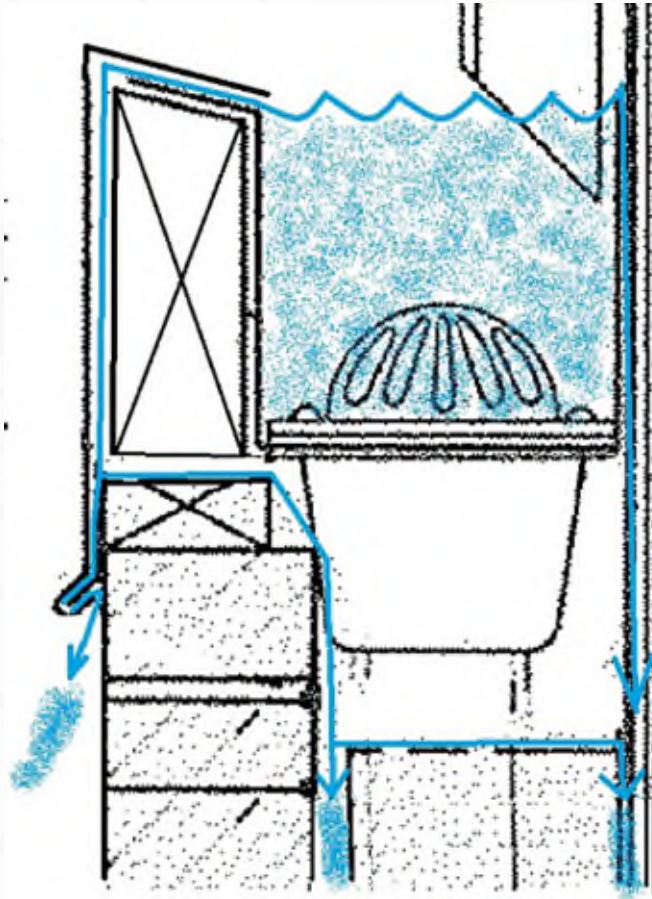
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## 4. Investigation Protocol - Water Testing (Gutters)

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# 4. Investigation Protocol – Open Windows



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## 4. Investigation Protocol – Open Windows

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# 4. Investigation Protocol – Open Masonry



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# 4. Investigation Protocol – Open Masonry

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# 5. Findings - Testing Summary (Review)

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**Original Complaint** - Owner complains of peeling wallpaper at windows, and water leaks. Unsure if they should replace the roof or if they should replace windows?

# 5. Findings - Testing Summary

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## 1. Windows:

- Sill Pans are defective, missing end dams and sloped to allow water to drain into the building.
- Window Construction is defective, missing sealant and internal water diverters.
- Primary cause for silver tape at window corners.

## 2. Masonry:

- Through wall flashing is missing above & below windows.
- Through wall flashing which is present has no end dams.
- Lintels are rusted and covered by sheet metal.
- Mortar bridging.
- Weep holes above grade sealed & covered by mulch at grade.

## 3. Roof:

- Gutters Leak into the building.
- Details are open to the weather including ridge.

# 5. Recommendations

## 1. Repair Options:

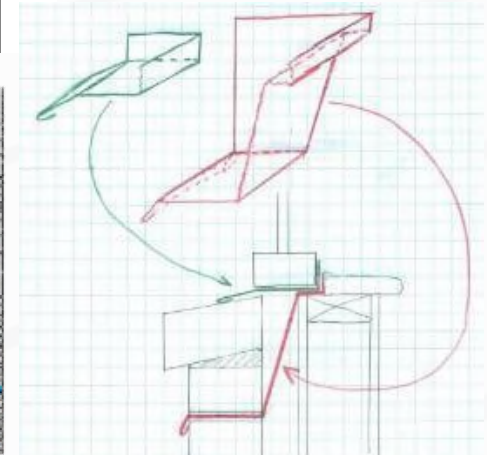
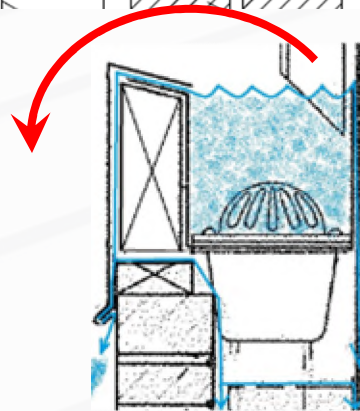
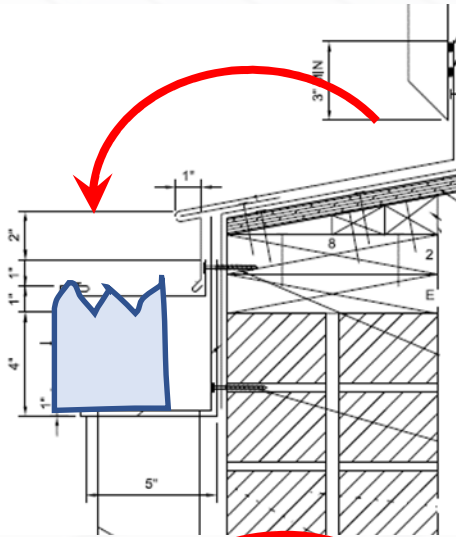
Good, Better, Best  
260K, \$550K, \$960k

## 2. Repair Recommendation:

- Better Option
- New windows
- Reconstruct the gutter
- New wall flashing above and below windows
- Minor Roof Repairs
- Remove wallpaper @ ext. walls

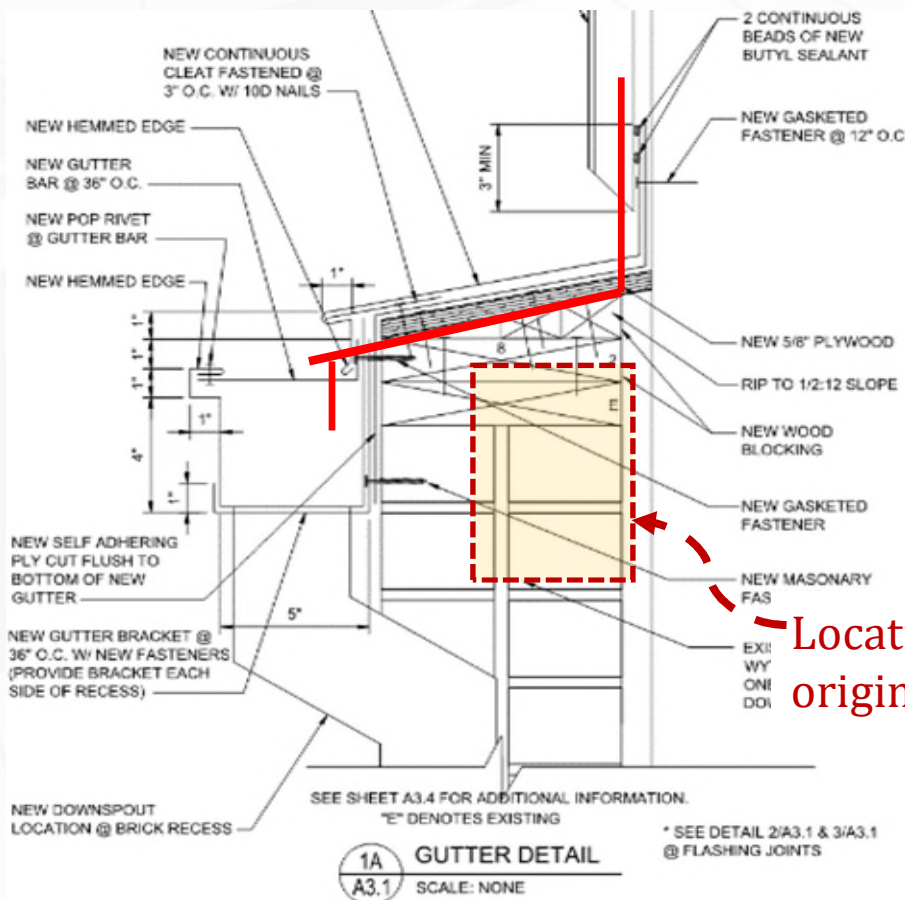
## 3. Site Repairs:

- Regrade areas where site slopes towards building
- Remove trees that are causing building damage
- Add site drainage for downspouts





# 6. Resolution – Gutter Reconstruction



Original

Reconstruction In-Depth

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## 6. Resolution – Wall Flashing Reconstruction

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**Original**

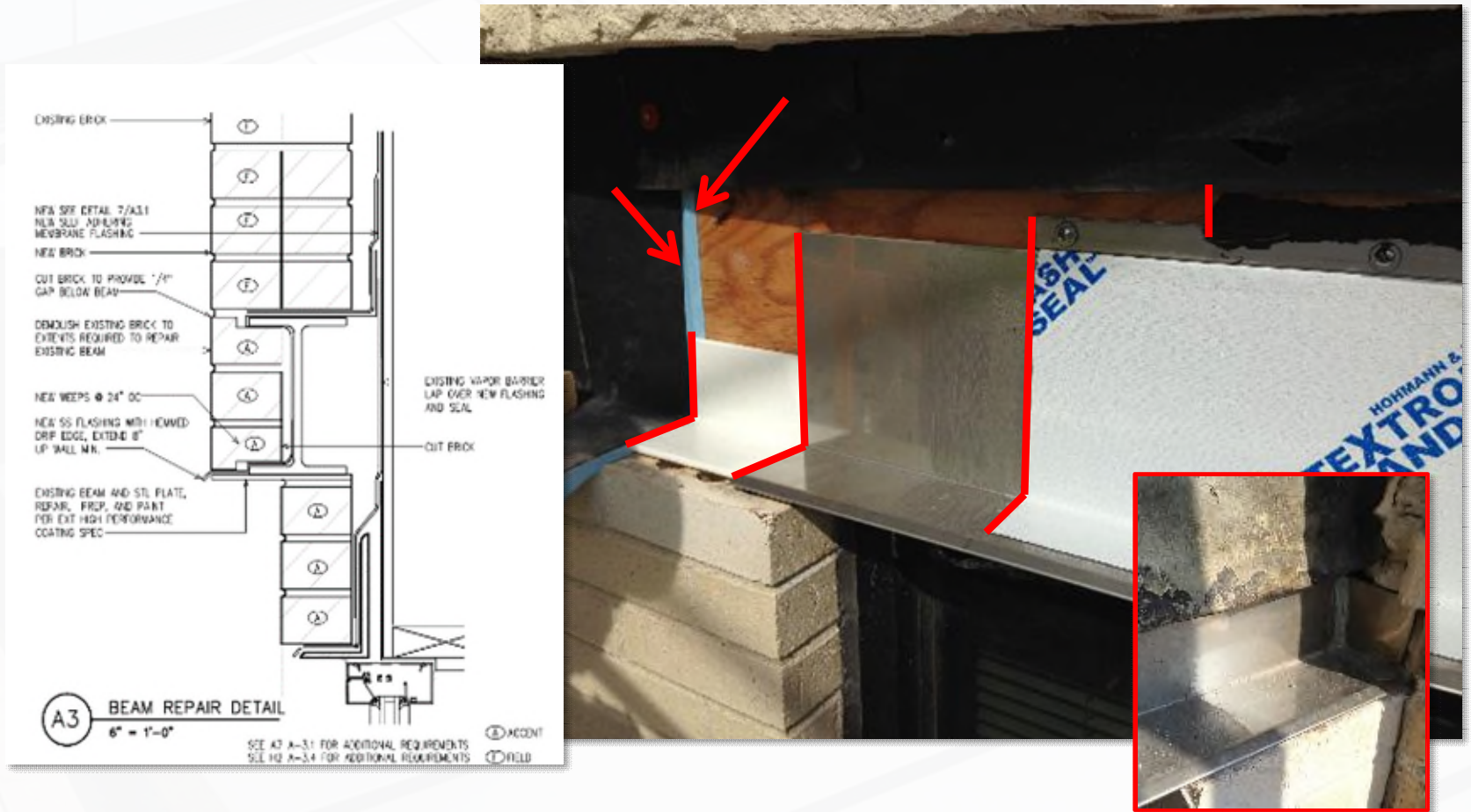


**Reconstruction**

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# 6. Resolution – Wall Flashing Reconstruction



## Reconstruction In-Depth

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## 6. Resolution – Wall Flashing Reconstruction – Below Windows

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**Original**

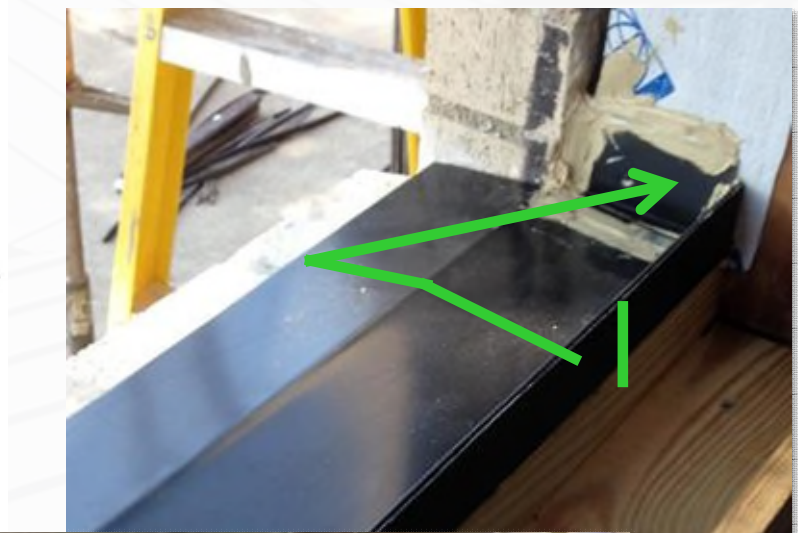
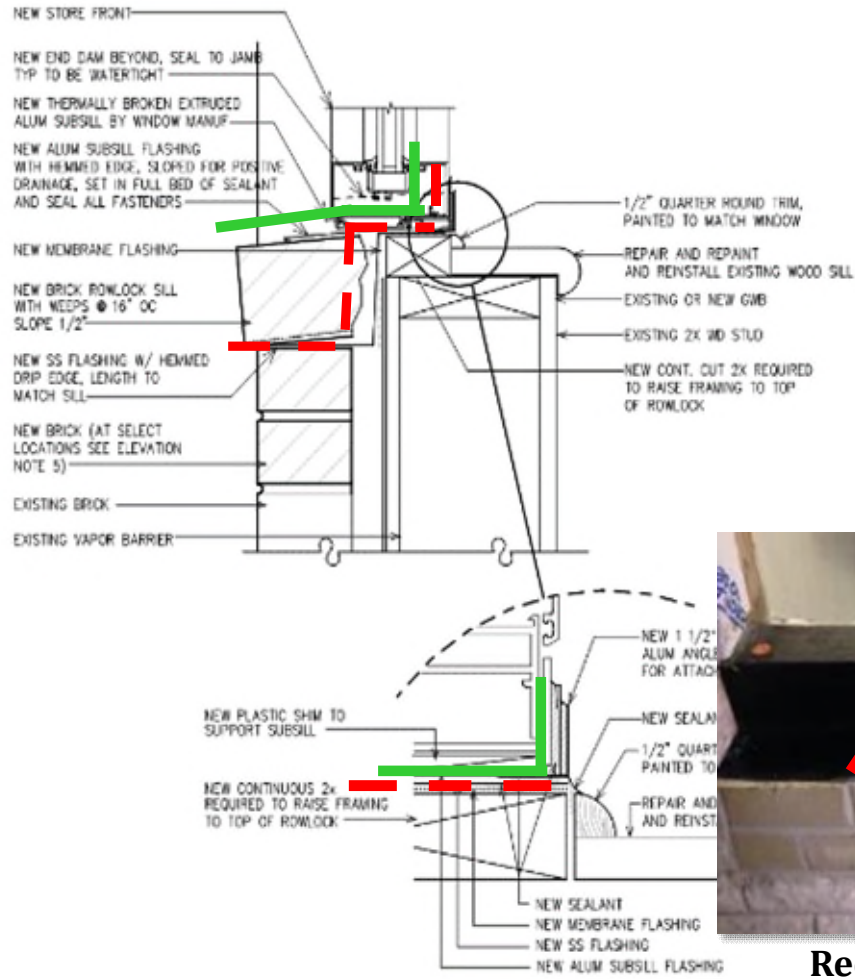


**Reconstruction**

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# 6. Resolution – Wall Flashing Reconstruction – Below Windows



**Reconstruction In-Depth**

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# 6. Resolution

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1. Addition of flashing reduces the actual window opening, resulting in a slightly smaller window.
2. Designing repairs to match consistently with existing elevation.
3. Removal of site trees created additional light/ glare at interior.
4. Matching masonry



# 6. Resolution – Interior Conditions

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**Original**

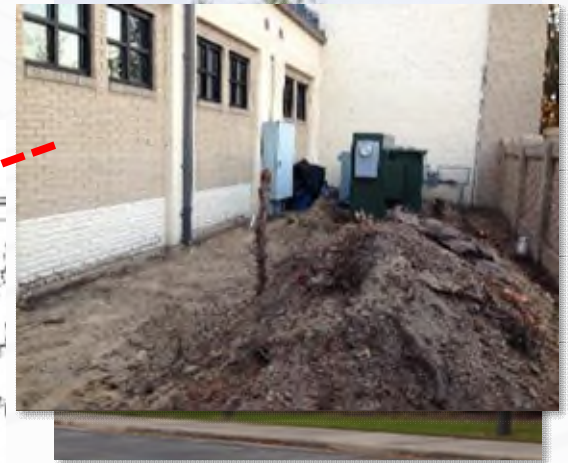
**Reconstruction**



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# 6. Resolution – Site Work



**Original**

**Reconstruction**



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# 6. Resolution – Completion

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# 6. Resolution – Gutter Reconstruction

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**Original**



Location of original gutter



**Reconstruction In-Depth**

# 6. Resolution – Completion (Physical Therapy)

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**Original**



**Reconstruction**

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## 6. Resolution – Completion (Exam Rooms North Elevation)

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**Original**



**Reconstruction**

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# 6. Resolution – Completion (Entrance)

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**Original**



**Reconstruction**

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# 6. Resolution – Completion (Office Wing)

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**Original**



**Reconstruction**

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# Presentation Outline

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1. Learning Objectives
2. Building Overview
3. Conditions / Symptoms (leaks)
4. Investigation Protocol:
  1. Visual Roof & Walls
  2. Review Existing Drawings
  3. Water Testing
  4. Open Windows
  5. Open Masonry
5. Recommendations
6. Resolution
7. Questions / Discussion & Review of other examples



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# This concludes The American Institute of Architects Continuing Education Systems Course

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# Contact our Business Development team for follow up:

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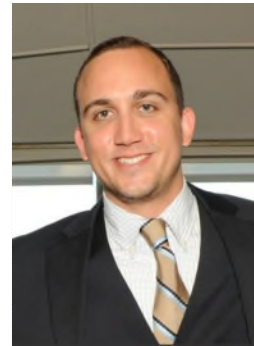
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