2009 MIAPPA Conference
Your Building and Things That go Bump in the Night
Traditional Scottish Saying

“From Ghoulies and Ghosties and Long Legged Beasties and Things That Go Bump In The Night Good Lord Deliver Us!”
Things That Go Bump In The Night

- You don’t always get what you think you are getting
- Inconsistent total building design concept
- Not enough research
- Inappropriate material selection
- Inappropriate system selection
- Inappropriate combining of system types
- Specification was silent, vague, or contradictory
- Critical details not provided
- Provided details were not relevant or buildable
What is This Presentation About?

– Problem recognition and solving
– Potential for energy reduction
– Maintenance

What Will be Presented?

– Building Technology Studio
  • What we can do for a project
– Various topics for discussion
  • Case study format

Resulting in:

– Recognizing a problem
– Knowing when you need help
– Helpful hints
Today’s Topics

• Facility Assessments
  – When and why

• Technology Assistance
  – Is there a better way?

• Peer Review Services
  – Are you getting what you pay for?

• Forensic Investigations
  – Why does it leak?
  – Break? Crack?
  – Not work? Work ineffectively?
Building Technology Studio

- Architects and Engineers
- What do we do?
  - Conduct forensic investigations
  - Provide technology assistance
  - Perform facility assessments
  - Conduct commissioning
  - Provide construction quality management
  - Provide construction dispute support
- Over 30 Years of Service for:
  - Architects
  - Owners
  - Contractors
  - Lawyers
  - Manufacturers
Facility Assessments
Technology Assistance
Peer Review Services
Forensic Investigations
Collegiate Rare Book Library

- Historic 1923 Design
- Except for a few changes
  - Essentially as-built

The Study

- Can a conservation environment be provided for the existing building?
- How to protect the architecture in doing so
- Space utilization, future program planning, and concepts for expansion
Exterior Wall Analysis

TVAP Analysis

Location: Detroit - solid year

With Prd Net Effective (65deg/72%)

4/28/2011

WUFI® Analysis

Book Cases at Exterior Wall
Exterior Wall Analyses

Exterior Wall Concepts

Book Cases at Exterior Wall
Exterior Window Analyses

Exterior Windows

Window Concepts

Your Building and Things That go Bump in the Night
Collegiate Rare Book Library

• To Summarize
  – Yes - the building can accommodate elevated humidity to an appropriate extent – IF:
    Some modifications are made to existing construction including:
    - Addition of heat trace to windows
    - Addition of heat trace behind the book shelves
    - Heating and ventilation is added to the space between interior finish materials and envelope
    - Addition of localized wall vapor retarder
    - Addition of roof vapor retarder
Holy Cross Children’s Services

- A non-profit with multiple facilities in multiple locations
- **Their Concern**
  - What do we have?
  - In what condition?
  - 1\textsuperscript{st} assessment in 1999
  - Established a baseline
- **Subsequent Assessments**
  - 2\textsuperscript{nd} – 2001
  - 3\textsuperscript{rd} – 2004
  - 4\textsuperscript{th} - 2008
**Summary for All Buildings**

**HOLY CROSS CHILDREN’S SERVICES**

**SUMMARY**

<table>
<thead>
<tr>
<th>FACILITY/BUILDING</th>
<th>Immediate</th>
<th>0-2 yrs</th>
<th>2-5 yrs</th>
<th>+ 5 yrs</th>
<th>Total</th>
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<tbody>
<tr>
<td>Moreau Center</td>
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<td>King House</td>
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<td>Katherine Drexel (Cabrini)</td>
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<td>St. Thomas</td>
<td></td>
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<tr>
<td>Kennedy/Andre House (St. Cecilia)</td>
<td></td>
<td></td>
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<tr>
<td>Hitchcock Center</td>
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<tr>
<td>Holy Cross-School</td>
<td></td>
<td></td>
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<tr>
<td>Holy Cross-Gym</td>
<td></td>
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<tr>
<td>Kenquest House</td>
<td>$800</td>
<td>$37,600</td>
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<td>St. Vincent</td>
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<td>Queen of Angels</td>
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<td>Clinton Campus-Boiler House</td>
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<td>Clinton Campus-Band Building &amp; Water Room</td>
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<tr>
<td>Clinton Campus-Maintenance/Garage</td>
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<td>$13,750</td>
<td>$90,500</td>
<td>$157,000</td>
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<tr>
<td>Clinton Campus-Sage Center</td>
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<tr>
<td>Clinton Campus-Preschool Center</td>
<td>-</td>
<td>$300</td>
<td>$2,800</td>
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<td>Clinton Campus-Van Eiland Center</td>
<td>-</td>
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<td>Clinton Campus-Chapel</td>
<td>-</td>
<td>$23,650</td>
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<td>Clinton Campus-Dining Building (original)</td>
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<td>Clinton Campus-Dining Building (addition)</td>
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<td>Clinton Campus-Gym</td>
<td>-</td>
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<td>$5,600</td>
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<td>Clinton Campus-Cardinal Mooney Center</td>
<td>-</td>
<td>$43,250</td>
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<tr>
<td>Clinton Campus-EJO Building</td>
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<tr>
<td>Clinton Campus-Recreational Center</td>
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<td>$22,000</td>
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<tr>
<td>Clinton Campus-Thomas Moore School</td>
<td>-</td>
<td>$50,300</td>
<td>$92,000</td>
<td>$51,500</td>
<td>$193,825</td>
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<tr>
<td>Clinton Campus-Monument and Pond Surrounds</td>
<td>-</td>
<td>$1,000</td>
<td>$200</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Immediate** | **0-2 yrs** | **2-5 yrs** | **+ 5 yrs** | **Total**

**Holland House** | $275 | $33,350 | $47,250 | $40,000 | $120,875

**Typical Building**
### Typical Building Summary

#### 2009 MIAPPA Conference

**Location** | **Work item description** | **0-2 yrs**
--- | --- | ---
Main Building | isolated cleaning, tuckpointing, and masonry repairs | $80,000

### Masonry Problem

<table>
<thead>
<tr>
<th>Location</th>
<th>Work item description</th>
<th>Estimated Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Building</td>
<td>isolated cleaning, tuckpointing, and masonry repairs</td>
<td>$80,000</td>
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</table>

#### Immediate Repairs Required

<table>
<thead>
<tr>
<th>Location</th>
<th>Work item description</th>
<th>Estimated Costs</th>
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</thead>
<tbody>
<tr>
<td>School Exterior (T)</td>
<td>Isolated cleaning, tuckpointing, and masonry repairs</td>
<td>$80,000</td>
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</table>

#### YEAR 1

<table>
<thead>
<tr>
<th>Location</th>
<th>Work item description</th>
<th>Estimated Costs</th>
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<tbody>
<tr>
<td>Main Building</td>
<td>Rebuild masonry at brick sill (9 locations)</td>
<td>$10,000</td>
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<tr>
<td>Main Building, north elevations</td>
<td>Remove sealant at lintel, paint lintel (16)</td>
<td>$2,000</td>
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<tr>
<td>1/2-story wings</td>
<td>Tuckpoint masonry, caulk under precast, seal precast</td>
<td>$4,000</td>
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</table>

#### Year 2-5

<table>
<thead>
<tr>
<th>Location</th>
<th>Work item description</th>
<th>Estimated Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Building</td>
<td>Replace wood doors</td>
<td>$4,000</td>
</tr>
<tr>
<td>Parking and drive areas</td>
<td>Repair roof in 2012</td>
<td>$100,000</td>
</tr>
</tbody>
</table>

#### Year 6-10

<table>
<thead>
<tr>
<th>Location</th>
<th>Work item description</th>
<th>Estimated Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parking and drive areas (24,000 sf)</td>
<td>Maintenance of exterior walls ($20,000 annual costs)</td>
<td>$100,000</td>
</tr>
</tbody>
</table>

#### Project No: 22270.000

**Holy Cross Children's Services**

**Building:** 2-story school/office

**Square footage:** 43,510
# Typical Summary for All Roofs

**HOLY CROSS CHILDREN'S SERVICES**

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### ROOF SUMMARY

<table>
<thead>
<tr>
<th>FACILITY/BUILDING</th>
<th>DATE INSTALLED</th>
<th>ROOF DESCRIPTION</th>
<th>REPAIR COST</th>
<th>REPL’T DATE</th>
<th>REPL’T COST</th>
<th>FACILITY TOTALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monroe Center</td>
<td></td>
<td>Flat, built-up bituminous roof</td>
<td>$11,000</td>
<td>2015</td>
<td>$100,000</td>
<td>$110,000</td>
</tr>
<tr>
<td>King House</td>
<td>circa 1996</td>
<td>Sloped, asphalt shingled roof</td>
<td>$200</td>
<td>2012</td>
<td>$15,000</td>
<td>$17,000</td>
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<tr>
<td>Katharine Dreisel (Gabin'rin)</td>
<td>Original</td>
<td>Low-slope built-up bituminous roof</td>
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<td>2015</td>
<td>$90,000</td>
<td>$95,500</td>
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<tr>
<td>Bowman (Garage)</td>
<td>Original</td>
<td>Asphalt shingles</td>
<td>$6,500</td>
<td>2009</td>
<td>$2,000</td>
<td>$8,500</td>
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<tr>
<td>Bowman (Main house)</td>
<td>Original</td>
<td>Sloped, slate shingled roof</td>
<td>$6,000</td>
<td>2009</td>
<td>$5,000</td>
<td>$11,000</td>
</tr>
<tr>
<td>St. Thomas</td>
<td>Original</td>
<td>Sloped, tile shingled roof</td>
<td>$6,000</td>
<td>2009</td>
<td>$5,000</td>
<td>$11,000</td>
</tr>
<tr>
<td>Kennedy/Andre House (St. Cecilia)</td>
<td>Original</td>
<td>Sloped, slate shingled roof</td>
<td>$10,000</td>
<td></td>
<td>$10,000</td>
<td>$10,000</td>
</tr>
<tr>
<td>Hitchcock</td>
<td>Original</td>
<td>Sloped, tile shingled roof</td>
<td>$15,000</td>
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<td>$15,000</td>
<td>$15,000</td>
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<tr>
<td>Holy Cross-School (south entrance roof)</td>
<td>2006</td>
<td>Flat, built-up bituminous roof</td>
<td>Warranty</td>
<td></td>
<td></td>
<td>$20,000</td>
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<tr>
<td>Holy Cross-School (main roof)</td>
<td>2006</td>
<td>Flat, built-up bituminous roof (coal-tar)</td>
<td>Warranty</td>
<td></td>
<td></td>
<td>$20,000</td>
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<tr>
<td>Kennewick House</td>
<td>2008</td>
<td>Sloped, asphalt shingled roof</td>
<td>Warranty</td>
<td></td>
<td></td>
<td>$20,000</td>
</tr>
<tr>
<td>Huron House</td>
<td></td>
<td>Sloped, asphalt shingled roof</td>
<td>Warranty</td>
<td></td>
<td></td>
<td>$20,000</td>
</tr>
<tr>
<td>St. Vincent</td>
<td>Flat, built-up bituminous roof</td>
<td>$20,000</td>
<td>2012</td>
<td>$100,000</td>
<td>$120,000</td>
<td></td>
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<tr>
<td>St. Vincent-Villa</td>
<td></td>
<td>Flat, rubber roof</td>
<td>$1,000</td>
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<td>$1,000</td>
<td>$1,000</td>
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<tr>
<td>Queen of Angels - Main Building</td>
<td>2005</td>
<td>Flat, rubber roof</td>
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<td>$2,000</td>
<td>$2,000</td>
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<tr>
<td>Queen of Angels - Garage</td>
<td>2005</td>
<td>Flat, rubber roof</td>
<td>$2,000</td>
<td>2012</td>
<td>$20,000</td>
<td>$20,000</td>
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<tr>
<td>Holland House</td>
<td></td>
<td>Sloped, asphalt shingled roof</td>
<td>Warranty</td>
<td></td>
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<td>$20,000</td>
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<tr>
<td>Garconor house</td>
<td></td>
<td>Sloped, asphalt shingled roof</td>
<td>Warranty</td>
<td></td>
<td></td>
<td>$20,000</td>
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<tr>
<td>Garconor house addition</td>
<td>2005</td>
<td>Sloped, asphalt shingled roof</td>
<td>Warranty</td>
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<td>Corcoran garage</td>
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<td>Corcoran Administration Building</td>
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<td>Standing seam metal roof</td>
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<td>Clinton Campus-Chapel, Brothers &amp; Trophy Rm</td>
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<td>$7,000</td>
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<td>Clinton Campus-Diner House</td>
<td>2003</td>
<td>Flat roof, rubber over original built-up</td>
<td>Asphalt shingles</td>
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<td>$2,000</td>
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<td>Clinton Campus-Band Room</td>
<td>2003</td>
<td>Flat roof, rubber over original built-up</td>
<td>Asphalt shingles</td>
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<td>$2,000</td>
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<td>Clinton Campus-Water Room</td>
<td>Flat roof, 1956, shingles 2003</td>
<td>Flat roof (rubber roof) sloped asphalt shingles</td>
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<td>2015</td>
<td>$100,000</td>
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<td>Clinton Campus-Chapel</td>
<td>org.1960, flood coat main roof 2003</td>
<td>Flat, built-up (coal-tar) bituminous roof</td>
<td>$11,000</td>
<td>2015</td>
<td>$100,000</td>
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<tr>
<td>Clinton Campus-Rooftop Park</td>
<td>1995 (orig. roof)</td>
<td>Flat, rubber roof</td>
<td>$7,000</td>
<td>2015</td>
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<td>Clinton Campus-Field House</td>
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<td>Sloped, asphalt shingled roof</td>
<td>$5,000</td>
<td>2006</td>
<td>$5,000</td>
<td>$5,000</td>
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<td>Clinton Campus-Chapel</td>
<td>Roof 1999, porch 1987</td>
<td>Asphalt shingles over asbestos shingles</td>
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<td>2015</td>
<td>$100,000</td>
<td>$111,000</td>
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<td>Clinton Campus-North Center</td>
<td>2002</td>
<td>Flat, rubber over built-up bituminous roof</td>
<td>$11,000</td>
<td>2015</td>
<td>$100,000</td>
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<td>Clinton Campus-Oasis Building (original)</td>
<td>Lower roof 2003</td>
<td>Flat, built-up bituminous roof</td>
<td>$11,000</td>
<td>2015</td>
<td>$100,000</td>
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**2009 MIAPPA Conference**

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Yours Building and Things That go Bump in the Night

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**Roof Problem**
Typical Summary of All HVAC/Boilers

<table>
<thead>
<tr>
<th>Facility/Building</th>
<th>Date Installed</th>
<th>Heat/Boiler Description</th>
<th>Repl’/ Repl’t Notes</th>
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<tbody>
<tr>
<td>Holland House</td>
<td>1970</td>
<td>Steam heat w/2 gas fired boilers</td>
<td>2014 $40,000 Replacement cost for 2 boilers</td>
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<tr>
<td>St. Thomas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>St. Vincent</td>
<td>1969</td>
<td>Hot water heat w/2 gas fired boilers</td>
<td>after 2020 N/A Evaluate in 2010</td>
</tr>
<tr>
<td>St. Vincent Villa (office area)</td>
<td>1997</td>
<td>Forced air furnace</td>
<td>after 2020 N/A</td>
</tr>
<tr>
<td>St. Vincent Villa (stateroom area)</td>
<td>1880</td>
<td>Forced air furnace</td>
<td>2015 $7,000</td>
</tr>
<tr>
<td>Holland House</td>
<td>1970</td>
<td>Steam heat w/2 gas fired boilers</td>
<td>2014 $40,000 Replacement cost for 2 boilers</td>
</tr>
<tr>
<td>Conception Hall</td>
<td>1996</td>
<td>Forced air furnace</td>
<td>after 2020 N/A</td>
</tr>
<tr>
<td>Conception House</td>
<td>1980</td>
<td>Steam heat w/ gas fired boiler</td>
<td>2012 $15,000</td>
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<tr>
<td>Cretin Administration Building</td>
<td>1985</td>
<td>6 Falcon air furnaces</td>
<td>after 2020 N/A Evaluate in 2005</td>
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<tr>
<td>Cretin Campus except Sage bldg</td>
<td>1995</td>
<td>Forced air furnace</td>
<td>after 2020 N/A Evaluate in 2005</td>
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<tr>
<td>Cretin Campus - Sage center</td>
<td>Original</td>
<td>Hot water heat w/ gas boiler</td>
<td>after 2020 N/A</td>
</tr>
<tr>
<td>Prioritized Repair Totals</td>
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<td></td>
<td>$581,000</td>
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Holy Cross Children’s Services

• How are the Assessments Used?
  • Assessment Used as:
    – A budgeting tool for:
      • Replacement
      • Repairs
    – A fund Raising Basis
      • Justification of funds needed
      • Can coordinate topics – for example
        – Similar roofs to be repaired
        – Lower cost by quantity
    – Maintenance Tool
      • Prioritized For regional managers
Public Corporation Roofs Evaluation

The Task
• Comparative cost analysis of roofing systems
• Similar performance for each system
• Compare different building types, uses, and locations

Results
Assuming a minimal performance level:
– What are installation costs?
– What are long term (Life Cycle) costs?
– Which system provides best long term value?

Considerations
• Maintenance requirements
• Service Life
• Cost of Replacement
• Reuse of materials
• The cost of money

Locations:
Phoenix
Minneapolis
Atlanta

Building Types
Evaluated Roof Criteria
Roof Types and Initial Cost

- **Roof System 1** - Thermoset Rubber membrane on concrete deck with separate vapor retarder
- **Roof System 2** - 4-Ply built-Up Roof on concrete deck with separate vapor retarder
- **Roof System 3** - Inverted Membrane Assembly on concrete deck no vapor retarder required
- **Roof System 4a** - Thermal Plastic membrane on concrete deck with separate vapor retarder
- **Roof System 4b** - Thermal Plastic Membrane on metal deck with separate vapor retarder

Example that follows
**Roof Life Cycle – 39 Years**

- University Building in Minneapolis, MN

### Roof Systems

<table>
<thead>
<tr>
<th>Roof System</th>
<th>Total Initial Cost</th>
<th>Total Life Cycle Costs [annualized] [per Year]</th>
<th>Life Cycle Costs per Roof SF [per year]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof System 1</td>
<td>$230,230</td>
<td>$27,847</td>
<td>$1.16</td>
</tr>
<tr>
<td>Roof System 2</td>
<td>$266,380</td>
<td>$29,739</td>
<td>$1.24</td>
</tr>
<tr>
<td>Roof System 3</td>
<td>$327,269</td>
<td>$24,045</td>
<td>$1.00</td>
</tr>
<tr>
<td>Roof System 4A</td>
<td>$223,336</td>
<td>$26,266</td>
<td>$1.09</td>
</tr>
<tr>
<td>Roof System 4B</td>
<td>$234,672</td>
<td>$27,600</td>
<td>$1.15</td>
</tr>
</tbody>
</table>

- **Roof System 1**
  - Roof System 1
  - **Roof System 2**
  - **Roof System 3**
  - **Roof System 4A**
  - **Roof System 4B**

24,000 SF Roof with 96 by 250-foot Perimeter with Minimal Inspection

Roof System 3 – Inverted Membrane Assembly on concrete deck no vapor retarder required

Roof System 4a – Thermal Plastic membrane on concrete deck with separate vapor retarder
Public Corporation

We found
• They are all good roofs – but:
  • Longest lasting roof - highest initial cost – No surprise
  • Roofs had different service lives – No surprise

However
• Replacement cost - best roof is less than for others.
• Yearly maintenance costs - less for the best roof
• The life cycle cost for best roof - substantially less than for a merely good roof
• Some of the best roof’s material - reusable at the end of its service life!

The Point
• How often is a life cycle approach used for design and what are its benefits?
• Can be utilized for nearly all building systems - if you have the appropriate mindset and technical support
• Results: better service, less maintenance, and better longevity
1899 Pennsylvania Avenue

- Existing building rehabilitation
  - New curtain wall system
- Shortly after occupancy
  - Insulating glass had to be replaced

Why?

- Prestigious law firm occupies building
- Energy and comfort problems
- Cold in winter
- Excessively warm in summer
- South and West facing elevations
- The wrong glass was installed
Insulating Glass Problem

1899 Pennsylvania Avenue
Performance Difference Between Specified and Installed

<table>
<thead>
<tr>
<th>Low Emissivity Coating Type</th>
<th>U-Value</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Winter</td>
<td>Summer</td>
<td>SHGC</td>
</tr>
<tr>
<td>Low-E Soft Coat [Specified]</td>
<td>0.29</td>
<td>0.28</td>
<td>0.38</td>
</tr>
<tr>
<td>Low-E Hard Coat [Installed]</td>
<td>0.33</td>
<td>0.33</td>
<td>0.62</td>
</tr>
</tbody>
</table>

Performance Changes:
- Winter Convective Heat Loss: +14%
- Summer Convective Heat Gain: +18%
- Summer Solar Radiation Gain: +63%

Very Different Performance Between Coating Types

Visual Difference Also
Insulating Glass Replacement

All work:
Performed at night and on certain weekends
Required tenant interruption and relocation coordination
1899 Pennsylvania Avenue

Lessons Learned

- Shop drawing review
  - Architect rejects original submission
    - Incorrect Low-E coating – did not meet specification criteria
  - INADEQUATE FOLLOW UP BY EVERYONE
    - Incorrect Low-E coating is installed
  - HVAC could not compensate
    - Even with extensive “tweaking”

- $1,000,000 later
  - Specified glass installed

- Additional $’s spent for:
  - “Tweaking” back HVAC
  - Tenant relocation
  - Repairing finishes
Facility Assessments
Technology Assistance
Peer Review Services
Forensic Investigations
Contractors - Peer Review

The charge – Improve the Exterior Envelope Performance and Quality

- The process has worked for many building types
  - Office buildings
  - Hospitals
  - Agricultural service buildings
  - High level containment agricultural buildings
  - Schools
- AE Design and CD’s peer review
- Construction consultation
- Acceptance testing consultation
The Process

- Input during design
- Input during bidding
- Input during shop drawings, submittals, and mock-ups
- Periodic construction observation
- Assistance in planning and observation of testing

Laboratory Mock-Up

Construction Site Mock-Up
The Benefits

• A Neutral Third Party Review – resulting in:
  – Expertise beyond that of other parties of the design and construction team
  – Decreased risk for Owner, architect, and contractors
  – Increase quality and performance of the exterior envelope
  – Minimal cost – estimated at approximately 1 to 2 % of the cost of the exterior envelope
An Example

McCarthy Building Companies

USDA Waste Water Pretreatment Plant

- Problem: Air infiltration performance – extremely low limit
- High risk facility – biological containment
- Contractor very concerned about accomplishing required performance
- Normal building design and construction process not sufficient
The Process

- Peer review of design documents
- Submittal reviews
- Meetings with contractors
- Mock-up observations and testing
- Full time on site construction observation
- “Hands on” solution of problem details during construction
- Coordinated whole building air infiltration test

The Result

Successful test with infiltration performance exceeding that specified - less than 25% of allowable

Mock-up Air Infiltration Test

Whole Building Air Infiltration Test
2009 MIAPPA Conference

Your Building and Things That go Bump in the Night

Facility Assessments
Technology Assistance
Peer Review Services
Forensic Investigations
State Library and Archive

- **Window Condensation**
  - Occupied 1997 – condensation first winter
  - Inappropriate glass specified
  - Non-thermally improved framing specified

- **Concerns:**
  - Building must remain functional
  - Contents must have a conservation environment – 50% relative humidity
  - Contents could not be exposed to the exterior environment during correction
    - Rare irreplaceable volumes
    - Potentially damaged if moved
    - Where to store archivally?
• State Library and Archive
  – Considered and Abandoned Concepts
    • Replace Insulating Glass units
    • Replace glass/window framing system
    • Apply increased mechanical system warming of the windows
    • Decrease the archival interior environment
  – Concepts Not Workable
    • Archive contents fragile
    • Cost and disruption of window replacement
  – Evaluated Concept
    • Heat trace the window framing members
    • Thereby warming the glass also
    • How will we know if it works?
Wintertime Condensation

Shading Devices Increase the Potential for Condensation
Laboratory Test Mock-Up for CRF

Verified Installed Window System Performance

2009 MIAPPA Conference
Software Analyses – Sill Member

Existing Condition

Corrective Concept
On-Site Test Mock-Up
- Components and Aesthetics

Aluminum Receiver, Heat Trace Cable, Snap Cover

On/off Modulated by the DDC System, Heat Trace Cable Sequenced
State Library and Archive

• Results
  – The test mock-up documented temperatures agreed with the software analyses
  – The archived collection was not in jeopardy
  – Least costly aesthetic solution
  – Although heat trace has an electrical cost so does repeated humidification to replace humidity lost to condensation
  – Removes potential mold and material degradation issues
  – Reasonable disruption to daily activities

Finished Installation Appearance
Health System Data Center

– Problem: **Condensation During Construction**
  • Concrete walls
  • Metal “Z” furring
  • Electrical conduit and back boxes

– During Analysis: Discovered a Roof Problem
  • Entrapped water
Condensation During Construction

Concrete Wall
Condensation Run Down

Metal “Z” Furring
Condensation
Condensation During Construction

Electrical Box, Conduit, and “Z” Furring Cold Bridges

Roof Steel Beam Cold Bridge
Metal “Z” Furring Condensation Analysis

TVAP Analysis Illustrating Condensation Potential

Therm 5.2 Confirming Analysis and Corrective Concept
Electrical Back Box Condensation Analysis

TVAP Analysis Illustrating Condensation Potential

Therm 5.2 Confirming Analysis and Corrective Concept

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Roof Structural Component Condensation Analysis
Therm 5.2 Analyses

Existing Condition

Corrective Concept
During Analysis: Discovered a **Roof Problem**

- **Entrapped Water**
- **Preliminary Test**

*Your Building and Things That go Bump in the Night*
Concrete Cores Taken
  - Weighed, Bagged, Oven Dried, and Reweighed

3 Cores Taken for Entrapped Concrete Slab

Initial Weighing of Concrete Cores
Roof Make-up and Correction

- System included a vapor barrier and roof membrane with a 4-inch thick concrete slab and insulation between them
- Testing indicated the equivalent of $\frac{1}{2}$-inch depth of water in roof system trapped in concrete slab
  - Concrete was not sufficiently dry before being encapsulated
- What now?? It is built!
  - Roof system was periodically opened, protected and mechanically vented for a long period of time
  - Implanted sensors monitored falling moisture content until sufficiently dry to close the roof
Health System Data Center

– To Summarize

• A peer review prior to construction would have identified the condensation and roof issues
• Software and experience were able to produce a workable condensation solution
• Condensation solution could be implemented at the most opportune time - during construction
• Although not originally requested our roofing experience identified an unforeseen problem
• Roof correction could also be accomplished; however, it required a considerably longer period of time
Murphy’s Law

“Nothing is as Easy as it Looks
Everything Takes Longer Than You Expect
And if Anything Can Go Wrong,
It Will, at the Worst Possible Moment”

Clancy’s Law

“Murphy Was an Optimist”

Must Have Been Written About The Construction Industry

Old Irish Saying

“Questioning is the Door of Knowledge”
There are Some Buildings That Cannot be Saved