REPORT

In-Situ Moisture Survey of Flat Roofs

Plantation, FL

Presented to:

[Blank Space]
## TABLE OF CONTENTS

1. **INTRODUCTION**  
   1.1 Terms of Reference and Scope of Services  
   1.2 General Information  
   1.3 Assessment Work  
   1.4 Documents Reviewed  

2. **METHODOLOGY**  
   2.1 Background  
    2.1.1 What is Water Content?  
    2.1.2 Why is Water Content Important?  
    2.1.3 What is Infrared Thermography?  
    2.1.4 How Infrared Thermography Helps Locate The Wet Insulation? 4  
    2.1.5 How an Impedance Moisture Reader Measures Moisture Content? 5  
   2.2 The Apparatus  
    2.2.1 Infrared Imaging System  
    2.2.2 Moisture Meter  
    2.2.3 Drying Oven  
    2.2.4 Scale  
    2.2.5 Photo and Video Devices  
   2.3 The Procedure  
    2.3.1 Laboratory Measurement of Moisture Content  
   2.4 The Results  

3. **CONCLUSIONS**  
   3.1 Findings.  
   3.2 Recommendations.
3.3 Further Assessment/Testing

3.4 Final Remarks

**APPENDIX A:** Scope of Work

**APPENDIX B:** Roof Plans

**APPENDIX B:** Other Observations, Findings, and Recommendations
1. INTRODUCTION

1.1 Terms of Reference and Scope of Services

We were retained by [Redacted] to survey the moisture contents of the thermal insulation in roofing systems installed at the [Redacted].

The scope of our services was provided in our proposal letter dated May 9, 2011 and is included in Appendix A for reference purposes.

1.2 General Information

The [Redacted] is a 9-story tall structure of rectangular plan, located in Plantation, FL, built in 1992, and covered with six bituminous roofs.

Figure 1. The satellite view of the building obtained from the Broward County appraiser's website.

1.3 Assessment Work

The assessment field work was carried out on site on the following days:

- 7/14/2011 (nighttime IR survey),
- 7/15/2011 (core moisture level probing),
- 7/29/2011 (core specimen collection),
- 7/31/2011 (measurement of areas identified above the 8% threshold).

Observations and tests were conducted by Karol Kazmierczak (Kaz), AIA,ASHRAE,CSI,CDT,LEED-AP,NCARB, the Senior Building Science Architect of Building Enclosure Consulting, LLC and Cesar Soto, PE of Paramount Consulting and Engineering, LLC. The building maintenance staff provided access to the restricted areas.

1.4 Documents Reviewed
We reviewed two architectural drawing sheets produced by Thompson, Ventulett, Stainback & Associates Architects bearing numbers 2A-2.6 and 4A-6.2 including roof plan and roof details.

We found the design consisted of at least three different roofing systems:
- a built-up system over a cover board and 2" of insulation over a cast-in concrete deck,
- a built-up system over a cover board and 2" of insulation over a steel deck,
- built-up roofing membrane adhered onto a cellular lightweight insulating concrete poured over a corrugated steel deck, with embedded boards of min. R-19 insulation suspended 1" above the steel deck and separated from each other by 2" wide gaps filled with the lightweight concrete.

(The dimensions listed above were extrapolated because details do not provide specific dimensions relevant to the roofing makeup.)

Figure 2. Architectural plan of the upper roofs.
2. METHODOLOGY

The field work was conducted in accordance to the ASTM standard C1153, titled "Standard Practice for Location of Wet Insulation in Roofing Systems Using Infrared Imaging."

2.1 Background

2.1.1 What is Water Content?

Water content or moisture content is the quantity of water contained in a material. Two typical scales are used: Volumetric water content (expressed by volume ratio) and Gravimetric water content (expressed by mass ratio). The latter one is the subject of this document, and all references to moisture or water content should be read as the gravimetric moisture content, also represented by the abbreviation MC..

2.1.2 Why is Water Content Important?

Moisture trapped in an existing roofing adversely impacts its performance in several ways, including but not limited to the following aspects:

- The phase change of water (e.g. condensation and evaporation) causes large changes of volume and results in the gradual mechanical damage (e.g. this phenomena often results in common membrane blisters).
- The moisture reduces the tensile strength of built-up roofing materials.
- Moisture increases the thermal conductance of insulative materials; decreasing the thermal comfort in the adjacent spaces and increasing energy expenditures.
- Moisture also causes excessive foaming of a hot-applied adhesive and coating materials, such as hot asphalt, challenging the installation, compromising integrity of the adhesion, and causing pinhole craters which may lead to water intrusion.

Presence of moisture may indicate a potential roofing failure or a construction defect, such as rain water intrusion, or undesired water vapor diffusion, or incorporation of wet materials during the original installation.

The above consideration made the moisture content and moisture emission a benchmark for roofing specifications, as well as an indicator for failure investigations.
Figure 3. The infrared image of a suspect area at gridlines 21C-22C. The subsequent MC reading #17 confirmed the medium moisture content.

2.1.3 What is Infrared Thermography?

According to the American Society of Testing Materials, Standard ASTM C1153 titled "Standard Practice for Location of Wet Insulation in Roofing Systems Using Infrared Imaging:" the infrared thermography is the process of generating images that represent variations in infrared radiance of surfaces of objects.

2.1.4 How Infrared Thermography Helps Locate The Wet Insulation?

Water has a high heat storage capacity, as compared to other common materials. Therefore, the heat stored in wet materials can be detected with a thermographic equipment. This is best achievable following a change of surrounding thermal conditions, e.g. after sunset, because these materials would appear comparatively hotter than the adjacent areas.

There are many potential situations, such as e.g. presence of sand or water on the roofing surface, and differences in surface emissivities may produce distorted or irrelevant readings; therefore, this method requires a knowledgeable operator and is only used for initial reconnaissance.
2.1.5 How an Impedance Moisture Reader Measures Moisture Content?

The portable moisture "pin" readers measure electrical resistance between two pin electrodes driven into the material, and translates it into a reading of the approximate moisture content. The reading varies depending on the type of material measured, and therefore they are typically suitable for comparative measurements among same materials only. Calibration is performed by comparing the readings to the water content results obtained via laboratory measurements.

2.2 The Apparatus

2.2.1 Infrared Imaging System

We used the thermal imager IRISYS IRI 4010 produced by InfraRed Integrated Systems Limited, described by the following list: The imager's FOV is 20ºx15º, Spectral Response 8µm to 14µm, Thermal Sensitivity NETD ≤100mK (0.10ºC)@23ºC ambient and 25ºC scene temperature, Detector 160x120 pixels, uncooled microbolometer, Temperature range -10ºC to +250ºC, Radiometry by two movable temperature measurement cursors, User selectable emissivity correction from 0.1 to 1.0 in steps of 0.01 with reflected ambient temperature compensation. Accuracy is the greater of ±2ºC or ±2% of reading in ºC for ambient temperature -15ºC to +45ºC. The camera was calibrated in-house and found to consistently indicate +4.7ºC on 07/10/2011. The thermograms are displayed on 3 1/2" color LCD display and stored on an Secure Digital (MMC/SD) card, a built-in Class 2 laser is supplied to highlight the central measurement area.

2.2.2 Moisture Meter

We used the moisture meter BD-10 produced by Delmhorst. This is an impedance meter, which has two pin ports and features an analog readout with 0 to 100 reference scale for non-wood materials. Two custom-made 3 1/2" long pins were attached to the ports. In-device calibration was verified on 07/14/2011 and 07/24/2011.

2.2.3 Drying Oven

We used the custom-made air-forced electrical drying oven controlled by a mechanical thermostat, and we monitored the temperature by a contact thermometer with a digital display visible from the front and a contact temperature sensor, both placed at the air exhaust. The sensor temperature range is -40º to 135º C (-40º to 275º F) and its resolution in the 100º to 135º C range is 0.25º C. The sensor was connected to the data logger which logged the temperature every 30 seconds. No other materials were present in the
oven at the oven at the time. The exhaust air temperature as a function of
time is plotted on the chart below.

![Exhaust Air Temperature Chart](chart1)

Chart 1. Chart representing the exhaust air temperature.

### 2.2.4 Scale

We used the laboratory scale VB-302A manufactured by Virtual
Measurements & Control Inc. This is a bench scale of capacity 600 grams
and resolution 0.01 gram. This scale was calibrated on 07/15/2011.

### 2.2.5 Photo and Video Devices

The conditions and the survey process were selectively recorded by
camcorder Sony HDR-CX550 and camera Panasonic LUMIX DMC-FZ18.

### 2.3 The Procedure

The process included the following steps:

1. The architectural plan sheet was used as a field recording sheet for
each roof deck. A reference point and two dimensional axis system (x-
axis and y-axis) were established. The reference grid was found to be
already marked on the roofing.

2. A checklist was used to ensure that all necessary equipment, supplies
and documentation are available and operational for the moisture
survey.

3. We visually determined potential problem areas before sunset;

4. Using the infrared thermography we found hot spots on the roofing
surface. We adjusted our readings for the following conditions:
   - underdeck heating or cooling units that may affect a limited area of the
     roofing above;
   - venting of hot fumes which can cause ‘hot trails’;
• daytime shading caused by sunlight obstructions (i.e., trees, billboards, adjacent building, or intermittent clouds) of the roof surface causing uneven heat conduction;
• moisture and ponded water on the roof surface; we found them below air conditioning units on roofs #4 and #5.
• sand and gravel on the roof surface,
• windy conditions at the roof top level potentially causing irregular infrared readings due to convection across the roof surface.
• roof patches; due to their very large number, we did not convey their locations on the attached roof plan for clarity.
• we also excluded areas covered with equipment curbs, boots, and pitch pockets. These were found particularly dense on the roof #4, where two chillers are located. Due to their number, we only fragmentarily marked them on the roof plan for clarity.
• we also excluded the areas covered by the equipment loose-laid on the roof, such as concrete-block weighted antenna platforms on the roof #5 and weighted conduit raceways populating the roof #1.
• we also adjusted for the delaminated and blistered areas. Membrane delamination was found to be particularly populous at the southern portion of the roof #5.

5. We marked the hot spots on the roofing surface with a yellow and green spray paint.

6. At 43 marked locations, we took relative moisture readings from the core of the lightweight concrete insulation located 3" below the roofing surface, and noted them. We also noted the temperature for reference adjustments.

7. Using a liquid reinforced asphaltic roofing cement applied with a spatula, we fixed the roof penetrations created by core readings, and we double-checked to make sure we sealed them all.

8. The probed areas which exhibited high moisture reading or exhibited water squeezing from the penetrations, or large blistering were marked with word "WET." Other areas were outlined with orange spray, indicating medium moisture content. These areas which were found at par with the remainder of the roofing, were marked with the word "DRY."

9. Using a 2" diameter core drill, we took core specimens at three previously measured locations (core readings #11, 12, and 34) representing dry, moist, and wet conditions. These reference specimens were subsequently used to verified their moisture content by laboratory measurements as described in the paragraph 2.3.1 below.
10. Results from the gravimetric analysis were used to calibrate the relative moisture readings taken earlier as described in the paragraph 2.3.1 below.

11. **Roof Composition.** In course of the core drilling, we noted the following makeup of the roofing:

   - 1/2" built-up asphaltic membranes (thicker at a patch location #12)
   - 1.75"-2.5" lightweight cellular concrete
   - up to 5.25" of expanded polystyrene foam (EPS)

(Maximum total roofing depth found: 7.5 inch)

This composition is similar to one of the roofing systems found during the design review (p. 1.4), made of a built-up roofing system on a lightweight concrete on a steel deck, with embedded expanded polystyrene foam. We have not found any mechanical fastening; also, we have not seen any pattern indicating the mechanical fastening and gaps among EPS boards while performing the IR survey.

![Figure 4](image-url). The infrared picture of a suspect area at gridline 20F. Dark area behind is the roofing surface is surface-wetted by the condensate dripping from the AC unit. The subsequent MC reading #18 confirmed the roofing insulation is wet.
2.3.1 Laboratory Measurement of Moisture Content

In order to quantify the readings from the impedance moisture reader, three core cuts were cut and removed for further testing at locations earlier identified as dry, moist, and wet. Following the modified ASTM Test Method D 1864, the specimens were immediately double-bagged in water-vapor impermeable polyethylene film to avoid any loss of moisture during storage and transportation, and subsequently weighted with 0.01g precision, and dried in a ventilated oven at 115°C ±3°C, and then weighted again. After approximately 12 hours, once the weight stabilized, the difference between the two readings divided by the latter reading indicated the moisture content by mass. Due to the composition of the roof, and heat vulnerability of the other components, this method was used only with respect to the lightweight concrete specimens. Other specimens have been weighted and stored in a dessicator.

The resulting gravimetric moisture content was correlated with the impedance readings, as illustrated in the table below. The resulting average multiplier was found to be 0.46 times the impedance reading, and was used to calculate the moisture content of the locations core-probed by the impedance meter, and listed in the table below. The deviation in the correlation was found to be ±1% of the moisture content.

<table>
<thead>
<tr>
<th>sample</th>
<th>multiplier</th>
<th>Delmhorst</th>
<th>MC oven</th>
<th>deviation</th>
<th>original</th>
<th>dry</th>
<th>difference</th>
<th>MC</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>0.48344</td>
<td>15%</td>
<td>7.3%</td>
<td>0.02416</td>
<td>50.73</td>
<td>47.3</td>
<td>3.43</td>
<td>0.072516</td>
</tr>
<tr>
<td>#3</td>
<td>0.46315</td>
<td>20%</td>
<td>9.3%</td>
<td>0.003868</td>
<td>71.6</td>
<td>65.53</td>
<td>6.07</td>
<td>0.092629</td>
</tr>
<tr>
<td>#2</td>
<td>0.43125</td>
<td>35%</td>
<td>15.1%</td>
<td>-0.02803</td>
<td>38.05</td>
<td>33.06</td>
<td>4.99</td>
<td>0.150938</td>
</tr>
<tr>
<td>average multiplier</td>
<td>0.46</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.4 The Results

a) The results are tabulated in the table below. The numbers in the far left column represent the number of the core reading and correspond with numbers shown on the map on the next page and in the Appendix B.

<table>
<thead>
<tr>
<th>core reading number</th>
<th>Delmhorst Impedance Reading</th>
<th>average MC%</th>
<th>range upper</th>
<th>range lower</th>
<th>Interpretation</th>
<th>size of the area (sf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>22</td>
<td>10.1</td>
<td>11</td>
<td>9</td>
<td>MOIST</td>
<td>entire roof</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>9.2</td>
<td>10</td>
<td>9</td>
<td>MOIST</td>
<td>entire roof</td>
</tr>
<tr>
<td>3</td>
<td>28</td>
<td>12.9</td>
<td>14</td>
<td>12</td>
<td>MOIST</td>
<td>entire roof</td>
</tr>
<tr>
<td>4</td>
<td>Beyond Scale unverified</td>
<td></td>
<td></td>
<td></td>
<td>WET</td>
<td>244</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>9.2</td>
<td>10</td>
<td>9</td>
<td>MOIST</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>18</td>
<td>8.3</td>
<td>9</td>
<td>8</td>
<td>MOIST</td>
<td>11</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>Beyond Scale</td>
<td>unverified</td>
<td></td>
<td>WET</td>
<td>63</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>Beyond Scale</td>
<td>unverified</td>
<td></td>
<td>WET</td>
<td>48</td>
</tr>
<tr>
<td>9</td>
<td>30</td>
<td>13.8</td>
<td>15</td>
<td>13</td>
<td>WET</td>
<td>48</td>
</tr>
<tr>
<td>10</td>
<td>22</td>
<td>10.1</td>
<td>11</td>
<td>9</td>
<td>MOIST</td>
<td>63</td>
</tr>
<tr>
<td>11</td>
<td>35</td>
<td>15.0</td>
<td></td>
<td></td>
<td>CORE SAMPLE</td>
<td>WET</td>
</tr>
<tr>
<td>12</td>
<td>14</td>
<td>7.0</td>
<td></td>
<td></td>
<td>CORE SAMPLE</td>
<td>DRY</td>
</tr>
<tr>
<td>13</td>
<td>20</td>
<td>9.2</td>
<td>10</td>
<td>9</td>
<td>MOIST</td>
<td>96</td>
</tr>
<tr>
<td>14</td>
<td>22</td>
<td>10.1</td>
<td>11</td>
<td>9</td>
<td>MOIST</td>
<td>72</td>
</tr>
<tr>
<td>15</td>
<td>20</td>
<td>9.2</td>
<td>10</td>
<td>9</td>
<td>MOIST</td>
<td>150</td>
</tr>
<tr>
<td>16</td>
<td>15</td>
<td>6.9</td>
<td>7</td>
<td>6</td>
<td>DRY</td>
<td>n/a</td>
</tr>
<tr>
<td>17</td>
<td>20</td>
<td>9.2</td>
<td>10</td>
<td>9</td>
<td>MOIST</td>
<td>375</td>
</tr>
<tr>
<td>18</td>
<td>35</td>
<td>16.1</td>
<td>17</td>
<td>15</td>
<td>WET</td>
<td>52</td>
</tr>
<tr>
<td>19</td>
<td>30</td>
<td>13.8</td>
<td>15</td>
<td>13</td>
<td>WET</td>
<td>32</td>
</tr>
<tr>
<td>20</td>
<td>22</td>
<td>10.1</td>
<td>11</td>
<td>9</td>
<td>MOIST</td>
<td>120</td>
</tr>
<tr>
<td>21</td>
<td>20</td>
<td>9.2</td>
<td>10</td>
<td>9</td>
<td>MOIST</td>
<td>75</td>
</tr>
<tr>
<td>22</td>
<td>15</td>
<td>6.9</td>
<td>7</td>
<td>6</td>
<td>DRY</td>
<td>n/a</td>
</tr>
<tr>
<td>23</td>
<td>15</td>
<td>6.9</td>
<td>7</td>
<td>6</td>
<td>DRY</td>
<td>n/a</td>
</tr>
<tr>
<td>24</td>
<td>20</td>
<td>9.2</td>
<td>10</td>
<td>9</td>
<td>MOIST</td>
<td>20</td>
</tr>
<tr>
<td>25</td>
<td>16</td>
<td>7.3</td>
<td>8</td>
<td>7</td>
<td>DRY</td>
<td>n/a</td>
</tr>
<tr>
<td>26</td>
<td>17</td>
<td>7.8</td>
<td>8</td>
<td>7</td>
<td>DRY</td>
<td>n/a</td>
</tr>
<tr>
<td>27</td>
<td>17</td>
<td>7.8</td>
<td>8</td>
<td>7</td>
<td>DRY</td>
<td>n/a</td>
</tr>
<tr>
<td>28</td>
<td>15</td>
<td>6.9</td>
<td>7</td>
<td>6</td>
<td>DRY</td>
<td>n/a</td>
</tr>
<tr>
<td>29</td>
<td>20</td>
<td>9.2</td>
<td>10</td>
<td>9</td>
<td>MOIST</td>
<td>48</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>Beyond Scale</td>
<td>unverified</td>
<td></td>
<td>WET</td>
<td>15</td>
</tr>
<tr>
<td>31</td>
<td>18</td>
<td>8.3</td>
<td>9</td>
<td>8</td>
<td>MOIST</td>
<td>36</td>
</tr>
<tr>
<td>32</td>
<td>35</td>
<td>16.1</td>
<td>17</td>
<td>15</td>
<td>WET</td>
<td>20</td>
</tr>
<tr>
<td>33</td>
<td>22</td>
<td>10.1</td>
<td>11</td>
<td>9</td>
<td>MOIST</td>
<td>100</td>
</tr>
<tr>
<td>34</td>
<td>22</td>
<td>9.0</td>
<td></td>
<td></td>
<td>CORE SAMPLE</td>
<td>MOIST</td>
</tr>
<tr>
<td>L1</td>
<td>18</td>
<td>8.3</td>
<td>9</td>
<td>8</td>
<td>MOIST</td>
<td>203</td>
</tr>
<tr>
<td>L2</td>
<td></td>
<td>Beyond Scale</td>
<td>unverified</td>
<td></td>
<td>WET</td>
<td>80</td>
</tr>
<tr>
<td>L3</td>
<td>22</td>
<td>10.1</td>
<td>11</td>
<td>9</td>
<td>MOIST</td>
<td>176</td>
</tr>
<tr>
<td>L4</td>
<td>15</td>
<td>6.9</td>
<td>7</td>
<td>6</td>
<td>DRY</td>
<td>n/a</td>
</tr>
<tr>
<td>L5</td>
<td>14</td>
<td>6.4</td>
<td>7</td>
<td>6</td>
<td>DRY</td>
<td>n/a</td>
</tr>
<tr>
<td>L6</td>
<td>15</td>
<td>6.9</td>
<td>7</td>
<td>6</td>
<td>DRY</td>
<td>n/a</td>
</tr>
<tr>
<td>L7</td>
<td>14</td>
<td>6.4</td>
<td>7</td>
<td>6</td>
<td>DRY</td>
<td>n/a</td>
</tr>
<tr>
<td>L8</td>
<td>15</td>
<td>6.9</td>
<td>7</td>
<td>6</td>
<td>DRY</td>
<td>n/a</td>
</tr>
<tr>
<td>L9</td>
<td>18</td>
<td>8.3</td>
<td>9</td>
<td>8</td>
<td>MOIST</td>
<td>184</td>
</tr>
</tbody>
</table>
Figure 5. The overall plan of the roof with the core readings marked in sequential numbers. See also the plans reproduced in the Appendix B.
The area ratios were summarized for your convenience below:

<table>
<thead>
<tr>
<th>Roof #</th>
<th>approximate total moist and wet area (sf)</th>
<th>approximate total area (sf)</th>
<th>percentage area above the 8% threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof 1</td>
<td>5,718</td>
<td>5,718</td>
<td>100%</td>
</tr>
<tr>
<td>Roof 2</td>
<td>257</td>
<td>257</td>
<td>100%</td>
</tr>
<tr>
<td>Roof 3</td>
<td>405</td>
<td>405</td>
<td>100%</td>
</tr>
<tr>
<td>Roof 4</td>
<td>74</td>
<td>1,828</td>
<td>4%</td>
</tr>
<tr>
<td>Roof 5</td>
<td>1,820</td>
<td>13,074</td>
<td>14%</td>
</tr>
<tr>
<td>Roof 6</td>
<td>643</td>
<td>4,031</td>
<td>16%</td>
</tr>
</tbody>
</table>

3. CONCLUSIONS

On basis of our observations, testing, and measurements, we identified the gravimetric moisture content of areas of the lightweight concrete insulation serving as a substrate of the roofing system installed in the building.

3.1 Findings.

The gravimetric moisture content was summarized in the table above, corresponding with the map reproduced above. Also, for your convenience, the moist and wet areas were marked directly on the roofing surface with an acrylic paint.

3.2 Recommendations.

We recommend the moist and wet concrete areas are dried, and the deficient membrane areas are renewed.

3.3 Further Assessment/Testing

There is no further testing necessary to fulfill the stated purpose of this moisture survey.

3.4 Final Remarks

This document has been prepared to assist you in the identification of the moisture content of the roofing installed on the building. The comments contained in this report are not to be viewed as being fully comprehensive in nature, but are representative of observed conditions. We have no other direct knowledge of (and offer no warranty regarding) any concealed...
conditions that may subsequently affect the performance of the various building systems beyond what was revealed during our site visit.

We reserve the right to alter or amend our comments regarding these items if new circumstances associated with the condition of the project site or materials are brought to light by further investigations at a later date. If you have any questions regarding these observations or our general conclusions, please contact me at your earliest convenience at my cell number (786) 877-7108.

We thank you for your confidence in Building Enclosure Consulting LLC.

Karol Kazmierczak  AIA,ASHRAE,CSI,CDT,LEED-AP, NCARB

Senior Building Science Architect
APPENDIX A:
Scope of Services
Base Scope of Services

Background Document Review: We will review any available construction documentation, submittals, ASI’s, and RFI’s related to the failed assemblies, and current and past maintenance logs and documents, any past failure investigation reports. This review is necessary for us to become familiar with the complex building enclosure details prior to undertaking the fieldwork.

Visual Observation: We will visit the site and visually examine the roof and adjacent assemblies.

Moisture Survey: We will perform testing per the ASTM standard C1153, titled "Standard Practice for Location of Wet Insulation in Roofing Systems Using Infrared Imaging."

Reporting: Following the visual review and testing, we will provide a written report documenting observations and findings, including detailed analysis and possible solutions. Photographs of the chosen observations will be included in the report. Observed deviations from the construction documentation will also be reported. If any moisture is detected, we will mark its extent on the roofing surface and provide a dimensioned plan.

Limitations

This scope of work is intended to provide a specific assessment of the present conditions of compromised areas of the building envelope as related to the weatherization function and repair recommendations only. Depending on the extent and nature of any problems that may be observed, additional forensic work may be recommended to aid in confirming the general extent of the problems and allow development of a scope of repairs.

Specifically excluded are: performing any repairs including the repair of the exploratory openings, the assistance in negotiating with an original builder, original architect, neighbors, and authorities having jurisdiction, fire and life safety issues, and assistance in litigation support.

The work will require nighttime access to the roofs. We assume such an access will be provided instantly, and will not be limited or delayed. Otherwise, we will charge extra for the time spent waiting for the access, by the hourly rate.

These services would be provided under a separate proposal if required.
APPENDIX C:
Other Observations, Findings, and Recommendations.
In course of our work, we made a number of observations besides the moisture survey. The roof is often considered the most important part of a building enclosure; therefore, we would like to share the list below, in which we emphasized performance aspects relevant to perils of the High Velocity Hurricane Zone, in which the building is located:

1. Uplift resistance. We observed a poor cohesive strength of the lightweight concrete and the expanded polystyrene foam specimens obtained from the core drilling. Also, we found no indication of a mechanical attachment. Roof #1 and Roof #6 are not protected by tall parapet walls, which would reduce roof uplift loads. Wind pressure increases with height, so this would be particularly important for the Roof #1 (the top roof of the building) due to its wind exposure.

Therefore, based on the observations of the core specimens and our general observations, we recommend the bond-plate pull tests following the FBC Testing Application Standard (TAS) Appendix D to be used in order to verify the wind uplift resistance. If a remedial attachment by mechanical fasteners engaging the roofing to the underlying steel deck is found to be necessary; such a fastening would be least expensively done prior to re-roofing.

We also observed a number of permanent equipment items lacking a positive attachment to the building structure, such as conduits, and antennas weighted with concrete blocks. These items present a windborne debris blow off hazard. Their attachment should be engineered to withstand the code-prescribed combinations of loads.

2. Puncture Resistance. Puncture resistance describes the roofing resistance against windborne debris perforation. This is of paramount importance for flat roof crowded with antennas and mechanical equipment, which are challenging to temporary protect (e.g. tarp) after a wind event. The existing 1/2” thick built-up roofing adhered onto a concrete substrate has a superior puncture resistance, which would be difficult to match with any other roofing material.

3. Movement Resistance. The differential structural movement between the midspans of the roofing decks and the adjacent walls is not accommodated within the existing system, leading to cracking, stretching, and moisture-related failures observed along bottoms of walls. Such a transition can be spanned by the majority of modern, elastic roofing membranes using inorganic reinforced felts. Due to their compatibility with the existing system, asphalt-based materials, (e.g. SBS) would be recommended for the base flashing.

4. Adjacent assemblies. We observed failed sealant joints and open flashing joinery around roofing, resulting from their differential movement exceeding the sealant movement capability. These deficiencies of
adjacent flashing and joinery are known to contribute to rain water intrusions. They are particularly pronounced around the Roof #6, which is surrounded by a bare concrete coping; and this kind of a coping is also known to allow for rain water intrusion. The conspicuous water-related deficiencies would need to be repaired to avoid wetting of the roof assembly.

5. Delamination. We observed numerous areas exhibiting delamination or lack of adhesion between layers of bituminous membrane, including blisters, and fishmouths. Also, the core drilling #12 exhibited delaminated membranes. These areas should be cut open, dried, and removed prior to repairs.

6. Prolonged Wetting. Many areas were observed to be subjected to a prolonged water exposure, including the areas wetted by the direct condensate discharge from AC units on roofs #4 and #5. These surfaces were also typically observed to suffer a loss of aggregate, indicative of the membrane deterioration. Their surface temperature was observed to be elevated disproportionally to the later-measured core moisture content, indicating high water content in the membrane itself. Such areas should be re-sloped to achieve positive drainage, wherever possible. The deteriorated membrane should be replaced. Condensate should be collected by a dedicated plumbing and discharged directly into the storm leaders.

Figure 6. Conspicuous water-related flashing and sealing deficiencies at the Roof #6.