





Evaluation and Testing

Wright Brothers National Memorial Monument

CAPE HATTERAS NATIONAL SEASHORE

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ANA Job No. 16-115
February 6, 2017

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1.0 INTRODUCTION

An investigative program was carried out at the Wright Brothers National Memorial Monument, located in Kill Devil Hills, North Carolina. The objectives of the work were to 1) determine as-built conditions that may be leading to moisture infiltration; 2) evaluate potential moisture intrusion pathways using nondestructive and minimally destructive methods. Engineer Michael Schuller of Atkinson-Noland was present on site November 29 to December 1, 2016, with Wayne Ruth of Masonry Solutions, and Chris Rhodes and Brad Siver of Amidon. McGee and Sons Plumbing was also on site to conduct roof drain leak tests and videoscope surveys.

The following diagnostic procedures were carried out as part of the investigative program.

- Surface penetrating radar scans
- Infrared thermography imaging
- Pachometer metal scanning
- Videoscope examination at drilled holes
- Laboratory chloride testing of mortar samples and stone scrapings
- Roof drain water leak test
- Drain pipe videoscope surveys
- Stone paver investigations
- Foundation space investigation

This report includes a description of tests conducted both on site and in the laboratory, investigative results, discussion, and conceptual recommendations for addressing moisture infiltration and other issues.

2.0 SURFACE PENETRATING RADAR SCANNING

Surface Penetrating Radar (SPR) is a nondestructive method typically used to determine subsurface conditions of building elements, locate structural reinforcing bars, locate regions of deterioration or distress, and evaluate internal moisture content. On this project SPR was instrumental in providing information to better understand construction typology at stone masonry and concrete sections. SPR and other techniques described in this report were used at interior and exterior walls, to map concealed subsurface conditions. The SPR system was calibrated on a solid stone stair wall at the lobby level to arrive at an appropriate dielectric constant for system setup. Note that moisture and salts attenuate microwave radar signals, reducing penetration depth and complicating data interpretation. Scans were able to resolve features within about 12 inches of the wall face; at some locations signals were able to penetrate 24 inches or deeper into the section.

SPR techniques use reflections of microwave energy to identify internal anomalies. A GSSI SIR-3000 radar unit was used with a 1500 MHZ antenna mounted in a wheeled trolley for on-site scanning. The method provided information on the interior makeup of scanned sections, including:

- as-built conditions,
- detecting voids or rubble fill behind stone at the interior of walls,
- locating, conduit, and roof drains,
- determining thickness of concrete sections,
- locating reinforcement in concrete sections.



Figure 1. Surface penetrating radar scanning. Left: calibration at stone in lobby; right: scanning at interior concrete, 2nd level.

A total of 26 radar scans were conducted at interior and exterior wall sections. Radar scan locations are shown in the section drawing included in Appendix A. Data was post-processed in the office for interpretation; all radar scans are included in Appendix B.

Radar scanning provided several significant discoveries and conclusions:

1. Walls are significantly wet or saturated at all locations scanned, with a likely high salt content. Both of these conditions attenuate microwave energy, limiting the investigation depth.
2. Scans from the interior, at concrete walls, show horizontal and vertical reinforcement near the interior wall face. A second reinforcement layer was not detected at depth within the wall; detection is likely limited by saturated conditions. See Appendix B scans 003, 004, and 017 to 029.
3. Scans through concrete taken from the interior were intended to detect concrete thickness. Due to attenuative effects described above, concrete thickness was rarely detected by scans. The exceptions are at scan 018, where a reflection that could be the back of the concrete was observed at a depth of 2’-0”; also seen in this scan is what could be a layer of reinforcement at a depth of 1’-6” from the interior face. A similar slight reflection is seen in Scan 021 at a depth of 2’-0”.
4. A series of scans conducted from the exterior, at the south stone wall just east of the entry door, detected an embedded metal drain pipe leading from the gutter above the entry door. The drain pipe is located approximately 10 inches deep from the exterior wall surface; stone thickness at this location is greater than 18 inches. The drain pipe appears to be 4 inches diameter. See Appendix A scan 005.
5. Two scans conducted at the north elevation cornerstone detected a strong metallic signature behind the cornerstone. There appears to be a metallic box or plaque behind the cornerstone, measuring approximately 10 inches high by 14 inches wide. See Appendix A scan 6 and 7.
6. Stone thickness facing lobby walls varies from 8 to 10 inches at the east and west walls, to 14 to 15 inches thick at the south wall. Reflections at the backs of stones ranged from very strong, indicating voids behind stones, to somewhat strong, likely meaning the space between stones is filled with mortar or grout.
7. A void signature appears in several vertical scans at the east and west lobby walls, (See Appendix A scans 009, 013, and 014). This strong reflection suggests a significant void exists approximately 40 inches from the interior face, possibly behind exterior facing stones. The

height of this void above the lobby floor puts the void space between grade and 2’-6” above grade at the exterior.

8. Scans at the south wall show stones 14 to 15 inches thick, with a significant void (or saturated mortar) between interior and exterior stones. Mortar head joints appear to be empty or delaminated from adjacent stone. See Appendix A scan 011.

3.0 PACHOMETER SCANNING

An eddy-current pachometer was used to calibrate and supplement SPR scanning. The pachometer detects embedded metals, and, at locations where SPR scans provided reinforcement depth, the pachometer was used to estimate reinforcement diameter. The pachometer was used mainly at structural concrete walls for scanning at interior surfaces. Results of pachometer scanning are combined with SPR results in the above SPR discussion section.



Figure 2. Pachometer scanning to search for metal stone anchors at the lobby.

4.0 INFRARED THERMOGRAPHY

Infrared thermography techniques measure heat emitted from surfaces to identify general condition, moisture, and subsurface anomalies. Transmission and emission of heat energy is affected by moisture content, internal voids, variations in materials or construction quality, and near-surface delaminations and spalls. A FLIR T420 thermal imaging camera was used to image the entire exterior and portions of the interior wall surfaces.



Figure 3. Infrared thermography scanning.

Interior temperatures were intentionally elevated using the Monument's dehumidifier system beginning Monday November 28, to provide a thermal gradient across wall sections. Two space heaters were also installed the morning of November 29 at the second and third levels to augment heat generated by the dehumidifier system.

Thermograms were captured throughout the Memorial exterior and at some interior lobby walls at three different times:

1. Prior to roof drain moisture tests, between 2:14 and 2:35 p.m. on Tuesday November 29.
2. During roof drain moisture tests between 7:08 and 8:43 a.m. on Wednesday November 30
3. At the conclusion of the heating cycle before sunrise and after a minor rain event, between 6:31 and 6:55 a.m. on Thursday, December 1.
4. Miscellaneous scans at lobby and interior concrete walls, between 9:02 and 10:55 a.m. on Thursday, December 1.

A total of 147 thermal MSX images were recorded for analysis and interpretation; a corresponding visual light photograph was taken with each thermal image. Infrared images are provided in Appendix C. A Tramex moisture meter was also used at isolated locations in the lobby to validate and augment moisture-related findings of the infrared surveys.

Significant observations made as a result of infrared thermography scans are illustrated and discussed below.

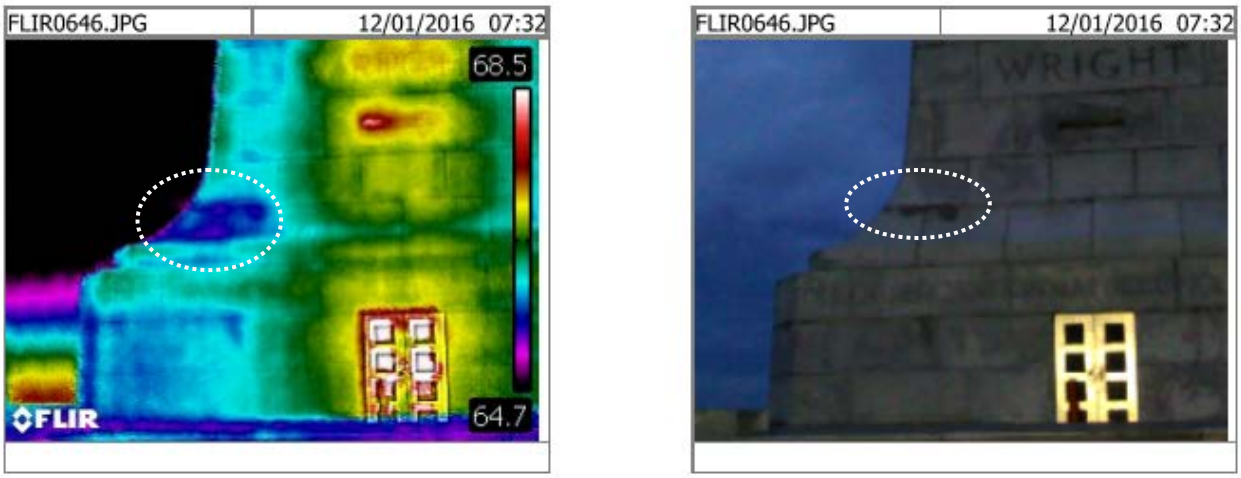


Figure 4. Exterior image taken after a rain event. Bulk water is observed and detected leaking from joints, at a joint where flashing is indicated on original construction details.

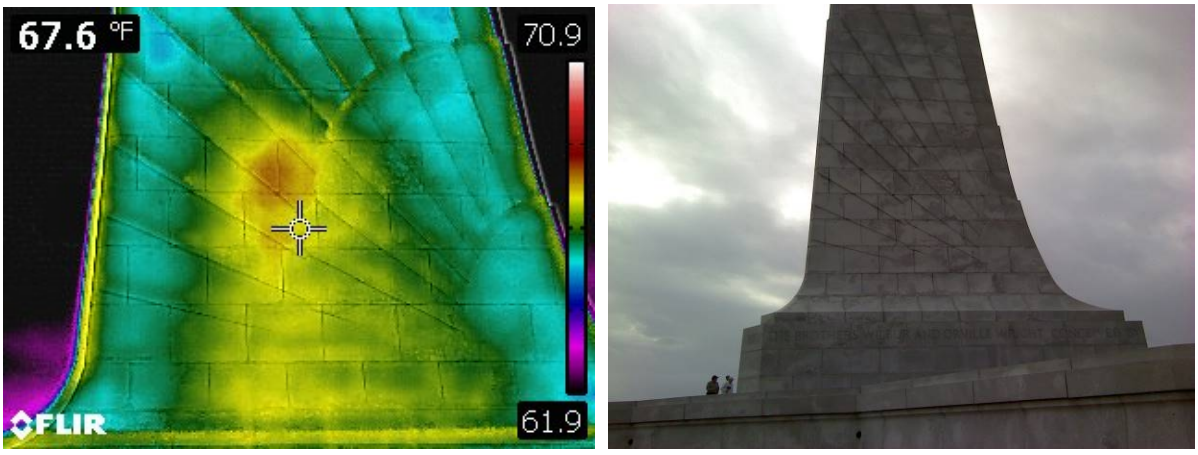


Figure 5. Internal heat penetrating through walls; walls are thinnest at the center portion and correspondingly these areas show the greatest temperatures. See plan drawing in Appendix A for wall thickness. Uneven surface appearance is not evident in infrared image, suggesting color variations are not caused by moisture variations.

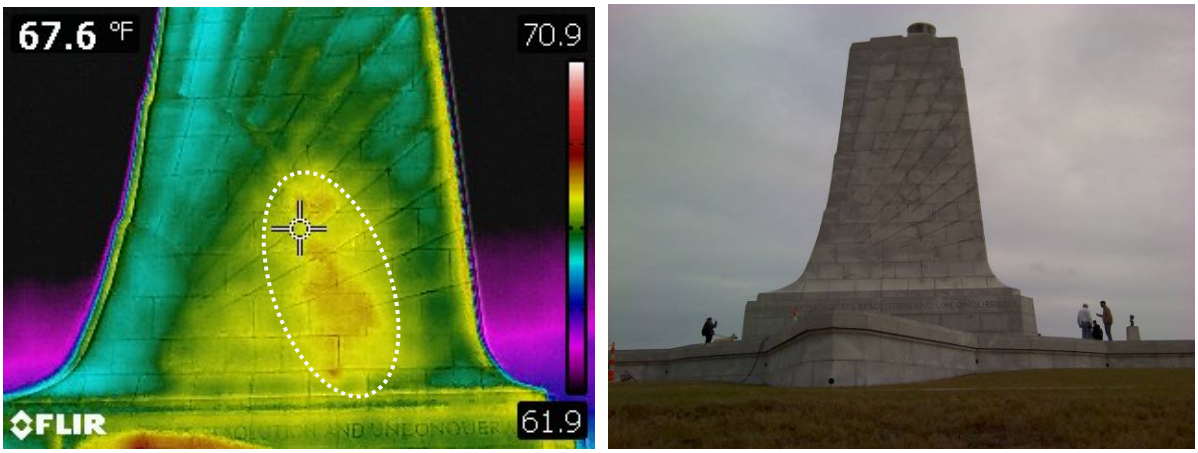


Figure 6. Heating effect apparent. Slight temperature differentials (reddish-orange zones) suggest differential internal construction. Uneven surface appearance is not evident in infrared image.

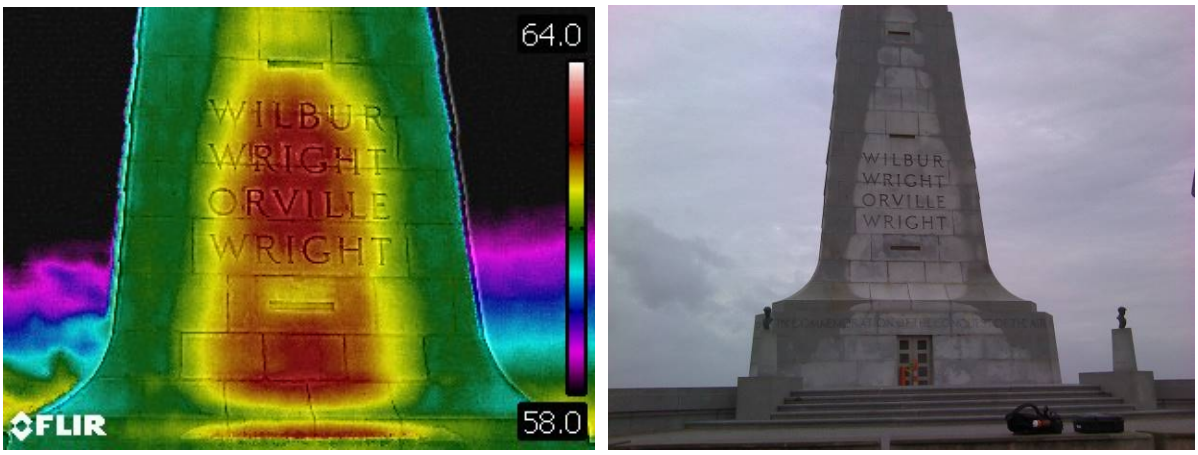


Figure 7. After 2 days of internal heating, temperature differentials are apparent. Higher temperatures at the middle of this elevation increase drying effects; corners are cooled by evaporative effects.

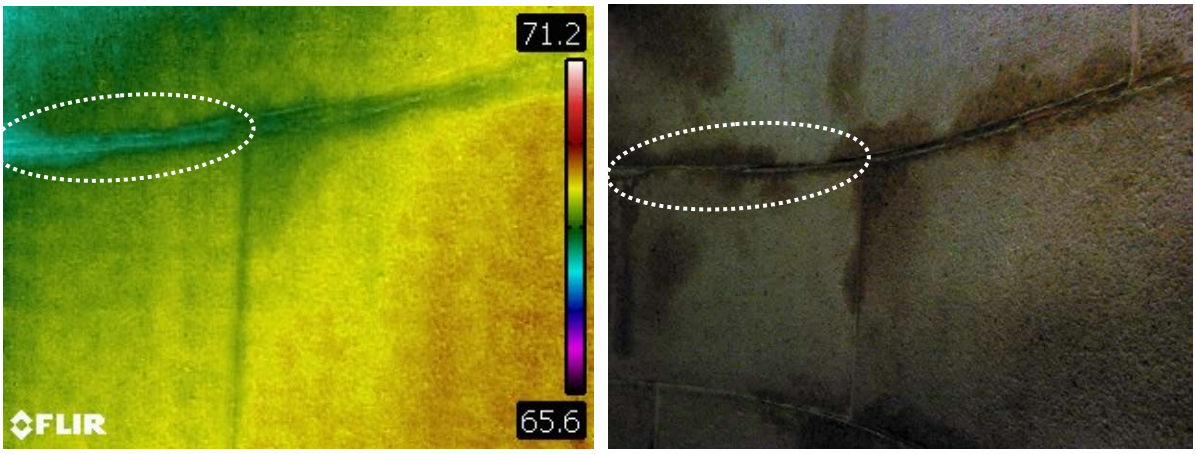


Figure 8. Interior lobby mortar joints. Water leak shows as coolness at mortar joint. Damp zones do not appear cooler indicating no evaporative cooling action.

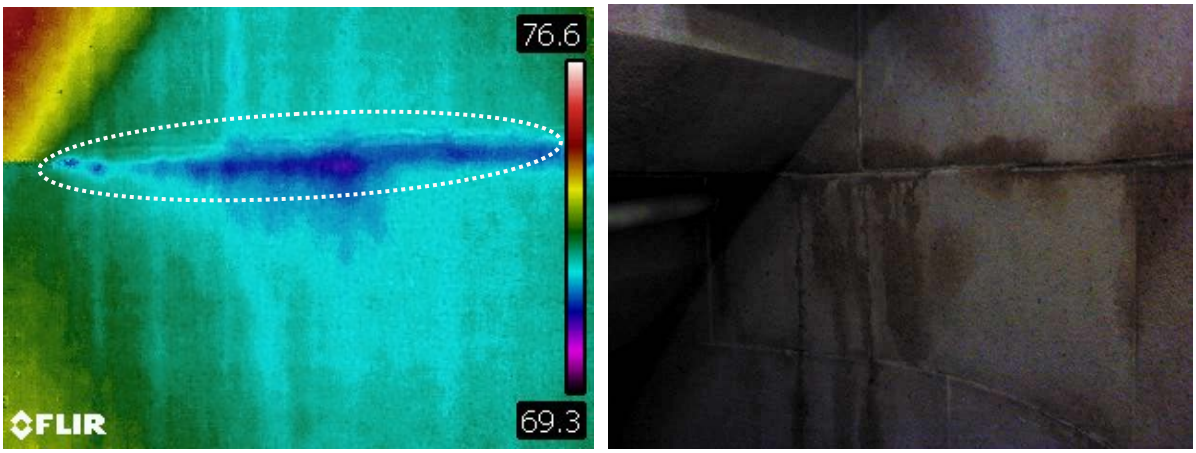


Figure 9. Interior lobby mortar joints. Water leak shows as coolness at mortar joint. Damp zones do not appear cooler indicating no evaporative cooling action.

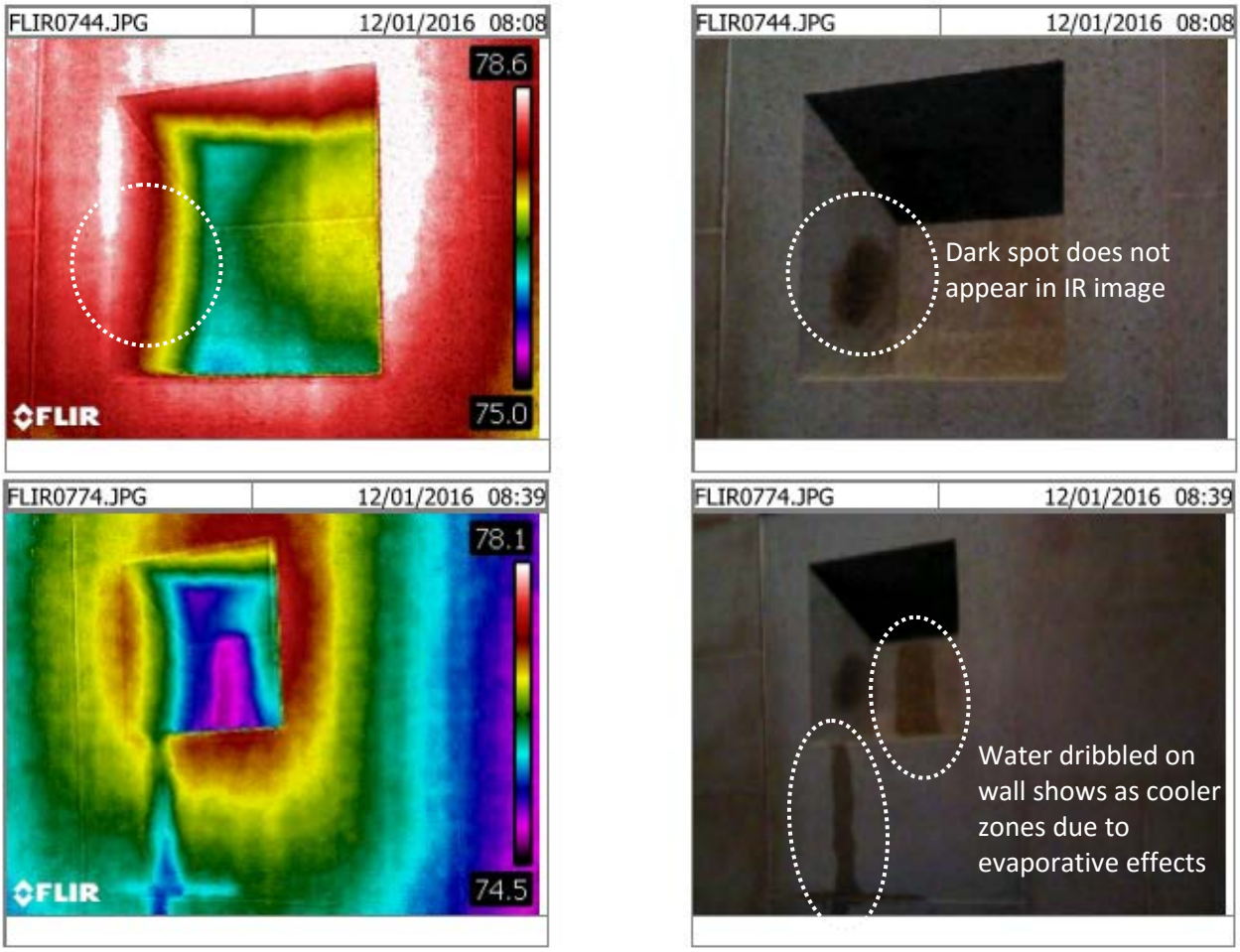


Figure 10. Blotches on stone does not appear in infrared image (top images); water dribbled down stone face is cooler due to evaporation effects (bottom images).

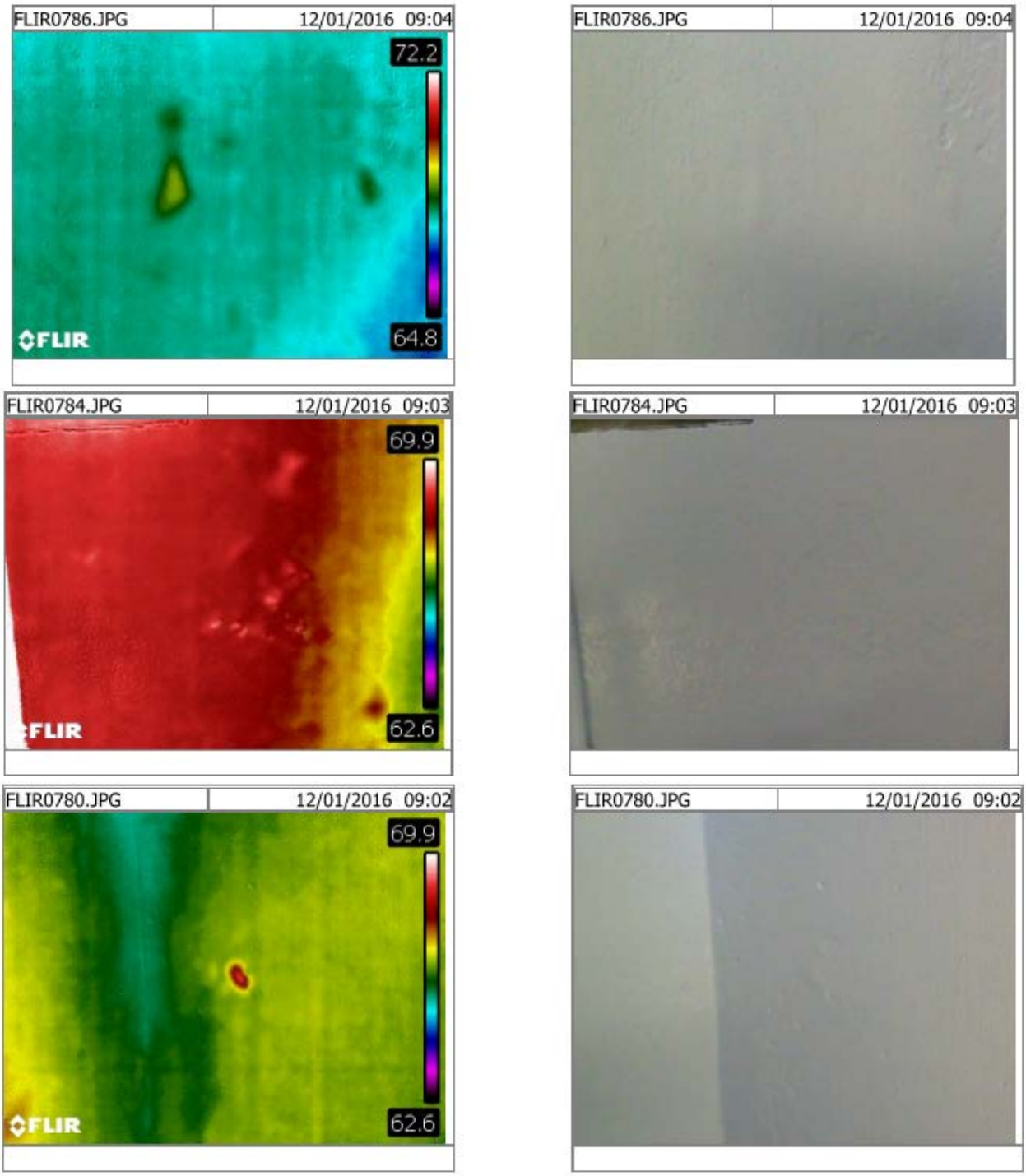


Figure 11. Image of interior painted concrete surface. Paint blisters are not always visible, but show in the infrared image as warmer zones.

5.0 WATER TEST AT ROOF DRAIN

McGee and Sons Plumbing used and inflatable plug to seal the roof drain pipe near its outfall. Water was pumped to the top of the Monument to fill the drain. The water level fell immediately and after 24 hours the inflatable plug was removed. When the drain plug was removed approximately 3 to 5 gallons water flowed from the outlet. This water volume suggests water remained in 7 to 8 feet of the 4-inch inside diameter drain pipe, and that a leak exists approximately 8 feet in from the outlet point under the stone paving. The outfall itself is located 24 feet from the monument.



Figure 12. Plug removal at completion of roof drain water test.

6.0 DRAIN PIPE VIDEOSCOPE EVALUATION

McGee and Sons Plumbing recorded observations made during videoscope examinations; recordings will be provided digitally. Plumbing videoscope included evaluations at the following locations; a summary of observations is included in Appendix D.

- Roof drain
- Floor drain at steps
- Roof trench drain above the entry door
- Clean out plug at walk way near front door entrance

7.0 LABORATORY TESTING

A series of samples were removed from mortar joints and stone surfaces for laboratory testing. Samples were removed from the following locations:

1. Sample 1: west elevation, mortar bed joint approximately 5’-0” above grade; pointing mortar from 0 to ¾” deep.
2. Sample 5: west elevation, mortar bed joint approximately 5’-0” above grade; bedding mortar from 1.5” to 2.5” deep. Tan color.
3. Sample 3: west elevation, mortar bed joint approximately 5’-0” above grade; bedding mortar from 1.5” to 2.5” deep. Greenish color when wet.
4. Sample 4: interior mortar head joint at stairs, pointing mortar 0 to 0.5” deep.

5. Sample 2: interior mortar head joint at stairs, bedding mortar 0.5” to 1” deep.
6. Sample 6: stone scrapings from interior pink granite at stairs, 2nd level.
7. Sample 7: stone scrapings from gray granite at interior, top of monument directly beneath beacon.

Samples were oven dried, crushed by hand with a mortar/pestle, and tested for chlorides and sulfates. Chlorides were present in all samples. Chloride concentrations were very high in exterior mortar samples, increasing with depth. Interior mortars had lower but still significant chloride contents. Stone scrapings, taken at locations where stone surfaces were sugaring, flaking, and powdering, showed lower but still significant salt content.

Sulfate contents were highly variable, with sulfate levels measured to be between 200 ppm and greater than 800 ppm.

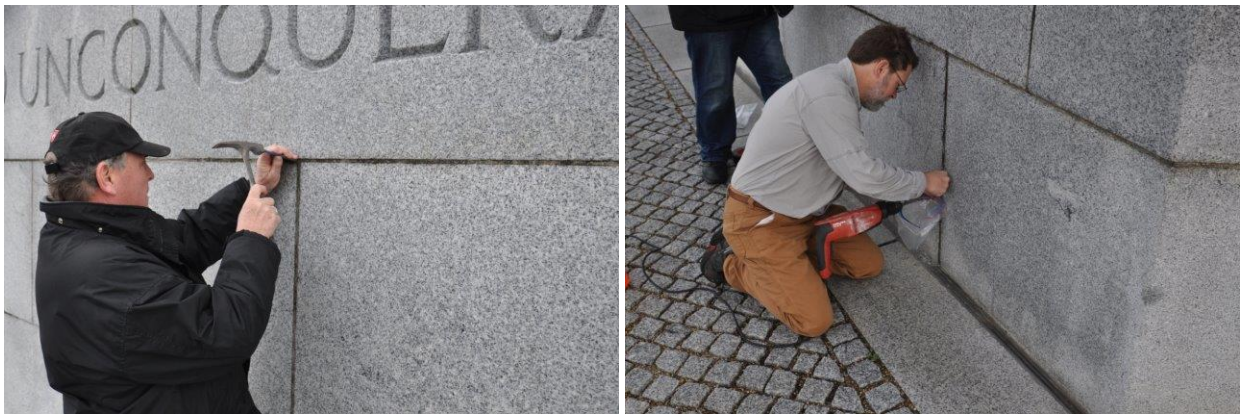


Figure 13. Mortar removal for laboratory analysis using hand tools and drilling.



Figure 14. Scrapings removed from deteriorating stone surfaces. Left: stone at interior stairs, 2nd level. Right: interior granite surface at top beneath beacon.

Table 1. Chloride and sulfate concentrations.

Sample No.	Sample Location and Type	% NaCl (Sample)	Sulfates (ppm)
1	West Elevation, pointing mortar	1.5	200 to 400
5	West Elevation - 1.5"-2.5"	2.2	200 to 400
3	West Elevation head joint, 0.5"-1.0" deep	4.3	200 to 400
4	Interior @ Stairs - pointing mortar	0.24	>800
2	Stairs/ Interior bedding - 0.5"-1.0"	0.74	>800
6	Stone @ interior stairs, 2nd level	0.12	200 to 400
7	Gray Granite @ interior, top beneath beacon	0.08	>800



Figure 15. Mortar and stone samples tested for chlorides and sulfates.

8.0 WALL VIDEOSCOPE EVALUATION

A videoscope was inserted into 3/8-inch diameter holes drilled into mortar joints to observe interior conditions. Videoscope observations are noted throughout this report; a total of 22 still images and 11 videos were recorded at the following locations:

- Foundation void space beneath lobby floor
- Exterior mortar joint
- Interior mortar joint
- Empty conduit at the left side of the electrical panel, 3rd level
- Roof drain cleanout area at access hatch
- Electrical conduit above abandoned light fixture, east side of stairs.



Figure 16. Videoscope evaluation at an abandoned lighting conduit (left) and at the roof drain cleanout hatch (right).

Mortar joint videoscope evaluation

Video scope observations were made at two exterior mortar joints and one interior mortar joint. A single 3/8-inch diameter hole was drilled at each of the three locations and holes cleaned with water for videoscope observations.

West elevation exterior. Hole drilled in head joint. Videoscope images 5 and 7 and video 6 saved. Joint was observed to be solid to 10 inches deep.

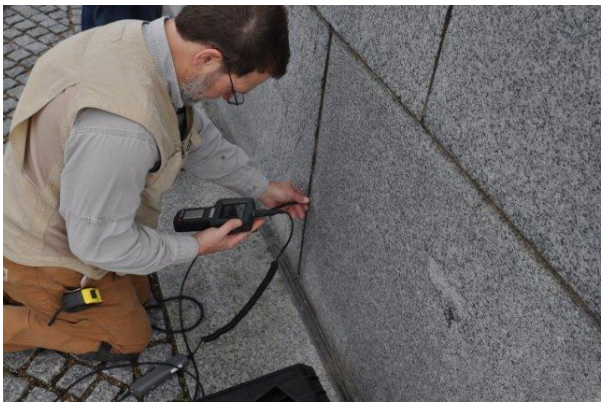


Figure 17. Videoscope evaluation at exterior mortar head joint.



Figure 18. Videoscope evaluation at exterior mortar head joint at location indicated by arrow.



Figure 19. Field notes showing mortar joint composition at exterior wall face. Videoscope image is at transition between pointing mortar and brown joint fill beneath.

West wall interior at lobby. The hole was drilled to a depth of 10 inches. The adjacent stone unit measured 8 inches thick, and hard solid concrete (or granite?) was encountered at a depth of 10 inches. The mortar joint itself was completely solid full depth, with pointing mortar at the outer 3 inches. Mortar at the interior beyond pointing mortar was greenish in color. Photographs 20 and 21 are included below; video 19 and 22 were also saved.

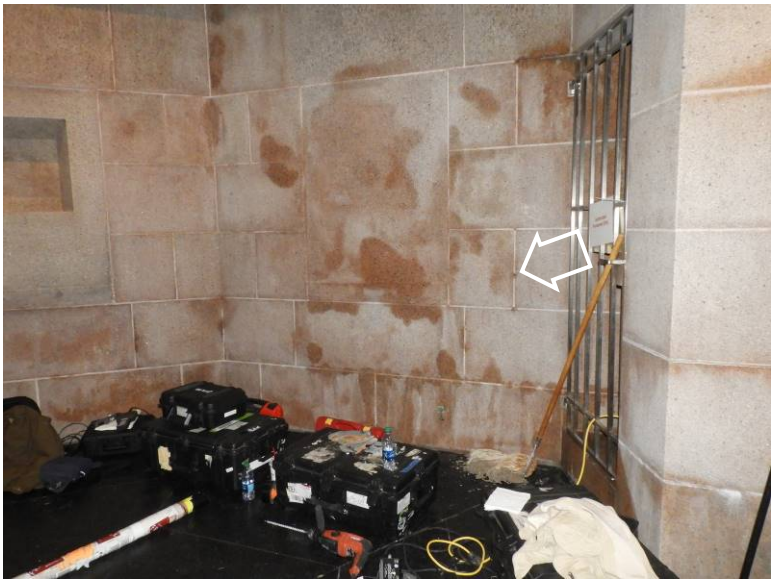


Figure 20. Videoscope at interior head joint at location indicated by arrow.

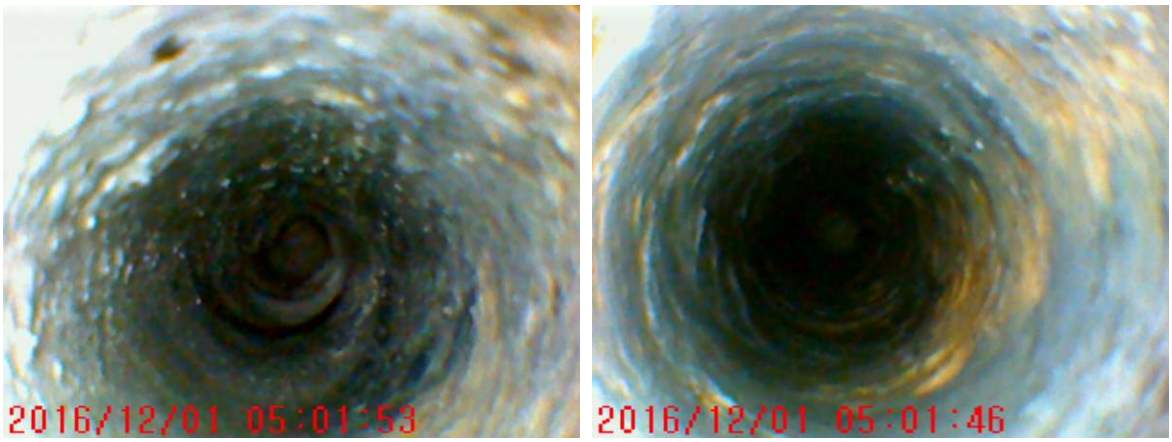


Figure 21. Videoscope photographs 20 and 21; mortar joints were observed to be solid full-depth. The videoscope scope hole is indicated in the top photograph.

9.0 CONDUIT AND ACCESS PANEL VIDEOSCOPE INVESTIGATIONS

Conditions were investigated at 2 conduit locations and at the 2nd level roof drain cleanout as described below.

3rd level electrical panel. Conduit investigated exiting to left side of box is 2" diameter. Significant corrosion debris was observed at the bottom of the conduit, but the conduit appears to remain intake. Two abandoned cables were observed at about 4 feet in from the box. Conditions at the interior were dry with no dampness observed. Photos and video 22 to 29 were recorded.



Figure 22. Videoscope images at conduit to left of 3rd level electrical panel. Corrosion was moderate to severe with oxidation flakes collecting at the bottom of the conduit.

3rd level electrical box. Conduit at the top of the panel was completely filled with old cable and the videoscope could not be inserted. The conduit was very wet and dripping water. Photos 36 and 37 recorded.

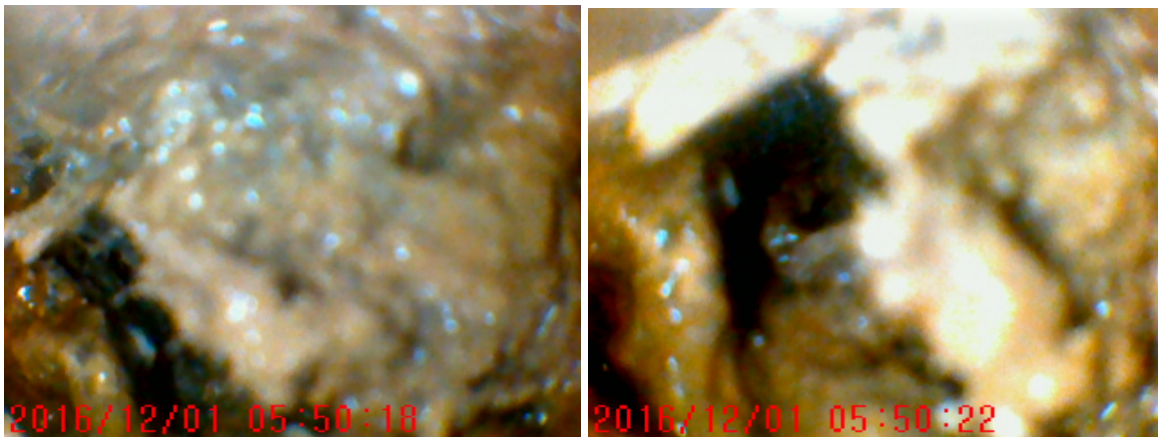


Figure 23. Videoscope evaluation at conduit exiting top of 3rd level electrical panel; interior was very wet with water dripping from conduit.

2nd level hatch at roof drain cleanout. Roof drain is cast iron pipe with minor superficial corrosion. Conditions within box are dry with no evidence of moisture intrusion or stains. Minor condensation was observed on a sheet metal sleeve. Video 30 to 35 recorded.

1st level conduit at removed light fixture, east stairs. Severe corrosion noted with localized wetness. Conduit is collapsed and corroded fully through the section 12 inches up from the fixture. Videos and photos 39 – 41 recorded.



Figure 24. Videoscope evaluation at 1st level conduit above removed light fixture. Severe corrosion and moisture noted.

10.0 PAVEMENT INVESTIGATION

Three granite pavers are missing at the Monument's northeast corner. Existing conditions were evaluated by locally removing sand and drilling beneath the pavers. Granite pavers were measured to be 3 ¼" square to 4" square by 3" deep, over 1" mortar, with concrete slab beneath. Coarse sand fills joints ranging from ½" to 1"wide.

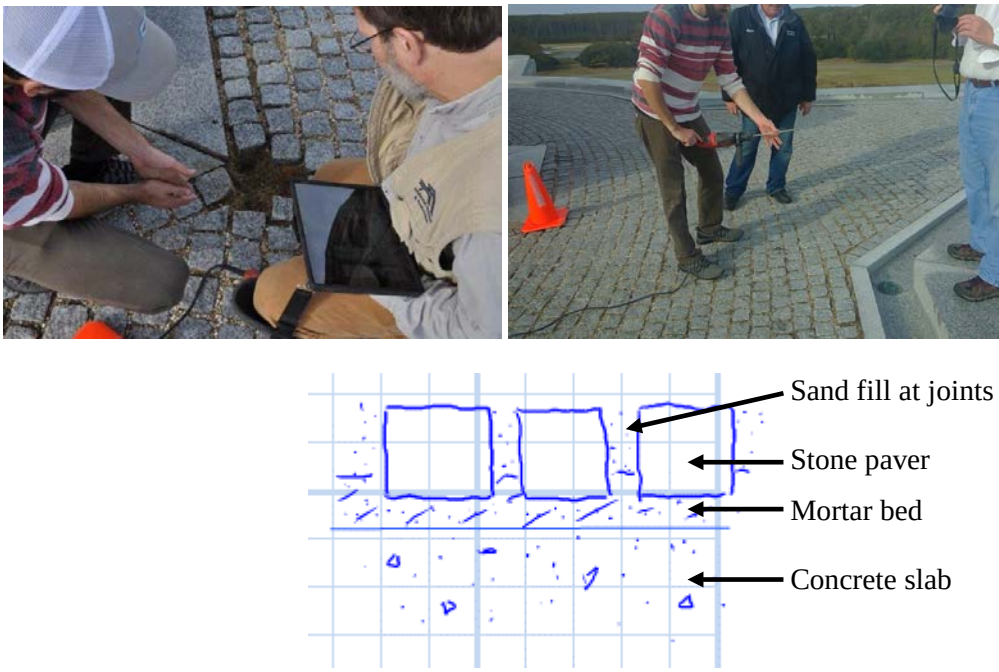


Figure 25. Exterior pavement investigation, northeast monument corner.

11.0 FOUNDATION SPACE INVESTIGATION

Subgrade conditions were observed via a floor drain at the southwest corner of the lobby. The floor drain does not appear to be original but was formed by coring several 2-inch diameter holes through the concrete floor structure.

As seen in the building section in Appendix A, the foundation consists of a concrete slab beneath the lobby floor, with a series of concrete columns and walls supporting the Monument above (also seen in the historic photograph provided in Figure 27). The foundation itself is a monolithic slab at the bottom of a large open space beneath the Monument. This space was investigated using the videoscope and a plumb bob, using a high-power LED light to illuminate the space.

The void space measured 33'-3" from the lobby floor to the top of the monolithic slab at the base of the foundation void. There was standing water approximately ½ to 1 inch deep on the slab at the bottom of the void space. A floor section is provided in the field sketch below; see also field notes in Appendix A.



Figure 26. Videoscope examination at floor penetration.

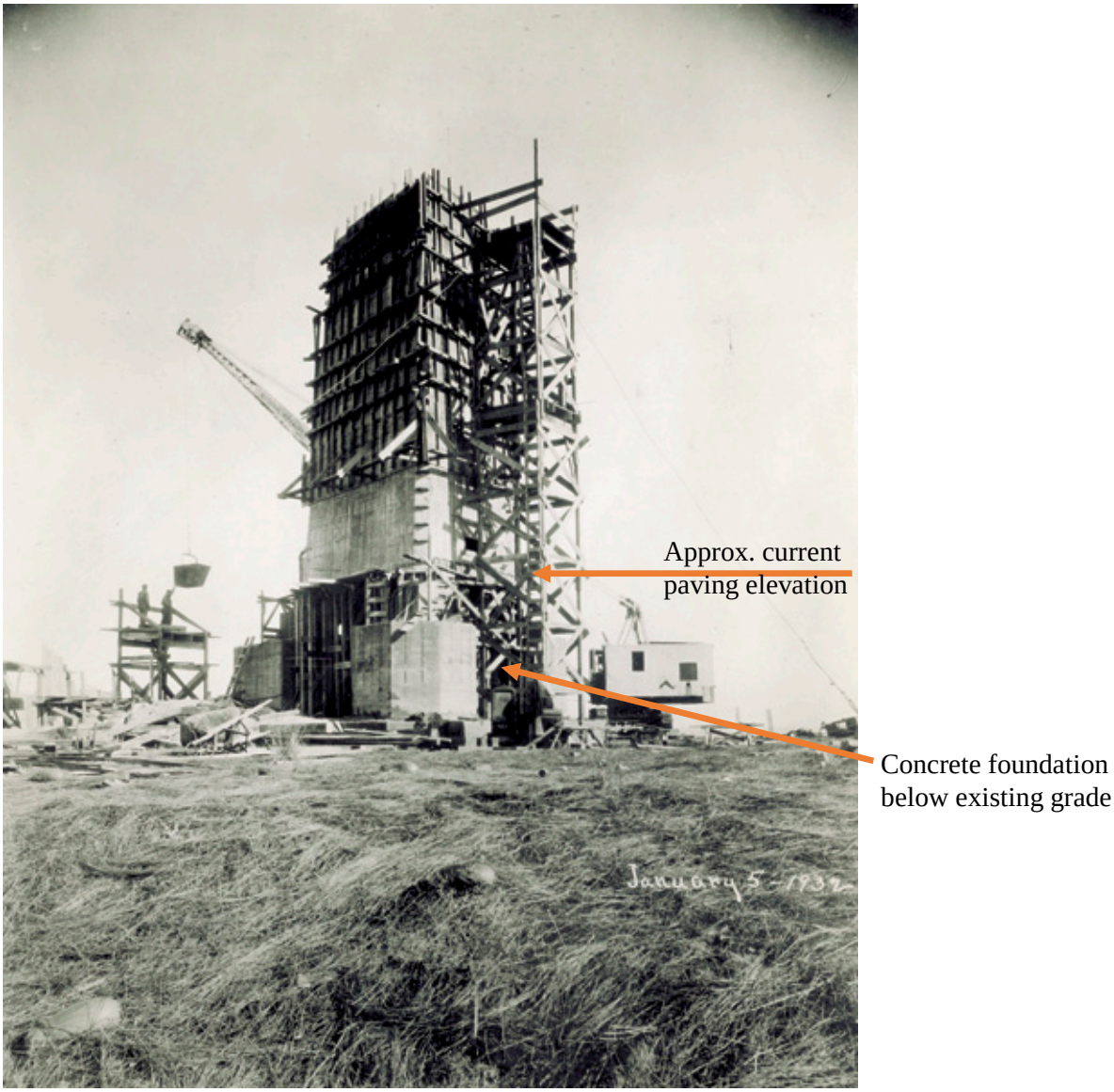


Figure 27. Construction photograph, dated January 5, 1932.

12.0 SUMMARY AND DISCUSSION

Moisture intrusion into the Monument is well-documented. Water is observed running from mortar joints at the interior and exterior and pooling at the lobby floor both during and following precipitation events (see photo in Figure 28). Water also enters the interior via electrical conduit, where leaks are significant enough to fill buckets with 5 to 10 gallons of water after a rainstorm.

Some type of flashing was originally installed (see photo in Figure 28) to collect moisture. Water was observed running out of the joint at the flashing level after a minor rain event. Some weeps were reportedly installed after the last mortar repointing effort but it is unclear if these weeps are functioning in any significant fashion.

Exterior mortar joints are commonly delaminated (Figure 29), providing many point sources for moisture entry. Radar scans suggest internal voids behind some stones; these voids serve to collect and transport moisture which appears as leaks to interior.



Figure 28. Water pooling in lobby (left) and exiting joint at flashing (right).



Figure 29. Example of delaminated mortar joint; delaminations permit moisture ingress during rainstorms.

Conduits (both in-service and abandoned) are moderately to severely corroded. Conduits often leak significant amounts of water (more than can be explained by just water coming in on location) suggesting water collecting behind stone is transported and concentrated by damaged conduits.

The blotchy, uneven appearance at interior and exterior stone surfaces (see Figure 29 and Figure 30) appears to be related to salt hydration rather than localized moisture leaks. The salt chromatographic effect is well known (reference Charola, A. Elena, and Blauer, Christine, *"Salts in Masonry: An Overview of the Problem,"* Restoration of Buildings and Monuments 2015, Birkhauser, 21(4-6): 119-135) and appears as internal salts hydrate through absorption of atmospheric moisture. The dehumidifier was turned off to facilitate heating for infrared scans, and dark spots appeared at interior stone surfaces within 24 hours. These dark spots look like dampness but could not be detected by IRT or moisture meter and hence are not free moisture, but moisture held within hydrating salts. This phenomenon has been in place since early in the Monument's life, and color variations visible today also appear in historic photographs.

All mortar samples tested showed very high chloride levels. The danger of having high chloride contents in mortar is the potential for corrosion of embedded metals such as anchors and concrete reinforcing bars, and the potential for damage resulting from salt crystallization and salt hydration. Chloride-induced corrosion of steel elements contained within cementitious materials such as concrete and mortar typically does not occur until a certain chloride ion threshold is surpassed. Chloride contents above the threshold indicate that corrosion is highly likely, but not necessarily certain. The American Concrete Institute Committee 222, *Corrosion of Metals in Concrete*, lists chloride ion thresholds for several different concrete applications. Chloride contents for new construction are recommended to be below 0.10 percent by weight of cement (BWOC) for concrete in wet conditions and 0.20 percent BWOC in dry conditions. These "design values" may be somewhat conservative and the committee lists research results showing corrosion initiation at chloride concentrations ranging from 0.2 percent BWOC to as high as 0.7 percent BWOC. A reasonable value for the critical chloride concentration, based upon research results, is in the range of 0.4 to 0.6 percent BWOC. Recommended chloride limits are not provided for masonry mortars and, for lack of adequate supportive data, mortar chloride limits are assumed to be similar to concrete chloride limits.

The chloride concentrations listed in Table 2 show have been converted to % chloride by weight of cement in the sample, assuming either Type N or Type S cement-lime-sand mortar. All measured chloride concentrations are extremely high, exceeding the level suggested as being required to initiate corrosion by 1.7 to 280 times. Measured chloride contents are great enough to initiate steel corrosion regardless of mortar type at all locations sampled.

Based on the chloride profile of mortar sampled at different depths, it appears that original bedding mortar used beach sand high in chlorides, and that chlorides have migrated throughout the joints to newer pointing mortars.

The concrete structure is reinforced, and, considering the extremely high chloride levels found in mortars, there is a high potential for reinforcement corrosion. It is possible that the interior paint coating is minimizing oxygen diffusion, limiting corrosion activity, but the high corrosion potential suggests a significant future problem.

Table 2. Mortar chloride test results.

Sample No.	Location	% Chloride ion by weight of sample	% Chloride ion by weight of cement in sample	
			Type N mortar	Type S mortar
1	West Elevation, pointing mortar	1.5	9.9	7.5
5	West Elevation - 1.5"-2.5"	2.2	14.5	11.0
3	West Elevation head joint, 0.5"-1.0" deep	4.3	28.4	21.5
4	Interior @ Stairs - pointing mortar	0.24	1.6	1.2
2	Stairs/ Interior bedding - 0.5"-1.0"	0.74	4.9	3.7

13.0 RECOMMENDATIONS

Moisture penetration

Measures must be undertaken to minimize moisture intrusion and facilitate moisture exit from the wall system. The first step is to address all open mortar joints, delaminated mortar joints, and other point sources for moisture entry. Skyward-facing joints are particularly vulnerable and must be sealed to be waterproof, usually requiring a sealant joint covered by a lead cap or other suitable aesthetic treatment.

Embedded conduit must be removed or filled with a non-shrink injection grout to prevent moisture accumulation and transfer. Injection grout should have an integral corrosion inhibitor to minimize future corrosion potential.

Additional investigation is needed to characterize solidity of grout fill between facing stones and the underlying concrete structure. Conditions at the space between stone and concrete would best be investigated by removing 2-inch diameter cores, drilled from the interior, and viewing with a videoscope. A total of 5 potential coring locations were marked while on site. General locations are called out on the drawing in Appendix A and marked on masking tape at each location as shown in Figure 30. Radar scanning was conducted to locate metal reinforcement and potential core locations were marked to miss subsurface reinforcement. Sections of removed cores can be tested for alkali-aggregate reactions and chloride concentrations.

Void spaces within masonry walls permit moisture to collect and travel within the wall system. Voids in in mortar joints and behind stones are best treated by injecting with a fluid grout, specially designed to be compatible with historic materials. Injection can be carried out using low pressure and small-diameter holes drilled into mortar joints. Injection from both the interior and exterior will be required to treat the massive wall sections.



Figure 30. Potential core locations are marked at the interior with chalk and masking tape.

Salt contamination

Salts present at interior lobby stones may be removed by poultice applications. Poultices would likely remove only near-surface salts and, considering the structure's mass and high measured chloride levels, poultice efforts would likely have to be repeated at regular intervals, potentially every 3 to 5 years.

A more permanent solution would be to remove salts using electro-osmosis. This process is more commonly used with concrete construction, and a sample installation should be demonstrated at a small area prior to full-scale design and implementation.

Considering the extremely high chloride concentrations and high potential for metal corrosion, internal concrete reinforcement and stone anchors should be checked for damage and deterioration. Reinforcement corrosion can be mapped using the half-cell potential method, or spot-checked using small localized probes to expose embedded reinforcement. Depending on conditions uncovered it may be prudent to take preventative measures now, before corrosion becomes critical. One approach to halt metal corrosion is installation of an impressed current cathodic protection system to halt the corrosion process.

HVAC System

The internal dehumidification system appears to be working well at keeping internal humidity levels low enough to control salt hydration. When the dehumidifier was turned off, salt hydration stains were evident within 24 hours, disappearing rapidly once the system was again operational. The system should be checked regularly for proper operation. Air balance should also be checked to ensure internal spaces are positively pressurized. Negative internal pressure could be exacerbating moisture intrusion by drawing moisture through mortar joints into interior spaces.

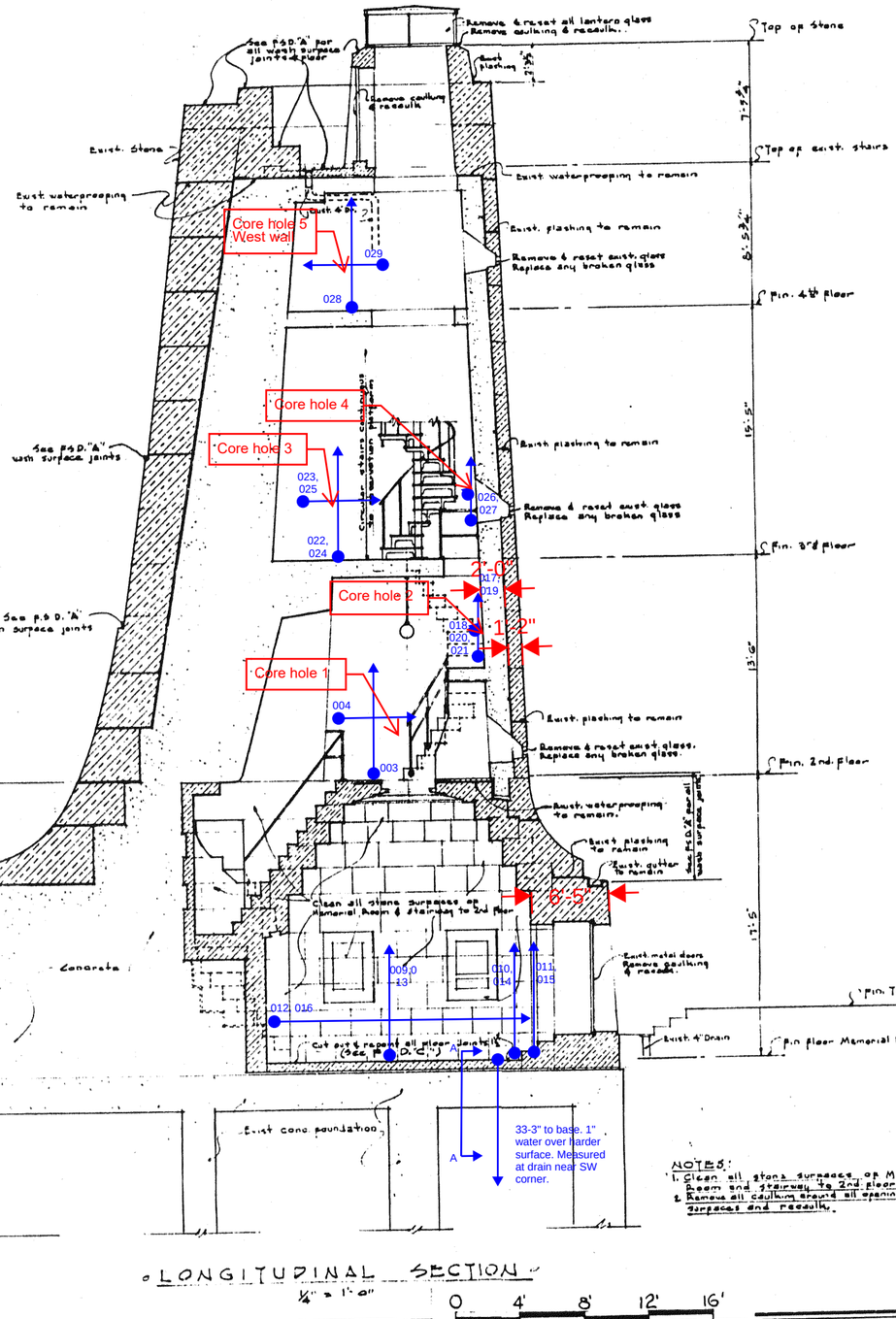
Louvers at the south elevation, used for dehumidifier makeup and exhaust air, should be opened and installation inspected to ensure the collar joint between stone and concrete is 100 percent sealed to prevent hot humid air from penetrating behind stone.

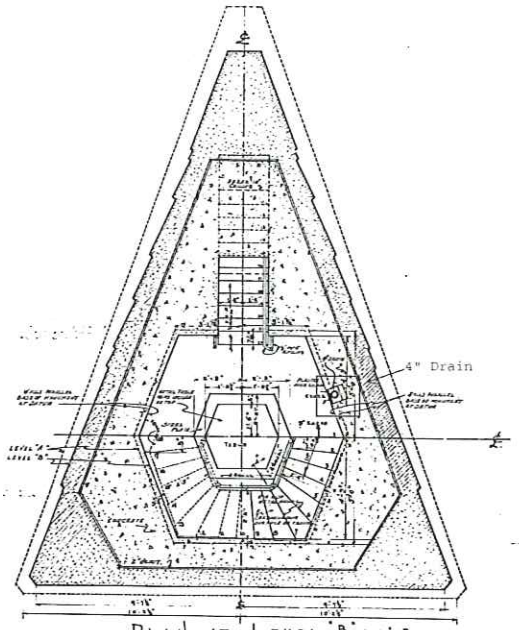
APPENDIX A

TEST LOCATIONS AND FIELD NOTES

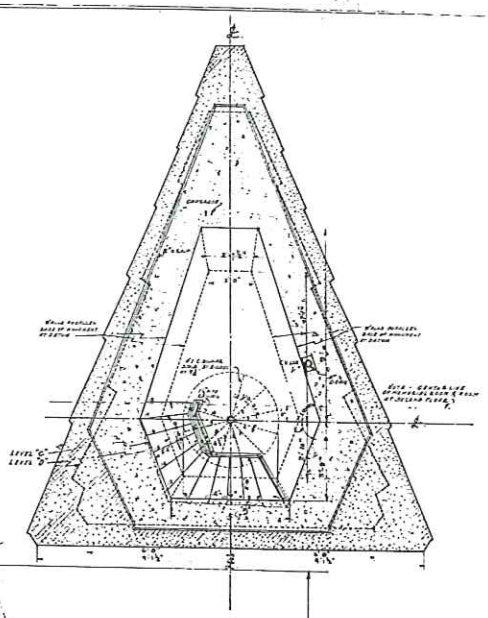
Radar scan locations are shown as blue arrows, with the arrow showing the scan direction.

Locations for corehole drilling are noted as well.

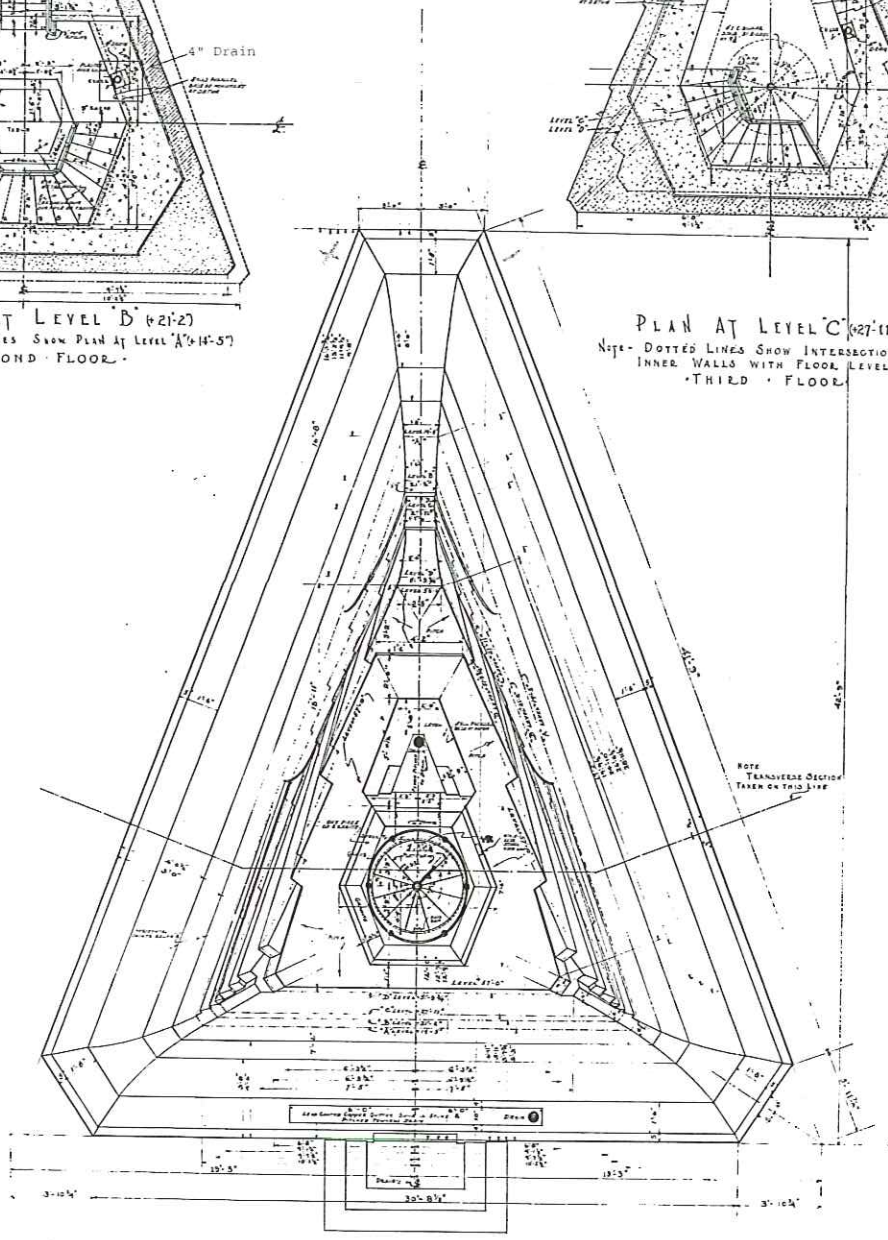

Remove & reset all lantern glass
Remove caulking & reseal.
See P&D "A" for all wash surface joints & floor
Remove caulking & reseals
Exist. flashing
Top of stone
Exist. Stone
Top of exist. stairs
Exist. waterproofing to remain
Exist. waterproofing to remain
Exist. flashing to remain
Core hole 5 West wall
029
028
Remove & reset exist. glass Replace any broken glass
Fin. 4th floor
Core hole 4
Core hole 3
Exist flashing to remain
See P&D "A" wash surface joints
023, 025
026, 027
Remove & reset exist glass Replace any broken glass
022, 024
Fin. 3rd floor
2'-0"
017, 019
Core hole 2
1'-2"
018, 020, 021
See P&D "A" wash surface joints
Core hole 1
004
003
Exist. flashing to remain
Remove & reset exist. glass. Replace any broken glass.
Fin. 2nd floor
See P&D "A" for all wash surface joints.
Exist. waterproofing to remain.
Exist flashing to remain
Exist. gutter to remain
See P&D "A" for all wash surface joints
6'-5"
Clean all stone surfaces of Memorial Room & stairway to 2nd floor
Concrete
009, 013
010, 014
011, 015
Exist. metal doors Remove caulking & reseal.
012, 016
Fin. Terrace
Cut out & repoint all floor joints (See P&D "C")
Exist 4" Drain
Fin floor Memorial Room
Exist conc foundation
A
A
33-3" to base. 1" water over harder surface. Measured at drain near SW corner.
13'-6"
17'-5"
15'-5"
6'-5 3/4"
7'-7 3/4"
35'-4 3/4" to bottom of pier
LONGITUDINAL SECTION
1/4" = 1'-0"
0 4' 8' 12' 16'
Fin floor
Flush joints
Repoint
Resilient mastic pack all floor joints
Exist stone paving (Approx. 6" thick)
Exist stone paving (Approx. 6" thick)
F.S. DETAIL "C"
(Memorial Room floor)
1"Stone
5" Topping Slab
28 1/4" Structural Slab
32 1/4"
Section A-A Floor
NOTES:
1. Clean all stone surfaces of Memorial Room and stairway to 2nd floor level.
2. Remove all caulking around all openings, clean surfaces and reseal.
DRAWN BY
CHECKED BY
UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
PLANNING AND CONSTRUCTION DIVISION
REGIONAL OFFICE
REGION ONE
RCD NO.
SHEET 4 OF 4
REHABILITATION OF MONUMENT
MONUMENT
WRIGHT BROTHERS NATIONAL MEMORIAL
DRAWING NO. NMEM-WB 2020
DATE: 2 MAR 1954



PLAN AT LEVEL 'B' (+21'-2")
NOTE- DOTTED LINES SHOW PLAN AT LEVEL 'A' (+14'-5")
· SECOND · FLOOR ·



PLAN AT LEVEL 'C' (+27'-11")
NOTE- DOTTED LINES SHOW INTERSECTION OF OUTER & INNER WALLS WITH FLOOR LEVEL AT 'D' (+31'-4½")
· THIRD · FLOOR ·



PLAN THRU LANTERN

SCALE = ½" = 1'-0"

34/3500
SHT 3 of 9

WRIGHT MEMORIAL
KITTY HAWK N.C.
DRAWING NO. 103
REVISIONS
STRESS SHEET
TYPED BY
DATE 6/22/34
SCALE 1½"=1'-0"
TRACED BY
CHECKED BY
FINISHED BY
TILLEY BOOTH & ALFRED EASTON JR.
ARCHITECTS
NEW YORK CITY

G711-26

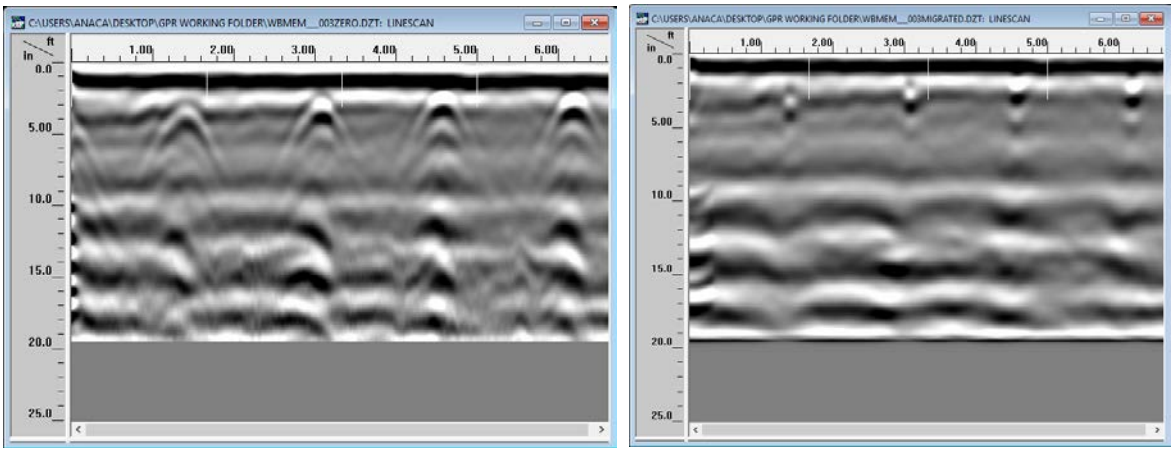
APPENDIX B

SURFACE PENETRATING RADAR SCANS

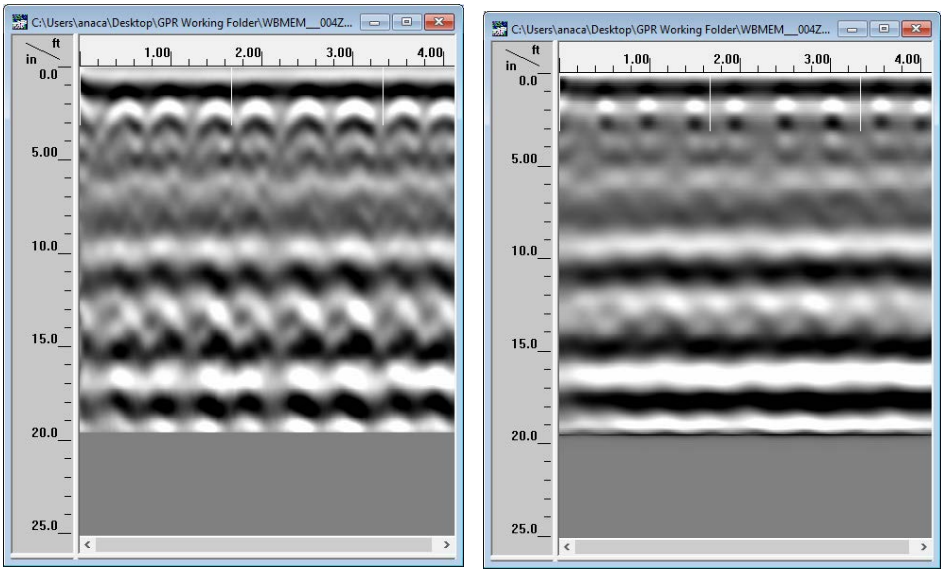
All surface penetrating radar scans saved on site are shown below. For scans at reinforced concrete sections, the second image in each pair includes data reduction to migrate traces to clarify reinforcing bar positions.

In each image the horizontal scale is in feet, along the length of the scan.
The vertical scale is inches into the depth of the wall, with the wall face at 0 inches.

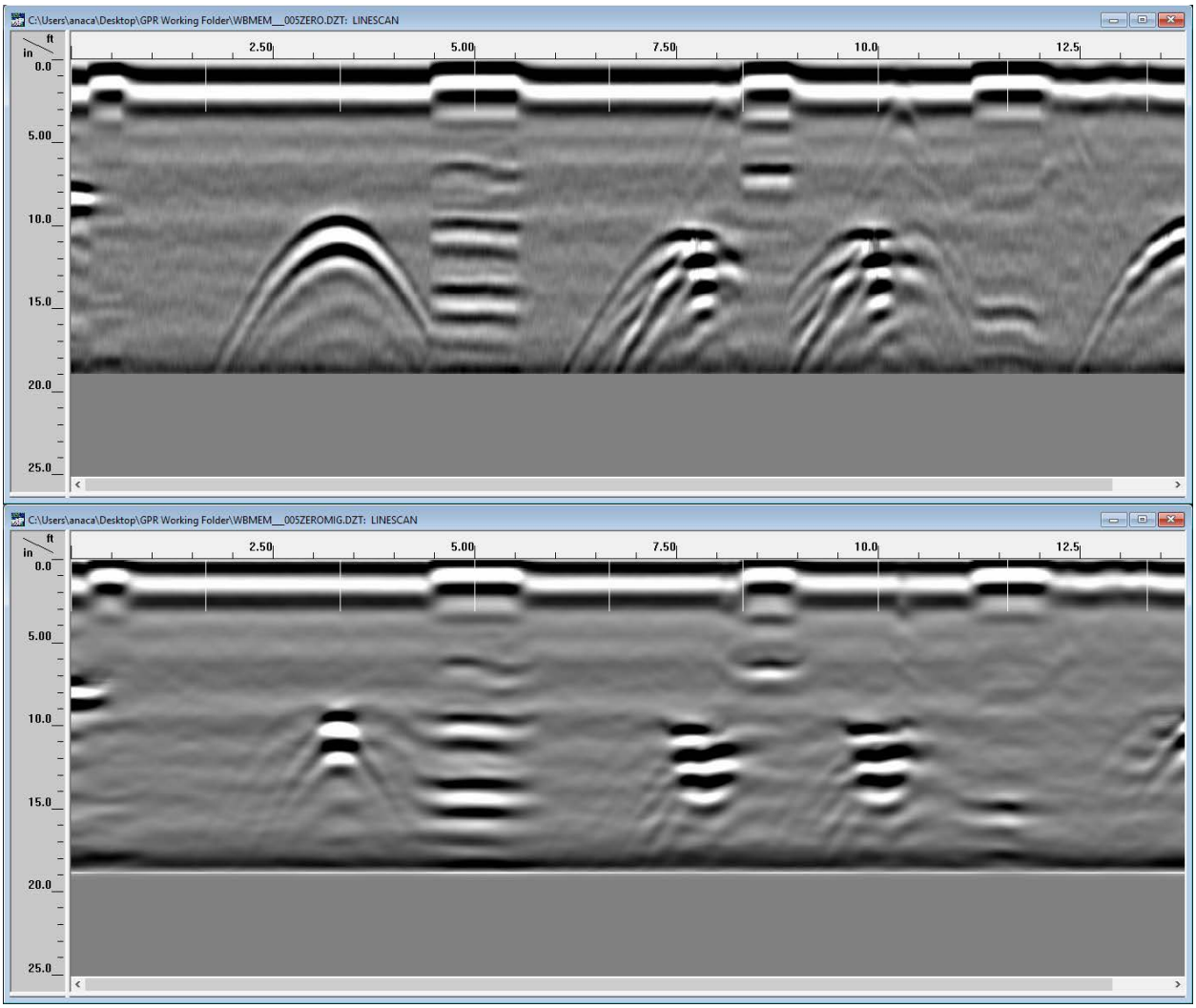
Numbered scan locations are shown on the Monument section in Appendix A.



Scan 003, vertical scan, 2nd level interior, from floor upwards. Reinforcement at 17 to 19 ½" spacing. Depth varies: 3 to 4 inches.

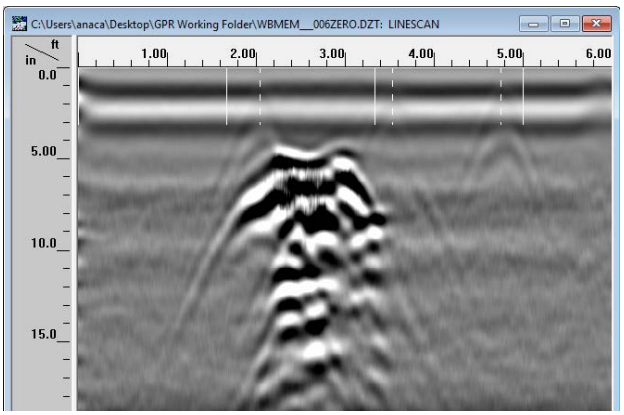


Scan 004: Horiz. @ 4' above 2nd floor. Reinf. @ 5" to 7" spacing. Depth = 1 3/4 "

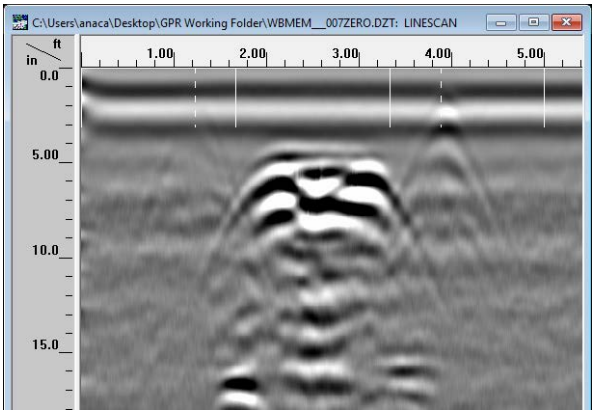


Scan 005: exterior, south elevation at drainpipe to east of entry door, 4 horizontal scans each, separated by wheel spins. Drainpipe detected at approximate 10 inch depth from wall face.

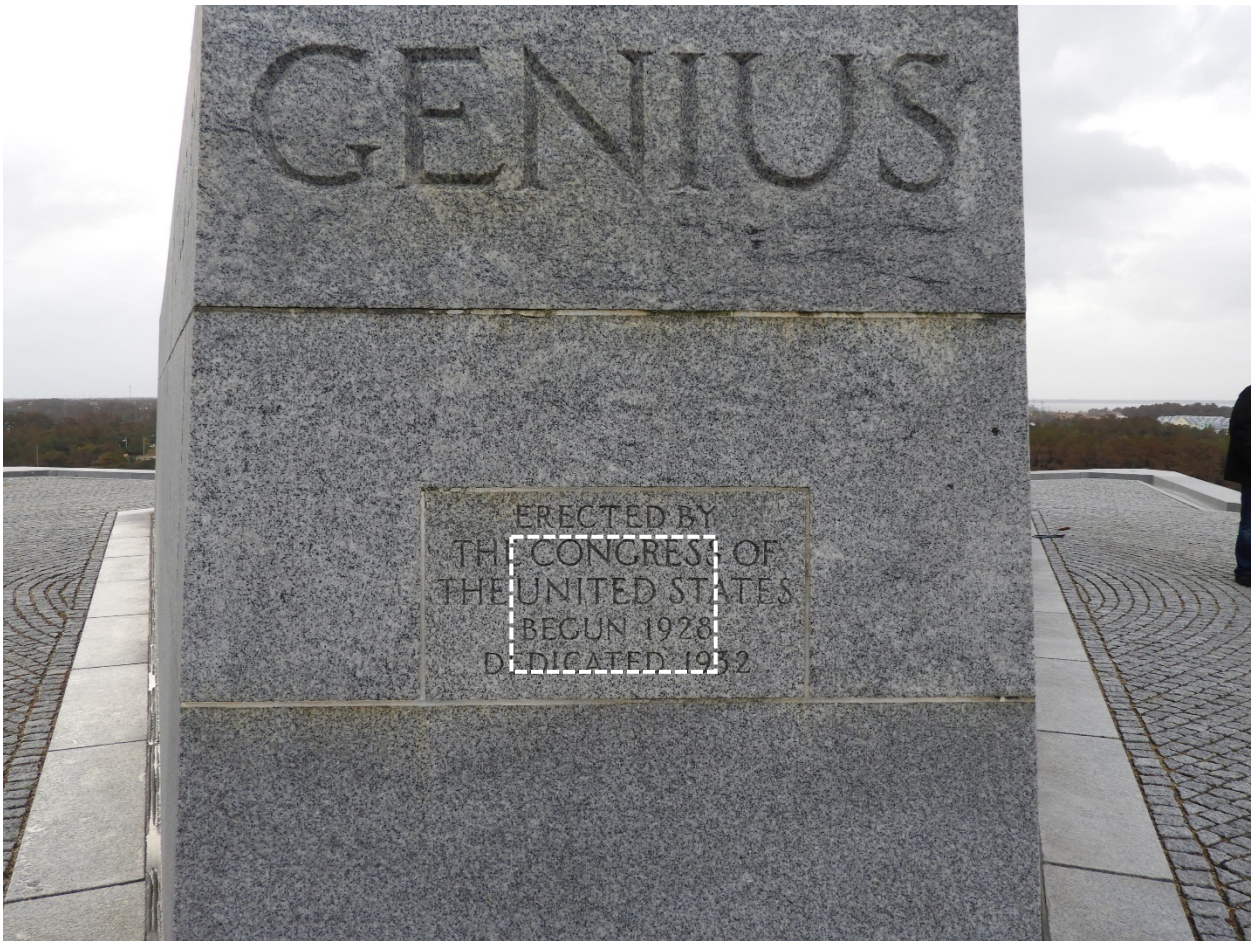
Scans at exterior, north elevation at “cornerstone.” Markers (dashed lines) at mortar joints.



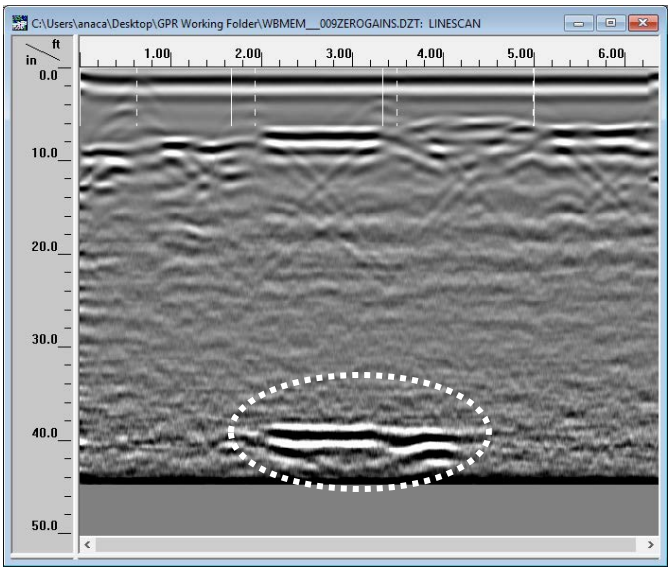
Scan 006: exterior vertical



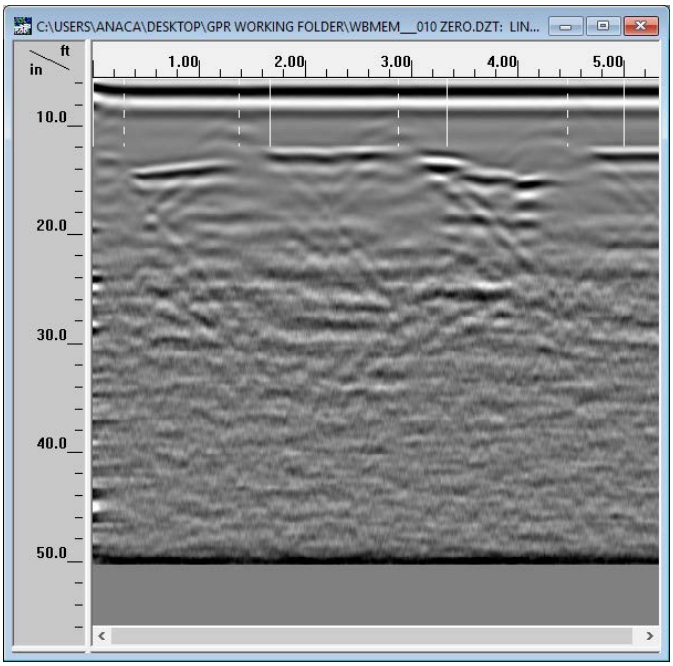
Scan 007: exterior horizontal



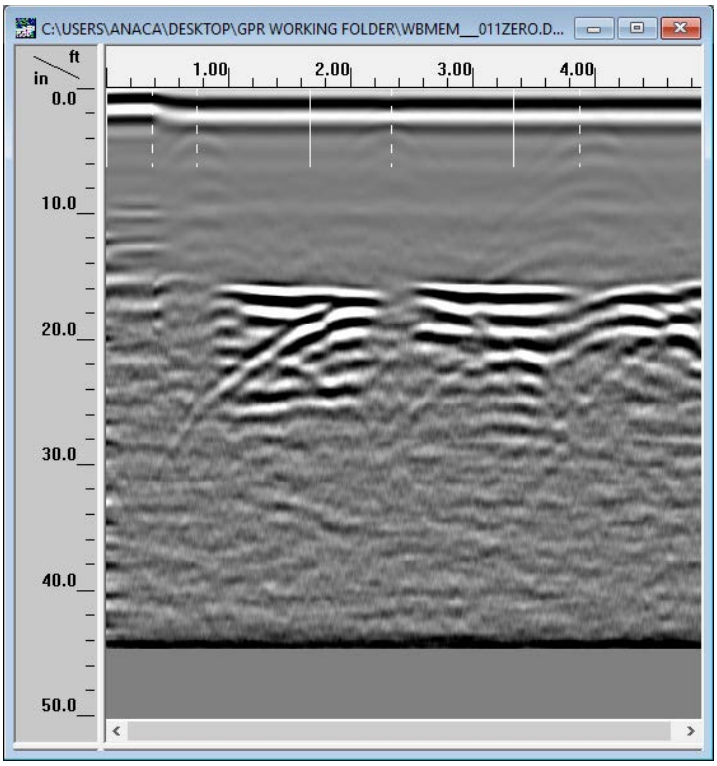
Photograph at “cornerstone” with embedded metal element shown as dashed outline.



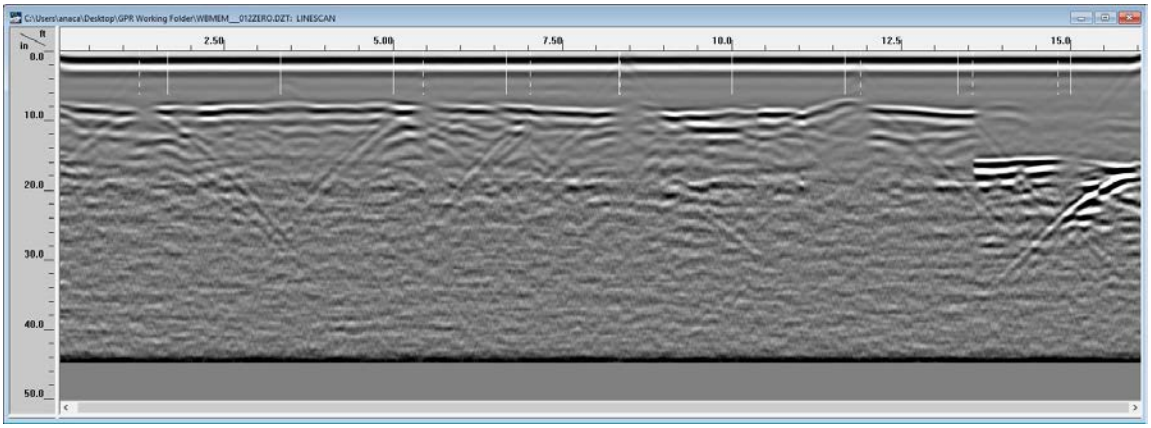
Scan 009: Interior Lobby, vertical, east wall. Stone veneer thickness varies from 8 to 9 inches, with voids behind some stones; backs of stones are somewhat irregular. Strong reflection at 40 inches deep (outlined) suggests a void behind the exterior stone at this location, from 2'-6" to 4'-6" above the interior floor line (above exterior pavement grade).



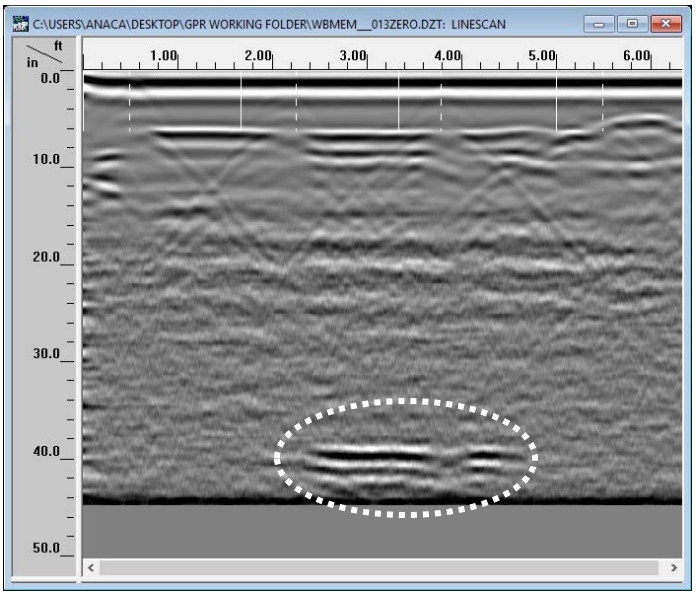
Scan 010: Interior lobby, vertical, east wall. Stone thickness 8 to 10 inches. Reflections at backs of stone suggest moderate voids in grout fill.



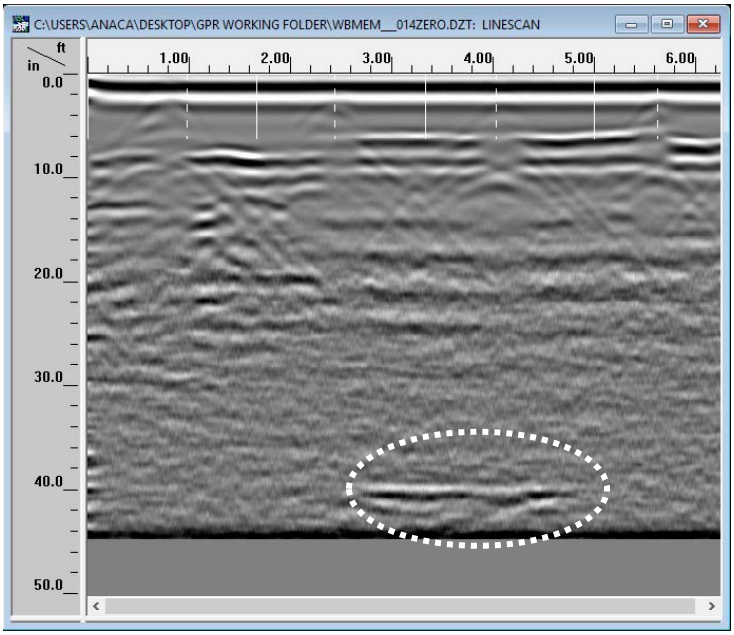
Scan 011: interior lobby, vertical scan, south wall to east of door. Stone much thicker, measuring at 14 to 15 inches thick. Strong reflections suggest significant voids behind stones.



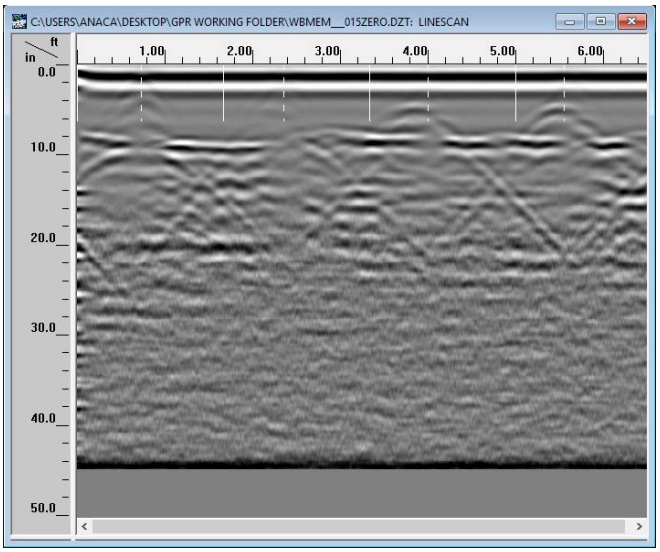
Scan 012: Interior lobby, horizontal, east wall. Stones transition from approx.. 8 inch to 14 inches thick at southeast corner. Reflections at back of stones suggest moderate to significant voids are present behind stones.



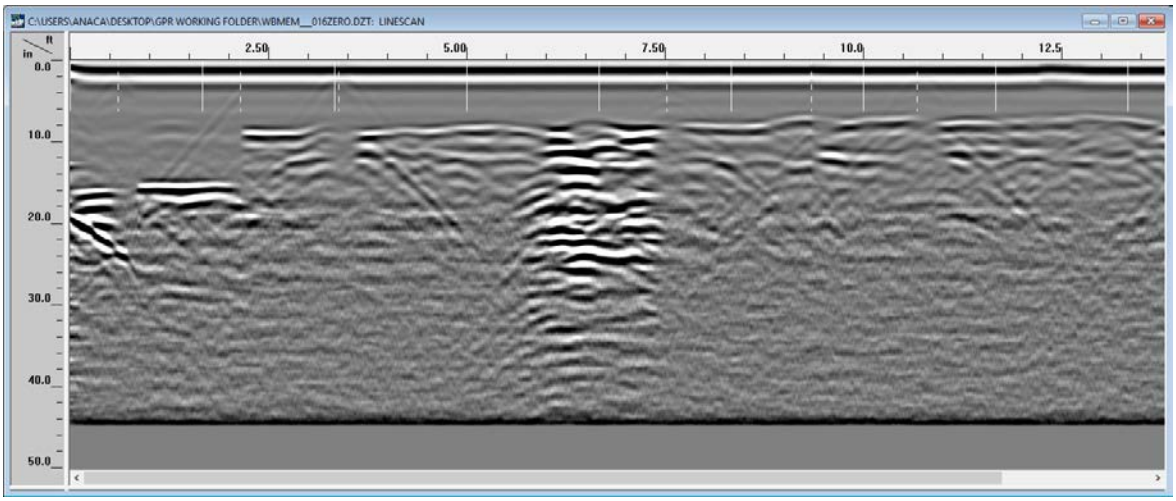
Scan 013: Interior lobby, vertical, west wall. Stone thickness 6 to 7 inches; same isolated void as seen in Scan 009.



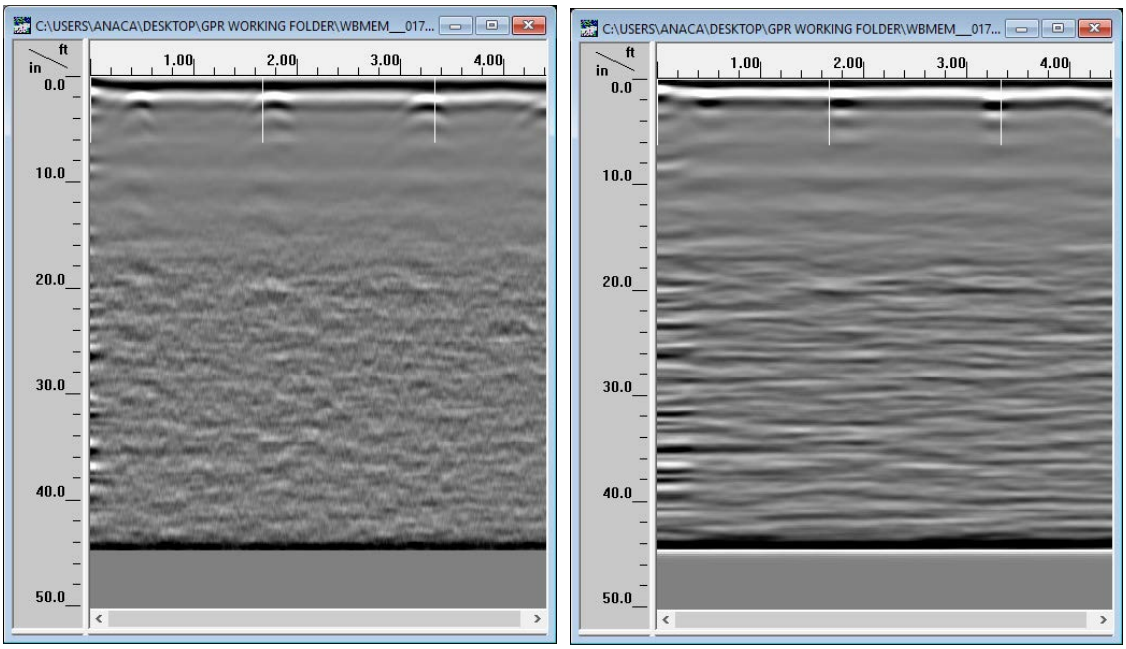
Scan 014: Interior lobby, vertical, west wall. Stone thickness 6 to 7 inches; same isolated void as seen in Scan 009 and 013.



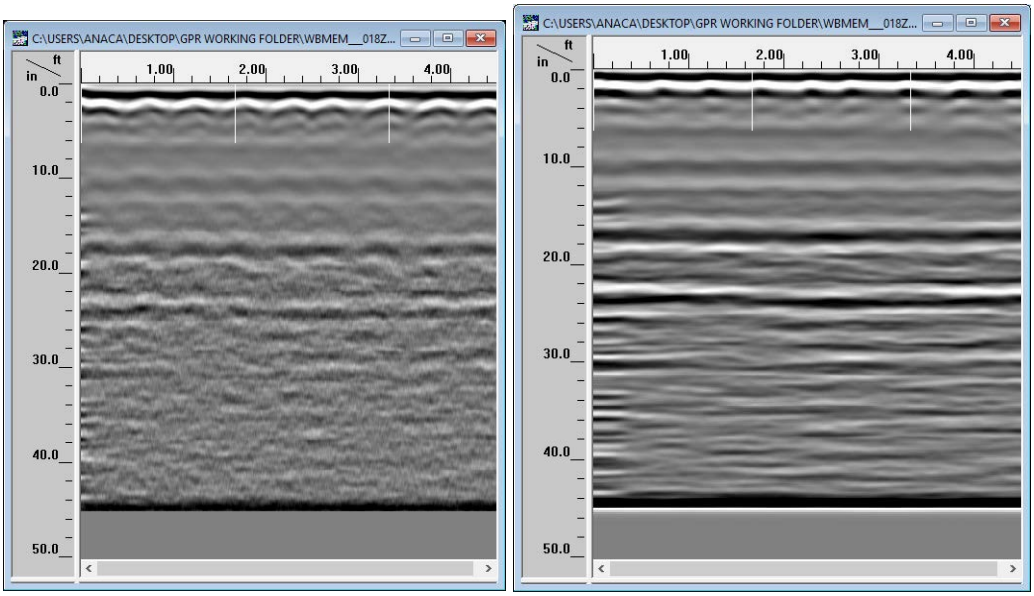
Scan 015: Interior lobby, vertical, south wall to west of door. Stone thickness 7 to 8 inches; significant mortar joint voids.



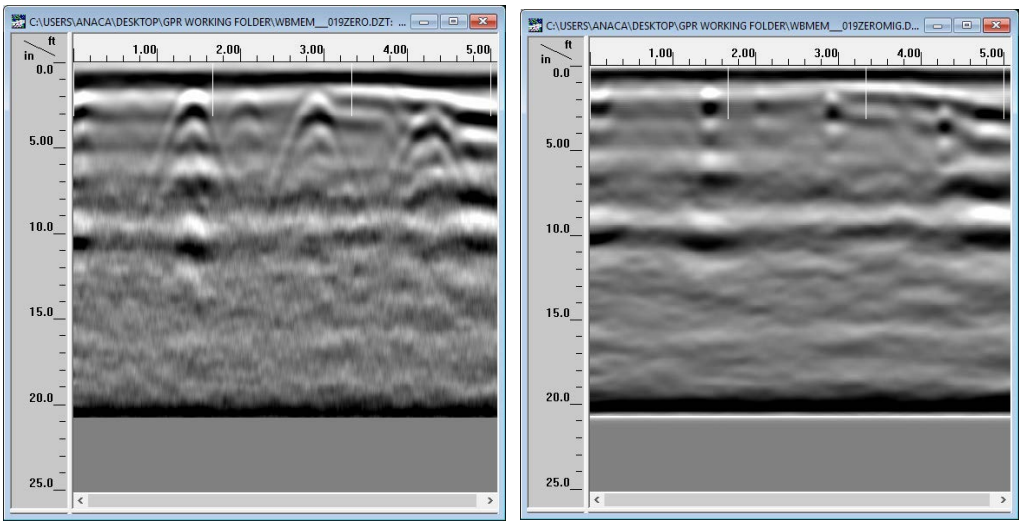
Scan 016: Interior lobby, horiz., west wall/ Stone thickness transitions from 15” to 8” at southwest corner.



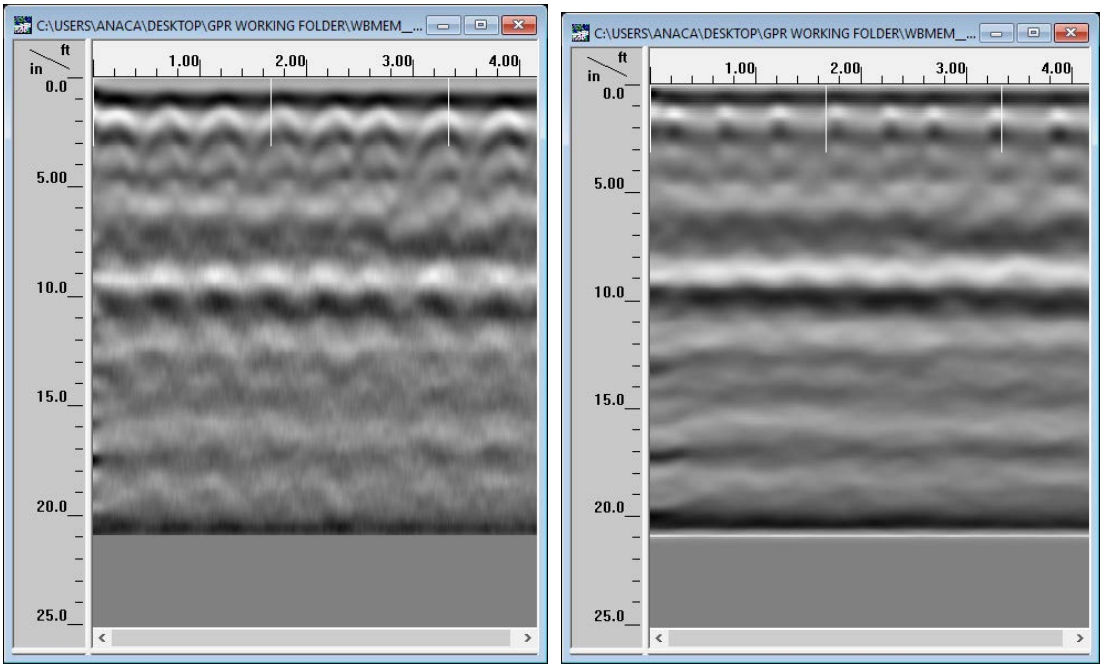
Scan 017: 2nd level concrete from stairs. South wall, vertical. Concrete very wet beyond about 18" depth.



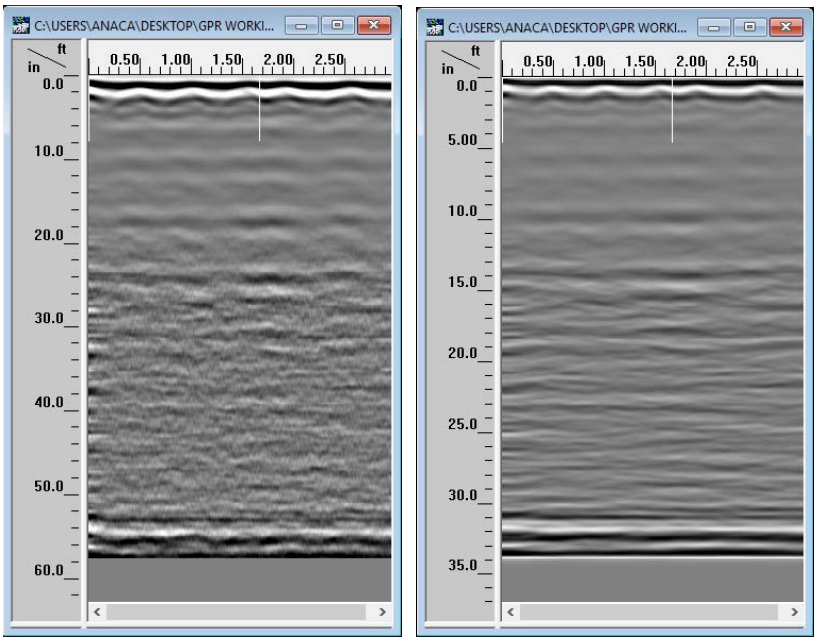
Scan 018: Same as 017, horizontal. Concrete 18" or 24" thick?



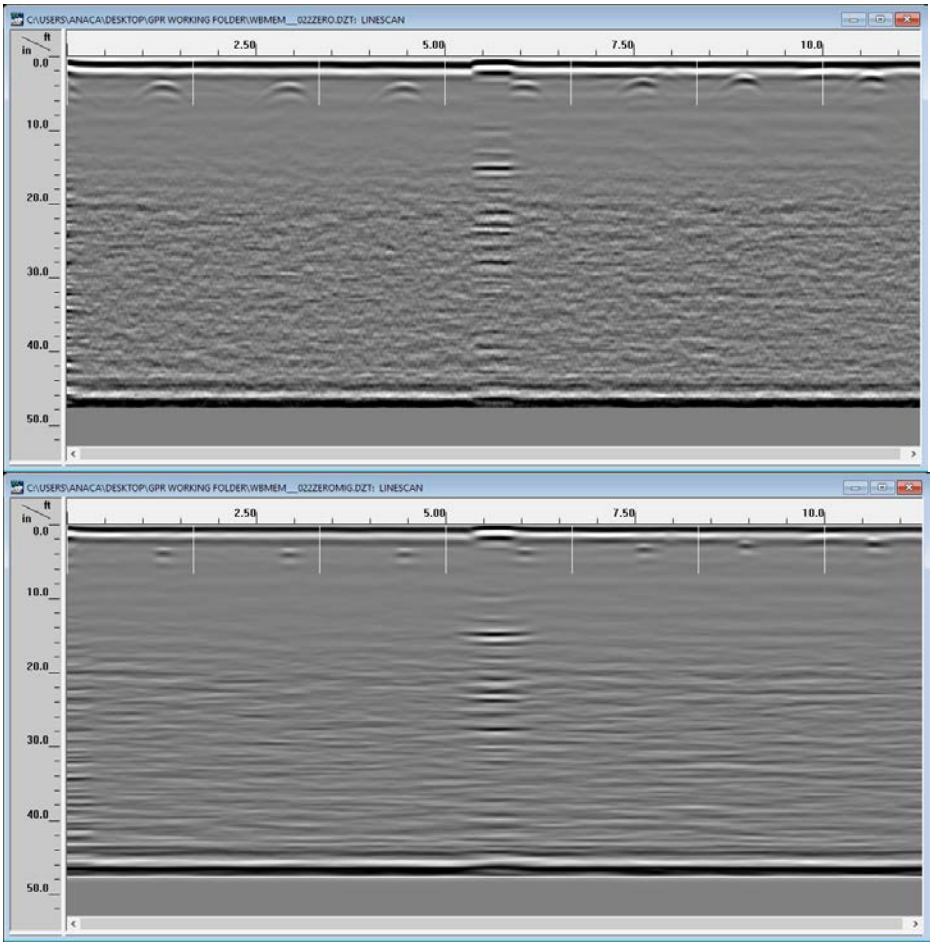
Scan 019: Same as 017, reduced time, rebar at 6" to 17" spacing, depth = 1 3/8" to 2 1/4"



Scan 020: Same as 018, reduced time, rebar at 5" to 8", depth = 1"

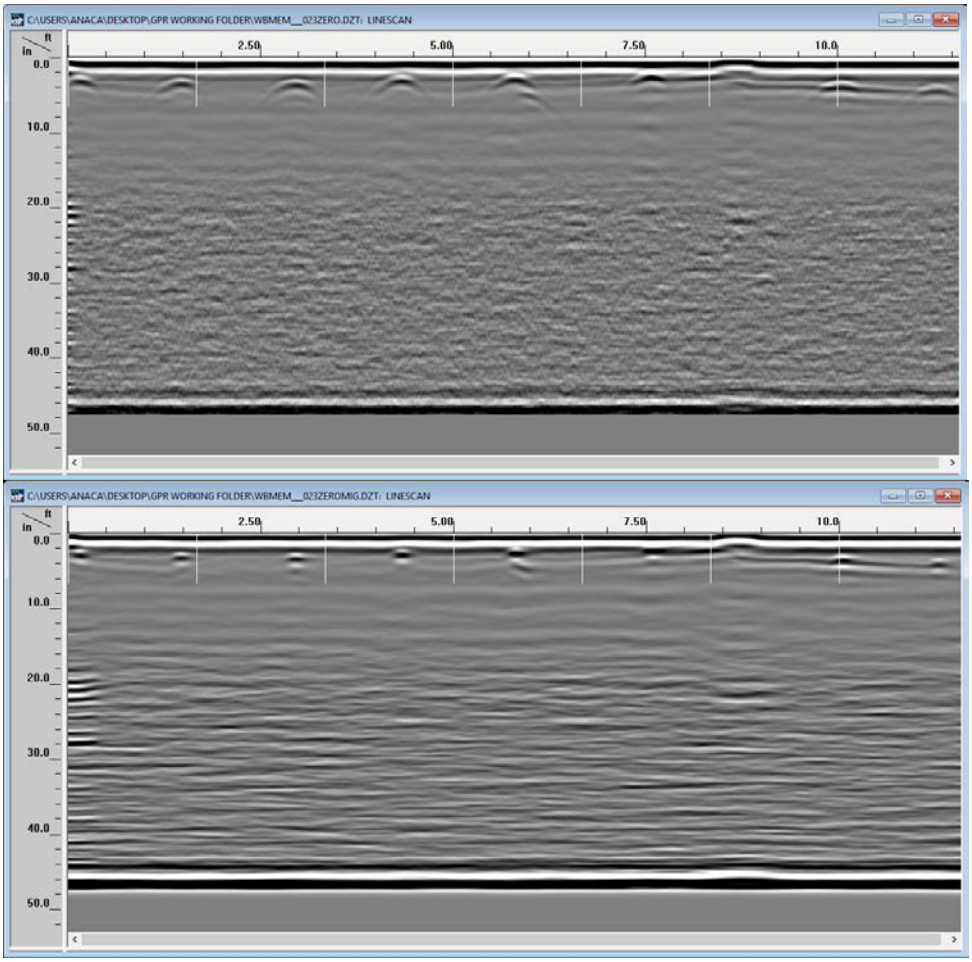


Scan 021: Same as 018, Same as 017, horizontal. Concrete 22" deep?

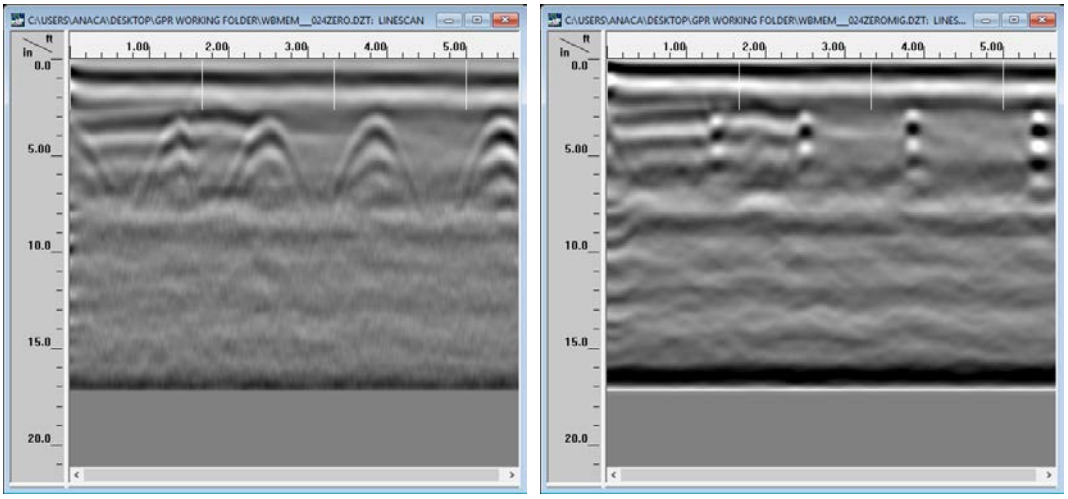


022

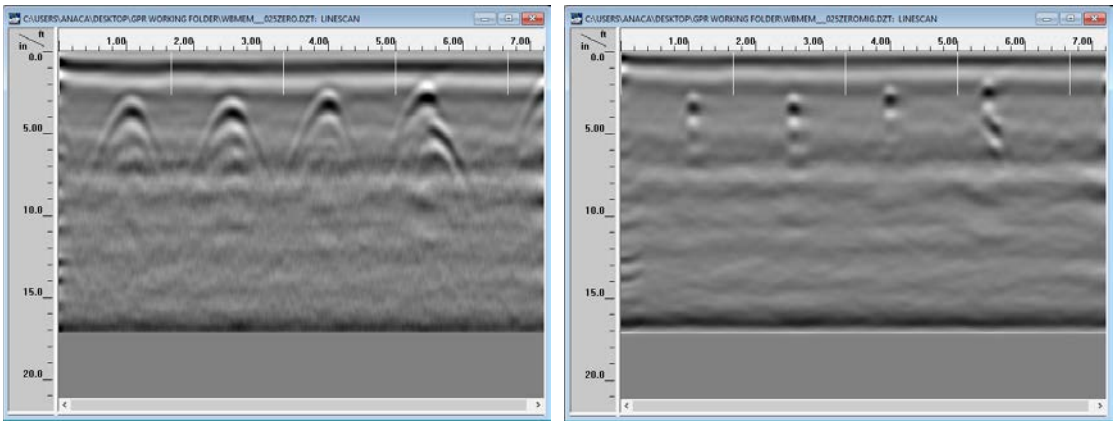
Scan 022, 024: 3rd level, vertical. Rebar at 14" to 19" , depth = 3"



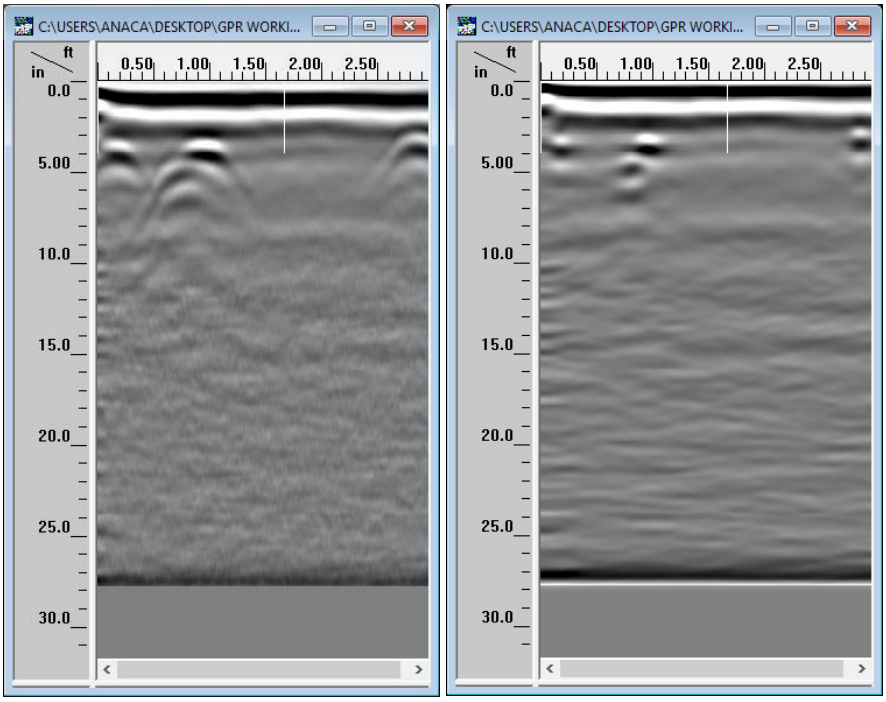
Scan 023: 3rd level conrete, horizontal. Rebar at 16", depth = 1 5/8" to 3"



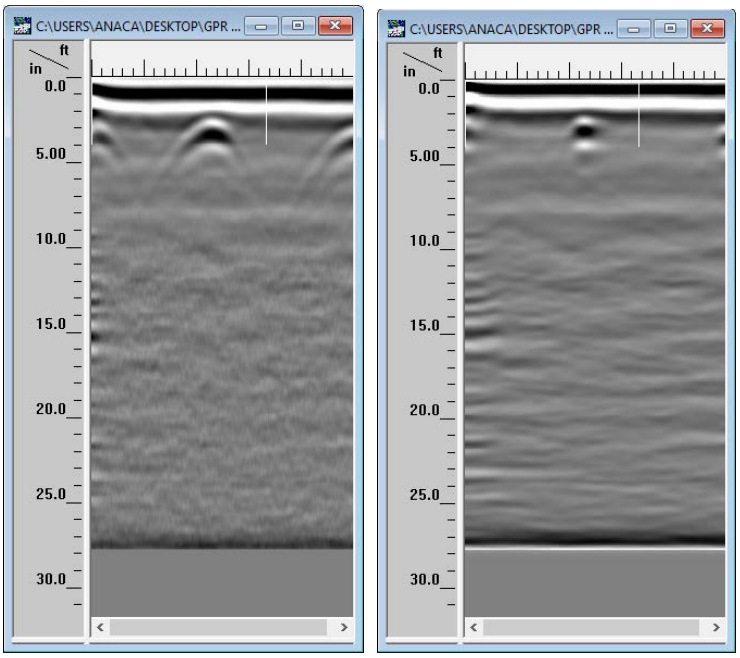
Scan 024: same as 022, 3rd level, vertical. Rebar at 14" to 19" , depth = 3"



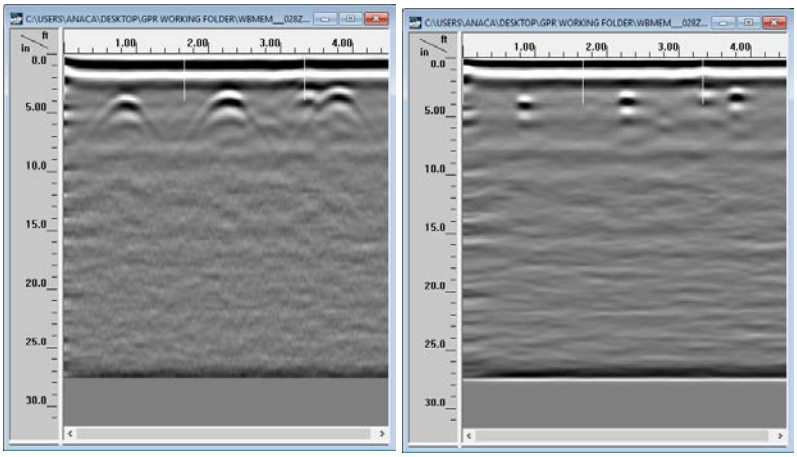
Scan 025: same as 023: 3rd level concrete, horizontal. Rebar at 16", depth = 1 5/8" to 3"



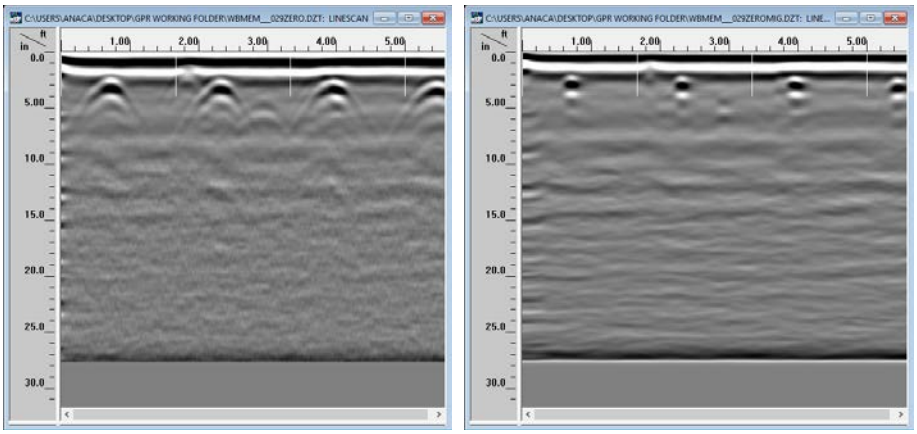
Scan 026: vertical, 3rd level concrete South wall



Scan 027: horizontal, 3rd level concrete South wall



Scan 028: 4th level vertical concrete, west wall, rebar at 16" to 17". One extra bar?

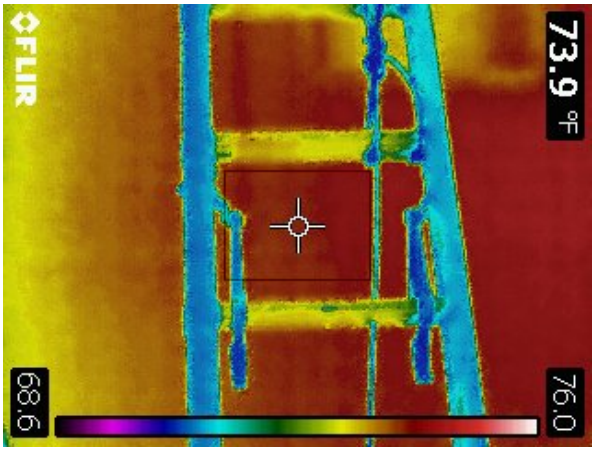


Scan 029: 4th level concrete, horizontal, west wall, rebar at 6" to 18".

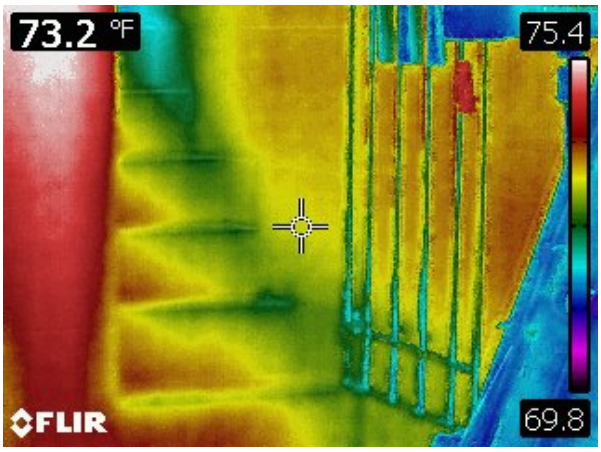
APPENDIX C

INFRARED THERMOGRAPHY SCANS

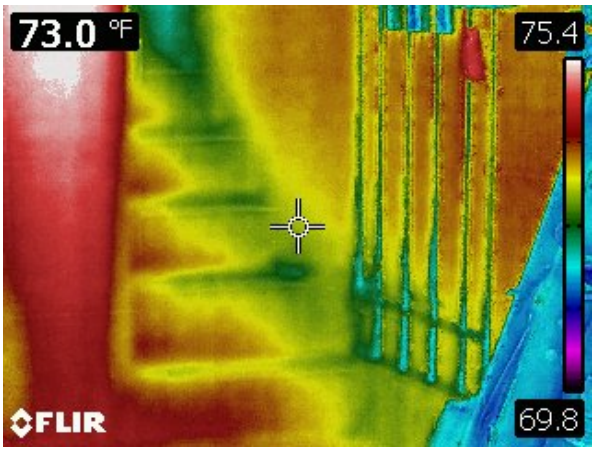
Infrared Thermography Scan Set 1: Tuesday November 29 between 14:14 and 14:35

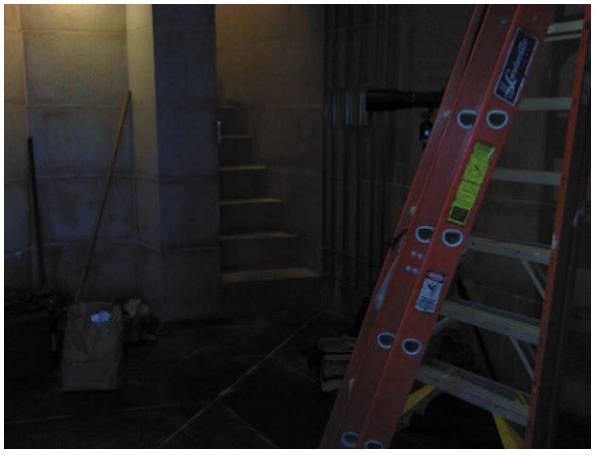




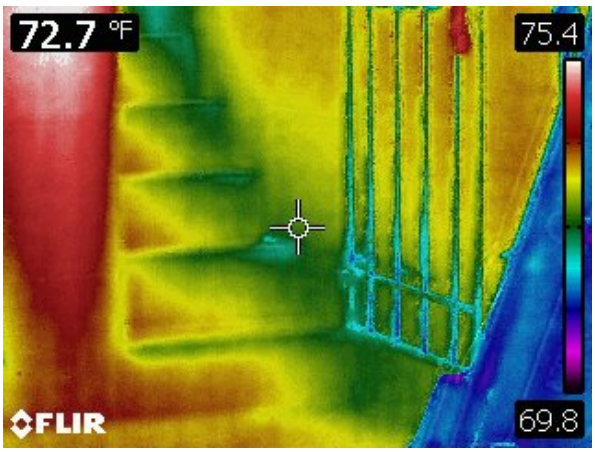




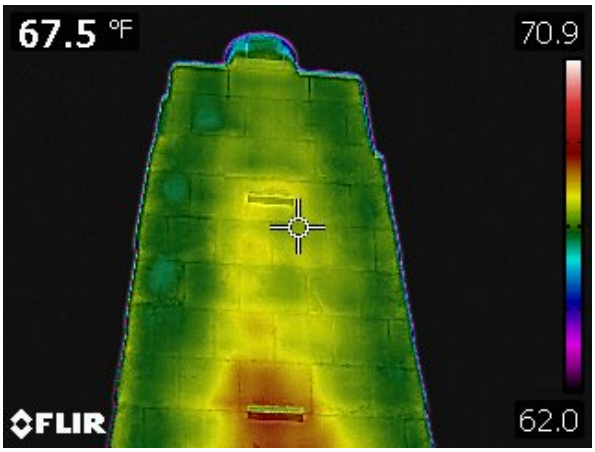




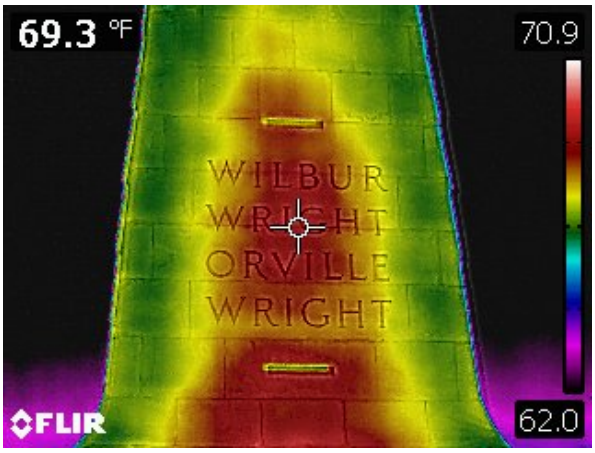
Infrared Thermography Scan Set 1: Tuesday November 29 between 14:14 and 14:35









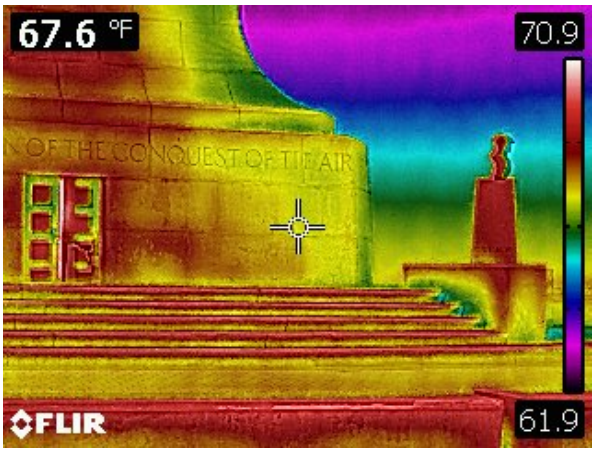




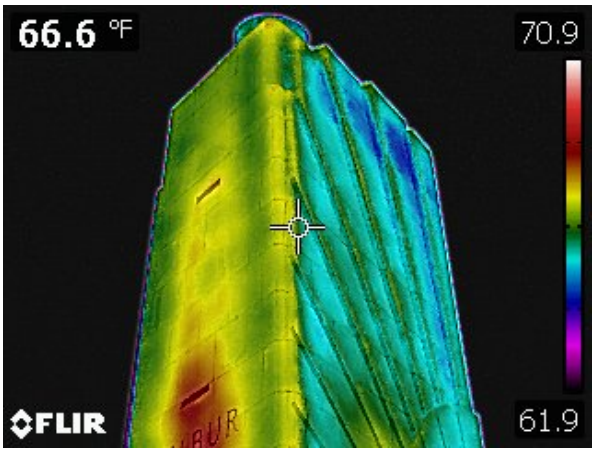
Infrared Thermography Scan Set 1: Tuesday November 29 between 14:14 and 14:35





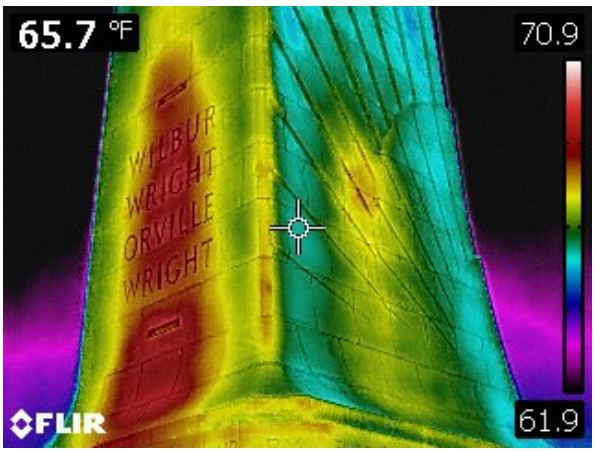




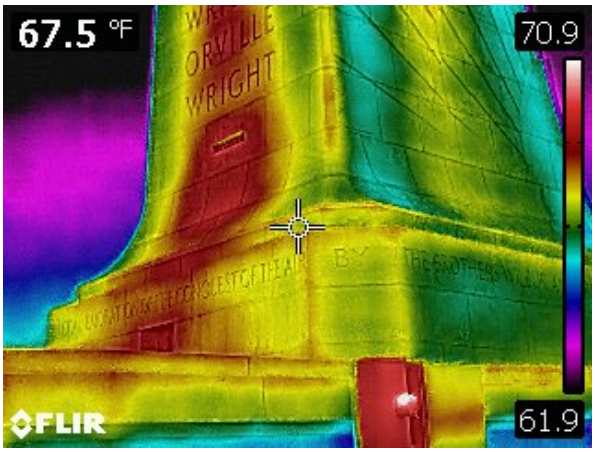




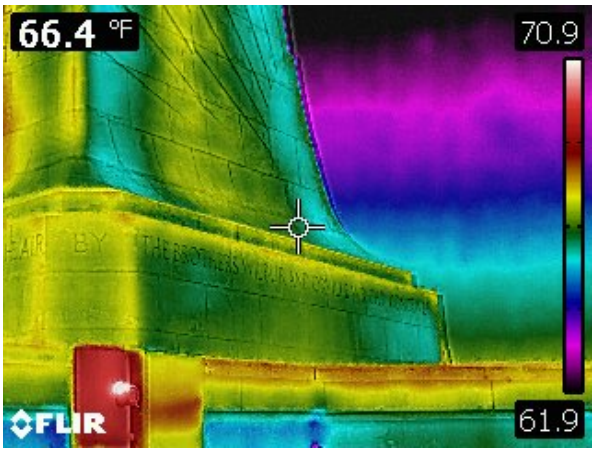
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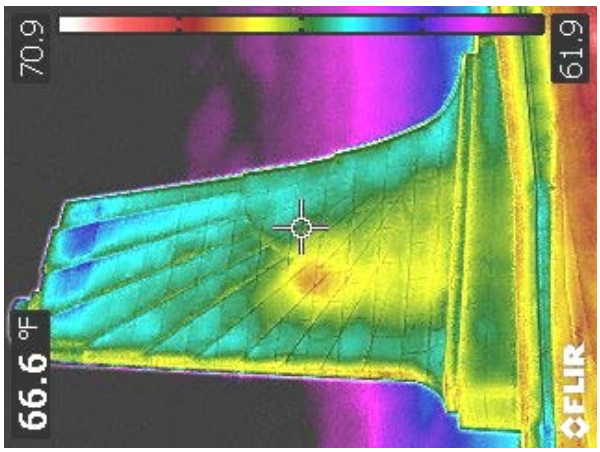




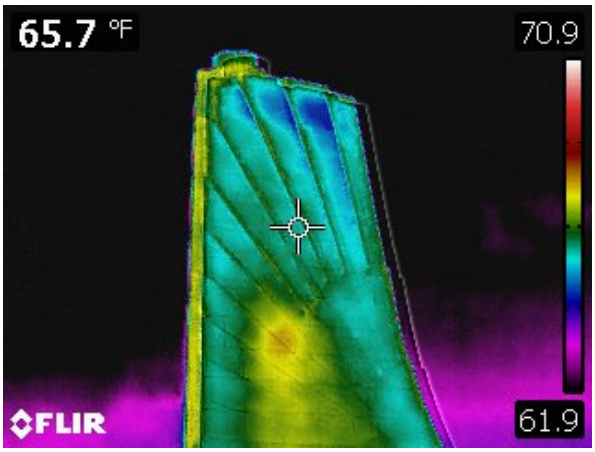




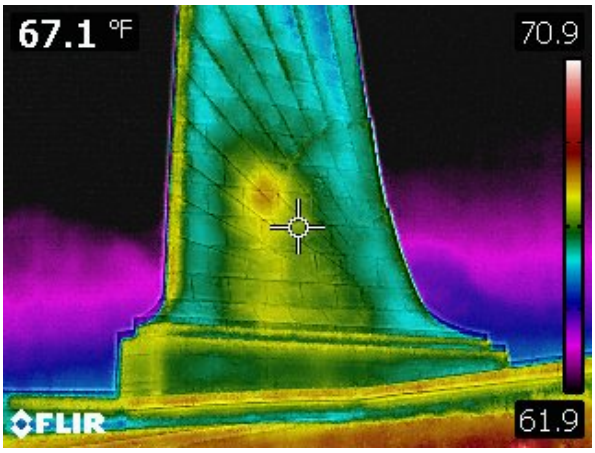
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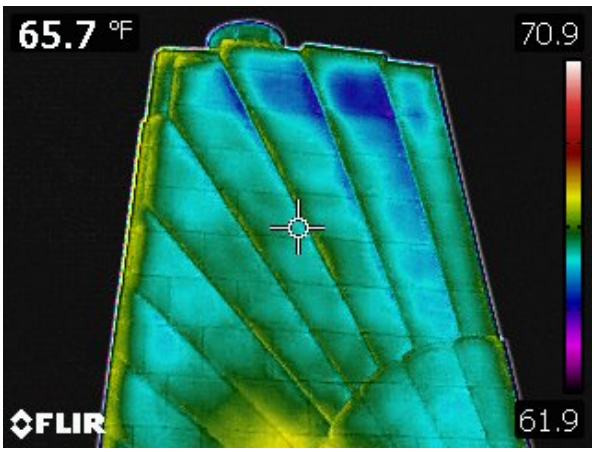




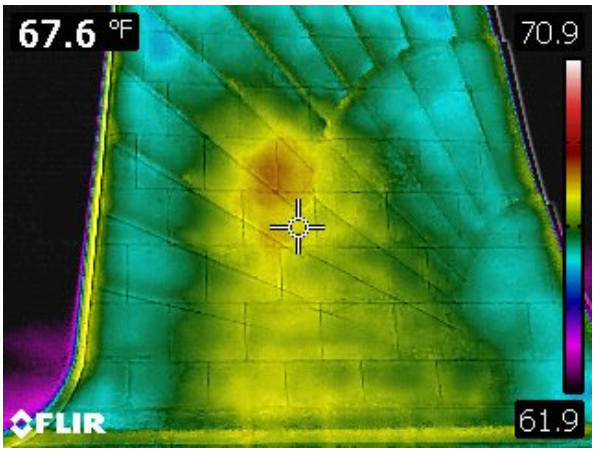




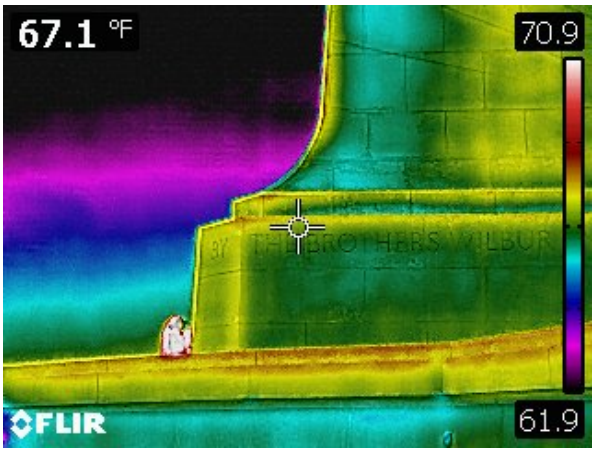
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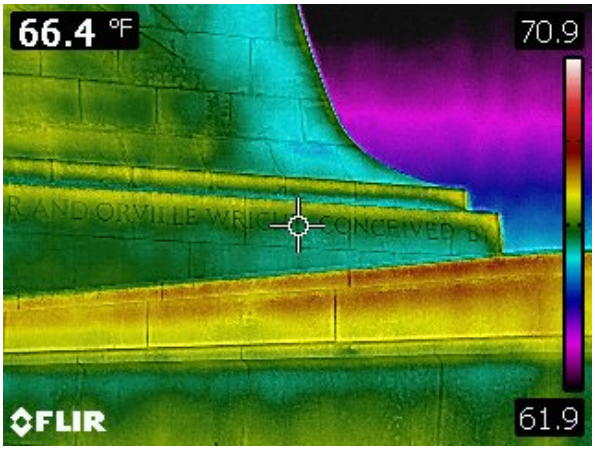




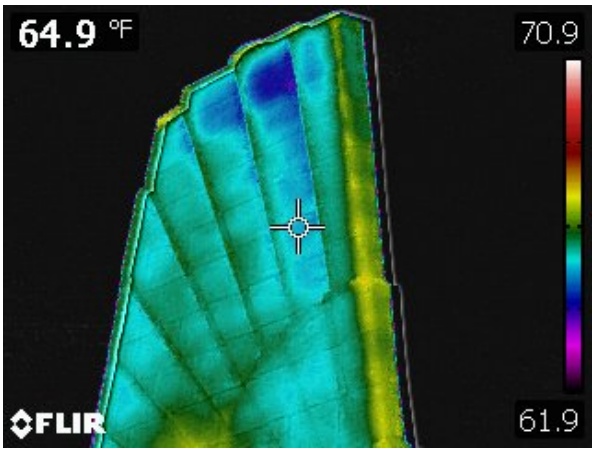




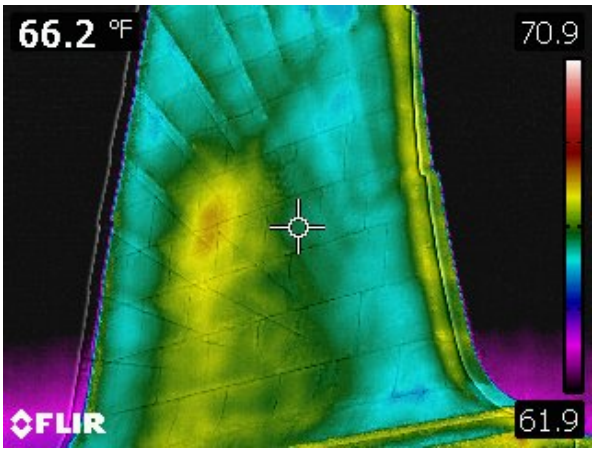
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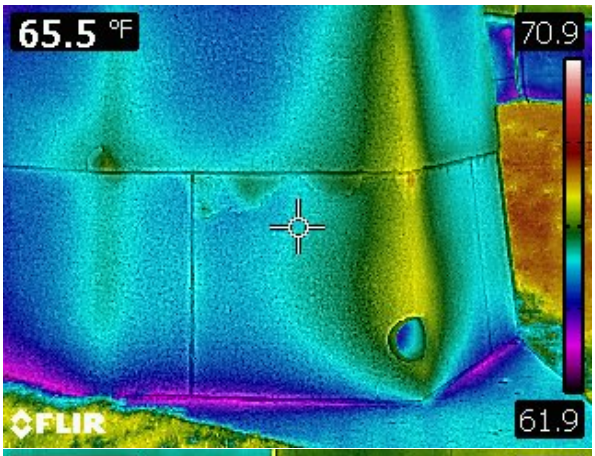




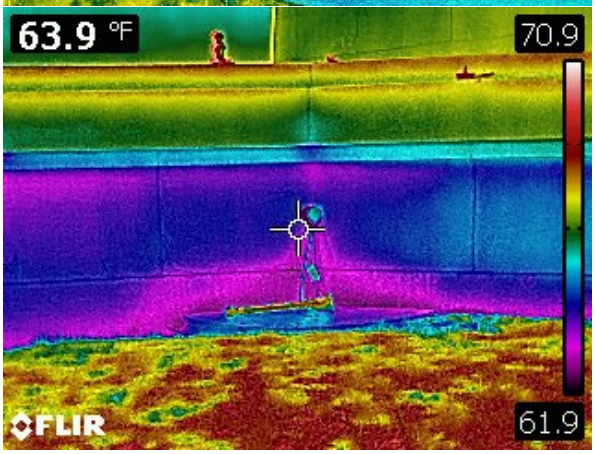
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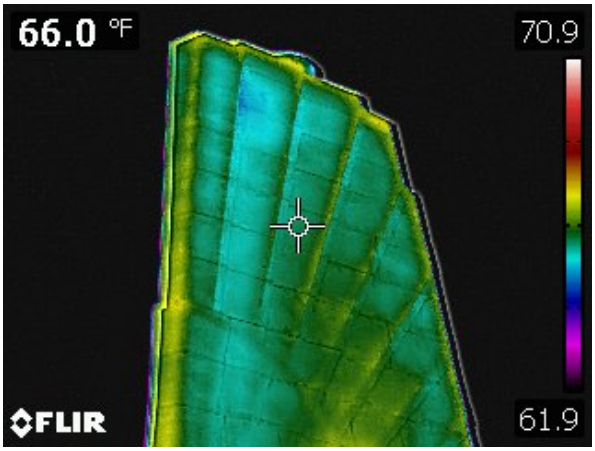




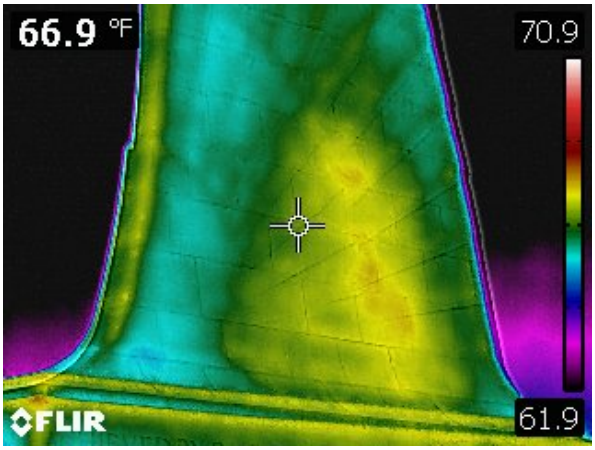







66.0 °F
70.9
61.9
FLIR




66.9 °F
70.9
61.9
FLIR



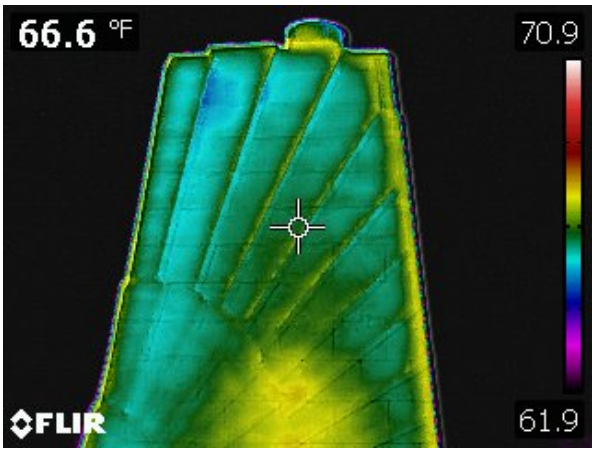

66.4 °F
70.9
61.9
FLIR



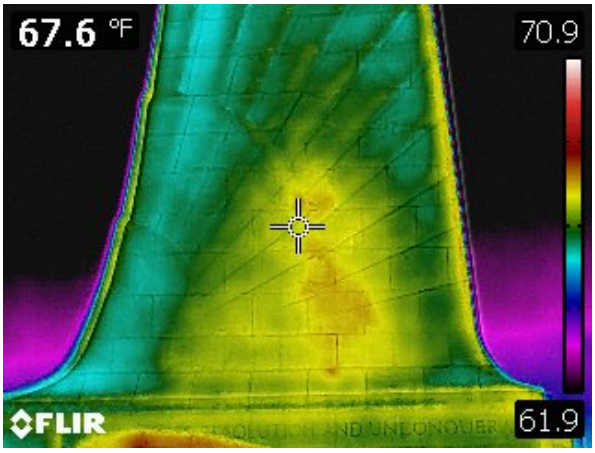
Infrared Thermography Scan Set 1: Tuesday November 29 between 14:14 and 14:35














67.8 °F
70.9
61.9
FLIR



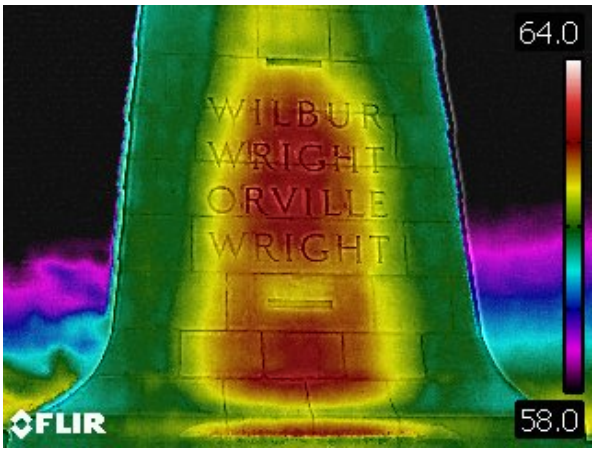

67.3 °F
70.9
61.9
FLIR



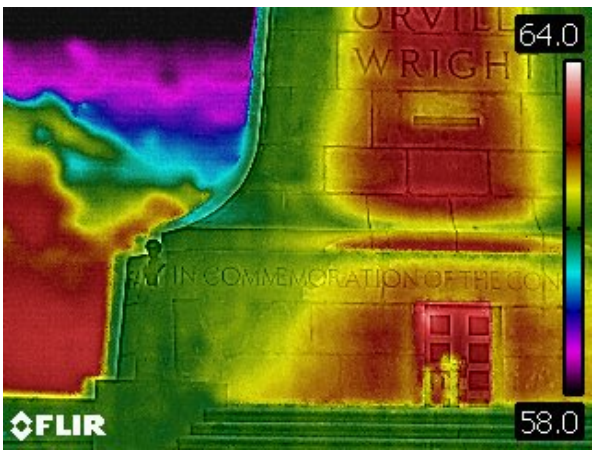
Infrared Thermography Scan Set 2: Wednesday November 30 between 07:08 and 08:43, during roof drain leak test





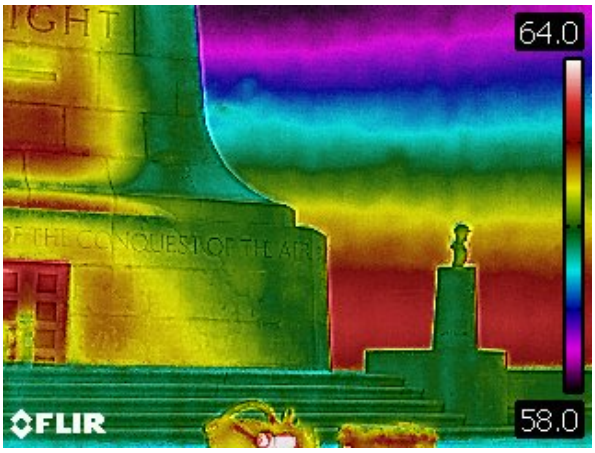








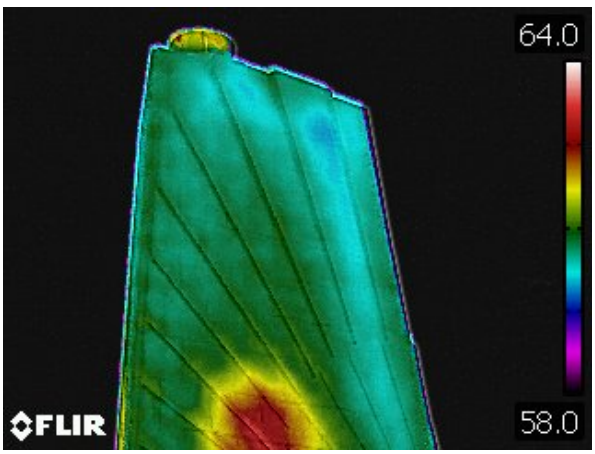
Infrared Thermography Scan Set 2: Wednesday November 30 between 07:08 and 08:43, during roof drain leak test





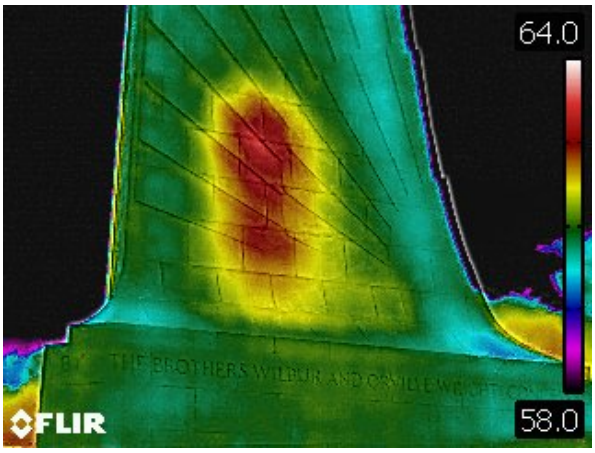




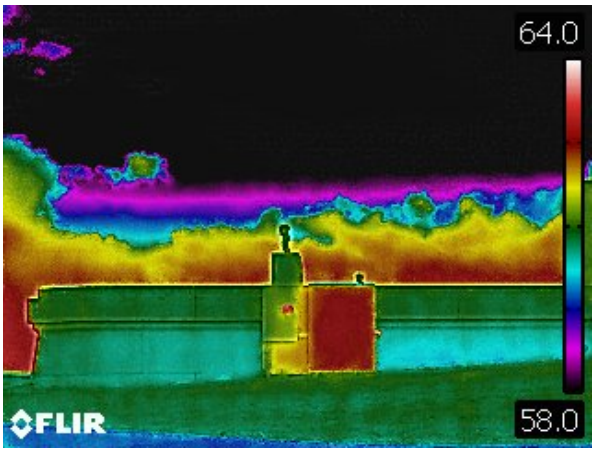




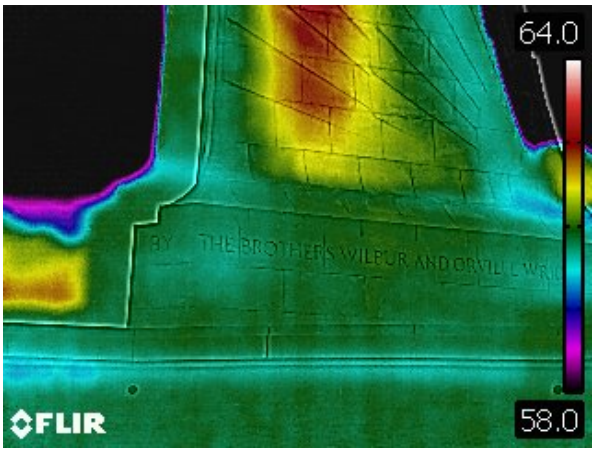
Infrared Thermography Scan Set 2: Wednesday November 30 between 07:08 and 08:43, during roof drain leak test





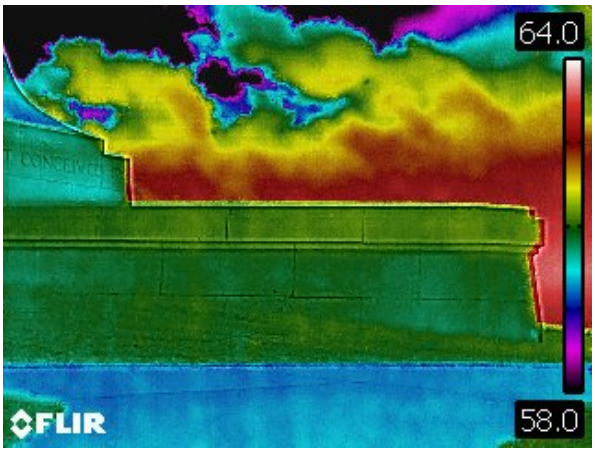




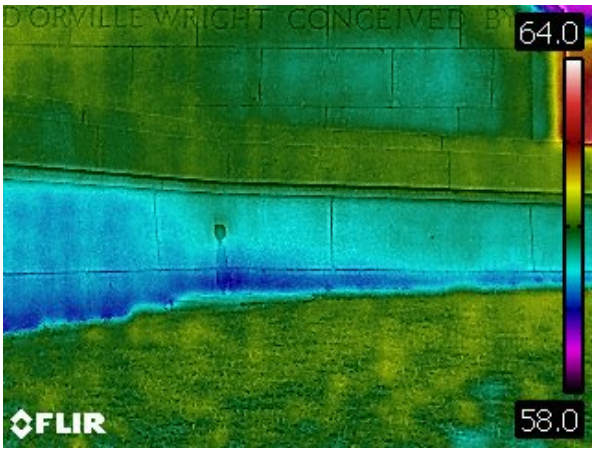




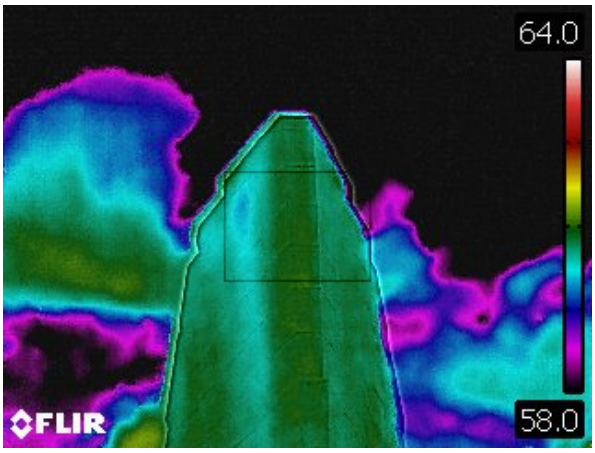
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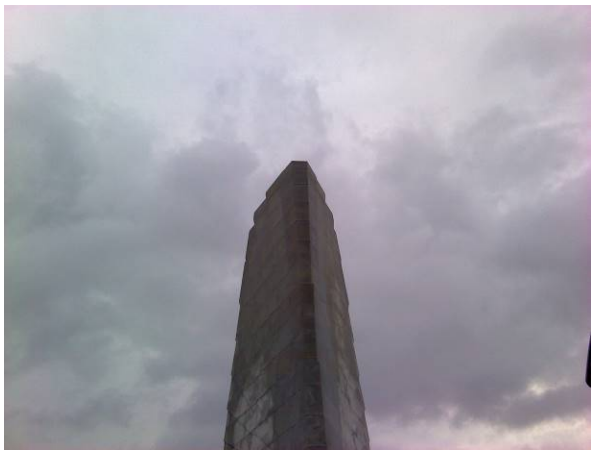




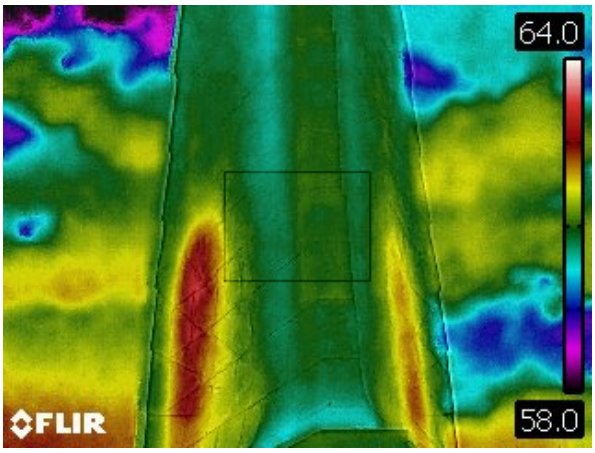




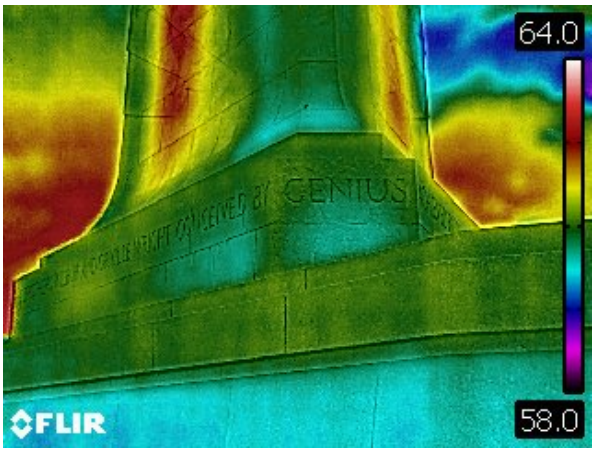




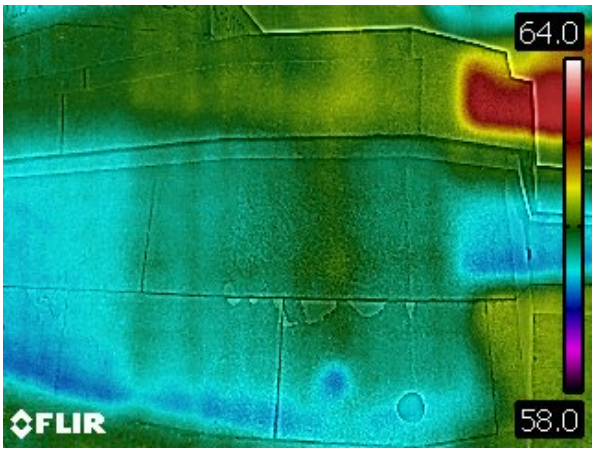
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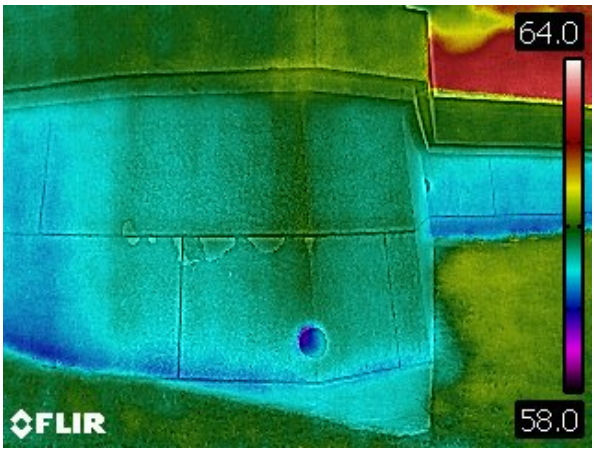




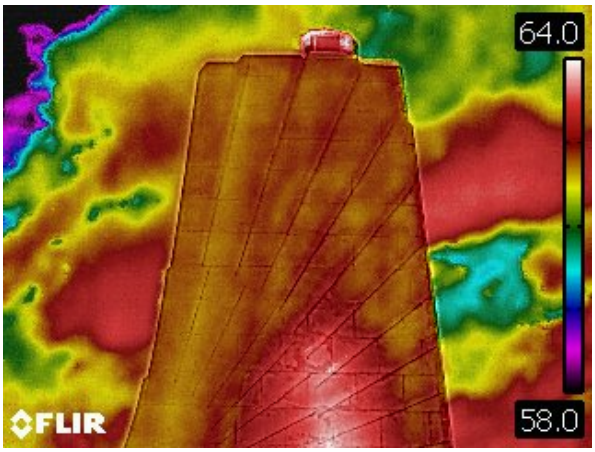




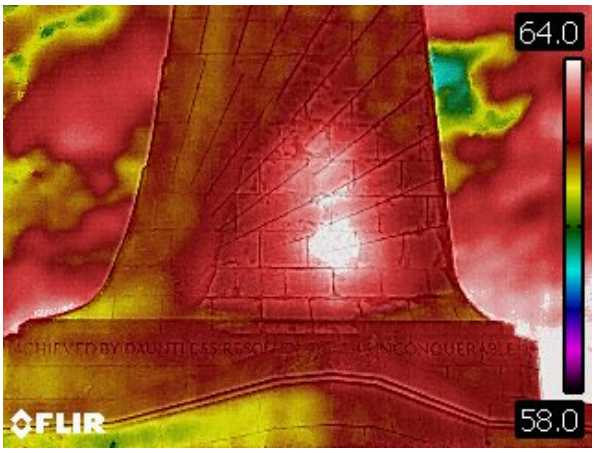
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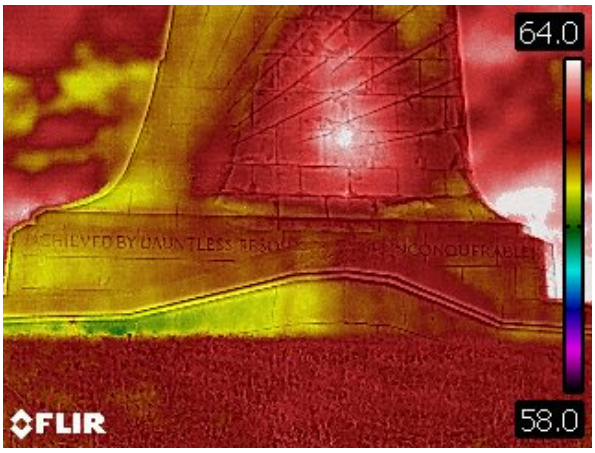




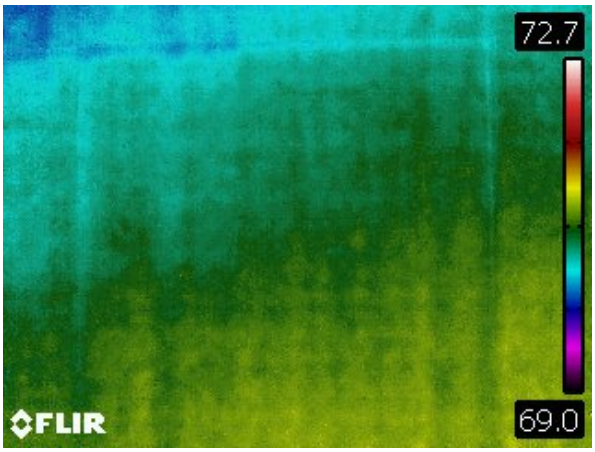




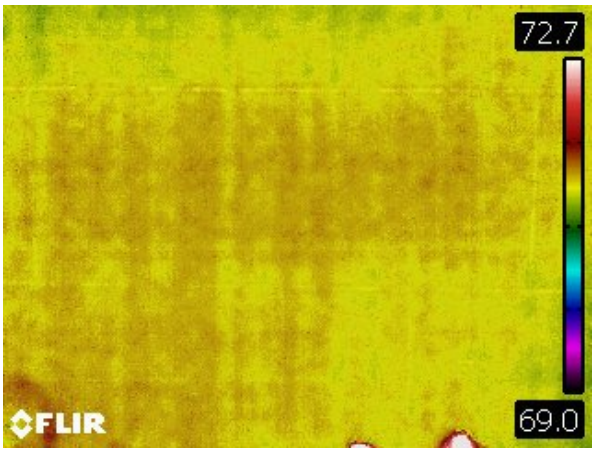
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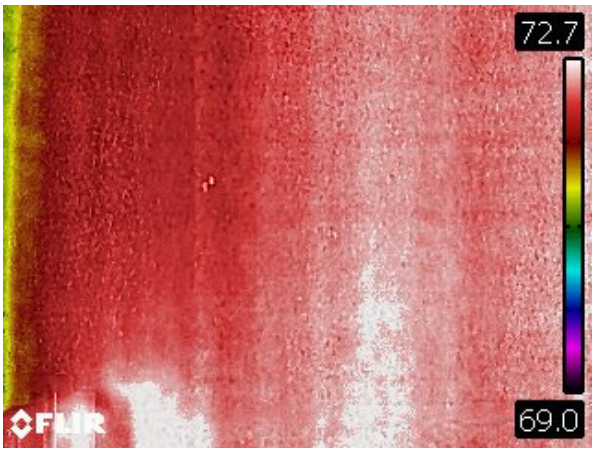




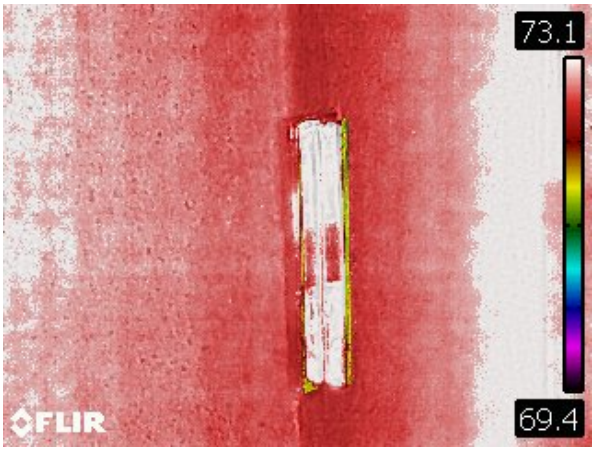


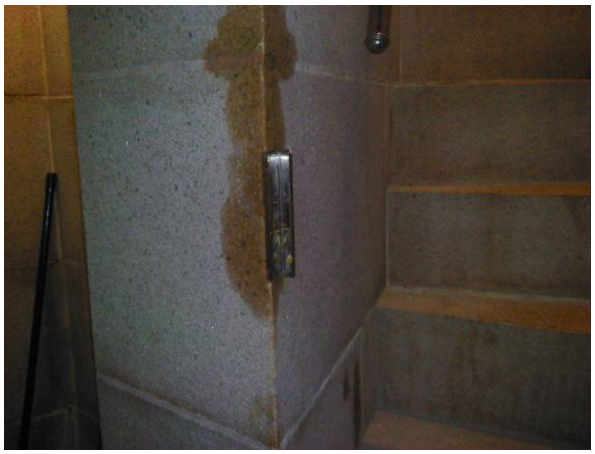


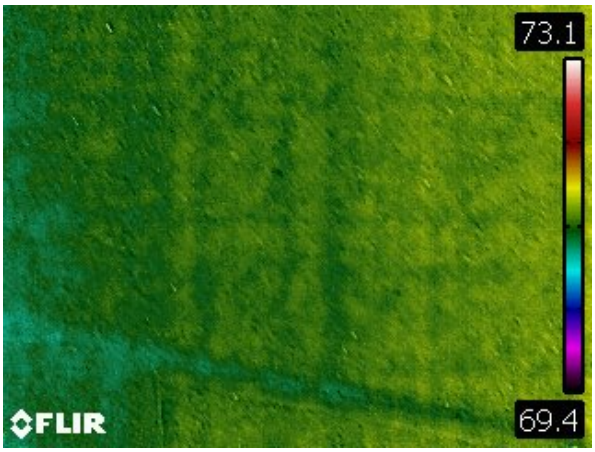
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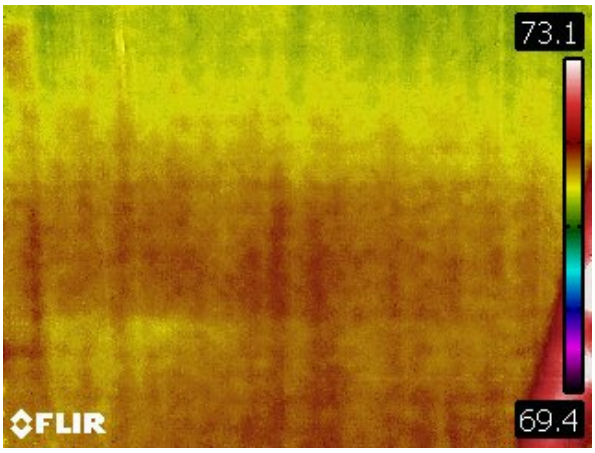


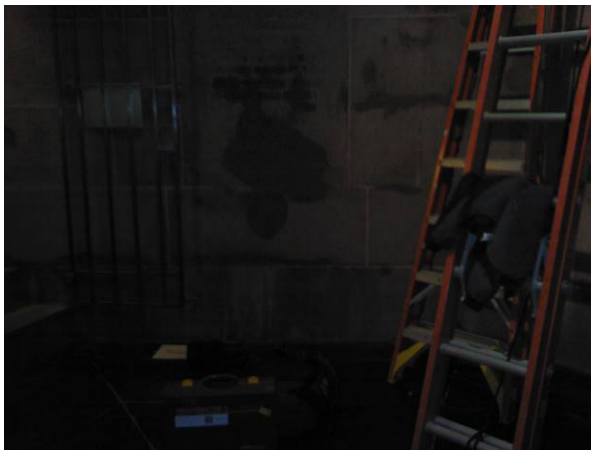


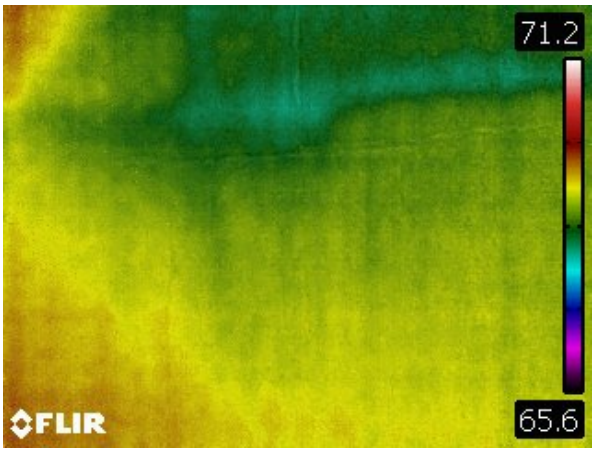




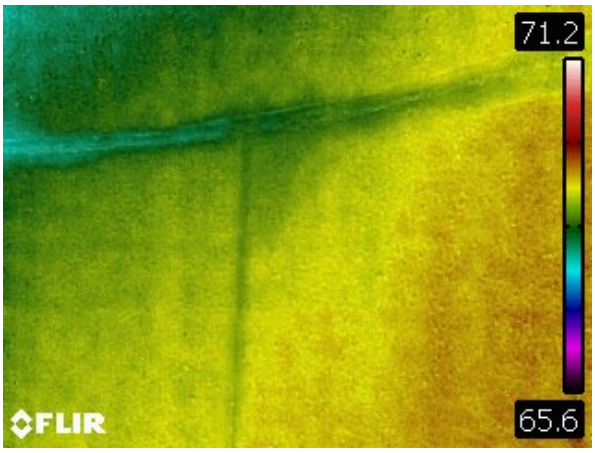
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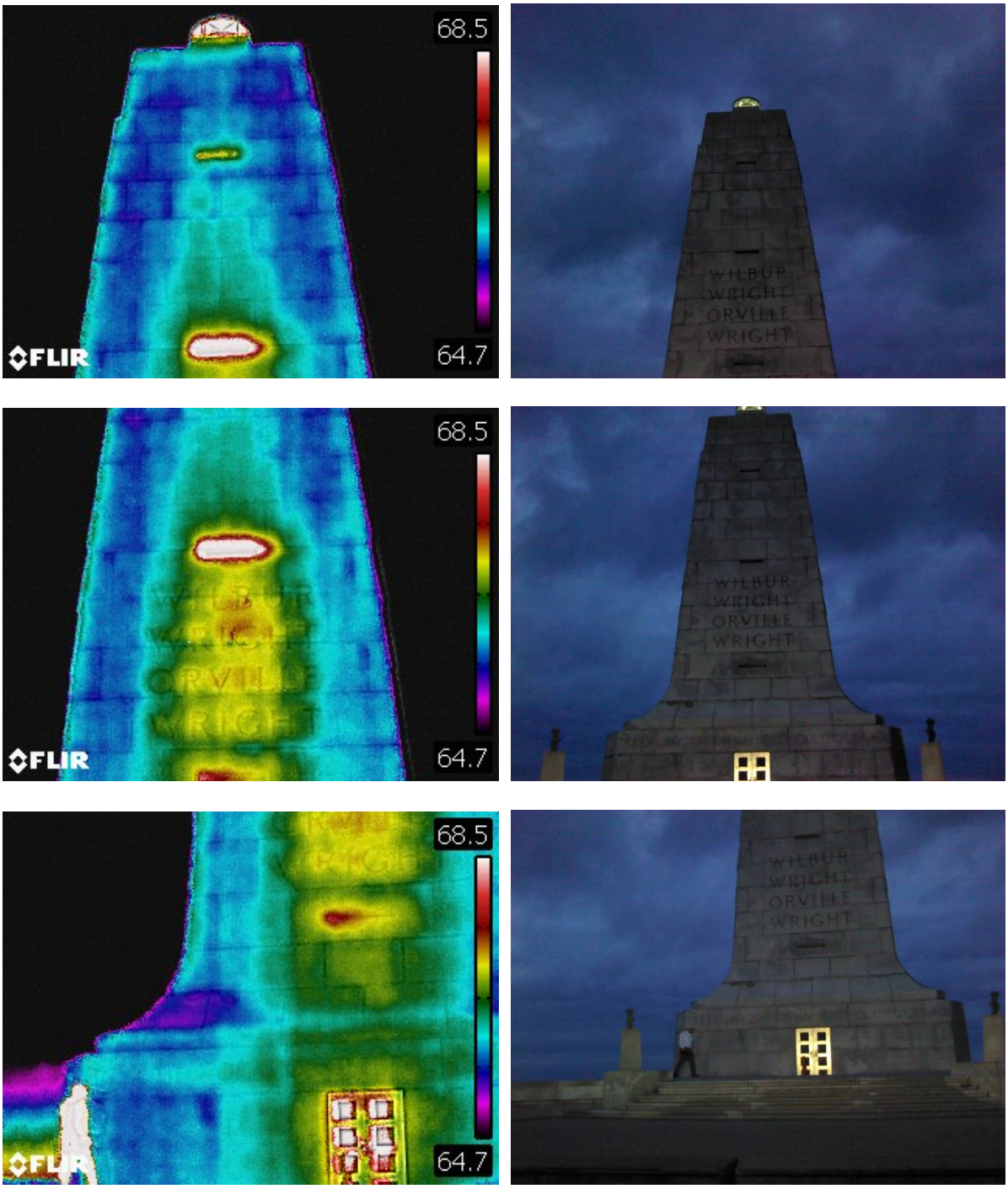


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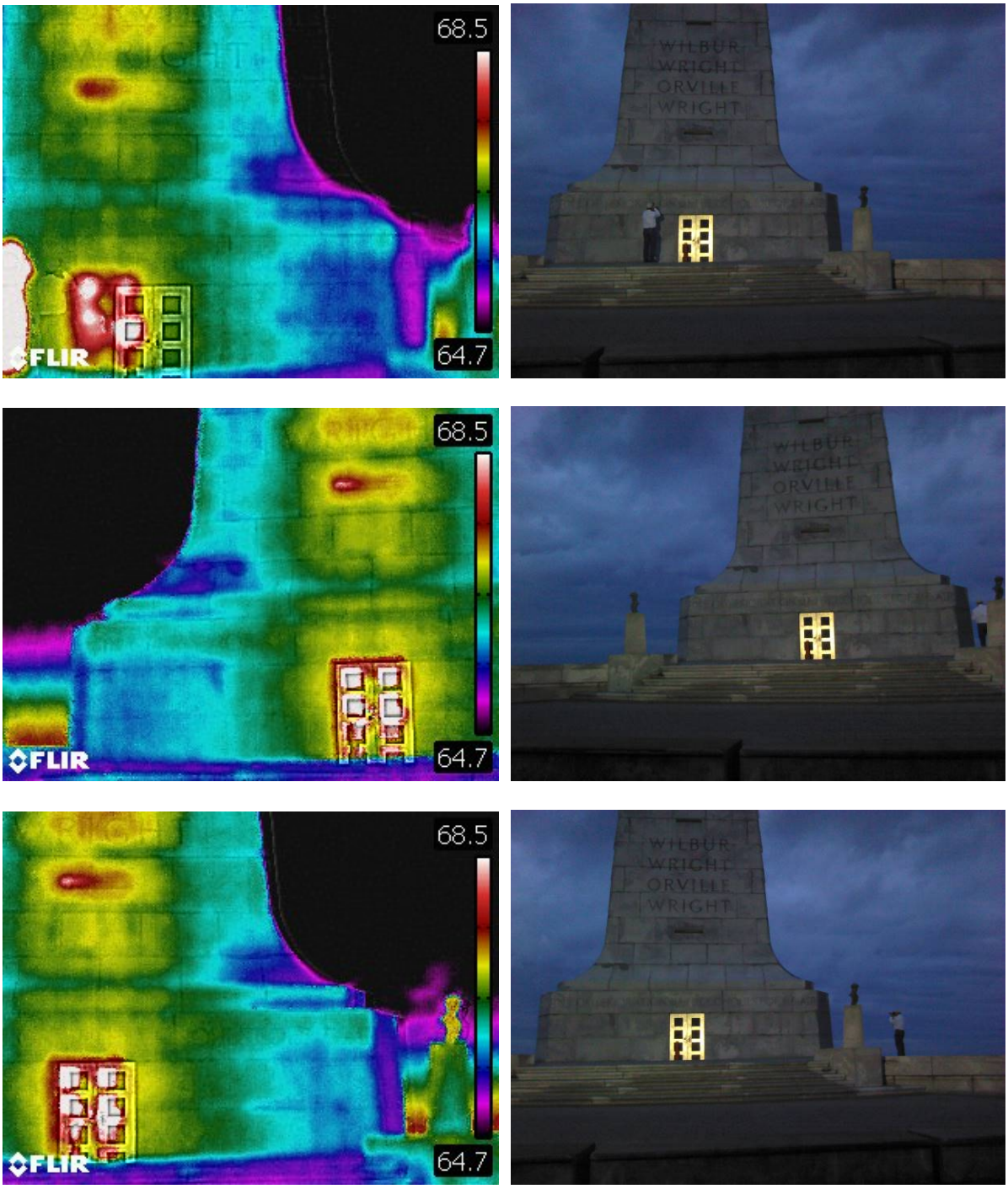




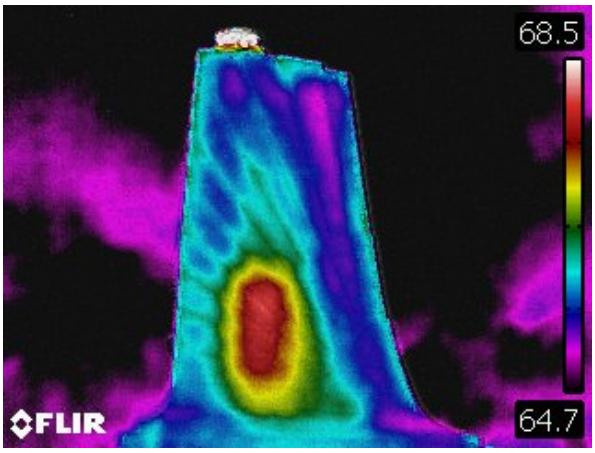
Infrared Thermography Scan Set 3: Thursday December 1 between 06:31 and 06:55, after roof drain leak test



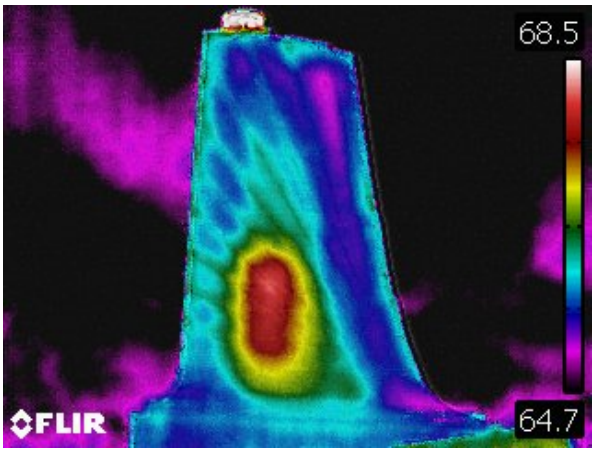
Infrared Thermography Scan Set 3: Thursday December 1 between 06:31 and 06:55, after roof drain leak test



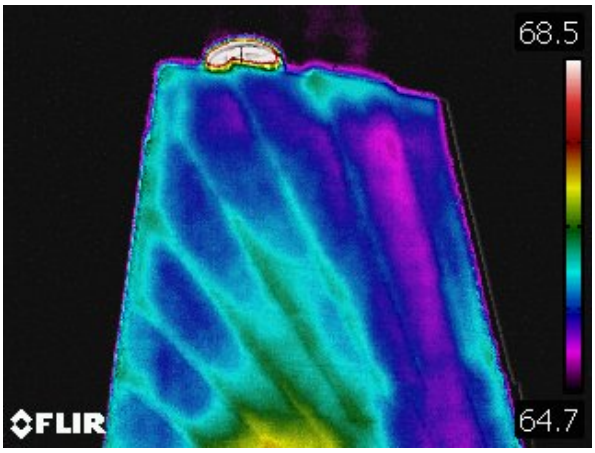
Infrared Thermography Scan Set 3: Thursday December 1 between 06:31 and 06:55, after roof drain leak test

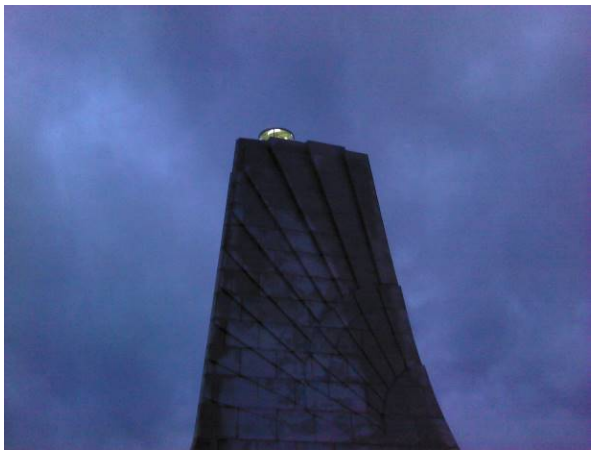




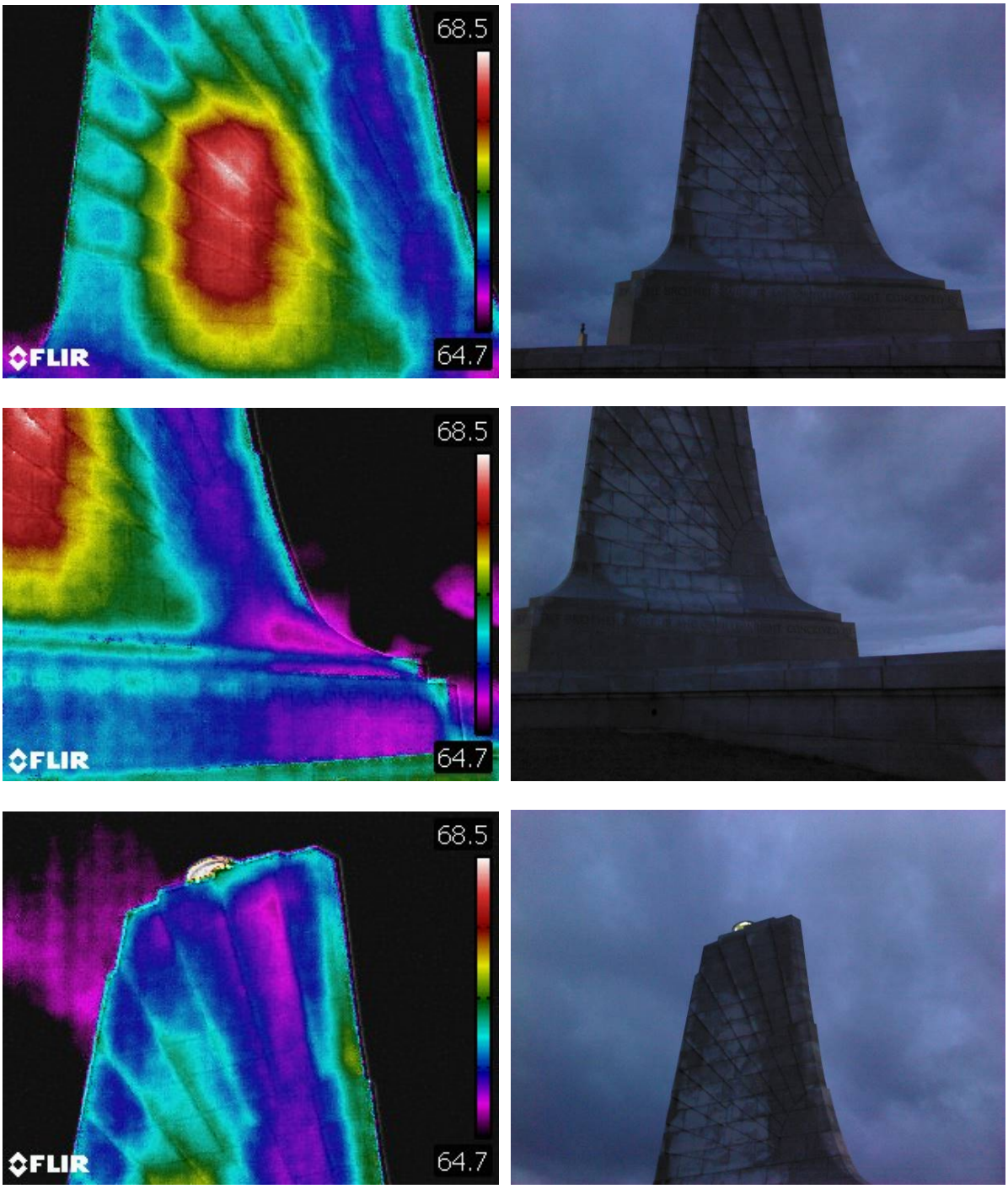




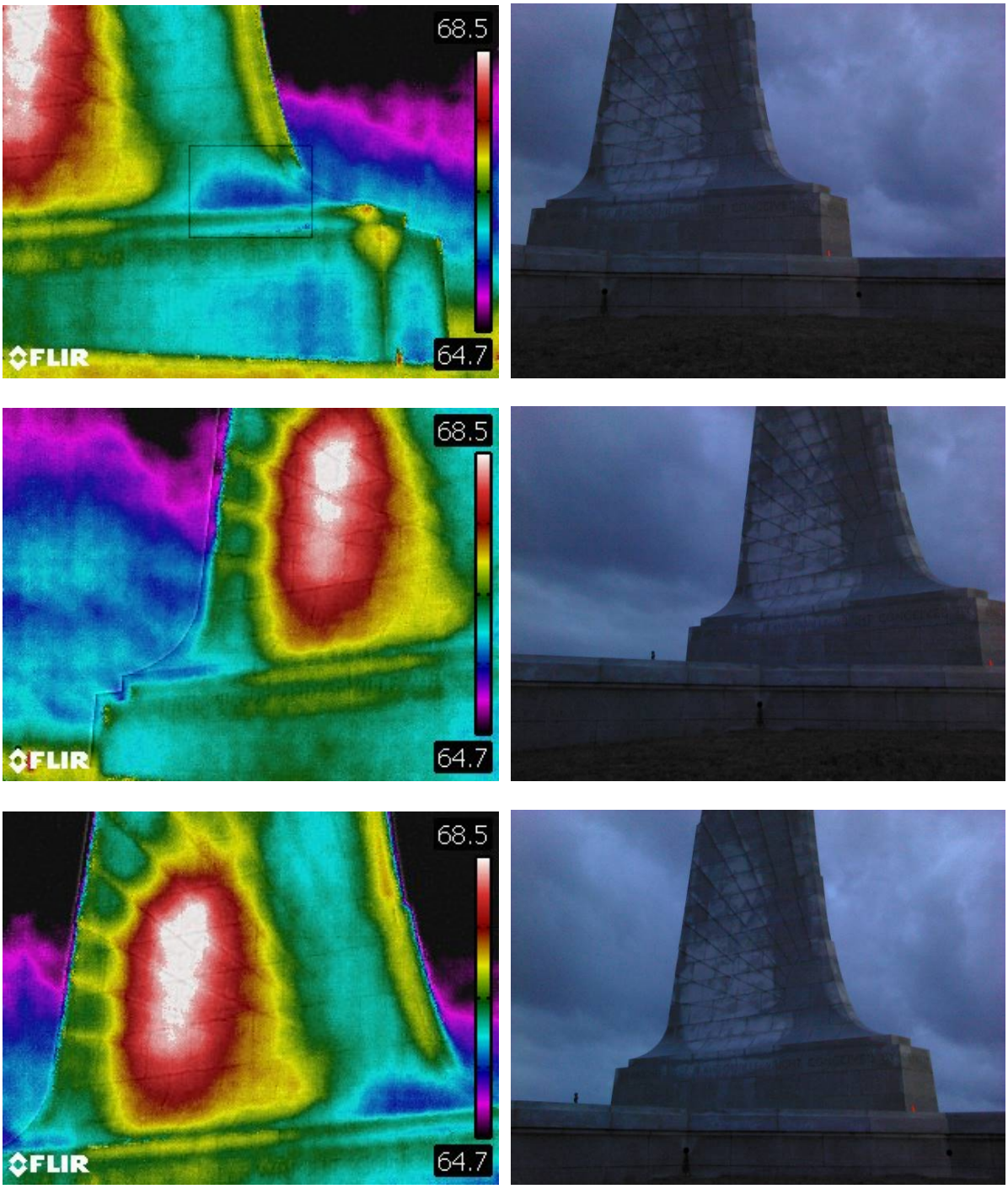




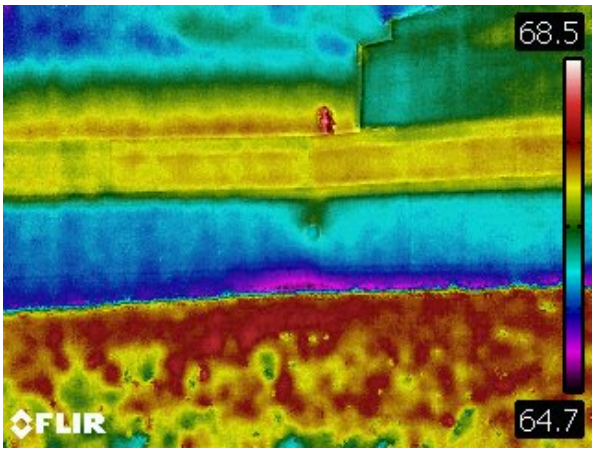
Infrared Thermography Scan Set 3: Thursday December 1 between 06:31 and 06:55, after roof drain leak test



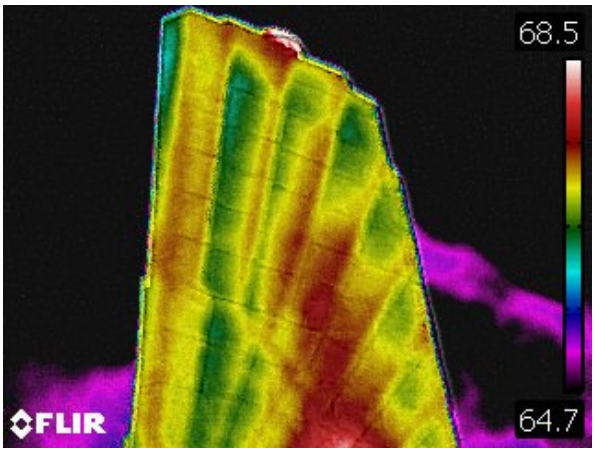
Infrared Thermography Scan Set 3: Thursday December 1 between 06:31 and 06:55, after roof drain leak test



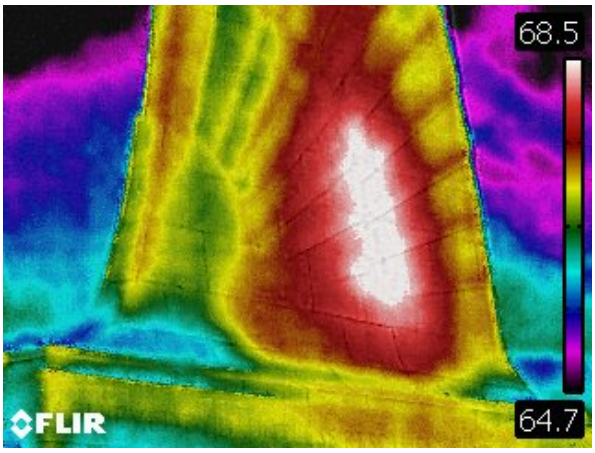
Infrared Thermography Scan Set 3: Thursday December 1 between 06:31 and 06:55, after roof drain leak test





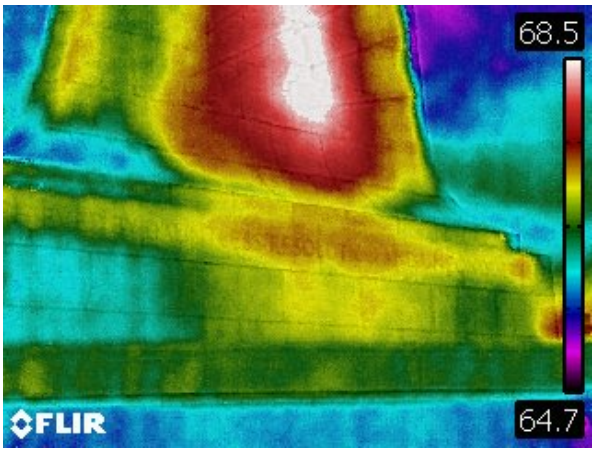




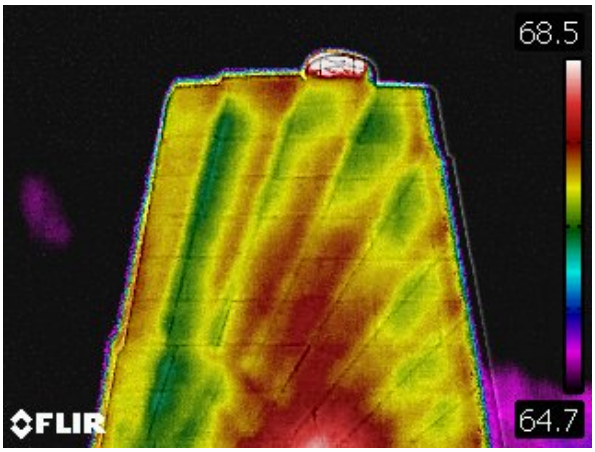


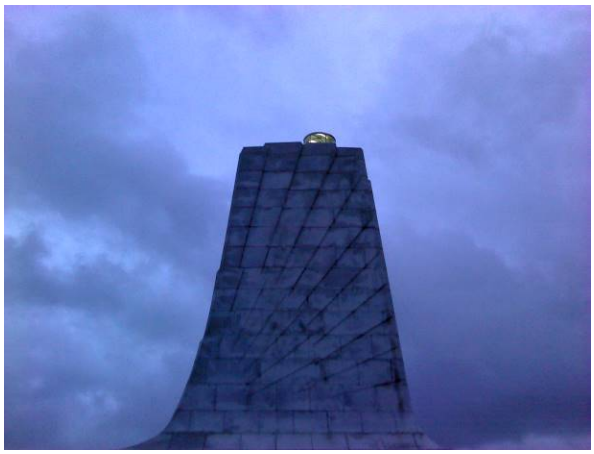


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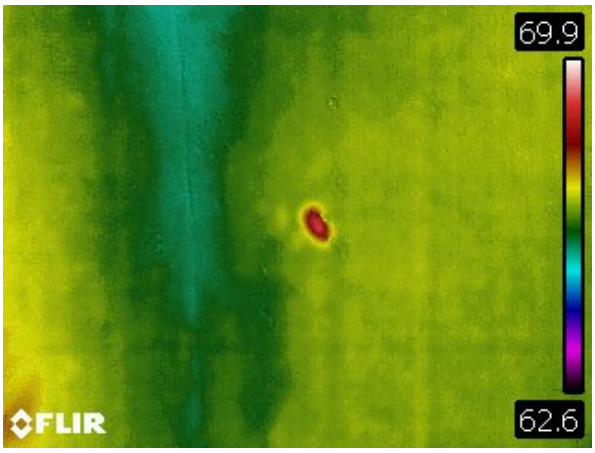


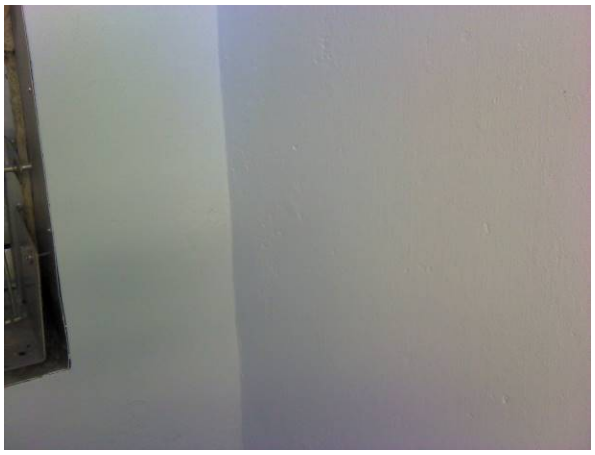


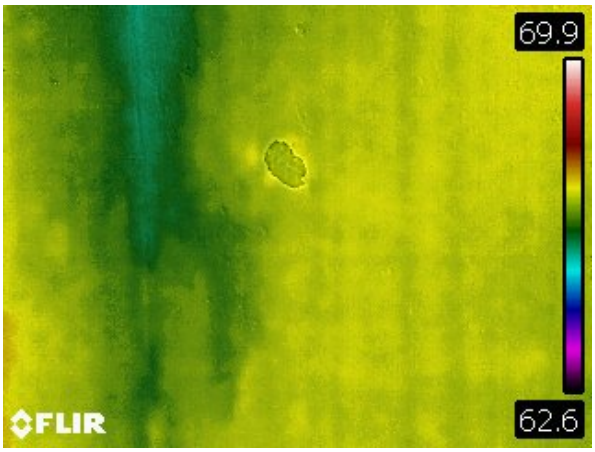




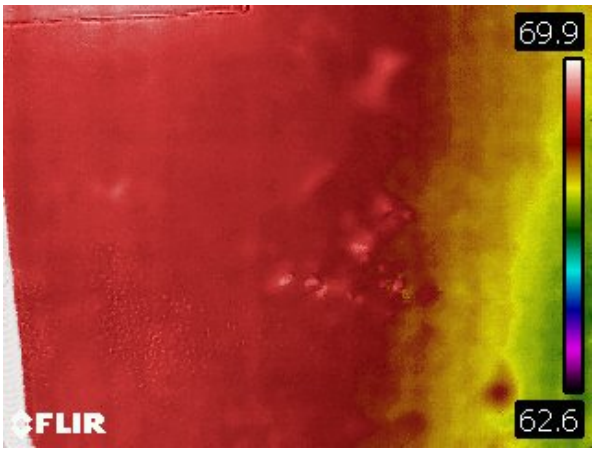
Infrared Thermography Scan Set 4: Thursday December 1 between 09:02 and 10:55, Miscellaneous interior scans





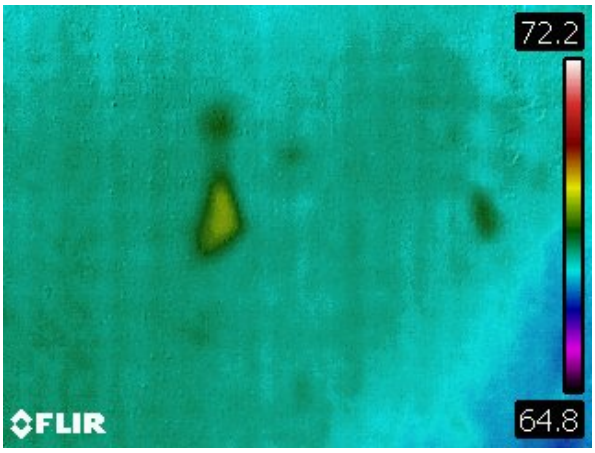


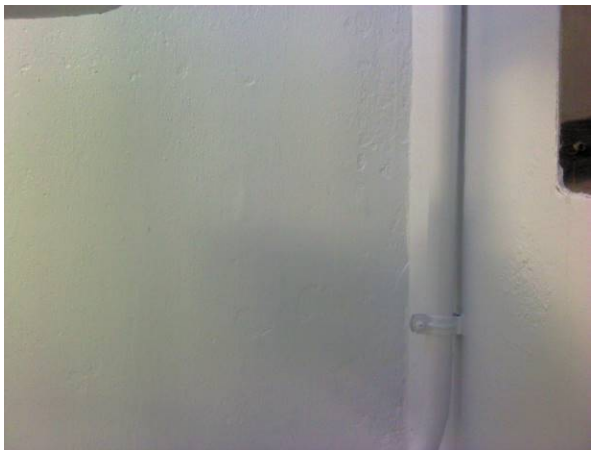


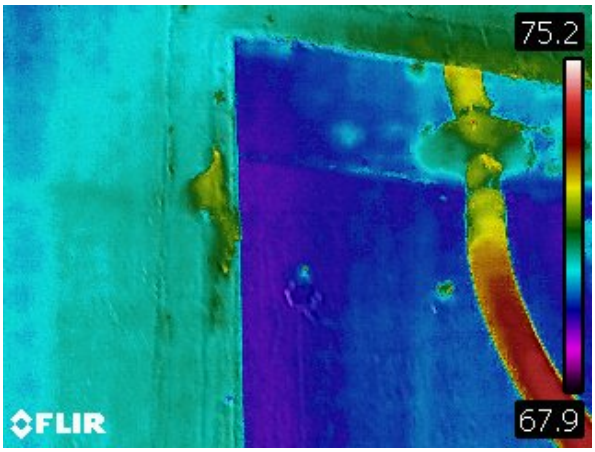




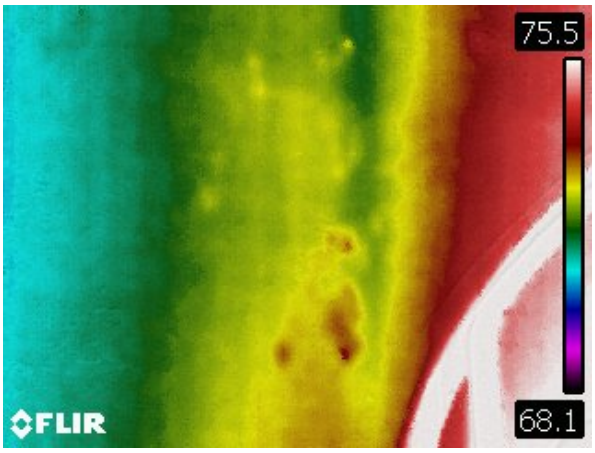
Infrared Thermography Scan Set 4: Thursday December 1 between 09:02 and 10:55, Miscellaneous interior scans

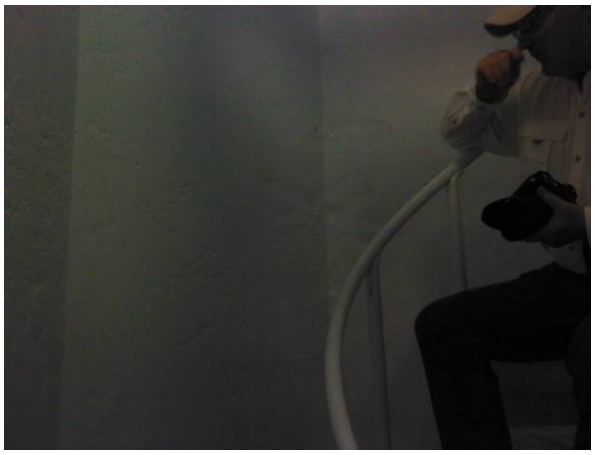




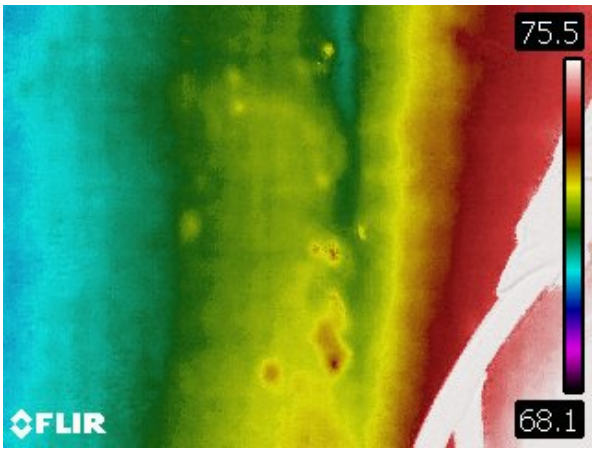


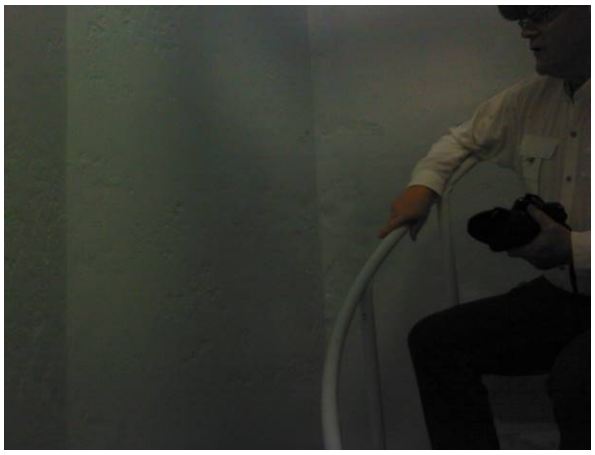


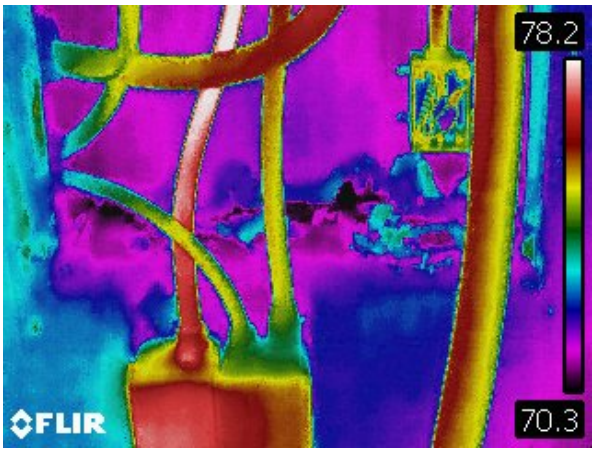




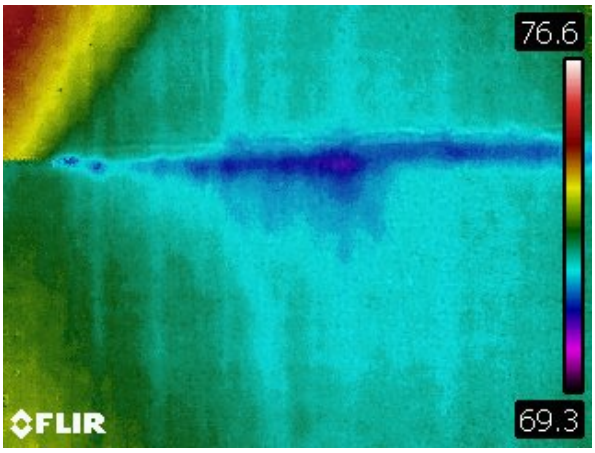
Infrared Thermography Scan Set 4: Thursday December 1 between 09:02 and 10:55, Miscellaneous interior scans





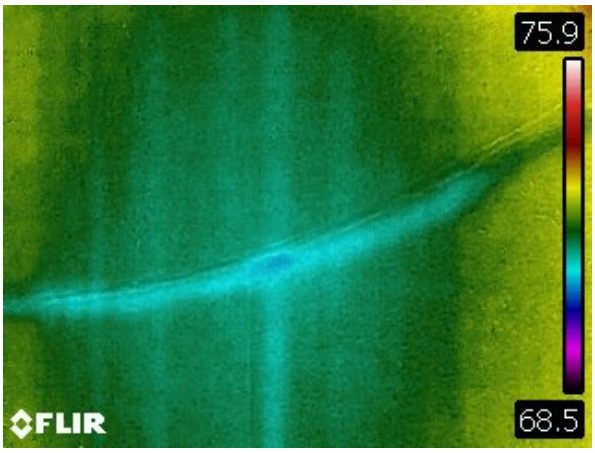




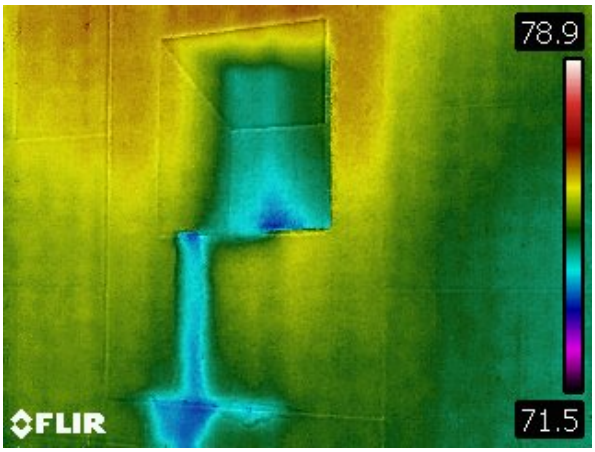


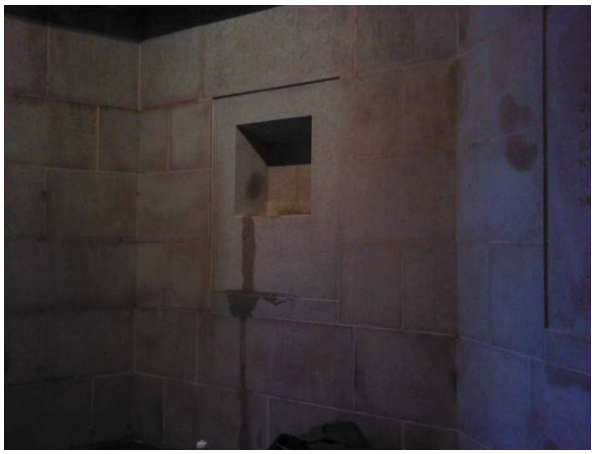


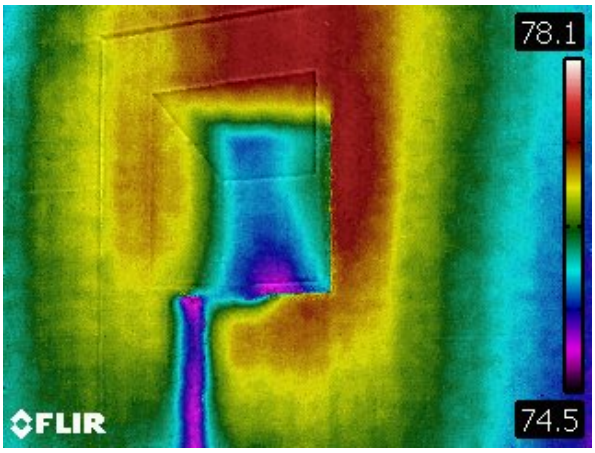
Infrared Thermography Scan Set 4: Thursday December 1 between 09:02 and 10:55, Miscellaneous interior scans





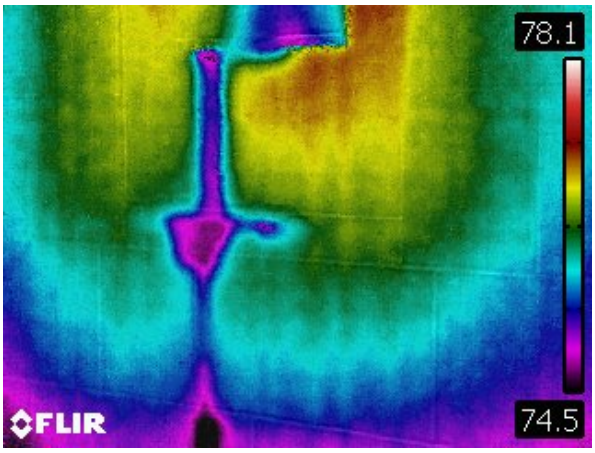


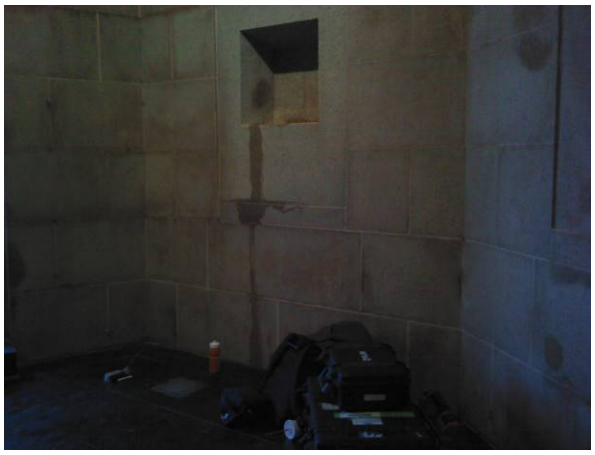


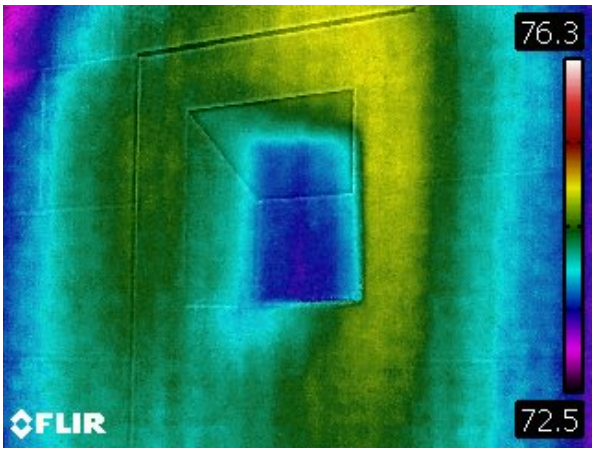




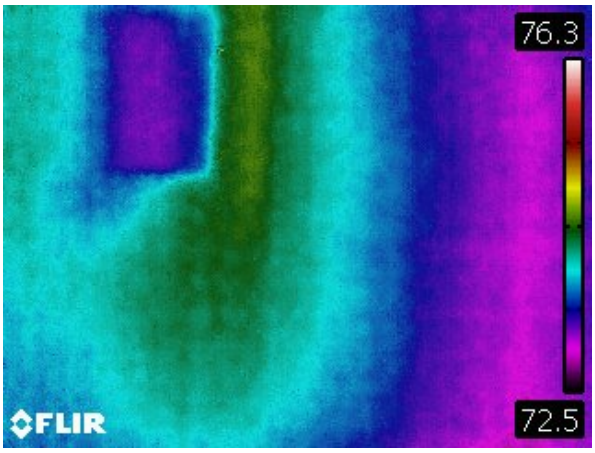
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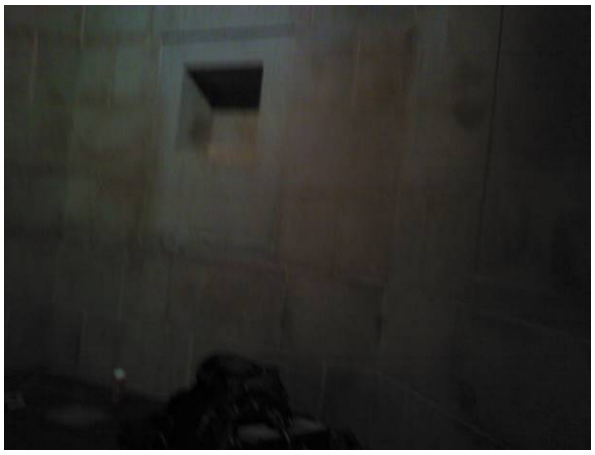




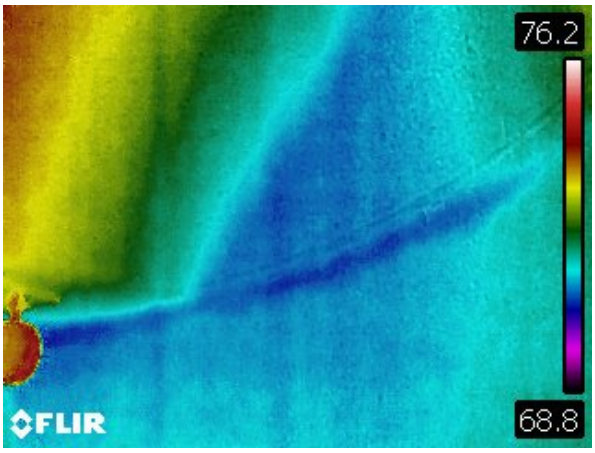








Infrared Thermography Scan Set 4: Thursday December 1 between 09:02 and 10:55, Miscellaneous interior scans





APPENDIX D

DRAIN PIPE VIDEOSCOPE: SUMMARY

Prepared by: McGee and Sons Plumbing
February 3, 2017

McGee & Sons . . presents . . .

The Gentleman Plumber, Inc.

208 W. Fresh Pond
Kill Devil Hills, NC

Phone: 252-480-3124
Fax: 252-255-1347
E-mail: mcgeeobx@aol.com



PROPOSAL

Good for 30 days

Date: February 3, 2017
Phone: 410-299-4227
E-mail: wtruth@masonrysolutions.com

Proposal Prepared For:

Wayne Truth
Masonry Solutions International, Inc.
10815 Beaverdam Road, Suite D
Cockeysville, MD 21030

Job Address:

Wright Brothers Memorial
S. Croatan Highway
Kill Devil Hills, NC 27948

Description of Work

Wright Memorial Roof Drain and Area Drain Report

Roof Drain:

On roof drain scope at the 52 foot mark, discovered a some what rusted anchor bolt protruding through roof drain pipe and at the 56 foot mark found a out of alignment roof drain piping with unreasonable angles and a bulge in the piping that you can see in the video. Camera eye and cable would not go any further past this point. Went to ground level of exit point of roof drain and ran camera eye 4 feet into pipe and found pipe to be broken and not connected all the way. Proceeded to run camera another 25 feet and found the previous defected pipe that is out of alignment and with the bulge coming through the side. Could not run camera eye any further. Removed rubber caulk from around roof drain grate connection and installed Oakum Wrap Seal and poured and caulked with iron 8oz of lead.

Floor Drain at Steps:

Ran camera eye 28 feet and camera eye was stopped and could not go any further due to what appears to be a plastic bottle and a 2 x 4. This drain exits out at ground level on east side of the Monument. Ran electric sewer cable with retriever head to clean out the drain and remove the objects. Was able to get drain cleared to drain, but could not remove objects. Further work will be needed. This drain is also tied into the rain gutter above the door and the clean out plug in the walk area in front of the door. This drain is not connected to the roof drain.

Roof Trench Drain above Door:

Ran camera eye 10 feet and discovered a roll of solder that has been left in drain line. This drain ties in with the grate floor drain in front of the door and clean out.

Clean Out Plug at Walk Way in Front of Door Entrance:

Ran camera eye 2 feet into clean out and found T fitting that ties roof trench drain and floor drain at steps together.