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Addendum # 1

LOI # 7449393

TITLE: Engineering Services Building Envelope Repairs and Leak Investigation
RI Youth Training School

Submission Deadline: 13 Feb 2012 @ 11:00 AM (Eastern)

- **This addendum releases Attachment A - A report and analysis conducted by the firm of Simpson, Gumpertz & Heger**

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11 May 2010

SIMPSON GUMPERTZ & HEGER

Engineering of Structures
and Building Enclosures

Mr Arn Lisnoff
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Project 100264 – Leakage Investigation, Roosevelt Benton Youth Assessment Center, Pastore Government Center, Cranston, RI

Dear Mr. Lisnoff:

As requested, Simpson Gumpertz & Heger Inc. (SGH) visited the Roosevelt Benton Youth Assessment Center (YAC) and Youth Development Center (YDC) sites on 25 February 2010 to meet with you and the building managers, review the ongoing leakage to the interior, and perform a brief visual assessment of the roof and exterior wall areas. We returned to the YAC site on 6 and 7 April 2010 to investigate the water leakage into Unit A105 ("Area 1"; see Appendix A). While on site we also tested two other areas at the southern portion of the west wing ("Areas 2 and 3") that are also experiencing leakage problems Our investigation consisted of visual inspection, water testing, and probe openings to view concealed construction conditions. Knollmeyer Building Corp. assisted us by creating probe openings on 7 April 2010. This letter summarizes our findings, conclusions, and repair options for your consideration We also include cost estimates for some of the repair work discussed below. Knollmeyer also provided assistance with the cost estimating task.

1. BACKGROUND AND INFORMATION PROVIDED BY OTHERS

SGH performed a peer review of Ricci Greene's (RG) architectural design documents for Gilbane Building Co. back in 2006. We summarized our concerns regarding the design in our November 2006 letter to Gilbane. We understand that the RI DOA obtained a copy of this letter from Gilbane or another party This letter describes many concerns regarding the design of the building envelope, such concerns regarding the through-wall-flashing design; weather barrier; lack of continuity of weatherproofing between adjacent wall and roof systems; lack of perimeter flashing at wall openings, such as windows, louvers, and glass block assemblies; and inadequate detailing of complex conditions, such as parapet terminations. Please refer to this letter for additional information. Our scope of work during this phase included only the peer review; no additional consulting, site visits, or other services were requested of or provided by SGH.

Back in 2008/2009, at the request of Gilbane, we provided a proposal to investigate leakage through second-floor masonry walls above roof areas, but our proposal was not accepted.

The following information was provided by the RI DOA, the building management and maintenance staff, and/or Gilbane:

- The building is currently experiencing leakage in numerous areas. According to you, the most-concerning leak occurs at and around Unit A105, which is an occupied unit. Leakage began during or shortly after the construction phase back in 2007 and has occurred steadily ever since.

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- There is a history of roof and wall leakage, some of which has reportedly been successfully repaired by the roofer, Capeway Roofing Repairs were also made to the masonry wall below the louver at the roof area above Unit A105, and other "repairs" were made to various masonry and through-wall-flashing conditions, such as sealing weep vents shut, applying clear sealers to masonry, and applying aluminum brake metal over masonry at some through-wall-flashing joints. The repairs attempted at the masonry and through-wall flashing do not appear to be effective; there did not appear to be any significant relief from leakage following these repairs.

- The building houses troubled juveniles and includes various types of interior space, such as residential units, gymnasium and weight room space, kitchens, bathrooms, and office space.

- RG was the architect of record. Gilbane was the program manager/construction management (CM) agency. No general contractor (GC) was engaged; the RI DOA held the contracts for the subcontractors who performed the construction work.

- The Youth Assessment Center (YAC) is constructed similarly to the Youth Development Center (YDC), which is located in the Pastore Government Center just a few miles away. The YDC is experiencing similar leakage problems as the YAC. We understand that many of the same parties were involved in the construction of the two buildings.

- The DOA does not possess shop drawings or as-built architectural drawings

- Some ceilings are damaged due to glycol/plumbing leaks (stains pink in color).

We performed a brief cursory review of the 1 May 2008 and 31 October 2008 leakage reports provided by RG. RG's findings appear to be based on visual inspection alone; it appears that no water tests were performed, though they did observe ongoing leakage when they visited the site during a rainstorm. RG reported leakage to the interior due to a variety of roof, wall, and through-wall-flashing defects, but the cause for some of the leaks was not conclusively identified.

2. GENERAL OBSERVATIONS AND PROBE OPENINGS

Below we summarize our general observations from our inspection, probe openings, and water testing work. Our comments generally refer to the areas above and adjacent to Unit A-105 unless otherwise noted, though other areas of the building appear to be constructed similarly. Refer to Appendix A at the end of this report for locations of each probe opening and water test.

2.1 General

The one- and two-story structure includes a structural steel frame with concrete floor slabs. Roof decks are a combination of concrete and corrugated steel decking. Exterior walls are mainly brick masonry cavity walls with concrete masonry unit (CMU) backup walls. Windows and curtain walls interrupt the opaque walls in various areas. At the tops of some masonry walls corrugated metal panels are installed over the brick (Photo 2). Roofing consists of fully adhered single-ply EPDM membrane installed over mechanically attached polyisocyanurate insulation Roof edges consist of a combination of parapets and fascias/gravel-stops (Photo 3).

The floor plan of the building is unusual; there is a somewhat rectangular central portion with multiple roof levels, and a Y-shaped wing extends from both the east and west sides of the central building. Each arm of each Y-shaped wing contains at least three different roof levels (Photo 1)

2.2 Interior Survey

We note signs of leakage to the interior in the following general areas:

- Ceiling tiles, often below transitions between roof levels and below at least one louver (i.e. Unit A105; Photos 4 – 5). We note water stains and/or rust on various structural, electrical, and mechanical components located above ceilings, such as at lights, pipes, steel beams, and at joints and other penetrations through steel and concrete roof decks
- We note water stains at the sill and jambs of at least one glass-block wall located at the end of a corridor (Photo 6). (We did not investigate glass-block issues during this phase of our work.)

2.3 Exterior Masonry Walls and Through-Wall Flashing (Four Probe Openings)

General

- As noted above, exterior masonry walls consist of a clay brick veneer over a CMU backup wall. Extruded polystyrene (XPS) cavity insulation is present in the cavity and wire ties engage the longitudinal wire reinforcement within the CMU backup wall (Photo 7). Wire ties are located at approximately 18 in. o.c. in both directions. The weather barrier on the backup wall is a thin liquid-applied product, black in color, and fairly rigid/brittle; it appears to be an asphalt-based dampproofing material (Photos 8 – 9).
- Due to the unusual geometry of the building and the large number of roof levels that run longitudinally and parallel, there are long runs of through-wall flashing (TWF) adjacent to many of the roofs, including Area 1 (Photos 3 and 10) Various tight/acute inside corner conditions (Photo 11) and other unusual transitions such as parapet terminations and windows intersecting the TWF (Photo 12) create various complicated flashing conditions.
- The TWF assembly consists of a laminated copper-fabric layer combined with an L-shaped exposed stainless steel drip edge (Photo 13). The laminated copper-fabric material includes a heavy nonwoven felt layer atop a thin, flexible copper sheet/film. A fabric mesh backing layer is present on the underside of the copper film. The copper-fabric flashing extends from the metal drip back to the backup wall, where it turns up approximately 8 in. and is secured to the wall either with a sealed termination bar or at a horizontal reglet joint in the CMU (Photos 8 and 14)

- Veneer masonry at the Area 1 louver opening returns back to the face of the backup wall

Defects

- In various areas the fabric is not bonded down to the stainless steel drip edge, including some areas several feet long (Photos 15 – 22). We were able to identify some of these areas prior to making probe openings by inserting a 12 in long, approximately 0.020-in thick, metal feeler gage between the fabric flashing and the metal drip (Photos 18 and 19). Some laps/seams in the stainless steel are not bonded/ sealed (Photos 20 and 21). We observed one lap in the fabric flashing (Probe 2), and it also is not bonded or sealed (Photo 16).

- We are able to insert our feeler gages (and other thin instruments, such as notebook covers) between fabric flashing and metal drips at various other areas of the west wing We checked one area of the east wing, above the leaky Unit C-103, and note similar results (i.e., no bond between fabric and metal drip at some areas; Photo 22)

- The fabric flashing is delaminating within itself in various areas (Photos 23 – 24)

- Weep vents are not located at the lowest point on the flashing; they are raised up one course (Photo 25). Weep vents are sealed shut in many areas (Photo 26); this appears to be a remedial attempt at reducing leakage through the walls/flashing.

- Other apparent remedial measures are also present, such as sealant installed along the outer edge of the metal drip (Photo 27), and aluminum brake metal applied over the face of the brick at inside and outside corner conditions (Photo 28).

- Apparent freeze-thaw damage is visible at the mortar/bed joint immediately above the TWF in many areas (Photos 24 and 25).

- Termination bars at the top edge of TWF are not tight to the backup wall at some locations between fasteners (Photo 29), though the fabric does appear to be sealed to the backup wall at these locations.

- We note longitudinal wire reinforcing protruding from the bed joint in the CMU backup into the air cavity (i.e., "exposed") at one location (Photo 30).

- At Probe 2, below the louver, no dampproofing is installed on the CMU backup wall (Photo 31). We do not know if this is related to the repair work that we understand was performed in this area.

- Parapet and Roof Edge Terminations at Rising Walls:

    - The TWF at the Area 1 and Area 2 parapet terminations (Probes 3 and 4) is not continuous (Photos 32 and 33).
    - We observed two TWF assemblies that appear to drain into the body of a parapet wall (rather than out onto the surface of the roof) at Area 1 (Probe 3). The main TWF assembly immediately above the roof does not turn up vertically

at the side/edge of the parapet and does not include an end dam. We note a second TWF assembly that is buried in the wall and does not appear to drain anywhere outside the parapet/wall system (Photo 34). This second, buried TWF is not connected to the backup wall.

- Vertical edges of the EPDM membrane at parapet ends are terminated in surface-applied J-beads/receiver-strips (a.k.a. blind-nailers); the J-beads are applied to the surface of the brick and do not integrate with the TWF or weather barrier on the backup wall (Photo 33).
- Probe 4 at the roof edge termination at Area 2 does not include an end dam, similar to Probe 3 at Area 1 (Photo 35).
- Parapet and roof edge terminations located elsewhere on the building appear to be constructed similarly (Photos 36 and 37).
- The CMU backup is interrupted by a round steel or iron member at Probe 4 at Area 2 (Photo 38). The joint between the CMU and the metal member appears to be mainly filled with mortar, though cracks are present in the mortar and the dampproofing is not continuous over the member or across the cracks.

Other

- Some areas appear to have been repaired previously, as indicated by nonmatching mortar (Photo 39), and other atypical sealant, mastic, and metal cap products discussed above. We also note that a rubberized-asphalt-membrane "pocket" is installed over a portion of the parapet termination in Area 1 (Probe 3; Photo 51). This condition is atypical and appears to be a remedial measure.

- We note that a layer of TWF is also located at grade (i.e. at the first floor; Photos 40 and 41). This flashing appears to be constructed similarly to the problematic TWF flashing described above

- The fabric flashing at Probe 2 was partially damaged during removal of the brick masonry above.

2.4 Roofing, including Parapets and Roof Edges (Three Probe Openings)

General

- The roofing system consists of (from top to bottom) a fully adhered 0.060 in. thick black Carlisle EPDM membrane, multiple layers of mechanically attached rigid polyisocyanurate (iso) insulation boards with fiberglass facers, and a structural deck (Photo 42)

- A precast concrete plank deck is present at Area 1, though Area 2 and various other areas of the building include corrugated metal decking. At Area 1 it is unclear if sloped insulation is provided or if a sloped concrete topping layer is in place. Corrugated decking below Area 2 runs almost parallel (slightly skewed) to the longitudinal exterior walls, and structural steel I-beams run perpendicular to the walls and extend to the CMU backup of the walls (Photo 43).

- No vapor barrier is present below the insulation.

- Seams in the EPDM membrane are treated with butyl seam tape.

- Various penetrations and flashings are present, such as round pipe penetrations with pipe-wrap flashings and pitch pockets at irregular penetrations (Photos 44 and 46). We do not note any complex, unusual, or otherwise suspicious roof penetrations. A lightning protection system is in place along many roof edges. Most clips for the lighting wires are adhered in place (Photo 47), though at upstands/"spikes," the attachment brackets are screwed down through the roofing with a single lag screw or bolt (Photo 48).

- Relatively small patches are present in various locations at various roof levels (Photo 49). The patches generally appear to be in good condition.

- Metal roof edge flashings (i.e., gravel stops/fascias) are in place at most roof edge conditions, including tall (approximately 6 in.) and short (approximately 24 in.) parapets (Photo 50). Two different roof edge flashing styles are present; one includes an F-shaped base/bar that is installed over the EPDM and is secured to the vertical surface of the roof edge blocking, and the other type includes a horizontal flange that in fastened down to the top surface of the blocking and is covered (stripped in) with EPDM. These components overlap the materials below by approximately 5 in. Most F-clip-style flashings are installed tight down to the roofing membrane below, though at occasional areas, there is a small gap between the membrane and metal bar/flashing above.

- At roof edge conditions, the roof membrane does not appear to connect to (or overlap/ counterflash) the dampproofing on the CMU backup wall. The bottom edge of the associated wood blocking is visible below the edge of the membrane at Probes 7 and 8 (Photos 55 and 57).

Defects and Damage

- We note no obvious defects at the exposed surface of the roof membrane. We note occasional small pieces of debris, such as fasteners and washers and screws related to the lightning protection system, on the surface of various roof areas, though we do not note any related damage to the membrane. We also note occasional partial "nail pops" (i.e., fasteners beneath the membrane that are beginning to back out) at some west wing areas away from Areas 1 to 3, though there does not appear to be any associated damage to the membrane (Photo 52)

- Our roof probe through the EPDM membrane at Area 1 (Probe 6) uncovers liquid water in the roof near the rising wall at Area 1 (Photos 42 and 53). The insulation in this area is softened. We also observe sandy, cementitious debris at the concrete deck at this probe. The debris is similar in appearance and consistency to the mortar of the adjacent rising wall.

- The roof membrane easily pulls away from the surface of the softened iso under light hand pressure at our probe location (Probe 6). It appears that the insulation facer is partially delaminated from the foam core. The bond strength here is compromised

- As we walk the surface of the roof we note that the underlying insulation appears to be softened/spongy in other areas, including various areas near rising walls.
- We note heavily bowed insulation in various areas above Unit C-103, which is located in the east wing of the building (Photo 54).
- We note slight ponding/puddling at isolated roof areas, including one location at Area 2, due to lack of positive slope to drains. Water accumulation is less than 1 in.

2.5 Louvers (Three Probe Openings, including Two Masonry Openings that Exposed Louver Conditions)

General

- The louver includes an aluminum perimeter frame and multiple aluminum blades. The blades are oriented in an unusual way; the outer portion of the blades are sloped in toward the building rather than sloped to drain toward the exterior. The louver is attached to the adjacent masonry at the jambs with metal angles. The louver appears to be attached to the adjacent steel beam at the head and appears to be supported by the brick masonry veneer at the sill. The louver sill condition appears to be deflected downward slightly at the midpoint where a vertical joint is located.
- An aluminum sill pan flashing is present at the base of the louver. The sill pan includes an upturned leg at the inboard edge, welded end dams at the ends/corners, and a metal splice plate at the midpoint that is weatherproofed with sealant (Photos 58-59).
- The interior joints of the louver are weatherproofed with sealant (Photo 60)

Defects

- There is no flashing or other material connecting the perimeter of the louver to the weather barrier (dampproofing) of the adjacent masonry wall system (though there is a pan flashing at the sill, as noted above). Cavity insulation is visible from the interior of the mechanical space (Photos 61 and 62) Interior mechanical space is visible through our probe openings in the brick veneer.
- A reverse pitch/slope is present at the louver sill flashing pan; the pan slopes to the interior rather than the exterior (Photo 59).

2.6 Other

- We note that hot- and cold-water pipes are present above some stained ceiling tiles though the pipes do not appear to be related to the leakage observed.

3. WATER TESTING

We performed water tests using a calibrated AAMA hand nozzle at low pressure (approximately 0 psi) and an approximate 3 ft x 5 ft calibrated spray rack that sprays water at a rate of 5 gal/sq ft/hr. We summarize the results of our water tests in the table below.

Test ID	Location	Test Type	Approx. Duration (min.)	Leakage Observed	Other Comments
Water Test 1 (WT1)	Area 1 – Roof (Photo 63)	Flood test/ spray rack	120+	None*.	*Water noted on floor of Unit A-105 below though not coming from roof/ceiling above (Photo 64); likely related to spigot leakage and TWF at grade.
WT2A	Area 1 – TWF via weep vent, just east of louver (Photo 65)	Hand nozzle, < 1 psi	30	None	
WT2B	Area 1 – TWF via weep vent, below east portion of louver	Hand nozzle, < 1 psi	20	None	
WT2C	Area 1 – TWF via weep vent, below east portion of louver	Hand nozzle, < 1 psi	20	<u>Heavy leakage</u> into Unit A-105 (drips from above; Photos 66 – 67) and adjacent common space/dayroom (noted at 10 min.)	Feeler gage enters between fabric flashing and metal drip here; also location of seam in metal drip flashing Leakage occurs at location of stained ceiling tiles and other water stains below.
WT3	Area 1 – Masonry and TWF by west portion of louver (Photo 68)	Spray rack	< 5	<u>Heavy leakage</u> into Unit A-105 (drips from above; Photo 69) and adjacent common space/dayroom (noted almost immediately; <3 min.).	Louver masked off with plastic. Leakage occurs at location of stained ceiling tiles and other water stains below
WT2A (repeat)	Area 1 – TWF via weep vent, just east of louver	Hand nozzle, < 1 psi	30	None	
WT4	Area 1 – EPDM at parapet termination at rising wall	Hand nozzle, < 1 psi	30	None.	
WT5	Area 1 – weep vent above east portion of parapet termination	Hand nozzle, < 1 psi	45	None.	Test above atypical rubberized asphalt membrane (RAM) pocket flashing

Test ID	Location	Test Type	Approx. Duration (min.)	Leakage Observed	Other Comments
WT6	Area 1 – Corrugated metal panels and roof edge flashing (gravel stop) above west portion of louver (Photo 70)	Spray rack	55	None.	Spray rack oriented to spray up under edge of gravel stop; louver, masonry and TWF below masked off with plastic; overspray contacts EPDM roofing above.
WT7	Area 1 – Louver frame and aluminum pan flashing below, west sill corner (Photo 71)	Pond test with hand nozzle, < 1 psi, water applied intermittently	20	None	Water applied intermittently so as not to overflow onto masonry and TWF below
WT8	Area 1 – Louver frame and aluminum pan flashing splice below midpoint of sill	Pond test with hand nozzle, < 1 psi, water applied intermittently	15	None.	Water applied intermittently so as not to overflow onto masonry and TWF below; splice plate at joint in aluminum pan flashing at this location.
WT9	Area 2 – Roof area, northeast portion by rising wall	Spray rack placed horizontally (facing roof)	60	None.	
WT10	Area 2 – TWF via weep vent near east end (Photo 72)	Hand nozzle, < 1 psi	50	Leakage into interior space below (noted at 20 min.).	Leakage occurs at location of stained ceiling tiles and other water stains below; EPDM at parapet below masked off with plastic.
WT11	Area 2 – Masonry and TWF above east portion of wall (Photo 73)	Spray rack	75	Heavy leakage into interior space below (noted at 30 min.) (Photos 74 – 75)	Water collects on structural elements and travels several yards from test location through flutes in metal decking and on flanges of steel I-beams; spray rack moved closer to east end at 40 min. mark and leakage intensity increased immediately; EPDM at parapet below masked off with plastic. Leakage occurs at location of stained ceiling tiles and other water stains below.

Test ID	Location	Test Type	Approx. Duration (min.)	Leakage Observed	Other Comments
WT12	Area 3 – Roof, southwest end	Spray rack	60	None.	
WT13	Area 3 – EPDM and roof edge flashing (gravel stop) at parapet at outside building corner (Photo 76)	Spray rack	30	Leakage running down inside face of CMU wall (noted at 20 min. though likely started earlier).	Leakage occurs at location of water stains/ streaks on inside surface of CMU wall
WT13A	Area 3 – EPDM and roof edge flashing (gravel stop) at parapet at outside building corner; water directed at gap between gravel stop and EPDM below (Photo 77)	Hand nozzle, < 1 psi	10	Heavy leakage running down inside face of CMU wall (noted at < 5 min.) (Photo 78).	Leakage occurs at location of water stains/ streaks on inside surface of CMU wall.

3.1 Through-Wall Flashing (TWF)

- During WT2C, 3, 10, and 11, water leaked to the interior through various unsealed/ nonadhered joints in the TWF. WT 3 was halted almost immediately (under 5 min.) due to heavy leakage to the interior. The lack of an end dam or other reliable transition also contributes to leakage during WT 10 and 11

- During WT1, we noted water on the floor of Unit A105 near the east exterior wall. The water appears long before any water drips from the ceiling area above and appears to be related to the east exterior masonry wall. We suspect that it is due to incidental water from the nearby spigot leaking through the TWF that is located at grade, though we did not investigate this leakage path further.

3.2 Roofing, Roof Edges, and Parapets

- Our flood test of the roof surface at Area 1, WT1, did not result in leakage to the interior. Our testing of the roof surface at Area 2, WT9, also did not result in leakage.

- Our test at the parapet termination condition at Area 1, WT5, did not result in leakage to the interior. The water from this test appeared to contact only the eastern half of the flashing condition due to location of the weep vent above the rubberized-asphalt-membrane pocket present there. We did not test the west portion of the parapet termination due to the lack of a weep vent above this area and due to the likelihood that water from such a test would overspray onto an area that had leaked previously.

- During WT13 and 13A at a roof edge condition at Area 3, water leaks into the building at the roof edge. It appears that water travels inward on the underside of the wood blocking, bypasses the dampproofing and enters at the top of the CMU backup wall. However, since we did not complete any probe openings at these locations, we cannot confirm this exact leakage path.

3.3 Louver

- No water leakage occurs during our "pond" tests of the aluminum sill flashing pan below the louver at Area 1, WT7 and 8.
- We did not water test the perimeter of the louver due to the likelihood that overspray from such tests would contact the defective TWF that leaked during our previous tests.
- We did not water test the duct area inboard of the louver.

4. DISCUSSION AND CONCLUSIONS

Below we discuss the significance of the defects and water leakage described above. The TWF at the masonry cavity walls is the primary leakage source, though we also note problems with various roof edge, parapet, louver, and backup-wall conditions. We discuss each system below.

4.1 Exterior Masonry Walls and Through-Wall Flashing

Through-Wall Flashing (TWF)

The majority of water leakage we investigated at Areas 1 and 2 results from the TWF problems discussed above. Leakage at Area 1 is fairly concentrated to the area immediately below the defective flashing and leaks down through joints in the precast concrete planks. Some leakage also enters the adjacent roof system, damaging the roof insulation and reducing the uplift capacity of the roof. This finding is supported by the fact that the most-severe roof damage is in close proximity to leaky areas of TWF at the rising wall, and by the apparent mortar washout present in the roof system noted at Probe 6. This leakage is also damaging interior finishes, such as ceiling tiles and tectum wall panels, as well as wetting various mechanical and electrical components.

Previous surface-level attempts to address the TWF problems, such as sealing weep vents shut and applying sealant along the outer edge of TWF, have been unsuccessful in preventing leakage. In fact, the sealant applied at the edge of the TWF appears to be trapping water on the flashing, which actually exacerbates leakage. Trapping the moisture also exacerbates freeze-thaw damage at the bed joint below the first course of masonry.

Water entering the building at defects in the TWF travels long distances within the metal flutes of the corrugated steel decking and on flanges of structural steel beams below Area 2, as well as leaking down immediately below the defective wall flashing. The lengthy, relatively unbroken water paths created by the decking and steel beams may seem to indicate roof leakage to the building occupants when wall leakage is actually the problem (though damage to the roof is also occurring due to this leakage path).

Much of the leakage results from water running down the exterior surface of the wall that hits the leading edge of the TWF and passes through the unbonded joint between the fabric flashing and the metal drip below. Water also bypasses the flashing assembly at unsealed joints and laps in the fabric flashing and the metal drip below. Water in the wall/air cavity (i.e., water that enters the system somewhere above the TWF level) likely also contributes to leakage as it flows down within the cavity and contacts these same unsealed joints and laps in the TWF. This latter leakage path occurs because brick masonry is a porous, absorptive material that allows water to enter the wall system by direct water penetration (primarily through the mortar joints in the wall). Repairs made to date attempted to address the primary (former) leakage path from the exterior, but did not address the secondary (latter) leakage pathway. Therefore, repairs will need to address both surface water and water in the cavity to be effective.

Parapet terminations at rising walls are common features on the building and the TWF is not continuous or effective at these conditions. Therefore, any reliable TWF repair will require reworking the TWF at and around parapet termination conditions. In addition, in many areas of the building, clerestory-style windows are located down at the level of the TWF. Removal and reinstallation of these windows will also be needed to allow widespread TWF replacement work.

Other

It is our experience that dampproofing is not a very reliable weather barrier, particularly when subjected to bulk water. The liquid-applied product is often not continuous over cracks, holes and other miscellaneous voids in the substrate to which it is applied, as evidenced by the discontinuity in the dampproofing that we observed in Probe 4. In addition, a large breach in the layer is present at Probe 2. Similar large breaches may be present elsewhere. It is unclear if miscellaneous discontinuities in the dampproofing layer are also contributing to leakage into the building. These defects have the potential to be another contributing leakage source, though these areas cannot readily be independently evaluated without first correcting the primary leakage pathway at the TWF.

4.2 Roofing

The field of the roof and the typical penetrations such as drains and pipe penetrations appear to be in relatively good condition. We did not observe any leakage pathways through these areas. The only significant problem appears to be the lack of continuity between the roof flashing at the roof edges/parapets and the weather barrier and flashing of the wall systems above and below.

Unfortunately significant areas of the roof have been damaged due to ongoing leakage through the adjacent rising walls. The roof membrane is adhered to the fiberglass facer of the iso roof insulation; wetting the insulation has caused it to soften, reduced its thermal effectiveness, and has begun to cause the fiberglass facers to delaminate from the foam core. Delaminated facers to which the EPDM membrane is bonded compromise the uplift resistance of the roofing system.

The extent of this damage is currently unclear. Our findings are based on inspection of the roof surface in various areas and one probe opening at Area 1 (Probe 6). We suspect that, due to the widespread leakage at the building and the apparent widespread nature of the TWF problem, other roof areas are likely damaged and will require partial or full replacement. Additional investigation of the extent of roof damage is warranted. Such investigation should include various probe openings and measurement of the moisture content of the roof insulation removed at probe openings, and could also include thermal or nuclear scans

4.3 Parapets and Roof Edges

The extent of the roof edge leakage problem is currently unclear. Further investigation is warranted at parapet and roof edge conditions, including further water testing and probe openings, in order to fully understand the mechanics and extent of these leakage pathways

See above for discussion of TWF defects located at and around parapet terminations.

4.4 Other – Louvers and Windows

Louvers do not include full-perimeter-flashing provisions. Pan flashing is present below louvers, though the jambs, heads, and sills of louver conditions do not connect to the weather barrier (i.e , the dampproofing) of the adjacent cavity wall system. This lack of continuity could allow water in the exterior cavity area to directly enter the mechanical space, though we do not observe any obvious signs of leakage into the second-floor mechanical space. It carries a risk of leakage into this space and additional leakage into the occupied space below, though we did not test these leakage paths, mainly due to the difficulty in testing the wall area without allowing water to contact the leaky TWF below. The welded end dam conditions at the louver pan flashing appear to be reliable, though the sealant-filled splice plate condition likely will degrade over time and eventually allow water to bypass and enter the wall cavity below. The reverse slope on the louver pan allows water to pond/collect at the sealed splice, which will accelerate this degradation.

Additional investigation of the louver perimeter conditions may be warranted to determine if the lack of flashing at these locations is also contributing to the building leakage. Additional investigation of the louver design and louver blade orientation also is warranted to determine if the louver assembly was installed properly.

We did not review window conditions as part of this phase of investigative work. However, considering the lack of continuity of the weather barrier tie-in at the louvers and that shown in the original architectural drawings, investigation of the window perimeters is warranted. As various clerestory-style windows are located down at the level of the TWF, investigation of these windows should be completed prior to completing any TWF work.

We note that TWF conditions above windows and louvers are constructed similarly to typical masonry TWF (fabric flashing and so on); therefore, investigation of these conditions is warranted, also.

Investigation of other suspect systems, such as glass-block walls, may also be warranted. This was not part of the scope for this phase of investigative work.

5. REPAIR OPTIONS EVALUATION

Below, we describe two general repair options to address the primary leakage sources identified during our investigation. Option A is the preferred option with respect to technical merit and long-term performance and durability. Option 2 is a more-economical, though less desirable, option in terms of performance and maintenance requirements. We have not included a complete remove-and-reconstruct option for the masonry cladding systems, as we understand that this option is not feasible (though this option would allow a remedy to the inherent weaknesses related to use of a dampproofing product as a weather barrier in a cavity wall).

These repairs generally apply only to wall areas located between roof levels. We did not investigate leakage into the building at and around grade, so we do not discuss remedial work needed to address any leakage there. We suggest you consider investigating this leakage during a later phase.

Regardless of the repair method selected, we recommend you perform all desired repairs on a mockup area (such as at Area 1) and water test the area after the work is completed in order to evaluate its effectiveness. This mockup work should be completed before beginning any widespread work at the building. We also recommend performing the additional investigative work noted above, such as evaluating windows, roof edge conditions, and TWF by grade further, prior to completing any widespread work. Other leakage paths beyond those currently identified may be present; therefore, it is currently unclear if completing the repairs discussed below will be 100% effective.

5.1 Through-Wall Flashing (TWF)

5.1.1 Option A – Remove and Replace TWF (Preferred Repair Option)

Replace the existing TWF with a more-reliable flashing system that consists of a one-piece stainless steel or copper flashing with an interior upturned leg, fully soldered joints and transitions, and a reliable connection to the weather barrier on the backup wall. This work should correct the major leakage observed at the defective TWF. This work should include transitions at parapet terminations at rising walls (including extending the TWF up and over/ around raised parapets) and removal and reinstallation (or replacement) of clerestory-style windows and any louvers located down at the TWF level.

Downsides to this repair method include the following:

- It requires removal of at least three to four courses of the brick masonry immediately above the TWF.
- It is more costly than Option B.
- It likely will require removal of windows and louvers located immediately above the flashing.
- It does not address any additional leakage through voids or other defects that may be located higher up on the backup wall.

5.1.2 Option B – Apply Elastomeric Coating to Exterior Surface of Wall (Less-Reliable Option)

Cover the exterior surface of the masonry with an opaque elastomeric coating product (or continuous sheet membrane), including connecting/bonding this layer to a new metal base flashing that conceals the existing metal drip edge. This option should stop water from entering the wall cavity from the masonry and therefore is likely to be effective at addressing related leakage sources. Sealant at the perimeter of windows, louvers, and similar wall penetrations will need to be cut out so that the coating can extend into the wall opening, and then new sealant will need to be installed. This option is a less-expensive approach to Option A.

Downsides to this repair method include the following:

- This option effectively changes the design of the wall system from a draining cavity wall system (generally a more-desirable system) to a surface-sealed system.
- It is likely to significantly change the appearance of the walls, including extending the coating around outside building corners.
- It may not provide a reliable seal at penetrations such as pipes and brackets
- If a coating system is used, it will require periodic maintenance such as "touch-up" and reapplication to remain effective.
- It may not allow a durable condition at clerestory-style windows.
- It will not allow a reliable termination at the perimeter of a work area unless some masonry is deconstructed and rebuilt.

5.2 Roof and Roof Edges

Replacement of wet, damaged roof areas are warranted due to the reduced uplift resistance, reduced thermal performance, and the likelihood that trapped moisture will begin to deteriorate the adhesion of the lap seams in the field of the EPDM roofing, creating future leakage problems in the building. You should consider waiting to replace the damaged roofing until the associated wall repairs are complete in order to prevent leakage from damaging the new roofing (and to prevent damage that may result from construction activity along the rising walls). However, in the interim between wall and roof repairs, there will be an increased risk of damage due to reduced uplift resistance of the roof system(s).

The extent of the roof edge leakage problem is currently unclear. Additional investigation is warranted to fully understand the extent of leakage and damage. Therefore, we do not describe specific repair methods for the roof edges at this time.

5.3 Louvers, Windows, and Other Conditions

It is currently unclear if additional repairs are warranted at louvers and windows (and other areas not fully investigated during this phase. Additional investigative work is needed prior to generation of reliable repair options.

Investigation of TWF conditions by grade is also warranted.

Investigation of the performance of the dampproofing weather barrier on the CMU backup walls may also be warranted

Should you elect to consider repairing only small areas of wall at a time, there will be a risk of leakage at the connections between new and existing work. With respect to TWF repairs, the unbonded, discontinuous nature of the existing flashing assembly likely will make it difficult to reliably connect new TWF materials to it, though including an end dam may provide some protection. With respect to the elastomeric coating repair option, wherever the elastomeric coating terminates, there will be a path for water in the adjacent cavity to travel onto the existing, unrepaired TWF behind the coating and leak to the interior, unless the coating is connected to the backup wall through rebuilding the masonry veneer there.

6. COST ESTIMATE FOR REPAIRS

These cost estimates and related quantities generally apply only to wall areas located between roof levels. The estimates presented here do not consider wall areas at and around grade (i.e., first-floor areas), though investigation of these areas is warranted. The unit cost estimates assume a relatively large amount of work will be released (say 100 lf of wall or more). Additional mobilization costs will likely be needed if the work will be completed in smaller phases

Actual construction costs will depend on many factors, such as economic climate, contractors' current workloads, material costs, and so on; please consider these costs to be approximations only. Executing work at large areas of the building is likely to be more cost-effective than repairing small areas at a time.

We do not include or imply any guarantees regarding the accuracy of these costs, and this does not constitute an estimate to complete the work.

6.1 TWF

6.1.1 Option A – Remove and Replace TWF (Preferred Repair Option)

- Cost per Lineal Foot (lf): $200 to $300
- Cost for Entire Building: $250,000 to $350,000 (approximately 1,200 lf per our quantity takeoff)
- Cost for Area 1: $12,000 to $18,000 (approximately 50 lf per our quantity takeoff)

This includes removal and reinstallation of windows where applicable, as well as transitions at parapet terminations.

6.1.2 Option B – Apply Elastomeric Coating to Exterior Surface of Wall (Less Reliable Option)

- Cost per Square Foot (sq ft): $8 to $14
- Cost for Entire Building: $42,000 to $74,000 (approximately 5,200 sq ft per our quantity takeoff)
- Cost for Area 1: $3,000 to $5,500 (approximately 360 sq ft per our quantity takeoff)

This includes removal and reinstallation of sealant around windows and louvers.

6.2 Field-of-Roof Repairs/Replacement and Roof Edges

The extent of general roof repair work required is currently unclear; therefore, we provide only a square foot cost estimate for roof replacement. The estimate includes removal of the existing roof system, installation of a sheet vapor barrier on the deck (where applicable), new polyisocyanurate insulation to match existing insulation thickness, a high-compressive-strength glass-fiber-faced gypsum cover board, and an EPDM membrane.

- Cost per Square Foot (sq ft): $20 to $25
- For example, we estimate that replacement of approximately one-half of the roof at Area 1 (approximately 550 sq ft) would cost approximately $12,000 to $15,000, and replacement of this whole roof area (approximately 1,100 sq ft) would cost $22,000 to $29,000.

The extent of repair work required at roof edges is currently unclear; therefore, we do not provide costs for this condition at this time.

6.3 Design/Consulting Fees

We recommend that you plan for design fees associated with the work options discussed above. Since the current scope of investigation and/or design work that may be required is currently unclear, we do not provide a cost estimate at this time.

Please feel free to call if you would like to discuss any of our findings further or if you would like to pursue additional investigative work at the project. We would be happy to participate in a conference call or meeting with you to discuss your options.

Sincerely yours,

Michael J. Louis	Derek B. McCowan	Douglas R Pac
Senior Principal	Senior Staff I – Building Technology	Staff I – Building Technology

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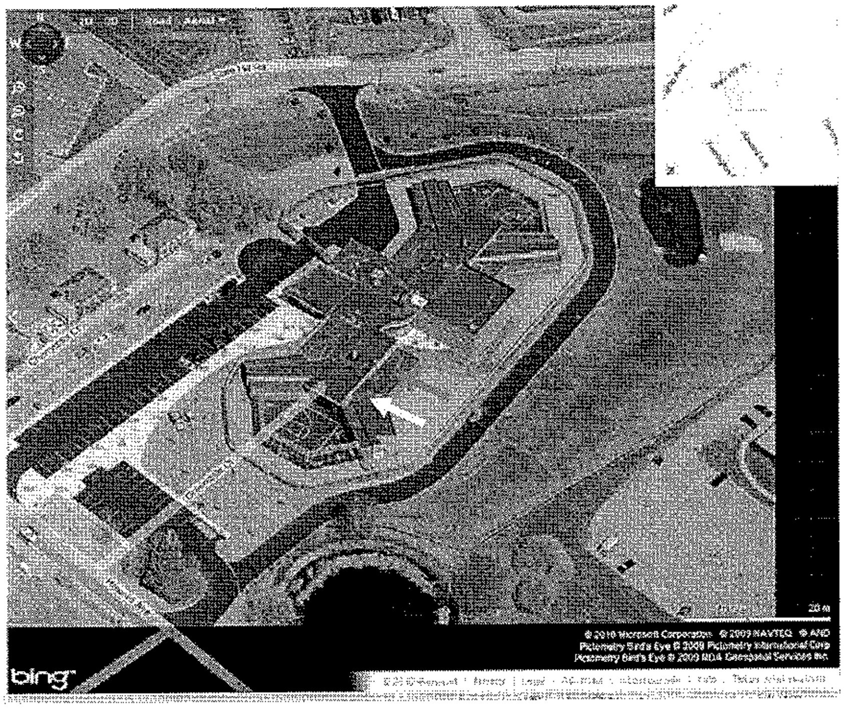


Photo 1

Arial photo of building provided by Microsoft Bing/Pictometry Area 1 (red arrow), Area 2 (yellow arrow), Area 3 (blue arrow).

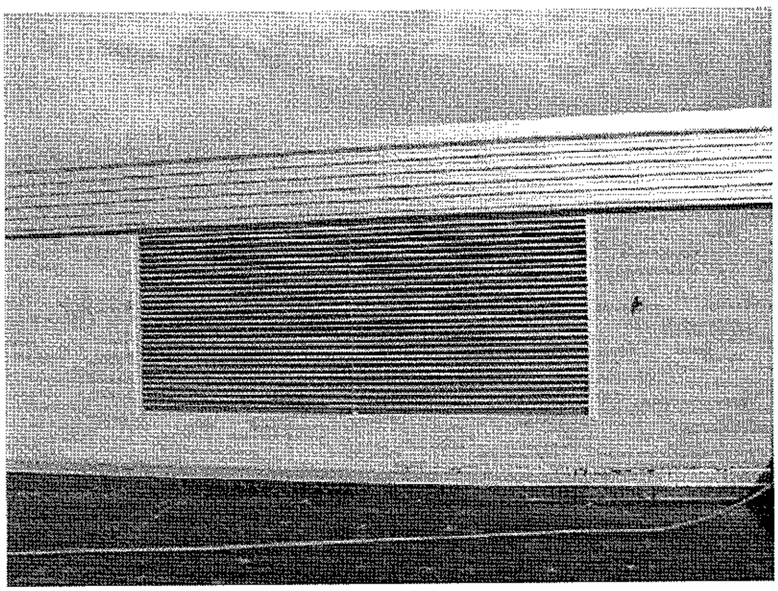


Photo 2

Typical brick veneer, corrugated metal panel cladding, and louver (Area 1).

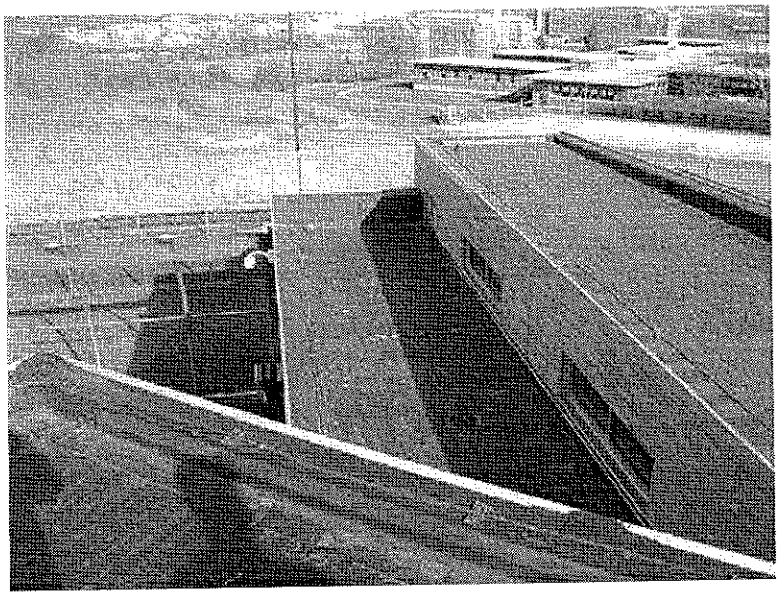


Photo 3

Typical EPDM roofing conditions

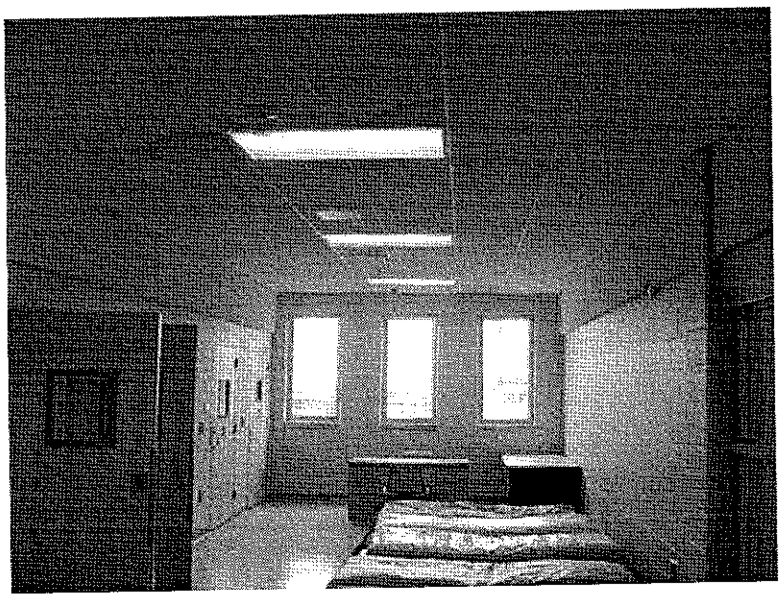


Photo 4

Water-stained ceiling tiles by Unit A-105, below Area 1

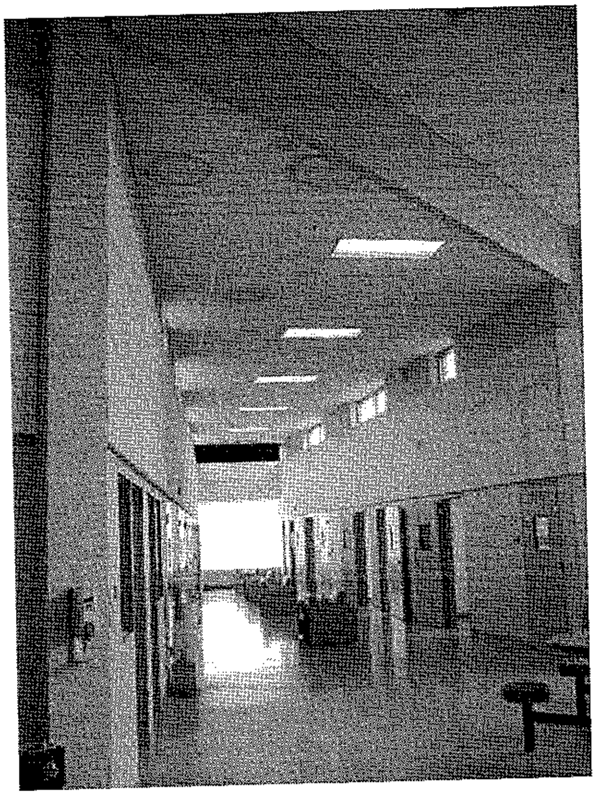


Photo 5

Water-stained ceiling tiles below Area 2.

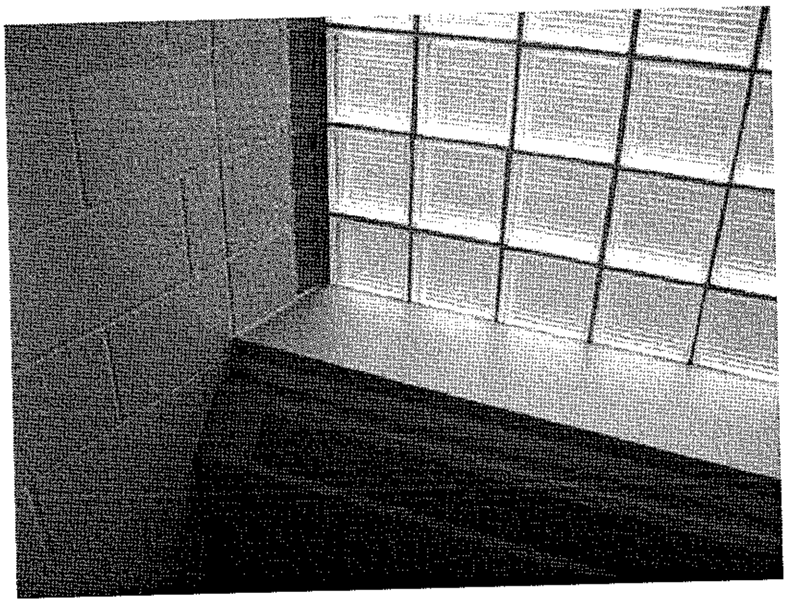


Photo 6

Water stains at sill of glass-block wall.

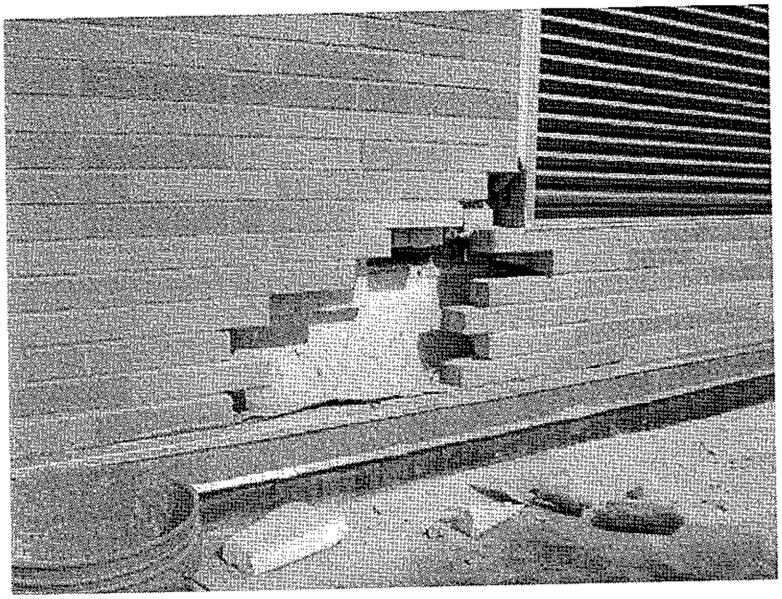


Photo 7

Probe 1, showing XPS cavity insulation, and through-wall flashing

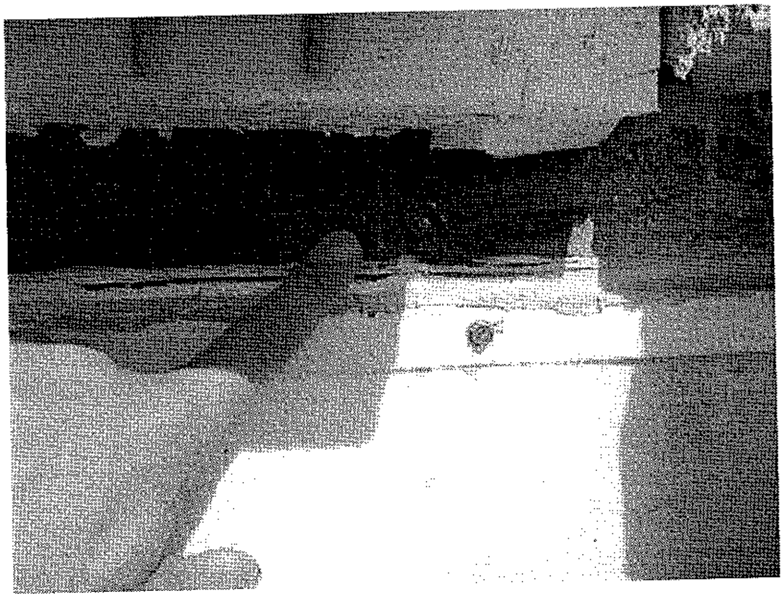


Photo 8

Probe 1, showing dampproofing on CMU backup, and termination bar and sealant at top edge of fabric flashing.

Photo 9

Small area of dampproofing scraped away to show thickness

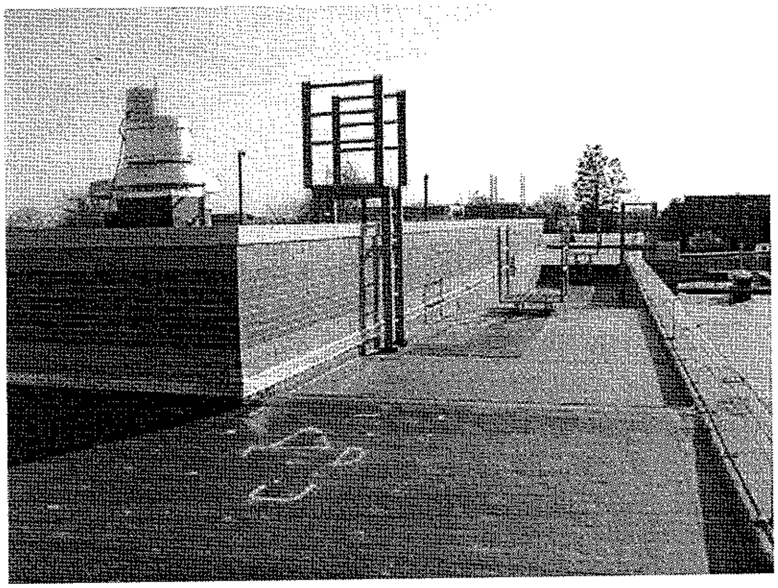


Photo 10

Long run of TWF.

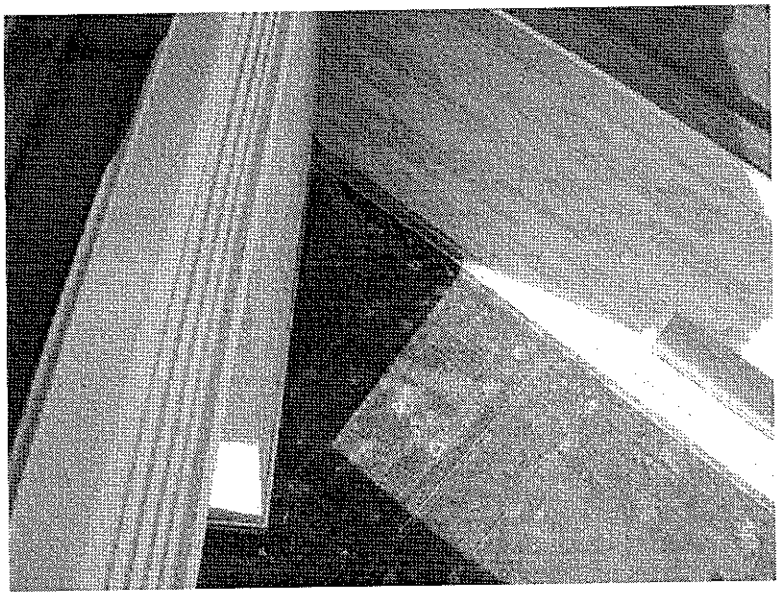


Photo 11

Tight/acute inside corner condition that complicates flashing.

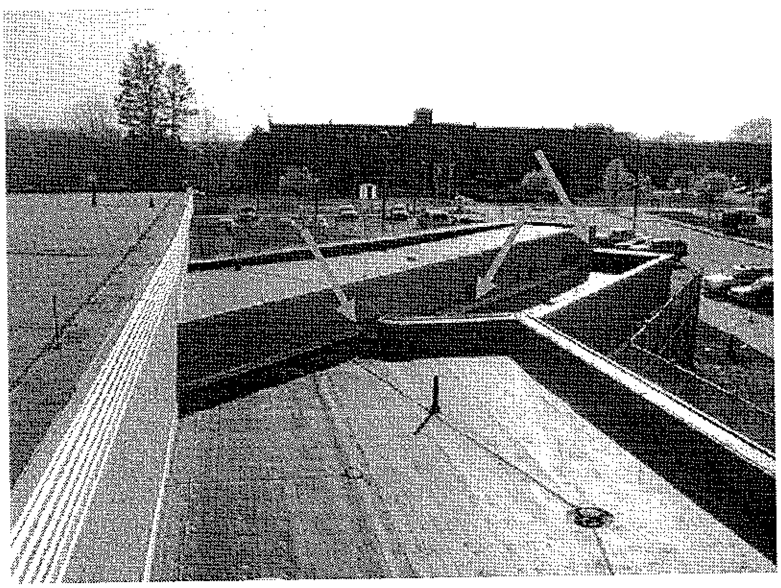


Photo 12

Multiple roof areas with various transitions

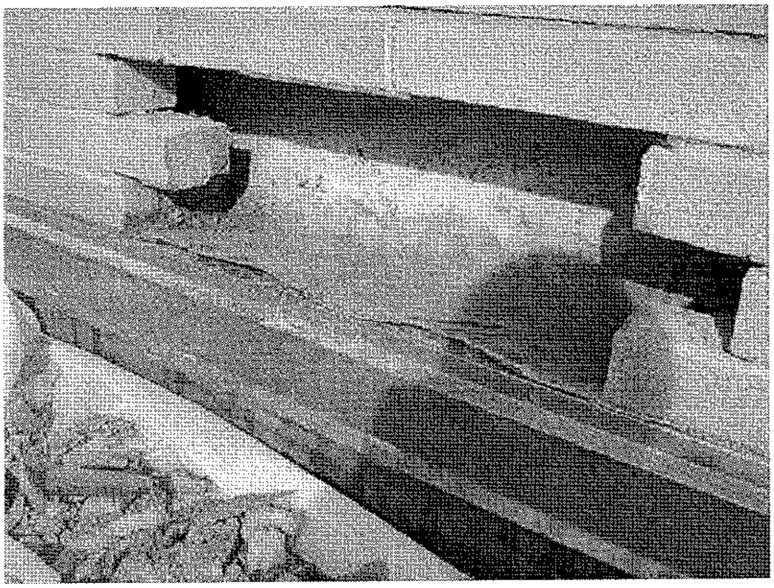


Photo 13

Fabric flashing and metal drip (i.e., TWF assembly) at Probe 1.

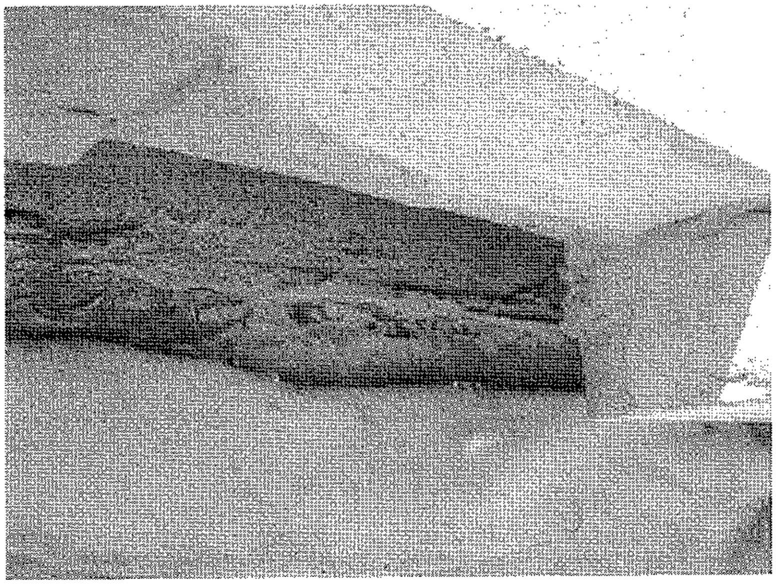


Photo 14

Copper sheet portion of fabric flashing that terminates in reglet at CMU backup wall at Probe 2.

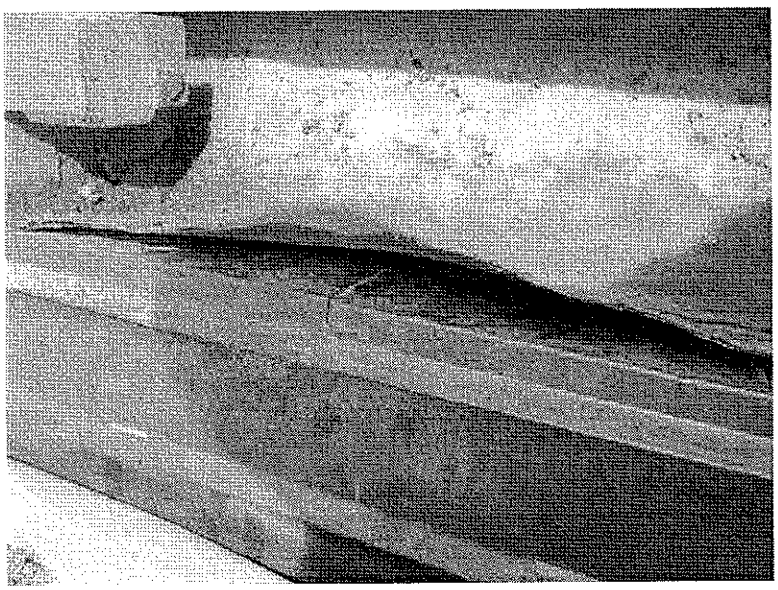


Photo 15

Unbonded fabric flashing at Probe 1

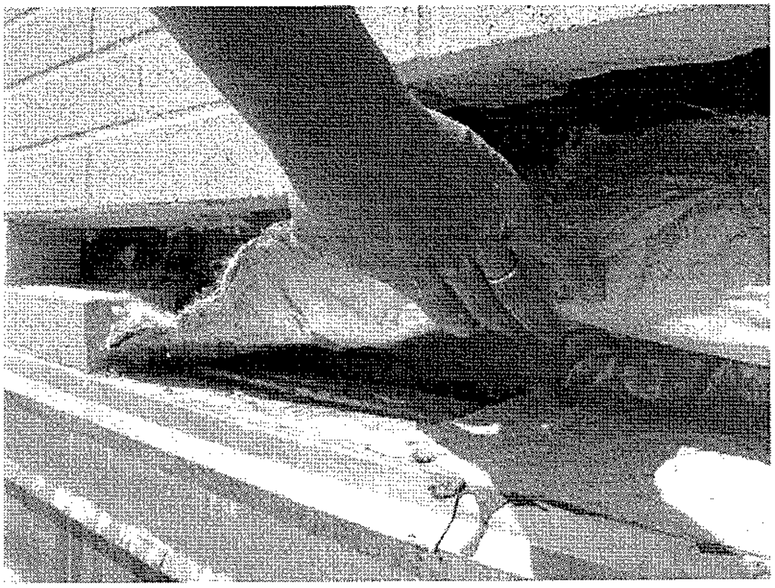


Photo 16

Unbonded fabric flashing at Probe 2.

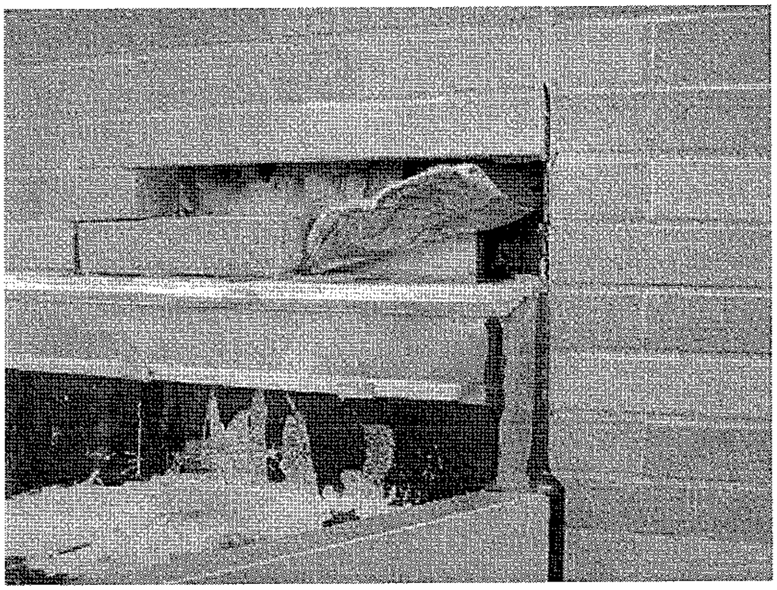


Photo 17

Unbonded fabric flashing and no end dam at Probe 4.

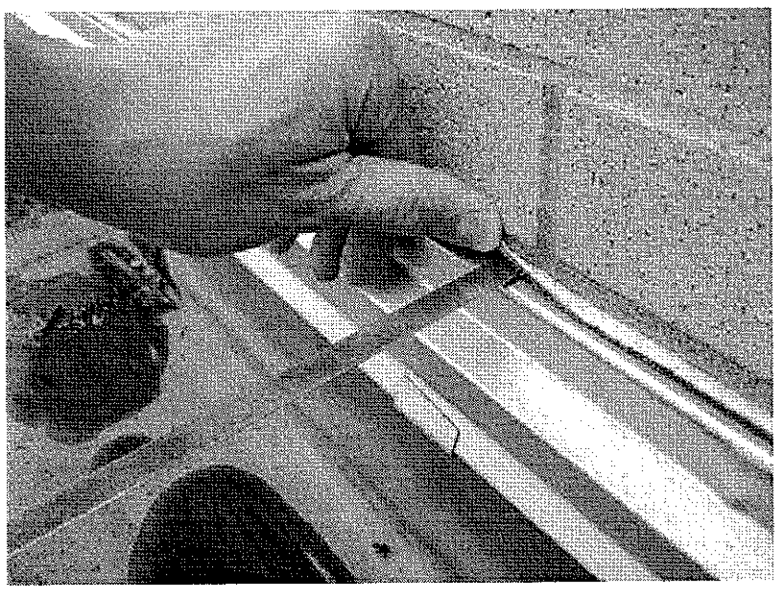


Photo 18

Feeler gage inserted between fabric flashing and metal drip, indicates lack of bond between these layers.

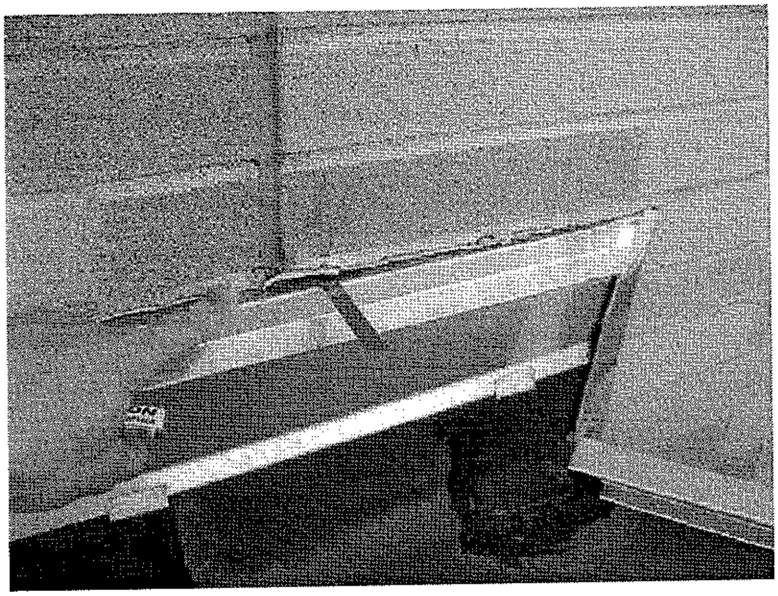


Photo 19

Feeler gage inserted between fabric flashing and metal drip.

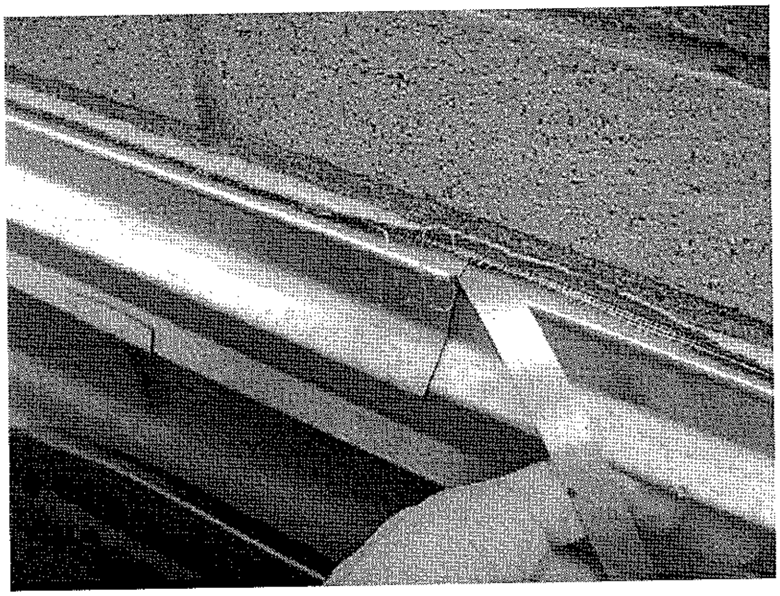


Photo 20

Feeler gage inserted in unsealed/unbonded seam in metal drip flashing.

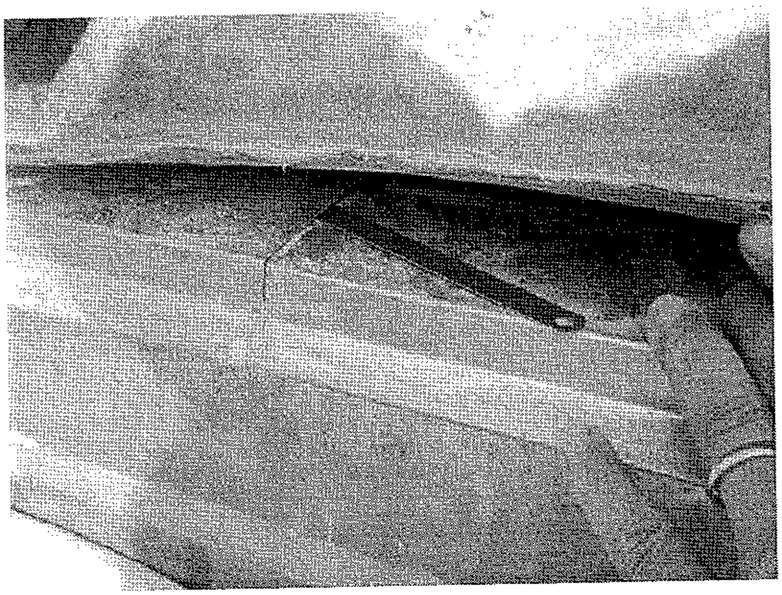


Photo 21

Feeler gage inserted in unsealed/unbonded seam in metal drip flashing at Probe 1

Photo 22

Material inserted between fabric flashing and metal drip, area over Unit C-103.

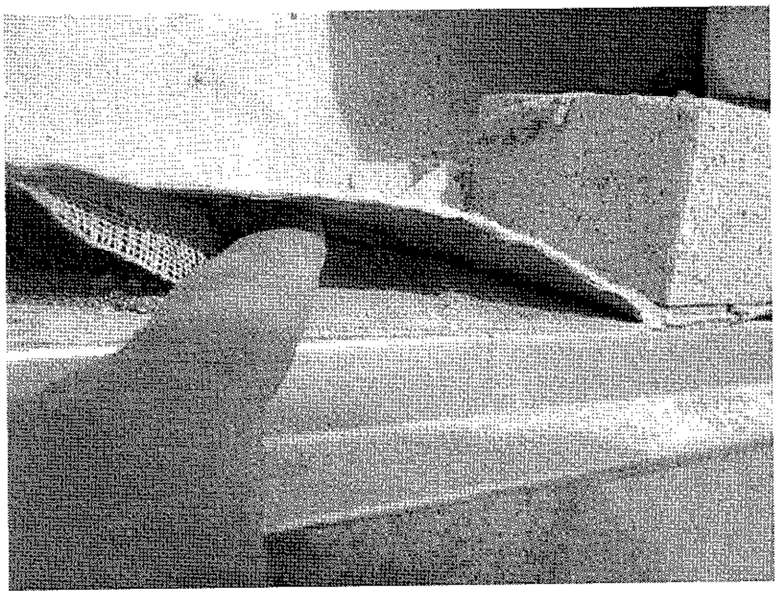


Photo 23

Delaminated fabric at Probe 1.

Photo 24

Delaminated edge of fabric flashing and deteriorated mortar joint.

Photo 25

Weep vent raised up above TWF level, and deteriorated mortar joint at TWF level.

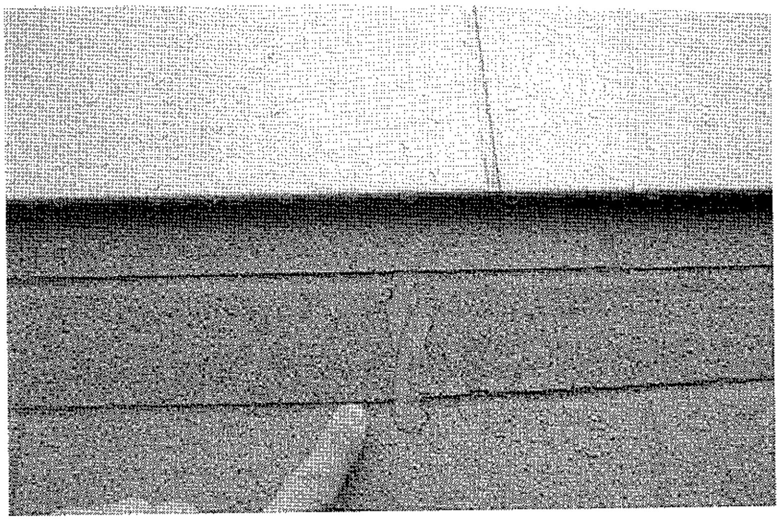


Photo 26

Sealed weep vent, apparently an attempt to reduce leakage.

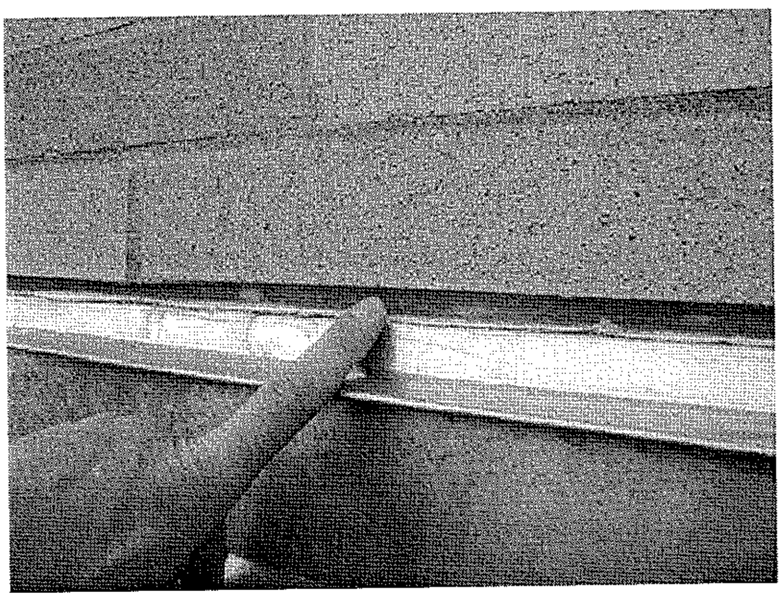


Photo 27

"Remedial" sealant in place between fabric flashing and masonry above.

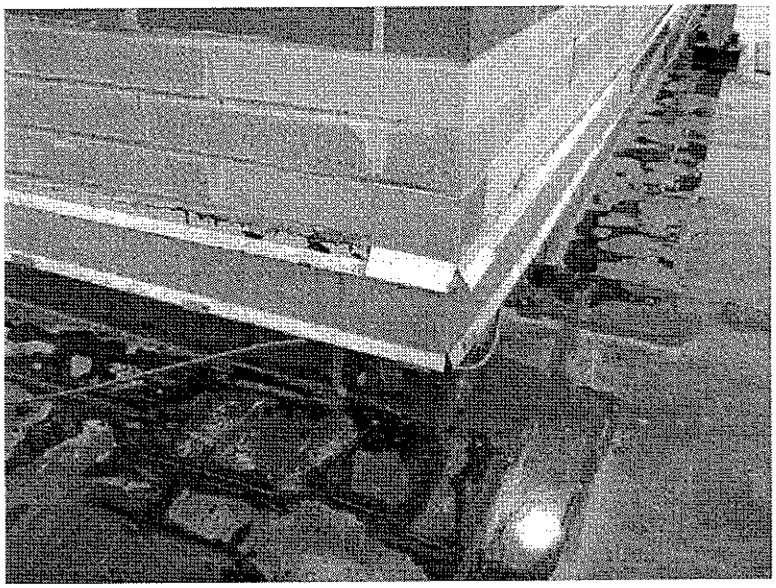


Photo 28

"Remedial" metal cap over flashing joint/transition at outside corner.

Photo 29

Pressure bar at top edge of fabric flashing not tight to backup wall

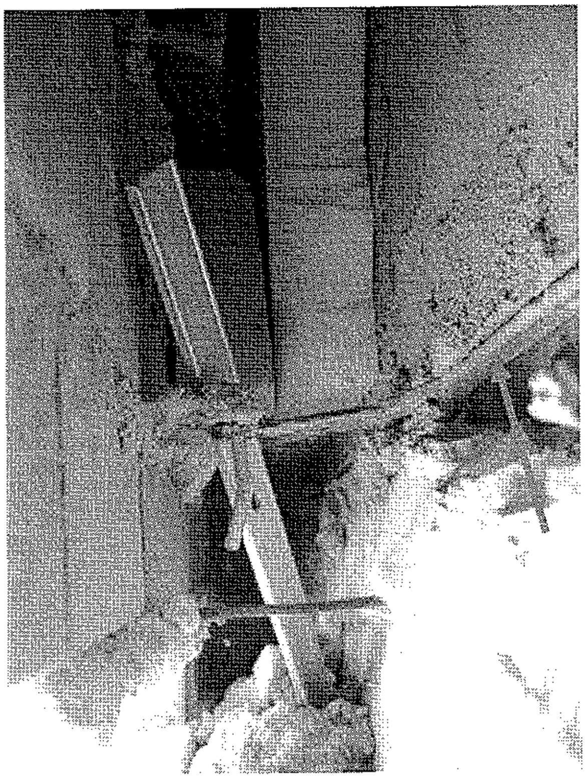


Photo 30

CMU wire reinforcing "exposed" in cavity.

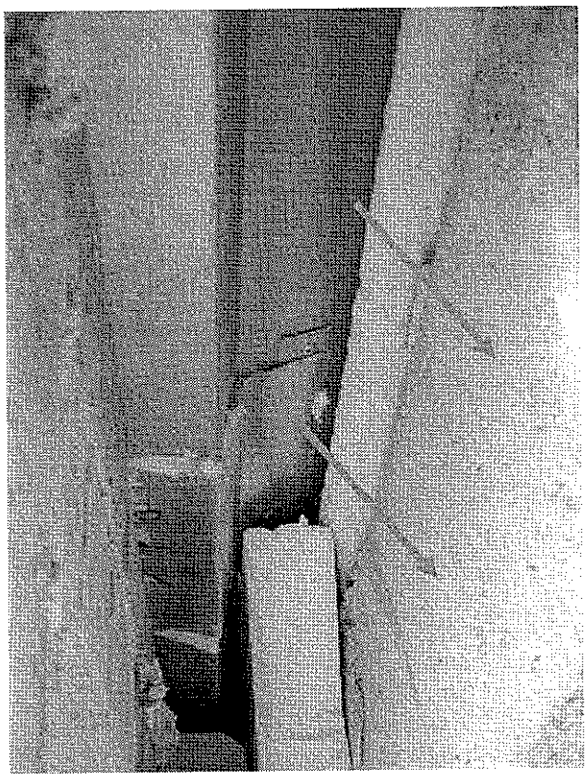


Photo 31

CMU backup missing dampproofing at Probe 2 (view within wall cavity).

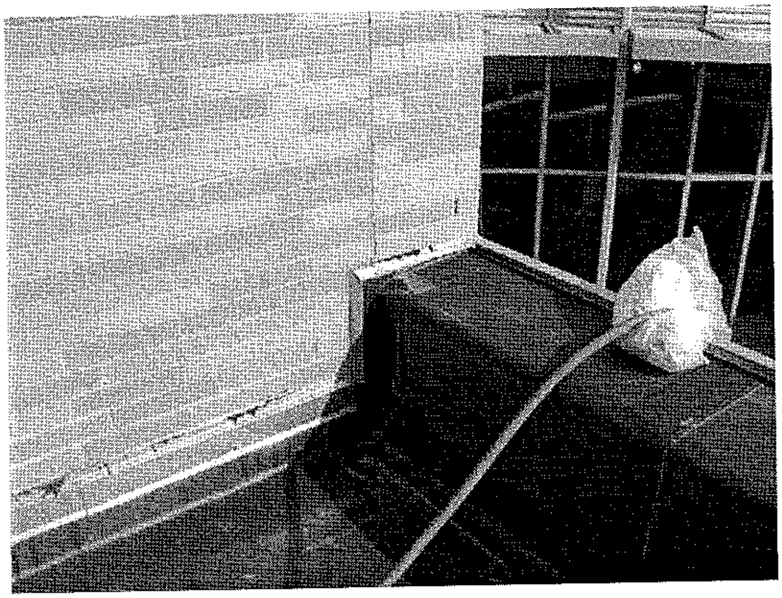


Photo 32

Parapet termination at rising wall at Area 1 (location of Probe 3).

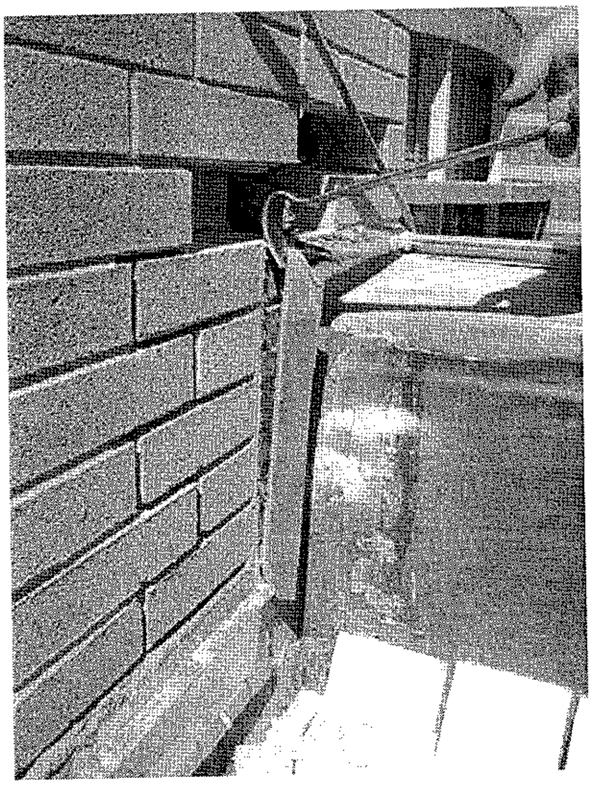


Photo 33

Probe 3 showing how the TWF ends at the parapet edge; only a surface applied J-bead turns up the vertical transition.

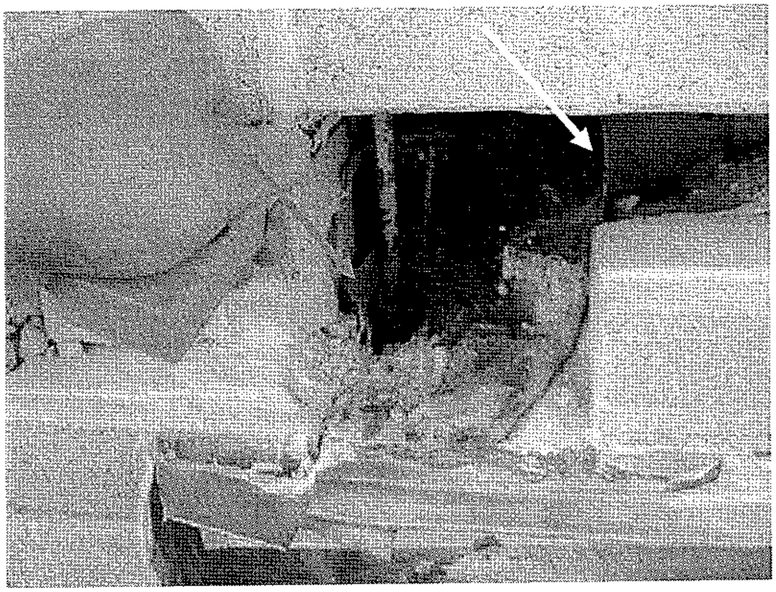


Photo 34

View at Probe 3; note the fabric flashing buried deep in the wall that does not drain to the exterior (red arrow). Also note the atypical rubberized-asphalt-membrane pocket that was exposed during the probing (yellow arrow).

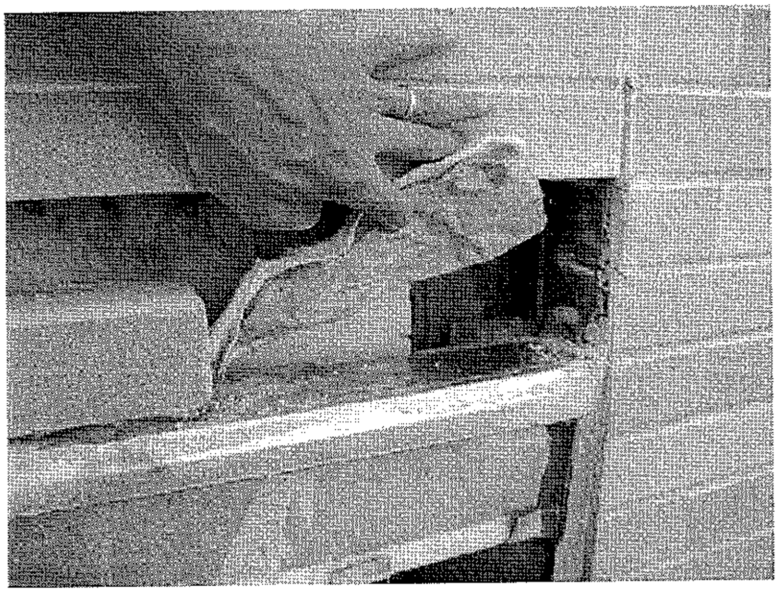


Photo 35

TWF termination at Area 2 wall (Probe 4); note that no end dam is present.

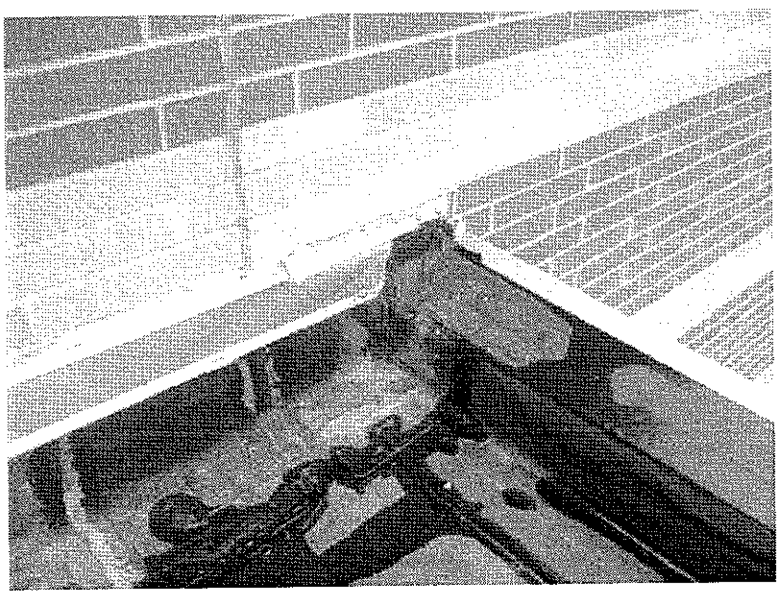


Photo 36

Roof edge termination/ transition

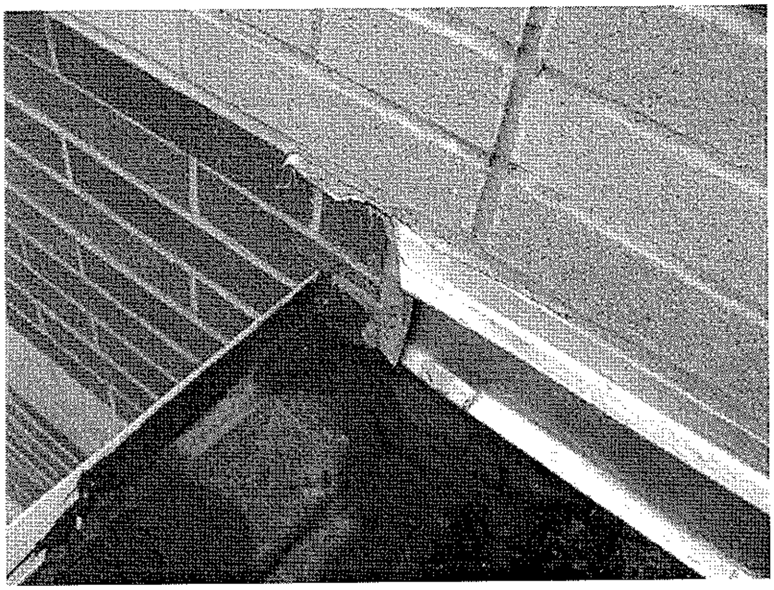


Photo 37

Roof edge termination/ transition.

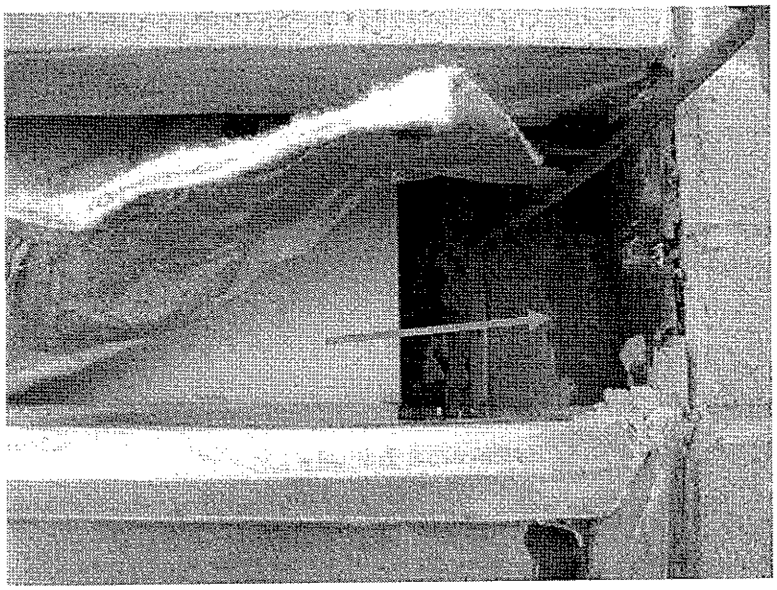


Photo 38

Metal pipe or column that interrupts CMU backup at Area 2 wall.

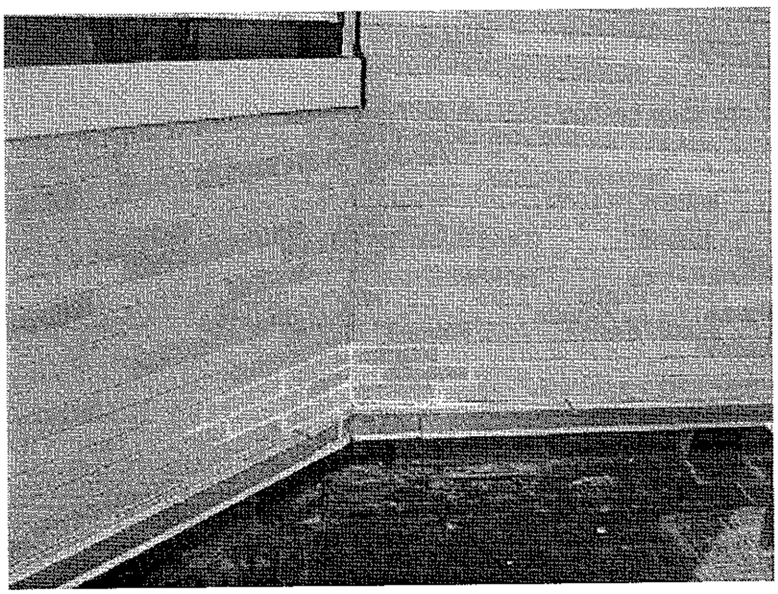


Photo 39

Nonmatching mortar at an apparent masonry patch location.

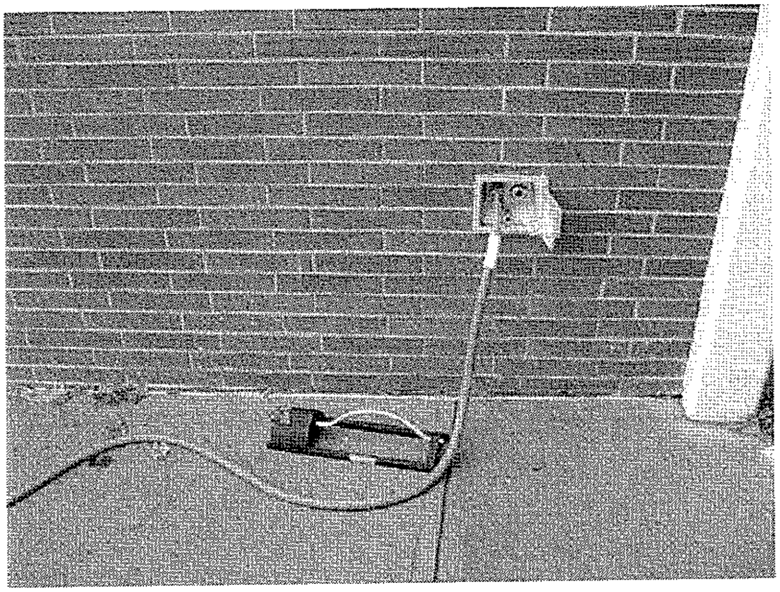


Photo 40

TWF at grade that resembles the problematic TWF flashing above low roofs.

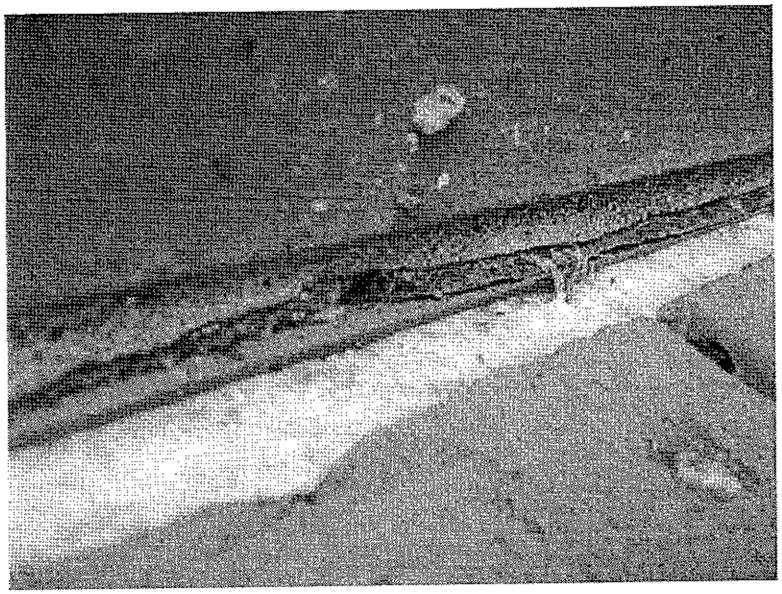


Photo 41

Up-close view of TWF at grade.

Photo 42

Roof probe (Probe 6); note the pink color of moisture-indicating paper that indicates presence of water

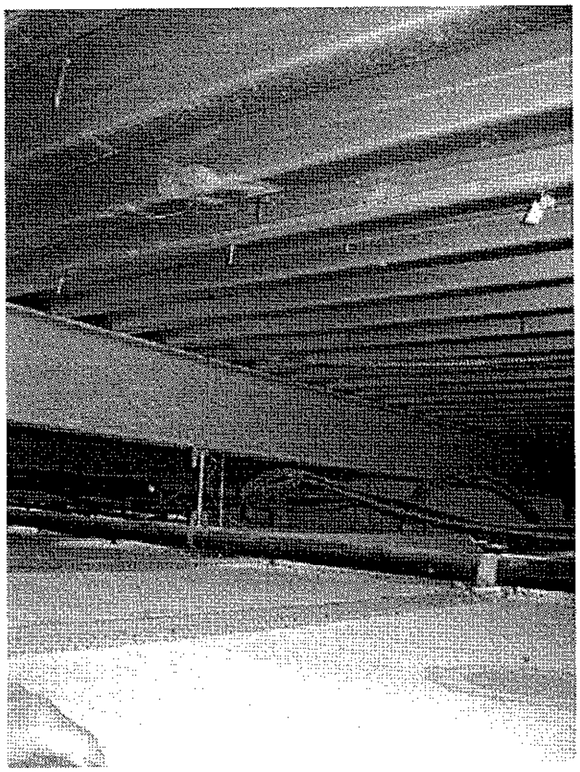


Photo 43

Corrugated steel decking and steel I-beams supporting Area 2.

Photo 44

Roof penetration flashing detail at Area 1; no obvious defects noted

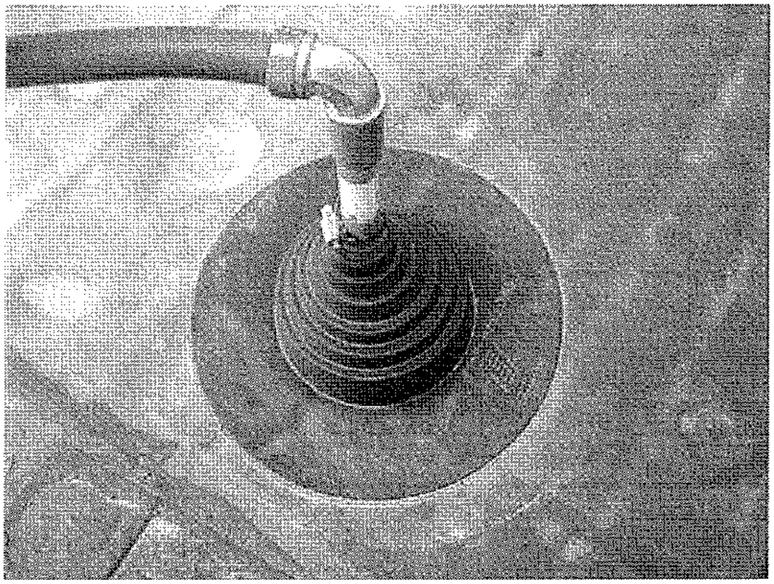


Photo 45

Roof penetration flashing detail at Area 1; no obvious defects noted.

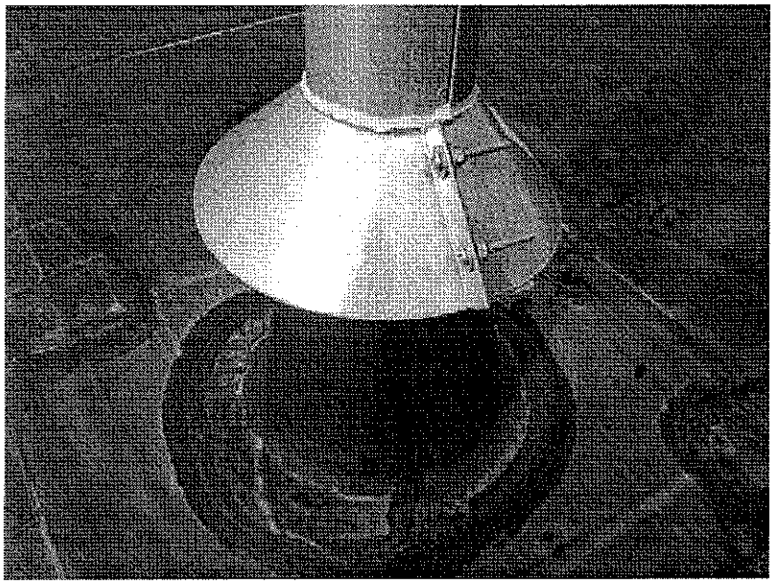


Photo 46

Roof penetration flashing detail at Area 1; no obvious defects noted.

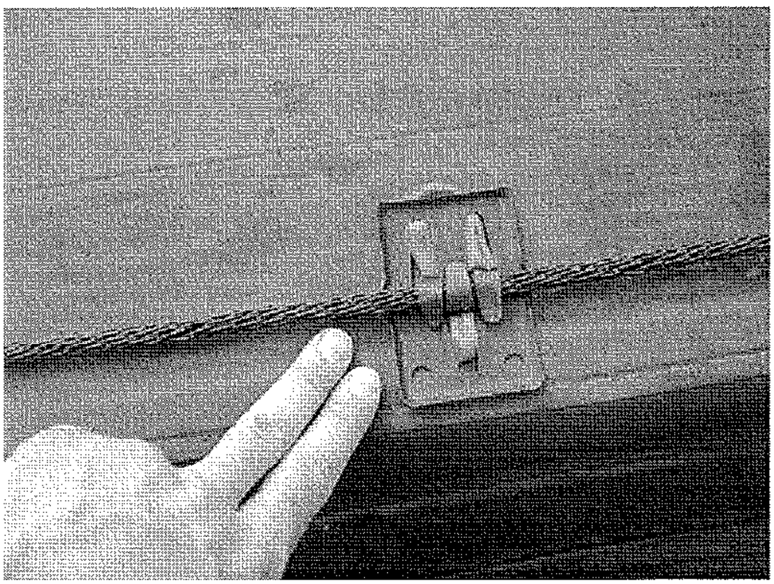


Photo 47

Adhered clip for lightning mitigation system.

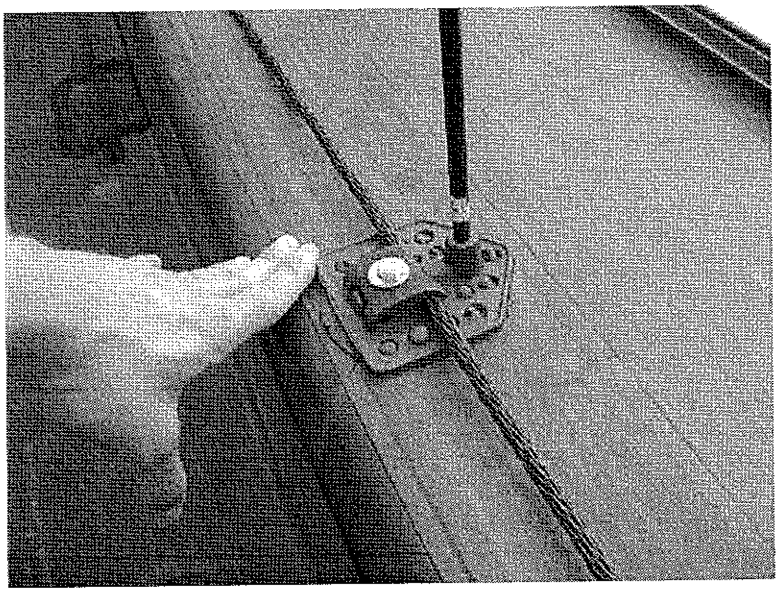


Photo 48

Anchored component for lightning mitigation system.

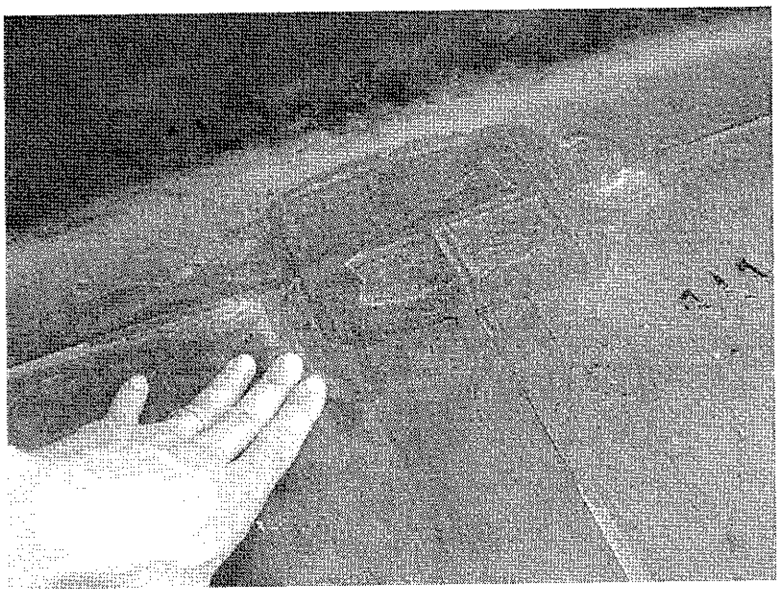


Photo 49

Typical patch in EPDM roofing.

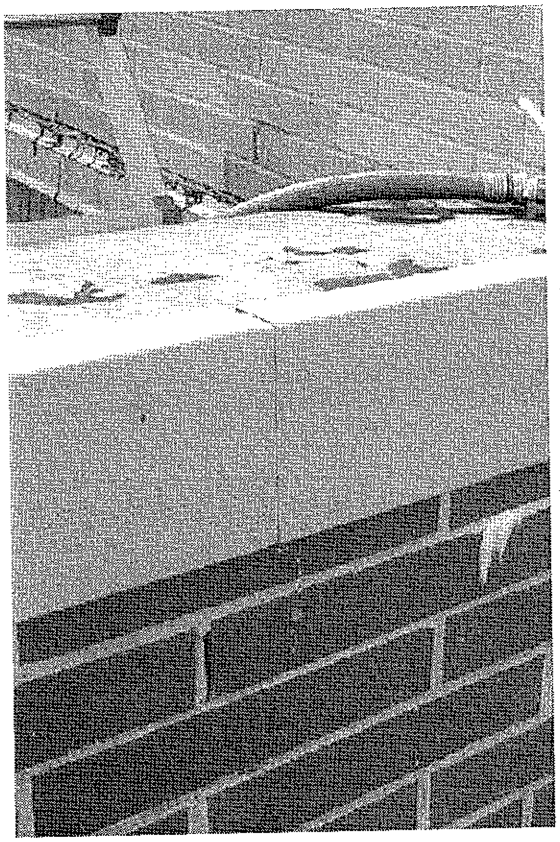


Photo 50

Typical roof edge flashing/ gravel stop with fascia (F-shape).

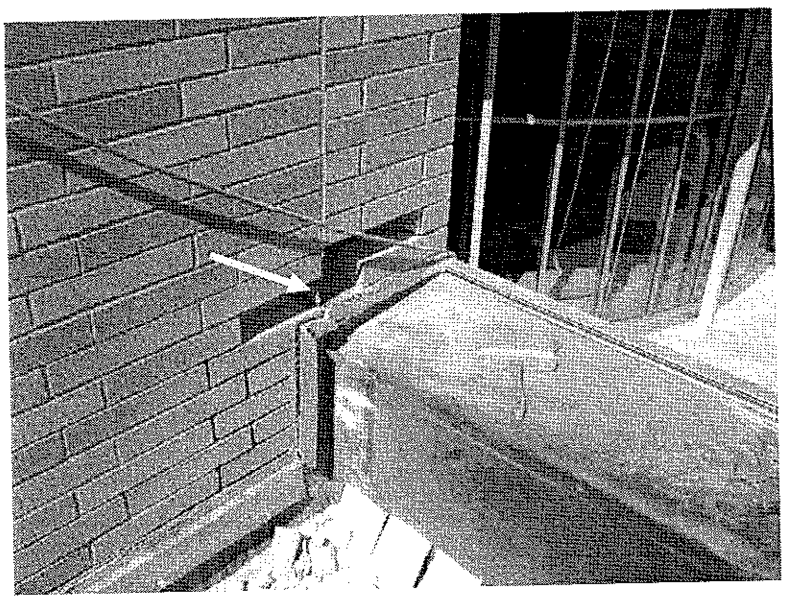


Photo 51

Atypical RAM pocket at parapet termination at Probe 3

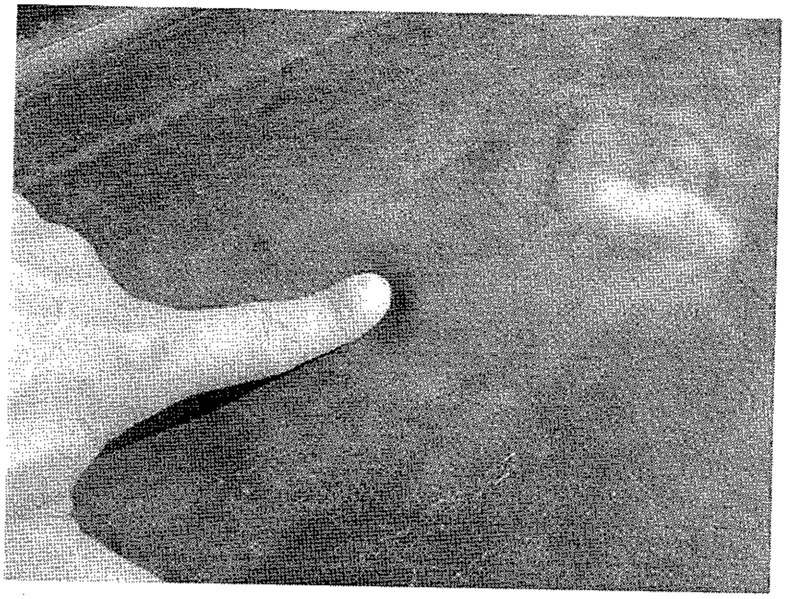


Photo 52

Partial nail pop visible through roof membrane; membrane currently is not damaged

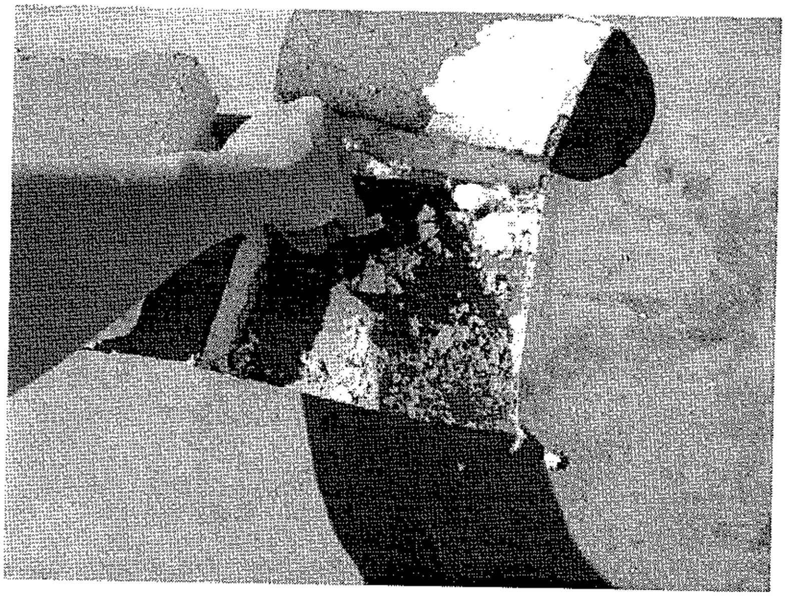


Photo 53

Roof probe (Probe 6); note the pink color of moisture-indicating paper that indicates presence of water.

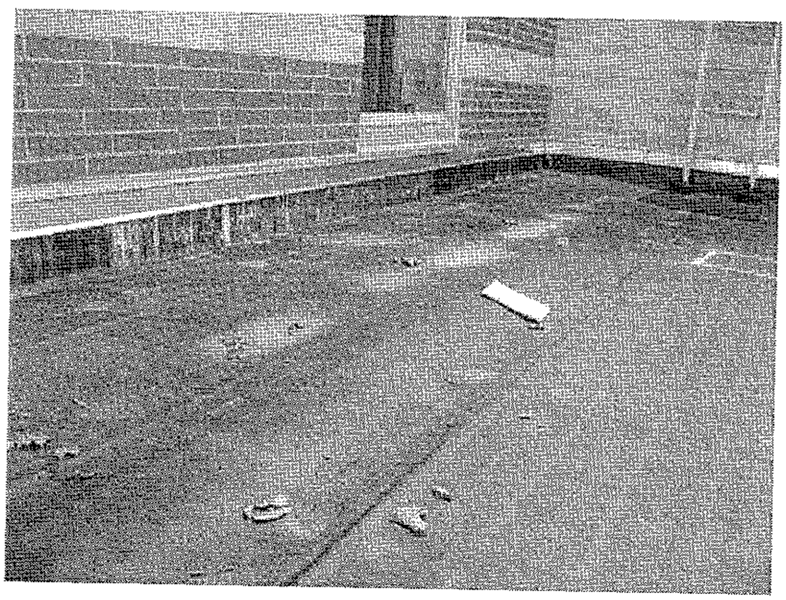


Photo 54

Roof insulation bowed over Unit C-103

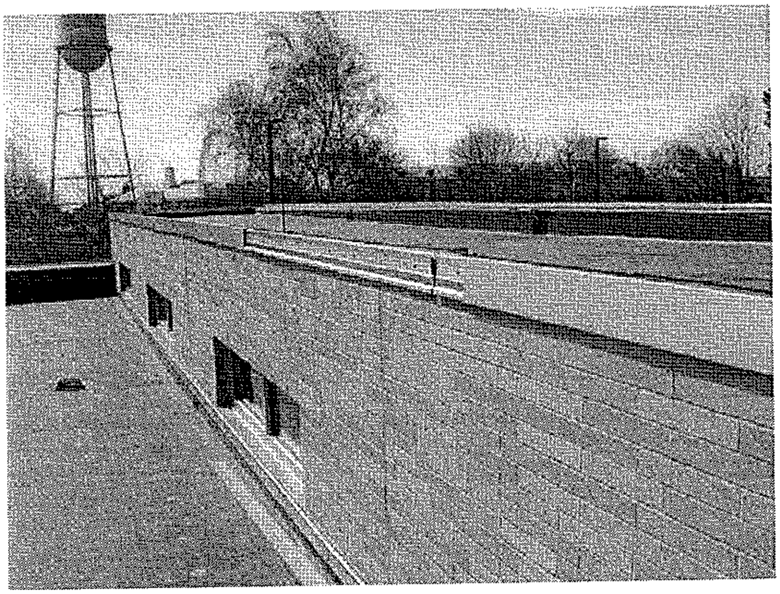


Photo 55

Roof edge flashing/fascia cap removed (Probe 7).

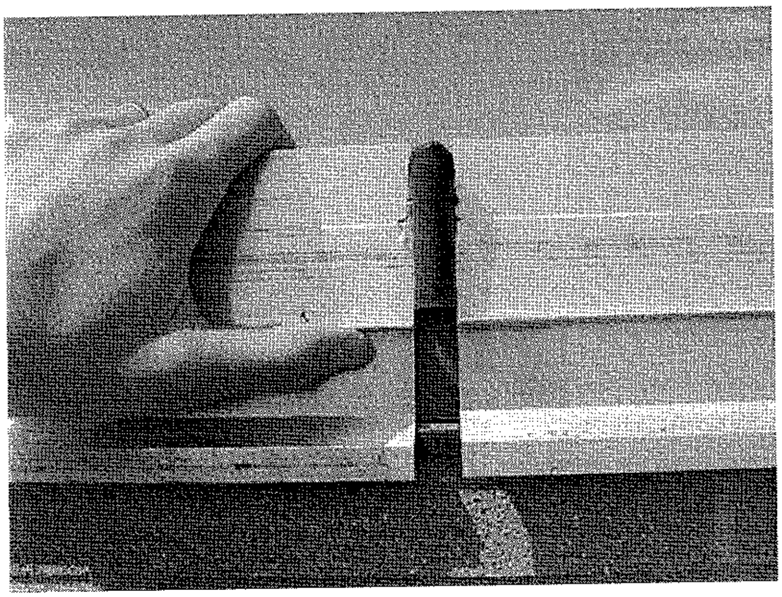


Photo 56

Joint in base component of roof edge flashing.

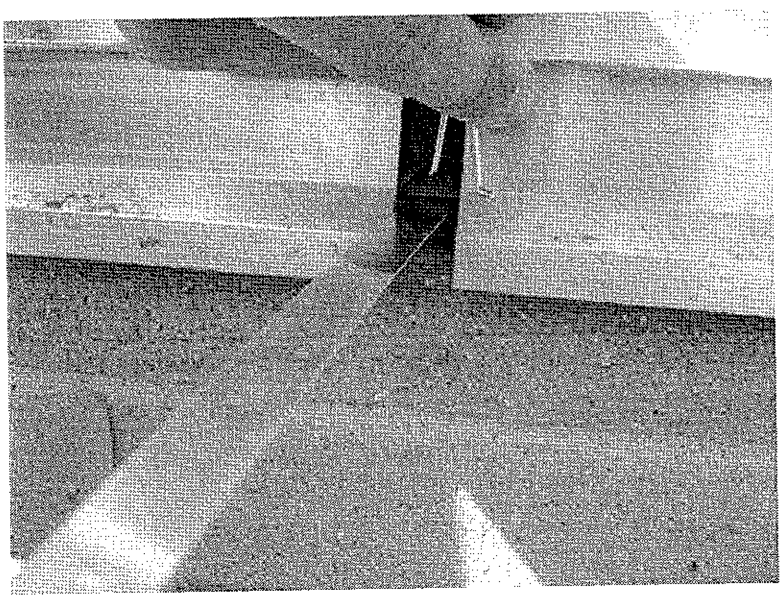


Photo 57

Up-close view of joint in base component of roof edge flashing; note the edge of the EPDM membrane, the wood blocking, and the unsealed joint beneath the blocking (feeler gage inserted).

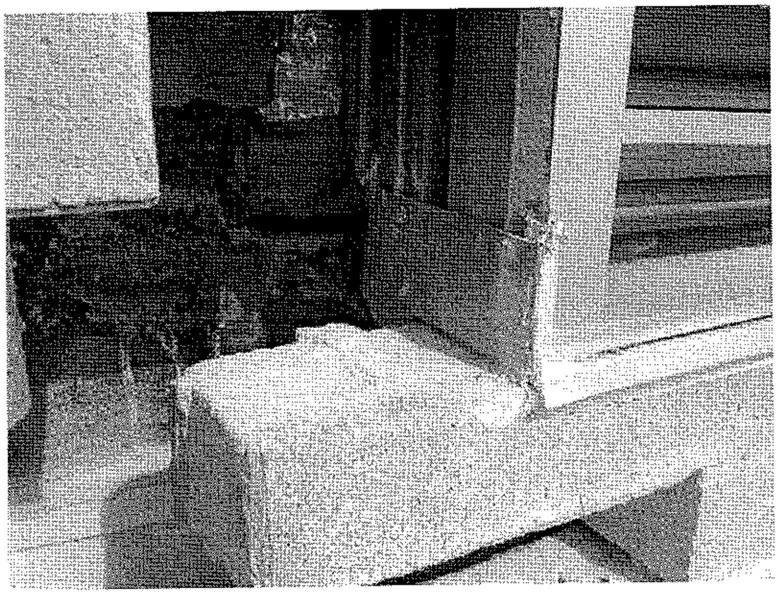


Photo 58

End dam at aluminum pan flashing below louver

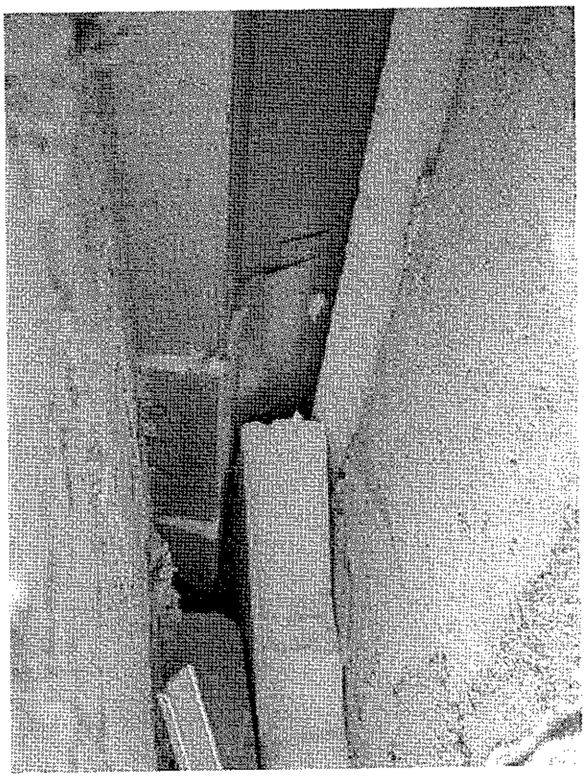


Photo 59

Splice in aluminum pan flashing below louver. Also note the reverse pitch at the flashing.

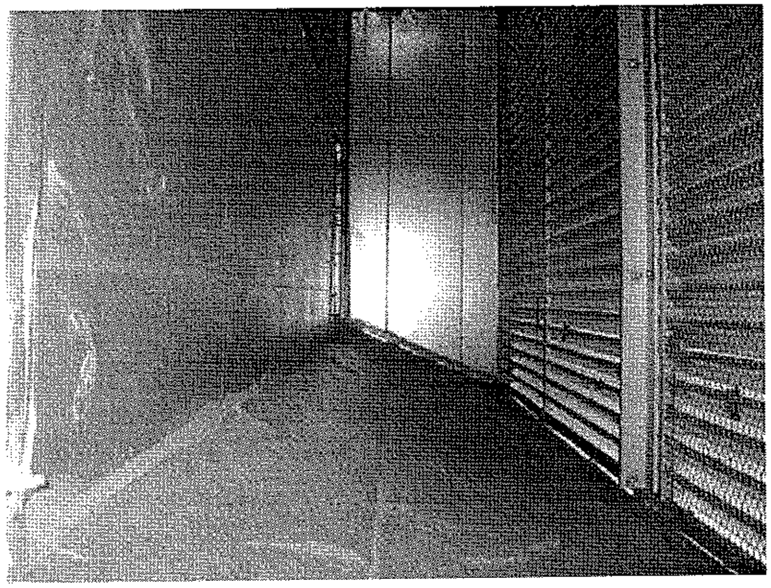


Photo 60

Sealed joints within louver.

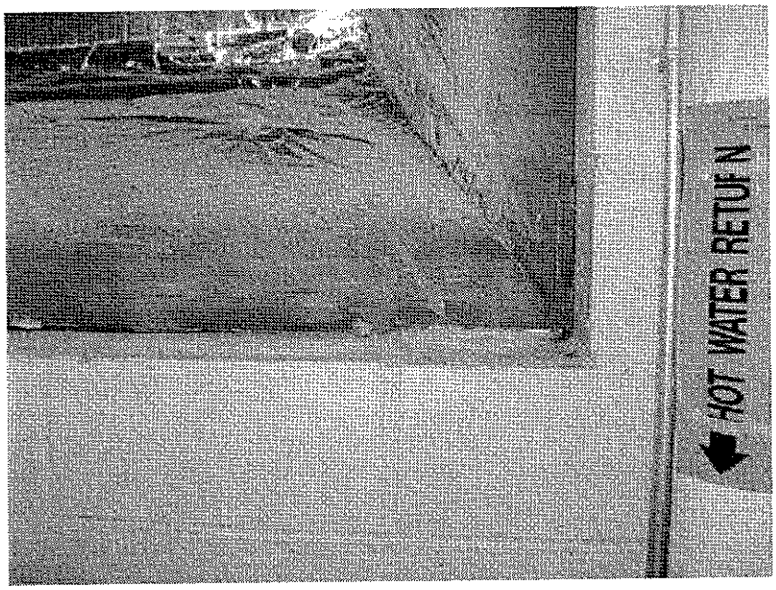


Photo 61

Exterior cavity insulation visible from interior/ mechanical space by louver

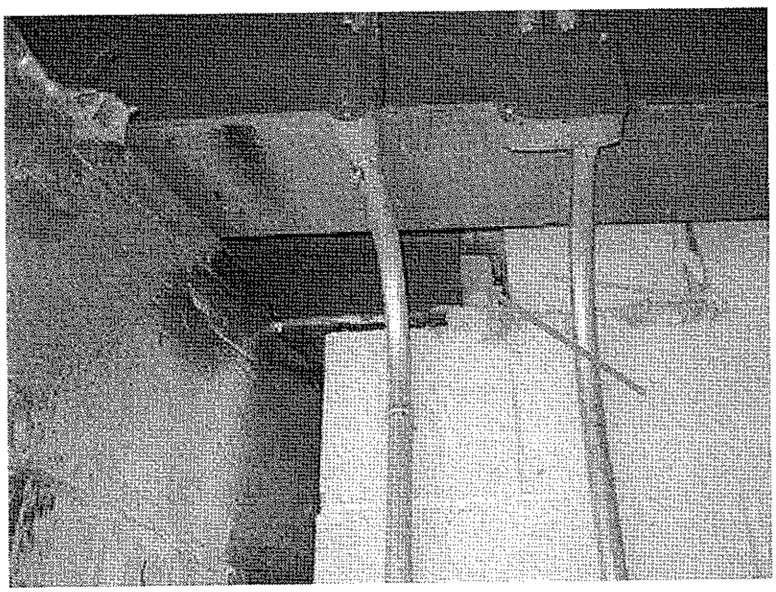


Photo 62

Exterior cavity insulation visible from interior/ mechanical space by louver.

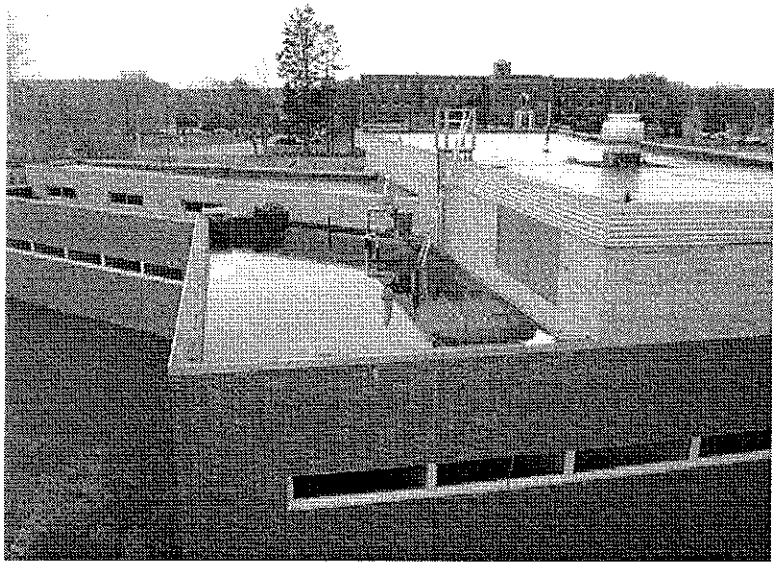


Photo 63

Roof flood test in progress (WT1).

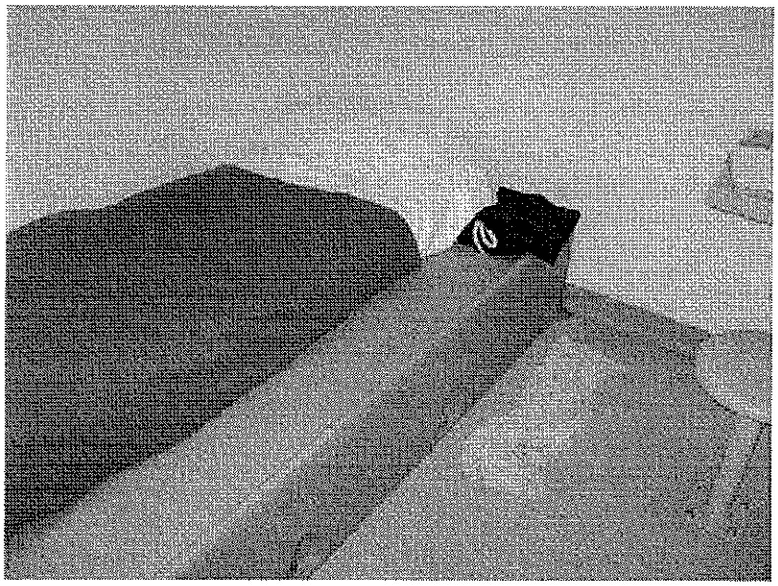


Photo 64

Water noted on the floor during WT1

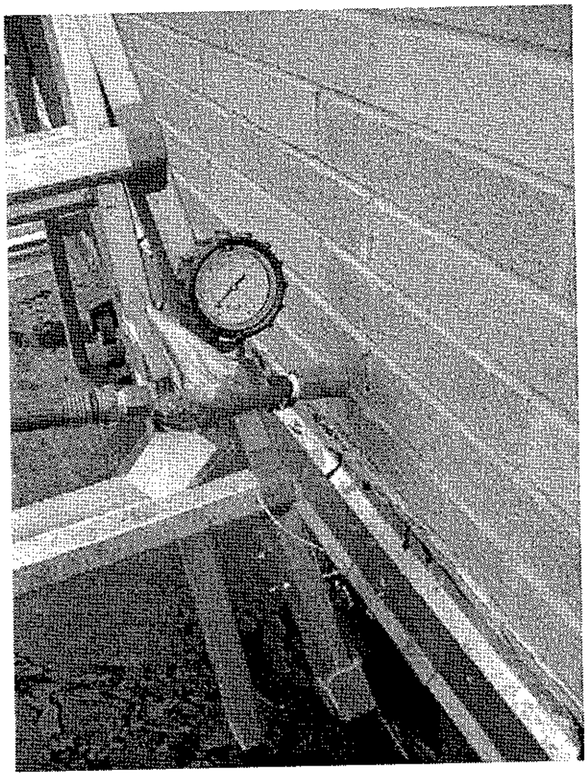


Photo 65

Water test in progress at weep vent (WT2).

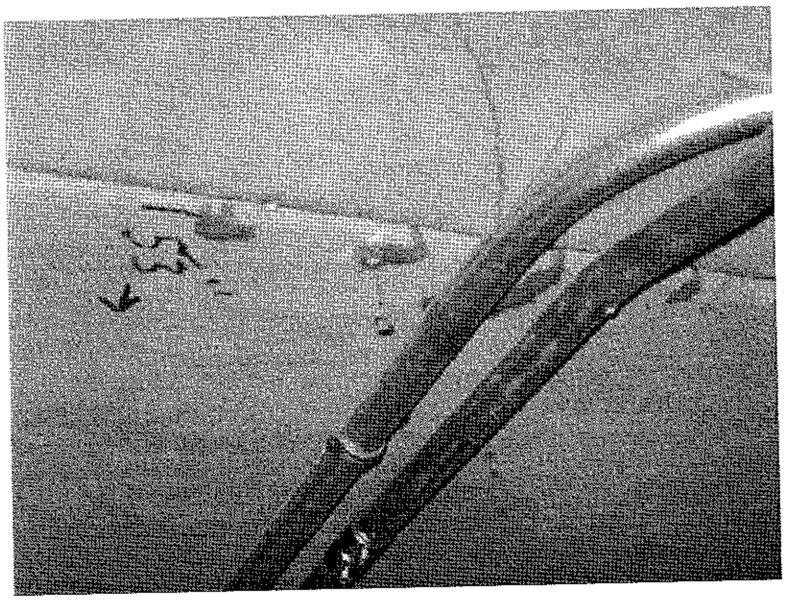


Photo 66

Water passing through joint between precast concrete deck planks during WT2C.

Photo 67

Water collecting on floor during water test.

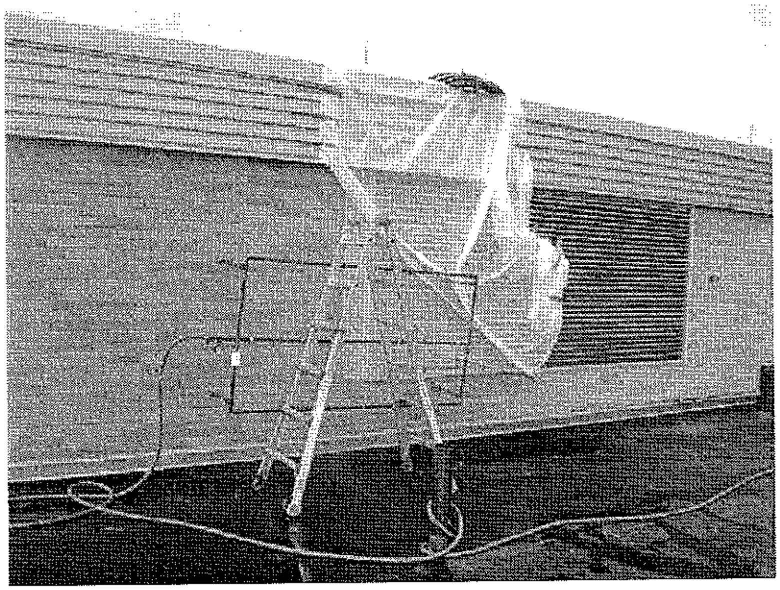


Photo 68

WT3 in progress.

Photo 69

Heavy leakage during WT3; note the water collecting on the floor.

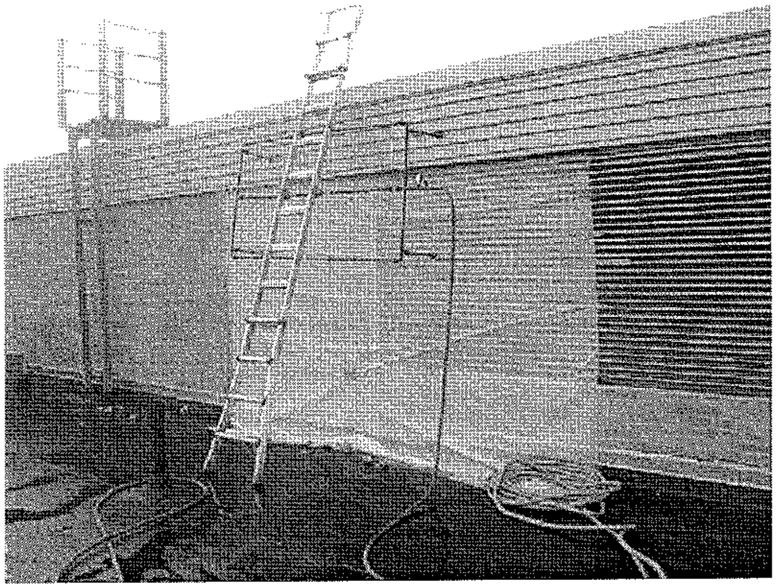


Photo 70

WT6 in progress; louver, masonry, and TWF masked off to isolate (i.e., test) corrugated panels and roof edge flashing.

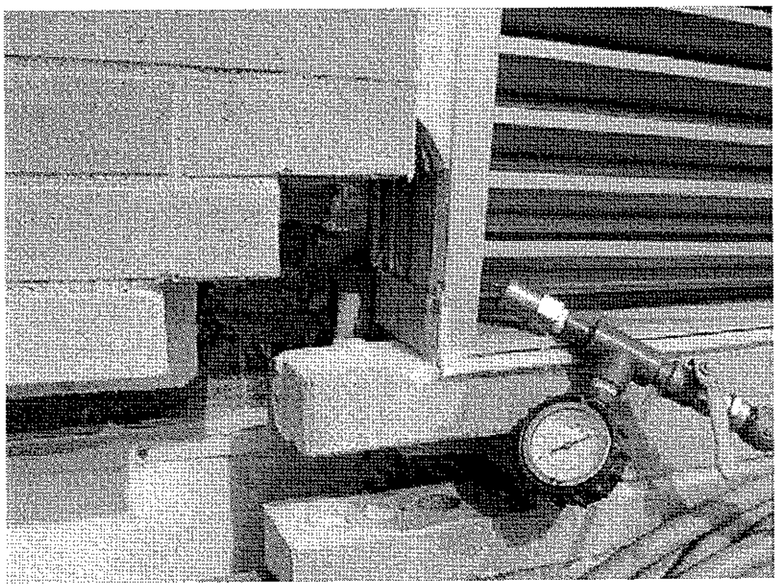


Photo 71

WT7 in progress.

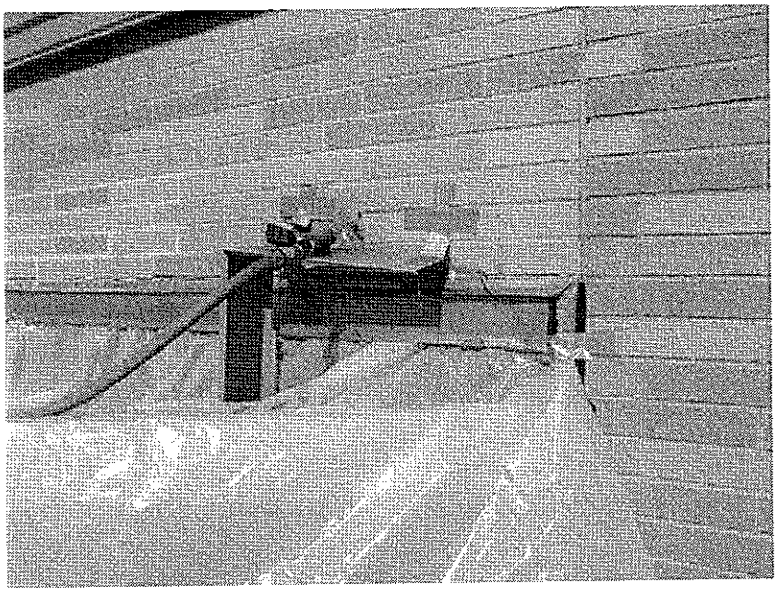


Photo 72

WT10 in progress.

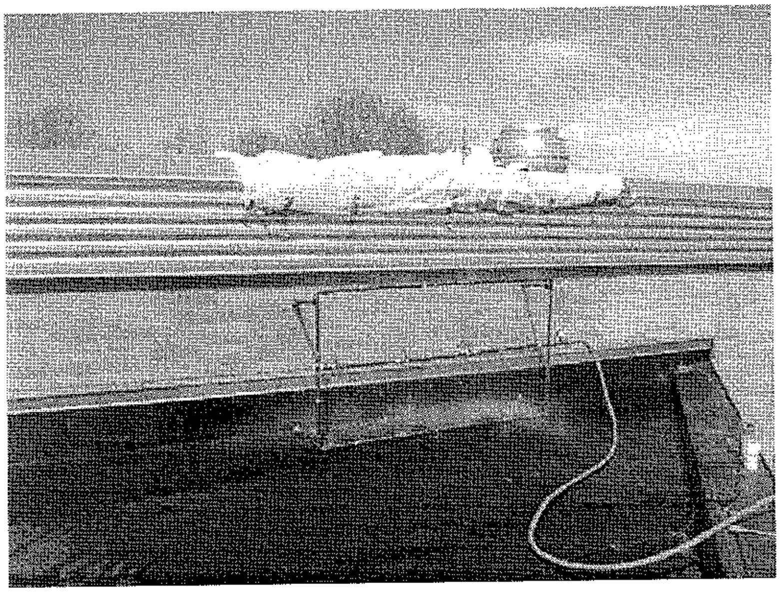


Photo 73

WT11 in progress.

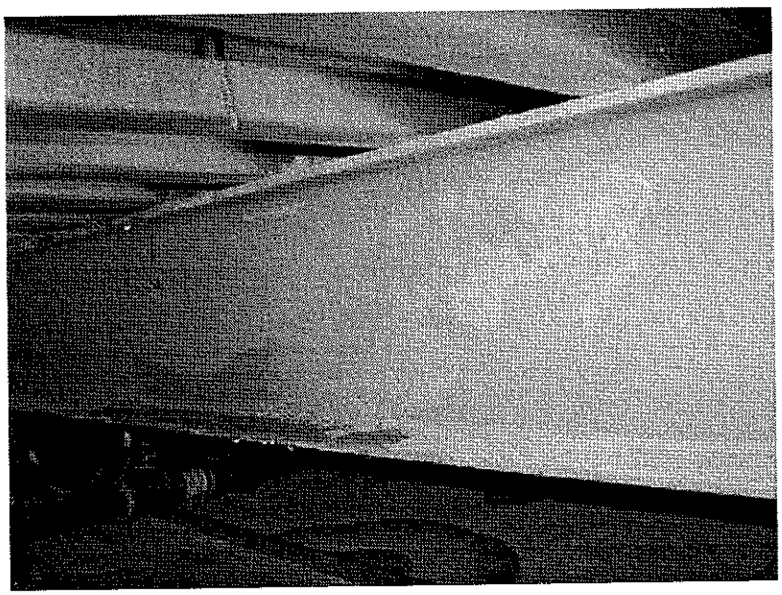


Photo 74

Water collecting on flange of steel beam and dripping off during WT11.

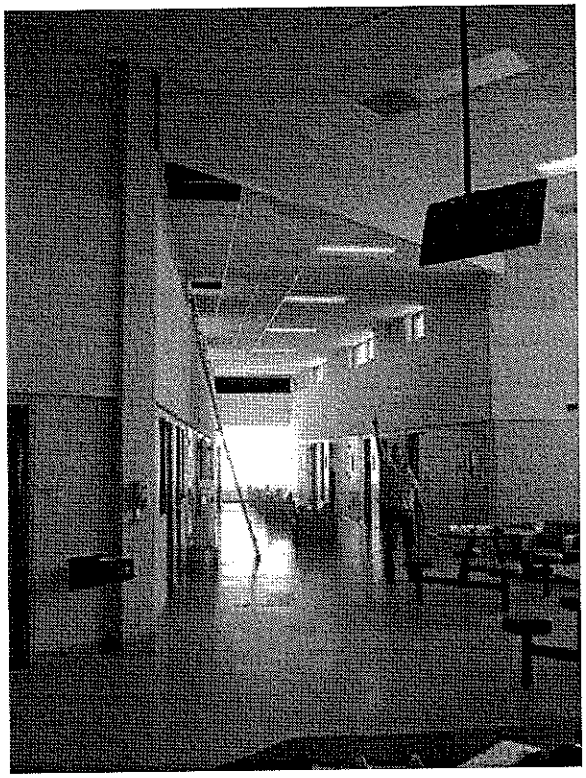


Photo 75

Water leakage during WT11; note wet ceiling tiles and water collecting on the floor.

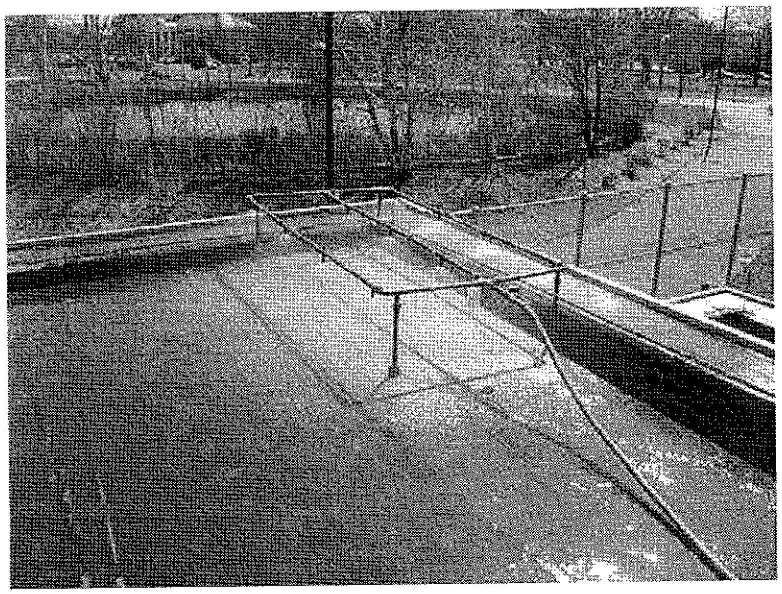


Photo 76

WT13 in progress

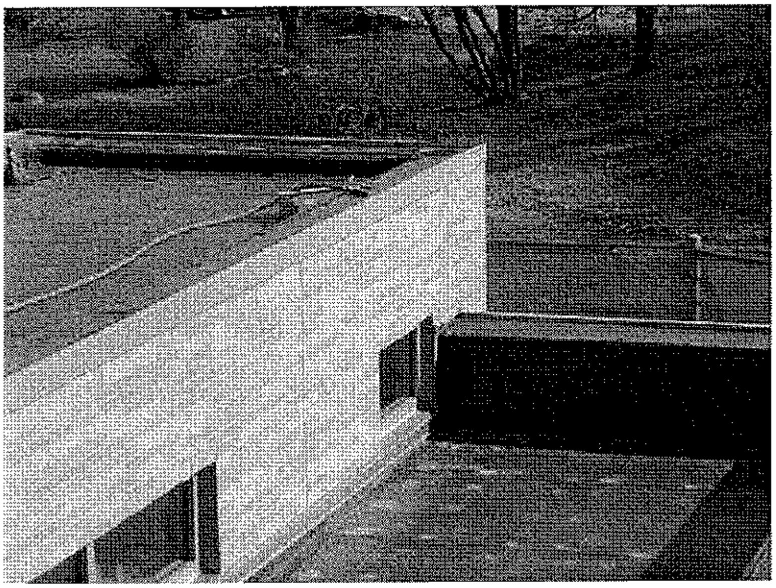


Photo 77

WT13A in progress.

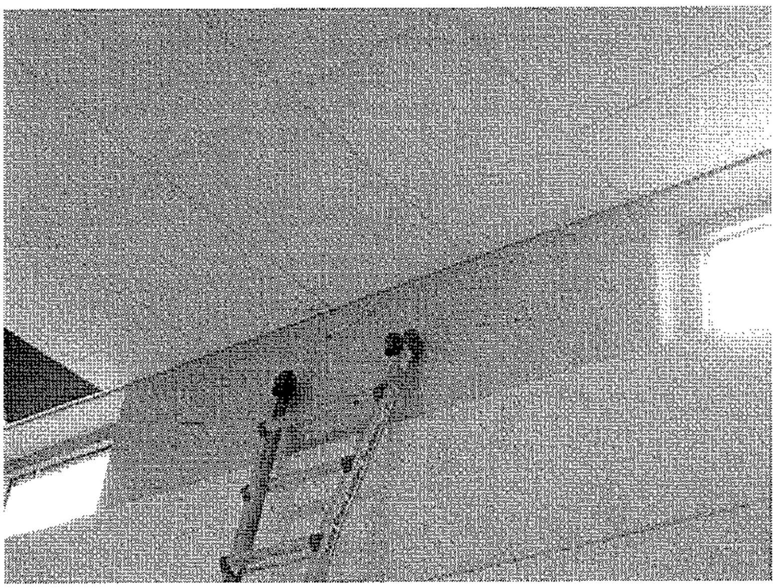
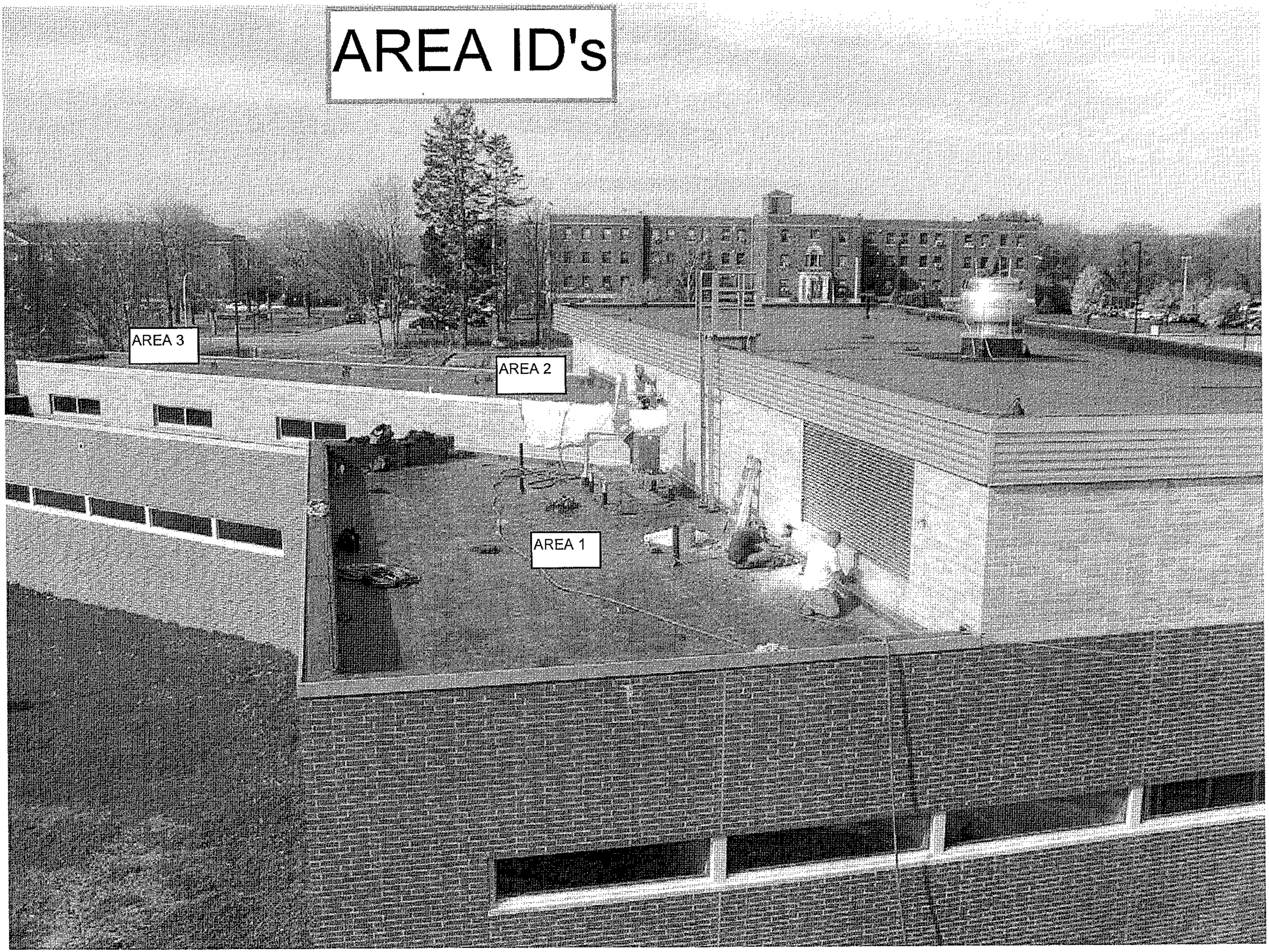


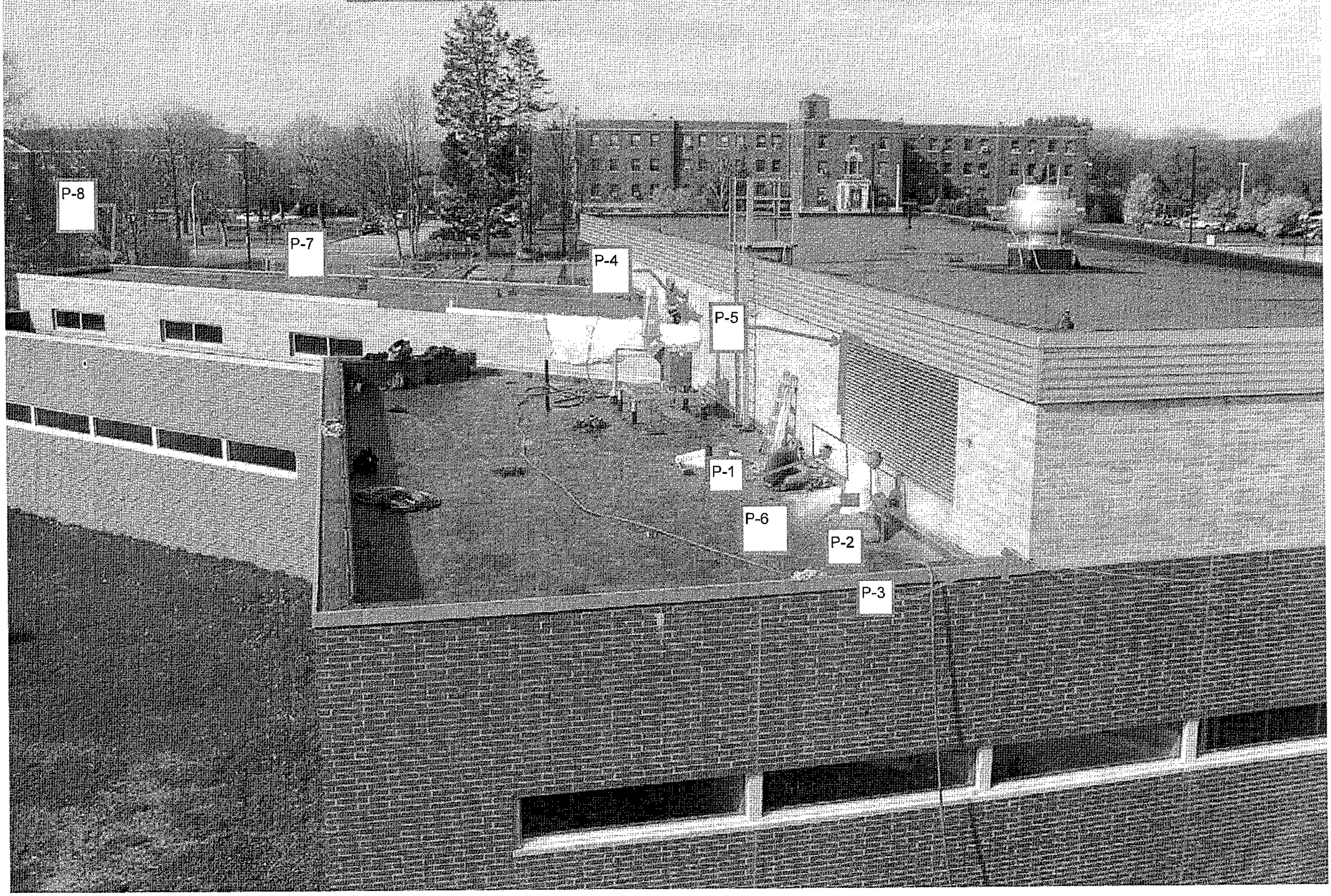
Photo 78

Heavy leakage during WT13A; note the pink color of moisture-indicating paper that indicates presence of water.

APPENDIX A


AREA ID's
AREA 3
AREA 2
AREA 1

PROBE LOCATIONS



WATER TEST LOCATIONS