Gale Associates, Inc.
703 Hebron Avenue | Glastonbury, CT 06033
P 860.430.5660 F 860.430.9072
www.galeassociates.com

November 17, 2023
DRAFT REPORT

Marco Aglieco, Buildings and Facilities Manager
Town of Windsor – Building Maintenance
275 Broad Street
Windsor, CT 06095

Re: DRAFT Evaluation Report
Humidity Mitigation
Oliver Ellsworth Elementary School
730 Kennedy Road
Windsor, Connecticut
Gale JN 977810

Dear Mr. Aglieco:

In accordance with our agreement, Gale Associates Inc. (Gale) performed a visual evaluation and in-situ testing of portions of the existing building enclosure systems components for the Oliver Ellsworth Elementary School (the School) located at 730 Kennedy Road, Windsor, Connecticut. Gale's evaluation included qualitative air infiltration/exfiltration testing, smoke tracing, and infrared surveys at representative rooms and locations designated by representative(s) of the Town of Windsor and through consultation with Gale.

A preliminary walkthrough of the facility was performed on October 18, 2023, to familiarize Gale with space logistics. Representatives from Gale visited the School on November 2 and 3, 2023, to conduct the visual evaluations and testing. An additional day of testing was performed on November 13, 2023, which included additional classroom pod locations and supporting spaces. Refer to ***Figure 4*** for approximate testing locations. Access to the building spaces was coordinated and provided by the Town of Windsor and their on-site security and custodial staff. The purpose of the evaluation is to provide the Town of Windsor with a better understanding of the building enclosure conditions observed, air infiltration/exfiltration sources, and how they may be contributing to the elevated levels of humidity within the building during the Summer months. The purpose of this report is to provide our opinions for potential repairs of the building enclosure system(s) at typical building enclosure conditions. Please find below a Room Designation Plan and 1968 floor plans (***Figures 1 through 3***).

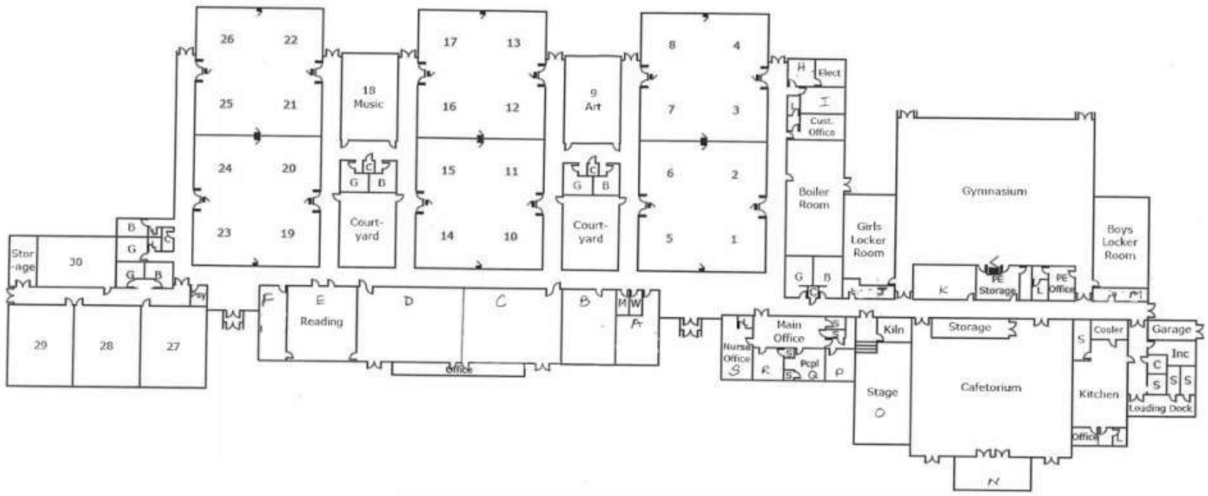


Figure 1 – Room Designation Plan used for test area designations.

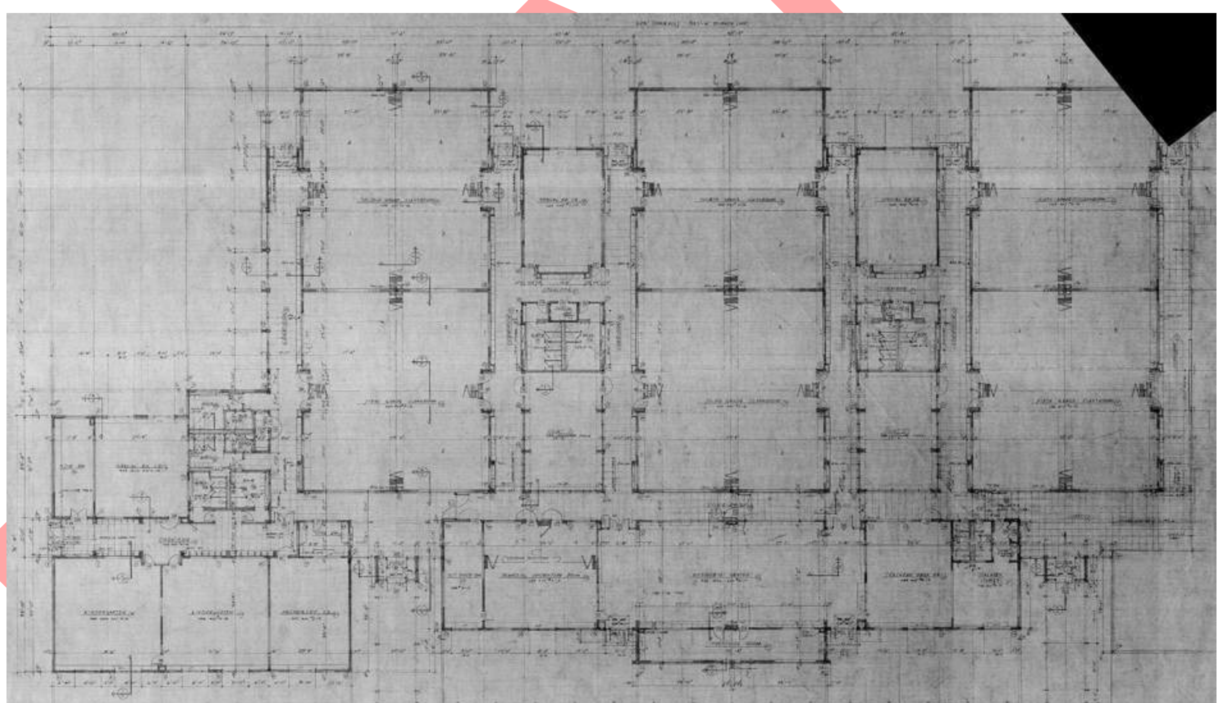


Figure 2 – 1968 - Western Floor Plan

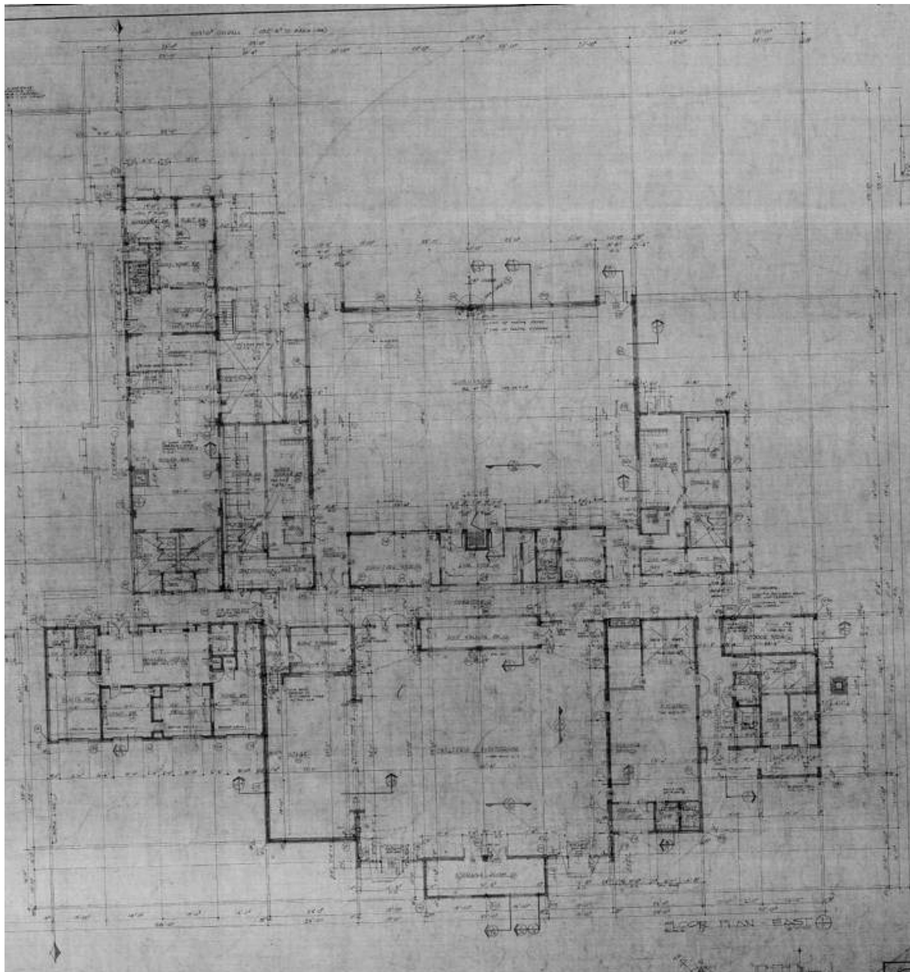


Figure 3 – 1968 - Eastern Floor Plan

Gale's scope of services performed included the following:

- Initiated the project via teleconference to establish the schedule for field services, deliverables, and to coordinate access and site logistics with the Owner. Minutes of the meeting and a milestone schedule were developed and distributed by Gale.

- Reviewed portions of original plans, specifications, reports, and similar data made available to Gale. The documents made available to Gale consist of:

    - A set of 1968 Kennedy Road Elementary School, now Oliver Ellsworth School, Drawings produced by the Public Building Commission (***Figures 2 and 3***)

    - A set of HVAC Contract Document drawings produced for the Oliver Ellsworth School HVAC renovation project, dated March 2017.

    - An Oliver Ellsworth Room Designation Plan of current room designations (***Figures 1****)*.

- Interviewed personnel familiar with the facility and the leak/repair and moisture issue history, performed during the initial kick-off meeting with Gale, Town of Windsor, EnviroMed, and Van Zelm in attendance on October 18, 2023.

- Viewed the interior of the facility, including areas of readily accessible interior surfaces of exterior walls, roof decking, and other exterior building enclosure barriers.. It should be noted that during the initial kick-off meeting, facilities personnel reported increased humidity related issues generally occurring throughout the building.

- Performed infrared thermography on portions of the exterior building enclosure to assist in locating potential air and thermal loss.

  - An aerial drone infrared survey was performed on the evening of November 2, 2023.

  - Handheld infrared surveys were performed on the afternoon and evenings of November 2, 3, and 13, 2023.

- Gale performed a modified version of ASTM E1186 Standard Practice for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems. Gale utilized blower door equipment to provide controlled flow direction through pressurization or depressurization of the select spaces to assist with infrared scanning and smoke trace testing from the inside and outside of those same spaces. . The Town of Windsor and Oliver Ellsworth facilities representatives coordinated with Gale to provide access to the building interior for this evaluation.

  - Note that to maximize the effectiveness of the scans, a temperature differential of approximately 15 - 20 degrees Fahrenheit was maintained between the interior and exterior and the testing spaces were pressurized between 15 - 50 Pa, depending on the overall room/location size and existing air leakage within the space(s).

  - Note that these testing techniques are qualitative in nature and did not determine quantitative air leakage rates across the building enclosure.

- Evaluated the building enclosure systems and related accessory construction for general conformance with industry standards at the time of construction and as relevant to the reported high humidity levels.

- Prepared this letter report, in electronic format, outlining our findings and opinions. This letter report includes:

  - Background information
  - Methodology used to evaluate the portions of the building enclosure systems included in this project.
  - Observed conditions of the specific locations included in this evaluation.
  - Results of field testing performed.
  - Opinions regarding the probable cause of air infiltration/exfiltration and elevated levels of humidity associated with the building enclosure.
  - Basic options for repairs.
  - Plans (redlined on copies provided by the Owner) with observed conditions and comments.
  - Photographic documentation of existing conditions incorporated throughout the body of the report.

- Met with the Town of Windsor at an in-person meeting on the evening of November 14, 2023, to present and review the letter report. Meeting minutes will be developed and distributed by Gale to clarify the next steps relative to building enclosure consulting services.

Background Information

The Town of Windsor has reported that there is an ongoing moisture-related issue within Oliver Ellsworth Elementary School building and has requested Gale to prepare a summary report identifying potential building enclosure air breaches and opinions on potential repair actions. Gale has developed the scope of services below based on input from the Town of Windsor.

Existing Conditions and Observations

The following is a summary of Gale's observations of existing exterior building enclosure conditions:

- Roofing predominantly consists of a loose gravel surfaced built up roof terminated with a metal edge.
- Generally, exterior envelope components at single-story sections of the building appear to consist of a concrete foundation supporting single or multi-wythe brick masonry and a "Waylite" block back-up wall extending from grade level up and transitioning to metal wall panels.
  - Waylite block consists of "a refined lightweight cellular aggregate produced by agitating and rapidly cooling the silicates and alumina silicates of lime, and sulfur compounds. This process produces minute air cells in the material, which are the active insulation and lightweight principle."
  - R-value for this type of masonry block is estimated at approximately R1.5.
- At portions of the building and predominately at the gymnasium, cafeteria, and supporting spaces between, exterior envelope components appear to consist of a concrete foundation formed to support a single or multi-wythe brick masonry and a "Waylite" block back-up wall extending from grade level upward and transitioning to a soffit overhang that is clad with "Glasweld" panels. The soffit panels transition to an existing metal-panel façade system that measures approximately 13-feet and extends upward to the existing metal roof edge.
  - Glasweld panels consist of "an exterior-grade, steam cured, asbestos-reinforced, incombustible panel with an all-mineral enamel surface".
- The blue-colored metal wall panels and sheet metal sill covers appear to have been added at some time after the original building construction. Per the 1968 plan, 3-inch limestone was noted to exist behind these wall panels with no evidence of an air barrier between interior and exterior construction. The actual constructed conditions and presence of insulation or air/vapor barriers behind these panels is unknown. A limestone windowsill is also noted to exist beneath the blue metal sill cover (**Image 1**).
- Atmospheric staining and efflorescence were noted to be present at various locations on the building. The atmospheric staining was predominantly observed to occur at brick masonry piers and chases (**Image 2**).

- Painted plywood infill panels were observed to have been installed over several of the existing louvers as noted per the 1968 Drawings (**Image 3**).

- Early signs of deterioration and peeling paint were observed occurring in the plywood soffit panels located adjacent to clerestory windows. Some of the soffit panels adjacent to the clerestory windows were observed to be dislodged and buckling at the joints between panel sections. It should be noted that, per the 1968 Drawings, "Glasweld" panels were originally installed at the soffit, but Gale could not confirm whether the existing panels were removed or abandoned in place. "Glasweld" panels were observed to still be in place and generally found at soffits of the single-story building sections.

- During a cursory review of the existing conditions, Gale observed an unsealed void in the brick masonry occurring between a clerestory window frame and the adjacent brick pier.

- Several fasteners used to secure the vertical mullion covers between the clerestory windows were observed to be missing resulting in unsealed penetrations that can provide a path for air and water migration.

- Plywood was observed to be installed over an existing, roof-level louver on the exterior side of Room 7.

- The window glazing gaskets and perimeter sealant at clerestory windows were observed to generally be in a deteriorated and failing condition. Several glazing sashes were found to be loose, and Gale was able to move the sash within the frame.

- The joints between sections of sheet metal flashing that are located beneath the clerestory windows had been originally welded/soldered to provide a continuous flashing. Several of the lap joint connections between flashing sections were observed to have failed.

- The fiberglass reinforcing fabric embedded in the built-up roof system was observed to be partially exposed at several roof edge locations. Several of the worst-case locations that were observed appeared to occur at the western roof edge of the building and adjacent to the roof access ladder at the pitched roof area.

- The window gaskets located within grade-level window assemblies were generally observed to be deteriorating or missing. Gale observed atmospheric staining and spider webbing forming around several window units. The conditions typically indicate the presence of uncontrolled air movement through the exterior wall assembly.

- The exiting windows that were observed to be present at Room N do not appear to be part of the original construction as they are now shown in the 1968 Drawings provided.

Image 1 – Exterior view of main entrance and entrance door illustration blue cladding placed over limestone elements.

Image 2 – Atmospheric staining and efflorescence observed on face brick pier, located at the exterior side of the office space between Rooms D and C.

Image 3 – View of plywood infill where existing louvers were noted to be present located adjacent to the entrance to Room C.

Image 4 – View of stained plywood sheets at clerestory soffit (red arrow), a condition generally observed at clerestory windows. Note: Similar looking Glasweld panels used in original construction (white arrow).

Image 5 – View of dislodged plywood soffit.

Image 6 – View of plywood sheet over existing louver at the exterior side of Room 7.

		
Image 7 – Hole in brick pier between clerestory and louver, indicated by red dashed circle.		Image 8 – View of missing fastener at vertical mullion between clerestory windows. Condition observed at several locations.
		
Image 9 – View of deteriorating perimeter sealant located at the exterior side of Room 26.		Image 10 – View of displaced flashing and failed sealants located at the exterior side of Room 26.

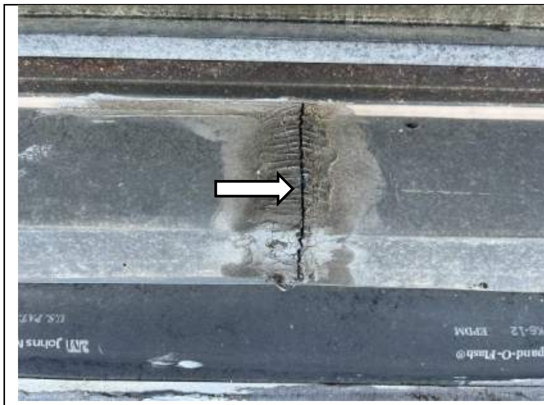


Image 11 – View of failed lap seam weld at sill flashing located beneath clerestory window. Note: Condition typical at all sill flashing joints.

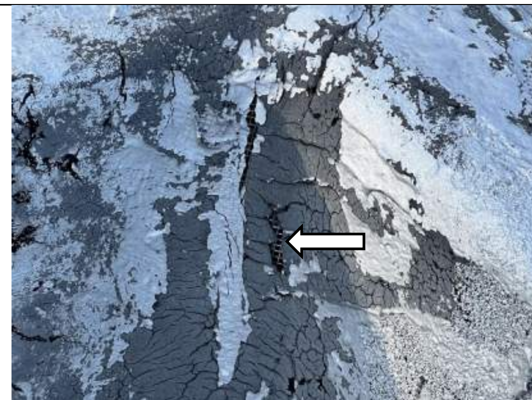


Image 12 – View of exposed reinforcing ply located at the roof above the western exit.

Image 13 – Representative view of failed window glazing gasket at Room S, the Nurse's Office.

Image 14 – View of missing glazing gasketing.

Image 15 – Partial south elevation view of Room N. New windows have been added since the original construction drawings did not indicate windows at these locations.

Image 16 – View of the exterior wall assembly from within the first-floor soffit. Note the spider webs and atmospheric staining between the metal roof deck and the infill extruded polystyrene insulation (EPS) insulation.

The following is a summary of Gale's observations of interior building enclosure related conditions at observed locations:

Gymnasium and Adjacent Spaces

- Step cracks observed at existing chases, piers, and masonry unit walls in the gymnasium space.
- Relative humidity within the gymnasium was generally recorded to be less than 30% at time of testing. It should be noted that dehumidifiers were running in the space prior to testing.
- In the Boy's Locker Room, the relative humidity was observed to be approximately 35%

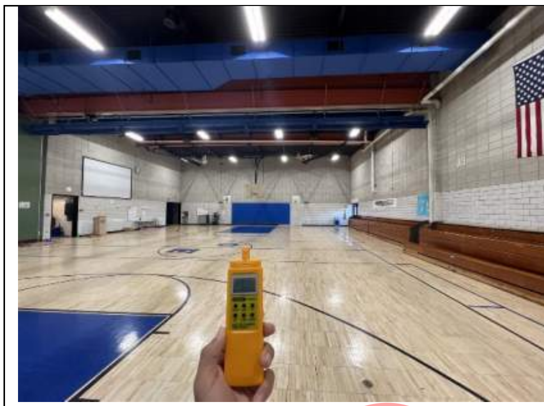


Image 17 – Overall interior view of the gymnasium. Relative humidity in the gymnasium was observed to under 30% prior to pressurization.

Image 18 – View of a vertical crack at interior wall chase in the gymnasium.

Image 19 – View of step cracking crossing both mortar joints and masonry units. Similar cracks were observed at other faces of interior walls in gymnasium.

Image 20 – Overall interior view of Gymnasium. Relative humidity in the Boy's Locker Room space was observed to be approximately 35% prior to pressurization.

Cafeteria and Adjacent Spaces

- The interior perimeter walls within the cafeteria space are generally composed of brick masonry extending upward to an acoustical dropped ceiling.
- At the stage space, a painted CMU wall extends upwards to the partially exposed steel roof deck.
- At Room N, a painted masonry unit wall leading to an acoustical dropped ceiling with the steel roof decking above was observed.
- Stained acoustical ceiling tiles in the existing dropped ceiling were observed in Room N.
- Step cracks at joints between and within the masonry unit wall at the Stage O space were observed.
- Formation of what appeared to be efflorescence was observed at the interior faces of masonry unit walls at the Stage O space.

Image 21 – Overall interior view of the cafeteria.

Image 22 – Relative humidity in the gymnasium was observed to be 21.0% prior to pressurization.

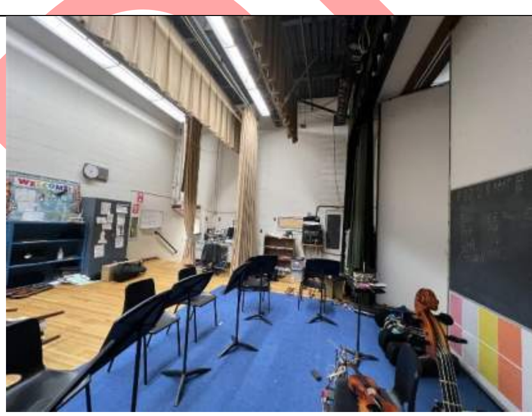


Image 23 – Partial view of the Stage O space.

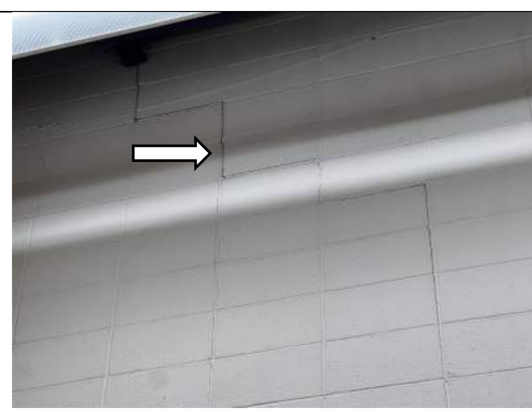
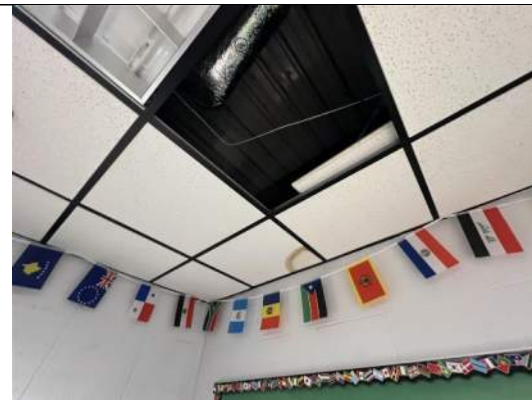


Image 24 – View of step crack at masonry unit joints in the Stage O space.

		
Image 25 – View of what appears to be efflorescence over existing masonry unit wall, located in the Stage O space.		Image 26 – View of stained dropped ceiling panel, located in Room N.

Classrooms

- Classrooms at the Oliver Ellsworth Elementary school generally consist of two (2) styles of construction. The first and most prevalent and known as the "Pods" that consist of groups of four (4) classrooms that are separated by movable partitions. The second are designed as typical construction with unit masonry walls separating each of the classroom spaces.
- The Pod classrooms include clerestory windows located along the ceiling-to-wall transition and steel-framed bulkheads located beneath the windows and suspended from the ceiling adjacent to the partition walls.
- The typical classrooms include punched window openings and fenestrations with casement-style operable windows.
- The classrooms observed included an acoustical ceiling grid that provides a buffer between the underside of the roof deck and the occupied space. A view within the ceiling plenums revealed the presence of EPS placed along the transition between the corrugated-metal roof deck and the unit masonry back-up wall. The insulation appeared to be sporadically adhered and joints between board sections and along the roof deck transition were observed to be unsealed.

Image 27 – Overall interior view of a Pod-style classroom with the clerestory windows along the ceiling line and a bulkhead below and along both side of the room.

Image 28 – Overall view of a typically constructed classroom with a punched-window opening.

Image 29 – A partial view of the roof-to-wall transition above the clerestory windows within the ceiling plenum of a Pod-style classroom. Note, the gap between the steel beam and the top of the infill wall, and EPS insulation installed at the roof-to-wall transition.

Image 30 – A partial view of the roof-to-wall transition within the ceiling plenum of a typical classroom. Note, EPS insulation at the roof-to-wall transition.

Field Testing Summary

As part of the air infiltration evaluation, Gale utilized door-mounted fan units to subject select interior spaces to both positive and negative pressure as a way to better highlight the functional performance of the space. Several acoustical ceiling tiles were relocated as required to achieve a pressure differential within the ceiling plenum, allow for the observation of above-ceiling conditions, and to perform the IR survey and smoke trace testing of suspected leak source path conditions. Additionally, the interior of the building was heated to approximately 70 °F to create a temperature differential that better highlights potential air leakage paths and thermal heat loss. During testing, there were several conditions encountered that were observed to potentially be factors contributing to air infiltration/exfiltration, which can be associated with elevated humidity levels previously reported within the school. The suspect conditions/area(s) generally observed to be leading contributors in air infiltration/exfiltration include roof-to-wall transitions, soffits, mechanical louvers, thermally inefficient fenestrations, penetrations in masonry walls, and infiltration paths at the window sill level of the clerestory windows.

The applied fan pressure differentials were documented to vary between each of the evaluated spaces, but generally exceeded +/-15 Pa at the time of testing. The inconsistency in achievable pressure differentials is likely tied to the overall amount of air leakage associated with each space. The purpose of performing the ASTM E1186, *Standard Practice for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems* test was to provide the client with qualitative information regarding potential air movement paths through the exterior enclosure. The number of fan units utilized for each of the test locations was generally dictated by the size of the space(s) tested and time restrictions. A testing configuration utilizing (1) fan was generally used for classrooms and office clusters as the three (3) fan testing configuration was used for larger spaces such as the gymnasium, cafeteria, and their adjacent contiguous spaces. The applied pressure differentials were also observed to be affected while the existing air intakes were running during testing.

While subjecting the cafeteria and adjacent spaces to positive and negative pressure differentials, Gale performed a thermographic infrared (IR) imaging survey from the interior and exterior of the space(s) respectively. Ahand-held IR camera and a DJI Mavic enterprise unmanned aerial vehicle (UAV) drone were used to provide video and infrared photographs of the localized exterior building enclosure conditions. During the application of a pressure differential within the space,, thermographic imaging revealed thermal anomalies occurring at the roof-to-metal fascia transitions, at soffits, and at the perimeters of the existing fenestrations. At the roof level, thermal anomalies were also observed occurring in the field of the roof around select existing roof drains, vent pipes, exhaust fans, and other mechanical equipment.

Gale recorded the interior humidity readings prior to and during the evaluation testing. Generally, relative humidity levels prior to testing were below 30% humidity with the highest readings attainted in the Gymnasium (29.1%) and Boy's Locker Room (35.3%) respectively, with the lowest readings recorded in classroom and office spaces(15.5% in Room E). It should be noted that dehumidifiers were typically in use at all occupied spaces during Gale's visit(s). Humidity levels were observed to generally decreased during testing with the greatest difference between start and conclusion of testing being in the Gymnasium with relative humidity decreasing to as low as 18.8%.

Gale systematically mobilized air leakage testing equipment between the spaces requested to be evaluated by the Owner. The intent of the testing scope is to provide all parties with infrared scanning and smoke trace testing results for each of the designated testing area(s) as per **Figure 4**.

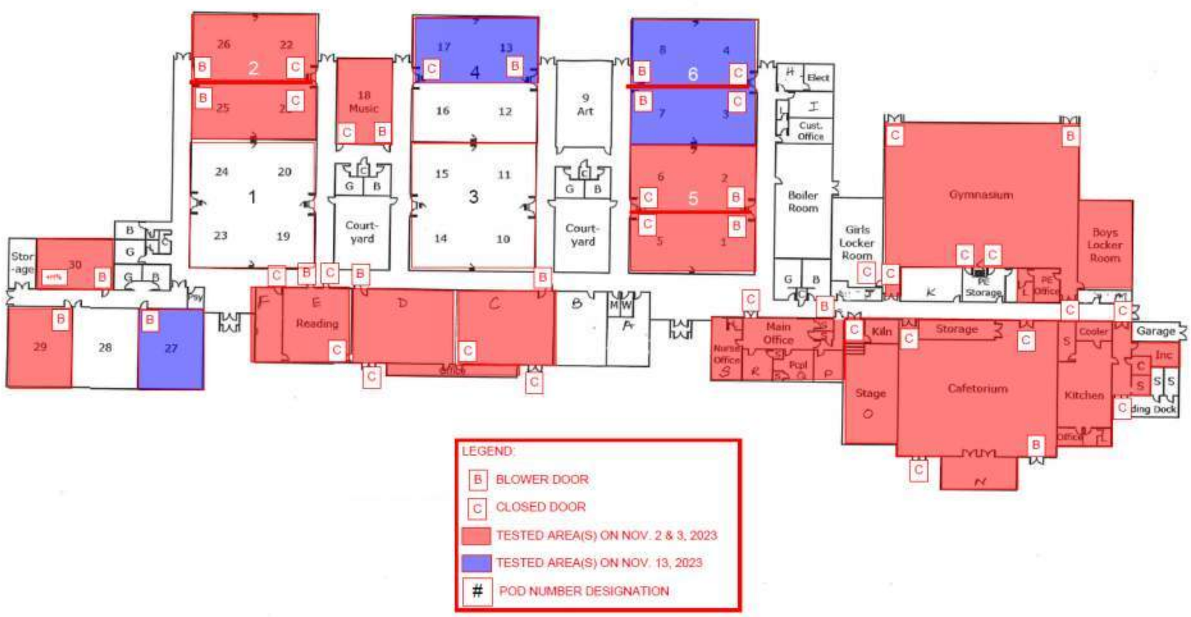


Figure 4: Redlined Room Designation Plan depicting testing areas. Classroom pods indicated by occupied grade level per the 1968 Drawings.

Gymnasium and Adjacent Spaces

The evaluation of the gymnasium included select adjacent spaces. Connectivity between adjoining spaces was achieved by propping the doors open to Room L, the PE office, and the Boy's Locker Room when the blower doors were placed at one (1) of the gymnasium exterior egress doors. The evaluation testing of the Gymnasium space incorporated the induction of both positive and negative pressure in the space(s).

As viewed from the interior while introducing the space to a negative pressure differential, infrared thermography was utilized to survey for evidence of air movement through the exterior building enclosure. Gale observed evidence of air permeating through existing step cracks and vertical expansion joints in the unit masonry walls, at electrical and plumbing penetrations through the exterior walls, and along the roof-to-wall transitions via infrared scanning.

A review of the exterior conditions, while subjecting the space to a positive pressure differential, revealed thermal anomalies appearing along the interface between the metal fascia panels and the roof edge metal, at soffits, around fenestration openings, and around several roof drains.

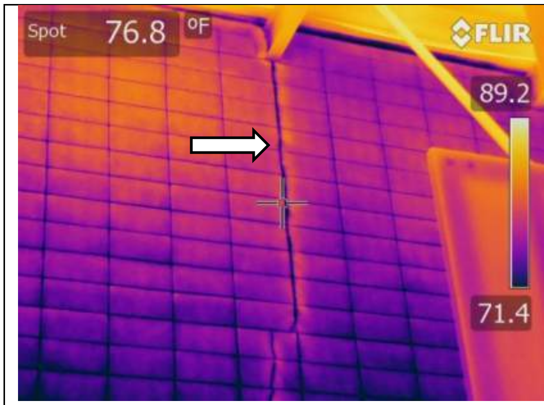


Image 31, Negative Pressure – Interior infrared image showing evidence of air infiltration at the vertical joint and step crack.

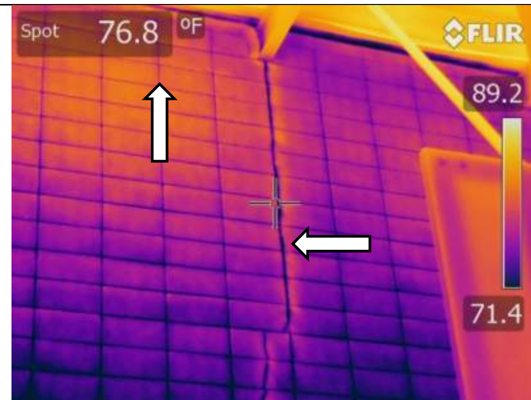


Image 32, Positive Pressure – Interior infrared image showing evidence of air exfiltrating at the vertical joint and roof to wall transitions.

Image 33, Negative Pressure – Interior infrared image showing evidence of air infiltration at the vertical joint and step crack.

Image 34, Negative Pressure – Interior infrared image depicting heat loss at roof drain penetrations as viewed from the interior. Thermal bridging and air infiltration at the steel beam and block wall were also noted.

Image 35, Negative Pressure – Interior infrared image depicting thermal loss and air infiltration at interior roof-to-wall transition.

Image 36, Negative Pressure – Interior infrared image depicting concentrated “cool” signatures at the transition from column chase-to-CMU wall at mortar joint locations.

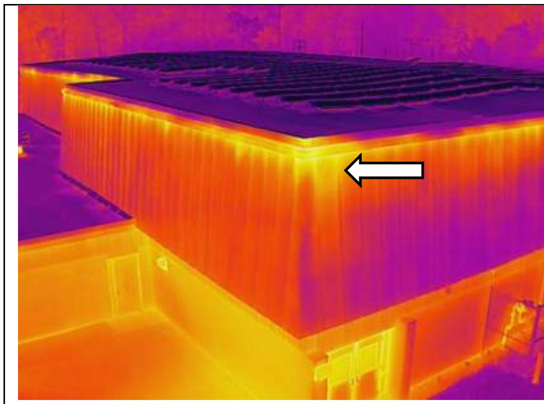


Image 37, Positive Pressure – IR view of what appears to be warm interior air exfiltrating at the roof-to-wall transition.

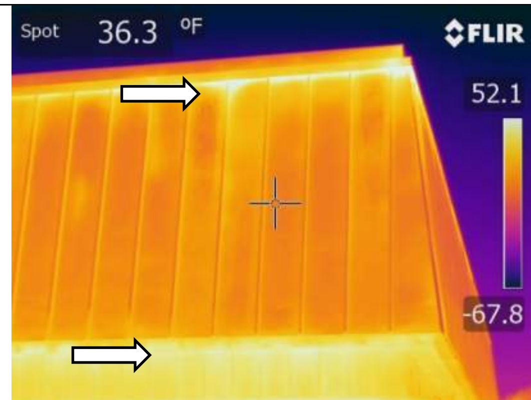
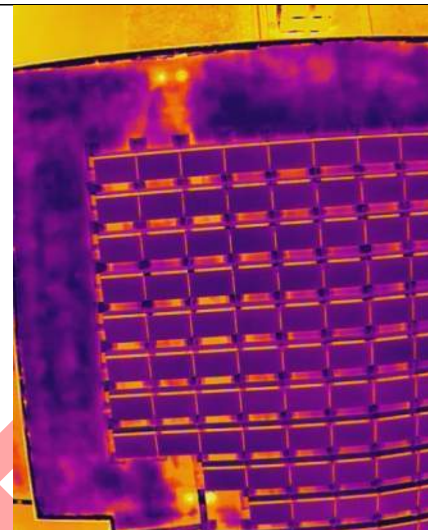


Image 38, Positive Pressure – IR view of what appears to be warm interior air exfiltrating at the roof-to-wall transition as well as the soffit.

Image 39 – Exterior infrared image illustrating air exfiltration along the soffit between the existing metal wall panel and metal fascia during the application of positive pressure. The brightest areas indicate the most air exfiltration.

Image 40, Positive Pressure – Exterior infrared image depicting thermal loss signatures at door perimeters during pressurization of the Gymnasium. The brightest areas indicate the most air exfiltration.

		
Image 41, Positive Pressure – Exterior infrared image depicting thermal loss signatures at door perimeters during pressurization of the Gymnasium. The brightest areas indicate the most air exfiltration.		Image 42, Positive Pressure – Representative view of heat signatures at the roof above the Gymnasium. Thermal anomalies were predominately visible at existing roof drains, sumps, and adjacent insulation crickets.

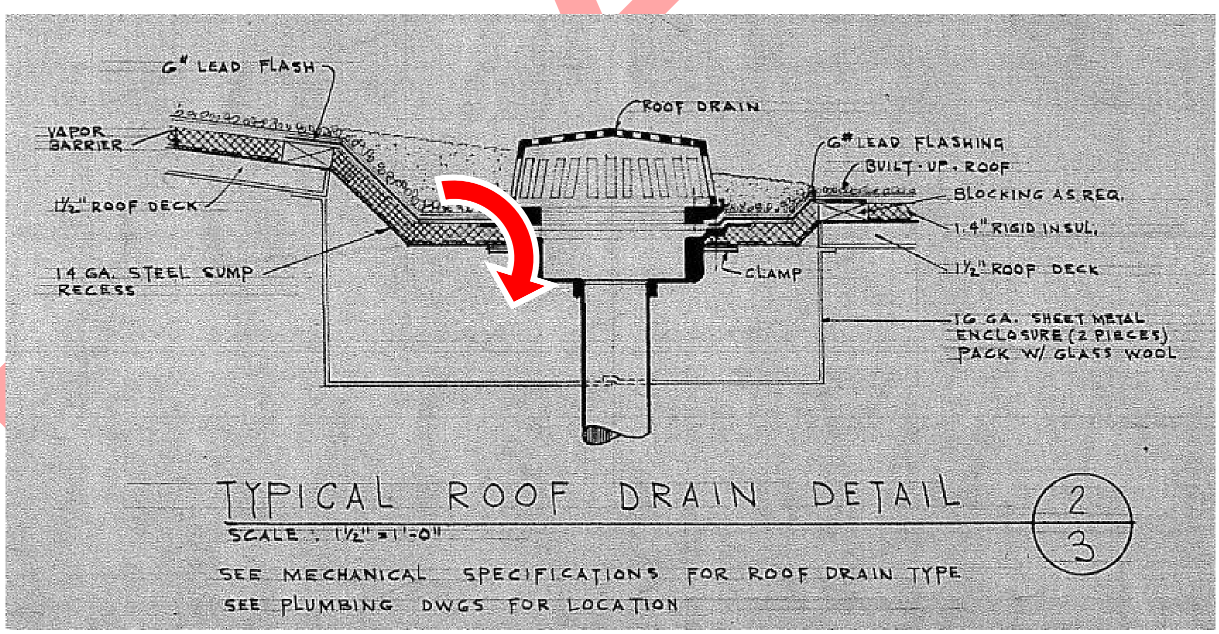


Figure 5: Typical roof drain detail. Taken from Detail 2/3 of the 1968 Drawings.

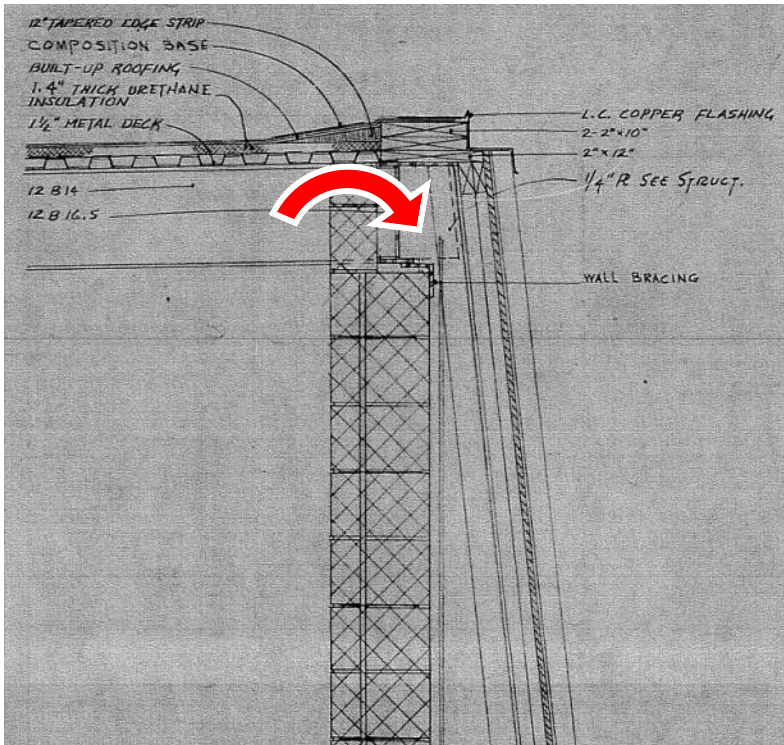


Figure 6: Roof-to-wall section detail. Typical at areas where metal fascia transitions to BUR roof, detail taken from Detail 3/13 of the 1968 Drawings.

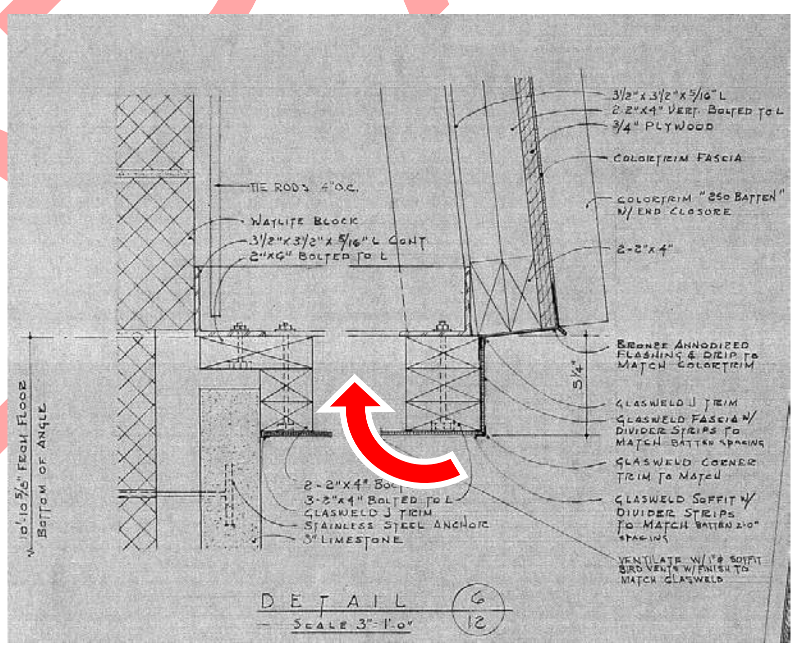


Figure 7: Soffit section detail. Typical construction at metal wall panel to metal fascia soffit transition. Detail taken from Detail 6/12 of the 1968 Drawings.

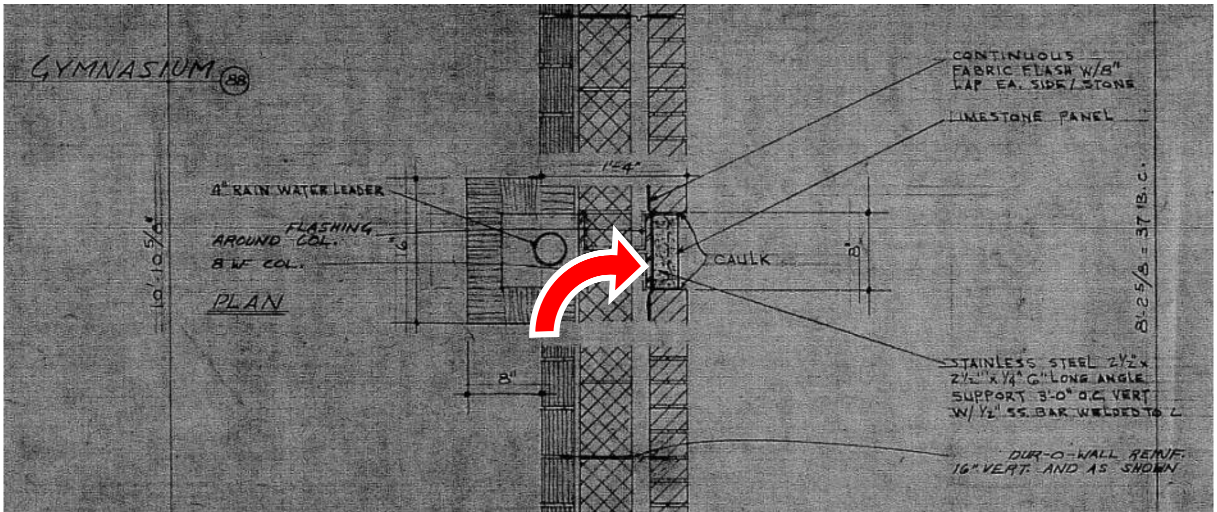


Figure 8**:** Plan view of column section at the Gymnasium.

Cafeteria and Adjacent Spaces

The evaluation of the Cafetorium included select, adjacent spaces. Connectivity between adjoining spaces was achieved by propping the doors open to the Stage area, Room N, Storage rooms, and the Kitchen when the blower doors were placed at one (1) of the exterior egress doors. The evaluation testing of the Cafetorium space incorporated the induction of both positive and negative pressure in the space(s).

As viewed from the interior while introducing the space to a negative pressure differential, infrared thermography was utilized to survey for evidence of air movement through the exterior building enclosure. Gale observed evidence of air permeating through existing step cracks in the unit masonry walls, around wall penetrations to the exterior, and along the roof-to-wall transitions.

A review of the exterior conditions while subjecting the space to a positive pressure differential revealed thermal anomalies appearing along the fascia-to-edge metal transition, soffits, fenestration, and existing drains at the roof. Heat signatures were generally noted to translate between interior and exterior spaces.

Windows in Room N, presumed not to have been part of original construction, were observed to allow significant air movement/heat loss between the existing unit masonry wall and the steel lintels at the window head. During (de)pressurization of the room, air movement was observed emanating from what is likely space between the existing lintel and CMU wall. Flags within the space above the window were observed to move back and forth in relation to air movement during the pressurization and depressurization of the space.

Image 43, Negative Pressure – Interior infrared view of pipe penetration. Evidence of air movement at the penetration.

Image 44, Negative Pressure – Interior infrared view of cold signatures.

Image 45, Negative Pressure – Interior infrared image of cold signatures at the corner transition between the interior chase and masonry wall observed.

Image 46, Negative Pressure – Interior infrared image of cold signatures concentrated at the top corner of an exit door while negative pressure was applied at the interior.

Image 47, Negative Pressure – Interior infrared image taken during application of negative pressure of the fire extinguisher cabinet. Cold air signatures are present at the perimeter of the cabinet.

Image 48, Positive Pressure – Exterior infrared image of heat signatures along the head of a window unit in Room N while positive pressure was applied at the interior. This condition is typical at both windows in Room N.

Image 49, Positive Pressure – Exterior infrared image of heat signatures concentrated at joints between window sashes while positive pressure was applied at the interior, a typical condition observed at both windows located in Room N.

Image 50, Positive Pressure – Exterior infrared image of heat signatures concentrated at the limestone chase at Room N while positive pressure was applied at the interior.

Image 51, Positive Pressure – Interior view of heat signatures concentrated at an existing step crack located within the Stage O space. Note, similar conditions observed at existing cracks.

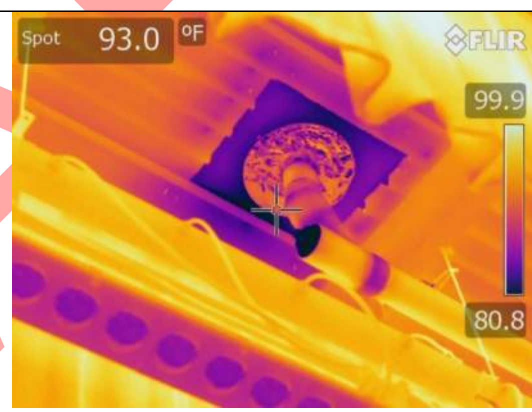
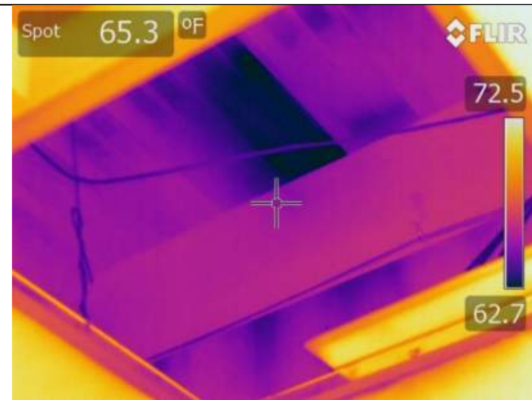


Image 52, Negative Pressure – Representative infrared image of drain sump heat signature. Generally, drain sumps were observed to be point(s) of heat loss.

		
Image 53, Negative Pressure – Infrared image of cold signatures between dropped-ceiling panel joints in Room N during the application of negative pressure.		Image 54, Negative Pressure – Infrared image of cold signatures in Room N, above the dropped ceiling.
		
Image 55, Negative Pressure – Infrared image of thermal anomalies occurring around the window perimeter within Room N.		Image 56, Negative Pressure – Infrared image of thermal anomalies occurring at the head of the window assembly within Room N.

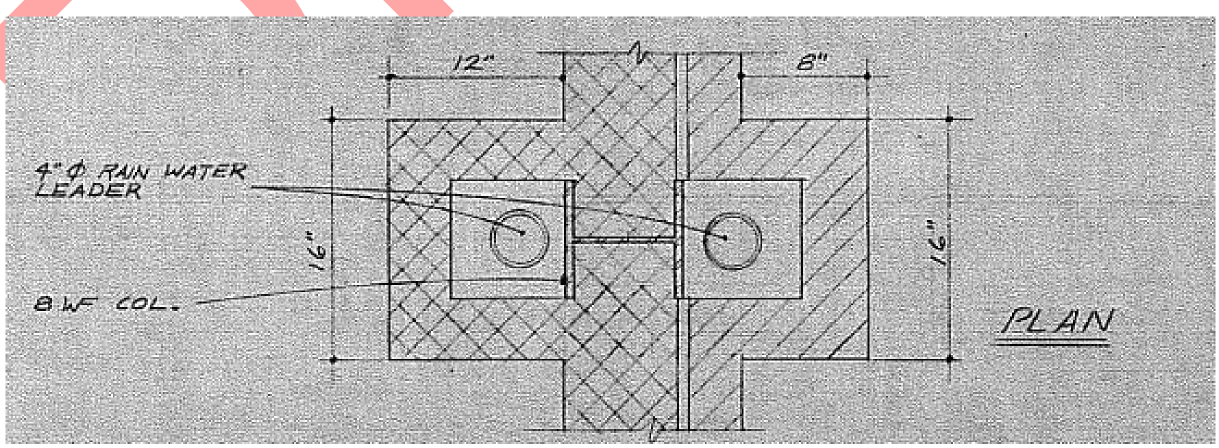


Figure 9: Plan view of chase section at the Cafeteria. Detail taken from 2/12 of the 1968 Drawings.

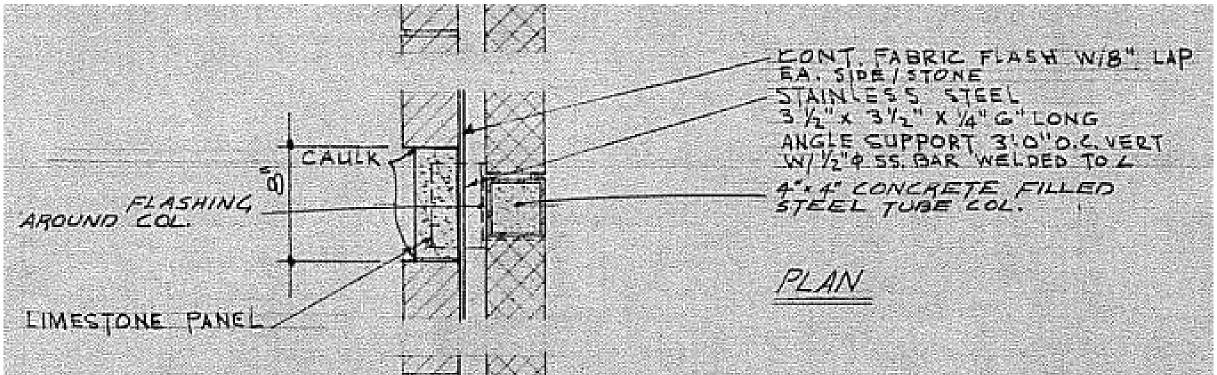


Figure 10: Plan view of chase section Room N. Detail taken from 1/12 of the 1968 Drawings.

Main Office and Adjacent Offices

The evaluation of the Main Office included select, adjacent spaces. Connectivity between adjoining spaces was achieved by propping the doors open to the Principals Office, the Nurse Office, Room R, and Room P when the blower door was placed with the doorway to the main corridor that is located adjacent to Room P. The evaluation testing of the Office space area incorporated the induction of both positive and negative pressure in the space(s).

As viewed from the interior while introducing the space to a negative pressure differential, infrared thermography and tracer smoke were utilized to survey for evidence of air movement through the exterior building enclosure. Gale observed evidence of air infiltration at the roof-to-wall transitions within the ceiling plenums, where EPS insulation boards had been installed, as well as evidence of unanticipated air movement around window assembly perimeters.

A review of the exterior conditions while subjecting the space to a positive pressure differential further revealed thermal anomalies. Concentrated heat signatures were observed between existing metal fascia and edge metal transitions. Elevated heat signatures were also noted at vent pipe penetration(s) on the roof

		
Image 57 – As viewed from within the ceiling plenum, EPS insulation had been installed		Image 58 – Negative Pressure – Representative infrared view of cold signatures at roof-to-wall transitions and wall joints.

Image 59, Negative Pressure – Representative infrared view of cold signatures at roof to wall transitions, wall joints, and at steel wall bracing.

Image 60, Negative Pressure – Infrared image of exterior facing interior wall on the west elevation. Cold signatures observed at wall penetrations and between existing EPS and CMU wall.

Image 61, Negative Pressure – Representative interior infrared image of cold signature(s) at windowsill.

Image 62, Positive Pressure – Exterior infrared image of office space(s) indicating heat signatures concentrated at roof-to-wall transitions and rooftop vent pipe.

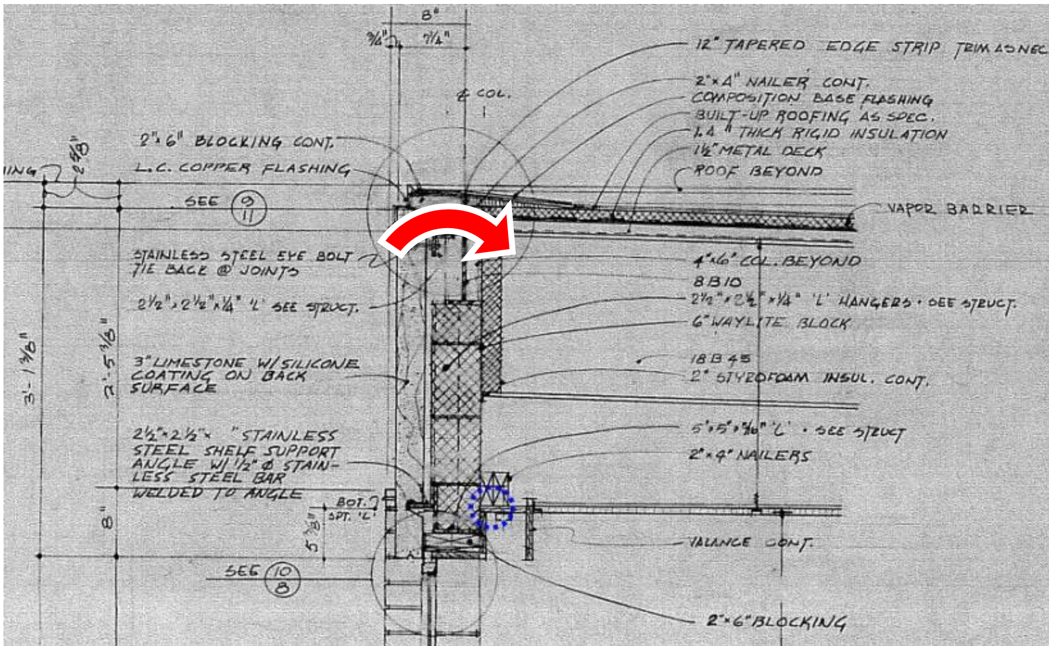


Figure 11: Typical window/wall section detail. Detail taken from 2/12 of the 1968 Drawings. Point of air infiltration during smoke testing indicated by blue dashed circle.

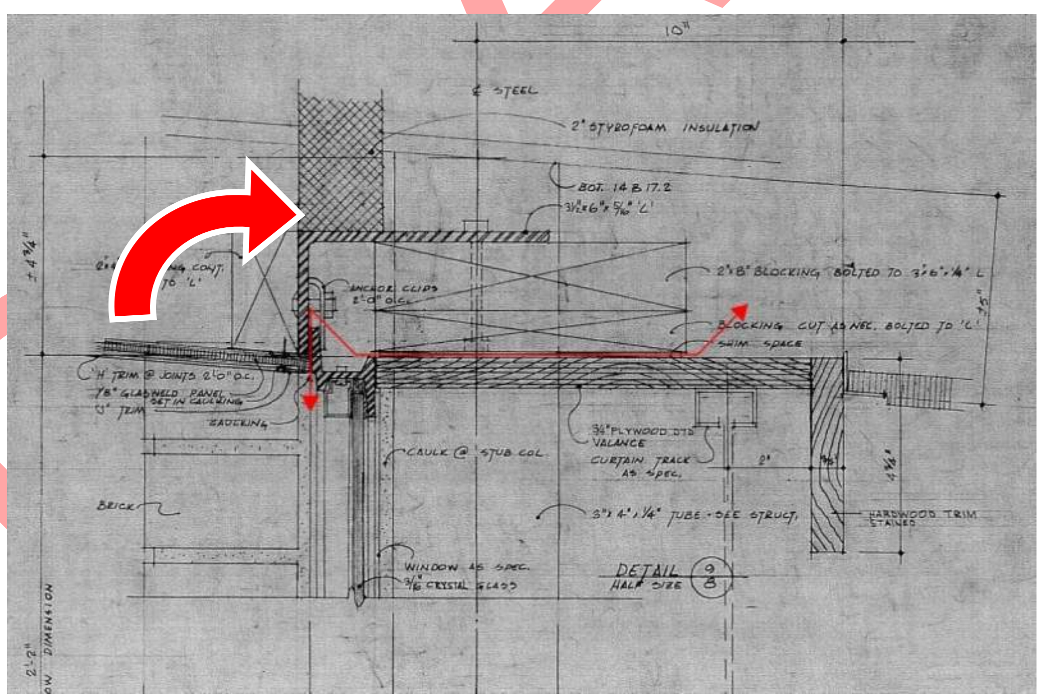


Figure 12: Typical window head section detail. Detail taken from 9/8 of the 1968 Drawings. Arrow indicating potential air infiltration path.

Pod #2, as indicated per Figure 4 (Rooms 21, 22, 25, and 26)

Due to interference with existing furnishings in place along the movable partition walls, evaluation testing in Pod #2 was divided into two (2) separate tests. Partition walls between Rooms 22 and 26 and Rooms 21 and 25 were partially opened to provide connectivity between adjacent spaces within the pod. The blower door was placed within the doorway to the corridor that is located adjacent to Room 25 and 26. The evaluation testing of the classrooms incorporated the induction of both positive and negative pressure in the space(s) while tracer smoke and infrared thermography were used to locate potential sources of air movement.

In Classroom 26, a previously created access hole through the drywall at the top of the bulkhead section that is located below the clerestory windows was found to provide a significant source of air movement into the classroom space. A view within the bulkheads appears to show connectivity between adjacent masonry pier walls as the space provides a chase for plumbing and electrical conduits.

Gale then mobilized smoke trace testing to the exterior side of the Room 22 clerestory window. Upon application of smoke to the base of the skirt flashing located beneath the existing lead-coated copper sill flashing, smoke was observed at the interior between the existing condensate gutter and stool. Smoke appeared to be exfiltrating from the joint between the stool and the windowsill frame.

Gale then mobilized blower door equipment for testing at Rooms 26 and 22. A blower door was set in place at the entrance to Room 25 and smoke trace testing was performed at the exterior side of Room 21. Upon application of smoke to the base of the skirt flashing at the sill, smoke was observed at the interior between the existing condensate gutter and stool.

		
Image 63 – View of testing pressure applied within Rooms 26 and 22 during testing. Approximately 11 Pa of positive pressure was applied using one (1) blower door fan.		Image 64 – View of relative humidity during testing at Rooms 26 and 22. Approximately 21.7% relative humidity shown.

Image 65, Negative Pressure – View of smoke infiltration testing in progress at the exterior. Note: Smoke observed at interior when applied to base of flashing beneath lead-coated copper sill flashing.

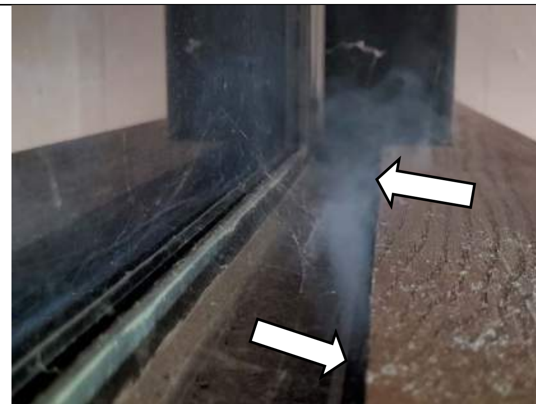


Image 66, Negative Pressure – Representative view of smoke infiltrating between the existing condensate gutter and stool, indicated by arrows.

Image 67, Negative – Evidence of air infiltration observed at the jamb of the window sash.

Image 68, Negative – Evidence of air infiltration observed at the sill of the clerestory windows.

Image 69 – Interior view of the bulkhead located beneath the clerestory windows in the Pod Classrooms.

Image 70 – View of the partially exposed masonry pier wall from within the bulkhead. Unsealed gaps between construction elements can provide a path for air movement through the exterior wall assembly.

Pod #4, as indicated per Figure 4 (Rooms 13 and 17)

Due to interference with existing furnishings in place along the movable partition walls, evaluation testing in Pod #4 was only performed on Rooms 13 and 17. Partition walls between Rooms 13 and 17 were partially opened to provide connectivity between adjacent spaces within the pod. The blower door was placed with the doorway to the corridor that is located adjacent to Room 13. The evaluation testing of the classrooms incorporated the induction of both positive and negative pressure in the space(s) while tracer smoke and infrared thermography were used to locate potential sources of air movement.

While introducing the space to a negative pressure differential of approximately 16Pa, Gale performed smoke trace testing directed at the exterior side of clerestory windows and found tracer smoke migrating through the window frame and appearing in the joint between the sill frame and the wood stool. Smoke tracer testing also helped identify the window sash frames as significant sources of air infiltration. Utilizing the infrared camera, Gale identified areas along the north (Playground) facing exterior unit masonry wall, where thermal anomalies appear to indicate substantial air infiltration occurring at the pier wall between Rooms 13 and 17 and along the roof-to-wall transition.

While introducing the space to a positive pressure differential, Gale utilized infrared thermography on the exterior side of the building to capture signs of air exfiltrating from window frames, the soffit condition, and from the tops of masonry piers.

Image 71 – Blower door fan unit installed within the doorway to Room 13.

Image 72 – Smoke tracer testing of the clerestory window perimeters.

Image 73 – Thermal anomalies observed occurring in the bulkhead and pier wall condition between classrooms.

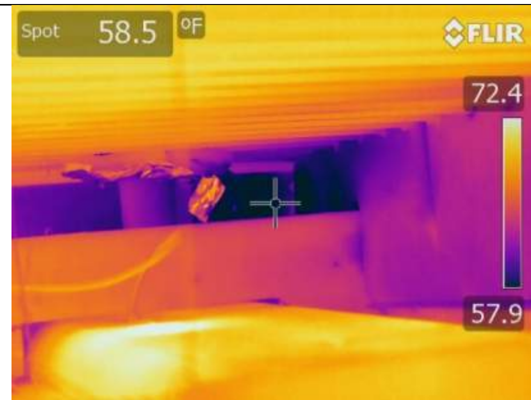


Image 74 – From within the ceiling plenum, the anomaly appears to originate from the exterior wall condition within the bulkhead.

Image 73 – Thermal anomalies observed occurring in the bulkhead and pier wall condition between classrooms.

Image 74 – From within the ceiling plenum, the anomaly appears to originate from the exterior wall condition within the bulkhead.

Pod #5 – as indicated per Figure 4 (Rooms 1, 2, 5, and 6)

Due to interference with existing furnishings in place along the movable partition walls, evaluation testing in Pod #5 was divided into two (2) separate tests. Partition walls between Rooms 1 and 5 and Rooms 2 and 6 were partially opened to provide connectivity between adjacent spaces within the pod. The blower door was placed within the doorway to the corridor that is located adjacent to Rooms 1 and 2. The evaluation testing of the classrooms incorporated the induction of both positive and negative pressure in the space(s) while tracer smoke and infrared thermography were used to locate potential sources of air movement.

Infrared thermography and tracer smoke were utilized to survey for evidence of air movement through the exterior building enclosure while introducing the space to a negative pressure differential. With the aid of infrared thermography, Gale observed evidence of air infiltration within the ceiling plenums. The process also identified areas around window glazing and the HVAC unit as potential source paths.

A review of the exterior conditions while subjecting the space to a positive pressure differential revealed thermal anomalies occurring along the soffits and at window perimeters.

Image 77 – View of testing pressure applied within Rooms 2 and 6 during testing. Approximately 13 Pa of negative pressure was applied using one (1) blower door fan.

Image 78 – View of relative humidity during testing at Rooms 2 and 6. Approximately 19.0% relative humidity shown.

Image 79, Negative Pressure – Representative image of smoke trace testing in Rooms 2 and 6. Direction of smoke indicated by white arrows.

Image 80, Negative Pressure – Infrared image of unit ventilator within classroom space. Darker "cold" spots indicate areas where unconditioned air is being drawn into the space.

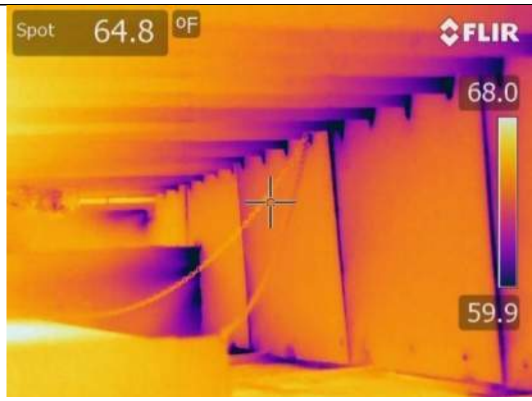


Image 81, Negative Pressure – Infrared images showing evidence of air infiltration occurring around the EPS insulation infill.	Image 82, Negative Pressure – Infrared image showing evidence of air infiltration at window sash perimeters.

Pod #6, as indicated per Figure 4 (Rooms 3, 4, 7, and 8)

Due to interference with existing furnishings in place along the movable partition walls, evaluation testing in Pod #6 was divided into two (2) separate tests. Partition walls between Rooms 3 and 7 and Rooms 4 and 8 were partially opened to provide connectivity between adjacent spaces within the pod. The blower door was placed within the doorway to the corridor that is located adjacent to Rooms 7 and 8. The evaluation testing of the classrooms incorporated the induction of both positive and negative pressure in the space(s) while tracer smoke and infrared thermography were used to locate potential sources of air movement.

As part of the evaluation of Classrooms 4 and 8, Gale installed plastic sheeting to temporarily isolate the windows, louver opening, and sill flashings associated with the classroom. The layers of isolation plastic were systematically removed to gauge an order-of-magnitude regarding the contributing sources of air infiltration. Despite isolating several potentially significant sources of air movement through the exterior enclosure, Gale was only able to achieve a pressure differential of approximately 26 Pa across both classrooms. The results may indicate that uncontrolled air movement is occurring due to unseen conditions that are providing a path for uncontrolled air movement. Following the removal of the temporary isolation, Gale performed additional smoke tracer testing and found similar typical results where tracer smoke was being drawn into the building through window perimeters, sill flashings, and louver openings.

Gale then mobilized blower door equipment for testing at Rooms 3 and 7 setting the fan apparatus in the entrance to Room 7 and smoke trace testing was performed at the exterior side of room. While under a negative pressure differential, Gale observed a significant amount of air infiltration emanating from the masonry unit pier wall that contains the HVAC louver ducts. A view from within the HVAC plenum space confirms the lack of insulation or air barrier considerations.

Within the ceiling plenum above the clerestory windows, Gale proceeded to remove a portion of the EPS insulation installed between the metal roof deck and the window head. The access provided a view within the built-out soffit and confirmed the lack of an effective air barrier solution. Unconditioned air infiltrating the soffit has the potential to bypass the insulation and enter the ceiling plenum.

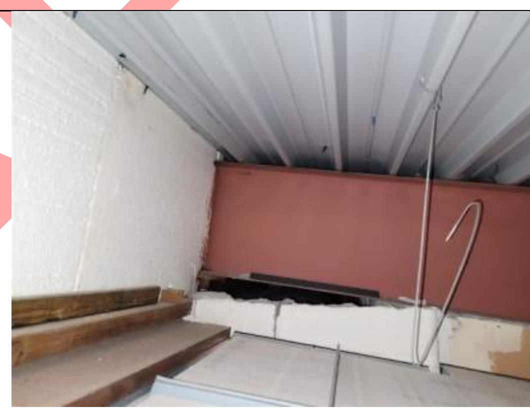
		
Image 83 – Plastic sheeting was install to provide temporary isolation to suspected air leakage source paths.		Image 84 – Tracer smoke observed being drawn into the building through the clerestory window frame.
		
Image 85 – Partial view of the area within Room 7 where access to the pier wall and soffit condition were attained.		Image 86 – Gaps between the steel roof deck, the structural steel membrane, and the top of the pier wall can provide a path for air movement.

		
Image 87 – Partial view into the pier wall that contains the HVAC ducts.		Image 88 – The pier wall space appears to provide connectivity between interior spaces through the roof deck flutes and over the top of partition walls.
		
Image 89 – Area where the EPS insulation was removed to provide a view into the soffit condition. Gale reinstalled the insulation at the conclusion of the evaluation.		Image 90 – Partial view within the built-out soffit located above the clerestory window assemblies.

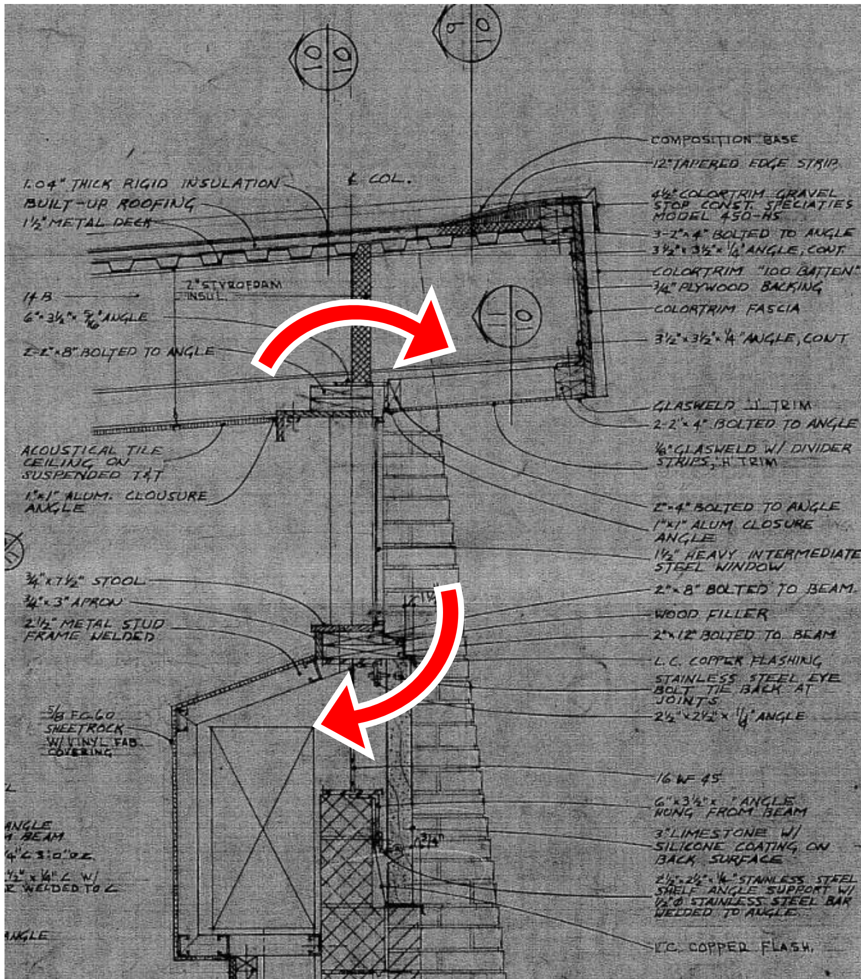


***Figure 13*:** Exterior facing wall section at Room 26. Section referenced from Detail 5/10 of the 1968 Drawings.

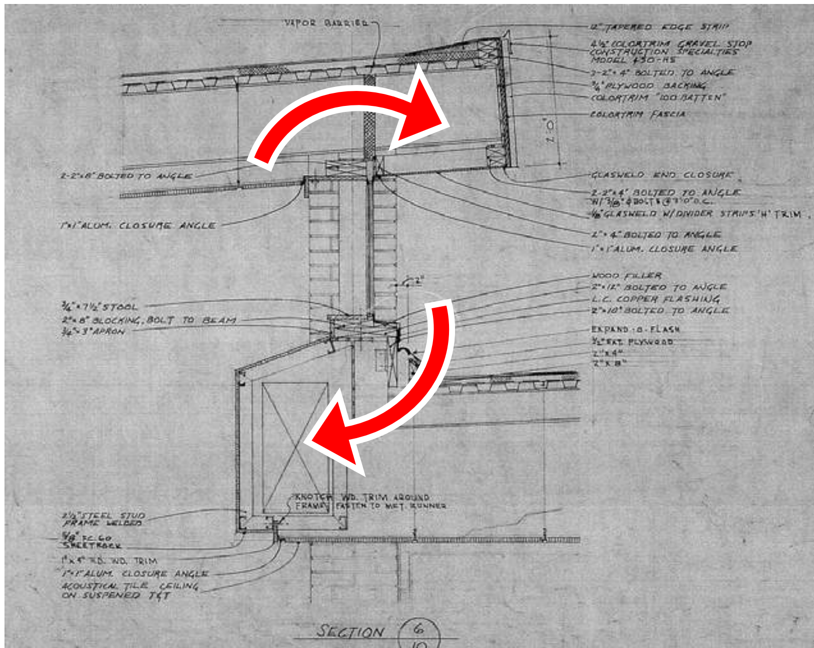


Figure 14: Clerestory window section. Taken from Detail 6/10 of the 1968 Drawings.

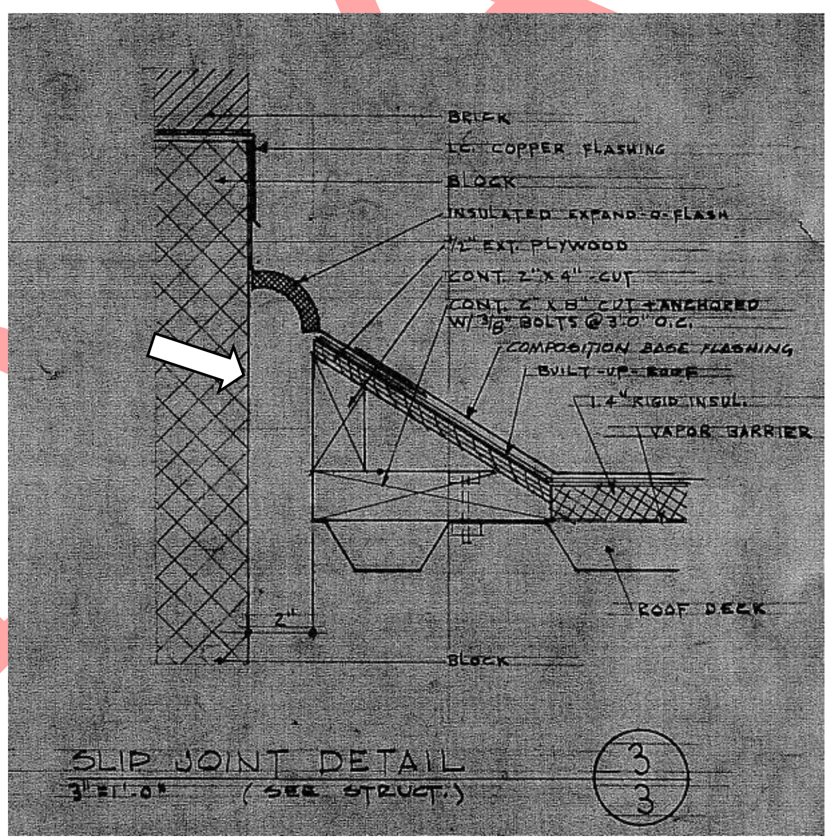


Figure 15: Typical slip/expansion joint detail. Taken from Detail 3/3 of the 1968 Drawings. Potential open interstitial space indicated by arrow.

Room 18

Gale mobilized to Room 18 and set blower door equipment up at the eastern entrance to the room. The evaluation testing of the Room 18 incorporated the induction of both positive and negative pressure in the space while smoke trace testing and an infrared survey were performed. During smoke trace testing and while the space was under a negative pressure, smoke was observed to be infiltrating between the window sash and frame, this observation is typical along the sill and corners of the windows at the windowsill level. During infrared scanning, cold signatures were observed emanating from behind the EPS insulation infills at the roof deck-to-exterior wall transitions.

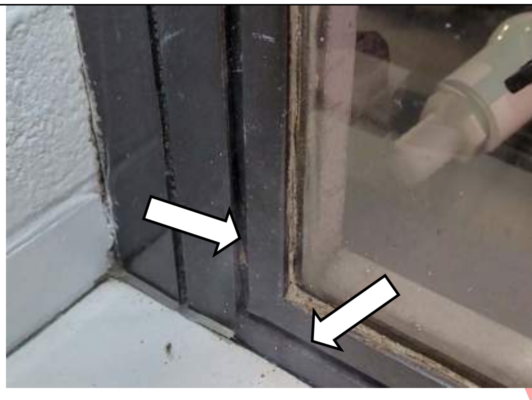


Image 91, Negative Pressure – View of smoke infiltration testing at the interior in progress. Smoke was observed to infiltrate between window frame and sash indicated by arrows.		Image 92, Negative Pressure – Infrared image of roof deck-to-wall interface located above the dropped ceiling in Room 18. Thermal anomalies appear at the transition between the roof deck and the EPS insulation infills.

Rooms E and F

The evaluation of Rooms E and F was performed by creating connectivity between the spaces by propping the doors open between the spaces while the blower door fan unit was placed within the Room E doorway to the main corridor. The evaluation testing of the spaces incorporated the induction of both positive and negative pressure in the space(s).

As viewed from the interior while introducing the space to a negative pressure differential, infrared thermography and tracer smoke were utilized to survey for evidence of air movement through the exterior building enclosure. Gale observed evidence of air infiltration at the acoustical ceiling-to-exterior wall transitions as well as evidence of unanticipated air movement around the window assembly perimeters. Cold signatures were also observed at masonry piers between Rooms D and E.

A review of the exterior conditions while subjecting the space to a positive pressure differential further revealed thermal anomalies between the metal fascia and roof edge metal transitions.

Image 93, Negative Pressure – Representative view of cold signatures at the corner(s) of window unit in Room E.

Image 94, Negative Pressure – View of smoke trace testing in progress at the interior. Smoke observed infiltrating between window sash and frame, observation typical along the sill and corners of windows at the sill level.

Image 95, Negative Pressure – Cold signatures observed at the interior pier/column between Rooms E and D.

Image 96, Negative Pressure – Cold signatures observed between existing EPS insulation and the roof deck.

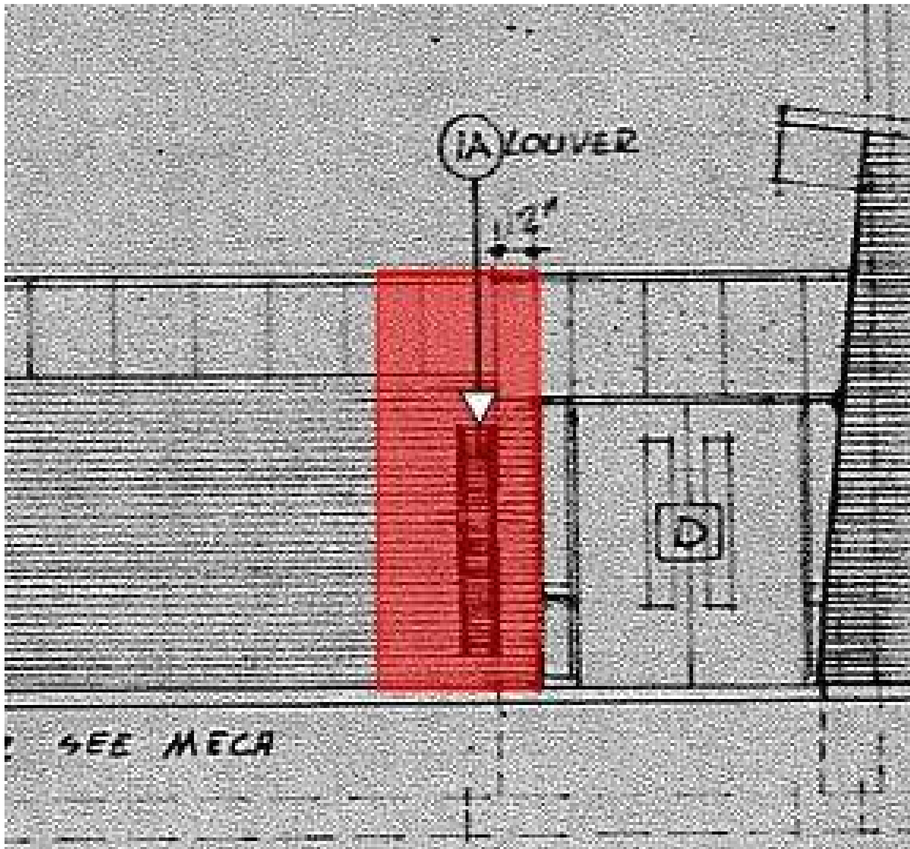


Figure 16: Exterior elevation between Rooms D and E. The approximate area of masonry pier indicated by red shaded area.

Rooms D and Office

The evaluation of Room D and the Office was performed by creating connectivity between the spaces by propping the door open between the spaces while the blower door fan unit was placed within the Room D doorway to the main corridor. The evaluation testing of the spaces incorporated the induction of both positive and negative pressure in the space(s).

As viewed from the interior while introducing the space to a negative pressure differential, infrared thermography and tracer smoke were utilized to survey for evidence of air movement through the exterior building enclosure. Gale observed evidence of air infiltration at the acoustical ceiling-to-exterior wall transitions as well as from behind wall-mounted cabinets and décor.

The acoustical ceiling tile located adjacent to the exterior egress door was relocated to provide a view of the underside of the roof deck. As is typical around most of the building perimeter, EPS insulation had been installed between the top of the wall/door head and the underside of the roof deck. Several steel angles were observed to pass through the insulation board and the gaps were filled with fiberglass batt insulation. The batt insulation was also observed to have been installed at the joint between the underside of the metal roof deck and the insulation board infill. Although the batt insulation may provide thermal value, the installation is not considered to be an air barrier.

A review of the exterior conditions while subjecting the space to a positive pressure differential further revealed thermal anomalies between the metal fascia and roof edge metal transitions. Thermographic images also provide visual confirmation of air leakage from the perimeter of the egress door.

Image 97, Negative Pressure – Infrared image of cold signatures occurring at column piers, along the roof-to wall-transition and from behind a bulkhead.

Image 98, Negative Pressure – Infrared image of cold signatures along the ceiling-to-wall transition and from behind wall-mounted cabinetry.

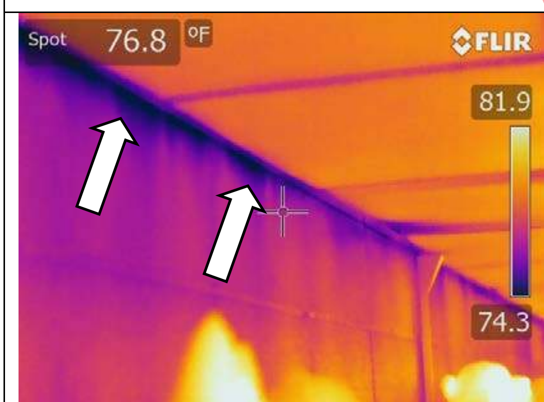


Image 99, Negative Pressure – Infrared image of cold signatures predominately emanating from behind the existing curtain valance, at the existing window, and behind existing cabinet in the office space between Rooms D and C.

Image 100, Negative Pressure – Infrared image of cold signatures emanating between the dropped ceiling and CMU wall in the office space between Room D and C.

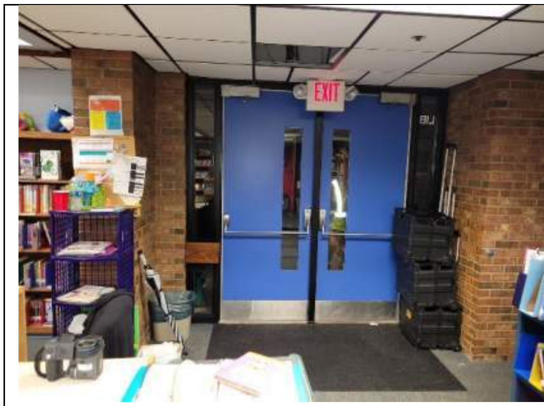


Image 101 – With a ceiling tile removed, Gale was able to review the existing conditions above the door head.		Image 102 – The discoloration of the batt insulation is an indicator of air movement through the material.

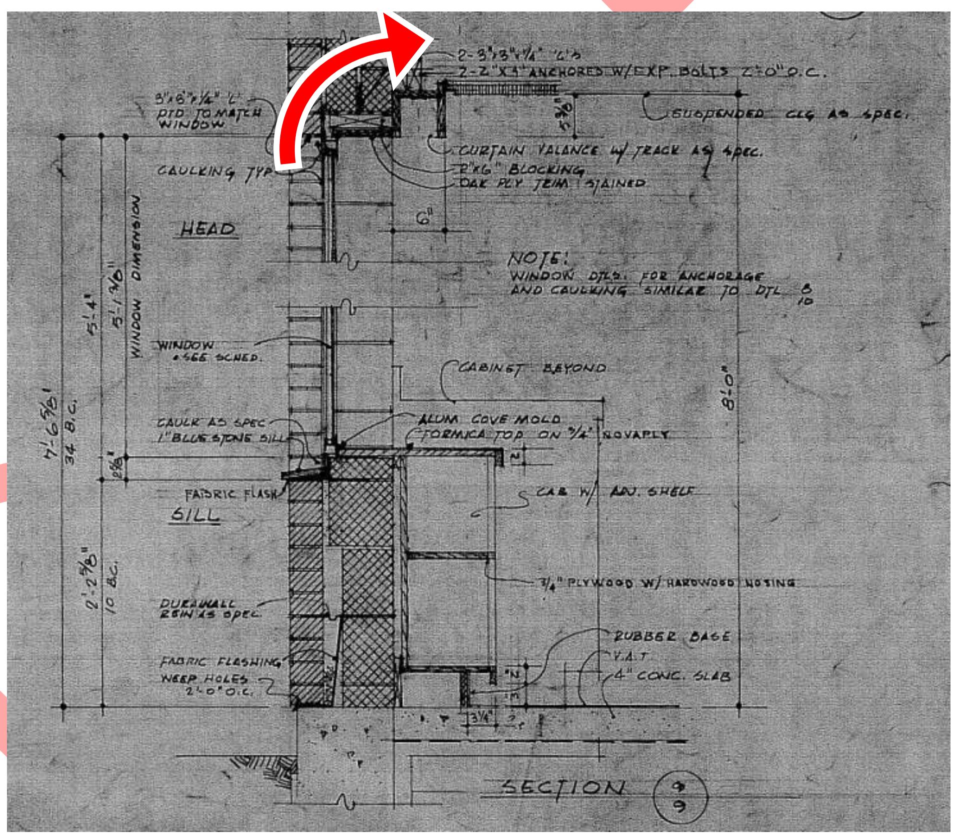


Figure 17: Wall section at office area between Rooms D and C. Section referenced from Detail 9/9 of the 1968 Drawings.

Room C

Gale mobilized to Room C and set the blower door fan unit within the doorway to the main corridor. The evaluation testing of Room C incorporated the induction of both positive and negative pressure in the space while smoke trace testing and an infrared survey were performed. Doors to the adjacent office space and Room B were closed to isolate the pressurization of the space. Applying pressurization of the space, thermal anomalies were observed along the top edge of the exterior entrance doorway and along the transition between metal wall panels (MWP) and roof edge metal. It should be noted that heat signatures between existing MWP and edge metal and along the head of window(s) were also observed at the adjacent Room B space. The door between spaces was noted to remain closed during testing.

Image 103, Positive Pressure – Infrared image at the exterior side of Room C. Concentrated heat signature along the top edge of the entrance to Room C.

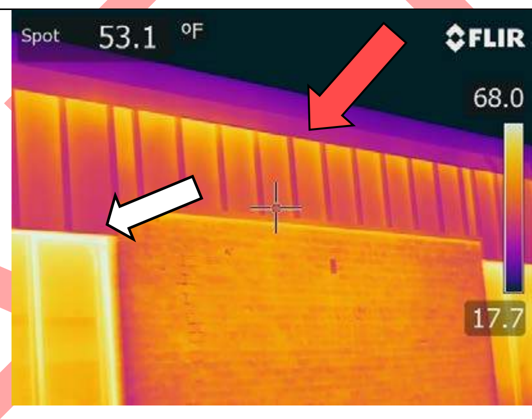


Image 104 – Infrared image at the exterior side of Room B. Traces of heat signatures at transition between metal wall panel and edge metal and at the head of existing window(s), indicated by red and white arrows, respectively.

Image 105, Negative Pressure – Infrared image at the interior side of Room C beneath clerestory window(s). Cold signatures observed at corner between brick pier and exterior facing CMU wall.

Image 106, Negative Pressure – Non-infrared view of interior side of Room C beneath the clerestory window(s).

Room 27

Gale's mobilization to Room 27 and had the blower door fan unit set within the doorway to the main corridor. The exterior side of the louver that supplies the forced air heating unit and the interior exhaust louver were temporarily isolated with plastic sheeting to get a better understanding of the potential amount of air passing through the system. The space was then negatively pressurized and the flow rate and pressure with the space were monitored while the plastic was in place and again after removal. Gale found an additional nearly 1000 cfm increase in air flow into the space while being subjected to an approximate negative 50 Pa pressure differential. This value is significant when considering that it took roughly 3165 CFM to create a 50 Pa pressure difference in the space with the sheeting installed. This amounts to roughly 1/3 of the total air flow needed to achieve a negative 50 Pa pressure difference in the entire room.

Smoke trace testing was also performed from the exterior resulting in smoke passing to the interior and appearing to infiltrate around the operable sashes and predominantly along the sill of the punched window opening. The infrared survey of the interior conditions also revealed typical air infiltration occurring along the EPS infill and metal roof deck interfaces.

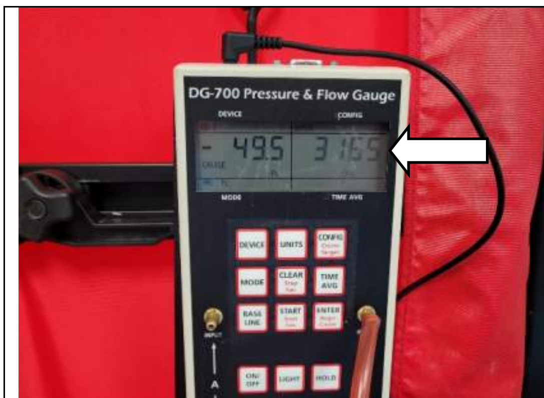


Image 107 – With isolation sheeting installed, an air flow rate of 3165 CFM is required to create a -50 Pa pressure difference within the classroom space.		Image 108 – With isolation sheeting removed, an air flow rate of 4155 CFM is required to create a -50 Pa pressure difference within the classroom space.

Image 109, Negative Pressure – Smoke tracer testing directed at the windowsill.

Image 110, Negative Pressure – Smoke tracer observed passing through the window sash-to-frame transition.

Room 29

Gale mobilized to Room 29 and set the blower door fan unit within the doorway to the main corridor. The evaluation testing of Room 29 incorporated the induction of both positive and negative pressure in the space while smoke trace testing and an infrared survey were performed. Applying pressurization within the space, thermal anomalies were observed along the metal roof deck to EPS insulation infill interfaces and well as an undetermined source located in the southwest corner of the room.

Smoke trace testing was performed at the exterior. Smoke at the interior was observed infiltrating at joint(s) between window sash and frame, typically at the windowsill level. Infrared scanning was performed in the space and revealed cold signatures at the exterior corner of the room and along wall to deck transitions.

Image 111, Negative Pressure – View of smoke trace testing in progress at the exterior. Smoke observed infiltrating at the interior during application of smoke along sill.

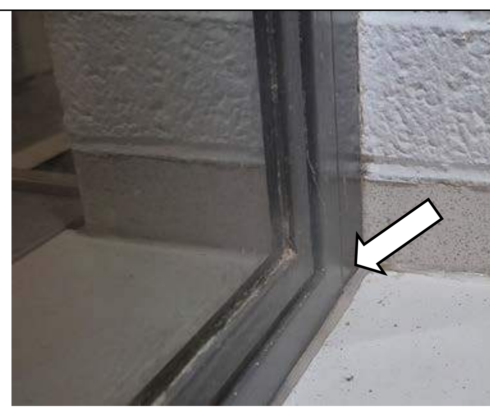


Image 112, Negative Pressure –Smoke observed infiltrating between window sash and frame, observation typical along the sill and corners of windows at the sill level.

Image 113, Negative Pressure – Cold signature at the exterior corner of Room 29.

Image 114, Negative Pressure – Infrared image of cold signatures at interior roof deck-to-wall transition.

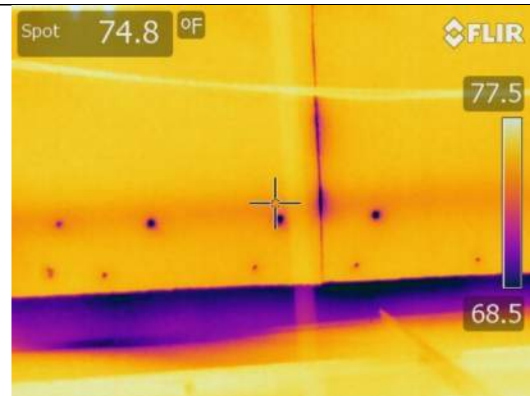
Room 30

Gale mobilized to Room 30 and set the blower door fan unit within the doorway to the main corridor. The evaluation testing of Room 30 incorporated the induction of both positive and negative pressure in the space while smoke trace testing and an infrared survey were performed. Applying a negative pressure differential within the space, thermal anomalies were observed along the metal roof deck to EPS insulation infill interfaces and well as an undetermined source located in the southwest corner of the room.

Smoke trace testing was performed at the exterior. Smoke at the interior was observed infiltrating at joint(s) between window sash and frame, typically at the windowsill level. Infrared scanning was performed in space and revealed thermal anomalies along wall to deck transitions.

Image 115 – View of pressurization within Room 30 during testing.

Image 116 – Stained mini blinds. Staining is more prominent on the middle shade located directly above the heating unit exhaust vent.

		
Image 117 – Exterior view of a window assembly within Room 30. Light from the interior could be seen shining through the louvers.		Image 118, Negative Pressure – Thermal anomalies occurring around the perimeter of the EPS insulation infills at the roof deck and between board sections.

Summary / Opinions

Interior moisture loading is affected by air infiltration more than by diffusion through building enclosure systems alone. Even a properly sized and effectively operating HVAC system that does not account for the actual amount of air infiltration allowed into or out of the building, will not produce the intended results for space conditioning. Treatment and correction of air leakage sources is required for the HVAC system to work efficiently and as intended. Note that there are other external effects that cause pressure differentials across the building enclosure including wind pressure and the stack effect (movement of air caused by the thermal differences between indoor and outdoor air).

Since this building was constructed in the late 1960's there was little effort to air seal and insulate the building. Over time, the exterior building enclosure systems have aged to a point where interior and exterior air can move past the building enclosure elements resulting in uncomfortable drafts or transport of moisture laden air. According to the laws of thermodynamics, warm air inherently will want to travel from areas of higher temperature to areas of cooler temperatures. In summer, during periods of high humidity, exterior air may be drawn into the building carrying excessive amounts of moisture, and during the winter, warm air from the interior will travel outward to cooler areas/surfaces. A word of caution during winter months, if there is a high humidity occupancy occurring, and air exfiltrates toward the cold envelope elements, there is the potential for condensation to form on those surfaces.

The partially vented, damaged, and discontinuous soffit conditions, HVAC louver chases, unsealed and uninsulated general and structural building enclosure penetrations such as beams/columns, drain leaders, and recessed fire extinguisher case(s), masonry chases, and cracks in masonry wall cavities located at exterior walls appear to be a contributors to air infiltration and thermal bridging at all spaces. As air bypasses the exterior cladding through deficiencies in the exterior wall, louvers, soffits and penetration, the porous masonry backup wall and penetrations through the backup wall can provide a path for air to enter the building. Thermal anomalies observed through infrared, during building pressurization indicated that air infiltration and thermal bridging occurs at these and similar areas. This is likely due to the existing cavity between interior and exterior wythes of masonry. It is recommended that penetrations through walls adjacent to the exterior be fully insulated and sealed to prevent air infiltration.

Roof-to-Wall Transitions

The roof-to-wall transition above ceilings appears to be a major contributor to the air infiltration/exfiltration noted at the school. It is Gale's opinion that air entering the exterior soffits has a nearly unrestricted path to enter the building through the acoustical ceiling plenum. The exterior wall assembly components by design do not include an air or substantial thermal barrier and generally rely on sealants, the concrete masonry units, and quality of construction to keep interior and exterior spaces separated. The Styrofoam EPS insulation infill is not classified as an air barrier and is doing little to combat air infiltration into the building. The discontinuous installation is also doing very little from a thermal insulation standpoint. Reconfiguration of the insulation and air sealing continuity strategy of below roof deck, the EPS closure, and the soffits is required. Consideration should be given to removing the soffit cladding, installing a continuous sheathing on the vertical wall sections between the top of the clerestory windows/backup wall up to the underside of the metal roof deck. An approved air barrier material should be installed over the sheathing infill and tied into the existing conditions above and below the insulation.

Summary of repair opinions: Reconfiguration of the insulation and air sealing continuity strategy between the bottom of roof deck, the EPS closure, and the exterior soffits.

Exterior Wall Penetrations

Penetrations into exterior walls are contributing the sources of air leakage due to unsealed perimeters and discontinuous backup wall. Gaps at perimeters of penetrations and windows create an air chase connection to the masonry cavity, which is uninsulated and does not incorporate an air barrier. Penetrations through masonry whether at interior or exterior wythes should be sealed.

Summary of repair opinions: Air seal an insulate penetrations through either interior or exterior brick / CMU masonry wythes.

Roof Drains, Vent Pipes, and other Roof Penetrations

Heat transfer was observed at drain sumps at both the interior and exterior sides of the building during infrared scanning. To reduce the effect of thermal bridging it is recommended that insulation be installed at and surrounding the drains below the roof deck. An air tightening method of interior surfaces to other roof penetrations should also be performed.

Summary of repair opinions: Insulate the drain bowls and surrounding roof deck.

Room N Windows

Thermal discontinuity and air infiltration was observed at window heads in Room N. These windows appear to not be original construction and were added after the completion of the building. It is recommended that the windows be further investigated for discontinuities in the sealing of the window perimeter, particularly at the window head and lintel conditions. Air tightness between the window and the back-up substrates must be achieved.

Summary of repair opinions: During window replacement, seal and insulate the window perimeters to the surrounding back-up construction.

Windows, Doors and Sealant Perimeters

Windows are minimally insulated, many are single-pane glazed, and were generally observed to have inconsistent and/or missing perimeter and glazing gaskets and sealants. Field testing identified windows as being a primary contributing source of air infiltration and thermal deficiencies. During smoke trace testing in classroom spaces, windows were observed to allow smoke to infiltrate, primarily between sash joints and window perimeters. Tracer smoke was observed to pass through the assembly as soon as smoke was applied. In Gale's opinion, thermally efficient double-glazed and properly sealed window perimeters that are tied to back-up substrates are a required upgrade to the existing building enclosure to reduce the effects of heat transfer and air infiltration. Air exfiltration was observed at most door astragals subject to pressurization. Review and replacement of door weatherstripping shall be considered.

Summary of repair opinions: During window replacement with thermally broken metal frames and insulated glazing units, seal and insulate the window perimeters to the surrounding back-up construction. Replace all window perimeter sealants between frames and brick masonry or other façade systems.

Roofing Expansion (Slip) Joint at Clerestory Windows

Prior to testing at Pod classroom spaces, there were reports by building occupant(s) of temperature fluctuations in conjunction with outside temperatures. During smoke trace testing there were two (2) conditions observed that resulted in visible air movement at the clerestory windows. At several rooms it was observed that, during the application of smoke to the base of skirt flashing at the exterior, smoke was observed emanating from between the existing interior condensate gutter and stool. According to the 1968 Drawings, an insulated "expand-o-flash" joint cover is detailed at the existing slip joint and is located beneath the lead-coated copper windowsill flashing. Construction beneath the existing skirt flashing was not observed, nor confirmed by Gale, and should be further explored to confirm construction. It is likely that this joint is allowing air circulating from within the roof system to enter the interior space. As part of the clerestory window replacement, the sill counterflashing and slip joint detail should be removed and replaced with a better insulated and airtight transition from windowsill to roofing system.

> Summary of repair opinions: Replace clerestory windows with thermally broken metal frames and insulated glazing units. Seal and insulate the window perimeters to the surrounding back-up construction. Replace windowsill flashing and related windowsill and roof flashings to create thermally more efficient and airtight transitions.

Roof System, Building Insulation and Building Air Barriers

As part of a full building enclosure renovation strategy, a wholistic approach of roof replacement that incorporates an air barrier and code-mandated insulation levels may be considered when the roof is nearing its intended service life, approximately 15 years from now. Areas of metal panel and brick masonry should be considered for full scale improvement, potentially including removal and replacement of the metal panels and perhaps over cladding of masonry areas with insulated and air-tight façade systems. It is also Gale's opinion that unconditioned air entering the duct chase can migrate through the building via unsealed deck flutes, the acoustical ceiling plenum as well as various partition walls.

We trust this information suits your needs at this time. Please do not hesitate to contact us if you require additional information regarding this matter.

Best regards,

GALE ASSOCIATES, INC.

Victor Mata
Staff Designer
Building Enclosure Consulting and Commissioning

Marc A. Loranger, P.E., LEED® AP, APT-RP
Sr. Associate / Partner

Enclosure:
- Appendix A – Order of Magnitude Cost Estimate

VRM/DAW/MAL:dlm

Appendix A

Preliminary Cost Estimate

GALE ASSOCIATES, INC.

ENGINEERING COST ESTIMATE

Facility Name	Oliver Elsworth School
Project Title:	Forensic Building Enclosure Evaluation
Design Phase:	Evaluation
Gale Project No.	977810
Date Prepared:	11/14/2023
Prepared by:	MAL
Checked by:	VRM
Date Updated:	11/17/2023
Total Sq Ft	n/a

Section #	Title	Material Cost	Labor Cost	Total
024119	Selective Structure Demolition	18,910.00	50,884.00	69,794.00
028216	Engineering Control of ACM	7,500.00	45,000.00	52,500.00
028313	Lead In Construction	0.00	21,000.00	21,000.00
040120	Maintenance of Unit Masonry	2,500.00	15,500.00	18,000.00
072200	Building Insulation	23,357.00	76,418.80	99,775.80
072419	Air/Vapor Barriers	21,660.00	25,543.00	47,203.00
075216	Modified Bituminous Membrane Roofing	37,840.00	77,680.00	115,520.00
076000	Flashing and Sheet Metal	3,600.00	9,120.00	12,720.00
079200	Joint Sealants	33,640.00	32,424.00	66,064.00
081100	Metal Doors and Frames	3,000.00	3,000.00	6,000.00
085101	Aluminum Windows and Glazing	329,500.00	185,300.00	514,800.00
	Division 1 General Requirements			146,511.70
	Subtotal			1,169,888.50
	15% Overhead and Profit			175,483.28
	Subtotal			1,345,371.78
	General Contractor Markup			201,805.77
	ESTIMATED CONSTRUCTION COST			1,547,177.54

Note: This cost estimate is based on the bidding climate anticipated at the time of document preparation and does not include escalation. The estimate is also prepared based on the assumption that the work will be competitively bid. Should bidding be limited to select contractors, actual costs may increase significantly with extreme fluctuations occurring in some instances.

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GALE ASSOCIATES, INC.

ENGINEERING COST ESTIMATE

Facility Name	Oliver Elsworth School	Gale Project No.	977810
Project Title:	Forensic Building Enclosure Evaluation	Date Prepared:	11/14/23
Design Phase:	Evaluation	Prepared by:	MAL
		Checked by:	VRM
		Date Updated:	11/17/23

Section #	Item Description	Quantity		Material Cost		Labor Cost		Combined	
024119	Selective Structure Demolition								
	Remove existing roof system (base of clerestories)	1,920	sf		0.00	1.45	2,784.00	1.45	2,784.00
	Dumpsters	3	ea	600.00	1,960.00		0.00	600.00	1,960.00
	Remove existing windows	226	ea	75.00	16,950.00	200.00	45,200.00	275.00	62,150.00
	SUBTOTAL	024119			18,910.00		50,884.00		69,794.00
028216	Engineering Control of ACM								
	Industrial Hygienist	6	wk		0.00	3,000.00	18,000.00	3,000.00	18,000.00
	Remove miscellaneous ACM materials	1	ls	4,500.00	4,500.00	24,000.00	24,000.00	28,500.00	28,500.00
	Landfill/hauling costs (estimated)	1	ls	3,000.00	3,000.00	3,000.00	3,000.00	6,000.00	6,000.00
	SUBTOTAL	028216			7,500.00		45,000.00		52,500.00
028313	Lead In Construction								
	Industrial Hygienist	6	wk		0.00	3,000.00	18,000.00	3,000.00	18,000.00
	Landfill/hauling costs (estimated)	1	ls		0.00	3,000.00	3,000.00	3,000.00	3,000.00
	SUBTOTAL	028313			0.00		21,000.00		21,000.00
040120	Maintenance of Unit Masonry								
	Brick masonry replacement (incidental)	1	ls	500.00	500.00	7,500.00	7,500.00	8,000.00	8,000.00
	CMU Gymnasium Cracks	1	ls	1,000.00	1,000.00	4,000.00	4,000.00	5,000.00	5,000.00
	CMU Cafeteria Cracks	1	ls	1,000.00	1,000.00	4,000.00	4,000.00	5,000.00	5,000.00
	SUBTOTAL	040120			2,500.00		15,500.00		18,000.00
072200	Building Insulation								
ClereStories	Remove and Replace Soffit Panels / Air Closure (Class)	1,104	sf	3.50	3,864.00	16.40	18,105.60	19.90	21,969.60
1st Floor Other	Remove and Replace Soffit Panels / Air Closure (Other)	1,128	sf	3.50	3,948.00	16.40	18,499.20	19.90	22,447.20
Gym and Café	Remove and Replace Soffit Panels / Air Closure (Other)	980	sf	3.50	3,430.00	16.40	16,072.00	19.90	19,502.00
Roof Drains	Insulate Roof Drains and Deck	1	ls	2,500.00	2,500.00	12,500.00	12,500.00	15,000.00	15,000.00
	Boom lift to access difficult areas	2	wk	2,800.00	5,600.00		0.00	2,800.00	5,600.00
	Scaffolding	3,212	sf	1.25	4,015.00	3.50	11,242.00	4.75	15,257.00
	SUBTOTAL	072200			23,357.00		76,418.80		99,775.80
072419	Air/Vapor Barriers								
ClereStories	Remove and Replace Soffit Panels / Air Closure (Class)	1,104	sf	3.75	4,140.00	3.75	4,140.00	7.50	8,280.00
1st Floor Other	Remove and Replace Soffit Panels / Air Closure (Other)	1,128	sf	3.75	4,230.00	5.75	6,486.00	9.50	10,716.00
Gym and Café	Remove and Replace Soffit Panels / Air Closure (Other)	980		3.75	3,675.00	3.75	3,675.00	7.50	7,350.00
	Boom lift to access difficult areas	2	wk	2,800.00	5,600.00		0.00	2,800.00	5,600.00
	Scaffolding	3,212	sf	1.25	4,015.00	3.50	11,242.00	4.75	15,257.00
	SUBTOTAL	072419			21,660.00		25,543.00		47,203.00
075216	Modified Bituminous Membrane Roofing								
HVAC Supports	Install 2-ply modified bitumen membrane system patches	2,000	sf	17.00	34,000.00	35.00	70,000.00	52.00	104,000.00
At Clerestory Base	Install SBS stripping membrane	1,920	lf	2.00	3,840.00	4.00	7,680.00	6.00	11,520.00
	SUBTOTAL	075216			37,840.00		77,680.00		115,520.00
076000	Flashing and Sheet Metal								
Base of Clerestory	Expansion joint cover	480	lf	7.50	3,600.00	19.00	9,120.00	26.50	12,720.00
	SUBTOTAL	076000			3,600.00		9,120.00		12,720.00
079200	Joint Sealants								
all window	Remove and replace sealant joint (Elev-15 ft or less)	3,816	lf	5.00	19,080.00	7.00	26,712.00	12.00	45,792.00
all door	Remove and replace sealant joint (Elev-15 to 50 ft)	672	lf	5.00	3,360.00	8.50	5,712.00	13.50	9,072.00
	Boom lift	4	wk	2,800.00	11,200.00		0.00	2,800.00	11,200.00
	SUBTOTAL	079200			33,640.00		32,424.00		66,064.00
081100	Metal Doors and Frames								
All Exterior Doors	Exterior Doors - weatherstripping update	24	ea	125.00	3,000.00	125.00	3,000.00	250.00	6,000.00
	SUBTOTAL	081100			3,000.00		3,000.00		6,000.00
085101	Aluminum Windows and Glazing								
all clerestory	Fixed windows (not greater than 3'x4')	104	ea	1,250.00	130,000.00	850.00	88,400.00	2,100.00	218,400.00
all others	Fixed windows (up to 4'x6')	114	ea	1,750.00	199,500.00	850.00	96,900.00	2,600.00	296,400.00
	SUBTOTAL	085101			329,500.00		185,300.00		514,800.00
	Division 1 General Conditions	Multiplier							
	Bonds, insurance, and warranty	0.03							30,701.30
	Interior protection	0.0065							6,651.95
	Mobilize and demobilize	0.027							27,631.17
	Submittal process	0.007							7,163.64
	Material storage and protection	0.007							7,163.64
	Superintendent, Project Manager	640	hrs @	rate	105.00				67,200.00
	TOTAL DIVISION 1								146,511.70