Ensuring Installation Quality: Field Testing Methods for Building Enclosure Components

By Sadil Eidda, EIT

THIS CASE STUDY illustrates some of the testing methods which can be employed in a new construction project to assess the adequacy of the installation of the building enclosure components. The testing techniques include ASTM D4263, *Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method* (concrete moisture testing);[1] ASTM E1186, *Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems*, Procedure 4.2.7, *Chamber Depressurization in Conjunction with Leak Detection Liquid*;[2] and dry film thickness (DFT) measurement. While these field-testing methods contribute to quality assurance, they should be viewed primarily as tools for an evaluation of the adequacy of installation of certain building enclosure components. By recognizing potential issues and addressing them, the project aims to reduce the likelihood of structural problems, which may lead to improved energy efficiency and cost savings.

INTRODUCTION

This case study focuses on a four-story surgery center under construction in Sacramento, California. The project has a progressive design-build delivery method, with the design-builder selected by the owner. The project's design phase commenced in late 2021, and the construction phase began in November 2022. The anticipated substantial date of completion is July 2025. The facility will encompass 268,000 ft^2 (approximately 24,900 m^2), featuring operating rooms, pre- and post-operative recovery bays, clinical exam rooms, clinical treatment rooms, single-occupant overnight patient recovery rooms, public space, operations spaces, imaging spaces, physical therapy spaces, and an administrative support space to facilitate patient support and education.

Our client, the design team, requested building enclosure testing and consulting services and provided a matrix of requested building enclosure testing on a mock-up and on the building. While our scope of services for this project included multiple phases and tests, our focus in this case study will be on some of the tests that were conducted on the low-slope roof and the exterior wall fluid-applied air- and water-resistive barrier (AWRB) to ensure quality assurance/quality control and support the long-term performance of the building enclosure components and systems. It is worth noting that we did not select any of the test methods, as other parties, such as the architect of record and manufacturers, selected the test methods.

The roofing assembly consists of a vapor barrier that was torched onto a primed concrete deck. Polyisocyanurate insulation was adhered to the vapor barrier using a low-rise urethane foam adhesive with ribbon patterns, spaced per manufacturer's recommendations. The coverboard was then adhered to the polyisocyanurate insulation using a similar installation process. Finally, the PVC membrane was fully adhered to the coverboard using a bonding adhesive. The substrate of the roofing assembly consists of a concrete composite steel deck, providing the necessary structural support and strength for the roof. The exterior walls consist of multiple systems including glass-fiber-reinforced concrete, a metal panel system, and a curtainwall system.

The testing conducted on the low-slope roof slab was the ASTM D4263.[1] This method helps detect the presence of moisture at the concrete surface prior to the installation of the vapor barrier. It is worth noting that ASTM D4263,[1] has been considered unreliable by many respected practitioners in the roofing industry. For example, in the article "Concrete Deck Dryness,"[3] the author has described that such historical and nonscientific method is inadequate for determining the dryness of concrete. This test, however, was included in the project specifications by the architect of record and approved by the roofing manufacturer. As a result, we performed it to meet the project requirements. Although there are alternative options for determining the dryness of the concrete, they may require more setup time, potentially resulting in an extended schedule.

This testing was performed to confirm dryness of the concrete surface prior to applying the vapor barrier as the presence of moisture in the concrete surface can still impact the installation of the vapor barrier, including the primer and adhesive.

Building enclosure performance testing is typically conducted during the construction phase of a new building, but it can also be provided in a retro-commissioning mode for existing structures when trying to ascertain the cause of leaks. Thermal transmittance in poorly insulated buildings results in heat and energy waste. To detect weak points such as thermal bridges in a building enclosure, a leak detection test identifies heat leaks, a specific type of heat loss. A heat leak is the phenomenon of unwanted heat transfer through a building enclosure from inside the building to the outside, or vice versa. Heat loss also includes air leakage, where outside air enters or exits the building and disrupts the indoor temperature regulation.

In this project, ASTM E1186[2] focuses on identifying air leakage locations within the building enclosure and air barrier system. These leaks would eventually lead to heat loss or gain. These test results help avoid unnecessary energy consumption or waste, saving resources.

Additionally, a DFT test was conducted to determine if the exterior wall fluid-applied AWRB met the manufacturer's required thickness. DFT testing provides a quantitative testing that can help ensure that the AWRB thickness is in conformance with the manufacturer's installation requirements and will serve as the air control layer as intended. Moreover, preventing air leakage is vital for the performance of the building, as uncontrolled air movement can contribute to moisture problems and subsequent deterioration of building materials.

The condition of the building enclosure components is important. If any component is compromised, potential problems will likely follow. This is where building enclosure field testing can help detect issues and offer immediate solutions.

FIELD TESTING PROGRAM

The concrete moisture testing was conducted using ASTM D4263, *Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method*. This test aims to detect the presence of moisture in concrete surfaces. This method helps in determining whether moisture is escaping the concrete's surface, suggesting possible issues with moisture vapor transmission[4] that could affect the adhesion of adhesives, flooring materials, and coatings. However, as previously mentioned and noted by industry professionals, this method has been criticized for its unreliability. An 18 in. by 18 in. (457 mm by 457 mm) polyethylene sheet is placed over the concrete surface by sealing its edges to conduct the test. The sheet is taken off after 16 to 24 hours, and the underside of the sheet along with the concrete surface are inspected for moisture. Visible condensation on the sheet or darkening of the concrete indicates excessive moisture, which indicates that moisture is being emitted from the concrete; thus, if the vapor barrier is applied over the concrete without allowing the concrete to dry first, it will affect the performance of its adherence (**Fig. 1**).

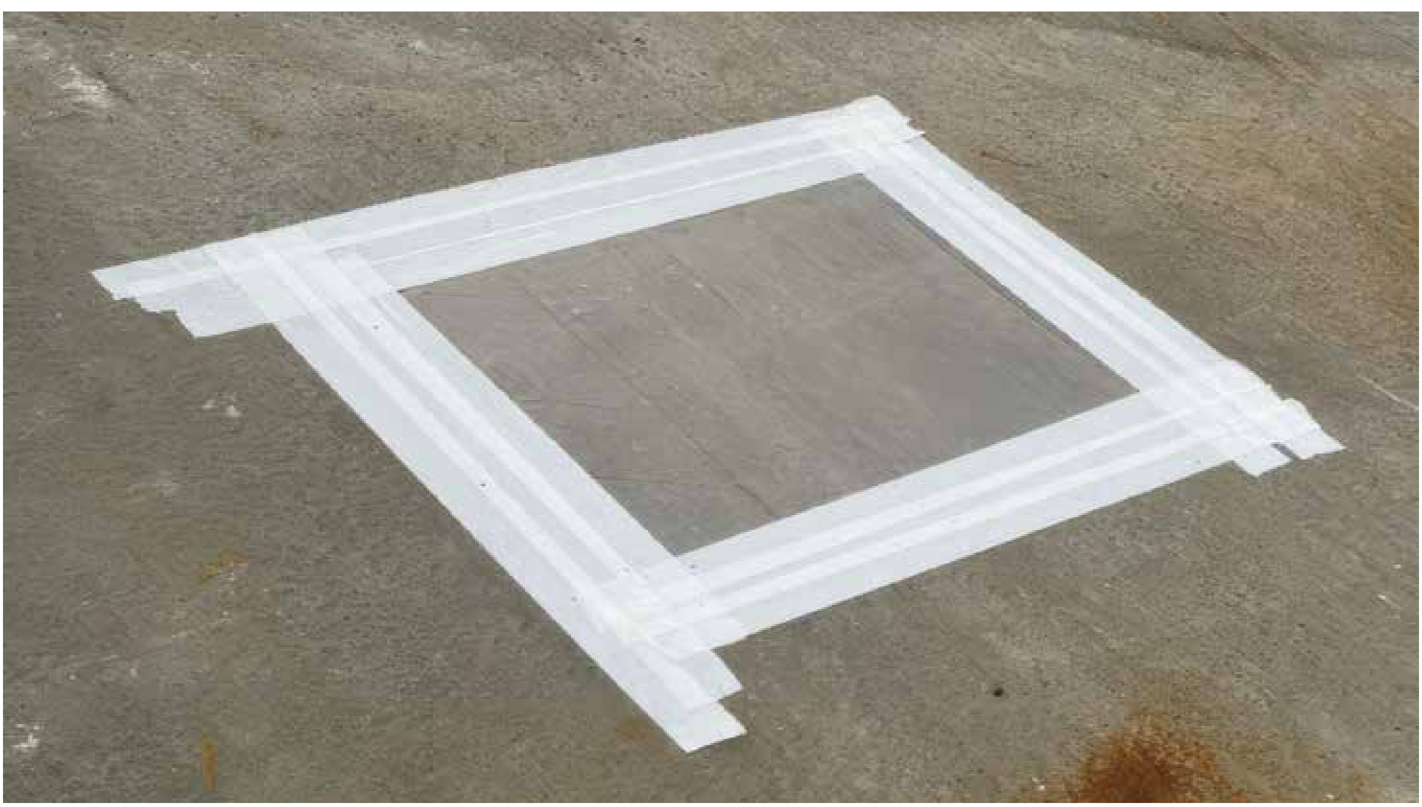

Figure 1. *Plastic sheet taped at concrete surface on the roof per ASTM D4263,* Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.

This test was performed on the roof, which had a footprint of approximately 58,000 ft^2 (5,400 m^2). The polyethylene sheets were specified in the project to be placed at fixed intervals to cover approximately 500 ft^2 (47 m^2) (**Fig. 2**). A vapor barrier was planned to be installed on top of the concrete slab to prevent any moisture from passing through once the slab was confirmed to be adequately dry. This test helped determine whether any moisture was being emitted from the concrete's surface. Several moisture issues could result from the moisture absorption by the slab, including mildew growth, structural problems, and damage to the roofing materials. Furthermore, these issues could cause the applied vapor barrier to debond and fail to adhere correctly to the slab.

The testing was planned to cover 10 locations per day, with each location representing about 500 ft^2 (47 m^2), resulting in approximately 5,000 ft² (465 m^2) tested daily. While this suggests the testing would only take 11 days, given the total roof area of 58,000 ft^2 (5,400 m^2), the actual testing period extended over 2 months due to December weather conditions in Sacramento, California. Sacramento experiences hot, dry summers and cool, wet winters, and frequent rain during this time repeatedly interrupted the schedule, making it difficult to conduct tests daily.

On days when rain occurred, all locations that were tested prior to the rain were retested afterward, as the concrete surface could absorb moisture from the rain. Moisture tests would fail if the concrete surface had not dried fully, causing condensation to be formed at the underside of the plastic sheet. On other days, testing had to be postponed entirely due to the rain.

The roofer's schedule required installing the vapor barrier on 5,000 ft² (465 m^2) of dry concrete surface daily. However, if it rained between completion of the test and the installation of the vapor barrier, the concrete moisture testing would need to be redone, even if the test had passed earlier that day.

The weather became the main factor in order to decide whether daily testing would be performed or not. These weather-related delays required careful coordination and scheduling to deal with the changing weather conditions. The extended time frame helped in completing the testing effectively by ensuring that the concrete had sufficient time to dry and monitoring the moisture level, thus preventing any moisture issues and protecting the roofing system.

In order to confirm that the concrete had sufficient time to dry and to monitor the moisture, we had to address the concrete moisture issues in cases where some sections did not pass the test prior to installing the vapor barrier, we had two available options based on the project conditions and limitations[5]:

1. Waiting for the concrete to dry out on its own, which is typically the preferred method if it does not delay or disrupt other ongoing work.
2. Dehumidifying, which is typically done by adding fans to accelerate drying.

The dehumidifying technique was utilized for this project to keep up with the project timeline (**Fig. 3**). The tests performed after implementing dehumidification passed, as this method expedited the drying of the concrete.

Moving on from the roof, the exterior walls were also tested at this new complex. Various methods were used to test them in order to ensure quality control and compliance with the manufacturer's standards and specifications of the fluid-applied AWRB membrane, which was installed on the sheathing.

The Chamber Depressurization in Conjunction with Leak Detection Liquid test was conducted following Procedure 4.2.7 of ASTM E1186, *Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems*. This method was selected by the architect of record because it is a non-destructive technique that aligns with the project's requirements and minimizes disruption. The purpose of this test was to detect and locate localized air leakage points in building enclosures and air barrier systems, which could potentially help in reducing energy loss and enhancing indoor air quality.

The testing involved the utilization of the DeFelsko PosiTEST AIR device, which consists of a polycarbonate test dome connected to an electronic unit for depressurization. A test solution, which consisted of a soapy liquid that would detect any air leakage, was uniformly applied to the test location, and then the

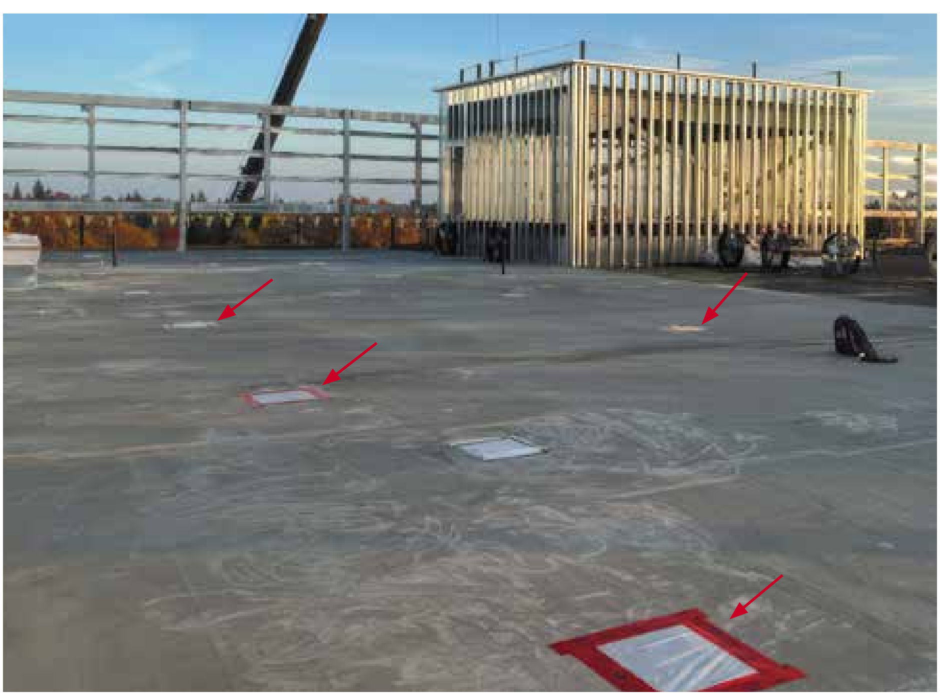

Figure 2. *Plastic sheets placed at fixed intervals (shown by red arrows).*

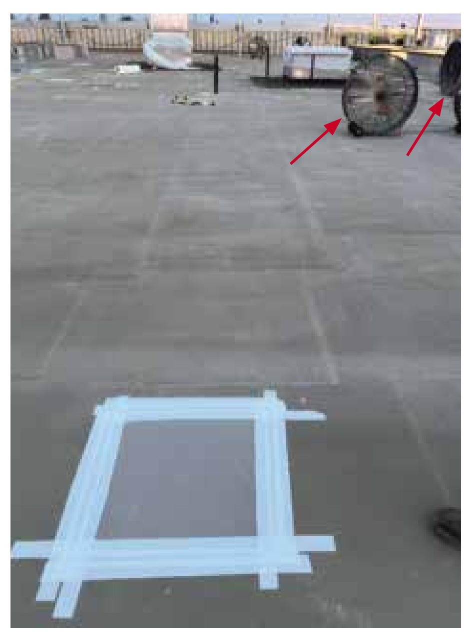

Figure 3. *Fans added around concrete for dehumidifying purposes (shown by red arrows).*

test dome was attached to the surface of the building enclosure at the test location and securely sealed (**Fig. 4**). The test area was depressurized from the normal atmospheric pressure of 14.7 psi to 0.0725 psi (101,325 Pa to 500 Pa). In case of failure, bubbles would be formed in the test solution, and the air barrier would need to be patched at the leak location to repair it. This test was done 8 to 10 times at isolated locations at each elevation of the building, focusing on sheathing joints and cladding attachments (**Fig. 5**). The test was passed at every location we tested during this project. In other words, no bubbles were observed throughout the test locations at all elevations. This test helped in detecting air leaks, which would have been eliminated if identified.

While the building may have some level of air leakage resistance regardless of the test, identifying and addressing specific air leaks can lead to more efficient operation of the HVAC system, eventually leading to energy savings and comfort for occupants.

Moreover, controlling air leakage is important for the structural integrity of the building, as uncontrolled air movement can lead to condensation when warm air infiltrates cool areas, increasing the moisture issues and causing damage to the building materials over time.

DFT testing was performed at selected locations on each elevation of the building to verify the thickness of the coating, which was applied on top of the sheathing, after it had dried (**Fig. 5**). The testing was done at nine locations at each of the north and south elevations and three locations at each of the west and east elevations. The north and south elevations were divided into three areas based on the completion of the coating installation, and each area was assigned three locations to be tested, totaling nine tests per elevation. For the west and east elevations, each elevation was treated as a single area, with three test locations assigned to each. The assignment of the areas was based on the differences in the elevation lengths, as the north and south elevations measure approximately 410 ft (125 m), and the east and west elevations measure approximately 152 ft (46 m).

This method was selected based on the AWRB manufacturer's recommendations that specified using this test in order to verify the coating thickness. The test involved taking a 1 in. by 1 in. (25 mm by 25 mm) cut, including the sheathing facer, and measuring the thickness using a caliper. The caliper was applied lightly so that it would not leave any marks on the coating.[6] The sheathing facer was measured to be approximately 15 mils (0.38 mm), consistent with the sheathing manufacturer's specifications. The AWRB manufacturer's minimum requirement is 17 mils (0.43 mm) DFT at the cured state.

In **Fig. 6**, the test result came out to 1.06 mm (42 mils). Since the cut included the sheathing facer, which was 15 mils (0.38 mm), the DFT for the coating alone would be 27 mils (0.69 mm), which is greater than the AWRB manufacturer's minimum requirement of 17 mils (0.43 mm). Thus, passing the test like the majority of the other locations that were tested. However, some of the other results yielded less than 17 mils (0.43 mm). The subcontractor was instructed to reapply the coating over the

Figure 4. *Testing process per ASTM E1186, Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems. No bubble formation was observed.*

Figure 5. *Partial view of an elevation prior to the dry film thickness and chamber depressurization in conjunction with leak detection liquid tests.*

Figure 6. *Passing result in the dry film thickness test.*

existing coating, using careful control to achieve the correct thickness that matched the AWRB manufacturer's standards. Ensuring that the membrane met these specifications confirms that it will serve as the air control layer as intended, as the membrane plays a crucial role in preventing air and water infiltration. This testing method validated the application process and confirmed that the installed thickness meets the AWRB manufacturer's specifications.

CONCLUSION

The tests carried out were helpful in assessing the adequacy of the installation of the building enclosure components as part of the quality assurance process. The concrete moisture testing detected moisture on the surface, which could affect the roofing system. Early detection allows for the implementation of preventive measures, such as using fans to accelerate drying and ensuring that the vapor barrier is applied only when the concrete is deemed adequately dry.

Performing the DFT testing at isolated locations at each elevation confirmed that the fluid-applied AWRB membrane was applied to the specified minimum thickness, ensuring that the membrane was applied in accordance with the AWRB manufacturer's standards and specifications.

The Chamber Depressurization in Conjunction with Leak Detection Liquid testing confirmed that air leakage was not present at the test location. This test showed how effective thorough checks are in identifying air leakage in specific locations, which potentially helps in saving energy and maintaining good indoor air quality.

These tests confirmed that the installation of the building enclosure components conformed to manufacturer and industry standards. The results of these testing methods highlighted the value of ensuring quality in the installation of building enclosure components and the role of quality assurance. While the focus of this article is on those three tests, it is essential to note that more comprehensive testing will be conducted in the subsequent construction phases. These future tests will further ensure the building's performance and address any potential issues. By proactively assessing building enclosures, risks are efficiently reduced, and potential enclosure-related failures are prevented. This approach helps maintain high construction standards, enhance quality, increase client satisfaction, and protect against future issues.

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ABOUT THE AUTHOR

SADIL EIDDA, EIT

Sadil Eidda, EIT, *has been working as a Restoration Engineer II at Walker Consultants in Houston, Texas, since 2022. She became involved with IIBEC in 2020 while studying at Drexel University, where she earned her bachelor's degree in architectural engineering in 2022. Before her current role, she held co-op positions at Pennoni Associates, Jacobs Engineering Group, and Trauner Consulting Services, gaining valuable experience across a wide variety of projects. In her current position, Eidda conducts condition assessments on building envelopes and parking garages, assists in creating construction documents, provides construction administration services, and performs field testing.*