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Standard Guide for Evaluation and Rehabilitation of Mass Masonry Walls for Changes to Thermal and Moisture Properties of the Wall[1]

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1. Scope

1.1 This guide addresses the evaluation of existing mass masonry walls for the potential addition of interior insulation and continuous air barrier or vapor retarder or other changes to the thermal and moisture management properties of the wall.

1.2 This guide describes methods for evaluating causes of water infiltration or other moisture accumulation related problems specific to mass masonry walls. This guide does not apply to walls that include provisions to manage bulk water through internal drainage, flashings, or other measures other than the moisture storage capacity of the wall.

1.3 This guide describes analysis, design, and specification of materials with the required thermal and vapor resistance to improve the energy performance of an existing mass masonry wall, but that would not create problematic conditions to the masonry units or within the masonry wall or interior of the building.

1.4 This guide applies to walls of solid or multiwythe masonry construction meeting the requirements of a "mass masonry wall" as defined herein and having an overall thickness of solid masonry not less than 8 in. This guide does not apply to masonry walls that, by design, are intended to manage water as a barrier wall system or drainage wall system.

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

[1] This guide is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.24 on Building Preservation and Rehabilitation Technology.

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2. Referenced Documents

2.1 *ASTM Standards:*[2]

C20 Test Methods for Apparent Porosity, Water Absorption, Apparent Specific Gravity, and Bulk Density of Burned Refractory Brick and Shapes by Boiling Water
C67 Test Methods for Sampling and Testing Brick and Structural Clay Tile
C1046 Practice for In-Situ Measurement of Heat Flux and Temperature on Building Envelope Components
C1155 Practice for Determining Thermal Resistance of Building Envelope Components from the In-Situ Data
C1498 Test Method for Hygroscopic Sorption Isotherms of Building Materials
C1794 Test Methods for Determination of the Water Absorption Coefficient by Partial Immersion
E96 Test Methods for Water Vapor Transmission of Materials
E398 Test Method for Water Vapor Transmission Rate of Sheet Materials Using Dynamic Relative Humidity Measurement
E631 Terminology of Building Constructions
E2128 Guide for Evaluating Water Leakage of Building Walls

2.2 *Other Standards:*

ASHRAE 160 Criteria for Moisture-Control Design Analysis in Buildings[3]
International Energy Conservation Code [4]
Secretary of The Interior's Standards for Rehabilitation [5]

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), 1791 Tullie Circle, NE, Atlanta, GA 30329, http://www.ashrae.org.

[4] Available from International Code Council (ICC), 500 New Jersey Ave., NW, 6th Floor, Washington, DC 20001, http://www.iccsafe.org.

[5] Available from Technical Preservation Services (TPS), National Park Service, 1849 C Street, NW (org 2255), Washington, DC 20240, http://www.nps.gov/tps.

3. Terminology

3.1 *Definitions:*

3.1.1 *liquid transport coefficient, absorption*—describes the capillary uptake of water (liquid moisture) when the imbibing surface is fully wetted. In the context of building physics, this corresponds to rain on a facade.

3.1.2 *liquid transport coefficient, redistribution*—describes the spreading of the imbibed water when the water source is shut off. No new water is taken up by the material, and the water present in the material begins to redistribute. In a building component, this corresponds to the moisture permeation in the absence of rain.

3.1.3 *mass masonry wall*—solid wall constructed of more than one wythe of masonry including all types of natural and unit masonry, such as brick, stone, and concrete masonry. "Mass masonry walls" refers to the mechanism of water management for the wall, specifically masonry walls with the ability to store and subsequently release bulk water.

3.1.4 *moisture*—generally refers to the presence of water in either the liquid or vapor form.

3.1.5 *moisture issues*—refers to any complaint or deficiency attributable to moisture. Typical issues include occupant discomfort, biological growth, corrosion, wood decay, staining, freeze-thaw damage, or other durability issue related to the presence of moisture.

3.1.6 *moisture permeation*—a process in which moisture (water or vapor) enters, flows, spreads within, and discharges from a material.

3.1.7 *water absorption coefficient*—mass of water absorbed by a test specimen per face area and square root of time.

3.2 See E631, Standard Terminology of Building Constructions, for general terminology.

4. Significance and Use

4.1 Energy conservation is being addressed more often on existing and historically significant buildings constructed with solid exterior mass masonry walls. Without proper evaluation, changes to the thermal and moisture properties of the exterior walls could have serious negative impacts.

4.2 A thorough understanding of the existing construction, condition, properties, initial moisture content, and water and air leakage potential are necessary before undertaking the addition of interior insulation, air barrier, vapor retarder, or other changes to thermal or vapor resistance of the wall.

4.3 Degradation of the existing masonry along with moisture related problematic conditions and indoor air quality issues could develop if alterations are undertaken in an improper manner to the exterior wall assembly.

5. Review of Project Documents

5.1 Available construction documents should be reviewed as outlined in Guide E2128.

5.2 Prior to undertaking a field evaluation and, if available, the original documents from time of construction should be reviewed to determine the general wall thickness, composition, and geometry. The presence of voids or other annular space should be identified.

5.3 Inspection reports, surveys, repair or alteration drawings, or other available documentation should be reviewed to gain a better understanding of the current condition of the exterior walls.

5.4 Since many buildings featuring mass masonry walls were constructed prior to modern construction delivery methods, it is recognized that construction documents are typically non-existent or limited. As such, any available photographs or other documentation of the building throughout time should be reviewed to help identify which portions of the building or wall assembly is original and which portions were added at later times.

6. Determination of Service History

6.1 Using the methods outlined in Guide E2128, a thorough evaluation of the building's service history should be conducted. The following activities should be included in the evaluation:

6.1.1 Documentation of physical symptoms of moisture damage or presence of moisture.

6.1.2 Interviews with occupants, maintenance staff, contractors, or other first-hand observers to correlate moisture related issues with the building maintenance/operation history or weather patterns, or both. Changes to the building's mechanical systems or mechanical system operations should be pinpointed as best as possible.

6.1.3 Review of maintenance and repair records for both the mechanical systems and building enclosure.

6.1.4 Review of vicinity weather records.

6.1.5 Correlations of moisture issues with other factors such as season of year, building elevations, wall height, interior conditions or use.

7. Initial Evaluation

7.1 The overall thickness of the wall should be determined or verified with field measurements at various locations throughout the building.

7.2 When accurate drawings of each wall section are not available, it will be necessary to determine the wall composition and wall assembly details of each critical or unique wall section.

7.3 Mass masonry walls historically have been constructed with a wide range of materials to include: brick, clay tile, concrete masonry units (CMU), terra cotta, and stone.

7.4 The exact wall composition should be verified through small discrete exploratory openings. The historic integrity of the existing wall should be carefully evaluated when selecting the locations to make the exploratory openings.

7.5 The wall composition can be determined through a combination of exterior and interior probes, borescopes, targeted removals, and various non-destructive testing techniques. The number and size of the openings should be kept to the minimum that is necessary to determine the composition of the wall, but sufficient to gather pertinent information on a representative sample of existing construction. At a minimum, the following should be recorded:

7.5.1 Overall thickness of the wall;
7.5.2 Type of material(s) present within the wall;
7.5.3 Number of wythes;
7.5.4 Thickness of each material or wythe;
7.5.5 Condition and material type of each wythe;
7.5.6 Presence and thickness of collar joint or voids within the wythes; and
7.5.7 Presence of water.

7.6 Examine the condition of all other materials making up the wall assembly. Determine if there is any existing evidence of previous freeze-thaw damage. Determine if any existing corrosion of any metallic elements such as veneer ties or embedded structural supports are present. Determine if there is any biological growth or other moisture related damage on existing organic materials.

7.7 If a collar joint is present, qualitatively assess how complete or full the joint is and if it is slowing moisture transport. Consideration should be given as to whether or not the collar joint will behave more like an air space and provide a capillary break between wythes or if the space is mostly solid and will provide bridging for moisture movement between wythes.

7.8 Qualitatively assess any air movement through and across the assembly to determine if drying potential is offered via convection, utilizing methods such as infrared thermography, smoke pencil, or other visual observations.

7.9 Determine whether the existing masonry features an existing coating or water repellant on interior or exterior surfaces. If so, determine what impact this product would have on the permeance and the liquid transport coefficient. Consideration should be given to how this product has performed historically and what the expected useful service life is for the proposed product.

7.10 Determine representative initial moisture contents and moisture permeation patterns of the existing wall using procedures described in Field Determination of Existing Moisture Content (Appendix X1).

8. Evaluation of Material Properties

8.1 The properties of the materials comprising the wall and also the properties of the same type of materials within the wall can vary widely and will result in inaccurate hygrothermal models if testing to determine the properties of the actual material properties is not undertaken. Published generic material property data may not match the existing materials in the building or structure.

8.2 If possible, representative samples should either be removed from the interior from the locations of exploratory openings or from other discrete locations. If a solid grout or collar joint is present, samples of such material should be included to determine the hygrothermal material properties. Consideration should be given to the location and number of samples to be removed and tested. Representative samples should be removed to ensure the variance in materials from the differing elevations, floors, and wythes are evaluated.

8.3 The following hygrothermal material properties should be determined using testing procedures indicated. Published values for a material of similar type and density are allowed to be used if samples are not available or project parameters will not afford the time for laboratory testing:

8.3.1 Bulk density per Test Methods C20.
8.3.2 Moisture storage function (sorption-isotherm curve) per Test Method C1498.
8.3.3 Test Methods E96 (or Test Method E398 for sheet materials) vapor permeance at range of moisture contents to develop the permeance as a function of moisture content.
8.3.4 Porosity per Test Methods C20.

8.4 The following material properties should also be determined. Empirical testing required to determine these properties can be costly and complex. It is acceptable to determine these properties analytically or using engineering judgment as described.

8.4.1 *Heat Capacity*—Selected using engineering judgment from published values in any of the referenced documents for a material of similar density.
8.4.2 *Thermal Conductivity*—Selected using engineering judgment from published values in any of the referenced documents for a material of similar density.
8.4.3 *Water Absorption Coefficient*—Test Methods C1794.
8.4.4 Once the water absorption coefficient is known and the moisture content at free saturation is determined from the sorption isotherm curve, the approximation of the liquid transport coefficient (absorption and redistribution) can be determined.

8.5 If the building is located in a region where freeze-thaw damage is of concern, the following properties should be determined for any material included in the wall that would be subject to freeze-thaw exposure:

8.5.1 Saturation coefficient per Test Methods C67.
8.5.2 50 cycle freeze-thaw test per Test Methods C67.

8.6 Engineering judgment will be required to interpret the results of the brick material testing conducted in accordance with Test Methods C67. A direct comparison of the values of historic masonry units should not be made to the requirements for modern masonry materials as the properties of masonry materials may have changed over time.

9. Evaluation of As-Built Thermal Properties

9.1 Thermal mass, a property directly related to a wall's heat capacity, is a phenomena that enables building materials to absorb, store, and later release significant amounts of heat. The materials within the wall absorb energy slowly and hold it for longer periods when compared to more light weight, modern framed, and thinner wall assemblies. The ability to store heat delays and reduces heat transfer through the mass wall, which generally impacts the need or level of required additional insulative materials.

9.2 The impact of the thermal mass should be carefully evaluated prior to undertaking any alterations to the wall or the addition of insulating materials to meet the U-factor requirement of energy codes.

9.3 U-factors do not account for the effects of thermal mass and may be inadequate in describing the heat transfer properties of mass masonry walls when considered independently. The heat flow through the wall is dependent on the materials' density, thermal conductivity, specific heat, and thermal diffusivity. Most energy codes and standards take the thermal mass into account when stipulating the prescriptive minimum insulation and U-factor requirements. As such, the U-factors and insulation requirements prescribed in such codes and standards are reduced for mass walls.

9.4 The project specific energy improvement performance goals and metrics should be defined by the project team. The compliance path of any particular codes and standards should be defined. Both the thermal mass of the existing wall and the U-factor of the upgraded assembly should ultimately be considered when assessing the potential energy savings of the proposed design compared to the existing performance. Alterations to the existing wall to improve energy performance should be evaluated to ensure a positive impact without creating detrimental effects to the long term performance of the existing masonry.

9.4.1 Based on the project specific energy improvement goals and requirements, the need for additional insulating materials (if any) should be carefully determined, evaluating the impacts of the existing thermal mass behavior of the wall and the targeted energy performance.

9.4.2 The thermal properties of the wall should be evaluated in accordance with one of the following methods:

9.4.2.1 *In-situ Testing*—Standard procedures exist for determining the actual thermal resistance of wall assemblies in the field, utilizing Practice C1046 and Practice C1155. It is challenging to use field methods to determine the thermal resistance of mass masonry walls due to the heat capacity of the wall when compared to more modern framed wall assemblies. Measures should be taken to have a large and somewhat constant temperature difference across the wall for 12 to 24 h during the test period. These evaluations are typically more accurate if undertaken on the elevation with the least direct solar radiation and that is protected with natural or artificial shading devices. It is important that engineering judgment be applied during the testing and when interpreting the results from the in-situ evaluation to ensure that the results reflect the actual performance of the wall assembly.

9.4.2.2 *Computer Modeling*—To accurately account for the thermal mass, an energy simulation software program that utilizes the attributes of the materials' density, thermal conductivity, specific heat, and thermal diffusivity, and is able to model the dynamic performance of the wall over time could be used.

9.4.2.3 *U-Factor Calculation*—The thermal conductance for each material observed in the wall assembly and the thickness of that material will be required to determine the total U-factor of the existing wall assembly. Unless there is repetitive and consistent thermal bridging, a one-dimensional U-factor calculation should be sufficient for an estimate of the U-factor. If conditions create frequent or significant thermal bridging, two-dimensional heat flow software should be used to determine an overall U-factor.

9.4.3 Published industry references can be used to determine the thermal conductivity of each material if this data is not collected during evaluation of material properties provided the published values match the density and composition of the materials within the wall assembly. With the thermal conductivity values and the known existing material thicknesses, the U-factor of the existing mass masonry wall can be analytically determined as follows:

$$U = 1/\Sigma(T\ i / k\ i) \quad (1)$$

where:

ki = thermal conductivity of a material, and
Ti = material thickness.

10. Diagnostic Water Testing

10.1 The addition of insulation, air barriers, or vapor retarders, or combinations thereof, may not correct or address existing active water infiltration. Conversely, the addition of such materials could conceal and exacerbate such issues if present.

10.2 A field evaluation to understand if water leakage is occurring into the building should be undertaken in accordance with Guide E2128. If water leakage is present, remedial repairs will need to be undertaken to address the leakage prior to undertaking any alterations to the interior of the building.

10.3 The addition of insulation, air barrier, or other materials that change the thermal or vapor resistance of the wall cannot be undertaken if bulk water is not managed properly or permitted to the interior of the building through the exterior wall.

10.4 Historically, mass masonry walls do not include a drainage space or other flashing materials to evacuate moisture from the wall. The walls rely on the inherent moisture storage capacity of the materials.

10.5 The execution of the diagnostic water testing should be carefully coordinated with the procedures of Appendix X1 in order to assess the moisture permeation patterns. Data from the humidity probes should include collection times prior to, during, and after the diagnostic water testing.

11. Hygrothermal Analysis

11.1 A series of transient hygrothermal analyses should be conducted in accordance with ASHRAE 160, Criteria for Moisture-Control Design Analysis in Buildings. All variables should be accurately accounted for to represent the findings of the initial evaluation and material properties. The standard assumptions outlined in ASHRAE 160 should be modified as follows:

11.1.1 The initial moisture content in each wythe of masonry should be defined. The findings and observations from the procedures of Appendix X1 should be coupled with the moisture storage function(s) determined as part of the material properties determination to determine the initial moisture content of the masonry.

11.1.2 The observations and findings from the procedures of Appendix X1 coupled with the observations of the diagnostic water testing should be used to define the moisture sources included in the hygrothermal analysis.

11.1.3 The actual hygrothermal properties of the materials being evaluated in the wall assembly should be used in the model in lieu of the generic materials included in the databases.

11.2 The performance of the existing wall as currently functioning should be compared carefully to the performance of any proposed changes to the assembly. Specifically, the following performance aspects should be addressed:

11.2.1 Any increases in the overall moisture content within the existing masonry expected to occur as a result of the addition of new materials should be evaluated. The impacts of the increased moisture, including the increased potential for corrosion of embedded metal element, should be assessed and mitigated if needed.

11.2.2 The increased potential for freeze-thaw damage within the masonry should be assessed. The critical moisture content and temperature gradient change across the wall assembly should be evaluated to assess the increased potential for freeze-thaw damage, to include the temperatures within the outermost one-half inch (½ in.) of the masonry under the original wall performance as compared to the proposed assembly. Additionally, the number of expected annual freeze-thaw cycles of the proposed wall assembly as compared to the existing wall assembly should be compared. Any increase in the freeze-thaw cycles should be carefully considered in conjunction with the masonry's saturation coefficient and freeze-thaw durability testing. The coincident moisture content of the materials when the additional freeze-thaw cycles are predicted to occur and the location within the wall assembly should also be considered.

11.2.3 The proposed wall's sensitivity to moisture sources should be compared to the existing wall's ability to accommodate moisture sources. If the proposed changes to the wall result in an assembly that is more sensitive to moisture sources, then additional repairs to mitigate moisture infiltration should be evaluated prior to the addition of the insulation, air barrier, or vapor retarding materials, or combinations thereof.

11.2.4 The goal of any proposed wall changes should be to comply with the failure criteria outlined in ASHRAE 160.

12. Evaluation of Repair Strategies

12.1 Oftentimes the primary goal of retrofit projects involving mass masonry walls is to improve energy performance. The insulation, air barrier, or vapor retarding materials, or combinations thereof, are added with the intent of reduction in energy consumption. This primary goal must be balanced with the long term functional performance of the existing wall.

12.2 In the case of buildings with historical significance, the preservation of the existing masonry's usable service life should be evaluated against any energy related improvement.

12.3 Typically, insulating materials and air barriers or vapor retarders, or combinations thereof, are added to the interior of the building in order to maintain the historic aesthetic of the exterior. Sometimes it is proposed to add such materials to the exterior. The historical significance of the building's exterior aesthetics should be carefully considered in such cases. The guidelines in the National Park Services Preservation Brief #3[6] and the Secretary for the Interior's Standards for Rehabilitation should be followed.

12.4 The addition of insulating, air barrier, or vapor retarding materials, or combinations thereof, to mass masonry walls alters the function and performance of these walls. The addition of such materials typically makes the walls more sensitive to moisture intrusion and alters how moisture is managed within the masonry. As such, the addition of such materials often may need to be coupled with repairs that would reduce the amount of water intrusion into the walls. Such repairs may include full scale repointing, and maintenance of such repairs should be considered.

12.5 It is noted that, the addition of air barrier or vapor retarding materials, or both, results in an overall reduction in the drying potential of mass masonry walls. All proposed repair assemblies should be carefully examined to determine if additional drying potential through other means, such as the use of ventilated interior cavity spaces, is required.

12.6 Altering the thermal gradient across the existing masonry wall through the addition of insulation can have an impact on the thermal expansion and contraction of the existing masonry. The results of the transient analysis should provide the annual temperature extremes within the masonry. If the analysis shows an increase in the annual temperature extremes within the masonry of the proposed insulated masonry wall assembly as compared to the existing masonry wall assembly, the need for thermal expansion provisions should be considered.

12.7 In some cases, it may not be advisable to make any changes to the thermal or moisture properties of the wall assembly if the changes would potentially create problematic conditions that would impact the continued long term performance of the wall or lead to other moisture related issues.

13. Keywords

13.1 existing thermal performance; interior insulation; mass masonry wall; vapor resistance

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[6] Hensley, Jo Ellen, and Aguilar, Antonia, *Improving Energy Efficiency in Historic Buildings*, National Park Service (NPS), U.S. Department of the Interior, Technical Preservation Services (TPS), 2011.

APPENDIX

(Nonmandatory Information)

X1. FIELD DETERMINATION OF EXISTING MOISTURE CONTENT

X1.1 The initial moisture content is imperative to understand when undertaking a transient hygrothermal model of existing wall assemblies, particularly if vapor retarders are to be installed. In many cases the assumptions as to the initial moisture content will be the deciding factor as to whether the models yield favorable or unfavorable results when evaluating whether to add insulation or vapor resisting materials.

X1.1.1 The existing moisture content of the masonry materials within the wall can be determined through determining the interstitial relative humidity and then comparing the humidity to the corresponding sorption isotherm curves.

X1.2 Determination of Test Locations

X1.2.1 Each unique wall assembly should be evaluated. At each test location, a minimum of three probes shall be installed at various depths as indicated below.

X1.2.2 For multiwythe mass masonry walls, a probe should be placed within each wythe. The depth of the probes shall be placed in a manner to obtain a profile through the entire wall assembly and generally at the center of each wythe of masonry, provided each wythe of masonry is less than 4 in. thick. Adjacent probes should be installed no greater than 12 in. vertically or horizontally from adjacent probes.

X1.2.2.1 For wythes of masonry greater than 4 in. in thickness but less than 8 in., probes should be installed 2 in. from each face.

X1.2.2.2 For wythes of masonry greater than 8 in., probes shall be installed at third points within the wythe.

X1.2.3 The orientation of the building should be considered when selecting the test locations. Historical weather data should be referenced to determine the amounts of driving rain and solar radiation expected for each elevation.

X1.2.3.1 Generally, elevations exposed to the greatest amount of driving rain and least amount of solar radiation will take on more water and dry out more slowly.

X1.2.3.2 Generally, elevations exposed to the least amount of driving rain and greatest amount of solar radiation will take on less water and will dry out more quickly.

X1.2.3.3 Generally, elevations exposed to the greatest amount of driving rains and greatest amount of solar radiation will take on more water, and the moisture will tend to be driven farther to the interior of the wall.

X1.2.4 Consideration should also be given to adjacent buildings and structures that could limit the amount of driving rain and solar radiation exposure and changes in exposure from floor to floor along the height of the building.

X1.2.5 Consideration should also be given to the time of year for the field investigation relative to the time in which the renovation will be executed. The initial moisture content will vary with the seasons, so the time in which the field data is collected should be coordinated with the start of construction to ensure initial conditions are similar to that of the data collected from the field investigation.

X1.3 Collection of Data

X1.3.1 Data logging relative humidity and temperature sensors should be obtained from a manufacturer with NIST traceable calibration equal to or better than ±2 % relative humidity at 50 % relative humidity and ±2 % relative humidity at 90 % relative humidity. These sensors should be encased in a cylindrical probe with a diameter less than approximately ⅜ in. The sensor should be connected to a cable that then connects into a digital display. Within a mass masonry wall, it is likely that the sensor will be exposed to 100 % relative humidity. The sensor should have the ability to remain accurate and not be damaged at such exposure.

NOTE X1.1—The installation of the probes requires drilling into masonry walls to various depths. To maintain the integrity of a historic masonry wall to the greatest extent possible, drilling should be limited to mortar head joints. As such, the diameter of the cylindrical probe must be small enough to fit within such a joint.

X1.3.2 Drill a hole at each test location to the appropriate depth utilizing a rotary hammer drill with a diameter drill bit no more than 0.04 in. (1 mm) greater than the diameter of the hole liner. Hole shall be drilled dry. Do not use water for cooling or lubrication; do not wet-core test hole. Clean hole and remove dust using a vacuum cleaner equipped with a filter.

X1.3.3 Hole liners should be cut to a length to suit depth of hole drilled into masonry. The hole liner should be a plastic or non-corroding metal tube with an inside diameter no greater than 0.04 in. greater than the probe's external diameter. Insert the hole liner to the bottom of hole and seal to surface surrounding masonry with joint sealant or caulk. Do not permit sealant to block ends of hole liner. Insert the probe into the liner so that the sensor is no more than ⅝ in. from the end of the hole. Seal the interior end of the liner around the sensor cable in a manner that is both air and water tight.

X1.4 Allow the data loggers to record data for a minimum of two weeks.

X1.4.1 This test period should include periods of clear, sunny conditions and a minimum of two rain events. The data loggers should continue to record information a minimum of 48 h after the completion of the rain event.

X1.4.1.1 If scheduling or other restrictions, or both, limit the length of the test duration, diagnostic water testing can be implemented at the test location to simulate a rain event. Consideration should be given to the type and duration of the diagnostic water testing in order to provide meaningful results.

X1.4.2 Install temperature and relative humidity data loggers at the exterior face of the wall and at the interior face of the wall to record the ambient temperature and relative humidity for the duration of the test.

X1.4.3 At the end of the test period, remove the probe and hole liner and fill the hole with a material matching the original and adjacent materials.

X1.5 Analysis of Data

X1.5.1 The data collected from the field investigation should be evaluated to determine a reasonable initial moisture content for the materials in the wall assembly. To do so, the relative humidity profile across the wall assembly, movement of moisture across the wall assembly, and drying potential for the wall assembly should be considered. Plotting the data as a function of time and identifying rain events or diagnostic water testing on the plot will be helpful in identifying patterns in moisture permeation.

X1.5.2 Engineering judgment should be used to determine a reasonable initial moisture content for the components of the wall assembly based on the data collected and the developed sorption isotherm curves.

X1.5.3 Consideration should be given to the following when determining the initial moisture content:

X1.5.4 Peak relative humidity within each wythe of the wall assembly during and after rain events. The time lapse between the peak relative humidity points should be considered to determine the rate at which moisture moves through the wall assembly, both through absorption and desorption.

X1.5.5 Actual vapor pressure can be calculated and evaluated utilizing the known saturated vapor pressure for each temperature and corresponding relative humidity at each data point. This data can be used as an additional method to evaluate the moisture movement across the profile of the wall assembly.

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