NCDOI OSFM Evaluation Services

Scope of DOI Evaluations: The purpose of this document is to provide clarification to Code Enforcement Officials (CEO), acting as agents for the Authority Having Jurisdiction (AHJ), on code requirements or guidelines for consideration when presented with a method or material not prescriptively addressed by the NC State Building Codes. This evaluation contains the performance characteristics given by the code to determine if the method or material meets the intent of the code in accordance with Section 105 of the NC Administrative Code and Policies. Code requirements are mandatory; recommendations beyond code requirements may be applied at the discretion of the CEO.

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Product Group: Adhered Masonry Veneer (AMV)

A. Intent: Adhered Masonry Veneer (AMV) has become a popular alternative to classical masonry veneers. Exterior applications of AMV have been subject to water penetration problems in recent years, primarily resulting from installation issues.

Both the 2009 North Carolina Building Code (NCBC) and the 2009 North Carolina Residential Code (NCRC) intend for the envelope of the building to be water resistant. Consequently, this document provides the CEO with information and sources of information necessary to assess compliance with the intent of either the NCBC or the NCRC.

1. AMV may be applied to a variety of substrates including cast-in-place concrete, concrete masonry, wood stud walls with various sheathing materials, and metal stud walls with various sheathing materials. Most of the water penetration damage observed in the field has involved wood frame and metal stud structures. Consequently, the scope of this document is generally limited to AMV installed on wood frame and metal stud structures.

2. Interior applications of AMV include decorative walls, decorative finish on interior archways, wainscots, decorative finish on enclosures for manufactured fireplaces. Life safety issues associated with interior applications are related to structural concerns such as falling units. Passing reference is, therefore, included in this document on installation of interior AMV.

3. Construction of the substrates for AMV is addressed to varying extents, discussed further below, in the NCBC and the NCRC. However, no ASTM standard exists governing the manufacture of AMV units. Units are proprietary to the manufacturer and must be evaluated as alternate materials by the CEO under Section 105 of the North Carolina Administrative Code and Policies.

B. Composition of AMV Wall Assemblies: Adhered Masonry Veneer is the term used by the NCBC and the International Building Code describing a facing material that is secured to a backing material by adhesive bonding. AMV is also referred to as Manufactured Masonry Veneer, Adhered Brick Veneer, Adhered Concrete Masonry Veneer, or Adhered Precast Concrete Veneer, depending on the material the units are made of. Available in both simulated stone and brick, AMV is thinner, lighter, and less

Figure 1a: Manufactured Masonry Veneer Textures – Cut Stone

Figure 1b: Manufactured Masonry Veneer Textures – Dry Stack

expensive than the classical anchored veneers. Typically, a conventional veneer is four to eight inches in nominal thickness and is supported off the building foundation system. AMV is $^{5}/_{8}$" to $2^{5}/_{8}$" in actual thickness. The substrate to which the AMV is adhered supports the weight of the veneer; much like an EIFS is supported by bonding the insulation board to the sheathing. In exterior wood and metal frame construction, the components of the AMV system are:

Figure 1c: Manufactured Masonry Veneer Textures – River Stone

1. **Wall Studs –** Wall studs are normally dimension lumber or cold formed metal studs sized for structural considerations; that is, the studs are sized for strength and serviceability. Strength considerations include resistance to crushing under compressive loads, resistance to flexural rupture under lateral loads, and resistance to buckling under both compressive and flexural loadings. Serviceability issues are addressed by limiting deflection under lateral loads to prevent cracking or buckling of the finish materials applied to the wall studs. Damage to the finish materials due to excessive deflection is unsightly in both interior and exterior applications and may facilitate water penetration into the wall cavity in exterior applications.

2. **Sheathing –**For wood frame construction, sheathing is typically either plywood or oriented strand board. Gypsum sheathing or cement board sheathings are more common in metal frame construction. Foam plastic sheathings are often used in residential construction, but should be used beneath AMV only when structurally tested as an assembly with the AMV, the substrate, and the wall studs. In the western United States sheathing is often omitted in exterior stucco claddings. Construction of this sort is referred to as "open frame construction." Open frame construction is discouraged in AMV applications due to the increased potential for water penetration associated with poor support for the weather resistive barrier.

3. **Weather Resistive Barrier –** A weather resistive barrier and associated flashings are required to prevent liquid moisture from penetrating the building envelope. Climatically specific moisture vapor flow must also be considered in the selection of materials for the water resistive barrier.

4. **Optional Rain Screen –** Manufactured drainage mats or vertical wood furring may be placed between the substrate and the weather resistive barrier to enhance drainage and equalize pressure differentials that would normally drive moisture through the cladding. This drainage layer is usually $^{3}/_{16}$" to ¼" thick.

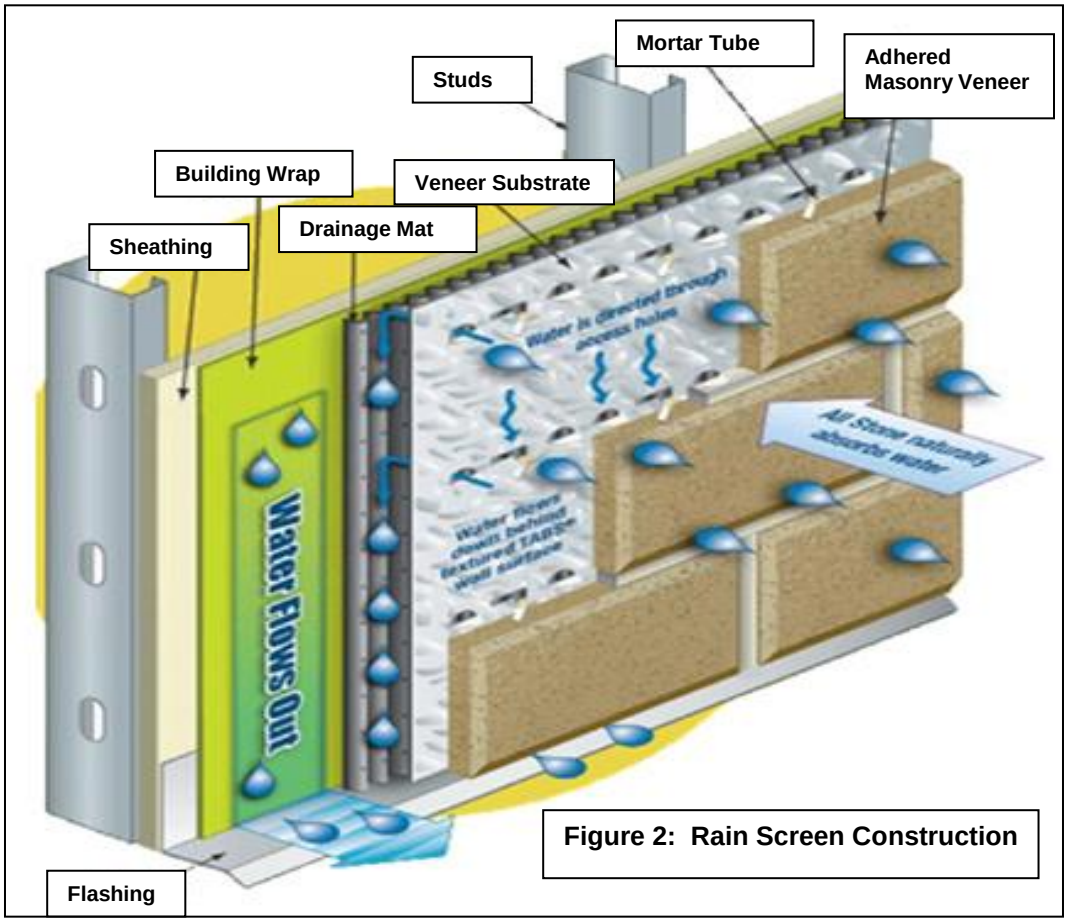

Figure 2: Rain Screen Construction

5. **Substrate –** A scratch coat of Portland Cement plaster is typically required as a substrate in wood and metal frame construction. The plaster is installed on metal lath, furred out ¼" from the weather resistive barrier behind the substrate to create a drainage plane. AMV may be applied directly to masonry or concrete barrier walls, or a scratch coat on lath may be applied to the masonry or concrete wall, depending on condition of the wall and moisture considerations. Systems using substrates other than masonry, concrete, or Portland Cement Plaster are beyond the scope of the codes and must be evaluated as alternate methods.

6. **Bedding Mortar –** Units are normally adhered to the substrate by buttering the units with a ½" thick layer of bedding mortar. Mixes for the bedding mortar are discussed in more detail in Section D of this document.

7. **AMV Units –** Usually, AMV units, other than thin brick, are molded from a light weight concrete mix similar to the mixes used for concrete masonry units. Molds for simulated stone units are cast from natural stone, and the concrete is surface tinted or colored during the casting process to look like natural stone. Thickness of the units may vary from $^{5}/_{8}$" to $2^{5}/_{8}$" in thickness. Units may be the size of an individual stone or brick, or units may be cast as panels of stone or brick up 720 square inches in area with the largest dimension up to 36".

8. **Joints Between AMV Units -** Joints between units are normally grouted with a mortar, and the grouted joints are tooled. Grouted joints are omitted when a dry stack appearance is desired.

C. Summary of Code Requirements: Code provisions governing AMV are somewhat dispersed. The NCBC directly references ACI 530-05/530.1-05 for AMV. While no direct reference appears in the NCRC for adhered masonry veneer, Chapter 43 has a general reference to ACI 530-05/530.1-05, and ACI documents are a valid basis for acceptance of alternate materials. ACI 530-05 requires a "moisture-resistant surface to receive the adhered veneer," consistent with the requirements for a weather resistive barrier required in Chapter 14 of the NCBC and Chapter 7 of the NCRC. Since the substrate commonly used is Portland Cement plaster, Section R703.6.2 of the NCRC and Section 2511 of the NCBC are applicable. Beyond basic limitations on unit dimensions, no requirements for AMV units are included in the codes; therefore, they must be evaluated as an alternate material under Section 105 of the North Carolina Administrative Code and Policies. Below is a summary of code references applicable to AMV:

1. **North Carolina Residential Code, 2009 Edition:**
   - Wood studs may be prescriptively sized in accordance with Section R602.3.1.
   - Prescriptive design tables for metal studs are located in Section R603.
   - Alternately, studs may be designed using the loading criteria in Chapter 3. Note that Table R301.7 requires deflection to be limited to the unbraced wall height divided by 360 for walls with a stucco finish. Limiting deflection to the wall height divided by 600 is recommended to minimize cracking of the substrate and subsequent water penetration, especially for metal studs. Note that $^{H}/_{600}$ is a recommendation and cannot be enforced as a code requirement.
   - Weather resistive barriers are addressed in Sections R703.2 and R703.6.3.
   - Section R703.6 is applicable to the stucco scratch coat, lath, and associated accessories.
   - Table R702.1 (1) specifies the minimum thickness of the plaster substrate. Two coats are required by Section R703.6.2 to comprise the total thickness specified in the table.
   - Proportions for the plaster mix are set forth in Table R702.1 (3). ASTM C 926 is referenced for further material and installation requirements for the plaster.
   - Installation of lath and accessories for the plaster is governed by ASTM C 1063.
   - Flashings are required by Section R703.8, and weep screeds are addressed in Section R703.6.2.1.

2. **North Carolina Building Code, 2009 Edition:**
   - Studs must be sized for the loading requirements of Chapter 16. Subject to the limitations of Sections 2308.2 and 2308.9.1, wood studs may alternately be sized

prescriptively using Table 2308.9.1 for structures classified as conventional wood frame construction. Table 1604.3 allows studs sized for a deflection of the wall height divided by 240 under wind or seismic loads. Limiting deflection to the wall height divided by 600 is recommended to minimize cracking of the substrate and subsequent water penetration, especially for metal studs.

- Weather resistive barriers are addressed in Sections 1403.2, 1404.2, and 2510.6. Unless tested in accordance with ASTM E 331, the wall system must be designed to drain water out of the wall assembly. Potential condensation within the wall assembly must also be addressed in the design.
- Sections 2510 and 2511 are applicable to the stucco scratch coat, lath, and associated accessories.
- By reference, the minimum thickness of the plaster substrate is governed by ASTM C 926, requiring a minimum thickness total thickness of $^{5}/_{8}$". Two coats minimum are required by Section 2512.1 to comprise the total thickness specified by ASTM C 926.
- Proportions for the plaster mix are set forth in ASTM C 926, Table 3. Seven acceptable base coat mixes are specified in this Table.
- Installation of lath and accessories for the plaster is governed by Section 2510 and, by reference, ASTM C 1063.
- Flashings are required by Sections 1403.2, 1404.2, and 1405.3. Weep screeds are addressed in Section 2512.1.2.
- Section 1405.9 references ACI 530-05 for AMV.
- Interior AMV is addressed in Section 1405.9.1. Maximum weights of interior veneers are allowed to be 20 psf. Deflections of horizontal members supporting the AMV, such as lintels, beams or arches, are limited to the span of the member divided by 600. Limitations on deflection in this case are intended to prevent veneer units from delaminating from the backup and falling when the member deflects.
- If exterior walls of frame construction are required to be fire rated, then the AMV must be included in the ASTM E119 test assembly used to establish the fire rating, unless fire rating is required only from the interior side of the wall. Differential expansion between the veneer and the backup and thermal bowing of the wall studs could cause delamination of the veneer from the backup under fire conditions resulting in loss of support for the veneer. For this reason, it may not be valid to assume the fire rating of the wall assembly without the veneer is applicable to the wall assembly with the veneer.
- Section 1704.13 provides the CEO with the option of requiring special inspection for the wall system on buildings regulated by the NCBC.

3. **ACI 530-05/530.1-05:** Design of AMV is governed by Section 6.3 of ACI 530-05. There are two options for compliance, a performance based option and a prescriptive option. The performance based option should only be allowed when a Registered Design Professional is retained to perform the design. Highlights of the prescriptive method are presented below.
   - AMV units are limited to $2^{5}/_{8}$" maximum in thickness. Units are limited to 720 square inches in face area with no dimension larger than 36".
   - Weight of the veneer for exterior applications may not exceed 15 psf.
   - Wall height, wall length, and area of the veneer are limited only by limitations on differential movement between the veneer and the backup. Differential movement may result from differential shrinkage between the veneer and the backup or thermal bowing of the wall. Uncontrolled differential movement can

cause cracking in the veneer and backup accompanied by subsequent water penetration. Generally, differential movement is controlled by designing a system of control joints and/or expansion joints for the wall. ASTM C 1063, referenced by both the NCRC and the NCBC, requires controls joints in walls at intervals no greater than 144 square feet and in ceilings, curves, and angled structures at intervals no greater than 100 square feet.

- Backup to the veneer is permitted to be masonry, concrete or Portland Cement plaster on metal lath. Metal lath may be applied over masonry, concrete, wood framing, or metal framing. In addition ACI 530-05 states, "Backing shall provide a continuous, moisture-resistant surface to receive the adhered veneer." This statement is consistent with the requirement for a water resistive barrier specified by the NCBC and the NCRC.
- Bond between the AMV and the substrate must be tested in accordance with ASTM C 482 and produce a minimum shear strength of 50 psi.

4. **North Carolina Administrative Code and Policies (NCACP), 2009 Edition:**
   - Section 105 of the North Carolina Administrative Code and Policies allows the consideration and acceptance of materials and methods outside of the prescriptive requirements of the technical codes provided evidence is submitted to the satisfaction of the CEO that the material or method complies with the intent of the technical codes.
   - For more information see the NCDOI Evaluation Services white paper "Process for Submission and Consideration of Alternate Material Design or Methods of Construction and Equipment" located on the NCDOI website at http://www.ncdoi.com/OSFM/Engineering/engineering_wpt.asp .

D. Materials for AMV Construction: Material specifications below are recommended for AMV construction. Certain materials are required by code or by references in the codes. These materials are distinguished by mandatory language associated with their specification. Examples of mandatory language are "shall," "must," and "required." Recommended materials are distinguished by use of non-mandatory language; for example, "should," "optional" and "recommended" are indicative of non-mandatory language.

1. **AMV Units -** AMV units have no material specifications mandated by the codes, nor are there any consensus standards for the units. Currently, there is an ASTM committee working on consensus standards, but the standards are not expected to be published for several years. As a result, the units must be evaluated as an alternate material under Section 105 of the NCACP. ICC-ES has an evaluation criteria for AMV units, AC 51, and AMV products should be evaluated using this criteria as a guide. See Section F2 of this document for recommended testing requirements.

2. **Bedding Mortar –** Bedding Mortar shall comply with ASTM C 270, and must produce a shear strength of 50 psi when tested in accordance with ASTM C 482. Several suggested mortar mixes are recommended by the Masonry Veneer Manufacturer's Association (Technical Reference 1). Color pigments, integral bonding agents, or other admixtures may be used when certified as acceptable by the AMV manufacturer and incorporated in the test mix. Calcium chloride should be prohibited as a mortar admixture, since calcium chloride will accelerate corrosion of any ferrous metal components of the wall assembly, including fasteners.

3. **Portland Cement Plaster -** Material specifications for Portland Cement plaster used for the substrate depend on the code governing the construction.
   - For single family construction, ASTM C 926 governs the materials for the Portland Cement plaster, and Table R702.1 (3) of the NCRC governs the mix proportions.
   - For applications regulated by the NCBC both the materials for the Portland Cement plaster and the mix proportions are governed by ASTM C 926. Any of the seven base coat mixes specified by ASTM C 926 are acceptable. Consult the manufacturer of the AMV for the preferred mix.
   - Acceptable cements are Portland Cement (ASTM C 150, Type I, II, or III), Masonry Cement (ASTM C 91, Type N, S, or M), Blended Hydraulic Cement (ASTM C 595, Type IP, I(PM), IS, or I(SM)), or Plastic Cement (ASTM C 1328).
   - Type “S” Hydrated Lime shall comply with ASTM C 206 or ASTM C 207 and shall contain no more than 8% unhydrated oxides when tested in accordance with ASTM C 25.
   - Sand aggregate shall conform to ASTM C 897, and Perlite, if used, must comply with ASTM C 35.
   - Mixing water must be potable.
   - Admixtures must comply with the appropriate ASTM specification governing the specific type of admixture, and admixtures must not interfere with bond of the bedding mortar to the finished plaster.
   - Reinforcing fibers, if used, shall be alkali-resistant fibers conforming to ASTM C 1116. Glass fibers, polypropylene, nylon, and carbon fibers are all regulated under this specification.

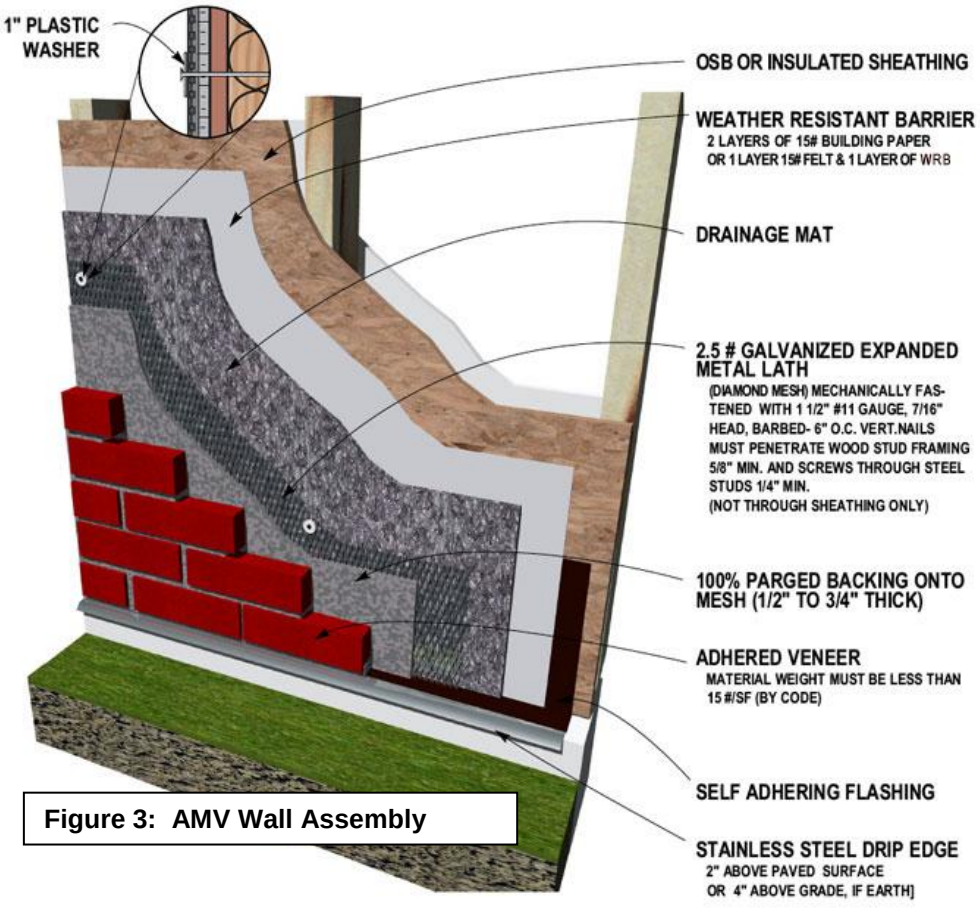

Figure 3: AMV Wall Assembly

4. **Lath –** Lath provides a base for the stucco to adhere to. Furring the lath off the sheathing a quarter ($^1/_4$”) inch helps create a drainage plane behind the stucco. Corrosion resistant metal materials are required by code for the lath. Several different types of lath are acceptable under ASTM C 1063, listed and discussed below:
   - Expanded metal lath is probably the most common lath used in North Carolina. Also referred to as diamond lath, expanded metal lath is manufactured by cutting slits in a light gage metal sheet and pulling the sheet to expand the slits into diamond shaped perforations. Governed by ASTM C 847, steel for the lath is specified as ASTM A 653 with a G60 galvanizing. ASTM C 847 allows lath weights of 2.5 lbs/yd^2 and 3.4 lbs/yd^2; although, expanded metal lath is also manufactured in a weight of 1.75 lbs/yd^2. Since AMV is a relatively heavy veneer, the stiffer 3.4 lbs/yd^2 lath is recommend for AMV installations. Expanded metal lath may be dimpled or ribbed to create a self-furring lath. This lath may also be paper backed with Grade D kraft building paper, intended as part of a weather resistive barrier.
   - Welded wire lath is manufactured from galvanized steel wire conforming to ASTM A 641 welded into a grid. ASTM C 933 governs the manufacture of welded wire lath. Typically, either a 1½”x1½”x 17 gauge or a 2”x2”x16 gauge mesh is acceptable for use with AMV. Self-furring mesh is manufactured by crimping the lath. The 16 gauge welded wire lath is also available with a paper backing, intended to reduce the amount of plaster used and reduce blowback during spray applications. Paper backing for this lath is not intended as a weather resistive barrier.
   - Woven wire lath, also called chicken wire, is governed by ASTM C 1032. Like welded wire lath, steel for woven wire lath must conform to ASTM A 641. Galvanized steel wire is woven into a mesh with hexagonal openings. Generally, woven wire lath is specified by the opening size and wire gauge. Two sizes are specified under ASTM C 1032, 1½”x17 gauge and 1”x20 gauge. As with the welded wire lath, the heavier gauge woven wire lath is best suited for AMV applications. Grade D kraft building paper backing is available, and the mesh may be crimped to create a self-furring lath.
   - Fasteners for attaching lath to wood frame:
     - 11 gauge galvanized roofing nails with $^7/_{16}$” head, or
     - 6d galvanized common nails driven and clenched to engage three strands of lath, or
     - Screws - No. 6, 0.136” diameter shank, Type A pan or wafer head, corrosion resistant and compatible with the metal lath in terms of galvanic corrosion, or
     - 16 gauge (0.062”) galvanized staples with a ¾” wide crown.
     - All fasteners must penetrate a minimum of ¾” into wood studs.
   - Fasteners for attaching lath to steel frame:
     - Screws - No. 6, 0.136” diameter shank, $^7/_{16}$” diameter pan or wafer head, corrosion resistant and compatible with the metal lath and metal studs in terms of galvanic corrosion.
     - Screws shall be self drilling or self tapping, penetrating a minimum of $^3/_8$” into metal studs.

5. **Lath Accessories - Lath** accessories include weep screeds, corner lath, casing beads, Cornerite (Corneraid), control joints, and expansion joints. Requirements for lath accessories are specified in ASTM C 1063. Schwartz and Pruter (Technical Reference 2) discuss lath and accessories in depth along with photographs of the

various accessories and schematic drawings of the various laths currently on the market. Materials for lath accessories include galvanized sheet metal, zinc alloy, and PVC. Lath accessories are very important in controlling the thickness of the stucco, creating joints at terminations and openings, controlling cracking, and helping remove water from behind the stucco.

- Weep screeds – Weep screeds are an accessory, required by code, used in exterior stucco applications to terminate stucco at the base of a wall or over a wall opening.
  - Designed to weep water out of the wall, weep screeds have a vertical attachment flange, required to be a minimum of 3 ½" long, which slides behind the weather resistive barrier and nails or screws to the backup material.
  - Weep screeds are required to be corrosion resistant material at least 0.019" thick (26 gauge if galvanized sheet metal).
  - The bottom edge of the weep screed is formed into a flange, usually sloped and perforated, intended to act as a screed to control the thickness of the stucco. Holes in the weep screed are generally plugged with plaster and are not very effective as weep holes. However, the stucco shrinks back from the flange as it cures leaving a gap where water can weep out from behind the stucco.
- Corner lath – Used to reinforce inside corners, corner lath is a piece of diamond mesh bent at an angle slightly greater than 90^{o}. The outstanding legs of the corner lath are lapped with the lath on each side of the corner and tied to the lath with wire.
- Corner reinforcing – Outside corners in exterior stucco applications are reinforced with products similar to Cornerite or Corneraid. Cornerite is bent-up sheet metal with welded wire flanges extending 2" in both directions from the corner. Typically, Cornerite is fully embedded in the stucco. A bullnose option is available for rounded corners. Corner reinforcing is important to prevent cracking of the stucco and subsequent water penetration in the vicinity of the building corners.
- Casing Beads – Casing beads are J-shaped metal accessories used at opening jambs and transitions between stucco and other materials. From an installation standpoint, casing beads provide a screed to control the stucco thickness at the termination. In service, casing beads provide a smooth termination for the stucco and a surface against which backer rod and joint sealant can be installed.
- Control Joints – In order to control drying shrinkage cracking of the stucco, control joints are installed. Control joints are M-shaped bent up sheet metal bellows with lath flanges for embedment in the stucco. Limited movement of the M-shaped bellows relieves tensile stresses in the stucco that would normally cause the stucco to crack. Typically, control joints are installed vertically at the corners of wall openings and at 144 square foot intervals in the field of the stucco.
- Expansion Joints – Significant cross grain shrinkage can occur in the floor bands of wood frame structures. Consequently, a horizontal expansion joint should be installed at each floor level above the first floor to prevent horizontal cracking of the stucco. An expansion joint is formed from two casing bead shapes with long flanges bent to interlock and create a slip joint. Backer rod and joint sealant is installed between the casing bead J's, allowing movement limited by the travel of the expansion joint, movement capability of the sealant, and the installed geometry of the sealant.

6. **Water Resistive Barrier (WRB) –** Both the NCBC and the NCRC require a water resistive barrier beneath the stucco and lath. A duel layer WRB is required with stucco and, by extension, AMV. Stucco adheres to the outer layer of the WRB, and when the stucco shrinks upon curing, this outer layer wrinkles and sometimes tears. Consequently, the outer layer of the WRB is a sacrificial layer intended to act as a slip sheet protecting the inner layer from wrinkling or tearing. Acceptable materials for the WRB are as follows:
   - Two layers of 15 lb. building felt complying with ASTM D226, Type I.
   - Two layers of 60 minute Grade D building kraft paper evaluated in accordance with ICC-ES Acceptance Criteria AC 38.
   - An inner layer of polymeric house wrap evaluated in accordance with ICC-ES Acceptance Criteria AC 38 with an outer layer of either Grade D building kraft paper or 15 lb. building felt. Some house wraps are manufactured with drainage features designed to help direct water to the flashings. House wraps should be vapor permeable, but not perforated. Perforated wraps generally leak.
   - A single layer of any of the above materials beneath paper backed lath.
   - A single layer of any of the above materials beneath a drainage mat or rain screen.

7. **Flashings -** Flashings are intended to weep water, which penetrates the exterior finish material, out from behind the finish material. Water penetrating the finish material is prevented from entering the building by the WRB. Intruding water runs down the WRB to the flashing, and the flashing directs the water out of the wall drainage space to the exterior of the building.
   - Galvanized sheet steel, rubberized asphalt, PVC, or copper may all be used as flashings.
   - Copper must be electrically isolated from lath and other metal accessories to prevent galvanic corrosion.
   - Aluminum should not be used with cementitous materials like stucco due to the potential for adverse chemical reactions with the alkalis in the cementitious material.
   - Flashings are required at the heads of all wall openings, the sills and jambs of windows and doors, at horizontal transitions between AMV and other materials, above projecting trim or horizontal expansion joints, at the intersection of exterior porches, decks, or stairs with the exterior wall, and at the intersections of low roofs against high walls (run-out conditions).

8. **Joint Sealants and Backer Rods -** Joints formed by casing beads around openings or at terminations and at expansion joints should be filled with appropriate backer rods and joint sealants.
   - Backer rods control the depth of the sealant and prevent adhesion of the sealant on the bottom side of the sealant to the substrate, thus preventing premature failure of the sealant. Closed cell foam backer rods should be used on exterior applications.
   - Joint sealants are formulated to allow environmentally induced movements of a joint while preventing water intrusion. Silicon or polyurethane sealants manufactured for exterior use with stucco, masonry, or EIFS are best suited for AMV applications. Sealants should be UV resistant and compatible with substrates. Primers are required with some sealants.

E. Installation Requirements: Most failures associated with AMV have been the result of poor installation, rather than faulty material. Below are some general installation requirements for AMV. Detailed material and installation specifications are provided in the Masonry Veneer Manufacturers Association Guidelines (Technical Reference 1), including pictorial details of most flashing and transition conditions normally encountered in the field. Schwartz and Pruter (Technical Reference 2) provide very detailed, well illustrated descriptions of the installation of WRB, lath, flashings and scratch coat stucco. A comprehensive checklist for stucco application is also provided in this reference. The AMV manufacturer's installation instructions should supersede the referenced documents only when the manufacturer's literature is more stringent than the reference documents or the manufacturer can show by testing in accordance with ASTM E 331 that his details will provide adequate water resistance.

1. **Installation of Water Resistive Barrier (WRB) –** WRB must be installed in shingle fashion starting at the bottom of wall and working up.
   - Two layers of materials in any of the combinations stated in Section D6 above are required.
   - Codes do not specify frequency of fastening for WRB. For house wraps and drainage mats follow the manufacturer's installation instructions. If there is an ICC-ES evaluation report on the product, then follow any fastening recommendations stated in the report. Otherwise, paper based WRB products should be fastened securely enough to maintain the integrity of the barrier and to hold the barrier in place until the lath is installed.
   - Lap successive shingles of barrier 2" at horizontal joints.
   - Lap barrier shingles 6" at vertical joints.
   - WRB should wrap continuously around both interior and exterior corners.
   - Laps in the second layer of the WRB should stagger with laps in the first layer, so that laps in the two layers do not occur at the same location.

2. **Installation of Flashings –** Flashing installation should be coordinated with the installation of the WRB.
   - Window and door flashings shall be installed in accordance with ASTM E 2112. For windows with flanges or mounting fins, ASTM E 2112 should be supplemented with FMA/AAMA 100. Very detailed illustrations of flashing installation are shown in both documents.
   - Lap opening head flashings, trim flashings, expansion joint flashings, and wall base flashings behind the WRB a minimum of 3".
   - Lap sill flashings over WRB. Seal intersections of sill and jamb flashings. Most residential windows leak at some point in their life. Proper protection of the opening framing is, therefore, imperative.
   - Provide end dams at flashing terminations.
   - One of the most vulnerable points in the field of a wall is at the eaves of low roofs located against a wall, which continues up above the low roof. Water runoff from the roof will be funneled behind the wall cladding at these locations unless run-out flashings are provided to divert the runoff into the gutters or away from the wall and off the roof.
   - Pre-manufactured PVC run-out flashings are available, and they tend to work better than field manufactured metal terminations. Unless the joints of the metal terminations are properly soldered, they are likely to leak.
   - Extend run-out flashings 2" outside the face of the AMV, rather than terminating them at the face of the substrate. Otherwise, the flashing is ineffective.

- Installation of the run-out flashings may require additional trips to the site by the roofer. Coordination between the roofer and the installers of the WRB and cladding materials is imperative.

3. **Installation of Lath and Accessories –** Lath and accessories should be installed in accordance with ASTM C 1063.
   - Weep screeds are required by code and must be provided at the base of all AMV walls, including walls terminating at a low roof, at the heads of openings, and at the horizontal transitions between AMV and other materials below the AMV. Weep screeds and flashing must also be provided at transitions in the substrate beneath the AMV, for instance a transition from wood framing to a CMU foundation wall. Omission of weep screeds has been a major cause of moisture build-up behind the AMV substrate on past installations. Proprietary drainage mats and wicks used in conjunction with metal flashing serve the same purpose as weep screeds and are an acceptable alternative.
   - When AMV is installed over an existing anchored masonry veneer, provision must be made to maintain open weep holes in the existing veneer.
   - AMV must terminate no closer than 4" above soil surfaces and 2" above paved surfaces. Grade clearances prevent capillary wetting of the AMV and substrates. In addition, clearances provide an inspection gap for pest control personnel inspecting for termites.
   - Lath shall be applied with the long dimension at right angles to the supports. Vertical joints between lath sheets must be staggered to avoid a continuous vertical joint on any one support except at control or expansion joints. Lapping the lath and staggering the joints ensures continuous reinforcing for the stucco, thus helping to control cracking.
   - Self-furring lath shall be installed with the protruding dimples toward the inside of the building in order to hold the lath off the sheathing. Cups should be up. Lath that is not self furring should be furred off the sheathing ¼" using special fasteners.
   - Edges of expanded metal lath sheets should be lapped at least 1" with adjacent sheets. Wire mesh lath should be lapped at least one full mesh opening.
   - ASTM 1063 requires lath to be fastened at 7" on center on all supports. For acceptable fastener types see Section D above. Common nails shall be bent over to engage at least three strands of lath. Screws shall engage at least three strands of lath, and the screws may pass through self-furring lath but may not deform the lath. Fastening lath side laps with wire at 7" on center is recommended practice.
   - Control joints shall, according to ASTM 1063, be installed at intervals not to exceed 144 square feet, and should be installed, vertically oriented, at the corners of all wall openings and any other re-entrant corners or wall penetration likely to facilitate cracking. Spacing of control joints is limited to 18 feet in any direction, and panels delineated by control joints are limited to an aspect ration of 2.5:1. While ASTM 1063 is intended primarily for three coat stucco finishes, AMV is a cementitous material and will shrink, as will the scratch coat substrate. Restrained shrinkage of cementitious materials causes cracking. Consequently, it is reasonable to apply the control joint requirements to AMV unless the manufacturer can show test data indicating his specific product will limit water penetration as intended by the code without the control joints.
   - Horizontal expansion joints should be installed at all floor levels above the first floor. In single-family construction weep screeds and associated flashing may be

substituted for expansion joint assemblies. The weep screeds can be blended with the veneer to produce a visually less intrusive joint.
- Lath shall terminate on each side of control joints and expansion joints in order to allow the joints to move as intended.
- Lath accessories should be wired to the lath or attached to the backup at intervals of 9" on center or less.
- Schwartz and Pruter, (Technical Reference 2) pp. 37-42, has an excellent discussion on integration of accessories, lath, and barrier, including guidelines on precedence of accessories at intersections of the accessories. For instance, control joints and expansion joints take precedent over all other accessories. Expansion joints would have precedent over control joints.

4. **Installation of Stucco Scratch Coat -** ASTM C 926 governs the proportioning, mixing and installation Portland Cement plaster, also known as stucco when used in exterior applications. Section D above discusses proportioning and mixing, summarizing the requirements of ASTM C 926, the NCBC and the NCRC. Below are the highlights of the requirements of these three documents governing installation of the plaster, as well as some recommendations from the Technical References indicated.
   - Stucco may be hand applied or spray applied.
   - According to both the NCBC and the NCRC, stucco that is concealed by finish materials is required to be installed in two coats for a thickness totaling $^{5}/_{8}$". The Masonry Veneer Manufacturer's Association (Technical Reference 1) recommends installing plaster utilized for AMV substrate in a single coat of ½". This recommendation is an acceptable alternate to the code requirement provided the installer can show that he can adequately control the thickness of the plaster.
   - Lath should be completely embedded in the plaster.
   - As soon as the plaster becomes firm, the surface shall be scored horizontally to facilitate bond of the bedding mortar. Scoring should be approximately $^{1}/_{8}$" deep, and the score marks should be spaced approximately ½" on center.
   - Stucco should be moist cured. Curing time will depend on ambient temperature and relative humidity. ASTM C 926 requires moist curing, but gives little guidance on curing time. Schwartz and Pruter (Technical Reference 2) recommend a curing period of 24 to 36 hours for scratch coat stucco.

5. **Installation of AMV Units –** Technical Reference 1, the Masonry Veneer Manufacturer's Association Guidelines, is the best general reference for the installation of AMV units. Manufacturer's installation instructions may provide product specific information. When the manufacturer's installation instructions are less stringent than the MVMA Guidelines and the codes, the codes and the Guidelines should govern.
   - Both the substrate and the AMV units should be dampened, saturated surface dry, prior to installing the units.
   - AMV units should be fully buttered (entire back face of the unit) with a half inch layer of bedding mortar.
   - Buttered units should be firmly pressed against the substrate and worked in a back and forth rotational motion until the mortar begins to grab the substrate. Once the mortar begins to grab, further motion will break the bond, and the unit

must be cleaned, re-buttered, and reset.

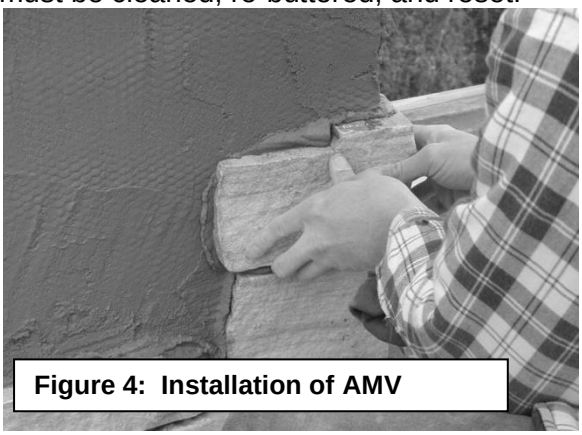

Figure 4: Installation of AMV

- Bedding mortar should be allowed to cure before joints between units are grouted.
- Grout should be installed with a grout bag and allowed to set thumb-print hard before the joints are tooled.
- AMV units and grout between units should not be installed across control joints and expansion joints. Installing units across control or expansion joints or fouling joints with grout may restrict movement of the joints and facilitate cracking of the veneer.
- Sloped AMV units should be used at window sills and horizontal transitions between AMV and other materials to drain water away from the face of the wall.
- Joint sealants should be installed in accordance with manufacturer's written instructions. Particular attention should be paid to substrate preparation, and if required by the manufacturer, primers should be applied.

F. Submittals Which May Be Required By the CEO:

1. **ICC-ES Report –** An evaluation report complying with ICC-ES AC 51 should be submitted. **Submittal of test data indicated below is not necessary if the product has been evaluated by ICC-ES with the exception of ASTM E 331 data**. An evaluation report for both interior and exterior applications and ASTM E 331 data for exterior applications is highly recommended for any product using substrates other than masonry, concrete, or Portland Cement Plaster. Products adhered directly to cement board with no WRB should be used in interior applications only. Gypsum wallboard should not be used as a substrate to which AMV is directly adhered, even on interior applications.

2. **Test Data -** If the manufacturer of the AMV does not have an evaluation report, then the CEO may use AC 51 as a guide to the testing required to establish acceptability. Testing conducted by a testing agency acceptable to the CEO, should include:
   - Density of the units, ASTM C 567, is required to determine the acceptance criteria for the absorption test and to compare with weight limitations from ACI 530-05. For exterior applications the veneer must weigh 15 psf or less. A weight of 20 psf is acceptable for interior veneers.
   - Compressive strength of units, ASTM C 192 and C 39 (1800 psi minimum), provides an indication of the overall structural quality and durability of the units.
   - Tensile strength of units, ASTM C 190, is important in resisting wind suction and tensile stresses due to restrained shrinkage. Note that ASTM has withdrawn this

standard. As a result, this data may not be available, and compressive strength and flexural strength may have to be extrapolated to assess tensile strength.

- Flexural strength of units, ASTM C 348, is important for resisting both wind and seismic loadings, as well as stresses associated with thermal and foundation movements.
- Moisture absorption per Section 4.6 of AC 51. Acceptance criteria is specified in Table 2 of AC 51 and is a function of density of the unit. Absorption is an important indication of durability and resistance to water penetration. In addition, absorption affects the shear bond strength between the unit and the bedding mortar. Units with excessively high rates of absorption may suck water out of the bedding mortar, reducing bond capability.
- Shear bond between units and the substrate, ASTM C 482 as modified by Section 4.7 of AC 51, indicates the resistance of the units to delamination from the substrate. Minimum shear bond strength is 50 psi.
- Compressive strength of mortar, ASTM C 109, indicates strength of the mortar and compatibility of the mortar with the units. Compressive strength of mortar shall not exceed the compressive strength of the units by more than 10%.
- Freeze-thaw test on veneer specimens, sampled in accordance with ASTM C 67, is a measure of durability. Samples should be subjected to 50 cycles of freezing and thawing, until they break or until they have lost 3% of their initial weight. Acceptance criteria per Section 4.2 of AC 51 is recommended.
- When Manufacturer's installation details deviate from MVMA guidelines, the CEO may request testing conducted in accordance with ASTM E 331 on a mock-up complying with exception #2 of Section 1403.2 of the NCBC to show the assembly is water resistant.

3. **Manufacturer's Installation Instructions –** Manufacturer's written installation instructions should be submitted. Where manufacturer's installation instructions are less stringent or less detailed than the Masonry Veneer Manufacturer's Association guidelines (Technical Reference 1), the MVMA guidelines, the codes, and this document should govern the installation.

4. **Installer's Credentials –** Evidence should be submitted by the installer that he has been trained and certified by the AMV manufacturer to install the manufacturer's products.

G. Field Inspection: Inspecting AMV is a two phase process. Integrity of the WRB and drainage plane are of prime importance. Consequently, WRB, flashing, and lath installation should be inspected while still visible. One approach to inspecting the WRB, the flashings and the lath is to require them to be installed prior to the framing inspection and inspect them at the framing inspection. Another approach would be to conduct a separate cladding inspection. Installation of the AMV units can be inspected during the building final inspection.

1. **Verify installation of the WRB –** At framing or cladding inspection verify the following:
   - WRB is two layers of material in one of the combinations indicated in Section D above.
   - WRB is secured to the sheathing without puckers or wrinkles.

- WRB is installed in shingle fashion with horizontal joints between successive tiers lapped 2" minimum.
- Any penetrations or tears in the WRB have been sealed.
- Flashings have been provided at locations required by the NCBC, the NCRC and the manufacturer's installation instructions or the Masonry Veneer Manufacturer's guidelines (Technical Reference 1).
- Flashings have been properly installed and sequenced with the WRB.
- Flashing joints are properly lapped and sealed.

2. **Verify installation of lath and accessories –** At framing or cladding inspection verify the following:
   - Lath is corrosion resistant material and one of the types permitted by ASTM C 1063 (See Section D above).
   - Lath is furred ¼" off the sheathing using either self-furring lath or furred off with fasteners designed for the purpose of furring the lath.
   - Lath is secured to the framing at 7" on center with fasteners complying with ASTM C 1063 (See Section D above).
   - Lath is lapped 1" at edges for expanded metal lath or 1 mesh opening for wire mesh lath.
   - Corner reinforcing is provided.
   - Weep screeds are provided at the bases of walls and the heads of openings, and weep screeds are properly installed with the attachment flange lapped behind the WRB at least 3".
   - Casing beads are provided at opening jambs and transitions between AMV and other cladding materials with sufficient clearance for installation of joint sealants. Alternate details are acceptable when the manufacturer provides test data in accordance with ASTM E 331 showing water penetration will not occur. The test assembly should comply with exception #2 in Section 1403.2 of the NCBC for buildings regulated by both the NCBC and the NCRC.
   - Control joints are installed at intervals not exceeding 144 square feet with no dimension between joints greater than 18 feet, unless the manufacturer can show test data indicating that greater spacing or elimination of control joints will not result in visible cracking leading to excessive water penetration of the veneer.

3. **Verify installation of AMV units –** At final inspection verify the following:
   - Lath is not visible in AMV joints.
   - AMV is not installed over control joints or expansion joints.
   - Clearance for weep screeds of 4" from soil and 2" from paved surfaces is maintained.
   - Joint sealants are installed.
   - There is no visible cracking in the veneer.

H. Reference Standards: The following standards are pertinent to AMV construction.

1. ACI 530-05/ASCE 5-05/TMS 402-05, "Building Code Requirements for Masonry Structures." American Concrete Institute, Structural Engineering Institute of the American Society of Civil Engineers, The Masonry Society.

2. ASCE 530.1-05/ASCE 6-05/TMS 602-05, “Specification for Masonry Structures.” American Concrete Institute, Structural Engineering Institute of the American Society of Civil Engineers, The Masonry Society.

3. ICC-ES Acceptance Criteria AC 38, “Acceptance Criteria for Water Resistive-Barriers,” effective November 1, 2009.

4. ICC-ES Acceptance Criteria AC 51, “Acceptance Criteria for Precast Stone Veneers,” effective March 1, 2008.

5. ASTM A 641-03, “Specification for Zinc-coated (Galvanized) Carbon Steel Wire.”

6. ASTM A 653-04a, “Specification for Sheet Steel, Zinc-coated Galvanized or Zinc-iron Alloy-coated Galvannealed by the Hot-dip Process.

7. ASTM C 25-06, “Standard Test Methods for Chemical Analysis of Limestone, Quicklime, and Hydrated Lime.”

8. ASTM C 33-08, “Specification for Concrete Aggregates.”

9. ASTM C 35-95, “Standard Specification for Inorganic Aggregates for Use in Gypsum Plaster.”

10. ASTM C 39-09, “Test Method for Compressive Strength of Cylindrical Concrete Specimens.”

11. ASTM C 67-03ae01, “Test Methods for Sampling and Testing Brick and Structural Clay Tile.”

12. ASTM C 91-03a, “Specification for Masonry Cement.”

13. ASTM C 109-02, “Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. Cube Specimens).”

14. ASTM C 144-04, “Specifications for Aggregate for Masonry Mortar.”

15. ASTM C 150-04, “Specification for Portland Cement.”

16. ASTM C 190-85, “Test Method for Tensile Strength of Hydraulic Cement Mortars.” Note: ICC-ES AC 51 references this standard, but ASTM lists this standard as withdrawn in 1990.

17. ASTM C 192-07, “Practice for Making and Curing Concrete Test Specimens in the Laboratory.”

18. ASTM C 206-03, “Specification for Finishing Hydrated Lime.”

19. ASTM C 207-04, “Specification for Hydrated Lime for Masonry Purposes.”

20. ASTM C 270-04, “Specification for Mortar for Unit Masonry.”

21. ASTM C 330-04, “Specification for Lightweight Aggregates for Structural Concrete.”

22. ASTM C 331-04, “Specification for Lightweight Aggregates for Concrete Masonry Units.”

23. ASTM C 348-08, “Test Method for Flexural Strength of Hydraulic Cement Mortars.”

24. ASTM C 482-02,”Test Method for Bond Strength of Ceramic Tile to Portland Cement.”

25. ASTM C 567-05a, “Test Method for Unit Weight of Structural Lightweight Concrete.”

26. ASTM C 595-03, “Specification for Blended Hydraulic Cements.”

27. ASTM C 847-00, “Specification for Metal Lath.”

28. ASTM C 897-00, “Specification for Aggregate for Job-mixed Portland Cement-based Plasters.”

29. ASTM C 926-98a, “Specification for Application of Portland Cement-based Plaster.”

30. ASTM C 933-04, “Specification for Welded Wire Lath.”

31. ASTM C 1032-04, “Specification for Woven Wire Plaster Base.”

32. ASTM C 1063-03, “Specification for Installation of Lathing and Furring to Receive Interior and Exterior Portland Cement Based Plaster.”

33. ASTM C 1116-10, “Standard Specification for Fiber-Reinforced Concrete.”

34. ASTM C 1328-03a, “Specification for Plastic (Stucco Cement).”

35. ASTM D 226-97a, “Specification for Asphalt-saturated Organic Felt Used in Roofing and Waterproofing.”

36. ASTM E 331-00, “Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference.”

37. FMA/AAMA 100-07, “Standard Practice for Installation of Windows with Flanges or Mounting Fins in Wood Frame Construction.”

I. Technical References: The following documents contain technical information useful in understanding AMV construction.

1. “Installation Guidelines for Adhered Concrete Masonry Veneer,” Masonry Veneer Manufacturer’s Association, Washington, D.C., June 08, 2010. Download free at www.masonryveneer.org .

2. Max Schwartz and Walter F. Pruter, “Builders Guide to Stucco, Lath, and Plaster,” Builder’s Book, Inc. Canoga Park, CA, 2007. Purchase at www.buildersbook.com .

3. John M. Melander, James A. Farny, and Albert W. Isberner, Jr., “Portland Cement Plaster/Stucco Manual,” Portland Cement Association, Skokie, IL, 2007. Purchase at www.cement.org .

4. Steve Easley, “Weatherproofing and Synthetic Stone Veneers,” GreenBuilder Magazine, December 2009.

5. National Home Builders Association, “Improving Drainage and Drying Features in Certain Conditions: Rain Screen Designs for Absorptive Claddings,” December 2008.

6. Dennis McCoy, “Manufactured Stone Nightmares,” Journal of Light Construction, December 2004.

7. Mark Parlee, “Rescuing a Manufactured-Stone Wall,” Journal of Light Construction, December 2008.

8. Joseph Lstiburek, “The Perfect Storm Over Stucco,” ASHRAE Journal, February 2008.

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