



Standard Guide for Design and Construction of Low-Rise Frame Building Wall Systems to Resist Water Intrusion¹

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1. Scope

1.1 This guide describes design, specification, selection, installation, and inspection of new building wall systems, exterior deck and stair components, doors, windows, penetrations and sealant joints of wood and metal frame buildings, typically four stories or less, to minimize water intrusion.

1.2 This guide does not address prevention of damage caused by water originating from the use of wet building materials or from indoor or outdoor humidity. Water from these sources can be important, and the potential for damage caused by water from these sources must not be overlooked in building design or construction.

1.3 This guide does not address roofing systems, except when the surface of a deck also serves as a roof and at locations where roof systems interface with building walls.

1.4 This guide does not address any type of barrier wall system.

1.5 This guide does not address any exterior insulation and finish system (EIFS).

1.6 This guide does not address foundation conditions where the bottom of a slab on grade or the grade of a crawl space is at or below the water table or subject to hydrostatic pressure.

1.7 This guide is intended to supplement and not duplicate building code requirements.

1.8 Maintenance, although important, is not covered in detail.

1.9 Application of finishes, such as paint and sealers, may be important in the performance of some types of cladding; however, this is not covered in detail.

¹ This guide is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.55 on Exterior Building Wall Systems.

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1.10 This guide applies only to constructions with sheathing, which facilitates installation of the weather-resistive barrier and associated flashings in a common plane.

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

1.12 *This standard may involve hazardous materials, operations, and equipment. 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 requirements prior to use.*

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2. Referenced Documents

2.1 *ASTM Standards*:²

- A153/A153M Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
- C11 Terminology Relating to Gypsum and Related Building Materials and Systems
- C43 Terminology of Structural Clay Products (Withdrawn 2009)³
- C55 Specification for Concrete Building Brick
- C62 Specification for Building Brick (Solid Masonry Units Made From Clay or Shale)
- C67 Test Methods for Sampling and Testing Brick and Structural Clay Tile
- C90 Specification for Loadbearing Concrete Masonry Units
- C126 Specification for Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Units
- C150 Specification for Portland Cement
- C168 Terminology Relating to Thermal Insulation
- C216 Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale)
- C270 Specification for Mortar for Unit Masonry
- C652 Specification for Hollow Brick (Hollow Masonry Units Made From Clay or Shale)
- C717 Terminology of Building Seals and Sealants
- C755 Practice for Selection of Water Vapor Retarders for Thermal Insulation
- C836 Specification for High Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane for Use with Separate Wearing Course
- C896 Terminology Relating to Clay Products
- C898 Guide for Use of High Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane with Separate Wearing Course
- C920 Specification for Elastomeric Joint Sealants
- C926 Specification for Application of Portland Cement-Based Plaster
- C957 Specification for High-Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane With Integral Wearing Surface
- C981 Guide for Design of Built-Up Bituminous Membrane Waterproofing Systems for Building Decks
- C1063 Specification for Installation of Lathing and Furring to Receive Interior and Exterior Portland Cement-Based Plaster
- C1088 Specification for Thin Veneer Brick Units Made From Clay or Shale
- C1127 Guide for Use of High Solids Content, Cold Liquid-

- Applied Elastomeric Waterproofing Membrane with an Integral Wearing Surface
- C1180 Terminology of Mortar and Grout for Unit Masonry
- C1186 Specification for Flat Fiber-Cement Sheets
- C1193 Guide for Use of Joint Sealants
- C1209 Terminology of Concrete Masonry Units and Related Units (Withdrawn 2009)³
- C1232 Terminology of Masonry
- C1299 Guide for Use in Selection of Liquid-Applied Sealants (Withdrawn 2012)³
- C1400 Guide for Reduction of Efflorescence Potential in New Masonry Walls
- C1405 Specification for Glazed Brick (Single Fired, Brick Units)
- D226 Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
- D1079 Terminology Relating to Roofing and Waterproofing
- D1970 Specification for Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steep Roofing Underlayment for Ice Dam Protection
- D3679 Specification for Rigid Poly(Vinyl Chloride) (PVC) Siding
- D4477 Specification for Rigid (Unplasticized) Poly(Vinyl Chloride) (PVC) Soffit
- D4756 Practice for Installation of Rigid Poly(Vinyl Chloride) (PVC) Siding and Soffit
- D5843 Guide for Application of Fully Adhered Vulcanized Rubber Sheets Used in Waterproofing
- D5898 Guide for Details for Adhered Sheet Waterproofing
- D5957 Guide for Flood Testing Horizontal Waterproofing Installations
- D6134 Specification for Vulcanized Rubber Sheets Used in Waterproofing Systems
- D6135 Practice for Application of Self-Adhering Modified Bituminous Waterproofing
- D6622 Guide for Application of Fully Adhered Hot-Applied Reinforced Waterproofing Systems
- D6864 Specification for Color and Appearance Retention of Solid Colored Plastic Siding Products
- E241 Guide for Limiting Water-Induced Damage to Buildings
- E331 Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference
- E547 Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Cyclic Static Air Pressure Difference
- E631 Terminology of Building Constructions
- E1105 Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Static Air Pressure Difference
- E1677 Specification for Air Barrier (AB) Material or System for Low-Rise Framed Building Walls
- E1825 Guide for Evaluation of Exterior Building Wall Materials, Products, and Systems
- E2112 Practice for Installation of Exterior Windows, Doors and Skylights

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 The last approved version of this historical standard is referenced on www.astm.org.

F1667 Specification for Driven Fasteners: Nails, Spikes, and Staples

2.2 *AAMA Standards:*⁴

AAMA 501 Methods of Test for Metal Curtain Walls

AAMA 501.2 Field Check of Metal Curtain Walls for Water Leakage

AAMA 502 Voluntary Specification for Field Testing of Windows and Sliding Doors

AAMA 850 Fenestration Sealants Guide Manual

AAMA IM-TM InstallationMasters Training Manual Window Selection Guide

2.3 *ACI Standards:*⁵

ACI 524 Guide to Portland Cement Plastering

2.4 *ANSI Standards:*⁶

ANSI/ASCE 7 Building Code Requirements for Minimum Design Loads in Buildings and Other Structures

ANSI/AHA A135.6 American National Standard for Hardboard Siding

ANSI/AAMA/NWDA 101/I.S. 2-97 Voluntary Specifications for Aluminum, Vinyl (PVC) and Wood Windows and Glass Doors

ANSI/AAMA/WDMA 101/I.S. 2/NAFS-02 Voluntary Performance Specification for Windows, Skylights, and Glass Doors

2.5 *APA Standards:*⁷

APA 303 Siding Manufacturing Specifications

Avoiding Moisture Accumulation in Walls

Buckling of Wood-Based Panel Siding

Installation of Stucco Exterior Finish Over Wood Structural Panel Wall Sheathing

Product Guide Performance Rated Sidings

2.6 *AWPA Standards:*⁸

AWPA C2 Lumber, Timbers, Bridge Ties and Mine Ties, Pressure Treatment

AWPA C28 Preservative Treatment by Pressure Processes of Structural Glue Laminated Members and Laminations Before Gluing

AWPA M4 Care of Pressure Treated Wood Products

2.7 *BIA Standards:*⁹

Technical Notes on Brick Construction

2.8 *CCMC Standards:*¹⁰

NRCC-45-673 Technical Guide for Sheathing, Membrane, Breather-Type

2.9 *CGSB Standards:*¹¹

CAN/CGSB 51.32-M77 Sheathing, Membrane, Breather Type

2.10 *CMHC Standards:*¹²

Wood-Frame Envelopes in the Coastal Climate of British Columbia

2.11 *CPA Standards:*¹³

ANSI/AHA 135.6 Hardboard Siding

Recommended Basic Application Instructions for Hardboard Siding

Coatings Specification for Field-Applied Coatings on Hardboard Siding

Finishing Recommendations for New Construction Using Unprimed and Primed Hardboard Siding

Maintenance Tips for Hardboard Siding

2.12 *CSSB Standards:*¹⁴

Wall Construction Manual

Grading Rules for Certigrade Red Cedar Shingles

Grading Rules for Certi-Split Red Cedar Shakes

Grading Rules for Tapersawn Red Cedar Shakes

2.13 *Federal Specification:*¹⁵

UU B 790a Building Paper

2.14 *ICC-ES Standards:*¹⁶

AC38 Acceptance Criteria for Weather-Resistive Barriers

AC39 Acceptance Criteria for Walking Decks

2.15 *MLPB Standards:*¹⁷

Stucco in Residential Construction

2.16 *NCMA Standards:*¹⁸

NCMA TEK Bulletins

2.17 *NELMA Standards:*¹⁹

Standard Grading Rules for Northeastern Lumber

2.18 *NRCA Standards:*²⁰

NRCA Roofing and Waterproofing Manual

2.19 *NWCB Standards:*²¹

Stucco Resource Guide

¹¹ Available from Canadian General Standards Board (CGSB), Gatineau, Canada K1A1G6.

¹² Available from Canadian Mortgage and Housing Corporation (CMHC), 700 Montreal Road, Ottawa, Ontario, K1A 0P7, Canada. <http://www.cmhc-schl.gc.ca>.

¹³ Available from Composite Panel Association (CPA), 19465 Deerfield Avenue, Suite 306, Leesburg, VA 20176. <http://www.pbmdf.com>.

¹⁴ Available from Cedar Shake and Shingle Bureau (CSSB), P.O. Box 1178, Sumas, WA 98295-1178. <http://www.cedarbureau.org>.

¹⁵ Available from General Services Administration (GSA), One Constitution Square, 1275 First Street, NE, Washington, DC 20417. <http://www.gsa.gov>.

¹⁶ The ICC Evaluation Service (ICC-ES) is reviewing Acceptance Criteria previously issued by the ICBO Evaluation Service. At the publication of this standard, AC38 and AC39 are considered Interim Criteria. ICC Evaluation Service, Inc., 5360 Workman Mill Rd., Whittier, CA 90601-2298. <http://www.icc-es.org>.

¹⁷ Available from Minnesota Lath and Plaster Bureau (MLPB), 10600 University Avenue NW, Suite 1-B, Coon Rapids, MN 55448. <http://www.mnlath-plaster.com>.

¹⁸ Available from National Concrete Masonry Association (NCMA), 13750 Sunrise Valley Drive, Herndon, VA 20171-4662. <http://www.ncma.org>.

¹⁹ Available from Northeastern Lumber Manufacturers Association (NELMA), 272 Tuttle Road, P.O. Box 87A, Cumberland Center, ME 04021. <http://www.nelma.org>.

²⁰ Available from National Roofing Contractors Association (NRCA), 10255 W. Higgins Road Suite 600, Rosemont, IL 60018. <http://www.nrca.net>.

²¹ Available from Northwest Wall and Ceiling Bureau (NWCB), 1032-A NE 65th Street, Seattle, WA 98115. <http://www.nwcb.org>.

⁴ Available from American Architectural Manufacturers Association (AAMA), 1827 Walden Office Square, Suite 550, Schaumburg, IL 60173-4628. <http://www.aamanet.org>.

⁵ Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094. <http://www.concrete.org>.

⁶ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036. <http://www.ansi.org>.

⁷ Available from APA – The Engineered Wood Association, 7011 S. 19th Street, Tacoma, WA 98466-5333. <http://www.apawood.org>.

⁸ Available from American Wood Protection Association (AWPA), P.O. Box 361784, Birmingham, AL 35236-1784. <http://www.awpa.com>.

⁹ Available from Brick Industry Association (BIA), 1850 Centennial Park Drive, Suite 301, Reston, VA 20191. <http://www.gobrick.com>.

¹⁰ Available from Canadian Construction Materials Centre (CCMC), Institute for Research in Construction, National Research Council Canada, Montreal Road, Building M-24, Ottawa, Ontario K1A R6. <http://www.nrc-cnrc.gc.ca>.

- 2.20 *PCA Standards*:²²
Portland Cement (Stucco) Manual
- 2.21 *RIS Standards*:²³
Standard Specifications for Grades of California Redwood Lumber
- 2.22 *SMACNA Standards*:²⁴
Architectural Sheet Metal Manual
Residential Sheet Metal Guidelines
- 2.23 *SPC Standards*:²⁵
Guide to Southern Pine Siding
- 2.24 *SPIB Standards*:²⁶
Standard Grading Rules for Southern Pine Lumber
- 2.25 *SPRI Standards*:²⁷
Flexible Membrane Roofing: A Professional's Guide to Specifications
- 2.26 *SWRI Standards*:²⁸
Sealants The Professional's Guide
- 2.27 *TCA Standards*:²⁹
Ceramic Tile Handbook
- 2.28 *TLPC Standards*:³⁰
Lath and Plaster Systems Manual
- 2.29 *USDC-FPL Standards*:³¹
Gen. Tech. Rep. FPL-GTR-113 Wood Handbook—Wood as an Engineering Material
- 2.30 *USDC-NIST Standards*:³²
DOC PS 20 American Softwood Lumber Standard
- 2.31 *VSI Standards*:³³
Installation: A How To Guide
- 2.32 *WCLIB Standards*:³⁴
Standard No. 17 Grading Rules for West Coast Lumber

- 2.33 *WDMA Standards*:³⁵
WDMA I.S. 4 Water-Repellent Preservative Non-Pressure Treatment for Millwork
- 2.34 *WRCLA Standards*:³⁶
Installing Siding
- 2.35 *WSCPA Standards*:³⁷
Design Guide for Anchored Brick Veneer Over Steel Studs
- 2.36 *WWPA Standards*:³⁸
Natural Wood Siding: Selection Installation and Finishing
Western Wood Grading Rules

3. Terminology

3.1 *Definitions*—For terms used in this standard, refer to Terminology E631. For an explanation of terms that may be used in referenced documents refer to Terminologies C43, C168, C717, C896, C1180, C1209, C1232, and D1079.

3.2 *Definitions of Terms Specific to This Standard*:

3.2.1 *air retarder (AR)*—also commonly referred to as “air barrier” and “house wrap;” a material or system in building construction that is designed and installed to reduce air leakage either into or through an opaque wall. Refer to Specification E1677.

3.2.2 *barrier wall*—type of wall system that is intended to manage all precipitation at the exterior surface of the cladding and associated sealants and flashings. These walls are designed to prevent water intrusion by a combination of a water barrier on the exterior surface and temporary absorption of water.

3.2.2.1 *Discussion*—These wall systems consist of the exterior surface of the wall and the exterior surface of fenestration products, usually connected by a sealant joint. Barrier wall systems may include fenestration systems that collect and drain water to the exterior.

3.2.3 *building wall components*—materials that function as or are designated as being essential to the effective weatherproofing of the building.

3.2.4 *cladding*—the outermost component of the wall system that provides resistance to intrusion of water originating as precipitation into the wall. Examples of cladding are portland cement plaster (stucco), wood and wood-based siding, wood shingles, masonry veneer, and vinyl and aluminum siding.

3.2.5 *deck*—a horizontal surface intended for human occupancy or use that is exposed to the weather.

3.2.6 *drainage wall*—a wall system in which the cladding provides a substantial barrier to water intrusion, but which also incorporates means for dissipating water that may circumvent the cladding. For purposes of this standard a drainage wall is assumed to incorporate a concealed weather-resistive barrier over which drainage, away from water-sensitive components

²² Available from Portland Cement Association (PCA), 5420 Old Orchard Road, Skokie, Illinois 60077, <http://www.cement.org>.

²³ Available from Redwood Inspection Service (RIS), Division of the California Redwood Association, 818 Grayson Road, Suite 201, Pleasant Hill, CA 94523, <http://www.redwoodinspection.com>.

²⁴ Available from Sheet Metal and Air Conditioning Contractors' National Association (SMACNA), 4201 Lafayette Center Dr., Chantilly, VA 20151-1209, <http://www.smacna.org>.

²⁵ Available from Southern Pine Council (SPC), 2900 Indiana Avenue, Kenner, LA 70065-4605, <http://www.southernpine.com>.

²⁶ Available from The Southern Pine Inspection Bureau (SPIB), P. O. Box 10915 Pensacola, FL 32524-0915, <http://www.spib.org>.

²⁷ Available from Single-Ply Roofing Industry (SPRI), 411 Waverley Oaks Road, Suite 331B, Waltham, MA 02452, <http://www.spri.org>.

²⁸ Available from Sealant Waterproofing & Restoration Institute (SWRI), 400 Admiral Blvd, Kansas City, MO 64106, <http://www.swrionline.org>.

²⁹ Available from Tile Council of North America, Inc. (TCA), 100 Clemson Research Blvd., Anderson, SC 29625, <http://www.tileusa.com>.

³⁰ Available from Texas Lathing and Plastering Contractors Association (TLPCA), 1615 West Abram, Suite 101, Arlington, TX 76013, <http://www.tlpca.org>.

³¹ U.S. Department of Agriculture, Forest Service, Forest Products Laboratory (USDC-FPL) documents are available from the U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, <http://www.access.gpo.gov>.

³² Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 1070, Gaithersburg, MD 20899-1070, <http://www.nist.gov>.

³³ Available from Vinyl Siding Institute (VSI), National Housing Center, 1201 15th Street NW, Suite 220, Washington, DC 20005, <http://www.vinylsiding.org>.

³⁴ Available from West Coast Lumber Inspection Bureau (WCLIB), P.O. Box 23145, Portland, OR 97281, <http://www.wclib.org>.

³⁵ Available from Window and Door Manufacturers Association (WDMA), 401 N. Michigan Avenue, Suite 2200, Chicago, IL 60611, <https://www.wdma.com>.

³⁶ Available from Western Red Cedar Lumber Association (WRCLA), 1501-700 West Pender Street, Pender Place 1, Business Building, Vancouver B.C., Canada V6C 1G8, <http://www.wrcla.org>.

³⁷ Available from Western States Clay Products Association (WSCPA), 22815 Frampton Avenue, Torrance, CA 90501, <http://www.brick-wsepa.org>.

³⁸ Available from Western Wood Products Association (WWPA), 522 SW Fifth Ave., Suite 500, Portland, OR 97204-2122, <http://www.wwpa.org>.

of the wall, may occur. In addition to drainage behind the cladding, evaporation may play an important role in dissipating moisture in some types of cladding.

3.2.7 *drainage wall, cavity*—a type of drainage wall characterized by a vertical air space, which is either wholly or substantially unobstructed, between the weather-resistive barrier and the back surface of the cladding system. The space between the weather-resistive barrier and the cladding may be bridged, depending on the type of cladding, by masonry ties, vertical furring, or open-mesh synthetic polymer media.

3.2.8 *exterior wall*—a wall or wall component that defines the exterior boundary of a building.

3.2.9 *flashing*—a component or system typically composed of sheet material that is employed at interfaces between building components for the purpose of diverting water directly to the exterior or onto the weather-resistive barrier.

3.2.10 *frame building*—a building in which the walls and roofs are supported structurally by wood or light steel framing. Exterior surfaces typically are finished with cladding systems.

3.2.11 *hold points*—times in the course of construction where specific components are to be inspected prior to application or installation of covering components.

3.2.12 *low-rise*—a structure consisting of four or fewer stories of frame construction.

3.2.13 *manufacturer's recommendations*—design, application, or construction recommendations provided by the manufacturer or vendor of a product or system by means of mass-distributed product literature, catalogs, internet web sites or manuals. Manufacturers may also authorize individuals to issue project-specific recommendations.

3.2.14 *maintenance interval*—the period of time a building component will function successfully without requiring action to achieve its service life.

3.2.15 *maintenance manual*—a document organized by building components or systems in the CSI³⁹ or other format agreeable to the owner, which includes, at a minimum, the following: original drawings and specification, as-built changes, warranties and guarantees, vendor-provided maintenance instructions, anticipated maintenance life, anticipated service life, maintenance recommendations and requirements, and names, addresses and phone numbers of subcontractors and installers.

3.2.16 *pan flashing*—a type of flashing used at the base of large openings or penetrations, such as doors or windows. Pan flashings are designed to collect water and drain water directly to the exterior or onto the weather-resistive barrier. Pan flashings have an upturned inner leg and upturned end legs, which form a three-sided pan.

3.2.17 *plaza deck*—a deck, the components of which are covered with materials or systems intended to protect the structure and/or enclosed areas below from precipitation or irrigation water.

3.2.18 *portland cement plaster (stucco) system*—systems include plaster, with portland cement and aggregate, and typically on frame buildings, metallic lath. Portland cement plaster (stucco) cladding may also include adhered veneer such as thin brick, ceramic and thin stone veneer.

3.2.18.1 *Discussion*—For portland cement refer to Specification C150. For lathing and furring installation refer to Specification C1063. For portland cement plaster application refer to Specification C926.

3.2.19 *protected membrane plaza deck*—a plaza deck constructed with the waterproof membrane placed directly over the structural deck surface (usually concrete or wood panel sheathing) with a separate traffic-bearing surface, such as concrete, ceramic tile, or pedestal-supported pavers placed on top of the membrane.

3.2.20 *saddle flashing*—a type of flashing which covers the intersecting joint between a vertical surface and horizontal penetration or appendage, such as the right-angle intersection of a beam penetrating a wall, or the intersection of a parapet to a wall.

3.2.21 *self-adhering flashing*—some materials comply with Specification D1970. This term applies to membrane systems of several types in which modified asphalt or butyl rubber adhesive is applied in the factory to sheets of polyethylene, polypropylene, or foil to a total thickness of 0.5 to 1.5 mm (0.020 to 0.060 in.).

3.2.21.1 *Discussion*—This material, which is generally not intended for exposed use, can be used for areas requiring additional durability or resistance to wind-driven rain, such as flashing, reinforcement of corners, and as a lap sealant. When self-adhering flashings are used in conjunction with a weather-resistive barrier, the materials should be compatible. These types of membranes have very low vapor permeance, and as such, should be used with caution when applied over large areas or entire wall surfaces.

3.2.22 *service life*—the period of time a building component or system will function successfully without replacement or excessive repair, assuming reasonable or expected periodic maintenance is performed.

3.2.23 *sheathing*—a rigid panel material fastened to the exterior surfaces of wall framing members, which provides a continuous plane interrupted only by intentional wall openings (such as those for fenestration units) and by small panel spacing gaps.

3.2.24 *soffit*—the underside of exposed horizontal surfaces, such as plaza decks, bay windows, roof overhangs, and heads of recessed window and door openings.

3.2.25 *water intrusion*—water originating as precipitation that penetrates beyond the weather-resistive barrier of the wall.

3.2.25.1 *Discussion*—Water that penetrates past the outermost surface of a drainage wall and beyond the weather-resistive barrier that has the potential to cause deterioration of

³⁹ MasterFormat, 1995 Edition Master List of Numbers and Titles for the Construction Industry, is available from Construction Specifications Institute (CSI), 110 South Union Street, Suite 100, Alexandria, VA 22314-3351, <http://www.csinet.org>. This revised guide is used to classify construction resources, including project information, products, and human effort. The five-digit numbering system organizes construction specifications, project manuals, cost estimates, and data files.

sheathing or framing. If the water penetrates in sufficient quantities or occurs chronically, the deterioration may be significant. Larger amounts of water intrusion may also result in obvious leakage to the interior and damage to the interior wall finishes, interior furnishings and equipment. Damage to framing and sheathing can occur without obvious visible leakage to the interior.

3.2.26 *weather-resistive barrier*—the concealed barrier in a drainage wall system installed in exterior building walls before the installation of cladding.

3.2.26.1 *Discussion*—The weather-resistive barrier is not accessible and therefore is expected, along with associated flashings, to remain functional for the service life of the building wall system.

3.2.26.2 *Discussion*—Specifications for weather-resistive barriers include ICC-ES AC38 and CAN/CGSB 51.32-M77. Weather-resistive barriers may also meet the requirements of Specification **E1677** and function as air barriers.

3.2.27 *weather-resistive barrier, felt-based*—asphalt-saturated felts meeting requirements of Specification **D226**, which defines Type I and II.

3.2.27.1 *Discussion*—Type I felt is commonly called #15 felt and has a minimum weight of 560 g/m² (11.5 lb/100 ft²) per Specification **D226**. Type II is commonly called #30 felt and has a minimum weight of 1270 g/m² (26 lb/100 ft²) per Specification **D226**. Note that some manufacturers market one “#15” felt that meets Specification **D226** and another “#15” felt that does not meet Specification **D226**.

3.2.27.2 *Discussion*—The 2003 International Residential Code requires that felt have a minimum weight of 683 g/m² (14 lb/100 ft²) and comply with Specification **D226**. The 2003 International Building Code and the 2003 NFPA5000 code require that felt comply with Specification **D226**, Type I. The ICC-ES AC38 requires that felts comply with “ASTM **D226 – 97a**.”

3.2.28 *weather-resistive barrier, paper-based (building paper)*—asphalt-treated kraft paper conforming to ICC-ES AC38 or CAN/CGSB 51.32-M77.

3.2.28.1 *Discussion*—ICC-ES AC38 defines four grades that vary in water resistance from grade D (10 minutes) to grade A (24 hours). Grade D papers that exceed the minimum water resistance are available, for example, some manufacturers make a “60-minute” Grade D paper, which would have 1 hour of water resistance. The vapor permeance of the grades decreases from Grade D to Grade A. ICC-ES AC38 is based on Federal Specification UU B 790a.

3.2.29 *weather-resistive barrier, polymer-based*—polymer-based barriers are proprietary polymeric sheet materials manufactured for use as weather-resistive barriers. Commonly referred to as “house wraps,” they typically provide air barrier functionality in addition to being a weather-resistive barrier.

3.2.29.1 *Discussion*—Standards include ICC Acceptance Criteria AC38 and CAN/CGSB 51.32-M77. Air barrier functionality is defined by Specification **E1677**.

4. Summary of Guide

4.1 This guide describes principles, materials and procedures for the design and construction of walls and decks of

low-rise frame buildings to make them resistant to water intrusion from precipitation to minimize resulting damage.

4.2 This guide is based on the assumption that building wall systems are supposed to maintain their structural integrity for a period in excess of a traditional 30-year mortgage, and by extension, that water intrusion over that period is restricted to such a degree that water-induced structural damage is avoided. In essence the expectation is that a frame wall’s water shedding functionality will remain viable over a period in excess of a traditional 30-year mortgage, given that the building is not subject to abuse, and receives a reasonable level of maintenance. This guide recognizes that not all components of a building’s water-shedding system have the same life expectancies or maintenance requirements.

4.3 This guide includes both general and specific guidelines. Practical experience indicates that the guidelines, if properly implemented, will result in the assumption outlined in 4.2 being attained.

5. Significance and Use

5.1 This guide may be used by public agencies to set standards affecting the weather resistance, durability, and performance of new building wall systems, exterior deck and stair components, doors, windows, penetrations and sealant joints beyond those specifically defined in the building codes.

5.2 This guide may be used by building field inspectors as a resource for construction inspection during the construction phase of a project.

5.3 This guide may be used by private organizations or individuals to set standards affecting the weather resistance, durability, and performance of building walls.

5.4 This guide may be used by architects and engineers as a resource for making design decisions involving material selection, building wall detailing and specifications.

5.5 This guide may be used by architects and engineers as a resource for conducting submittal review and construction observation during the construction administration phase of a project.

5.6 This guide may be used by contractors as a resource and checklist for exercising field quality control.

6. General Design Principles

6.1 Guide **E241** provides a comprehensive discussion of means to avoid moisture damage in buildings. It addresses water in liquid and vapor states and discusses water that enters a building either during construction or after completion.

6.2 Building wall systems must accommodate the precipitation to which they will be exposed with provision for a prudent factor of safety. Climate, building siting and building design determine the exposure to precipitation.

6.2.1 Building designs and details that have a history of successful use in dry climates may not perform adequately in wetter climates.

6.2.2 Limiting exposure of exterior walls to precipitation by using projecting elements, such as roof overhangs and flashing drip edges is effective.

6.2.3 Do not expose walls or decks to roof runoff.

6.3 Walls are most susceptible to water intrusion at joints in, and penetrations of, the exterior cladding system and at junctures of walls with roofs and decks.

6.4 Precipitation intrudes into exterior walls and plaza decks primarily by three means: gravity, wind, and capillary suction. Limitation of intrusion by these primary transport mechanisms is a basic design principle. Limitation of water intrusion past the cladding system can be brought about by a variety of means. These include:

6.4.1 Limiting the component's exposure to precipitation.

6.4.2 Limiting inclusion of features in the design that are difficult to successfully execute. For example, limit the size, complexity, or number of penetrations.

6.4.3 Designing and constructing the cladding system (in particular, the joints, interfaces, junctures and penetrations) so as to provide a reasonably effective barrier to water intrusion.

6.4.4 Design and construct the cladding system so as to limit water intrusion by gravity or wind. This usually involves the use of sealants and flashings and relies on proper integration of the sealants and flashings with each other and with the system components. The degree to which the cladding system must prevent water entry, given that precipitation exposure remains constant, is inversely related to the degree to which the wall system can dissipate water that may penetrate the cladding system.

6.4.4.1 ANSI/ASCE 7 can be used to calculate the design loads due to wind on exterior envelope components.

6.4.5 Flashing elements often need to be properly integrated not only with the cladding system and sometimes with sealants, but also with the weather-resistive barrier. As implied in the definitions of drainage wall, flashing elements may be an integral part of the drainage system, and as such, must be properly integrated with both the weather-resistive barrier and the cladding system to function properly.

6.4.6 Limiting water intrusion past wood-based cladding systems may also be accomplished by limiting capillary suction. This can, in turn, be accomplished by the use of cladding materials with limited capillary suction, by configuring elements of the cladding system to limit capillary suction at joints, and by use of water repellants or coatings on elements of the cladding system.

6.5 Some intrusion of precipitation past the exterior cladding system (generally at joints, penetrations and junctures) can be expected in most climates. This moisture must be dissipated, for if it accumulates, damage can be expected. Where the degree of intrusion past the exterior cladding system is limited, the required capacity for dissipation may be reduced. A construction's capacity for dissipation must be consistent with the level of intrusion. Over sufficiently short time spans, however, or within certain limits, a construction may be able to store moisture without incurring damage. Therefore, under certain circumstances, moisture storage capacity may allow a construction to tolerate a temporary imbalance between intrusion and dissipation. Some constructions may tolerate greater magnitudes of temporary imbalance between intrusion and dissipation, or more prolonged periods of temporary imbalance

than others. Some constructions may tolerate imbalances of limited magnitude for appreciable time periods. No construction, however, can be expected to tolerate cumulative imbalances for long periods.

6.5.1 When some intrusion of precipitation past the exterior cladding system occurs, a weather-resistive barrier, if properly manufactured and installed, has proven, within limits, to be effective at preventing further intrusion of precipitation into the wall. Prevention of such further intrusion aids in dissipation of the water from the system.

6.5.2 Moisture within exterior walls and plaza decks may be dissipated by drainage or evaporation. Dissipation by drainage is typically more rapid. Evaporation aided by air movement (ventilation) is typically much more rapid than evaporation that depends solely on vapor diffusion. For these reasons, cavity drainage walls are typically effective at dissipating moisture that intrudes through the cladding system. With or without a cavity, drainage walls can generally be considered as robust designs that can tolerate greater degrees of imperfection in construction and maintenance than can barrier walls.

6.5.3 Evaporation unaided by ventilation, although typically slower than evaporation aided by ventilation, may nonetheless be important in dissipating moisture from building wall systems, especially in wall systems with limited potential for drying by drainage or air movement. Therefore, actions or practices with the potential to inhibit drying from the wall assembly systems (for example, use of vapor retarders) should not be undertaken without cognizance of this potential.

6.6 Maintenance can greatly influence durability of the exterior walls of frame buildings. Components directly exposed to exterior weather can be expected to require periodic maintenance on a schedule considerably shorter than the service life. This period is called the "maintenance interval." Access for maintenance of such components should be considered in the design. Most notable are sealant joints (which can be expected to require multiple replacements during the service life of the wall), and wood or wood-based components exposed to the weather, which can be expected to require refinishing with paint or stain or periodic application of water repellants. Seals integral with window units may likewise be expected to require maintenance or replacement within the duration of the service life.

7. Design Practices

7.1 Design practices for exterior cladding installation may be categorized as follows: (1) Design based on practical experience for the locality; or (2) Design based on understanding of principles such as those described in Section 6.

7.1.1 Design based on practical experience for the locality is the more traditional practice. In this approach, constructions are designed to emulate those that have, over the course of time, proven dependable in the locality. In practice, this approach usually involves cognizance of at least some of the principles outlined in Section 6. Designers using this approach may not, however, have reference to an organized list of principles such as described in Section 6. Because materials, products and installation methods, tools and personnel may change over time, this approach usually requires that design

principles such as those described in Section 6 be recognized and addressed. This approach may also be aided by use of numerical modeling, most likely to predict how moisture conditions behind a secondary weather-resistive barrier may be influenced by its vapor permeance.

7.1.2 Design based on understanding of design principles is practiced by evaluating whether a proposed construction takes the principles into account, and if necessary, altering the proposed construction so that they are followed. As implied in 7.1.1, the proposed construction may be a variant on a design that is common practice in a local area. Like designs based on practical experience, this approach may also be aided by use of numerical modeling.

7.2 Numerical modeling, using computer simulation models, can be used to predict moisture conditions within a proposed construction under a given set of conditions and assumptions. Most commonly, computer models are used to predict if a proposed construction, which may be resistant to precipitation leakage, can be expected to experience moisture accumulation as a result of vapor diffusion. Computer models may also be used to predict drying rates of walls fabricated with damp materials and enclosed before these materials dry thoroughly. Relatively simple one-dimensional hydrothermal models can be used for these purposes. Complex three-dimensional models may be used to predict moisture conditions in a given wall with assumed amounts and frequency of water intrusion into the wall. The utility of such models, however, relies on having realistic inputs for them. The more complex the model, the more inputs are required, all of which must be realistic.

7.2.1 Numerical modeling may be used to evaluate choice of a weather-resistive barrier material. Modeling can estimate if a material has the appropriate vapor permeance and water resistance for a chosen wall design and climate.

8. General Guidelines

8.1 Design of installations should be by one or more of the approaches outlined in Section 7, but whichever approach is used as the primary approach, a review of the final design with regard to the principles in Section 6 should be made.

8.2 Components that are not accessible without unreasonable effort (or damage to other components that will be costly to replace) should have a service life equal to that of the cladding system.

8.3 Conform to manufacturer's most current recommendations for design and installation of proprietary products, except when such practice can be shown, with supporting rationale accepted by the designer or owner, to violate a design principle in Section 6. (**Warning**—Deviation from manufacturer's written installation instructions may void warranties. Consult manufacturer about proposed changes.)

8.3.1 Particular attention should be paid to manufacturer's recommendations that are published by building code related organizations. For example, the ICC Evaluation Service publishes Evaluation Reports that contain specific manufacturer's instructions that are to be met for approval by building officials in applicable jurisdictions.

8.4 Conform to referenced standards and industry association recommendations for design and installation of non-proprietary materials and generic products, except when such practice can be shown to violate a design principle in Section 6.

8.5 Be aware that selecting a product that conforms to a standard does not assure that the product will perform adequately in all applications. Procedures for evaluating products used in exterior walls are discussed in Guide E1825.

8.6 In the case of conflict among the requirements of this practice, manufacturer's recommendations, or referenced standards and industry association recommendations, the most stringent should be followed, unless the most stringent can be shown to violate a design principle in Section 6 or can be shown as unnecessary to meet the basic performance requirements of this guide.

8.7 Quality control during construction, specifically the use of checklists and hold points, is recommended.

8.8 Sealant joints should be designed and executed so as to permit anticipated maintenance or replacement without extraordinary or unusual effort.

8.9 Before building commissioning, the designer or builder should communicate to the building owner the anticipated maintenance life and requirements of the construction, if the requirements deviate appreciatively from conventional expectations. A maintenance manual is one way that these can be communicated to an owner.

8.10 Field testing of water penetration may be done using Test Method E1105. When testing cavity drainage walls, water penetration through the veneer of the masonry portion of a veneer wall would not necessarily indicate a failure of the wall system. Windows may be field tested by AAMA 501, AAMA 501.2, and AAMA 502.

9. Drainage Walls

9.1 *Drainage Walls—General:*

9.1.1 *Materials:*

9.1.1.1 *Weather Resistive Barrier*—Generally, a desirable weather-resistive barrier membrane will have high resistance to water in a liquid form, moderate to low resistance to water in a vapor form, resistance to degradation by air, water, and ultraviolet radiation (prior to installation of cladding), resistance to tearing, and compatibility with adjacent materials, including sealants. There are several generic types of weather-resistive barriers commercially available, and within those types, there is a variety of proprietary products. (Refer to 3.2, Definitions.) Currently, each of these generic types is regulated by different sets of standards. Additional physical property and performance data is published by manufacturers using a wide variety of standards. The result is that it is difficult, if not impossible, for a user to make technically useful comparative evaluations among the types and products available.

9.1.1.2 The selection of a weather-resistive barrier, should take into account the nature of the cladding system. The potential for water to pass through cladding and the period of time that water may be held against the weather-resistive

barrier, varies from one cladding system to another. The long-term performance of a weather-resistive barrier may be improved in most drainage wall systems by designing and constructing the cladding to avoid cracks or gaps, as well as providing sealed joints so that relatively little water may bypass the cladding and reach the weather-resistive barrier.

9.1.1.3 Weather-resistive barriers consisting of rigid board materials and liquid troweled-on materials are not addressed in this standard.

9.1.1.4 A complete installation may include a weather-resistive barrier and one or more types of flashing material. Refer to 14.1.2 for a discussion of flashing materials.

9.1.2 *Design and Construction:*

9.1.2.1 Prior to installation of any cladding material or system, a weather-resistive barrier should be installed over the exterior wall sheathing. The weather-resistive barrier should be installed with appropriate flashing and penetration seals such that any wind-driven rain passing behind the cladding and reaching the weather-resistive barrier will drain to the exterior of the wall or evaporate.

9.1.2.2 Wall weather-resistive barrier will perform more effectively when installed over wall sheathing or other backing that will support the laps of the barrier permanently in tight contact. The mechanical support afforded to a weather-resistive barrier membrane by rigid sheathing commonly results in significantly less damage to the membrane during construction, less cumulative wind-induced stress to the membrane in long-term service, and may reduce the likelihood of water passing through membrane laps.

9.1.2.3 Install weather-resistive barrier materials horizontally with water-shedding (shingle) laps to provide a continuous barrier. Consult with manufacturers and building codes for minimum lap dimensions.⁴⁰ Exceeding minimum lap requirements is recommended as a simple method of improving reliability.

9.1.2.4 When using products that come pre-assembled with lath and weather-resistive barrier (typically paper-based) in the same roll, install laps with lath on lath and paper on paper.

9.1.2.5 Procedures for fastening of the concealed weather-resistive barrier depend on the type of sheathing used and upon whether the sheathing's mechanical properties permit secure fastening of the weather-resistive barrier to the sheathing. Unless the sheathing has reliable mechanical properties that permit reliable fastening of the weather-resistive barrier, fasteners must penetrate framing members. Workmanship in fastening the concealed weather-resistive barrier is important,

⁴⁰ At this writing, minimum lap requirements include the following: The 2003 International Building Code states a performance criterion, "provide a continuous water-resistive barrier behind the exterior wall veneer." The 2003 International Residential Code and the 1997 Uniform Building Code require horizontal laps of, "2 in. (51 mm)" and vertical laps of, "6 in. (152 mm)." The 2003 NFPA 5000 code requires horizontal laps of, "3 in. (76 mm)," and vertical laps of, "6 in. (152 mm)." Manufacturers of polymeric weather-resistive barriers have specific installation recommendations for their systems, which may be intended to have air barrier and weather resistance functions. One example of a manufacturer's recommendations is horizontal laps of 150 mm (6 in.), vertical laps of 150 to 300 mm (6 to 12 in.), and use of joint sealing tape over laps.

for the barrier may not function as intended if it is torn by careless installation of fasteners. The type of fastener used to install the concealed weather-resistive barrier can affect the risk of tearing. It can be anticipated that fasteners used to install the cladding system may puncture the concealed weather-resistive barrier.

9.1.2.6 Secure fastening of the cladding is of greater concern than is puncturing the concealed weather-resistive barrier by cladding fasteners. Securing some cladding systems requires that fasteners engage the framing and not only the sheathing. In these systems, fasteners that do not engage the framing can result in excessive leakage through the fastener penetration of the weather-resistive barrier and excessive warping, deflection or misalignment of the cladding, which can result in increased water penetration through the cladding. With a significant number of cladding systems, secure fastening requires that fasteners penetrate framing members, for example wood siding and lath for portland cement plaster (stucco) systems.

9.1.2.7 Except where adequate overhangs prevent water intrusion from wind-blown rain, roof membranes, underlayments or edge flashing should lap over the topmost portion of the wall weather-resistive barrier in such a manner as to prevent water intrusion.

9.2 *Drainage Wall Cladding—Portland Cement Plaster (Stucco):*

9.2.1 *Materials:*

9.2.1.1 Conform to Specification C926 plaster materials and Specification C1063 for lath materials.

9.2.1.2 For adhered ceramic tile, thin brick, or thin stone veneer, conform to TCA Ceramic Tile Handbook.

9.2.2 *Design and Construction:*

9.2.2.1 Refer to Specification C926 for plaster application, Specification C1063 for lath installation, the PCA Portland Cement (Stucco) Manual, and ACI 524. Refer also to guides produced by regional associations, the TLPCA Lath and Plaster Systems Manual, the MLPB Stucco in Residential Construction, and the NWCBS Stucco Resource Guide.

9.2.2.2 When wood panel sheathing is used in a wall that will be covered with portland cement plaster (stucco) cladding, refer to APA Installation of Stucco Exterior Finish Over Wood Structural Panel Wall Sheathing.

9.2.2.3 Soffit-type weeps and drip screeds should be installed at all intersections of vertical walls and soffits (including recessed window and door openings). Enclosed horizontal spaces should be vented between all joists.

9.2.2.4 For use with wood trim, refer to 9.3.2.1.

9.2.2.5 At wood-trimmed heads of windows, doors, and louvers and other penetrating features the joint between portland cement plaster (stucco) and wood should be protected with a sheet metal "Z" shaped flashing integrated with weather-resistive barriers.

9.3 *Drainage Wall Cladding—Wood and Wood Derived Products:*

9.3.1 *Materials:*

9.3.1.1 *Wood Siding and Trim*—For horizontal siding, the siding must be pattern material⁴¹ conforming to a siding grade by the rules of a recognized rules writing agency and graded under the supervision of an accredited inspection agency.⁴² Recognition requirements for rules writing and inspection agencies are outlined in U.S. Department of Commerce DOC PS 20. Wood used for vertical board-and-batten or board-on-board siding may be of standard board configuration (that is, not pattern lumber) but should be of a grade recognized as suitable for use on building exteriors. Knot size and quality are generally recognized as determining suitability for use on the exterior surfaces of buildings. Sound tight knots will not adversely affect performance. Lumber with unsound or loose knots, which may fall out, is not acceptable. Refer to the ALSC⁴³ for accredited rules-writing and inspection agencies.

(1) *Moisture Content*—At installation, siding and trim should be at approximately the equilibrium moisture content. One guideline is to have wood moisture content within the annual range of equilibrium moisture content reported for several locations in the U.S. in “Drying and Control of Moisture Content and Dimensional Changes” in the USDA-FPL Gen. Tech. Rep. FPL-GTR-113, Wood Handbook. If the wall on which the trim or siding will be installed is exposed to appreciable amounts of direct sun, the acceptable maximum moisture content value at installation should be reduced by two percentage points from the maximum annual moisture content for a given location as reported in the Wood Handbook. Specifying kiln-dried material improves the likelihood that siding and trim will be at appropriate moisture content level at time of installation, although material that has not been adequately dried can, up to some limit,⁴⁴ be brought to an acceptable moisture content by acclimation on site. The way to assure that application occurs at an appropriate moisture level is by checking wood products with a moisture meter.⁴⁵ Storage practices by lumber wholesalers and retailers will influence moisture content level as delivered to the job site. Storage and acclimation practices by carpentry crews influence moisture content level at installation.

(2) *Decay Resistance*—All species commonly used for siding and trim in North America are softwood species, and are recognized as having a degree of decay resistance higher than that of the more decay-prone hardwoods (for example, aspen). Decay resistance however varies appreciably from species to

species in the softwoods commonly used for siding and trim. Decay resistance also varies within species; heartwood content, and growth characteristics influence decay resistance. Redwood, western red cedar, and Alaska yellow-cedar are the most decay-resistant of the species commonly used in this application. The pines and spruces are the least decay-resistant of the species commonly used in this application. The degree of decay resistance required depends on climate, building siting and design, location on the building, siding pattern, and workmanship, and can also be affected by finish choice. Installation of siding on furring reduces the risk of siding decay, especially for flat-back sidings, (like shiplap,) that would otherwise have full back-surface contact with the weather-resistive barrier. Siding exposed to appreciable amounts of direct sun, although more subject to weathering and warping, is usually less prone to decay.

(3) *Dimensional Stability*—Thicker and narrower boards or patterns have less tendency to cup or split. The same is true for material with vertical-grain faces, as opposed to flat-grain faces. Narrower boards and patterns will undergo the same proportional amount of dimensional change as wider boards or patterns, but this translates into lesser total dimensional change. Splitting of siding is frequently the result of dimensional movement restrained by fasteners. Species of lower density, like redwood and cedar, are more dimensionally stable than higher density species.

(4) *Finish Retention*—Maintaining a finish (stain or paint) on lumber siding or trim will result in it staying flatter, will significantly reduce splitting and checking, and will inhibit surface erosion. Preventing surface checking also reduces the likelihood of decay establishment, which could otherwise be induced by liquid water absorption through surface checks. Penetrating stain finishes do not form surface films and will perform acceptably on virtually any wood surface. Latex stain finishes and paint finishes, on the other hand, are film-forming finishes and their performance can be greatly influenced by the nature of the wood surface. These finishes perform best on vertical-grain surfaces and on woods with gradual transitions in wood structure and density at earlywood-to-latewood interfaces (the cedars, redwood, and the white pines). Poorer performance of film-forming finishes can be expected on Douglas-fir and yellow pines (for example, Southern pine). Both film-forming and penetrating finishes perform better on rough-sawn than on smooth surfaces. Rough-sawn surfaces absorb more finish, and finish spread rates (area coverage per unit volume of finish) will thus be lower on rough-sawn surfaces.

9.3.1.2 *Hardboard*, primed panels conforming to ANSI/AHA A135.6.

9.3.1.3 *Plywood and Manufactured Wood Panels*—Exterior type, APA 303 series. Refer to APA Product Guide, Performance Rated Sidings.

9.3.1.4 *Wood Shakes and Shingles*—CSSB graded products.

9.3.1.5 *Fasteners*—Stainless steel, hot-dip galvanized steel, or non-corroding aluminum conforming to Specification F1667.

9.3.2 *Design and Construction:*

⁴¹ Examples of “pattern” siding are tongued and grooved, and bevel cut. The terminology and actual profile of pattern siding are determined by rules writing agencies.

⁴² For lumber grading rules, refer to the publications of CSSB (Grading Rules for Certigrade Red Cedar Shingles, Grading Rules for Certi-Split Red Cedar Shakes, and Grading Rules for Tapersawn Red Cedar Shakes), NELMA (Standard Grading Rules for Northeastern Lumber), RIS (Standard Specifications for Grades of California Redwood Lumber), WCLIB (Standard No. 17), or WWP (Western Wood Grading Rules); and SPIB (Standard Grading Rules for Southern Pine Lumber).

⁴³ Available from American Lumber Standards Committee (ALSC), Incorporated, P.O. Box 210, Germantown, MD 20875-0210, <http://www.alsc.org>.

⁴⁴ If the siding is to be installed on a wall with substantial sun exposure, adequate moisture content level is not likely to be achieved in unseasoned or minimally seasoned air-dried material by on-site acclimation.

⁴⁵ Correct use of a moisture meter includes making correction, where necessary for wood species and wood temperature at the time of reading.

9.3.2.1 *Wood Trim* may be of standard board or pattern configuration and should be of a grade recognized as suitable for exterior use on building exteriors. Trim should be prime painted or treated with a penetrating water-resistant sealer on all sides and ends prior to installation. Note that some sealers are not compatible with paint finishes. Joints should be bedded in an elastomeric sealant that is compatible with the intended finish treatment. Embedment of joints in sealant can improve the long-term water resistance of joints.

9.3.2.2 *Wood Board Siding*—For cedar siding, refer to the WRCLA, *Installing Siding*. For southern pine siding refer to the SPC, *Guide to Southern Pine Siding*. For information on western species refer to the WWPA *Natural Wood Siding: Selection Installation and Finishing*.

9.3.2.3 *Plywood Siding*—For guidance on selection and finishing refer to APA Product Guide, *Performance Rated Sidings*. Also refer to APA publications, *Avoiding Moisture Accumulation in Walls*, and *Buckling of Wood-Based Panel Siding*.

9.3.2.4 *Hardboard Siding*—Consult the following publications of the Composite Panel Association: *Recommended Basic Application Instructions for Hardboard Siding*, *Coatings Specification for Field-Applied Coatings on Hardboard Siding*, *Finishing Recommendations for New Construction Using Unprimed and Primed Hardboard Siding*, *Maintenance Tips for Hardboard Siding*.

9.3.2.5 *Wood Shakes and Shingles*—For cedar shakes and shingles consult the CSSB *Wall Construction Manual*.

9.4 *Drainage Wall Cladding—Vinyl Siding:*

9.4.1 *Materials:*

9.4.1.1 Select siding materials meeting Specification **D3679** and soffit materials meeting Specification **D4477**. For color fastness, select materials meeting Specification **D6864**.

9.4.2 *Design and Construction:*

9.4.2.1 Practice **D4756** includes installation instructions and installation detail drawings. Refer also to guidelines contained in the VSI *Installation: A How To Guide*.

9.4.2.2 For use with wood trim, refer to **9.3.2.1**.

9.5 *Drainage Wall Cladding—Fiber-Cement Siding:*

9.5.1 *Materials:*

9.5.1.1 Select materials meeting the requirements of Specification **C1186**.

9.5.2 *Design and Construction:*

9.5.2.1 Installation methods are similar to those recommended for wood-based siding. Refer to the manufacturer's installation recommendations.

9.5.2.2 Embed butt-joints in an elastomeric sealant. Manufacturers may provide cover strips for butt joints that do not occur over studs.

9.5.2.3 Prime coat unprimed siding units and prime cut ends using an alkali-resistant primer.

9.5.2.4 For use with wood trim, refer to **9.3.2.1**.

10. Cavity Drainage Walls

10.1 *Cavity Drainage Wall—General:*

10.1.1 The discussion in this section focuses on the use of clay and concrete masonry veneer in a cavity drainage wall

installation. This section is generally applicable to cavity drainage wall using a cladding of natural stone or other masonry veneer.

10.1.2 Note that other types of cladding may be designed as cavity drainage walls. Installation of furring strips on the weather-resistive barrier may be used to create a cavity drainage wall clad, for example, with wood board siding or stucco. For design guidance for cavity drainage walls using several cladding types refer to the CMHC *Wood-Frame Envelopes in the Coastal Climate of British Columbia*.

10.1.3 The most effective procedure in deterring water penetration into a building wall is the use of a cavity drainage wall system in combination with a weather-resistive barrier. Cavity drainage walls anticipate that water will penetrate the cladding. The water migrates down the interior face of the cladding until it comes in contact with flashing. There it is directed by the flashing to weep holes. The water is then channeled to the outside of the wall.

10.2 *Cavity Drainage Walls—Masonry:*

10.2.1 *General:*

10.2.1.1 Water penetration in a masonry cavity drainage wall is reduced through proper design and construction. Water can penetrate voids in the mortar joint or in the interface between the unit and the mortar, and to a lesser degree, through the masonry units and the hardened mortar.

10.2.1.2 Prior to installation of any cladding material or system, a weather-resistive barrier should be installed over the exterior wall framing or sheathing. The weather-resistive barrier should be installed with appropriate flashing and penetration seals such that any wind-driven rain passing behind the cladding and reaching the weather-resistive barrier will drain to the exterior of the wall or be evaporated.

10.2.2 *Materials:*

10.2.2.1 The masonry units should conform to appropriate Specifications **C55**, **C62**, **C90**, **C126**, **C216**, **C652**, **C1088** or **C1405**.

10.2.2.2 To determine absorption rate and requirement for wetting a masonry unit, see Test Method **C67**, field initial rate of absorption.

10.2.2.3 Mortar should conform to Specification **C270**.

10.2.2.4 Materials and proportions in mortar should be specified to match to the initial rate of absorption (IRA) of the clay masonry unit.

10.2.2.5 The method of measuring and batching materials for mortar should be by volume.

10.2.3 *Design and Construction:*

10.2.3.1 Conform to Guide **C1400** and, as applicable, to Brick Industry Association's Technical Notes on Brick Construction, National Concrete Masonry Association's NCMA TEK Bulletins, and the Western States Clay Products Association's Design Guide for Anchored Brick Veneer Over Steel Studs.

10.2.3.2 Minimize horizontal projections.

10.2.3.3 Functional, unpunctured flashing and weep holes should be provide at the base of walls above grade, above openings in the wall, below window sills, and at shelf angles, lintels, wall-to-roof intersections, chimneys, bay windows, and copings. Flashing should continue through the wall and be

turned up at least 200 mm (8 in.) on the inside. The flashing should be extended beyond the exterior face of the wall. The flashing should have end dams with weep holes at its discontinuous ends. Continuous flashing should have properly sealed splices and laps at least 150 mm (6 in.) at its joints. Weep holes shall be at least 5 mm ($\frac{3}{16}$ in.) in diameter and spaced less than 840 mm (33 in.) on center. Weep holes shall be located immediately above the flashing. Use care to prevent blocking the cavity with mortar.

11. Wood Framed Decks or Stairs with Exposed Framing and Decking

11.1 *Materials:*

11.1.1 Wood structural members that are exposed to the weather should be preservative treated in conformance with applicable AWPAs treatment standards or be from the heartwood of a naturally durable species in accordance with the provisions of the authority having jurisdiction. Treat cuts and penetrations (including drilled fastener holes) with commercial penetrating preservative according to the recommendations of AWPAs M4. The applicable AWPAs standards are AWPAs C28 and AWPAs C2 for glue-laminated members and solid-sawn members respectively.

11.1.2 Decking boards and non-structural components may be non-wood synthetic products manufactured specifically for the intended purpose.

11.1.3 Fasteners should be of steel with a hot-dip galvanized coating conforming to Specification **A153/A153M** or of Type 304 or 306 stainless steel.

11.2 *Design and Construction:*

11.2.1 The design should allow water to drain through the surface without collecting or being trapped.

11.2.2 Wood to concrete connections exposed to rain should be designed to provide sufficient drainage to avoid long-term exposure of column bases to standing water.

11.2.3 Wood beams of 100 mm (4 in.) nominal width or greater should be protected with a durable cap. Beams of 100 mm (4 in.) nominal width or greater have a greater propensity to develop top and end checks than do narrower members. Development of these checks allows water entry that frequently results in fungal decay. For this reason a ventilated metal cap flashing with a 13 mm (0.5 in.) air gap is recommended for exposed beams of 100 mm (4 in.) or greater nominal width.

11.2.4 When a ledger is installed to support deck framing, a layer of self-adhering membrane should be installed behind the ledger, extending at least 150 mm (6 in.) beyond the ledger on all sides and lap over the weather-resistive barrier below the ledger. A sheet metal “Z” shaped flashing should be installed on top of the ledger and integrated into the weather-resistive barrier.

11.2.5 Cantilevered joists and beams providing structural support for exposed wood decks are not recommended, but when used should conform to the following.

11.2.5.1 All beams, joists, and other deck supports extending through the wall should have full sheet metal saddle flashing where exposed to weather. An “L” shaped sheet metal base flashing should be used to cover the joint between the

horizontal deck framing and the wall, the horizontal leg of which should extend out at least 250 mm (10 in.) from wall and terminate in a minimum 6 mm ($\frac{1}{4}$ in.) vertical downturn set in sealant in a dado cut laterally in the top of the penetrating member. Alternately, a sheet metal or self-adhering membrane flashing may extend full length over the tops of penetrating members.

11.2.5.2 The weather-resistive barrier of the wall below a deck should extend up between cantilevered deck supports and be sealed to the penetrating members using an elastomeric sealant.

11.2.5.3 Wall framing between penetrating members should be blocked or covered with solid sheathing, and wall finishes should extend up to deck floor and be positively sealed to the penetrating members using an elastomeric sealant.

11.2.6 Non-wood decking manufactured from plastics or other synthetic products should be installed as directed by manufacturer, but should conform to the requirements above.

12. Plaza Decks or Stairs with a Protected Waterproofing Membrane

12.1 *Materials:*

12.1.1 Waterproof membranes should be specifically recommended by the manufacturers for the intended use.

12.1.2 Waterproofing membranes and associated materials should conform to, Specification **C836**, Specification **D6134**, materials listed in Guide **D6622**, or waterproofing membrane products listed in SPRI Flexible Membrane Roofing: A Professional’s Guide to Specifications.

12.1.3 Deck substrate materials and fasteners should be compatible with waterproofing materials.

12.1.4 The installer should provide a written description of maintenance requirements and frequency, repair procedures, and replacement procedures.

12.2 *Design and Construction:*

12.2.1 Refer to Guide **C898**, Guide **C981**, Practice **D6135**, Guide **D5843**, Guide **D5898**, Guide **D6622** and TCA “Method F103,” where applicable. The ASTM standards anticipate installation of waterproofing over a concrete substrate. Adapt these standards when waterproofing is to be installed over wood-based deck sheathing.

12.2.2 For design of sheet metal flashings at deck perimeters and deck posts, refer to the SMACNA Residential Sheet Metal Guidelines.

12.2.3 Decks should have minimum 2 % slope to drain at the level of the membrane after any deflections due to load or material creep have occurred. Although this is the minimum necessary for drainage, greater slope should be considered where design and construction constraints allow. When pedestal-supported pavers are utilized where water can drain between the pavers, the pavers need not slope, but the substrate at the underlying deck membrane should have minimum 2 % slope to drain.

12.2.4 Overflow drainage should be provided by scuppers, deck edges, redundant drains, or overflow drains so that water will overflow into the secondary drains before rising to a level sufficiently high to overflow door thresholds.

12.2.5 Membranes should be fully supported, and turned up at the walls, sills and jambs adjacent to sills at least 200 mm (8 in.) above wearing surface of the deck.

12.2.6 Ultra violet light protection cover may be required where the membrane is exposed above the wearing surface if the membrane material selected is not intended to be exposed due to potential mechanical damage and weathering, including solar radiation.

12.2.7 Where membrane decks are flashed with galvanized sheet metal at the wall base, all sheet metal embedded in or in contact with concrete or mortar bed decks should be cleaned, primed and covered with the membrane material used for the deck surface to avoid corrosion.

12.2.8 Joints of railings to walls should have saddle flashing installed.

12.2.9 Prior to installation of planters and landscaping, decks should be fully waterproofed.

12.2.10 Planter boxes and landscaping beds should have separate waterproof membranes and drain separately into drainage systems.

12.3 *Inspection and Testing:*

12.3.1 After completion of each deck, water test in accordance with Guide **D5957**.

13. Plaza Decks or Stairs with an Integral-Wearing Surface Waterproofing Membrane

13.1 *Materials:*

13.1.1 *Traffic Bearing Membranes*—Select materials complying with Specification **C957** or ICC-ES AC39. Elastomeric deck waterproofing systems are proprietary. The manufacturer should provide full specifications that may be modified for actual conditions of use, if appropriate and approved.

13.2 *Design and Construction:*

13.2.1 Refer to Guide **C1127**.

13.2.2 For design of sheet metal flashings at deck perimeters and deck posts, refer to the SMACNA Residential Sheet Metal Guidelines.

13.2.3 Decks should have minimum 2 % slope to drain after any deflections due to load or material creep have occurred. Disability access requirements may limit the slope across the path of travel.

13.2.4 All joints and corners should be fully flashed with systems that will allow the entire membrane to expand and contract within the tolerances of the design of the deck framing and sheathing.

13.2.5 The elastomeric deck system should be fully backed and should extend up the walls and sills at least 200 mm (8 in.) above the wearing surfaces (except the inside face of thresholds). The waterproof coating should be installed at wall base and deck before wall finishes are applied (or reglets and removable counterflashing should be provided) so the wall weather-resistive barrier laps over the membrane at least 50 mm. (2 in.).

13.2.6 The installer should provide a written description of, maintenance requirements and frequency, repair procedures, and replacement procedures.

13.3 *Inspection and Testing:*

13.3.1 Conduct water tests in accordance with Guide **D5957**.

14. Windows, Doors and Similar Wall Penetrations

14.1 *Products:*

14.1.1 *Windows and Doors:*

14.1.1.1 Select for exposure and performance as recommended in the AAMA Window Selection Guide.

14.1.1.2 Aluminum, vinyl (PVC) and wood windows and glass doors should conform to ANSI/AAMA/NWDA 101/I.S. 2-97 and ANSI/AAMA/WDMA 101/I.S. 2/NAFS-02, and each assembly should bear a label, verified by a third party agency, certifying that the product has been tested for performance class and grade. Water penetration testing of window products is usually accomplished using Test Method **E331** and Test Method **E547**.

14.1.1.3 For water-repellent (non-pressure treated) millwork require products meeting the requirements of WDMA I.S. 4.

14.1.2 *Flashings:*

14.1.2.1 Numerous types of flashing materials are available. Refer to Practice **E2112** (Appendix XI) for a discussion of door and window flashing materials.

14.2 *Design and Construction:*

14.2.1 Refer to Practice **E2112**, which provides detailed guidance for installation of doors with integral mounting flanges and several types of windows. Practice **E2112** includes instructions for integration of doors and windows with the weather-resistive barrier. The AAMA IM-TM InstallationMasters Training Manual provides guidance on installation from the perspective of training window installers.

14.2.2 Installation of doors without integral mounting flanges is not specifically addressed in Practice **E2112**. Practice **E2112** does, however, include applicable design principles, such as the use of pan flashings and methods used for integrating the weather-resistive barrier with windows that do not have integral mounting flanges.

14.2.3 Exterior doors that are not performance-rated should be installed in recesses or under canopies where they will be protected from wind-driven rain. Alternatively, the installed door assembly may be tested according to Test Method **E1105** at a minimum pressure of 140 Pa (2.86 psf).

15. Special Wall Configurations

15.1 *Beam Penetrations at Exposed Wall Surfaces:*

15.1.1 All beam penetrations should be protected by saddle flashing that provides 150 mm (6 in.) overlaps for wall water barriers. The beam leg should be counter flashed.

15.1.2 For design of flashings at beam projections, refer to the SMACNA Residential Sheet Metal Guidelines.

15.2 *Parapets at Roofs and Enclosed Guard Rails at Decks:*

15.2.1 All low-slope roofs should have parapets and roof perimeters conforming to recommendations of the SMACNA Architectural Sheet Metal Manual, the NRCA Roofing and Waterproofing Manual, or the specific published recommendations of manufacturer's of proprietary roofing systems.

15.2.2 Tops of wall parapets should have redundant waterproofing including installation of a self-adhering membrane

integrated into the wall water resistant barrier prior to the installation of sheet metal caps or copings.

15.2.3 When wood caps or copings are used, the top surface should be sloped for drainage minimum 2 %, and fasteners should not penetrate the tops unless countersunk and filled.

15.2.4 Joints of railings to walls should have saddle flashing installed.

15.3 *Protruding Decorative Trim, Ledgers, Ledges, etc:*

15.3.1 For design of sheet metal flashings at ledgers and ledges refer to the SMACNA Residential Sheet Metal Guidelines.

15.3.2 Elements of a wall system that are sloped, rather than vertical (90°), should receive additional attention in design and construction to reduce the potential for water entry through cladding or through the weather-resistive barrier. Typical weather-resistive barriers are most suitable for use where the maximum potential for drainage is provided by vertical installation. Supplemental protection may take the form of a flashing that extends over the cladding or a self-adhering membrane applied over the weather-resistive barrier. The type of supplemental protection required depends upon the type of cladding, the depth of the sloped element of the wall, and the adequacy of provisions for drainage of water off the weather resistive barrier.

15.3.2.1 Design and construct ledges to minimize fastener penetrations of weather resistive barriers or self-adhesive membranes. Avoid over-driving fasteners, which may tear or enlarge holes in weather-resistive barriers or self-adhesive membranes.

15.3.3 When constructed of wood, trim and ledgers extending beyond the vertical face of a wall should have top surfaces sloping outward, minimum 2 %, to facilitate drainage and should be protected by sheet metal counterflashing.

15.3.4 When constructed of portland cement plaster (stucco), trim extending beyond the vertical face of the wall should slope outward, minimum 4 %, and when in excess of 75 mm (3 in.), should be protected by either sheet metal counterflashing or by a self-adhering membrane integrated into the wall weather-resistive barrier.

15.3.5 When constructed of low density foam plastics integrated with portland cement plaster (stucco), trim should be installed over the top of the plaster brown coat and secured in place with a polymer-modified cementitious adhesive. The low density foam plastic trim should be covered with fiber glass reinforcing mesh and polymer-modified cementitious material prior to application of the portland cement plaster (stucco)

finish coat. Mechanical fasteners should not be used to secure the low density foam plastic through the plaster.

15.4 *Roof to Wall Transitions:*

15.4.1 All manufactured wood-derived panels exposed to weather below roof rakes, eaves, or copings should have top edges covered by sheet metal flashing that extends at least 76 mm (3 in.) below the top panel edge.

15.4.2 Where wall systems terminate above a roof, there should be sufficient space below the wall cladding to allow unimpeded water flow on the roof below the cladding. Installation of a removable roof counter flashing, which protects the transition between the cladding and the roofing, is recommended. A removable counter flashing will allow maintenance or replacement of the roofing without the necessity of demolishing the cladding system above the roofing. For flashings at wall cladding located above roofing, refer to the NRCA Roofing and Waterproofing Manual and the SMACNA Architectural Sheet Metal Manual.

15.4.3 On buildings with steep roofs special attention should be directed to the point where the eave edge of the roof terminates against a building wall. A flashing to deflect water on the roof away from this point should be provided. For examples of this type of flashing, sometimes known as a “kicker,” refer to the “Steep Roofing” section of the NRCA Roofing and Waterproofing Manual, the SMACNA Residential Sheet Metal Guidelines, and the NWPA Stucco Resource Guide.

16. Exterior Sealant Joints

16.1 *Materials:*

16.1.1 Sealant materials should be selected by using Guide C1299, Specification C920, and SWRI Sealants.

16.2 *Design and Construction:*

16.2.1 Sealants should be installed in accordance with Guide C1193. For installation instructions oriented to use with windows, consult AAMA 850.

16.2.2 As with other elements of an exterior wall system, consideration should be given to the expected frequency and quality of sealant maintenance. Construction details that rely entirely on the performance of sealant joints should receive particular attention in design and construction.

17. Keywords

17.1 building wall components; cladding; low-rise frame building; maintenance life; service life; water intrusion

APPENDIXES
(Nonmandatory Information)
X1. ADDITIONAL RESOURCES

X1.1 Numerous publications are referenced in this guide. These are listed in Section 2 of this guide. The following publications are representative of additional published resources.

Air Barrier System Detail Sketches, Air Barrier Association of America (ABAA), Walpole, MA.⁴⁶

Anderson, L. O., et al, *Construction Guides for Exposed Wood Decks*, Agricultural Handbook No. 432, Forest Service, U.S. Department of Agriculture, Washington, DC; U.S. Government Printing Office, 1985.⁴⁷

Bateman, Robert, *Nail-On Windows, Installation & Flashing Procedures for Windows and Sliding Doors*, DTA, Mill Valley, CA; 1995.⁴⁸

⁴⁶ Available from Air Barrier Association of America (ABAA), 1600 Boston-Providence Highway, Walpole, MA 02081, <http://www.airbarrier.org>

⁴⁷ Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, <http://www.access.gpo.gov>.

⁴⁸ Available from DTA, Inc., 495 Miller Avenue, Mill Valley, CA 94941, <http://www.dtainc.com>.

Dost, William A., and Botsai, Elmer E., *Wood: Detailing for Performance*, GRDA Publications, Mill Valley, CA, 1990.⁴⁹

Gorman, Jaffe, Rose, and Pruter, *Plaster and Lathing Systems Manual*, BNI Books, Div. of Building News, Inc., Los Angeles, CA, 1981.⁵⁰

McDonald, K., Falk, R., Williams, R., and Winady, J., *Wood Decks: Materials, Construction and Finishing*, Forest Products Society, Madison, WI, 1996.⁵¹

Wilcox, W. Wayne, Botsai, E. Elmer, and Kubler, Hans, *Wood as a Building Material*, Wiley & Sons, New York, NY, 1991.

⁴⁹ Available from Grand River Dam Authority (GRDA) Publications, PO Box 409, 226 West Dwain Willis Avenue, Vinita OK 74301, <http://www.grda.com>.

⁵⁰ Building News, Inc. (BNI), 1612 S. Clementine Street, Anaheim, CA 92802, <http://www.bnibooks.com>.

⁵¹ Available from Forest Products Society (FPS), 2801 Marshould Court, Madison, WI 53705-2295 USA, <http://www.forestprod.org>.

X2. GENERAL NOTES FOR CEMENT PLASTER (STUCCO) DETAILS
INTRODUCTION

The following notes are provided for clarification and as background for the details.

X2.1 Cement Plaster, for purposes of **Appendix X2**, refers to portland cement plaster, commonly known as “Stucco.” The stucco is also presumed to be a 3-coat application with a nominal 22 mm (7/8-in.) total thickness in accordance with Specification **C926**, Table 1. One-coat and two-coat systems are not addressed in **Appendix X2**.

X2.2 For purposes of **Appendix X2**, dimensions are noted in SI units with inch-pound units in brackets. See **X2.12**.

X2.3 Abbreviations used in the details:

- AJ = Architectural Joint
- CJ = Control Joint
- EJ = Expansion Joint
- GSM = galvanized sheet metal
- min. = minimum
- max. = maximum
- typ. = typical
- SAF = Self-Adhering Flashing
- w/ = with
- WRB = Weather-Resistant Barrier

X2.4 *General Considerations for Extreme Weather Conditions*—Snow build-up, recurring or extreme wind-driven rain, prolonged high humidity, and termite control have not been incorporated with these details. Some of these factors can be addressed with the following suggestions:

X2.4.1 *Snow Build-up:*

X2.4.1.1 Raise bottom of the foundation weep screed higher above grade and higher than at exposed paving locations. Additional footing or curb height may be required to raise the screed.

X2.4.1.2 Seal between the weep screed and the foundation/wall base.

X2.4.2 *Wind-Driven Rain:*

X2.4.2.1 Keep all exposed materials with minimum of 50-mm (2-in.) horizontal lap. Increase lap for better resistance to moisture rise between laps.

X2.4.2.2 Cover or seal exposed wood, or use pressure-treated or decay-resistant wood at exposed locations.

X2.4.3 *High Humidity* (Refer to Guide **E241** for further discussion):

X2.4.3.1 Provide ventilation in the wall cavities of parapets or deck rail walls over living spaces to prevent the build-up of humidity under the top wood cap or under a membrane flashing cap, when the walls are not otherwise insulated. Provide vent holes through the top and bottom of studs at deck parapet to interconnect the wall cavities. Consider the elimination of solid sheathing on the interior side of the parapet wall and adding furring strips to allow venting between stud cavities.

X2.4.3.2 Consider the addition of a sheet metal wall/parapet cap with a ventilation space connected to the wall cavities to allow moist air to rise out of the wall.

X2.4.4 Termite Control:

X2.4.4.1 Provide sheet metal sill plate protection or other methods accepted for regional practice.

X2.5 Wall Substrate—The walls for the stucco details presume a continuous, solid sheathing to act as support for the WRB and flashings. The building foundation is presumed to be concrete or masonry without below-grade waterproofing, so no integration between above- and below-grade waterproofing is shown.

X2.6 Durability —Conditions to avoid: There are several building conditions that are inherently likely to drain slowly or collect water. Any condition which retains water or moisture for long or recurring periods can be considered risky in detailing for long-term durability. The conditions to avoid with stucco exposed to weather include: stucco wrapped tops and bottoms of beams; wide flat ledges/deep recessed window sills; cantilevered wood decks; and wood penetrations at stucco walls.

X2.7 Crack Control—There are industry references available that address crack reduction in stucco walls. This document will not attempt to outline all crack reduction measures for stucco. However, excessive stucco cracks can result in exposure of the WRB and flashings to excessive amounts of water, which can lessen the durability of the stucco’s leak prevention system.

X2.8 Control Joints, Expansion Joints, and Architectural Joints—These stucco trim accessories divide areas of stucco and provide a weakened plane through the surface of an area of stucco, which helps to limit the amount and location of uncontrolled stucco cracking. Specification C1063 – 08 requires cutting the lath behind control joints to relieve stresses. There are other functions that these stucco accessories can provide, which cause confusion in the industry for the selection, placement and use of these particular accessories.

X2.8.1 For example, there are several one-piece, control joint products which are referred to by many terms, such as, “contraction-expansion joint,” “expansion control joint,” “expansion joint,” “V” joint, “M” joint, “J” joint, “double J” joint, “#15 joint,” and “XJ-15” joint.

X2.8.2 Except for definitions by TBLP & NWCB, there has not been clear, definitive differentiation between control joints (CJ) and expansion joints (EJ) in the industry. CJ and EJ provide similar and different functions. Both CJ and EJ can perform major functions of accommodating movement, controlling plaster depth and delineating decorative patterns and areas of stucco.

X2.8.3 Specification C1063 – 08 has new definitions for Control Joint—“a joint that accommodates movement of plaster shrinkage and curing along predetermined, usually straight, lines”; Expansion Joint—“a joint that accommodates movement beyond plaster shrinkage and curing.” See also Specification C1063, Annex A1.2.

X2.8.4 Control joints can accommodate less movement than expansion joints. For the most part, the industry does not indicate with dimensions how much movement a control joint should provide. The smaller movements from stucco shrinkage and thermal expansion-contraction of stucco can often be handled by control joints when located according to industry guidelines (See Table X2.1). CJ have discontinuous lath at each side in accordance with Specification C1063 – 08 (See Detail X2.1.2B).

X2.8.5 Expansion joints accommodate larger movements due to minor seismic displacements, substrate movement and foundation settlement. Standard two-piece expansion joints have movement limits governed by the product manufacturer with custom joints available to handle larger movement dimensions (See Details X2.1.3A to X2.1.3C). The amount of movement that can be accommodated by EJ, although relatively large, is nonetheless limited. EJ cannot be expected to prevent cracking in major seismic events or if there is large foundation settlement.

X2.8.6 This Appendix provides an additional joint detail termed an “architectural joint” (AJ) (See Details X2.1.2A and B). This joint is intended to be applied within the boundary areas outlined for CJ or between regular CJ. In this case, the AJ acts as a plaster depth screed and decorative stucco trim. The AJ installation differs from CJ as it is applied over continuous lath behind the AJ. Several stucco industry sources including BNI, NWCB, SVBLP, TBLP and WCLPI recognize the installation of a joint over continuous lath under certain circumstances and regional practice (See Table X2.2). Not cutting lath is not recognized by Specification C1063 – 08. Decorative architectural joints (AJ) are acceptable within the boundary

TABLE X2.1 Control Joint Locations

	Maximum Dimension Criteria	Reference Organization (see Table X2.2)
Stucco Area Limit	100–144 SF	NAAMM (1991); ACI (2004)
	144 SF	ASTM (2006); PCA (2003); TLPB (2001)
	150 SF	PCA(1996)
	150–180 SF	NWCB (1997)
CJ Distance Apart	10 FT	PCA(1996)
	10–18 FT	ACI (2004)
	16 FT	NAAMM (1991)
	18 FT	ASTM (2006); NWCB (1997); PCA(2003); TLPB (2001)
Length-to-Width Aspect Ratio	2.5:1	NAAMM (1991); ACI (2004); ASTM (2006); PCA(2003); TLPB (2001)
	3:1	NWCB (1997)

TABLE X2.2 Control Joint Reference List

Reference Organization/Publisher	Publication/Date
ACI — American Concrete Institute	ACI 524R. No discussion of control joints (CJ) or expansion joints (EJ).
ASTM International — American Society for Testing and Materials	Specification C11 – 04 for terms. No definition for CJ and EJ. Specification C926 – 06 for mixing and materials. See Appendix. No definition for CJ and EJ. Specification C1063 – 08 for lathing and fastening. See definitions for terms. Terminology E631 – 06.
BNI — Building News, Inc., Los Angeles, CA	Plaster and Lathing Systems Manual, by Gorman, Jaffe, Pruter, and Rose, 1988 (3rd ed.). <i>Note this is a compilation of stucco industry references current to 1988. See note 38, page 66, “Lath may be interrupted at each control joint. Where control joints are spaced closer than 12’, lath maybe broken at alternate joints.”</i>
MLPB — Minnesota Lath & Plaster Bureau	Stucco in Residential Construction, 2003 (Aug. 2004, June 2007), acknowledges that control joints are often omitted with residential stucco, but refers to Specification C1063 – 06 criteria. In the Lath Inspection Resource Manual, Dec. 2005, CJ and EJ are defined separately.
NAAMM — National Association of Architectural Metal Manufacturers	ML/SFA 920-91 (4th ed.). Appendix A shows CJ intersection details. It also shows a CJ example with continuous lath behind CJ. Another detail shows cut lath over the CJ flanges.
NWCB — Northwest Wall & Ceiling Bureau	Stucco Resource Guide, 1997 (3rd ed.). <i>See page 134, note 17 “Installing control joints over continuous lath is an approved method, but not when it is to function as an expansion joint.” Also, see details J1 & J3.</i>
PCA — Portland Cement Association	Portland Cement Plaster (Stucco) Manual, 1996 and 2003 (5th ed.) . <i>Note the 2003 edition for CJ location criteria is now consistent with Specification C1063 – 06. Does not distinguish between CJ and EJ.</i>
SVBLP — Sacramento Valley Bureau for Lath & Plaster	Lath & Plaster Systems Manual, 2001. <i>Note that it distinguishes between CJ over continuous lath at “restrained” construction assemblies and CJ with cut lath at “unrestrained” construction assemblies.</i>
TLPCA/TBLP — Texas Lath and Plastering Contractors Association/ Texas Bureau for Lath & Plaster	Systems Manual, 2001. <i>Note this is similar to NWCB manual, but includes separate definitions for “control joint” and “expansion joint.”</i>
WCLPI — Western Conference of Lathing and Plastering Institutes, Inc. (defunct)	“Control Joints: Exterior Lath and Plaster,” circa 1988. <i>Note this 8-page brochure includes many stucco details and shows both horizontal CJ over discontinuous lath and horizontal CJ over continuous lath.</i>

area for control joints. AJ is acceptable over lath in accordance with Plaster and Drywall Systems Manual, 3rd edition 1988 (note 38, p 66). Some regions do not cut lath at control joints with “restrained” stucco panels. Regional sources include: NWCB, TLPB, SVLPB, and SMA.

X2.9 *Control Joint Locations*—**Table X2.1** provides historical criteria for control joint locations. As can be seen the dimensions have varied in the past. Currently, most sources now follow Specification **C1063** – 08.

X2.9.1 **Table X2.2** lists various stucco industry sources that reference the topic of control joint versus expansion joint and cut versus uncut lath at joints.

X2.10 *Reveals and Back-to-Back Casing Beads*—Reveals are typically considered decorative trim. The plaster industry has not clearly acknowledged whether reveals can perform some of the stress control functions of control joints. Back-to-back casing beads are briefly described in some industry references as an alternate to controls joints and expansion joints. The sealant joint required between casing beads is

critical to performance.

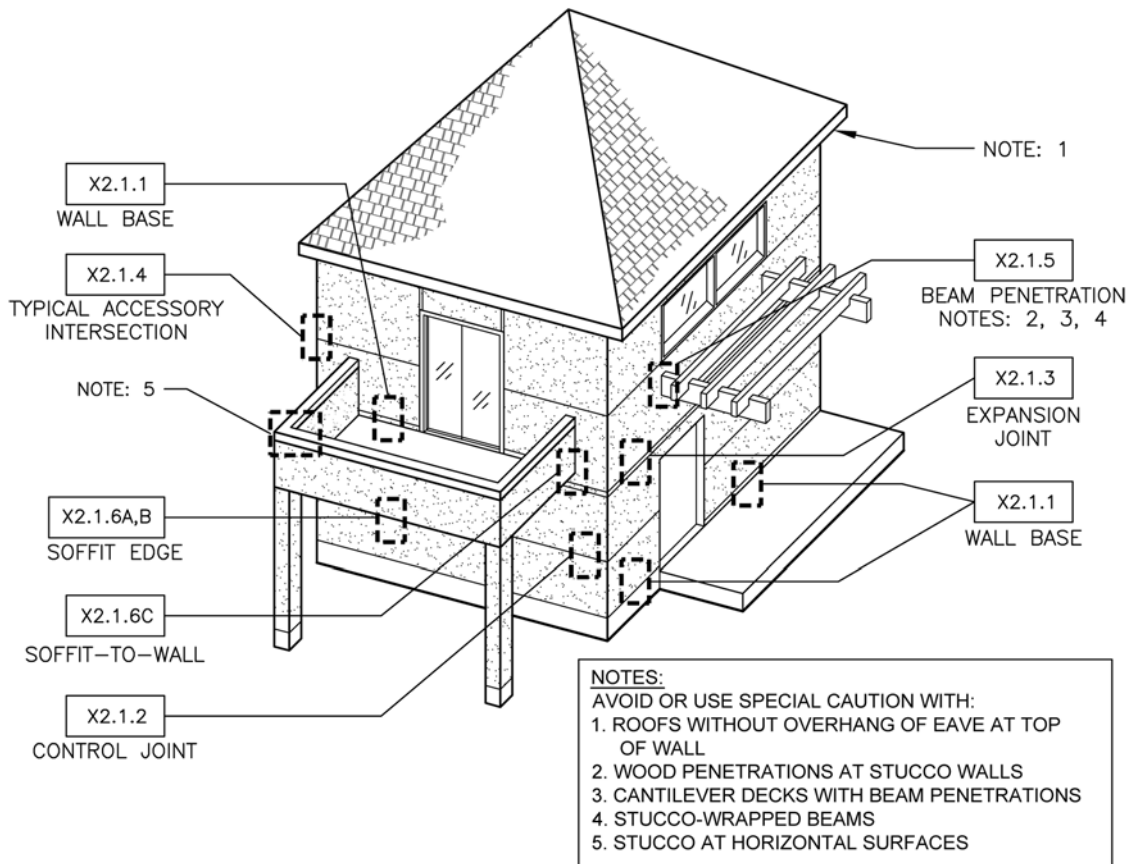
X2.11 *Limitations* —**Appendix X2** details are intended to supplement the details published by sources referenced elsewhere in the standard. The **Appendix X2** details are not intended to address all conditions or represent the only solutions. Some details show regional practices that may not be appropriate for all locations. See **6.2**.

X2.12 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. The SI units in Specifications **C926** – 06 and **C1063** – 08, and 2006 International Building Code (IBC) are not consistent with each other. The 2006 IBC has 7/8-in. stucco at 22.2 mm (0.875 in.). Specifications **C926** – 06 and **C1063** – 08 have 7/8-in. stucco at 22 mm.

X2.13 *Aluminum Stucco Accessories*—Typically aluminum stucco accessories are anodized. Anodized or painted aluminum stucco accessories manufactured for stucco applications

are considered protected from potential corrosion and require no further coating or separation from typical stucco when conforming to requirements of Specification C1063.

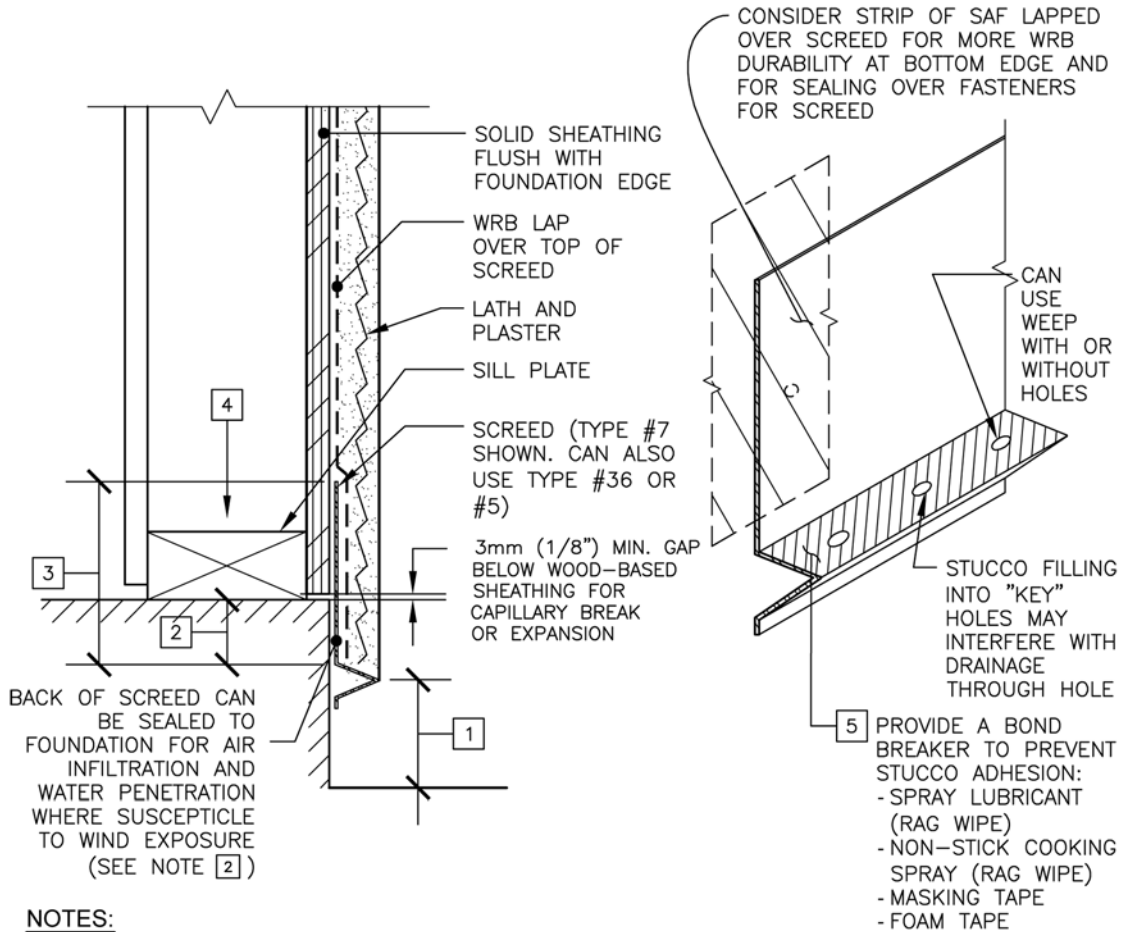
X2.1 CEMENT PLASTER (STUCCO) GUIDE DETAILS - Reference Drawing. The following diagram is a reference view of a prototypical building to generally show the location of the guide details.



X2.1 CEMENT PLASTER (STUCCO)

Detail Series:

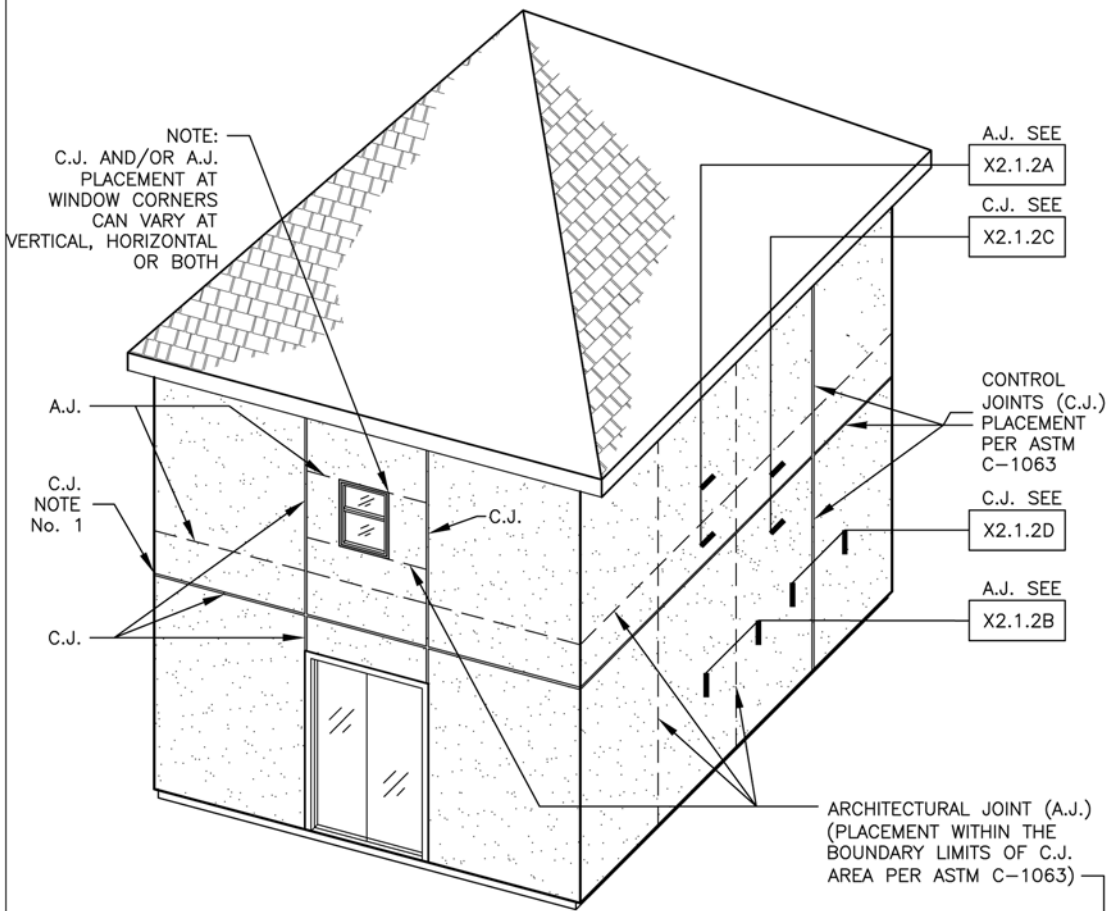
X2.1.1	Wall Base Screed (Cement Plaster Foundation)
X2.1.2	Control Joint, Architectural Joint & Reveal
X2.1.3	Expansion Joint
X2.1.4	Stucco Trim Laps, Ends & Corners
X2.1.5	Beam Penetration Flashing
X2.1.6	Soffit Edge Weep/Drip Screed



NOTES:

- [1] HEIGHT ABOVE HORIZONTAL SURFACE. DIMENSION GOVERNED BY BUILDING CODE (E.G. SOIL = 100mm (4") MIN., PAVING = 50mm (2") MIN.) AND CLADDING AND SHEATHING MANUFACTURERS' RECOMMENDATIONS. REGIONAL CONDITIONS WITH SNOW BUILD-UP, WIND-DRIVEN RAIN CAN INFLUENCE MINIMUM HEIGHT OF SCREED.
- [2] LAP OF SCREED BELOW BOTTOM OF SILL 25mm (1") MIN. SUFFICIENT TO PREVENT WATER SEEPING UP BEHIND WEEP UNDER SILL. CONSIDER A SEPARATOR MATERIAL, E.F. FELT, SAF, OR SEALANT BETWEEN SCREED AND CONCRETE. SHEET MATERIAL SEALS CAN LAP UP ONTO SHEATHING
- [3] DIMENSION OF SCREED LEG GOVERNED BY BUILDING CODE. HIGHER LEG ADDS DURABILITY TO BOTTOM EDGE OF WRB. (88mm (3 1/2") TYP.)
- [4] TERMITE SHIELD OR SILL PLATE INSULATION STRIP ON TOP CONCRETE NOT INCLUDED IN THESE WEATHERPROOFING DETAILS.
- [5] BOND BREAKER MATERIAL SHALL BE COMPATIBLE WITH WRB AND SAF. LIMIT APPLICATION TO INTENDED SURFACE.

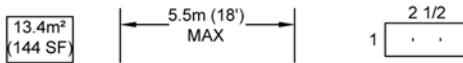
X2.1.1 WEEP SCREED AT CEMENT PLASTER FOUNDATION
 WALL BASE: GRADE, PAVING & DECK SURFACE



NOTE:

1. IN THIS CONCEPTUAL EXAMPLE, AN EXPANSION JOINT IS NOT USED AT THE FLOOR LINE. THIS EXAMPLE PRESUMES FULL WALL SHEATHING AND ANTICIPATES LITTLE OR NO SUBSTRATE MOVEMENT.

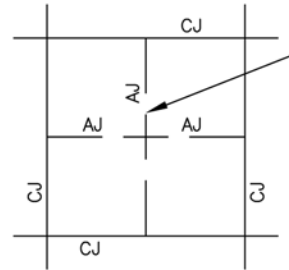
2. ASTM C-1063 RECOMMENDS PLACEMENT OF CONTROL JOINTS (C.J.) AT 13.4m² (144 SF) MAX.; 5.5m (18') APART MAX. & 2 1/2:1 MAX. ASPECT RATIO AREA



3. ARCHITECTURAL JOINT IS A "DECORATIVE" CONTROL JOINT, WHERE THE LATH NEED NOT BE DISCONTINUOUS, APPLIED WITHIN THE BOUNDARIES OF AN ASTM C-1063 C.J.

4. SEE X2.1.4 FOR TERMINATIONS OF C.J. AND E.J.

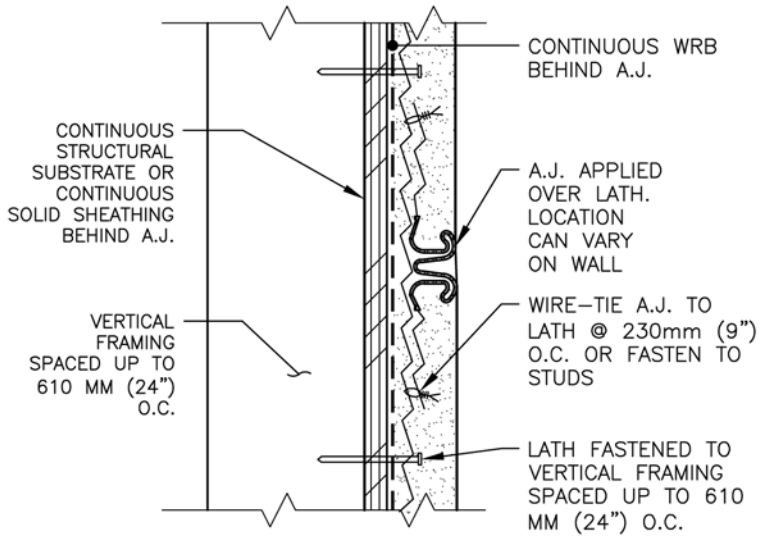
5. HIGHER STRESSES OCCUR AT OPENING CORNERS MAKING CONTROL JOINT OR SPECIAL DIAGONAL LATH REINFORCING STRIPS NECESSARY.



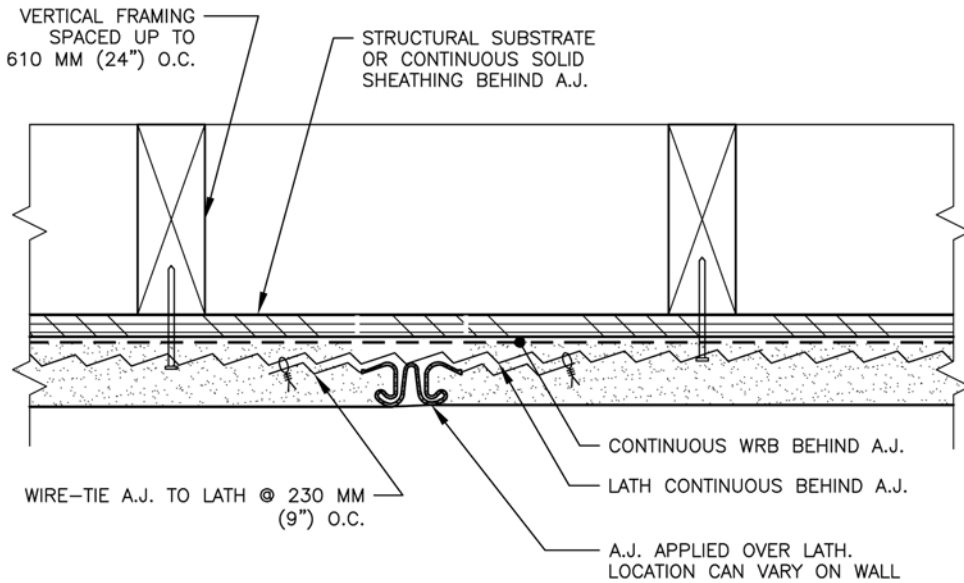
X2.1.2

CONTROL JOINT (C.J.) & ARCHITECTURAL JOINT (A.J.) LOCATIONS

1. SEE GENERAL NOTES FOR DISCUSSION OF A.J.

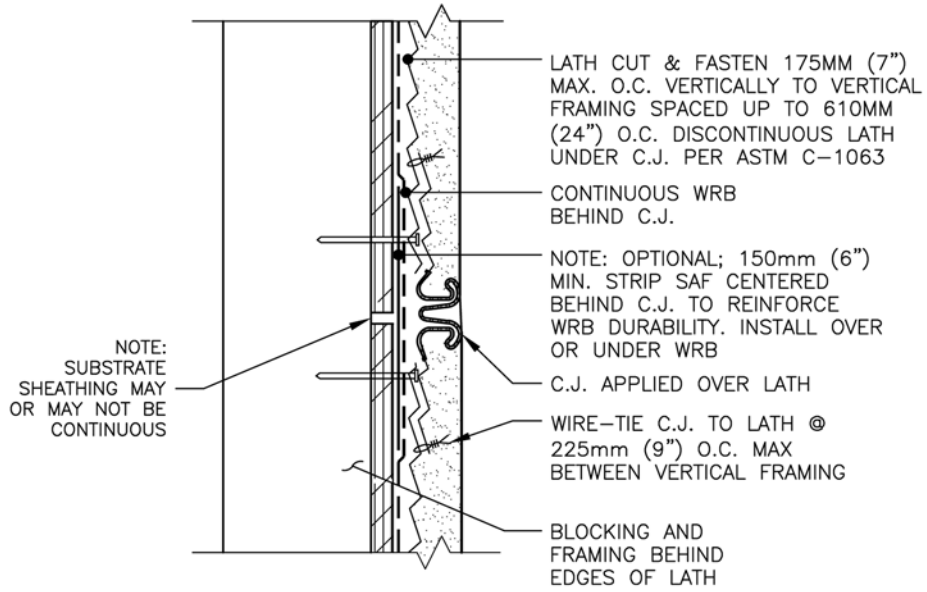


X2.1.2A HORIZONTAL ARCHITECTURAL JOINT (A.J.)

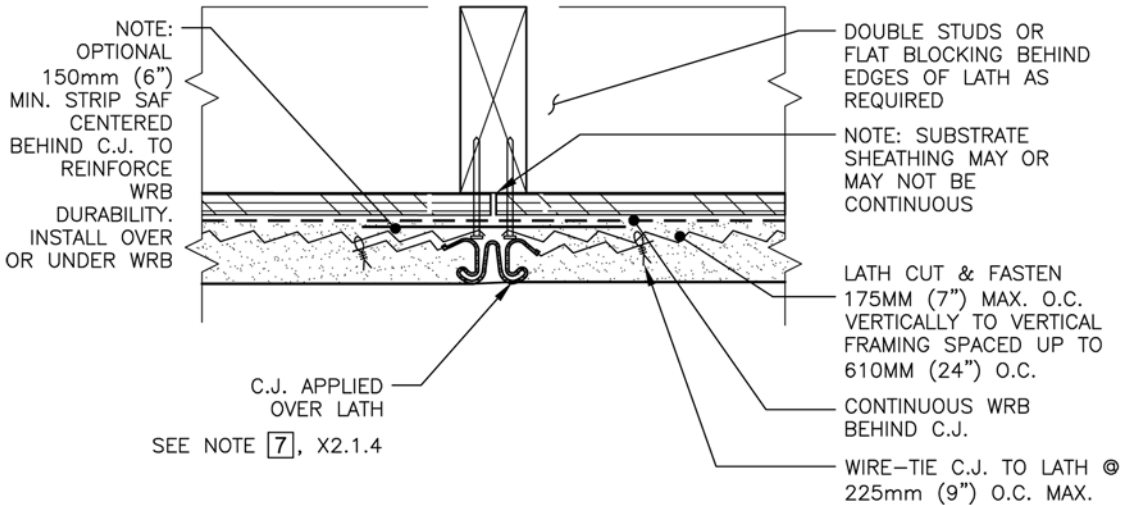


X2.1.2B VERTICAL ARCHITECTURAL JOINT (A.J.)



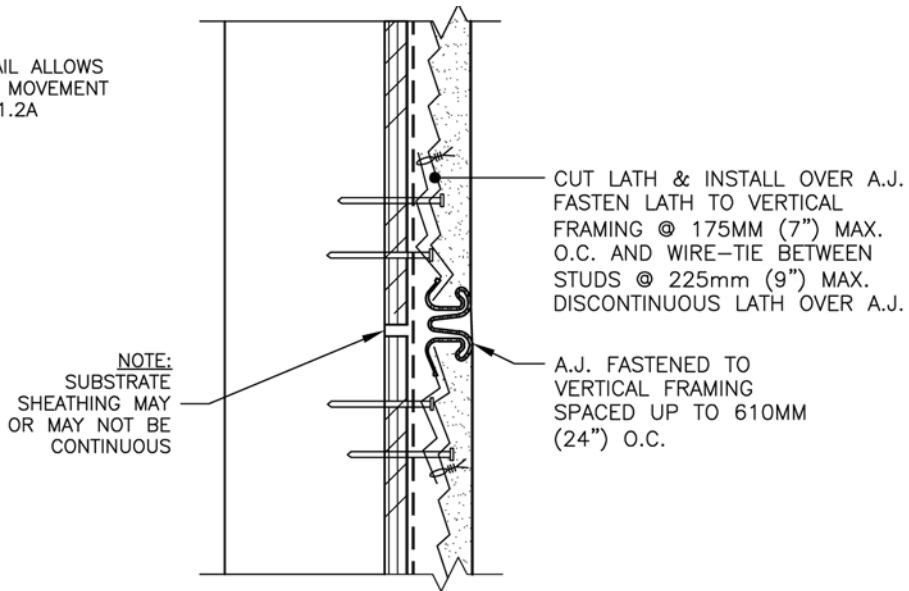


X2.1.2C HORIZONTAL CONTROL JOINT (C.J.)
(PER ASTM C-1063)

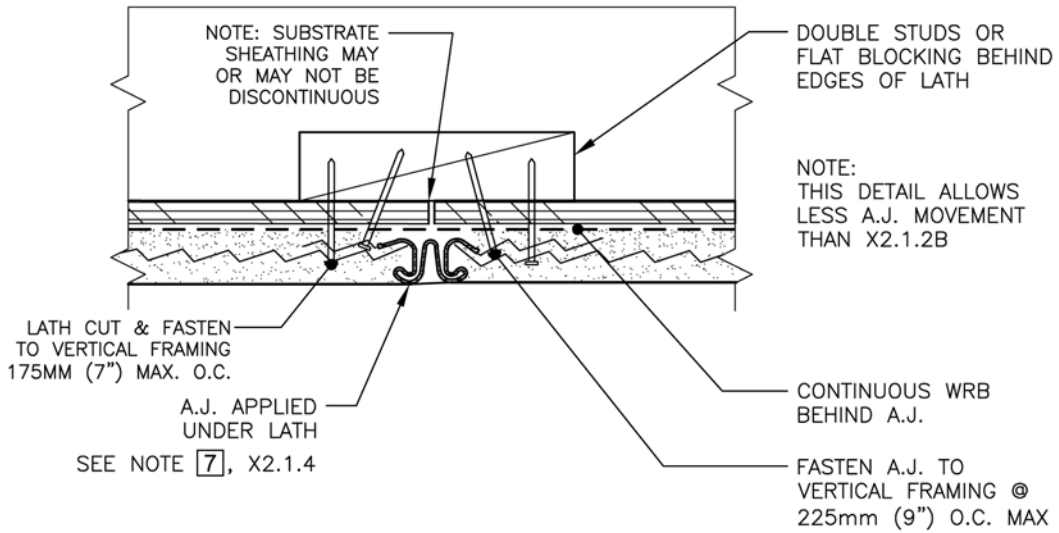


X2.1.2D VERTICAL CONTROL JOINT (C.J.)
(PER ASTM C-1063)

NOTE:
THIS DETAIL ALLOWS
LESS A.J. MOVEMENT
THAN X2.1.2A

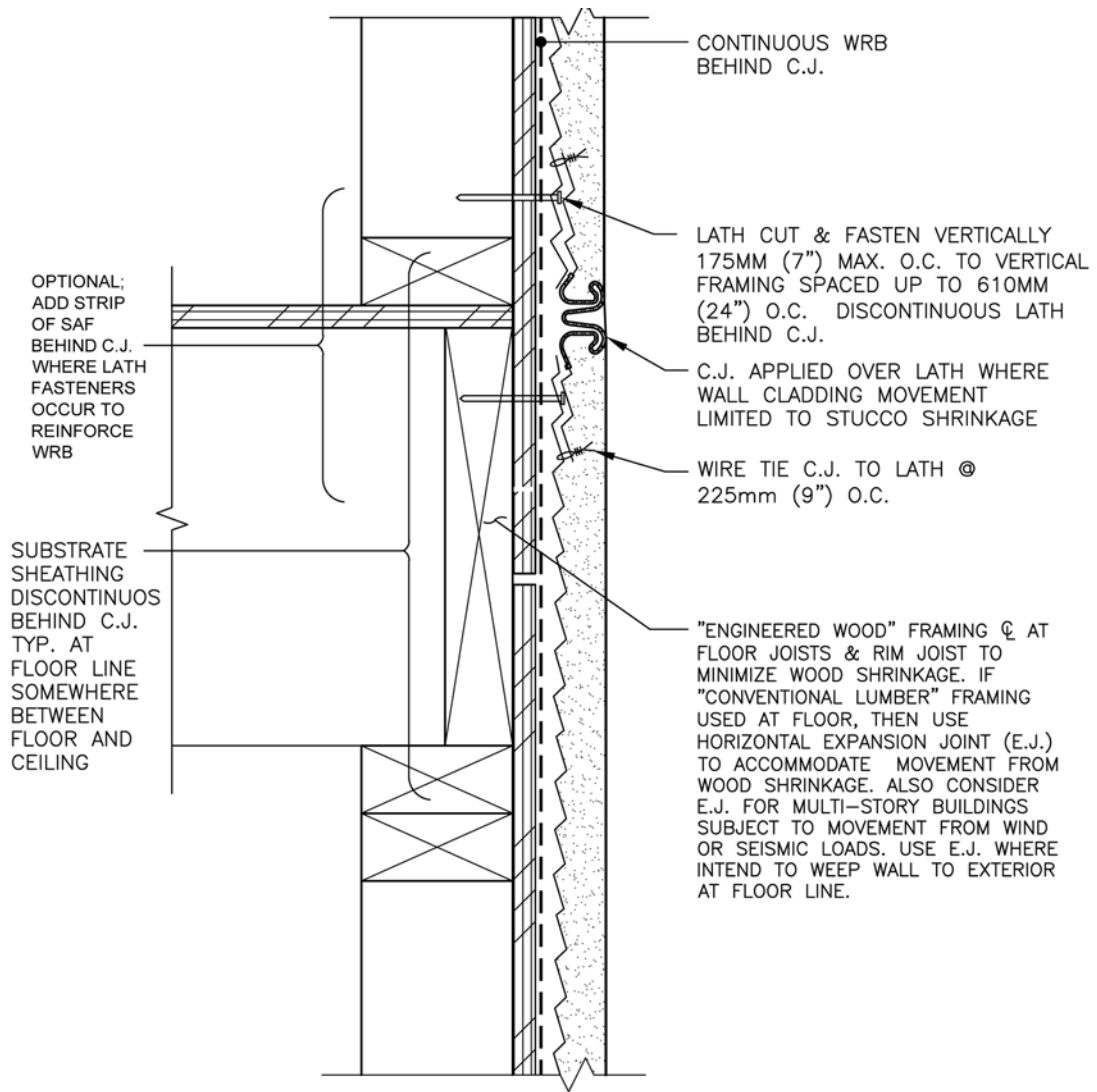


X2.1.2E HORIZONTAL ARCHITECTURAL JOINT (A.J.)
(ALTERNATE)



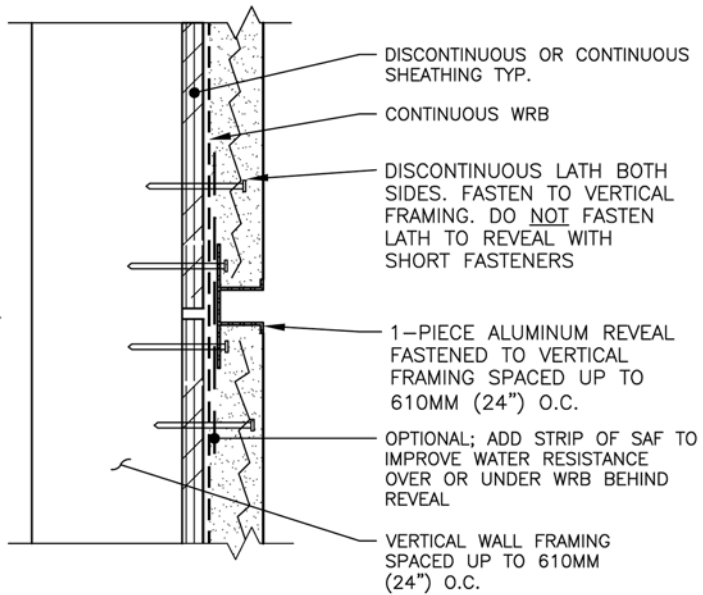
X2.1.2F VERTICAL ARCHITECTURAL JOINT (A.J.)
(ALTERNATE)





X2.1.2I HORIZONTAL CONTROL JOINT (C.J.) AT FLOOR LINE
 (PER ASTM C-1063) 0 1 2 3'

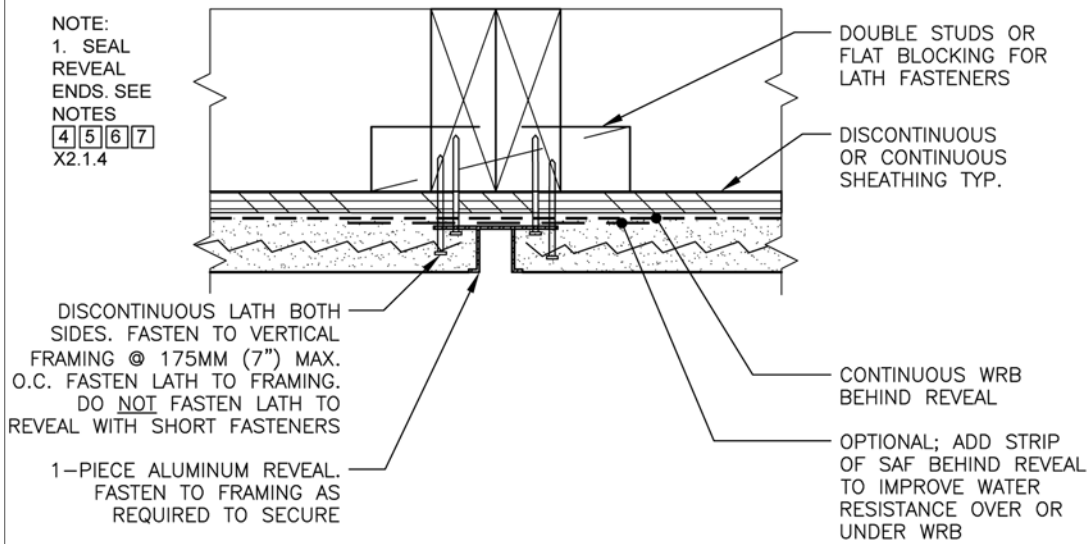
NOTES:
 1. CONSIDER SHIMMING BEHIND REVEAL TO IMPROVE DRAINAGE AT WRB.
 2. SEAL REVEAL ENDS. SEE NOTES 4 5 6 7 X2.1.4



X2.1.2G HORIZONTAL REVEAL - ALUMINUM



NOTE:
 1. SEAL REVEAL ENDS. SEE NOTES 4 5 6 7 X2.1.4

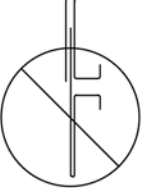
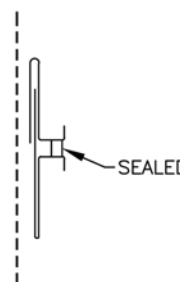





X2.1.2H VERTICAL REVEAL - ALUMINUM

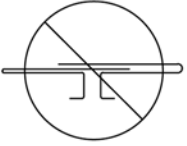
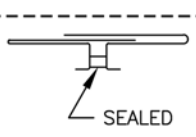
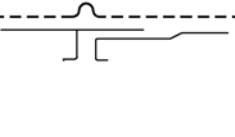
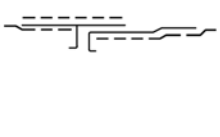


STUCCO WALL DETAILS:

HORIZONTAL E.J.-

 <p># 40</p>	 <p>SEALED</p>			
# 40 CAUTION	X2.1.3A	X2.1.3B	X2.1.3C	X2.1.3D

VERTICAL E.J.-

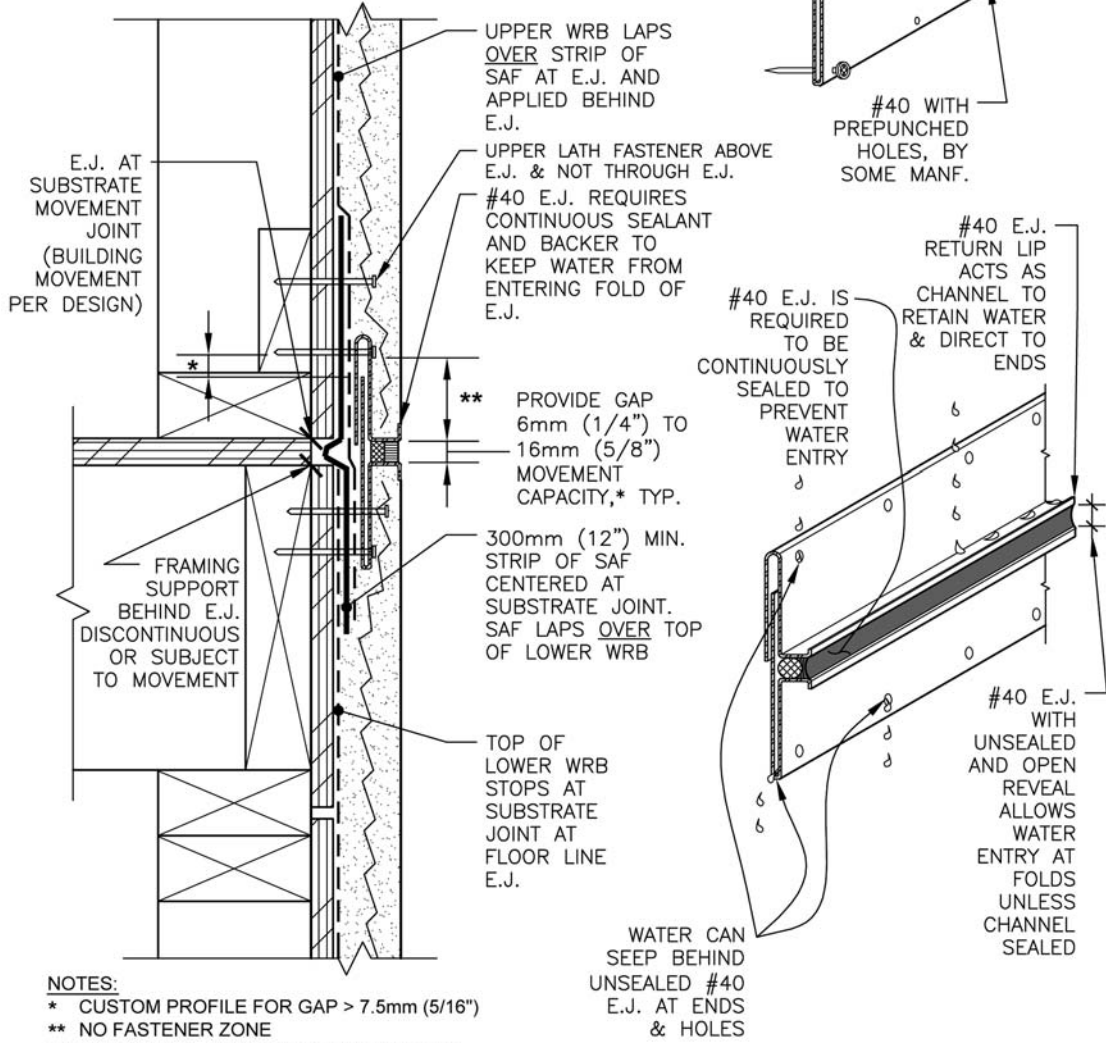
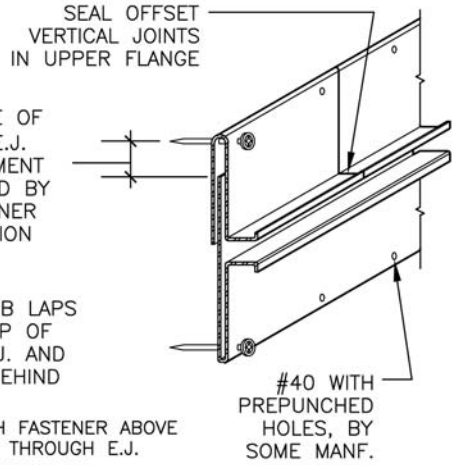
 <p># 40</p>	 <p>SEALED</p>		
# 40 CAUTION	X2.1.3A-1	SIM X2.1.3B	SIM X2.1.3C

NOTES:

THERE ARE A VARIETY OF CHOICES FOR ACCOMMODATING BUILDING AND/OR STUCCO WALL MOVEMENT. SELECTION OF A PARTICULAR TYPE OF EXPANSION JOINT SHOULD CONSIDER THE WATERPROOFING FEATURES IMPORTANT TO THE PROJECT AND CONSISTENT WITH THE BUILDING DESIGN AND CONSTRUCTION.

X2.1.3 EXAMPLES OF EXPANSION JOINTS (E.J.) FOR STUCCO WALLS

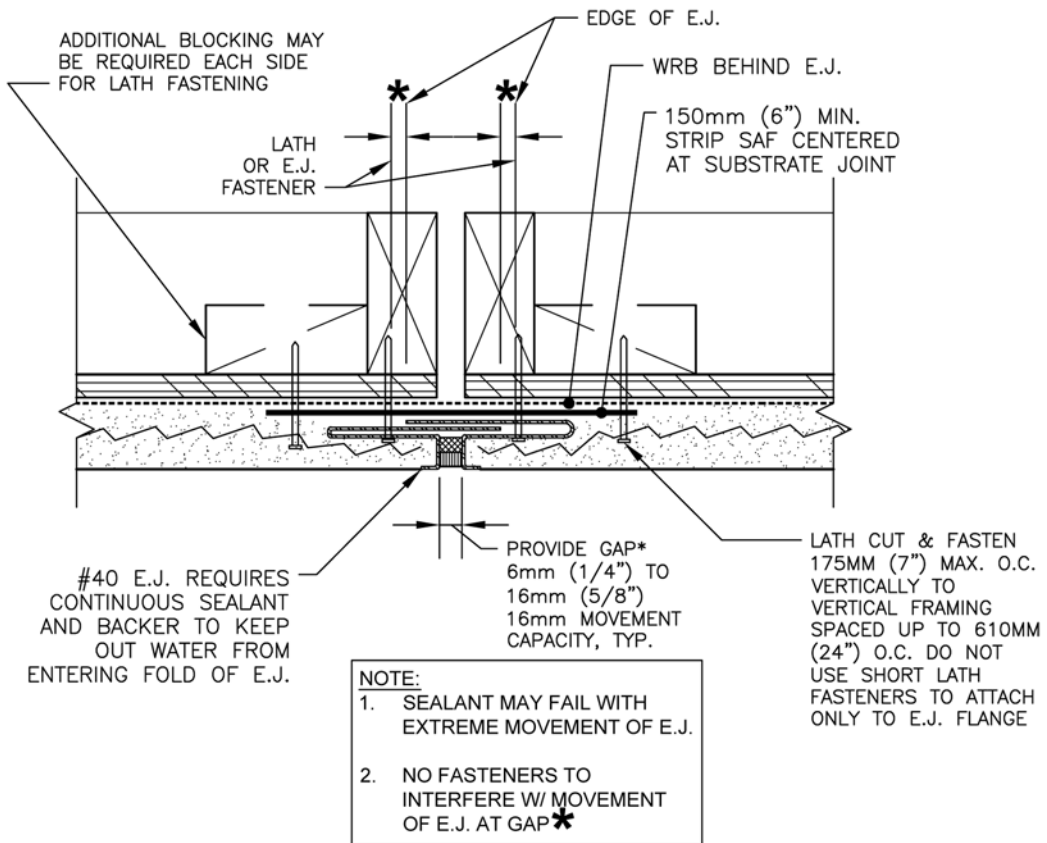
NOTE:
 1. #40 E.J. RECOMMENDED ONLY FOR VERTICAL LOCATIONS ONLY WHEN OPEN REVEAL IS SEALED, SEE X2.1.3A-1
 2. #40 E.J. IS REQUIRED TO HAVE WRB BEHIND FOR WALL DRAINAGE. DO NOT APPLY UPPER WRB OVER TOP OF E.J. UNLESS WEEP SLOTS PROVIDED ALONG FRONT LIP



NOTES:
 * CUSTOM PROFILE FOR GAP > 7.5mm (5/16")
 ** NO FASTENER ZONE
 1. SEALANT IN E.J. MAY FAIL WITH EXTREME MOVEMENT

X2.1.3A #40 HORIZONTAL EXPANSION JOINT (E.J.) - SEALED

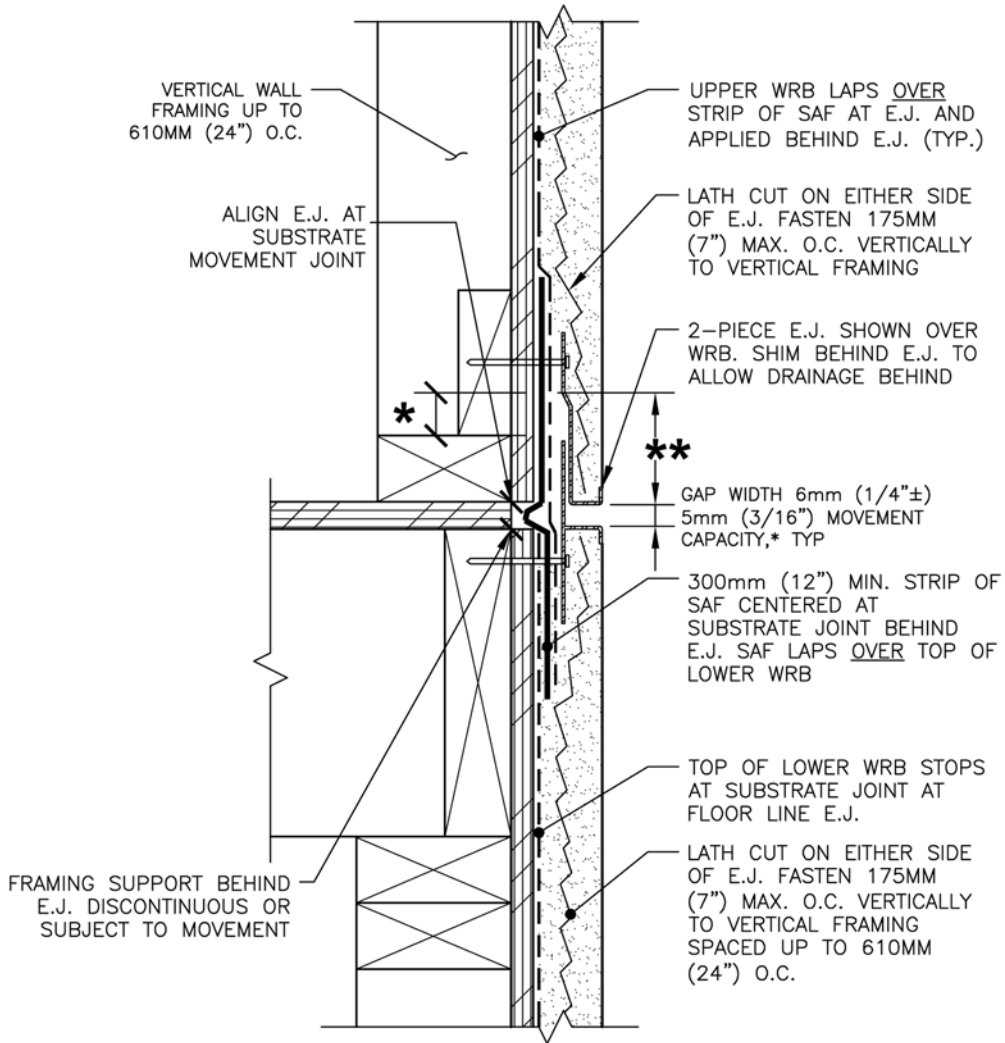




X2.1.3A-1 #40 VERTICAL EXPANSION JOINT (E.J.) - SEALED



NOTE:
EXAMPLE WHERE HORIZONTAL
EXPANSION JOINT NOT USED AS WEEP

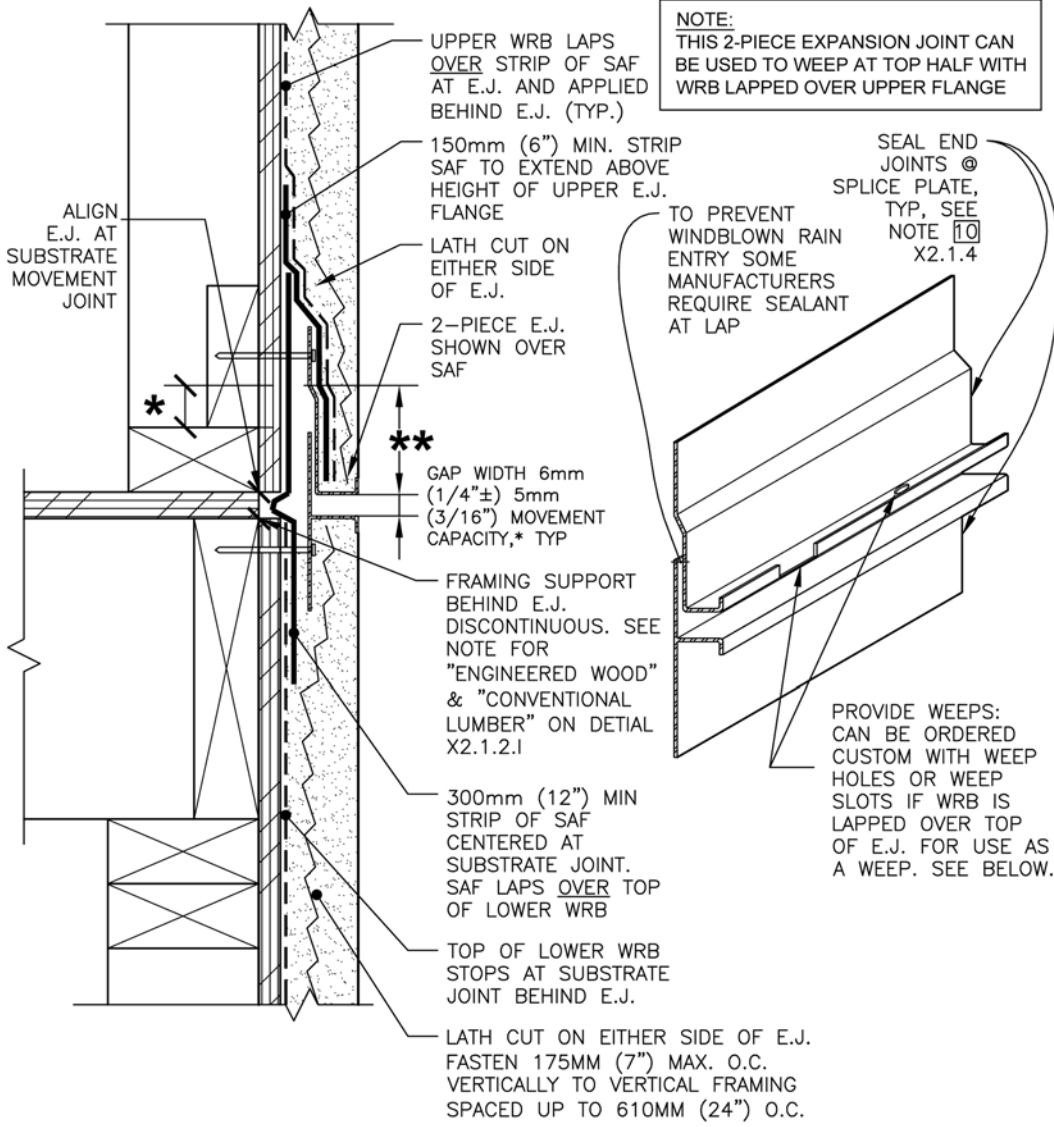


NOTE:
* STOCK MANUFACTURED E.J. HAVE LIMITED MOVEMENT. CUSTOM PROFILE REQUIRED FOR E.J. MOVEMENT > 5mm (3/16")
** NO FASTENER ZONE

X2.1.3B 2-PIECE HORIZONTAL ALUMINUM EXPANSION JOINT (E.J.)
(WALL DRAINAGE CONTINUES BEHIND E.J.)



NOTE:
EXAMPLE WHERE HORIZONTAL
EXPANSION JOINT USED AS WEEP

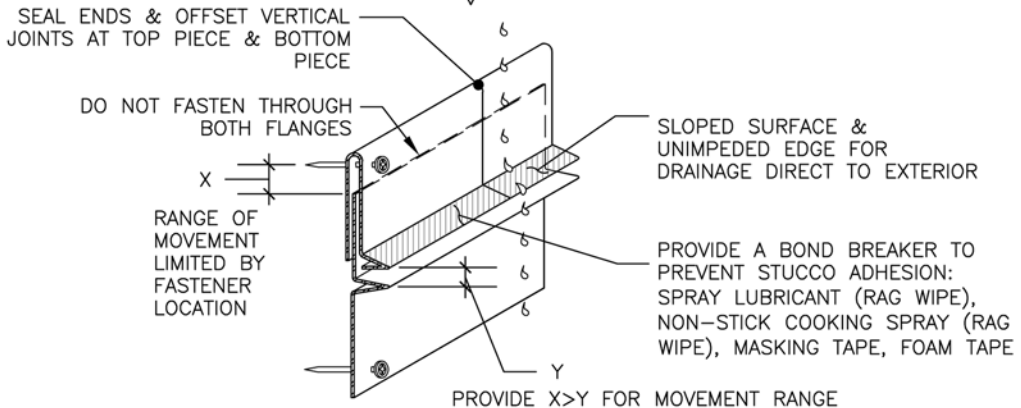
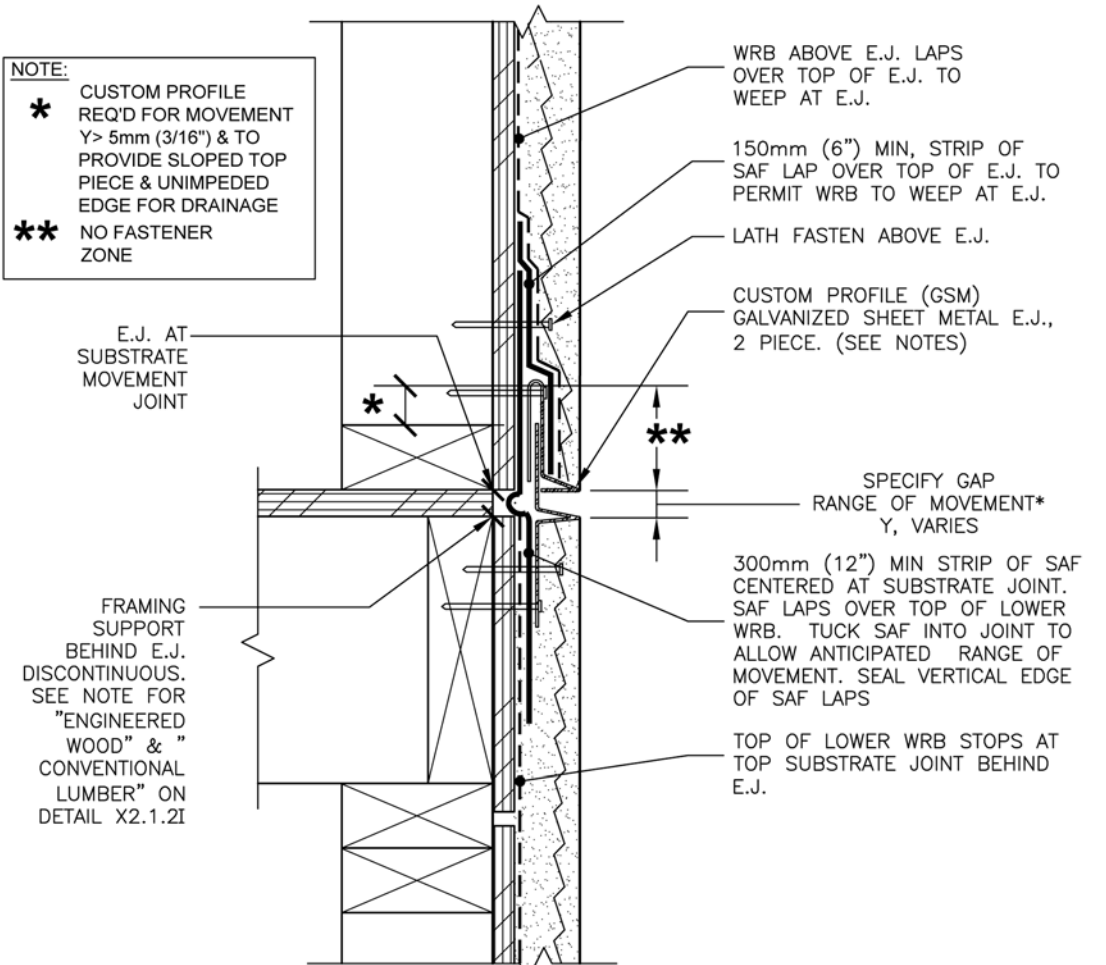


NOTE:
* STOCK MANUFACTURED E.J. HAVE LIMITED MOVEMENT. CUSTOM PROFILE REQUIRED FOR E.J. MOVEMENT > 5mm (3/16")
** NO FASTENER ZONE

X2.1.3C 2-PIECE HORIZONTAL EXPANSION JOINT (E.J.)—ALUMINUM (WALL DRAINAGE EXITS AT E.J.)

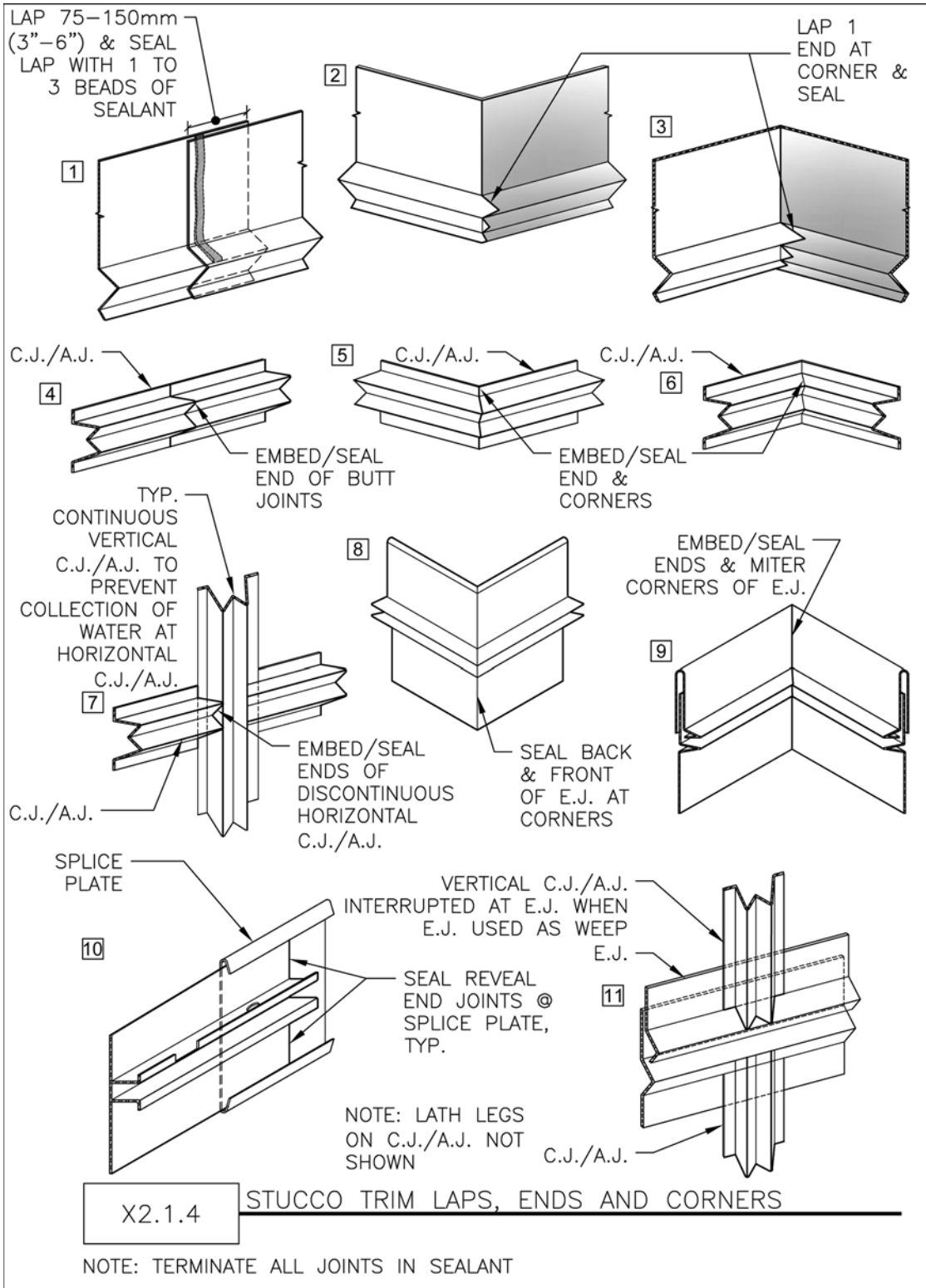


NOTE:
 * CUSTOM PROFILE REQ'D FOR MOVEMENT $Y > 5\text{mm}$ (3/16") & TO PROVIDE SLOPED TOP PIECE & UNIMPEDED EDGE FOR DRAINAGE
 ** NO FASTENER ZONE



X2.1.3D 2-PIECE HORIZONTAL EXPANSION JOINT (E.J.)—CUSTOM SHEET METAL (WALL DRAINAGE EXITS @ E.J.)





NOTES:

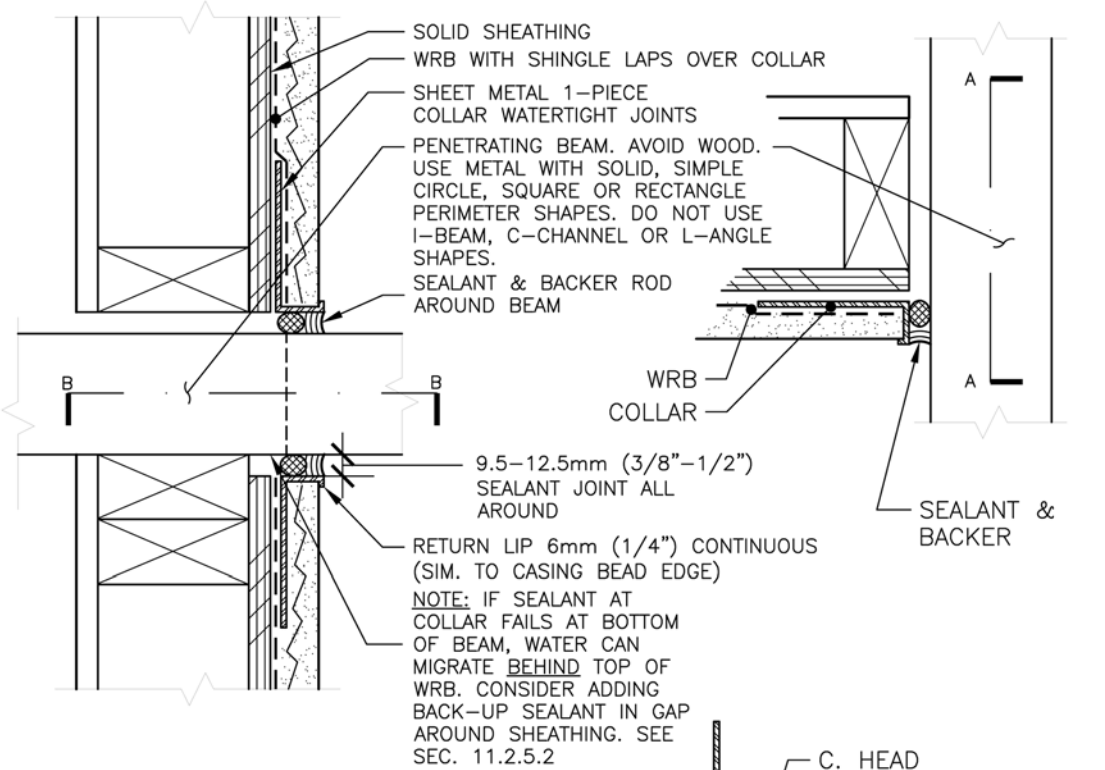
1. THE COLLAR AROUND BEAM SHOULD BE FLASHED IN SHINGLE FASHION SIMILAR TO WINDOW PENETRATIONS IN ASTM E-2112.
2. OPTIONAL; SET COLLAR FLANGES IN BEDDING SEALANT TO WALL

VERTICAL SECTION A-A

HORIZONTAL SECTION B-B

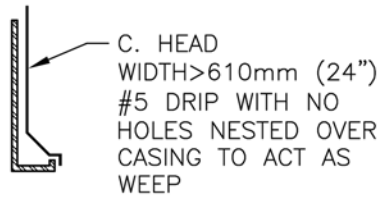
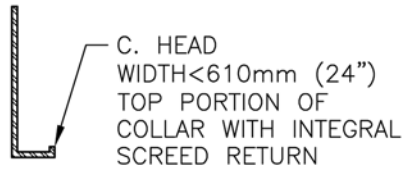
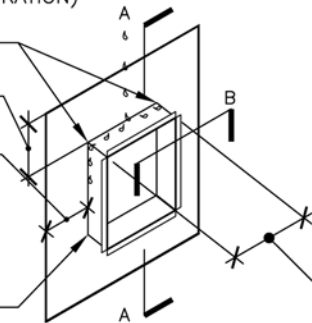
INSIDE

OUTSIDE



METAL 1-PIECE COLLAR
(BEFORE WALL PENETRATION)

- WATER WEEPS TO CORNERS & DOWN SIDES
- 50mm (2") MIN. FLANGE, AT TOP AND BOTTOM
- 150mm (6") MIN. FLANGE UNLESS VERTICAL EDGES AT SIDES OF WRB SEALED TO COLLAR OR 150mm (6") STRIPS SAF LAPPED OVER SIDE & TOP FLANGE
- GSM WATERTIGHT, SOLDERED COMPLETE (4) CORNERS TYP.



X2.1.5A

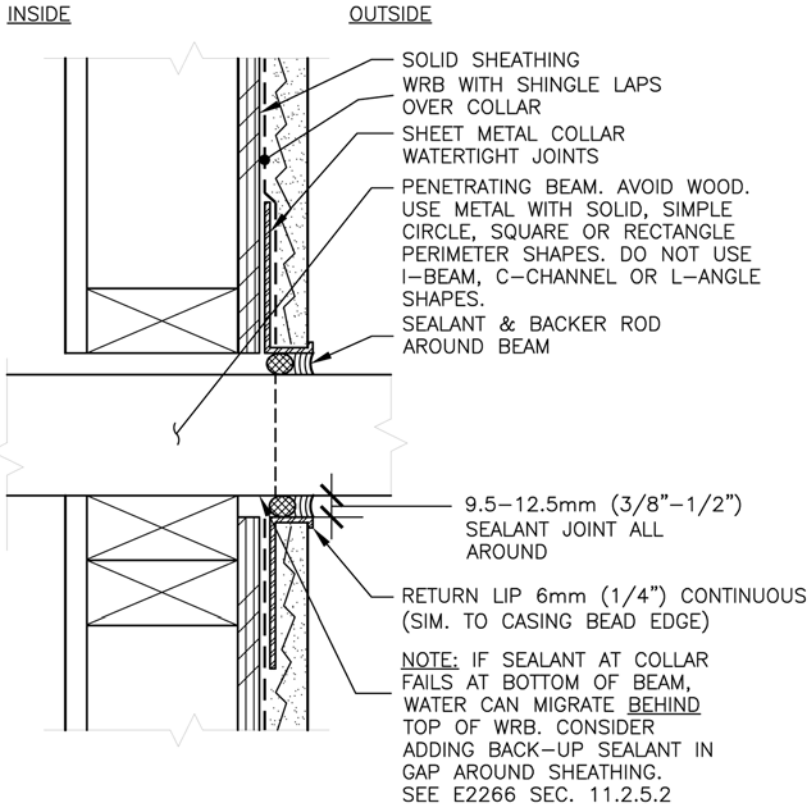
1-PIECE BEAM PENETRATION FLASHING COLLAR - SHEET METAL



NOTES:

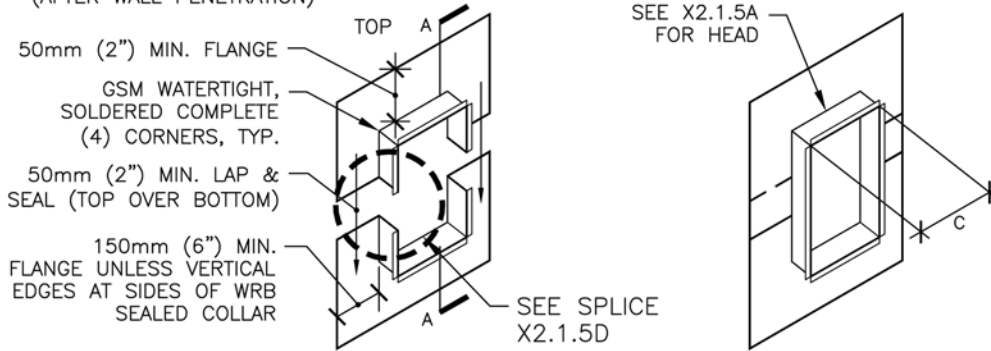
1. THE COLLAR AROUND BEAM SHOULD BE FLASHED IN SHINGLE FASHION SIMILAR TO WINDOW PENETRATIONS IN ASTM E-2112.
2. OPTIONAL; SET COLLAR FLANGES IN BEDDING SEALANT TO WALL

VERTICAL SECTION A-A



METAL 2-PIECE COLLAR

(AFTER WALL PENETRATION)



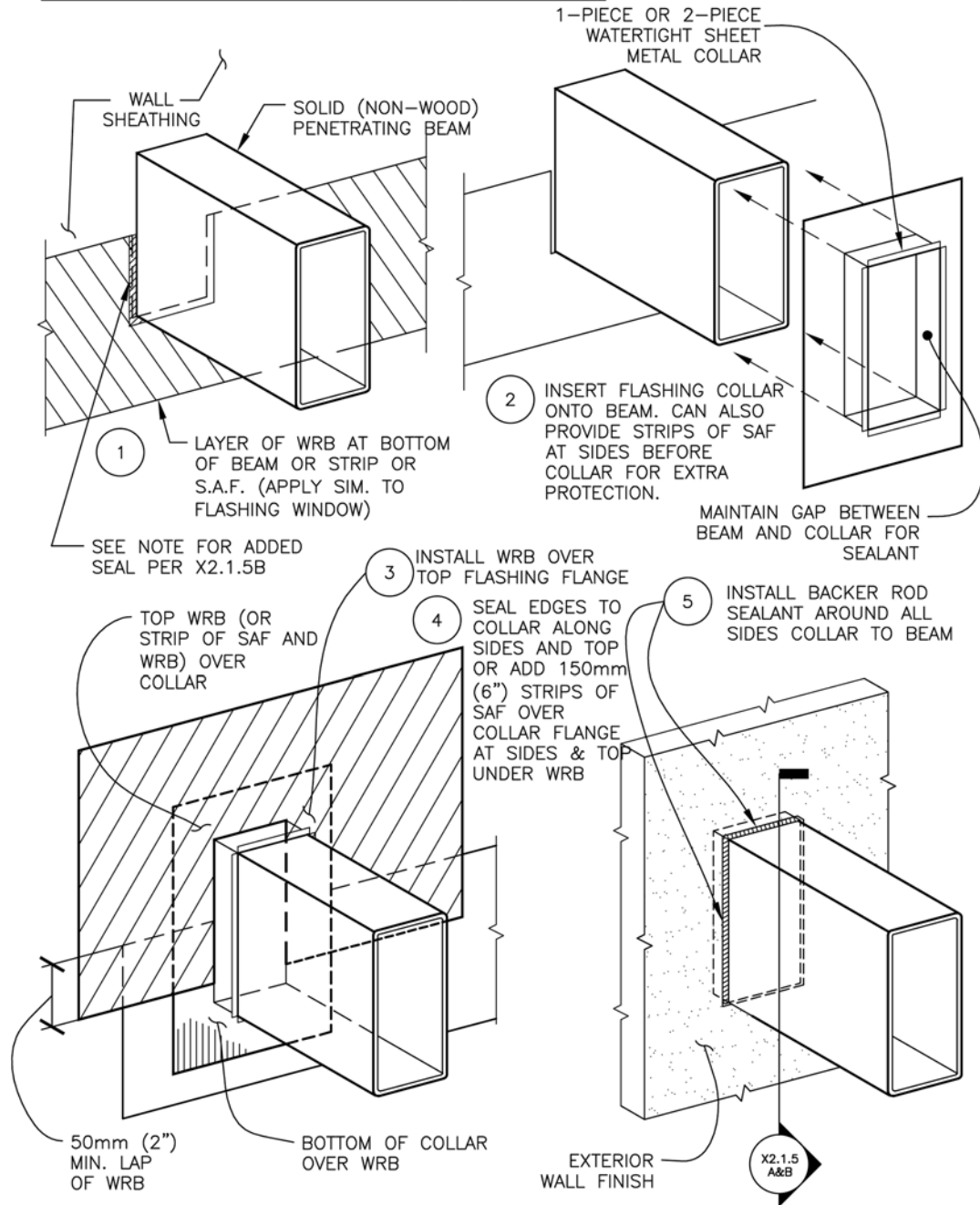
X2.1.5B

2-PIECE BEAM PENETRATION FLASHING COLLAR -

SHEET METAL



SEQUENCE FLASHING - 1-PIECE COLLAR (2-PIECE, SIM.)

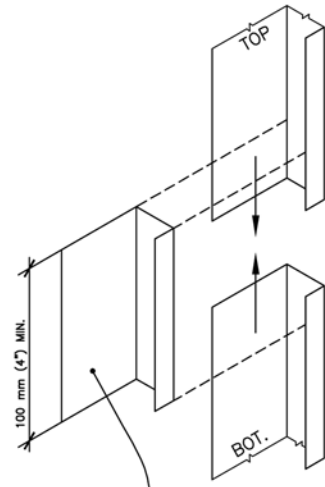


X2.1.5C BEAM PENETRATION FLASHING COLLAR - SHEET METAL

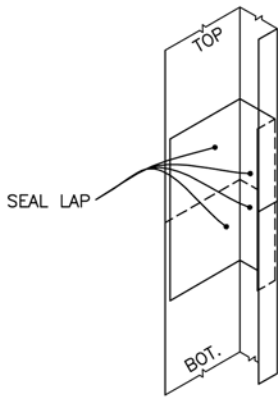


OPTIONS FOR SPLICING A 2-PIECE COLLAR

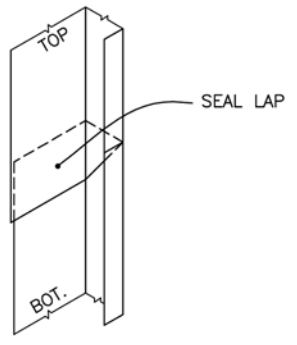
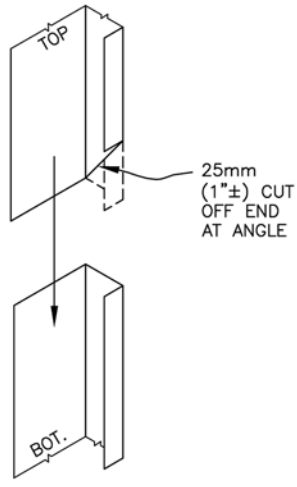
OPTION (A)



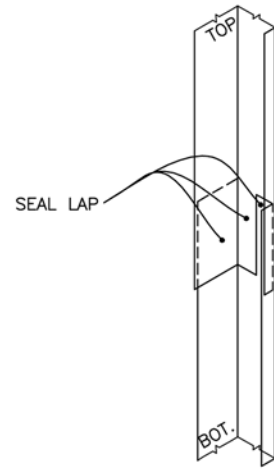
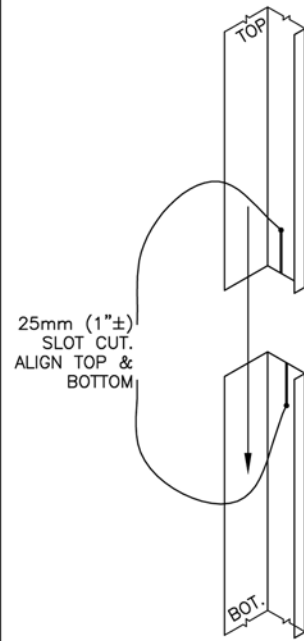
INSERT SIZED TO FIT TIGHT INSIDE WITH LIGHTER GAGE METAL



OPTION (B)

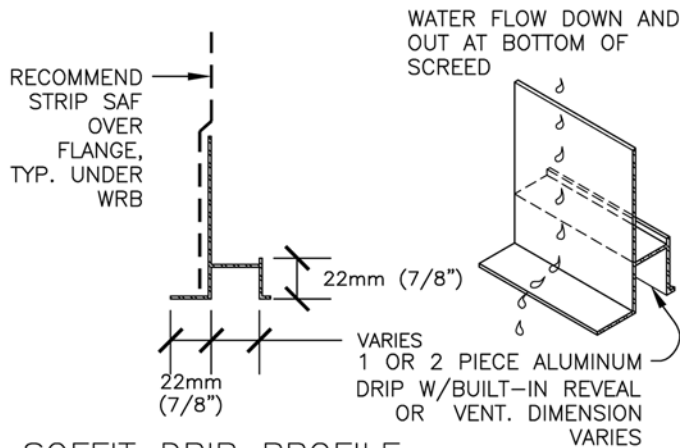
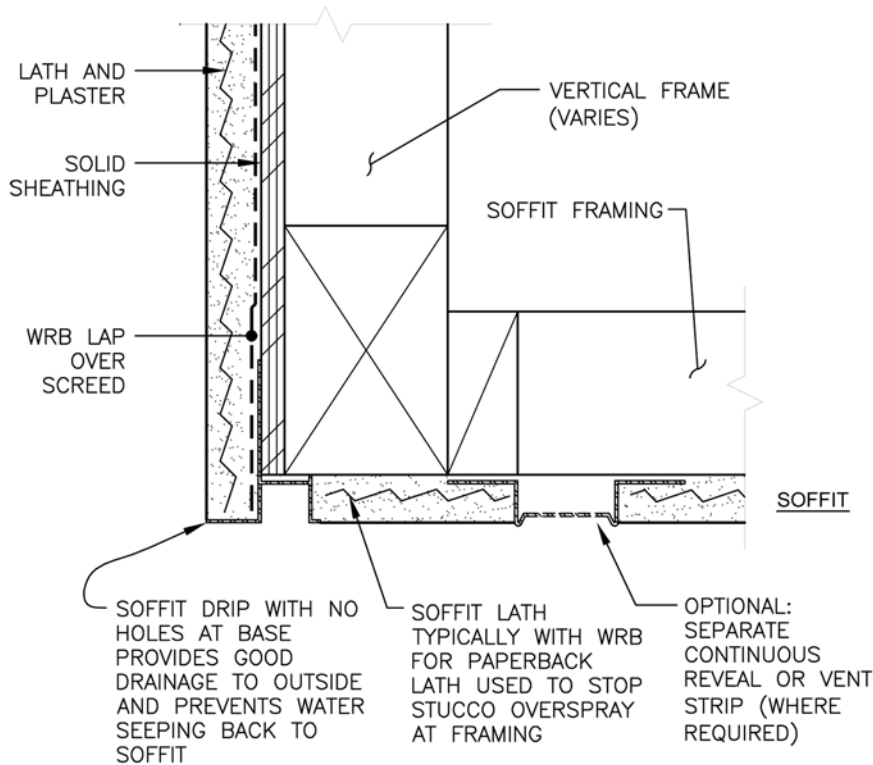


OPTION (C)



X2.1.5D SPLICE AT FLASHING COLLAR - SHEET METAL

VERTICAL WALL SECTION



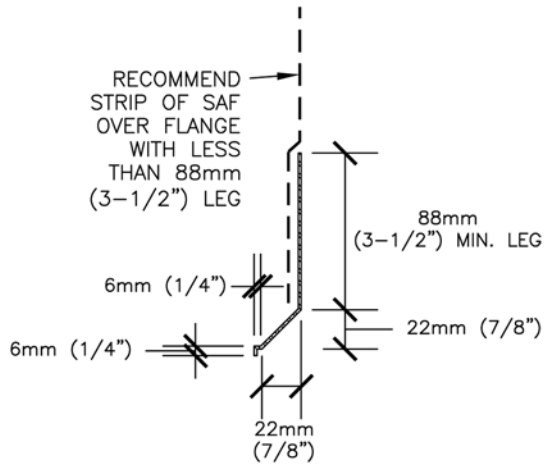
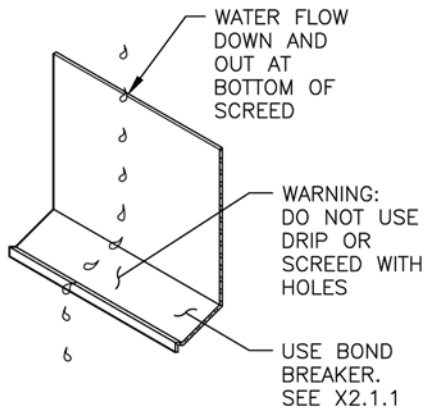
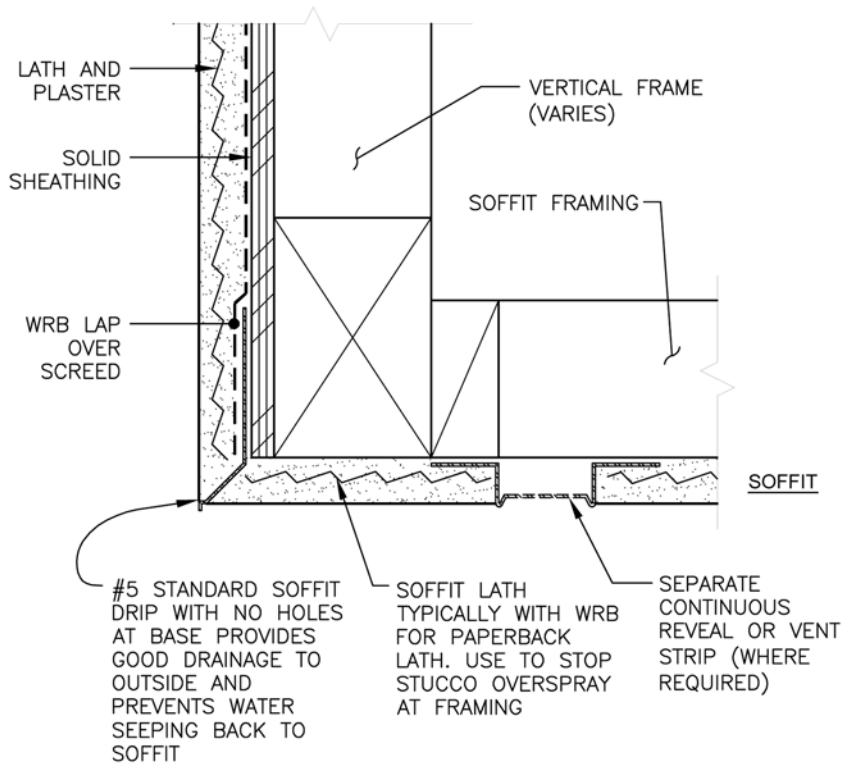
SOFFIT DRIP PROFILE

CONSIDERATIONS:

1. INTENT OF DRIP IS TO WEEP WATER OUT AND NOT SIT AT HORIZONTAL STUCCO LEG OR BE IMPEDED FROM DRAINAGE. THIS IS ONE OF SEVERAL EXAMPLES TO ACCOMPLISH WEEPING AT BOTTOM OF VERTICAL WALL.

X2.1.6A	SOFFIT EDGE WEEP/DRIP SCREED — NTS ALUMINUM
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VERTICAL WALL SECTION

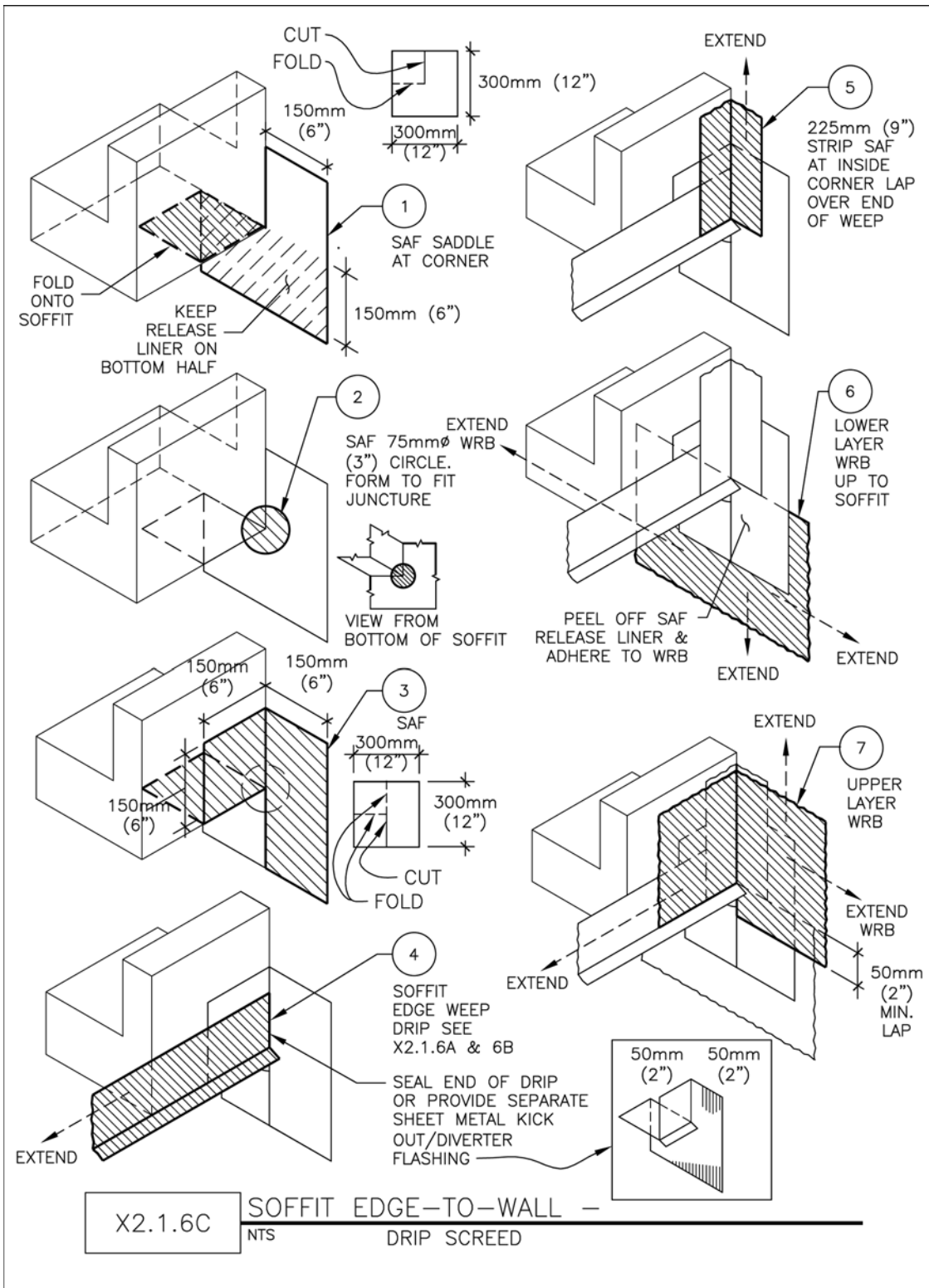


#5 DRIP PROFILE, TYP.

CONSIDERATIONS:

1. INTENT OF DRIP IS TO WEEP WATER OUT AND NOT SIT AT HORIZONTAL STUCCO LEG OR BE IMPEDED FROM DRAINAGE. THIS IS ONE OF SEVERAL EXAMPLES TO ACCOMPLISH WEEPING AT BOTTOM OF VERTICAL WALL.

X2.1.6B	SOFFIT EDGE WEEP/DRIP SCREED -
	NTS SHEET METAL



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