Investigating ICF Wall Construction Meeting the Requirements of NFPA 285

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Jensen Hughes | May 2025

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Acknowledgment

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Founded in 1930, the National Ready Mixed Concrete Association is the leading industry advocate. Our mission is to provide exceptional value for our members by responsibly representing and serving the entire ready mixed concrete industry through leadership, promotion, education and partnering to ensure ready mixed concrete is the building material of choice.

The Insulating Concrete Forms Manufacturers Association (ICFMA) is the North American non-profit trade association for the Insulating Concrete Forms (ICF) industry. The ICFMA was founded in 2014 by a dedicated group of manufacturers with the interest of improving the quality and acceptance of Insulated Concrete Form construction. Our mission is to promote and enhance the social, environmental, and economic value of Insulating Concrete Forms in the North American marketplace.

Launched in collaboration between ACI And Aramco Americas, NEx is registered as a 501(c)3 nonprofit organization. Its mission is to collaborate globally to expand and accelerate the use of nonmetallics in the built environment to drive innovation, research, education, awareness, adoption and deployment.

ACI established the ACI Foundation in 1989 as part of its commitment to support students' education, research, and innovation throughout the concrete industry. ACI Foundation is a not-for-profit 501(c)(3) organization. The Foundation supports a wide range of research and educational initiatives that contribute to keeping the concrete industry at the forefront of technological advances in material composition, design, and construction.

The vision of the Concrete Advancement Foundation is to be the resilient resource to collaboratively support concrete as the leading sustainable building material.

Disclaimer

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List of Acronyms

AAC – Autoclaved Aerated Concrete
ACM – Aluminum Composite Material
ASTM – ASTM International
BIA – Brick Industry Association
BTU – British Thermal Unit
CMHA – Concrete Masonry and Hardscapes Association
CMU – Concrete Masonry Unit
EIFS – Exterior Insulation and Finish System
EPS – Expanded Polystyrene
FR – Fire Retardant
FRT – Fire Retardant Treated
FRTW – Fire Retardant Treated Wood
IBC – International Building Code
ICF – Insulating Concrete Forms
ICFMA – Insulating Concrete Forms Manufacturers Association
MCM – Metal Composite Material
NCMA – National Concrete Masonry Association
NFPA – National Fire Protection Association
NRMCA – National Ready Mixed Concrete Association
OC – On Center
Pcf – Pound per cubic foot
UL – Underwriters Laboratories
WRB – Water-Resistive Barrier
XPS – Extruded Polystyrene
ZCM – Zinc Composite Material
k – Thermal Conductivity (W/m K)
ρ – Density (kg/m^3)
c_p – Specific Heat Capacity (kJ/Kg K)
$k \rho c_p$ – Thermal Inertia ($W^2 s / m^4 K^2$)

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Executive Summary

The objective of this project study was to determine compliance with the performance criteria of NFPA 285, *"Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Wall Assemblies Containing Combustible Components"*, for Insulating Concrete Forms (ICF) wall assemblies and associated window opening construction details. NFPA 285 is a consensus developed fire test standard promulgated by the National Fire Protection Association (NFPA) and referenced in the US Building Codes to evaluate the fire propagation characteristics of exterior wall assemblies containing combustible materials such as water-resistive barrier materials, foam plastic insulations, and combustible cladding materials.

Insulating Concrete Forms (ICF) are modular stay-in-place concrete forms that have expanded polystyrene (EPS) foam plastic panels on both sides held in place by cross ties. The cross ties are typically plastic but may be metal or have metal components. The cross ties hold the panels apart forming a cavity with a fixed width, into which concrete and reinforcing steel are placed to form the wall.

The use of combustible materials, such as expanded polystyrene, in an exterior wall assembly requires compliance with NFPA 285 by the applicable building code requirements to ensure excessive vertical and lateral exterior flame spread will not occur during a fire event. Specifically, Section 2603.5.5 of the International Building Code (IBC) (2000 through 2024 Edition) requires exterior wall systems incorporating foam plastic insulation materials to meet the requirements of NFPA 285 for buildings of Types I, II, III, and IV construction and of any height. Similarly, exterior wall assemblies on buildings of Type I, II, III, or IV construction that are greater than 40-feet above grade plane are required to comply with NFPA 285 if they incorporate a combustible water-resistive barrier (WRB) material per Section 1403.5 of the IBC (2012 and 2015 Editions), Section 1402.5 of the IBC (2018 and 2021 Editions), and Section 1402.6 of the IBC (2024 Edition).

As the ICF industry looked at protecting and expanding existing markets in commercial and multi-story construction, the need for compliance to NFPA 285 became paramount in creating the opportunity to expand ICF into larger markets. The benefits of airtightness, higher insulation levels for energy efficiency and the performance of thermal mass in larger buildings being driven by sustainability initiatives, provided the incentive for the ICF industry to overcome specific regulatory barriers to multi-story applications. In 2023, consultations with

the National Ready Mixed Concrete Association (NRMCA) resulted in a collaboration to conduct fire testing to NFPA 285. NRMCA and ICFMA, with support from NEx (An ACI Center of Excellence for Nonmetallic Building Materials), the ACI Foundation, and the Concrete Advancement Foundation, contracted Intertek in York, PA, to carry out the testing and engaged Jensen Hughes as the Fire Protection Engineering consultant to develop the testing plan, oversee the testing, and present an engineering judgment outlining the applicability of the results.

NRMCA, in collaboration with ICFMA, conducted two successful NFPA 285 tests on exterior wall assemblies incorporating an EPS ICF system, one clad with a standard clay brick façade and the second clad with aluminum composite materials (ACM) veneer.

Based on this successful testing, alternative wall constructions were developed for thermally thick and thermally thin veneers and the allowable alternate WRB materials based on exterior veneer being used. The additional wall construction features will result in wall assemblies which will maintain compliance with NFPA 285 and provide a comparable level of fire performance as the tested wall assemblies. The technical justification for the use of alternate wall system components is provided to support their use in an exterior wall assembly which will continue to meet the conditions of acceptance of NFPA 285. The additional wall assemblies which cover a broad range of claddings and alternate WRB's are referenced in this report.

Introduction

Insulating Concrete Forms (ICFs) combine reinforced concrete for strength and durability and expanded polystyrene (EPS) insulation for energy efficiency. ICFs are modular stay-in-place concrete forms that have EPS foam plastic panels on both sides held in place by crossties. The crossties are typically plastic but may be metal or have metal components. The crossties hold the panels apart forming a cavity with a fixed width, into which concrete is placed to form the wall (see Figure 1). ICFs may be delivered to the job site fully assembled or they may be delivered to job sites as panels and crossties which are then assembled as they are stacked up to build the wall. In both cases the ICF forms are stacked up to construct walls, concrete is placed in the cavity to form the structural component of the walls, and the EPS panels serve as the insulation of the wall assemblies. Per the 2024 Edition of the International Building Code (IBC) [1], Section 1903.3 requires ICF systems to conform with ASTM E2634, *"Standard Specification for Flat Wall Insulating Concrete Form (ICF) Systems*" [2].

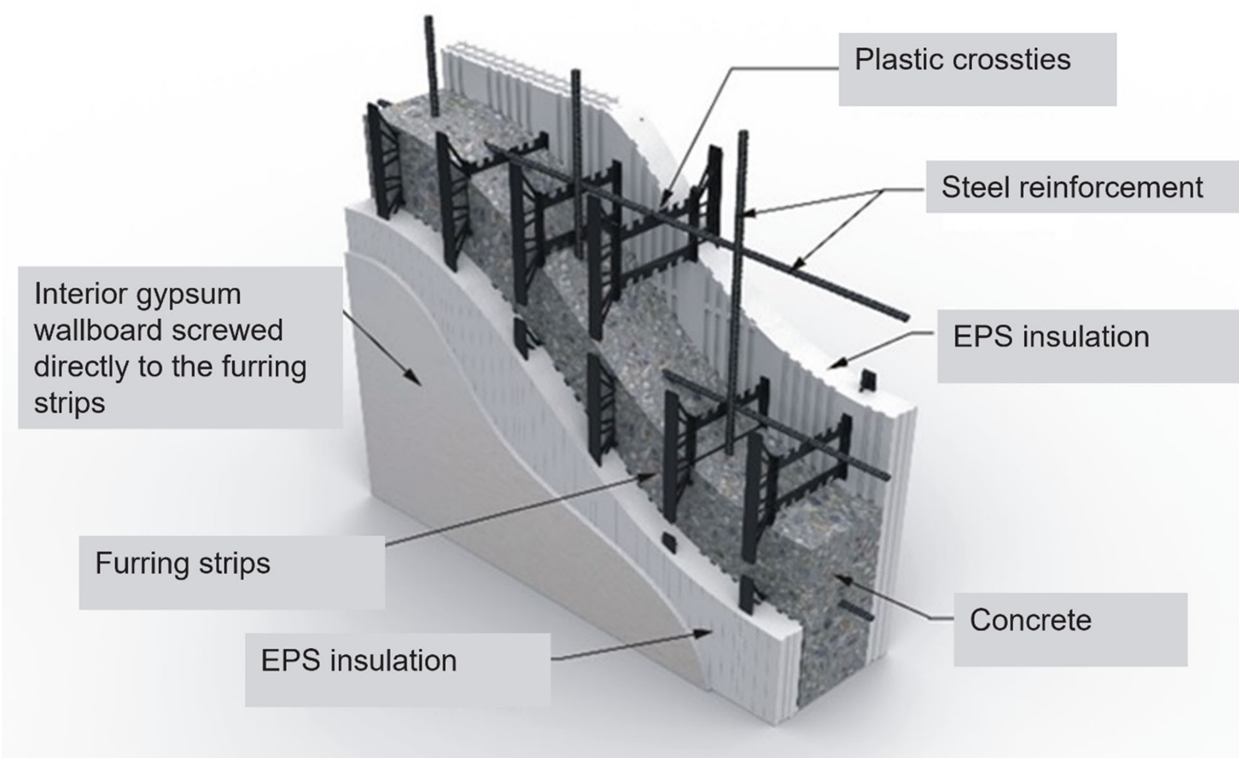

Figure 1. Typical ICF wall.

Use of combustible materials in an exterior wall assembly requires compliance with NFPA 285, *"Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Wall Assemblies Containing Combustible Components"* [3], by the applicable building code requirements to ensure significant vertical and lateral exterior flame spread will not occur during a fire event. Specifically, Section 2603.5 of the IBC (2000 through 2024 Editions) require exterior wall systems incorporating foam plastic insulation materials to meet the requirements of NFPA 285. NFPA 285 is a consensus developed fire test standard promulgated by the National Fire Protection Association (NFPA) and referenced in the US Building Codes to evaluate the fire propagation characteristics of exterior wall assemblies containing combustible materials such as water-resistive barrier materials, foam plastic insulations, and combustible cladding materials.

Compliance with NFPA 285 is required in the US Building Codes for buildings of Types I, II, III, and IV construction and of any height. There are exceptions within Section 2603.5.5 that do not require compliance with NFPA 285 when very specific construction requirements of the exterior wall are met. Similarly exterior wall assemblies on buildings of Type I, II, III, or IV construction that are greater than 40-feet above grade plane are to comply with NFPA 285 if they incorporate a combustible water-resistive barrier (WRB) materials per Section 1403.5 of the IBC (2012 and 2015 Editions), Section 1402.5 of the IBC (2018 and 2021 Editions), and Section 1402.6 of the IBC (2024 Edition).

This report describes a joint research project undertaken by the National Ready Mixed Concrete Association (NRMCA) and the Insulating Concrete Forms Manufacturers Association (ICFMA) with support from NEx (An ACI Center of Excellence for Nonmetallic Building Materials), the ACI Foundation, and the Concrete Advancement Foundation to determine NFPA 285 compliance for exterior walls constructed of ICFs. The project included the testing of ICF walls within various exterior wall constructions to determine ICF wall assemblies which met the performance criteria of NFPA 285 and the development of window opening construction details. Following the fire testing, an engineering analysis was conducted to demonstrate other ICF wall assemblies with similar but different components that can be recognized as meeting the performance requirements of NFPA 285. The following organizations and ICF brands were involved in the testing program to evaluate ICF fire performance:

- National Ready Mixed Concrete Association (NRMCA)
- Insulating Concrete Forms Manufacturers Association (ICFMA)
- Amvic
- BuildBlock
- Fox Blocks
- IntegraSpec
- Logix
- Nudura
- Quad-Lock
- Superform

Methodology

NRMCA in collaboration with ICFMA conducted two successful NFPA 285 tests of exterior wall assemblies incorporating an EPS foam plastic insulation ICF. One test incorporated a noncombustible standard brick veneer and a second test incorporated a combustible aluminum composite material (ACM) veneer which is a subset of metal composite material (MCM) veneers.

The tested wall assembly incorporating the brick veneer was generally constructed as follows per Figure 2 and Figure 3 (interior to exterior):

- ½-inch thick interior gypsum wallboard mechanically attached to the plastic crossties.
- Insulating Concrete Forms (ICF)
  - 2¾-inch thick EPS foam interior side
  - Nominal 4-inch thick concrete core
  - 4¾-inch thick EPS foam exterior side
- Tremco ExoAir 230 WRB
- Nominal 4-inch hollow clay bricks with Type S mortar and secured with Simpson Heli Brick Ties with a resultant air cavity depth of nominally 2-inches between the interior face of the brick and the face of the ICF foam.

A detailed description of the test assembly construction, the test results, observations, and test conduct of the above wall construction are reported in Intertek Test Report No. Q3578.01-121-24 R0, dated May 17, 2024 [4].

The tested wall assembly incorporating the ACM veneer was generally constructed as follows per Figure 4 and Figure 5 (interior to exterior):

- ½-inch thick interior gypsum wallboard mechanically attached to the plastic crossties.
- Insulating Concrete Forms (ICF)
  - 2¾-inch thick EPS foam interior side
  - Nominal 4-inch thick concrete core
  - 4¾-inch thick EPS foam exterior side
- ⅝-inch thick Type X exterior gypsum sheathing mechanically attached to the plastic crossties.
- Dupont Tyvek CommercialWrap WRB
- 4mm thick 3A Composites Alucobond PLUS Fire Retardant (FR) ACM panels with a resultant air cavity depth of nominally 3-inches between face of ACM and face of exterior gypsum sheathing.

A detailed description of the test assembly construction, the test results, observations, and test conduct of the above wall construction are reported in Intertek Test Report No. Q3578.02-121-24 R0, dated May 17, 2024 [5].

NRMCA in collaboration with ICFMA conducted an additional successful NFPA 285 screening test of an exterior wall assembly incorporating a combustible ACM veneer. The purpose of this test was to evaluate the screw fastener spacing used to secure the exterior gypsum sheathing to the furring strips of the plastic crossties. This testing approved the use of fastener spacing of 12-inch OC in the field of the board and 12-inch OC along the edges. A detailed description of the test assembly construction, the test results, observations, and test conduct of the above wall construction are reported in Intertek Test Report No. S0661.01-121-24, dated January 20, 2025 [6].

Based on the results of the successful NFPA 285 tested assembly, additional testing of WRB materials per ASTM E1354, *"Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter"* [7], and our experience with the NFPA 285 fire test, it is our engineering opinion that the various configurations of exterior wall assemblies described in Tables 1, 2, 3 will meet the fire performance requirements of NFPA 285.

Table 1: ICF With Thermally Thick Veneers NFPA 285 Compliant Assemblies

Wall Component	*Materials*
Interior Wallboard	1) Minimum ½-inch thick gypsum wallboard, full wall coverage from floor slab to floor slab, screw fastened to crossties with #6 1¼-inch self-drilling screws at 12-inch OC in the field of the board and 12-inch OC along the edges.
Core Wall System	1) Insulating Concrete Forms (ICF) a. EPS foam interior side b. Minimum 4-inch thick concrete c. EPS foam exterior side (maximum 4¾-inch thick) ***Total maximum allowable thickness of EPS (interior plus exterior) is 7½-inch NOTE: The EPS foam plastic insulation tested was Type II per ASTM C578 [8] with a density of 1.48 pcf and the insert panels were 1.33 pcf [4]. Maximum allowable foam thickness shall be calculated based on the total potential heat of 15,700 BTU/ft^2 for the tested foam.
Exterior Sheathing – Use either 1 or 2	1) None 2) Minimum ½-inch thick exterior gypsum sheathing, screw fastened to crossties with #6 1¼-inch self-drilling screws at 12-inch OC in the field of the board and 12-inch OC along the edges.
WRB Materials – Use either 1, 2	1) None (Not required when concrete wall is compliant with IBC Section 1402.2, Exception 1) 2) Any shown in Table 3 for Thermally Thick Veneers Note: WRB may be applied directly over EPS ICF foam or exterior sheathing (if included)

Wall Component	*Materials*
Exterior Veneer – Use either 1, 2, 3, 4, 5, 6, 7, 8, or 9	1) Brick - Standard nominal 4-inch thick clay brick; brick ties embedded into concrete core during pouring or mechanically attached directly into concrete core, installed in accordance with TMS 402/602 [9]. Air gap between exterior insulation and brick to be a maximum of 2-inches. 2) Concrete or precast concrete panels – Minimum 2-inch thick; Maximum 2-inch air gap between exterior insulation and concrete. Any standard non-open-joint installation technique can be used. 3) Concrete Masonry Units (CMU) - Minimum 4-inch thick CMU; maximum 2-inch air gap between exterior insulation and CMU. Any standard non-open-joint installation technique can be used. 4) Natural and Artificial Stone Veneer – Minimum 2-inch thick limestone or natural stone veneer or minimum 1½-inch thick-cast artificial stone veneer (complying with ICC-ES AC51 [10]); any standard non-open-joint installation technique such as shiplap, etc. can be used. 5) Autoclaved Aerated Concrete (AAC) Panels – Minimum 2-inch thick AAC panel. Use of any AAC panel system that has been successfully tested by the panel manufacturer in accordance with the NFPA 285 test method. Installed using standard non-open-joint installation techniques. 6) Stucco – Minimum ¾-inch thick, exterior cement plaster and lath. A secondary water-resistive barrier can be installed between the exterior insulation and the lath. The secondary water-resistive barrier can be 1 or 2 layers of asphalt building paper but shall not be full-coverage asphalt or butyl-based self-adhered membranes. WRB from Table 2 can be used as the secondary water-resistive barrier. 7) Thin Brick - Minimum ¾-inch thick clay brick fully adhered with cementitious mortar (standard or polymer modified) to min. ½-inch thick cement backer board or gypsum sheathing. A secondary water-resistive barrier can be installed between the board/sheathing and the brick. The secondary water-resistive barrier shall not be full-coverage asphalt or butyl-based self-adhered membranes. 8) Ceramic Tile - Minimum ⅜-inch thick ceramic tile bonded using non-combustible mortar adhesive to minimum ½-inch thick cement board or gypsum sheathing. 9) Exterior Insulation and Finish System (EIFS) – Use of any EIFS that has been successfully tested by the EIFS manufacturer via the NFPA 285 test method. Acceptable NFPA 285 testing shall consist of successful NFPA 285 test results on a wall assembly incorporating a comparable thickness or greater of combustible foam insulation (e.g. EPS). The EIFS shall be installed per the manufacturer's installation instructions to ensure the EPS edges are properly protected by the base coat and mesh.
Opening Protection	All wall openings (windows, doors, etc.) are required to be protected with two layers of ¾-inch thick fire-retardant treated (FRT) plywood installed at opening header, jambs and sill (door openings do not require sill protection). Alternatively, minimum 2× dimensional fire-retardant treated wood (FRTW) lumber the full width of the exterior wall assembly. Steel L shelf angle at the header minimum 2-inch × 6-inch × ¼-inch to support the exterior veneer, when required. An additional minimum 1.15 mm thick 1-inch × 2-inch × 4-inch steel "T" protective shield to be installed at the header. See Figures 2 and 3, for opening protection detail.

Table 2: ICF With Thermally Thin Veneers NFPA 285 Compliant Assemblies

Wall Component	*Materials*
Interior Wallboard	1) Minimum ½-inch thick gypsum wallboard, full wall coverage from floor slab to floor slab, screw fastened to crossties with #6 1¼-inch self-drilling screws at 12-inch OC in the field of the board and 12-inch OC along the edges.
Core Wall System	1) Insulating Concrete Forms (ICF) a. EPS foam interior side b. Minimum 4-inch thick concrete c. EPS foam exterior side (maximum 4¾-inch thick) ***Total maximum allowable thickness of EPS (interior plus exterior) is 7½-inch NOTE: The EPS foam plastic insulation tested was Type II per ASTM C578 [8] with a density of 1.48 pcf and the insert panels were 1.33 pcf [4]. Maximum allowable foam thickness shall be calculated based on the total potential heat of 15,700.5 BTU/ft^2 for the tested foam.
Exterior Sheathing	1) Minimum ⅝-inch thick, Type X exterior gypsum sheathing, screw fastened to crossties with #6 1¼-inch self-drilling screws at 12-inch OC in the field of the board and 12-inch OC along the edges.
WRB Materials – Use either 1, or 2	1) None (Not required when concrete wall is compliant with IBC Section 1402.2, Exception 1) 2) Any shown in Table 3 for Thermally Thin Veneers
Exterior Veneer – Use either 1, 2, 3, 4, or 5	1) Terracotta Cladding – Minimum 1¼-inch thick terracotta cladding system. Any standard installation technique can be used. 2) Fiber Cement Board - Minimum $^5/_{16}$-inch thick fiber cement board installed with a 1¼-inch overlap. Siding may be installed over maximum ⅞-inch deep, minimum 20-gauge vertical hat channels or directly attached to plastic crossties, per manufacturers installation instructions. Any standard open or non-open-joint installation techniques. 3) Plate Metal Cladding - Sheet metal exterior wall coverings including steel (minimum 0.0179-inch thick), aluminum (minimum 0.080-inch thick), or copper (minimum 0.0179-inch thick). Any standard open or non-open-joint installation technique can be used. 4) Stone/Aluminum Honeycomb Composite Panels – Use any stone/aluminum honeycomb composite building panel system that has been successfully tested by the panel manufacturer in accordance with the NFPA 285 test method. Acceptable testing shall consist of successful NFPA 285 test results on a wall assembly incorporating a noncombustible substrate directly underneath the composite panel. Installed using any standard open or non-open-joint installation techniques. 5) ACM System - Use any FR ACM system that has been successfully tested by the panel manufacturer via the NFPA 285 test method. Acceptable NFPA 285 testing shall consist of successful NFPA 285 test results on a wall assembly incorporating a noncombustible substrate directly underneath the ACM. Note: Attachment of veneer support structure to be screw fastened to plastic crosstie furring strip face.

Wall Component	***Materials***
Opening Protection	All wall openings (windows, doors, etc.) are required to be protected with two layers of ¾-inch thick fire-retardant treated (FRT) plywood installed at opening header, jambs, and sill (door openings do not require sill protection). An additional minimum 1.15 mm thick steel protective shield to be installed at the header over the entire window opening with a 4-inch leg over the wood buck and a 2-inch leg up the front the of the exterior sheathing. Alternatively, minimum 2× dimensional fire-retardant treated wood (FRTW) lumber the full width of the exterior wall assembly. See Figures 4 and 5, for opening protection detail.

Table 3: Allowed Water-Resistive Barrier Materials

Weather Resistive Barrier Manufacturer/ Product	Thermally Thick Veneer Table 1	Thermally Thin Veneer Table 2
3M™		
• 3015	X	
• 3015 NP	X	
BASF Wall Systems		
• MasterSeal AWB 660 Max. 15 mils DFT	X	
• Senershield-R Max. 20 mils DFT	X	
• Senershield-VB Max. 22 mils DFT	X	
Berry Global		
• Typar HouseWrap	X	
• Typar MetroWrap	X	
Carlisle		
• Barritech VP	X	
• CCW-705FR w/ Primers	X	
Dörken Systems		
• Delta®-Foxx	X	
• Delta®-Foxx Plus	X	
• Delta®-Fassade S	X	
• Delta®-Maxx Plus	X	
• Delta®-Vent S/Plus	X	
• Delta®-Vent SA	X	
DOWSIL™		
• DefendAir 200C	X	
Dryvit		
• Backstop NT	X	
DuPont		
• DuPont™ Tyvek® CommercialWrap®	X	X

Weather Resistive Barrier Manufacturer/ Product	Thermally Thick Veneer Table 1	Thermally Thin Veneer Table 2
• DuPont™ Tyvek® CommercialWrap® D	x	x
• DuPont™ Tyvek® HouseWrap™	x	
• DuPont™ Tyvek® ThermaWrap™	x	x
• DuPont™ Tyvek® Fluid Applied WB+ –	x	
• WeatherMate™	x	x
• Weathermate™ Plus	x	x
GCP Applied Technologies		
• Perm-A-Barrier® Aluminum Wall Membrane	x	
• Perm-A-Barrier® NPL	x	
• Perm-A-Barrier® VPL	x	
• Perm-A-Barrier® VPL LT	x	
• Perm-A-Barrier® VPS	x	
• Perm-A-Barrier® VPS LT	x	
Henry Company		
• Air-Bloc® 16MR	x	
• Air-Bloc® 17MR	x	
• Air-Bloc® 31MR	x	
• Air-Bloc® 33MR	x	
• Air-Bloc® 21 FR	x	
• Air-Block® All Weather STPE	x	
• Blueskin SA	x	
• BlueskinVP™ 160	x	
• MetalClad™	x	x
• Foilskin®	x	
Hohmann & Barnard		
• Enviro-Barrier™ NP	x	
• Enviro-Barrier™ VP	x	
JX Nippon ANCI, Inc.		
• JX ALTA™ Commercial Wrap	x	
• JX ALTA™ HP Wrap	x	
• JX ALTA™ LP Wrap	x	
Kingspan		
• Kingspan® GreenGuard® Max™ Building Wrap	x	x
• Kingspan® GreenGuard® Classic Building Wrap	x	
• Kingspan® GreenGuard® C500 Building Wrap	x	x
• Kingspan® GreenGuard® C2000 Building Wrap	x	

Weather Resistive Barrier Manufacturer/ Product	Thermally Thick Veneer Table 1	Thermally Thin Veneer Table 2
• Kingspan® GreenGuard® C2000SA Building Wrap	x	
• Kingspan® GreenGuard® RainArmor® Building Wrap	x	
• Kingspan® GreenGuard® Raindrop® 3D Building Wrap	x	x
• Kingspan® GreenGuard® HPW™ Building Wrap	x	
Momentive Performance Materials		
• GE Elemax 2600	x	
Polyguard		
• Airlok Flex	x	
• Airlok Flex VP	x	
• Flexguard	x	
Prosoco		
• R-Guard Spray Wrap	x	
• R-Guard MVP	x	
• R-Guard VB	x	
• R-Guard CAT-5	x	
Soprema		
• Sopraseal Stick VP	x	
Sto Corp		
• Sto Gold Coat® with StoGuard Fabric	x	
• Sto Emerald Coat® with StoGuard Fabric	x	
• Sto ExtraSeal™ with StoGuard Mesh	x	x
• Sto RapidGuard	x	
• StoGuard AirSeal	x	
• StoGuard VaporSeal	x	
STS, Inc.		
• Wall Guardian™ FW-100	x	
• Wall Guardian™ FW-100A	x	
Tremco		
• ExoAir 230	x	
• ExoAir 430	x	
VaproShield		
• BlockShield SA	x	
• CanShield VP	x	
• PanelShield SA™	x	x
• RevealShield™	x	x
• RevealShield SA™	x	x

Weather Resistive Barrier Manufacturer/ Product	Thermally Thick Veneer Table 1	Thermally Thin Veneer Table 2
• WallShield®	x	
• WrapShield®	x	
• WrapShield® SA	x	
W.R. Meadows		
• Air-Shield™ LM	x	
• Air-Shield™ LMP (Gray)	x	
• Air-Shield™ LMP (Black)	x	
• Air-Shield™ SMP	x	
• Air-Shield™ TMP	x	
• Air-Shield™ LSR	x	
• Air-Shield™ Aluminum	x	x

ENGINEERING ANALYSIS

The analysis which follows provides the technical substantiation for modifications to the tested wall assemblies for the following wall construction features:

1. Alternate core wall assembly construction
2. Alternate gypsum wallboard (interior and exterior)
3. Alternate WRB materials
4. Alternate exterior cladding materials
5. Alternate miscellaneous wall materials

It should be noted that the plastic crossties within the ICF are discrete in nature and are not full wall coverage elements within the exterior wall assembly. The majority of the crossties are embedded in the concrete core and unlikely to ignite and spread fire. Although these crossties are made of combustible plastic, their impact on the overall flame spread of the exterior wall assembly is negligible and is ignored as part of this analysis.

ALTERNATE CORE WALL ASSEMBLY CONSTRUCTION

Interior Gypsum Wallboard

The two tested exterior wall assemblies utilized ½-inch thick regular interior gypsum wallboard covering the interior face of the interior EPS foam plastic insulation. The interior gypsum wallboard was mechanically attached to the plastic ICF ties and provided thermal protection to the EPS insulation from the interior fire source during the NFPA 285 test. Increasing the thickness of the interior gypsum wallboard will provide additional protection to the interior EPS foam plastic insulation during a fire event. Based on this rationale, it is the opinion of Jensen Hughes that increasing the thickness of the interior gypsum wallboard from the tested ½-inch thickness will improve the overall performance of the assembly and will maintain compliance with the fire performance criteria of NFPA 285.

Concrete Core Wall

Both tested wall assemblies incorporated a 4-inch thick reinforced ready mixed concrete core. In an NFPA 285 test, the concrete core provides significant thermal protection to the wall assembly from the burn room fire exposure based on its increased rigidity, significantly higher thermal mass, and increased level of fire performance. Table 722.2.1.1 of the 2024 IBC provides minimum thicknesses for various hourly fire-resistance ratings. A normal siliceous gravel concrete wall with a minimum thickness of 3.5-inches will provide a 1-hour fire-resistance rating and a normal calcareous gravel wall with a minimum thickness of 3.2-inches will provide a 1-hour fire-resistance rating. Based on the documented fire performance of concrete construction, a concrete ICF core equal to or greater than 4-inches thick will provide the same or better fire performance than the tested 4-inch thickness and will maintain compliance with the fire performance criteria of NFPA 285.

ICF EPS Thickness

The EPS foam plastic insulation forming the interior and exterior face of the tested ICF was Type II per ASTM C578 [8] with a density of 1.48 pcf, and the insert panels were 1.33 pcf. The density values of the EPS foam plastic are documented in Intertek Test Report Q9018.01-106-31 R0, Dated April 4, 2024 [11]. The proprietary potential heat values of the EPS foam plastic insulation was provided to Jensen Hughes to perform this analysis. The overall combined thickness of interior and exterior EPS was nominally 7½-inches. The tested assemblies incorporated 2¾-inch thick EPS on the interior, a 2-inch thick EPS insert in the ICF directly behind the form's 2¾-inch thick exterior EPS.

Section 2603.5.3 of the IBC requires that the project exterior wall construction shall not include more foam plastic combustible fuel loading than any referenced tested wall assembly evaluated in accordance with NFPA 285. Since the referenced NRMCA/ICFMA NFPA 285 tested assemblies incorporated a total 7½-inch thickness of EPS, any wall assembly that utilizes the same BTU content or less (i.e. thinner) EPS will maintain the overall fuel content of the exterior wall assembly. Thus, a thinner installation of EPS will maintain compliance with NFPA 285. The EPS on the exterior side of the concrete core wall is limited to a maximum thickness of 4¾-inches based on the tested assemblies.

Section 2603.5.3 of the IBC allows different thicknesses or densities of the same foam plastic to be used in a wall system as long as the project Btu/ft^2 value does not exceed the Btu/ft^2 value used in the NFPA 285 test of the wall system. The following equation (Eqn. 1) may be used to calculate the overall potential heat value of the tested wall thickness of EPS foam plastic insulation based on the NFPA 259, *"Standard Test Method for Potential Heat of Building Materials"* [12], potential heat for the foam, the foam density, and the foam thickness. Once the total potential heat value of the tested wall was determined, that value can be used to calculate the new thickness of a different EPS foam. Table 4 provides the calculated potential heat value (Btu/ft^2) for the tested exterior wall assemblies and shall be the maximum potential heat value (Btu/ft^2) for comparison to proposed wall assemblies.

The potential heat value (Btu/ft^2) is determined by the following Eqn. 1 and is used to compare between the tested foam thickness and the proposed foam thickness:

NFPA 259 potential heat value (Btu/lb) x foam density (lb/ft^3) x foam thickness (ft) *Eqn. 1*

Table 4: Calculated Total BTU/ft^2 of Tested Assembly

ICF Foam Portion	Potential Heat (Btu/ft^2)
Foam Insert	3,845
ICF Interior/Exterior Foam	11,856
Total Tested	15,700

Exterior Gypsum Sheathing

The thermally heavy brick veneer test assembly [4] had no exterior gypsum sheathing installed over the EPS resulting in the EPS foam plastic insulation exposed within the air gap behind the brick facade. When a wall assembly is compared to the tested assembly that had the EPS insulation direct exposed to the air cavity, it is the opinion of Jensen Hughes that the installation of exterior gypsum sheathing over the EPS is a more conservative installation scenario. Exterior gypsum sheathing will provide thermal protection to the EPS insulation from an exterior fire source or a fire source that propagates into the façade air cavity space. This protection will shield the EPS from direct flame impingement for a duration of time that is longer than if the EPS was left exposed. It is acknowledged that the use of exterior gypsum sheathing may require the use of a combustible WRB material. Any WRB materials (per Table 3 above for Thermally Thick Veneers) used over the exterior sheathing are approved based on proprietary comparative flammability evaluations based on the WRB material included in NFPA 285 test over the EPS insulation. Based on this rationale, it is the opinion of Jensen Hughes that the thermally thick veneer wall assemblies approved under Table 1 may use ½- or ⅝-inch thick Type X exterior gypsum sheathing over the exterior EPS insulation and maintain compliance with the fire performance criteria of NFPA 285.

The exterior wall assembly clad with the ACM cladding material incorporated one layer of minimum ⅝-inch thick exterior gypsum wallboard installed over the EPS foam, behind the ACM wall panel. This layer of exterior gypsum wallboard provided thermal protection to the underlying EPS during the NFPA 285 fire exposure test. This layer of minimum ⅝-inch thick exterior gypsum wallboard is required for all ICF wall assemblies incorporating the thermally thin exterior veneers listed in Table 2 in order to maintain compliance with NFPA 285.

ALTERNATE WRB MATERIALS

WRB Materials Thermally Thick Veneers

The brick façade NFPA 285 test [4] incorporated the Tremco ExoAir 230 fluid applied WRB over the continuous ICF exterior EPS foam plastic insulation. Alternate WRB products having similar flammability properties as the tested WRB are included in the Thermally Thick Veneer column of Table 3 for use over the ICF exterior EPS foam plastic insulation in NFPA 285 compliant exterior wall assemblies. Comparative fire performance properties were developed by proprietary testing conducted by Jensen Hughes on these materials in accordance with ASTM E1354 (Cone Calorimeter apparatus) or by ASTM E1354 test reports provided to Jensen Hughes from various WRB manufacturers who performed testing at accredited third-party laboratories. Given that these alternate materials would be expected to perform similarly based on comparative fire performance properties, it is our engineering opinion that the materials listed in the Thermally Thick column Table 3 will not adversely impact the overall wall fire performance and will maintain compliance with NFPA 285.

WRB Materials Thermally Thin Veneers

In the ACM veneer test [5], the DuPont™ Tyvek® CommercialWrap WRB was installed over the exterior gypsum sheathing and under the ACM veneer. Alternate WRB products having similar or better flammability properties as the tested WRB are approved in the Thermally Thin Veneer column of Table 3 for installation over exterior sheathing. Comparative fire performance properties were either developed by proprietary testing conducted by Jensen Hughes on these materials in accordance with ASTM E1354 (Cone Calorimeter apparatus) or by ASTM E1354 test reports provided to Jensen Hughes from various WRB manufacturers who performed testing at accredited third-party laboratories. Given that these alternate materials would be expected to perform similarly based on comparative fire performance properties, it is our engineering opinion that the materials listed in the Thermally Thin column of Table 3 will not adversely impact the overall wall fire performance and will maintain compliance with NFPA 285.

EXTERIOR CLADDING MATERIALS

Thermally Thick Veneers

Brick

Common clay brick is a typical cladding material used in NFPA 285 tests to evaluate the ability of wall systems to comply with NFPA 285 when heavy masonry claddings are installed over the exterior face of the wall assembly. NRMCA/ICFMA's referenced test assembly [4] used an exterior clay brick veneer as the exterior wall covering. Therefore, common clay brick is an acceptable material for use as the exterior wall covering for Table 1.

The referenced tested wall assembly with brick veneers incorporated a 2-inch air space between the back of the brick and the face of the ICF exterior EPS foam plastic insulation. A review of the thermocouple data from these tests confirmed that the temperatures within the air cavity space were very low, indicating that minimal melting and/or burning of the EPS foam plastic insulation occurred. This is an expected wall fire performance as the brick provides significant thermal protection to the underlying foam plastic insulation materials from the exterior fire source. Further, when the two layers of ¾-inch fire-retardant treated wood (FRTW) and the header has an additional steel "T" protective shield, no fire penetration and minimal heating of the EPS foam plastic insulation occurs.

Concrete and Concrete Masonry Units

The fire-resistance provided by concrete masonry units (CMU) can be calculated per Table 1 of the NCMA TEK 7-1C, *"Fire Resistance Ratings of Concrete Masonry Assemblies"* [13], (NCMA has rebranded to CMHA). Assuming siliceous concrete, a minimum 2-inch equivalent thickness calculated using a 4-inch thick CMU will provide approximately 30 minutes of fire-resistance. Thus, based on the 25-minute exterior fire exposure to the exterior wall covering in the NFPA 285, the 2-inch equivalent thickness of concrete will protect the WRB and EPS foam plastic insulation, and can be used in lieu of the tested brick veneer.

The fire exposure conditions to the exposed side of a wall assembly tested in accordance with ASTM E119, *"Standard Test Methods for Fire Tests of Building Construction and Materials"* [14], are significantly more severe than the fire exposure conditions experienced by the exterior wall covering material in an NFPA 285 test. In an ASTM E119 test, the test sample is mounted onto the front of the test furnace and subjected to the fire exposure conditions generated within the furnace over the entire exposed wall surface. In an NFPA 285 test, only the exterior portion of the wall assembly directly over the window opening is subjected to full fire exposure conditions from the room burner and the window burner employed in this test method.

The temperature and heat flux produced by the burn room and window burner (as indicated in Table 8.1.6 of NFPA 285 for the calibration test) are significantly lower than what is produced by the test furnace in an ASTM E119 test. The time-temperature curve within the test furnace during an ASTM E119 fire exposure is 1,000°F (538°C) at 5 minutes, 1,300°F (704°C) at 10 minutes, and 1,550°F (843°C) at 30 minutes. In an NFPA 285 test, the average centerline temperatures measured 1-ft above the window opening are required to be 602°F (317°C) during the first 5 minutes, 870°F (466°C) between 5 and 10 minutes, 992°F (533°C) between 15 and 20 minutes, and 1,078°F (581°C) between 25 and 30 minutes into the test. The heat flux developed within the test furnace during an ASTM E119 fire exposure has been measured to be approximately 20 kW/m^2 at 5 minutes, 65 kW/m^2 at 15 minutes, and 88 kW/m^2 at 30 minutes [15]. Comparatively, the exposed surface heat fluxes generated during an NFPA 285 test 2-ft above the window opening are 9 to 19 kW/m^2 during the first 10 minutes of the test, 25 to 29 kW/m^2 during the middle 10 minutes of the test, and 34 to 38 kW/m^2 during the last 10 minutes of the test.

Thus, the thermal exposure conditions developed within an ASTM E119 test furnace are significantly more severe than the conditions developed on the exterior wall surface during an NFPA 285 test. Therefore, a material which provides a nominal 20 minutes of fire-resistance when subjected to the fire exposure conditions specified in ASTM E119 will demonstrate better fire-resistance performance in terms of remaining in-place, restricting heat passage to the unexposed surface, and preventing pyrolysis and ignition of materials on the unexposed surface during an NFPA 285 test. Additionally, during the NFPA 285 test, the exterior wall cladding is only subjected to the fire exposure conditions from the window burner for 25 minutes.

Therefore, a material that provides a fire-resistance rating equal to or greater than the duration of the NFPA 285 test will provide sufficient protection to underlying combustible when it is used as the exterior covering material over an exterior wall needing to comply with NFPA 285.

Assuming siliceous concrete, a minimum 2-inch thickness will provide approximately 30 minutes of fire-resistance. Thus, based on the 25-minute exterior fire exposure to the exterior wall covering in the NFPA 285 test, the 2-inch thickness of concrete will protect the WRB and EPS foam plastic insulation and can be used in lieu of the tested brick veneer.

The concrete or the CMU can be applied such that either no air gap or a very limited gap would exist between the concrete or CMU and the exterior combustible materials, as a nominal 2-inch wide air gap existed between the exterior combustibles and the brick veneer in NRMCA/ICFMA's NFPA 285 tested assembly. The concrete or CMU must be installed as a solid veneer without open joints (vertical or horizontal).

Based on this analysis, it is concluded that a minimum 2-inch thickness of concrete or a 4-inch thick concrete masonry unit with a maximum 2-inch air gap between it and the WRB applied to the exterior EPS may be used in lieu of the tested brick veneer and still meet the test conditions specified in NFPA 285.

Natural Stone Materials

Several UL Design Listings allow minimum 2-inch thick natural stone as an optional exterior wall covering material. Stone such as granite, limestone, marble, and sandstone are naturally occurring and provide fire-resistance based on their thickness, density, and composition.

One means to assess the thermal performance of a material is to develop a thermal inertia value. The thermal inertia is the product of the thermal conductivity, k (W/m·K), density, ρ (kg/m^3), and specific heat capacity, c_p (kJ/kg·K). A material which has a higher thermal inertia will absorb more heat and transfer the heat at a slower rate than a material with a lower thermal inertia. In order to provide the technical justification for the substitution of the minimum 2-inch thickness of natural stone materials in lieu of the tested brick veneer, the thermal inertia values for the materials were calculated.

Published literature values for the thermal conductivity, specific heat capacity, and density for standard clay brick and limestone are provided below in Table 5 [16]. Table 5 also includes the calculated thermal inertia ($k\rho c_p$) for each material.

Table 5: Thermal Properties for Brick, Various Natural Stone Materials, and Select Metals

Material	Thermal Conductivity (W/m·K)	Density (kg/m^3)	Specific Heat Capacity (kJ/kg·K)	Thermal Inertia (W^2·s/m^4·K^2)
Clay brick	0.69	1600	0.84	927
Limestone	1.26 – 1.33	2500	0.90	2,835 – 2,933
Granite	1.73 – 3.98	2640	0.82	3,745 – 8,616
Sandstone	1.83	2160 – 2300	0.71	2,806 – 2,988
Marble	2.07 – 2.94	2500 – 2700	0.80	4,140 – 6,350

The thermal inertia values for the natural stones range from more than double to more than nine times greater than standard clay brick. Therefore, a minimum 2-inch thickness of natural stone would be expected to provide improved thermal protection to the exterior WRB and EPS foam plastic insulation when compared to the tested brick veneer.

Natural stone can also be applied such that either no air gap or a very limited gap would exist between the stone and the EPS insulation. In the NFPA 285 test using the EPS ICF, a nominal 2-inch wide air gap existed between the EPS insulation and the brick still passed the NFPA 285 test.

The natural stone must be installed as a solid veneer without open joints (vertical or horizontal) as was with the brick veneer. The occurrence of open gaps, separations, etc. will provide a potential path for the fire to enter the wall cavity and spread within it.

Therefore, it is the opinion of Jensen Hughes that a non-open jointed, minimum 2-inch thickness of natural stone (limestone, granite, sandstone, and marble) may be used in lieu of the tested brick and still meet the test acceptance criteria specified in NFPA 285; as reflected in Table 1.

Artificial Cast Stone

Artificial cast stone is typically a Portland cement-based precast concrete product manufactured to simulate natural stone. The fire-resistance provided by concrete walls can be calculated per Table 722.2.1.1 of the 2024 IBC. A 3.5-inch thickness of siliceous concrete provides a 1 hour fire-resistance rating, and 4.3 inches provides a 1½-hour fire-resistance rating when subjected to the fire exposure conditions specified in ASTM E119. While not linear, a 2-inch thickness of siliceous concrete will provide approximately 20 to 30 minutes of fire-resistance. As discussed above for concrete and CMU, the ASTM E119 fire exposure conditions are much more severe than the NFPA 285 fire exposure conditions. A 2-inch thickness of artificial cast stone (concrete) will remain intact and in-place for the 25-minute duration during the NFPA 285 test the window burner is impinging on the exterior wall surface, with much lower exposure conditions.

Artificial cast stone can also be applied over a metal lath such that either no air gap or a very limited gap would exist between the stone and the underlying materials. In NRMCA/ICFMA's brick veneer NFPA 285 test, a nominal 2-inch wide air gap existed between the exterior gypsum sheathing and the brick, and the tested assemblies passed the NFPA 285 test.

The cast stone may be installed with or without open joints (vertical or horizontal). Based on this analysis, it is concluded that a minimum 1½-inch thickness of artificial stone will provide similar fire performance as the tested brick veneer in an NFPA 285 fire exposure and will meet the acceptance criteria specified in NFPA 285.

Autoclaved Aerated Concrete (AAC) Panels

Autoclaved Aerated Concrete (AAC) panels are precast steel reinforced concrete panels that are a mixture of sand, lime, cement, and gas generating materials. They are formed under high pressure, high temperature, and steam cured and are porous lightweight concrete exterior panels.

A review of several UL Design Listings for various AAC panels indicated a single layer of 2-inch thick AAC was capable of achieving a fire-resistance rating ranging from 1½- to 2-hours. As detailed in the technical rationale for concrete and CMU wall covering Section 1.3.1.2, the fire exposure conditions to the exposed side of a wall assembly tested in accordance with ASTM E119 are significantly more severe than the fire exposure conditions experienced by the exterior wall covering material in an NFPA 285 test.

The AAC panel shall be installed without open joints (vertical or horizontal). Based on this analysis, it is concluded that a minimum 2-inch thickness of AAC Panel will provide a similar fire performance as the tested brick veneer in an NFPA 285 fire exposure and will meet the acceptance criteria specified in NFPA 285.

Stucco

Table 8 of the NCMA/CHMA TEK 7-1C [13] indicates that a ¾-inch thickness of Portland cement-sand plaster will provide 20 minutes of fire-resistance. A nominal 20 minutes of fire-resistance means that the unexposed side of the ¾-inch thickness of Portland cement-sand plaster membrane would not exceed a maximum individual temperature rise of 325°F (181°C) above ambient during an ASTM E119 fire exposure test.

As detailed in the technical rationale for concrete and CMU wall covering Section 1.3.1.2, the fire exposure conditions to the exposed side of a wall assembly tested in accordance with ASTM E119 are significantly more severe than the fire exposure conditions experienced by the exterior wall covering material in an NFPA 285 test. In a Portland cement-sand plaster (stucco) on metal lath wall system, no air gap would exist between the stucco, exterior EPS insulation. In NRMCA/ICFMA's NFPA 285 test incorporating the brick veneer over the EPS foam plastic insulation, a nominal 2-inch air gap existed between the EPS and the brick. Thus, if the gap does not exist (as in a typical stucco exterior wall covering system), the insulation will exhibit less fire spread/damage.

Based on the above analysis, it was concluded that a minimum ¾-inch thickness of Portland cement-sand plaster (stucco) could be used in lieu of the tested brick veneer and still meet the test acceptance criteria described in NFPA 285.

Thin Brick

Thin brick is included in Table 1 for use with maximum 4¾-inch thick EPS foam plastic insulation based on several technical factors.

The thin brick line item in Table 1 specifies that the installation of the thin brick must be a mortar-based adhesion application over minimum ½-inch thick fiber cement or gypsum board. In our experience, thin brick cladding products have a variety of installation methods including both adhesion-based and mechanically fastened. The specified mortar-based adhesion method ensures that the thin brick cladding layer will be a closed joint system and that no air gap will be present between the cladding and the EPS foam plastic insulation. This thin brick installation method is more conservative than systems that incorporate air gaps between the EPS and the exterior wall covering.

The NFPA 285 fire performance of a thin brick system is also documented by the Brick Industry Association (BIA) who conducted a successful NFPA 285 test on a generic thin brick system incorporating ½-inch thick thin brick masonry units over a ½-inch thick fiber cement board substrate. The test report [17] and Jensen Hughes' engineering analysis [18] reports are publicly available at the links provided in this page's footnotes. The thin brick system in this NFPA 285 test was installed over 3-inches of extruded polystyrene insulation (XPS). In light of the results from this test program, it is our opinion that the use of this cladding system over a thermoplastic insulation (EPS) will yield nominally the same fire performance of the overall wall assembly.

Therefore, it is the opinion of Jensen Hughes that the use of thin brick systems installed as described in Table 1 over maximum 4¾-inches of EPS foam plastic insulation will maintain compliance with NFPA 285.

Ceramic Tiles

Minimum ⅜-inch thick ceramic tiles are set in a minimum ⅛-inch thick mortar bed over minimum ½-inch thick fiber cement board or exterior gypsum sheathing. This is a similar installation compared to thin brick systems and will provide a similar level of protection by acting as a flame barrier during the test as the ceramic tile is non-combustible and will not contribute to exterior flame propagation burning. Since fiber cement board or exterior gypsum sheathing on its own has been shown in other NFPA 285 tests to remain in-place sufficiently to protect and prevent flame propagation over combustible materials, it is the opinion of Jensen Hughes that when ceramic tile is adhesively bonded to the fiber cement board or exterior gypsum sheathing, direct flame impingement to the underlying foam plastic insulation material will not occur and compliance with NFPA 285 will be maintained.

Exterior Insulation and Finish System (EIFS)

EIFS veneer systems are typically constructed of three layers over the exterior insulation material: a based coat, integrated mesh, and a finish coat lamina. This three-piece veneer construction is installed directly to the exterior insulation material. EIFS manufacturers have conducted numerous successful NFPA 285 tests over the years over combustible and non-combustible exterior insulation materials.

Any EIFS system that has been successfully tested in accordance with NFPA 285 incorporating an EPS exterior insulation product with similar thickness to the above described wall assembly would be acceptable to use in the ICF exterior wall assembly. The successful NFPA 285 testing history of EIFS has demonstrated that the base coat, mesh, and finish coat prevented ignition of the EPS foam during the fire exposure test. Installation of an EIFS system would need to be installed in accordance with the product specific testing.

Therefore, it is the opinion of Jensen Hughes that EIFS is an acceptable wall covering material for use over the ICF as specified in Table 1.

Thermally Thin Veneers

Terracotta Cladding

Terracotta is included in Table 1 based on the exterior wall assembly clad with the combustible ACM wall panel system. In this test, the ACM panel located directly above the window opening in the test melted and allowed the WRB underneath to be exposed to direct flame impingement resulting in further elevated temperatures on the exterior face of the wall. This is typical performance of ACM panel systems in NFPA 285 tests, where approximately 20 to 25 minutes into the test the exterior cladding is compromised, allowing combustible materials beneath the cladding to burn, and potentially contribute to exterior flame spread over the assembly.

Terracotta is a clay-based material similar to the clay brick. Fire testing experience has shown that there is some cracking and minor fall away of terracotta tiles in the first 2- to 3-feet above the window header in an NFPA 285 test. However, the amount of material that falls away was not as severe as seen when ACM panels melt and open up in NFPA 285 tests. Additionally, the EPS is covered by minimum ⅝-inch thick Type X exterior gypsum wallboard which will prevent direct flame impingement to the EPS from the exterior fire source.

Based on our testing experience with Terracotta tile systems, it is expected that 1¼-inch thick Terracotta cladding would perform superior to the ACM panel cladding used in the NRMCA/ICFMA referenced test report [5]. As noted in the referenced test report, the ACM panel melted and exposed the WRB underneath to fire, while the Terracotta is a masonry type material that would not melt in an NFPA 285 test. Therefore, the Terracotta is included in Table 2 for use with maximum 4¾-inch thick exterior EPS foam plastic insulation. Because the Terracotta tiles do break away during direct flame impingement exposing the underlying substrate, it is our opinion that the Terracotta is considered as a thermally thin exterior wall cladding material and requires the layer of exterior gypsum sheathing over the EPS to prevent ignition of the EPS.

Fiber Cement Board

The allowance for use of a minimum $^{5}/_{16}$-inch thick fiber cement board is based on Jensen Hughes' experience with conducting and witnessing NFPA 285 tests. Fiber cement boards prevent ignition and free surface burning of the underlying foam plastic insulation and WRB materials and remain intact during a fire test. Various manufacturers (James Hardie, Nichiha, Allura, Swiss Pearl) produce fiber cement siding products which are nominally $^{5}/_{16}$-inch (0.312-inch) thick which have been used in successful NFPA 285 tests. For reference, Swiss Pearl panels are specified over combustible foam plastic insulation in a compliant exterior wall design in UL Design EWS0050.

Fire testing experience has shown that there is some cracking and minor fall away of cement fiber boards in the first 2-feet above the window header in a NFPA 285 test. However, the amount of material that falls away was not as severe as is typically seen when ACM panels melt and open up in NFPA 285 tests. The EPS is also covered by minimum ⅝-inch thick Type X exterior gypsum wallboard which will prevent direct flame impingement to the EPS from the exterior fire source.

Therefore, it is the opinion of Jensen Hughes that fiber cement siding is an acceptable wall covering material for use over the ICF with exterior gypsum sheathing as specified in Table 2.

Metal Exterior Wall Coverings

The baseline NFPA 285 test conducted by NRMCA/ICFMA which forms the basis for this analysis incorporated 4-mm thick combustible ACM panels installed over the EPS foam plastic insulation material covered by exterior gypsum sheathing [5]. Single skin, solid metal plate cladding systems are considered to produce a less severe fire scenario compared to ACM/MCM panels as they do not have a combustible core (i.e., overall, less combustible material) and will remain intact during a fire exposure with little or no melting, limiting direct flame impingement of the underlying combustible materials. The three metal plate panel types included in Table 2 are aluminum, steel, and copper.

Accounting for aluminum plate cladding, it is the opinion of Jensen Hughes that the testing of an ACM panel justifies the same metal material to be used as the cladding without the combustible core. Proprietary testing on walls with 0.080-inch (2-mm) thick and 0.160-inch (4-mm) thick solid aluminum panels have been reviewed by Jensen Hughes. This testing provides a basis for the minimum thickness (minimum 0.080 inches) that aluminum paneling must be to maintain NFPA 285 compliance over a combustible foam insulation. These tests, in combination with the successful NFPA 285 test of the ICFs with EPS foam plastic insulation covered by an exterior gypsum sheathing underneath an ACM form the basis for the use of 0.080-inch aluminum plate cladding.

Accounting for steel plate cladding, knowing that the aluminum panel will melt and expose the underlying insulation to the exterior window burner fire during a test (due to the approximate 1,220°F melting temperature for aluminum), the use of minimum 26-gauge solid steel panels would be expected to provide equivalent or better protection to an underlying combustible material since steel does not melt at temperatures produced by the NFPA 285 apparatus during the test. Carbon steel melts between 2,597°F and 2,800°F [19], where the NFPA 285 apparatus is calibrated to produce a maximum temperature of 1,314°F on the exterior face of the assembly during the test. Note that temperatures as high as 1,700°F can be produced when combustibles within the test assembly become involved in the exterior fire. Minimum 26-gauge (0.0179-inch) steel panels will not melt during the test and will continue to provide a physical barrier between an exterior flame exposure and the underlying combustible materials. Therefore, sheet steel cladding in lieu of ACM cladding will not adversely impact the overall wall assembly fire performance.

Accounting for sheet copper cladding, copper has a melting temperature of approximately 1,983°F [19]. Therefore, copper panels would not be expected to melt during an NFPA 285 exposure (ref. calibration temperatures in NFPA 285, Table 7.1.11), and the copper metal panel will perform similarly to a steel panel by remaining intact during the fire test and act as a flame barrier to the underlying combustible material, preventing direct flame impingement, unlike ACMs which will melt away. Therefore, minimum 25-gauge (0.0179-inch) thick copper panels would be expected to provide similar protection to underlying combustibles as the steel panels.

The minimum thicknesses established for of the aluminum, steel, and copper all exceed the minimum thicknesses specified in Table 1404.2, from the 2024 IBC, for these three materials to be used as weather coverings for exterior walls.

Stone/Aluminum Honeycomb Composite Panels

Stone and/or aluminum honeycomb composite panels are typically constructed of non-combustible exterior and interior faces. The core of the structure consists of a honeycomb like grid structure and all components are laminated together with a combustible adhesive material. Several different manufacturers produce these adhesively laminated panels and are required to be tested and successfully meet the fire performance criteria of NFPA 285 per the 2024 Edition of the IBC.

The baseline NFPA 285 test conducted by NRMCA/ICFMA which forms the basis for this analysis incorporated 4-mm thick ACM panels installed over the EPS foam plastic insulation material covered by exterior gypsum sheathing [5]. During this test, the ACM panels burned through and exposed the underlying WRB material and exterior gypsum sheathing to the exterior window burner. Depending on the materials of the laminated honeycomb composite panel, burning through the panel may or may not occur. Stone exterior skins may stay in place and not burn through, while metal skinned panels may burn through like the ACM panels. Jensen Hughes has reviewed several NFPA 285 test reports on these honeycomb composite panels and they have been shown to meet the fire performance criteria of NFPA 285. Based on these observations, Jensen Hughes is of the opinion that stone and/or aluminum honeycomb composite panels that have successfully passed NFPA 285 over a non-combustible substrate (exterior gypsum sheathing with a WRB) may be used as an alternate to the tested ACM panels.

ACM Wall Panels

The tested ACM clad exterior wall assembly utilized the 3A Composites Alucobond PLUS FR 4mm ACM wall panels. Any other ACM wall panel system that has been successfully tested in accordance with NFPA 285 over a nominally noncombustible substrate (exterior gypsum wallboard, mineral wool insulation, magnesium oxide board, etc.) would be acceptable to use in the ICF exterior wall assembly incorporating the layer of minimum ⅝-inch thick exterior gypsum sheathing. The successful NFPA 285 test demonstrated the layer of exterior gypsum sheathing prevented ignition of the EPS foam during the fire exposure test. Any other ACM wall panels system that has been tested in a wall assembly with a nominally noncombustible substrate would result in the same ICF wall fire performance. Installation of an alternate ACM wall panel system would need to be installed in accordance with the testing, including attachment system and tested air cavity space.

The ACM wall panel test qualifies MCM wall panel systems constructed using steel, copper, or any other metal with a higher melting temperature than aluminum. A zinc composite material (ZCM) wall panel cannot be qualified for use over the ICF wall system by the testing conducted by NRMCA/ICFMA because zinc has a lower melting temperature than aluminum. A separate ICF/ZCM clad exterior wall assembly test would be required to demonstrate compliance of this specific exterior wall assembly construction.

WALL OPENING PERIMETER PROTECTION

Thermally Thick Veneers (Figure 2 and Figure 3)

The Brick veneer exterior wall assembly successfully tested in accordance with NFPA 285 incorporated two layers of ¾-inch thick fire retardant treated (FRT) plywood installed around the perimeter of the wall opening – header, jambs, and sill. The header also had a steel L shelf angle, minimum 2-inch × 6-inch × ¼-inch, to support the exterior veneer. An additional minimum 1.15mm, 1-inch × 2-inch × 4-inch steel "T" protective shield installed at the header. These FRT plywood and steel elements installed around the opening perimeter protected the EPS at the test wall opening from the fire and hot gases from the burn room exiting through the wall opening. The perimeter of all openings in ICF exterior wall assembly (windows, doors, loading docks, etc.) must be protected with the two layers of ¾-inch thick FRT plywood and additional steel elements in the header to ensure adequate protection of the EPS inside the wall assembly is provided. Sills do not need to be protected at door openings.

Alternatively, the two layers of FRT plywood can be substituted for a single layer of nominal 2× dimensional FRTW lumber. This provides the same thickness of wood around the wall opening as in the tested assembly. Based on research conducted by the Forest Products Laboratory, dimensional lumber exposed to the ASTM E119 time-temperature curve will char at nominally 1½-inch per hour and the wood starts to degrade between 390°F to 572°F [20]. Since 2× dimensional lumber is nominally 1½-inches thick, it would be expected that at 1-hour the lumber would have burned away. The NFPA 285 test has a duration of 30-minutes, therefore, ¾-inch of unburned dimension lumber would still be present at the end of the test protecting the perimeter of the wall opening. It is our engineering opinion that nominal 2× dimensional FRTW lumber can be substituted for the tested two layers of ¾-inch thick FRT plywood around the wall opening perimeters and still maintain compliance with the fire performance criteria of NFPA 285.

Thermally Thin Veneers (Figure 4 and Figure 5)

The ACM veneer exterior wall assembly successfully tested in accordance with NFPA 285 described above at the beginning of the Engineering Analysis section was constructed with two layers of ¾-inch thick FRT plywood installed around the perimeter of the wall opening – header, jambs, and sill. This FRT plywood installed around the opening perimeter protected the EPS foam plastic insulation at the test wall opening from the fire and hot gases from the burn room exiting through the wall opening. The perimeter of all openings in the exterior wall assembly (windows, doors, loading docks, etc.) must be protected with the minimum two layers of ¾-inch thick FRT plywood to ensure adequate protection of the EPS foam plastic insulation inside the wall assembly is provided. An additional minimum 1.15mm, 2-inch × 4-inch steel protective shield installed at the header. Sills do not need to be protected at door openings.

Alternatively, the two layers of FRT plywood can be substituted for a single layer of nominal 2× dimensional FRTW lumber using the same rationale as provided above for the Thermally Thick Veneers.

EIFS (Figure 6 and Figure 7)

When EIFS are utilized on the exterior side of ICFs, the wall opening protection requires additional details to ensure the EIFS is properly installed.

Typically, EPS boards which are installed around openings in exterior walls have the base coat and mesh layer wrapped around the exposed edges and onto the back face of the EPS. This back wrapped mesh is typically embedded in the EIFS base coat material on the front, back, and exposed edge of the EPS board. The EPS boards prepared in this manner are then installed onto the exterior either adhesively to the wall or the board is mechanically fastened with screws/washer to the exterior wall. In the case of ICF construction, the EPS boards are integral to the overall wall construction as the concrete is poured into the form and the crossties secure the EPS in place.

Figures 6 and 7 at the end of this report provide the required installation practice of the mesh layer to properly protected the edges of the EPS. This installation practice secures the mesh layer to the wood blocking around the wall opening prior to the pouring of the concrete. This ensures the mesh layer is imbedded in the concrete and the foam is protected like the traditional back wrapping method. Once the concrete is poured, the base coat and finish coat of the EIFS system is installed. It is our engineering opinion that the installation method of the mesh layer with the appropriate base coat and finish coat will maintain compliance of the EIFS at the wall openings.

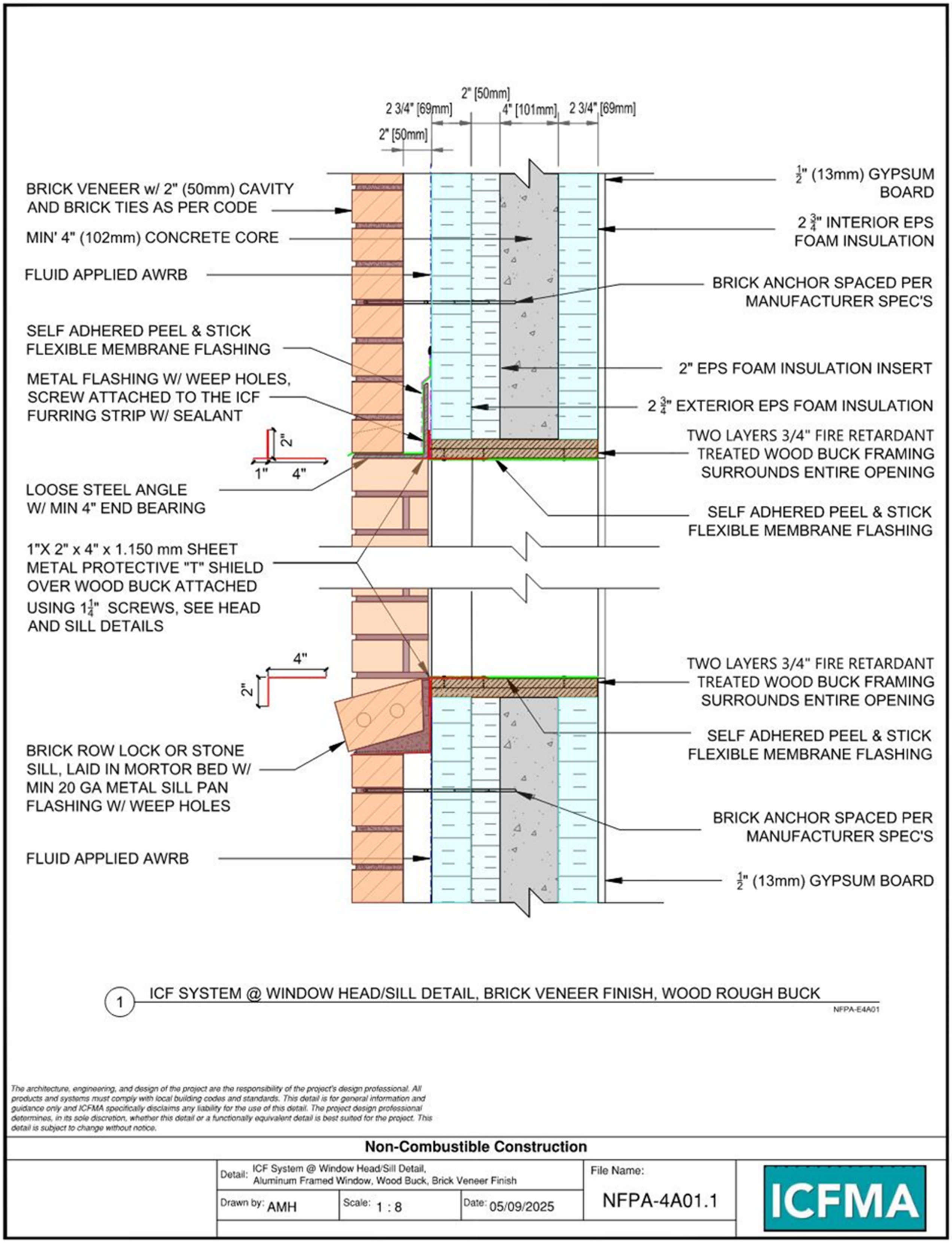

Figure 2. Exterior wall assembly incorporating brick veneer header and sill.

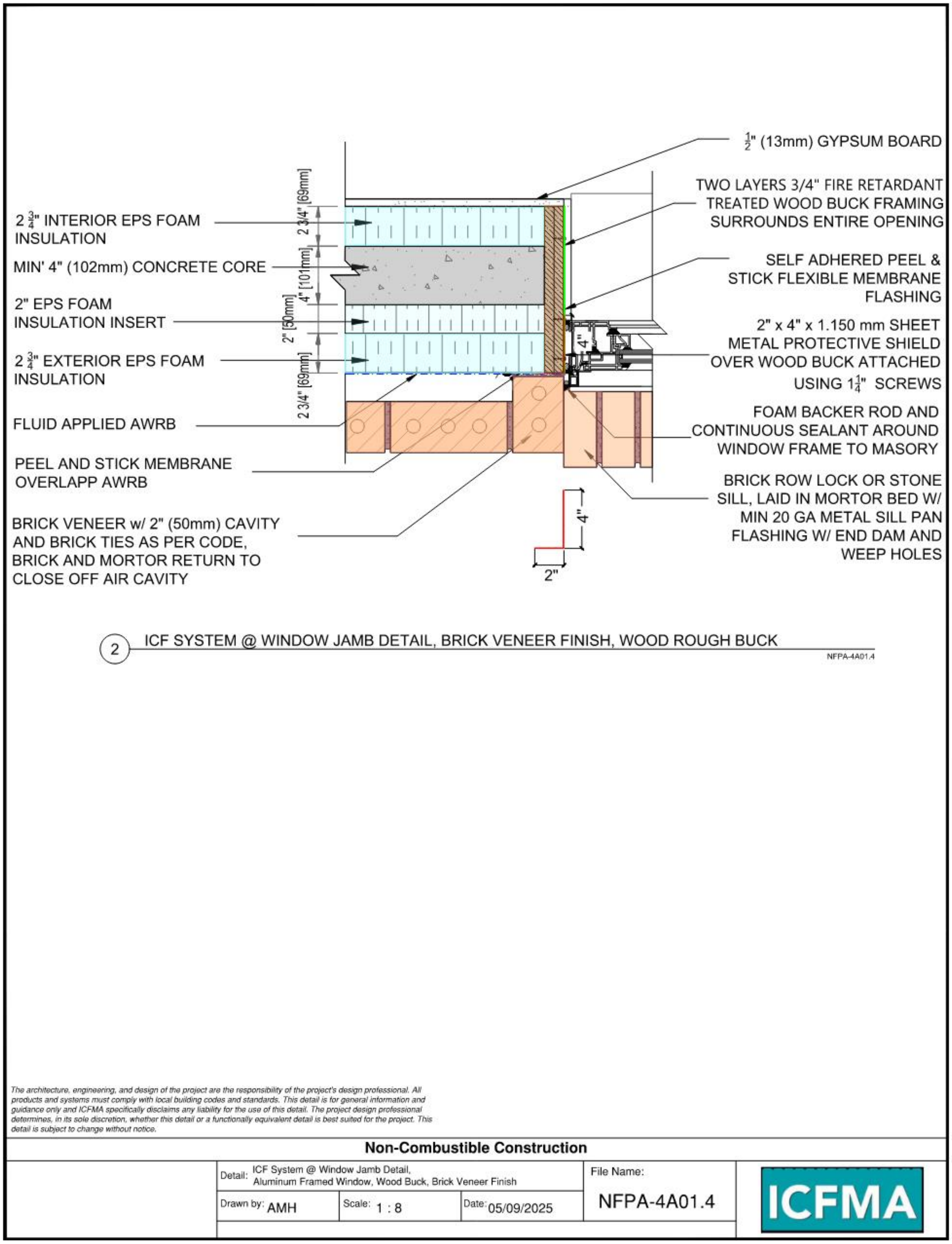

Figure 3. Exterior wall assembly incorporating brick veneer jambs.

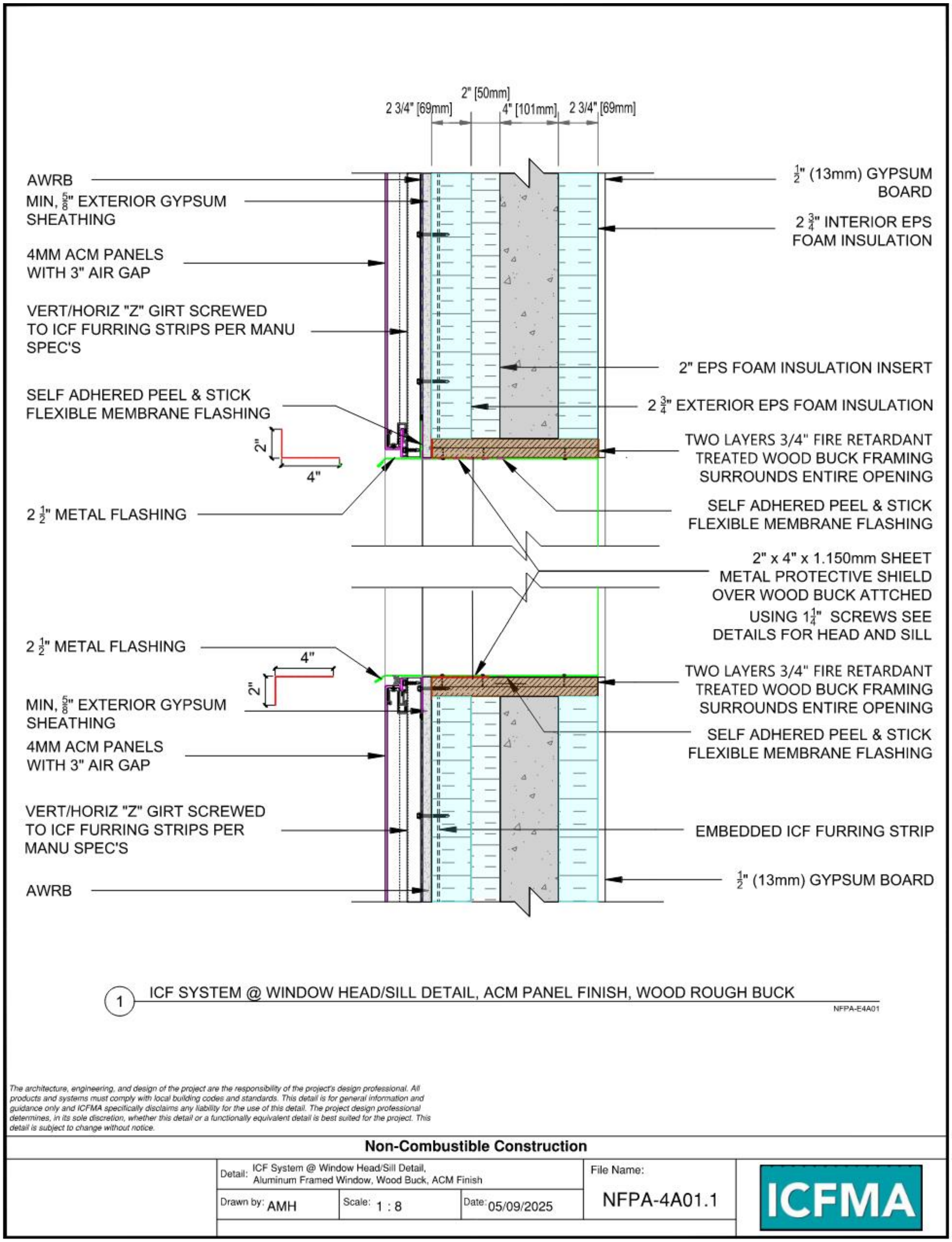

Figure 4. Exterior wall assembly incorporating ACM veneer header and sill.

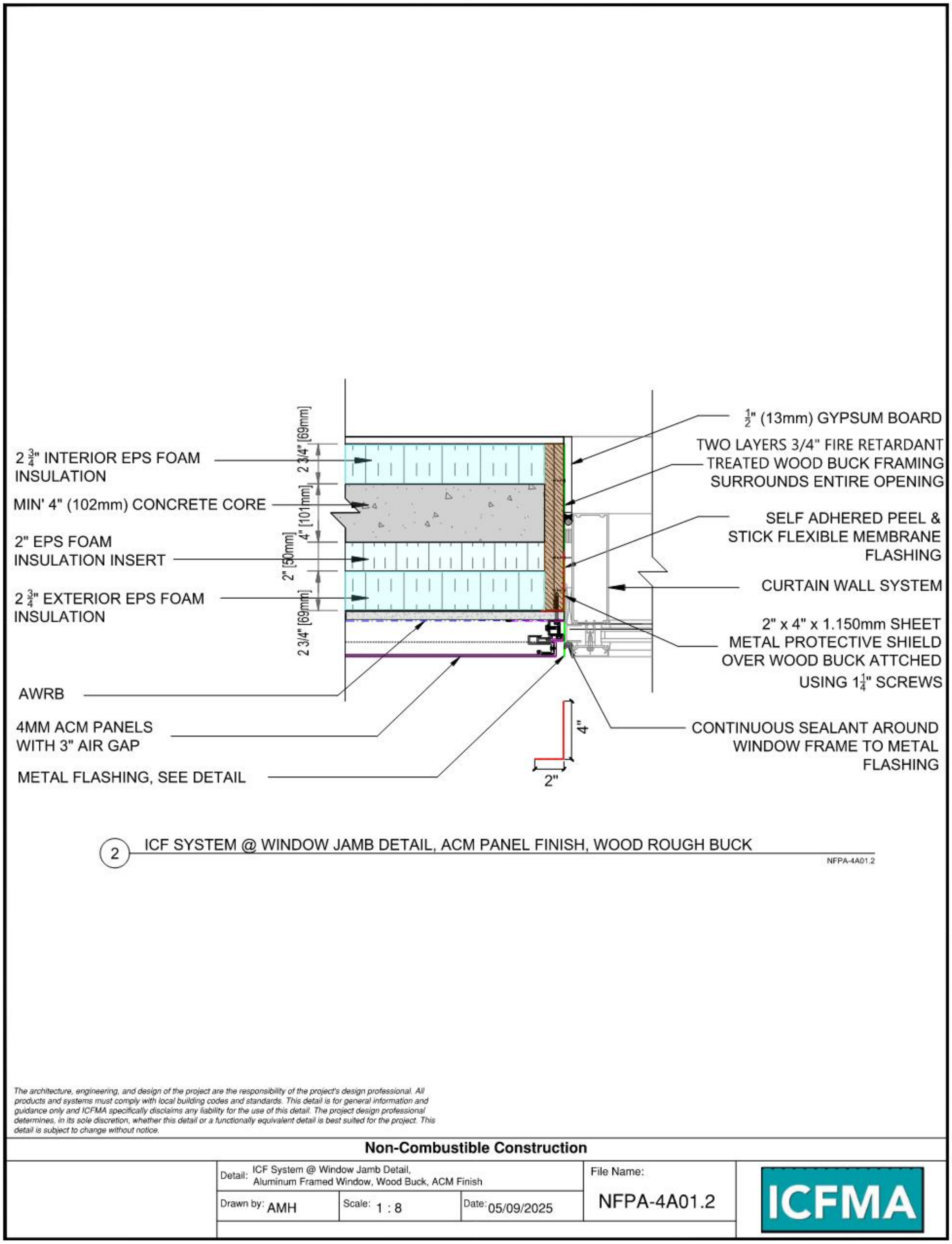

Figure 5. Exterior wall assembly incorporating ACM veneer jambs.

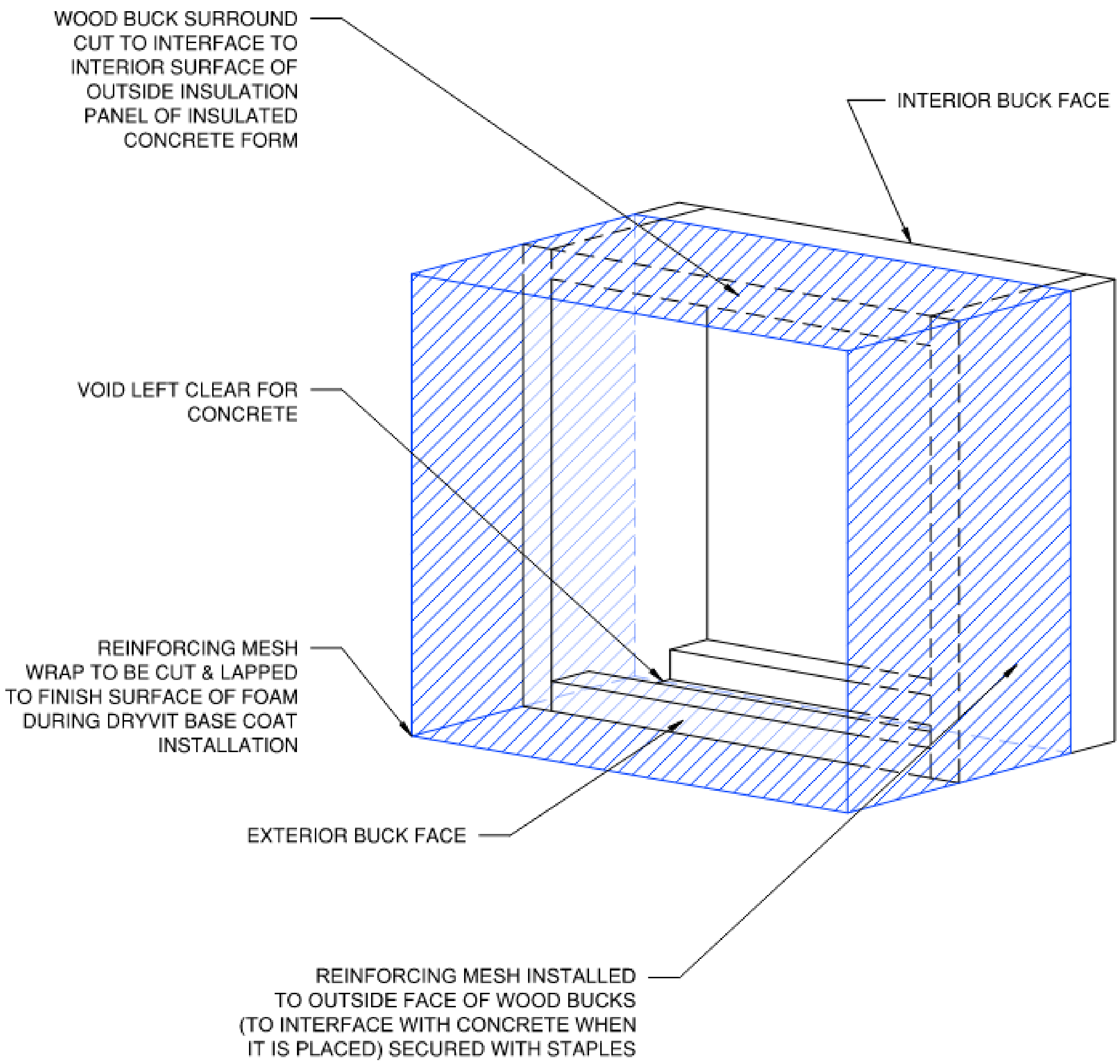

Figure 6. Exterior wall assembly incorporating EIFS reinforcement mesh at wall opening.

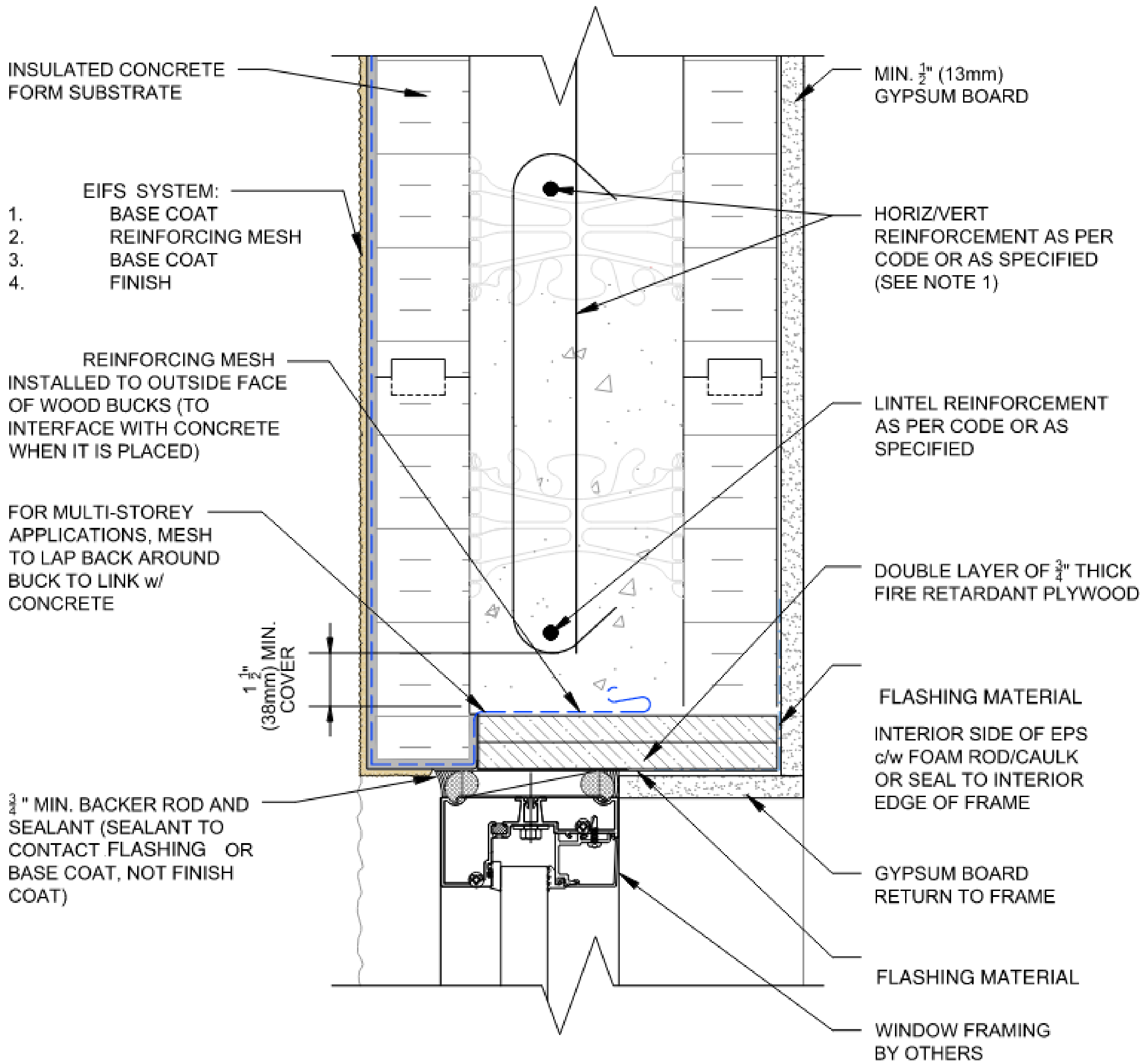

Figure 7. Exterior wall assembly incorporating EIFS reinforcement mesh detail at wall opening.

Conclusion

NRMCA in collaboration with ICFMA conducted two successful NFPA 285 tests on exterior wall assemblies incorporating an EPS ICF system covered by a standard clay brick façade and an ACM veneer. Based on this successful testing, alternative wall constructions were developed as detailed in Table 1 and Table 2 of this report for Thermally Thick and Thermally Thin Veneers, respectively. Table 3 provides the allowable alternate WRB materials based on exterior veneer being used. The additional wall construction features will result in wall assemblies which will maintain compliance in NFPA 285 and provide a comparable level of fire performance as the tested wall assemblies. The technical justification for the use of additional wall system components is provided to support their use in an exterior wall assembly which will continue to meet the conditions of acceptance of NFPA 285.

This analysis is based on the specific construction materials installed in the manner described in the reference test report(s). Changes or modifications to the construction and/or materials from the tested assembly or the analysis described in this report may result in a different fire performance and may change the analysis. This analysis does not address performance characteristics such as weatherability, durability, or structural issues.

References

These NFPA 285 compliance tables are generated based on the following test reports:

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3. National Fire Protection Association. (2023). *NFPA 285, Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Wall Assemblies Containing Combustible Components.* Quincy, MA: National Fire Protection Association.
4. Intertek Test Report Q3578.01-121-24 R0, dated May 17, 2024
5. Intertek Test Report Q3578.02-121-24 R0, dated May 17, 2024
6. Intertek Test Report No. S0661.01-121-24, dated January 20, 2025
7. *ASTM E1354-25 Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter*. (2025). (ASTM International) doi:10.1520/E1354-25
8. *ASTM C578-23 Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation*. (2023). (ASTM International) doi:10.1520/C0578-23
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The Insulating Concrete Forms Manufacturers Association (ICFMA) is the North American non-profit trade association for the Insulating Concrete Forms (ICF) industry. The ICFMA was founded in 2014 by a dedicated group of manufacturers with the interest of improving the quality and acceptance of Insulated Concrete Forms construction. Our mission is to promote and enhance the social, environmental, and economic value of Insulating Concrete Forms in the North American marketplace.

NEx, an ACI Center of Excellence for Nonmetallic Building Materials

Launched in collaboration between ACI And Aramco Americas, NEx is registered as a 501(c)3 nonprofit organization. Its mission is to collaborate globally to expand and accelerate the use of nonmetallics in the built environment to drive innovation, research, education, awareness, adoption and deployment.

ACI Foundation

ACI established the ACI Foundation in 1989 as part of its commitment to support students' education, research, and innovation throughout the concrete industry. ACI Foundation is a not-for-profit 501(c)(3) organization. The Foundation supports a wide range of research and educational initiatives that contribute to keeping the concrete industry at the forefront of technological advances in material composition, design, and construction.

Concrete Advancement Foundation

The vision of the Concrete Advancement Foundation is to be the resilient resource to collaboratively support concrete as the leading sustainable building material.

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