ICC-ES Evaluation Report

ESR-2435*

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DIVISION: 03 00 00—CONCRETE
Section: 03 37 00—Specially Placed Concrete

REPORT HOLDER:

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EVALUATION SUBJECT:

TRIDIPANEL 3D/EVG PANELS™

1.0 EVALUATION SCOPE

Compliance with the following code:

2009 *International Building Code*® (IBC)

Properties evaluated:

- Structural
- Fire resistance

2.0 USES

The Tridipanel 3D/EVG™ panels are used in the construction of exterior and interior, load-bearing and non-load-bearing, shear walls and non-shear walls, and floors and roofs, in fire-resistance-rated and non-fire-resistance-rated construction.

3.0 DESCRIPTION

3.1 General:

The Tridipanel 3D/EVG™ panel consists of a three-dimensional welded-wire space truss incorporating diagonal cross wires welded to welded-wire reinforcement (WWR) on each side of an integral core, which is an expanded polystyrene (EPS) foam plastic insulation board. The Tridipanel 3D/EVG™ wall, floor and roof panels must be placed in position, and a wythe of concrete or shotcrete (concrete facing) is applied to each side of the EPS core with the concrete facing covering the welded wire reinforcement. The panels are structurally designed with two wythes of concrete facings acting compositely with the diagonal cross wires. Figure 1 describes all panel variations recognized in this evaluation report. See Figures 2 through 17 for typical construction details. The Tridipanel 3-D/EVG™ is shop-fabricated with fully automated and tolerance controlled equipment. For use in fire-resistance-rated construction, see Section 4.2.3.

3.2 Materials:

3.2.1 Expanded Polystyrene (EPS) Foam Plastic: The core is a Type I modified EPS foam plastic complying with ASTM C578, having a nominal density of 1.0 pound per cubic foot (16 kg/m^3) as manufactured by Poliestireno Alfa Gamma, S.A. de C.V. (ESR-1006), Insulfoam LLC (ESR-1788) and Fanosa S.A. de C.V (ESR-2744). The insulation has a flame-spread index of 25 or less and a smoke-developed index of 450 or less when tested in accordance with ASTM E84 at a 6-inch (152 mm) thickness for EPS boards recognized under ESR-1788 and ESR-1006, and at a 4-inch (102 mm) thickness for EPS boards recognized under ESR-2744.

3.2.2 Reinforcement: The welded-wire reinforcement, manufactured from galvanized and bright welded wire, complies with ASTM A185 with the welded-wire reinforcement spaced $^1/_2$ inch (12.7 mm) from the insulation core faces. See Figure 1. The diagonal (through-the-core) truss wires act as shear transfer elements and comply with ASTM A82. The welded-wire reinforcement, including the diagonal wires, have a minimum yield stress of 60 ksi (420 MPa). Deformed steel reinforcing bars, when used as additional reinforcement, must have a minimum yield stress of 60 ksi (420 MPa) and must comply with Section 3.5.3 of ACI 318-08 and IBC Section 1903.

3.2.3 Concrete: Concrete must be normal-weight concrete complying with the applicable code, and have a maximum aggregate size of $^3/_8$ inch (9.5 mm), a minimum slump of 2 inches (51 mm), and a minimum compressive strength of 2,500 psi (17.2 MPa) at 28 days. Aggregate must comply with ASTM C33. The concrete must comply with Chapter 19 of the IBC. The top concrete facing of a roof or floor system can be applied manually to the Tridipanel 3D/EVG™ panels as specified by the registered design professional. For walls and the bottom side (soffit) of floor and roof panels, concrete can be applied either pneumatically (mechanically applied by different techniques including shotcrete, or pressurized plastering equipment) or manually (hand applied).

3.2.4 Shotcrete: Shotcrete, if specified by the registered design professional, must be normal-weight concrete complying with IBC Section 1913, and must have a minimum specified compressive strength of 2,500 psi (17.2 MPa) at 28 days. Aggregate size must not exceed $^3/_8$ inch (9.5 mm) and the aggregate must conform to Gradation No. 1 in Table 2.1 of ACI 506R-90.

4.0 DESIGN AND INSTALLATION

4.1 Structural Design:

4.1.1 General: This report only recognizes panel strength and fire-resistance ratings. Information pertaining to the code conformance of other aspects of the building design, including but not limited to weather protection and interior finishes, is outside the scope of this evaluation report and must be submitted to the code official for review and approval. Concrete walls, roofs and floors formed by the Tridipanel 3D/EVG™ panels must be designed and constructed in accordance with Chapters 16 and 19 of the IBC. For each building structure constructed with concrete walls, floors or roofs formed by the Tridipanel 3D/EVG™ panels, engineering plans, construction specifications, and structural calculations must be submitted to the code official for approval, and must provide details relating to job-specific design and construction. The structural calculations must be based on load requirements and loading combinations as required by the IBC. The structural calculations must confirm, considering each applicable limit state including both strength limit state and serviceability limit state, that the load effects due to applied loads do not exceed corresponding structural capacities determined in accordance with IBC Chapter 19 with modifications provided in this section (Section 4.1). The structural design (engineering plans and structural calculations) must ensure, under each applicable loading combination, that both concrete facings of roof and floor assemblies, installed with equal or different concrete thickness on the top and bottom of the panel, share the total load in accordance with, and proportional to, their relative stiffnesses. For wall assemblies, load application and support condition must be designed and detailed to ensure that each wythe is loaded and supported equally. These design requirements require evaluation of a complete load path, considering the applied loading, the boundary conditions of each concrete facing and the adequacy of the diagonal wires.

4.1.2 Flexural Strength for Resisting Out-of-plane Loading: The flexural strength of concrete walls, roofs and floors constructed with the Tridipanel 3D/EVG™ panels, subjected to out-of-plane flexural loads, must be determined in accordance with the applicable provisions of ACI 318-08 and IBC Chapter 19. However, the following two limitations must be observed:

a. The contribution of compression welded wire steel mesh must be excluded.

b. The distance from the extreme compression fiber to the neutral axis, c, must be maintained to be equal to, or less than, the thickness of the compression concrete facing, t_c (*i.e.,* $c \le t_c$).

4.1.3 Axial Compression and Axial Compression with Flexure (Eccentric Axial Loads): The strength of axial compression and combined axial compression and flexural strength for load-bearing structural members constructed from Tridipanel 3D/EVG™ panels must be determined in accordance with the provisions of ACI 318-08 Chapter 10 and Chapter 21, as applicable. The design strengths typically must be calculated by constructing Load-Moment (P_n-M_n) interaction diagrams using moment magnification in accordance with Sections 10.10.5 through 10.10.7 of ACI 318-08. The buckling load and flexural stiffness (*EI)* must be calculated using procedures described in Section 10.10.6 of ACI 318-08.

4.1.4 Deflection:

4.1.4.1 Out-of-plane Deflection: The out-of-plane deflection of the Tridipanel 3D/EVG™ panels due to transverse loads must be determined in accordance with the IBC, ACI 318-08 and a rational analysis using principles of mechanics with due consideration of the effect of EPS core and diagonal wires. When calculating out-of-plane deflection of a concrete structure constructed of Tridipanel 3D/EVG™ panels, the effective moment of inertia (I_e) must be taken as 0.4 of the gross moment of inertia (I_g).

4.1.4.2 In-plane Deflection: For a structural wall constructed of the Tridipanel 3D/EVG™ panels subjected to in-plane shear load, both flexural and shear deformation must be considered in calculating the displacement. In this case, the displacement at the top of the wall panel due to lateral in-plane force (V) is calculated as follows:

For a cantilever wall:

$$\Delta_c = \Delta_b + \Delta_v = \frac{Vh^3}{3E_c I_{eff}} + \frac{1.2Vh}{E_v A} \quad (4\text{-}1)$$

For a fixed-fixed wall:

$$\Delta_c = \Delta_b + \Delta_v = \frac{Vh^3}{12E_c I_{eff}} + \frac{1.2Vh}{E_v A} \quad (4\text{-}2)$$

where:

Δ_c = Total in-plane lateral deflection at the top of a wall with respect to the bottom of the wall within a story, in. (mm)

Δ_b = In-plane lateral deflection due to bending (flexure) deformation, in. (mm)

Δ_v = In-plane lateral deflection due to shear deformation, in. (mm)

V = In-plane lateral load at nominal load or at strength level load, kips (kN)

H = Wall height, in. (mm)

E_c = Modulus of elasticity of concrete, ksi (MPa)

A = Horizontal cross-sectional area of the concrete wall facings, in.^{2} (mm^2)

I_{eff} = Effective moment of inertia, in.^{4} (mm^4)

E_v = Shear modulus or modulus of rigidity = 0.4 E_c, ksi (MPa).

The relative rigidity or stiffness of a shear wall (k_w) is defined as the inverse of its total lateral deflection:

$$k_w = \frac{1}{\Delta_b + \Delta_v} \quad (4\text{-}3)$$

The calculated relative rigidities of shear walls can be used to determine the lateral load distribution to each shear wall in accordance with IBC Section 1604.4.

4.1.5 In-plane Shear Load Resistance: Structural walls constructed of Tridipanel 3D/EVG™ panels must be designed in accordance with applicable provisions of ACI 318 and IBC Chapter 19. Structural walls constructed of Tridipanel 3D/EVG™ panels that are part of structures assigned to Seismic Design Category (SDC) C, D, E, or F, must be designed in accordance with Chapter 21 of ACI 318, including Sections 21.1, 21.4, 21.9 and 21.10, as special reinforced concrete structural walls with the modifications noted in Sections 1908.1.1 through 1908.1.5 of the IBC, and conforming to limitations prescribed in ASCE/SEI 7 for special reinforced concrete shear walls. The total thickness of the wall, h, must be taken as the sum of the two wythes. As required by Section 4.1.1, above, load application and support condition must be designed and detailed to ensure each wythe is loaded and supported equally. For shear walls constructed of Tridipanel 3D/EVG™ panels, with an aspect ratio

(height-to-length ratio) (or *AR*) less than or equal to 1.0 (*i.e., AR≤1.0*), the seismic design must be based on the following parameters: a seismic response modification factor, R = 3.5; the deflection amplification factor, C_d = 3.5; and the system overstrength factor, Ω_0 = 3.0. Concrete shear walls constructed of Tridipanel 3D/EVG™ panels with aspect ratios larger than 1 are outside of the scope of this evaluation report.

4.1.6 Openings in Walls: The portion of the Tridipanel 3D/EVG™ wall above openings must be designed as a beam in accordance with reinforced concrete strength design principles and the requirements of ACI 318 (refer to Figures 6, 7, and 17 of this report), including ACI 318 Section 21.9, as applicable. Wall sections adjacent to such openings must be designed to resist additional loads due to the presence of the opening (refer to Figures 15 and 17 of this report).

4.2 Assembly and Construction:

4.2.1 General: The Tridipanel 3D/EVG™ panels must be installed in accordance with the approved plans, which must show particular details relating to job-specific design and construction. Typical details and Technical Manual Parts 1 & 2 (August 2012 Issue) can be retrieved from the manufacturer's website: www.tridipanel.com.mx. At all times, a copy of the manufacturer's instructions must be available on the jobsite during installation. Foundation walls, footings, and other supporting structures receiving Tridipanel 3D/EVG™ panels must be level and free of dirt and loose material. Reinforcement for anchoring panels to supports must be as shown on the approved plans. The Tridipanel 3D/EVG™ panels must be plumb and true in their final location, with location and alignment conforming to the approved plans. Allowable construction tolerances must be as noted in the Specifications for Structural Concrete for Buildings (ACI 301).

Panels must be temporarily braced as determined by the registered design professional to resist wind pressure and loading related to the application of concrete. Embedded electrical, plumbing and mechanical hardware and accessories shown on approved plans must be installed in the proper location and fastened by wires or other appropriate means. The interior and exterior finishes must be applied as described on the approved plans and in accordance with the IBC. Evaluation of the finishes is beyond the scope of this report.

4.2.2 Concrete Application: Concrete must be applied to both faces of the Tridipanel 3D/EVG™ panel to the thickness shown on the approved plans. Concrete must be applied as described in Section 3.2.3 or 3.2.4 of this report. In lieu of applying concrete by methods described in Section 3.2.3, the wall panels can be set between forms. The concrete is then placed from the top, in a manner that complies with the IBC. Poured wythes of concrete facings must be at least 1.25 inches (32 mm) thick. Special care must be taken to ensure complete filling of any void space between the insulation and the welded-wire reinforcement.

4.2.3 Fire-resistance-rated Construction: For use in fire-resistance-rated construction, walls consisting of the Tridipanel 3D/EVG™ panels, designed in accordance with this report and Table 1, have fire-resistance ratings as shown in Table 1 of this report.

4.3 Special Inspection:

Special inspection must be performed in accordance with IBC Sections 1704.4 and 1913, as applicable. The duties of the special inspector include verification of compliance with the approved plans, specifications and this report, including, but not limited to, welded-wire reinforcement size, cover, and spacing; and identification of Tridipanel 3D/EVG™ panels in accordance with Section 7.0 of this report. In addition to items prescribed in IBC Table 1704.4, for shotcrete application, the duties of the special inspector include verification of sampling and preparation of test specimens, and conformance with acceptance criteria in IBC Section 1913.10.3.

5.0 CONDITIONS OF USE

The Tridipanel3D/EVG™ panels described in this report comply with, or are suitable alternatives to what is specified in, the code indicated in Section 1.0 of this report, subject to the following conditions:

5.1 The Tridipanel 3D/EVG™ panels must be installed in accordance with this report, the manufacturer's installation instructions as noted in Section 4.2 of this report, and applicable code provisions. If there is a conflict between the manufacturer's published installation instructions and this report, this report governs.

5.2 The Tridipanel 3D/EVG™ panels must be delivered, stored and handled in such a manner that the insulation is not punctured and the welded-wire fabric is not deformed.

5.3 Plans, specifications and structural calculations, showing compliance with this report and the code, must be submitted to the code official for approval. The structural design (engineering plans, specifications and structural calculations) must ensure, under each applicable loading combination, that both concrete facings of roof and floor assemblies share the total load in accordance with, and proportional to, their relative stiffness. For wall assemblies, load application and support condition must be designed and detailed to ensure that each wythe is loaded and supported equally. The plans, specifications and structural calculations incorporating the Tridipanel 3D/EVG™ panels must be prepared by a registered design professional when required by the statutes of the jurisdiction in which the project is to be constructed.

5.4 Concrete walls incorporating the Tridipanel3D/EVG™ wall panels must be constructed with concrete facings of equal thickness.

5.5 Concrete walls incorporating the Tridipanel3D/EVG™ wall panels, when used as seismic force–resisting systems, must be designed and detailed as special reinforced concrete structural walls as defined in ASCE/SEI 7 (special structural walls defined in IBC Section 1908), in accordance with Sections 4.1.5 and 4.1.6 of this report.

5.6 Cuts in panel wythes, and holes or other openings in panels, are not permitted unless shown on the approved plans.

5.7 This report only recognizes the structural performance of wall, roof and floor structural assemblies incorporating the Tridipanel 3D/EVG™ panels, and fire-resistance ratings of walls incorporating the Tridipanel 3D/EVG™ panels. Performance pertaining to the code conformance of other aspects of the buildings, including but not limited to weather protection and interior finishes, is outside the scope of this evaluation report.

5.8 Special inspection must be performed in accordance with Section 4.3 of this report.

5.9 For Tridipanel 3D/EVG™ panels used as part of a roof assembly, justification must be submitted to the

code official demonstrating that the panels with the roof covering comply as a Class A, B, or C roof assembly, as required by IBC Section 2603.6, with the classification complying with the minimum classification requirements for the building.

6.0 EVIDENCE SUBMITTED

Data in accordance with the ICC-ES Acceptance Criteria for Concrete Floor, Roof and Wall Systems and Concrete Masonry Wall Systems (AC15), dated February 2010; and a quality control manual.

7.0 IDENTIFICATION

For field identification, all packages of the delivered Tridipanel 3D/EVG™ panels covered by this report must bear the name and trademark of the manufacturer (Insteel Panelmex, S.A. de C.V.) and the evaluation report number (ESR-2435). The face or edge of the insulation on each Tridipanel3D/EVG™ panel must be identified in accordance with ESR-1006, ESR-1788 or ESR-2744.

TABLE 1—FIRE-RESISTANCE RATINGS OF TRIDIPANEL-3D/EVG™ WALLS[1]

CONCRETE FACING THICKNESS (EQUAL ON BOTH FACE)		FIRE-RESISTANCE RATINGS	
Inches	**mm**	**Carbonate Aggregate**	**Siliceous Aggregate**
1.5	38	1.5 hours	1 hour
2	51	2 hours	2 hours

[1]The fire-resistance ratings are applicable only to concrete walls consisting of Tridipanel 3D/EVG™ panels recognized under this evaluation report (see Figure 1) and jobsite-applied concrete facings.

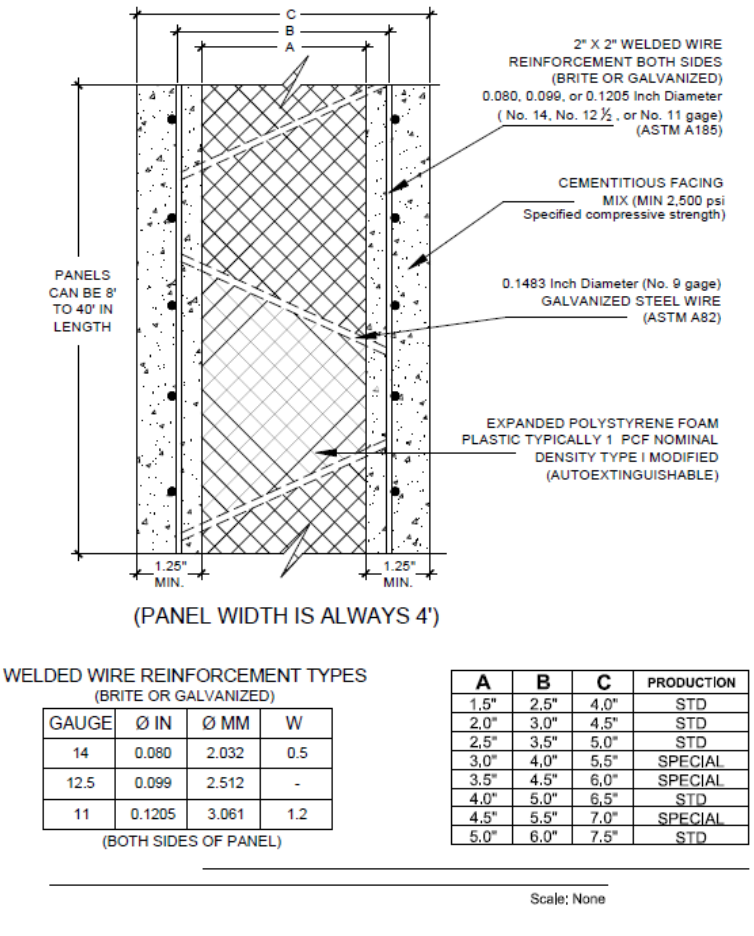

FIGURE 1—TRIDIPANEL PANEL VARIATIONS

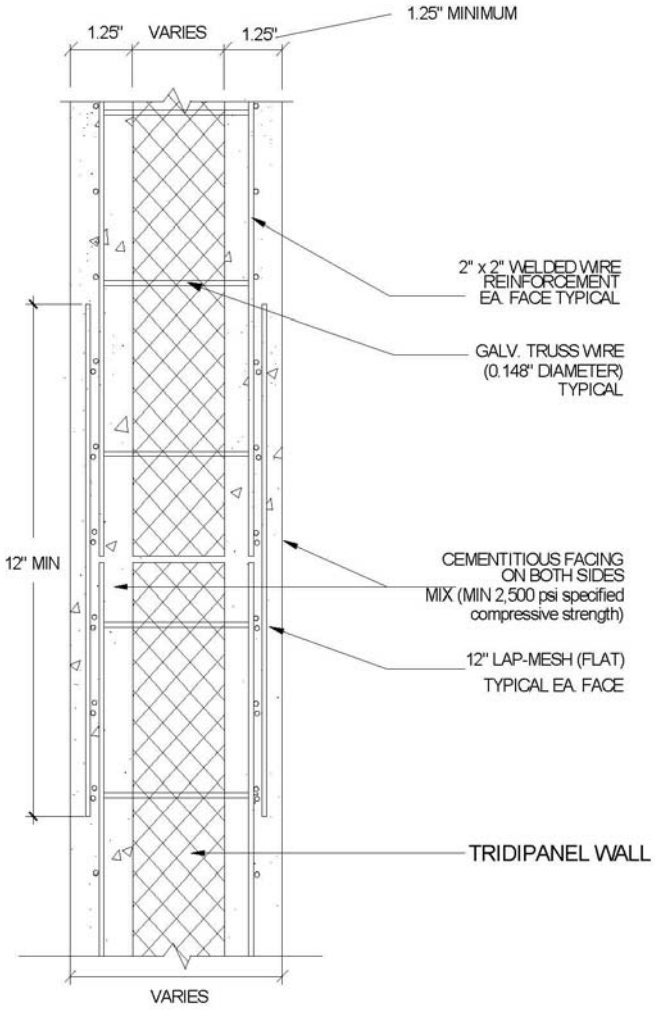

FIGURE 2—DETAIL OF WALL JOINT

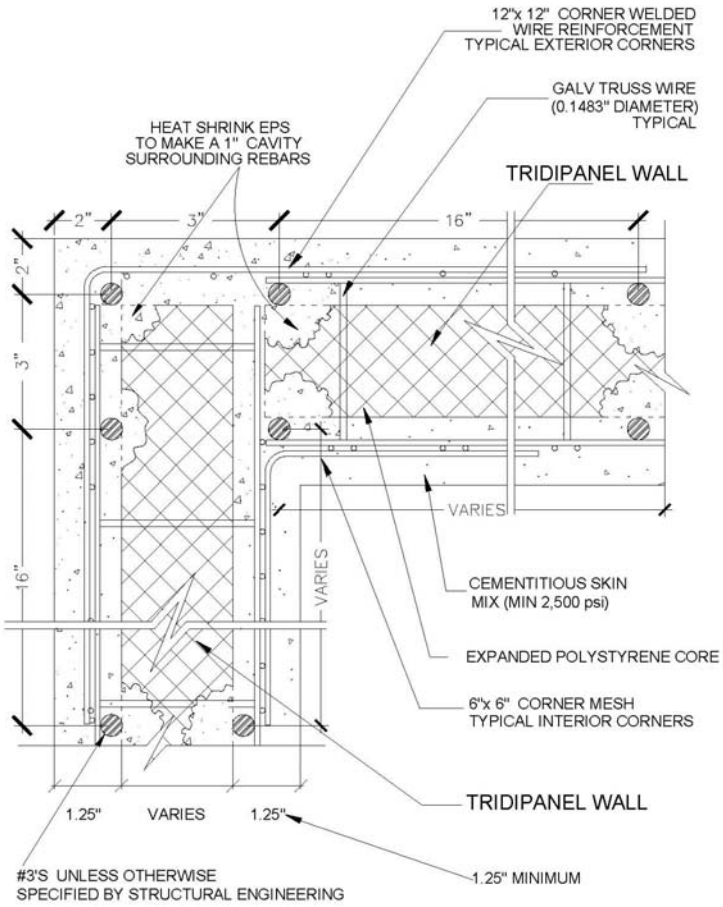

FIGURE 3—SHEER WALL CORNER DETAIL

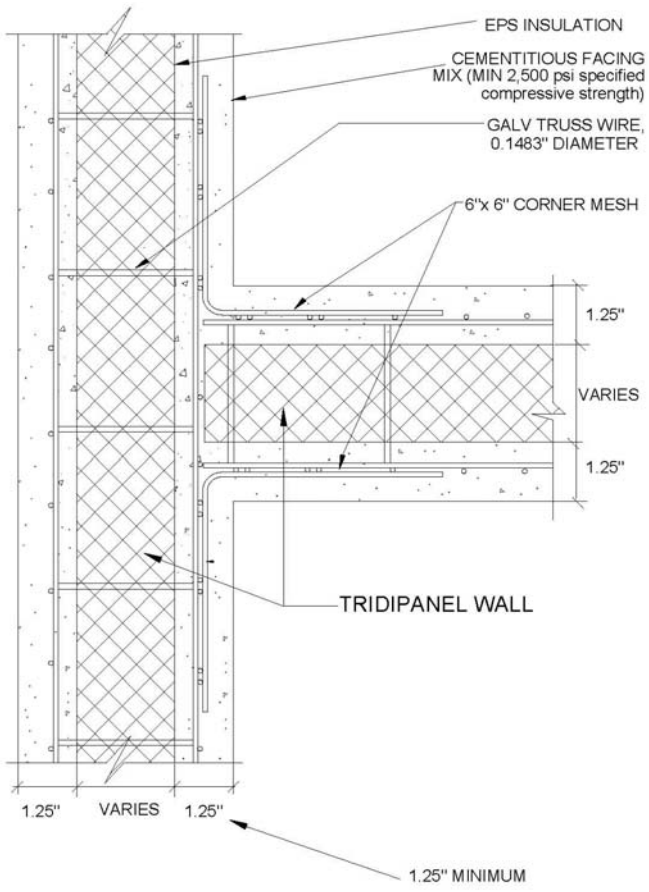

FIGURE 4—WALL INTERSECTION DETAIL

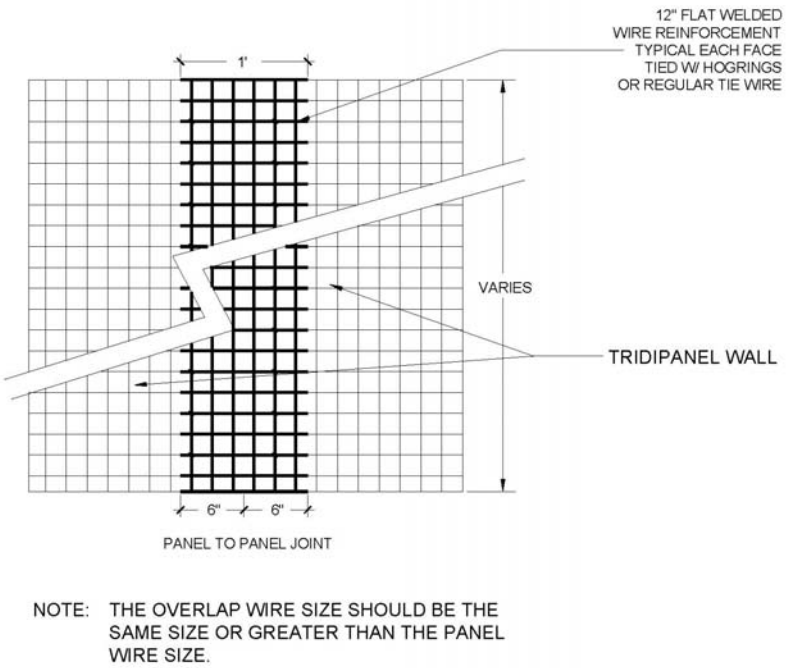

FIGURE 5—DETAIL OF WALL JOINT OVERLAP

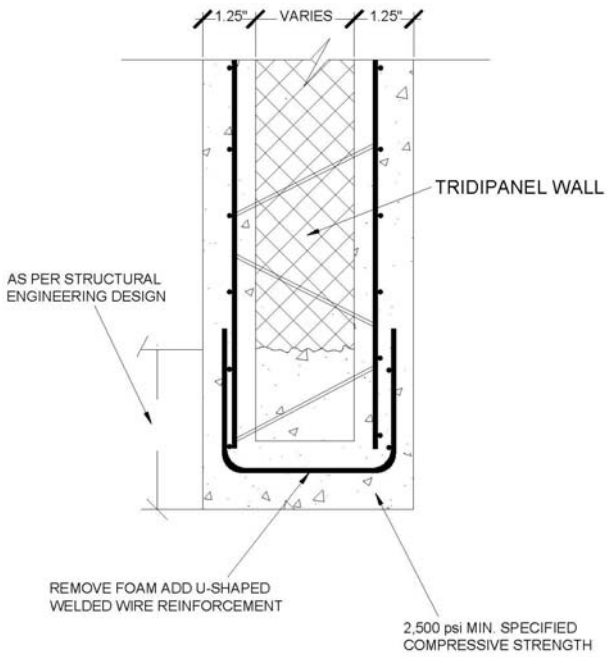

FIGURE 6—DETAIL OF LINTEL BEAM (FOR USE ON OPENINGS)

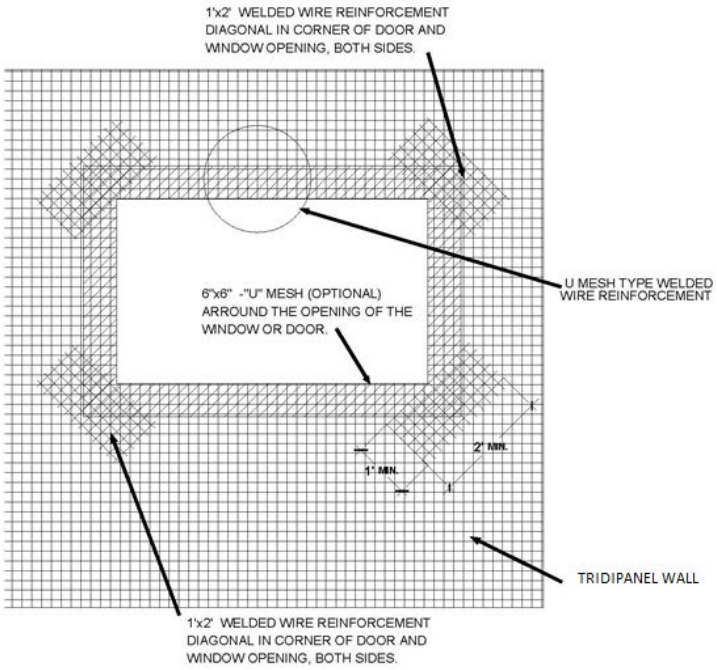

FIGURE 7—DETAIL, REINFORCEMENT IN DOOR AND WINDOW CORNERS

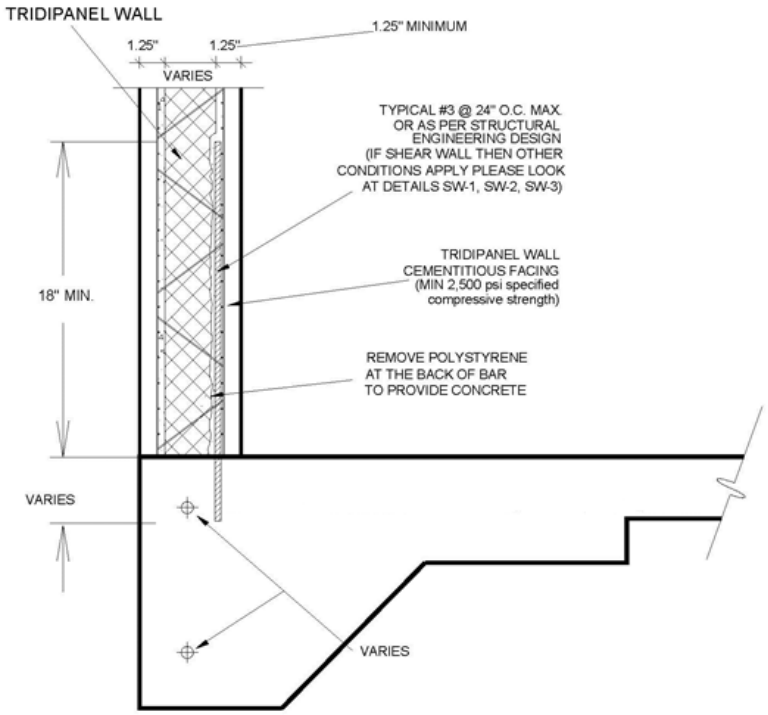

FIGURE 8—DETAIL, EDGE FOOTING/WALL CONNECTION (PERIMETER WALLS)

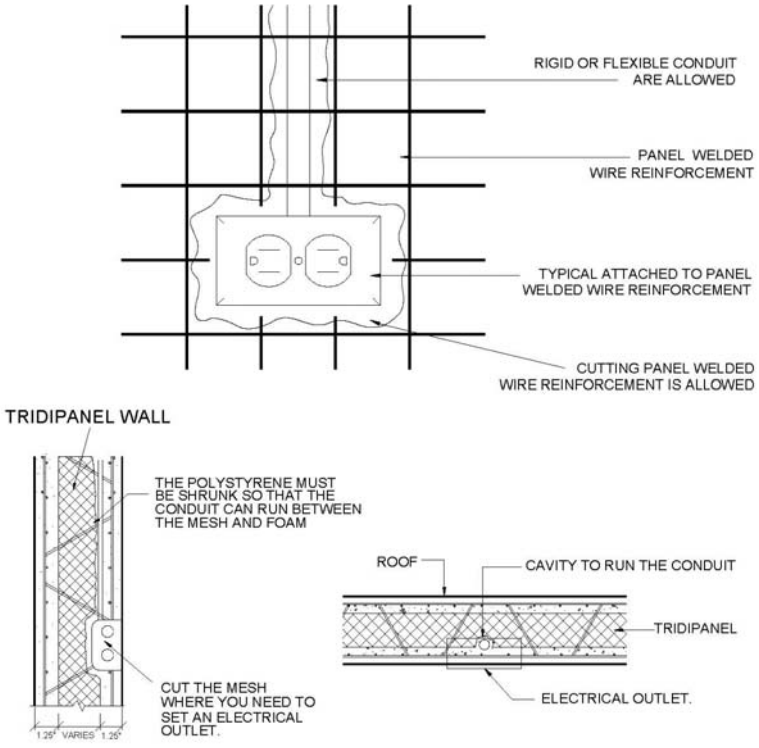

FIGURE 9—ELECTRICAL INSTALLATION DETAILS

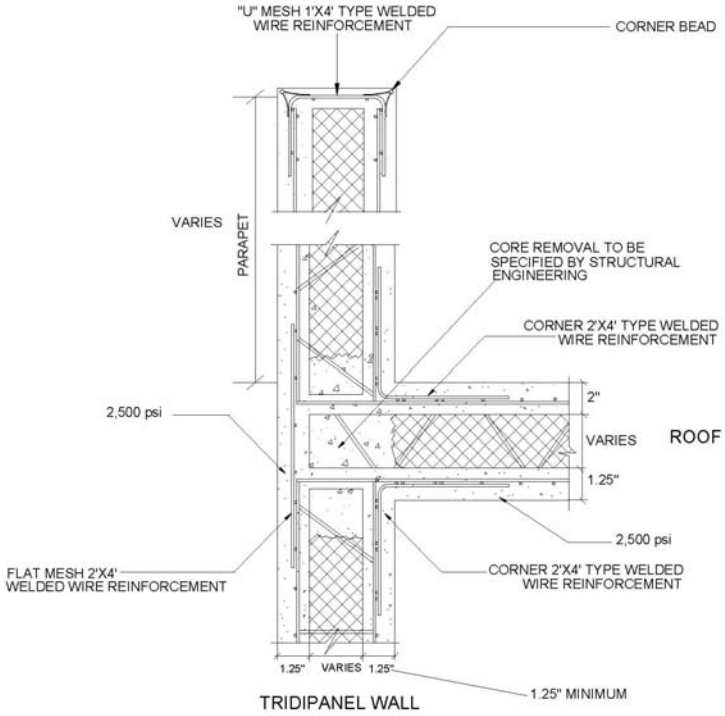

FIGURE 10—PARAPET DETAIL

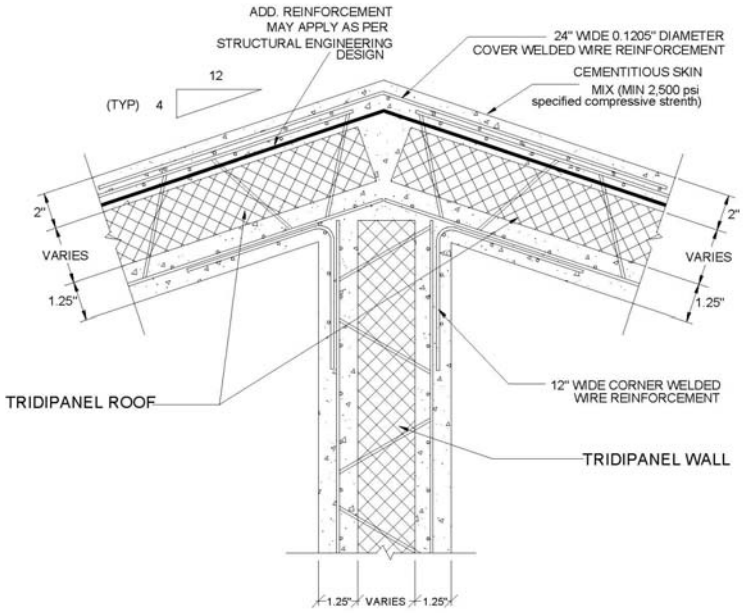

FIGURE 11—DETAIL, WALL AT ROOF RIDGE CONNECTION

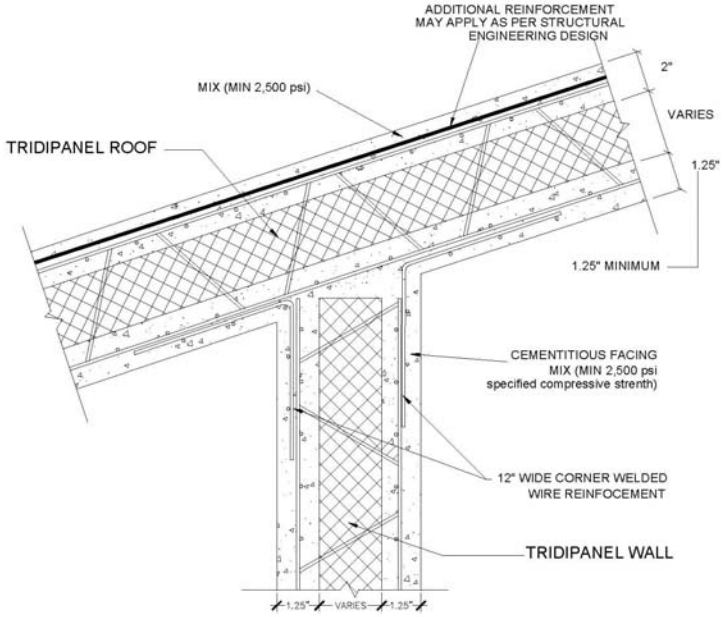

FIGURE 12—DETAIL, WALL SLOPED ROOF CONNECTION

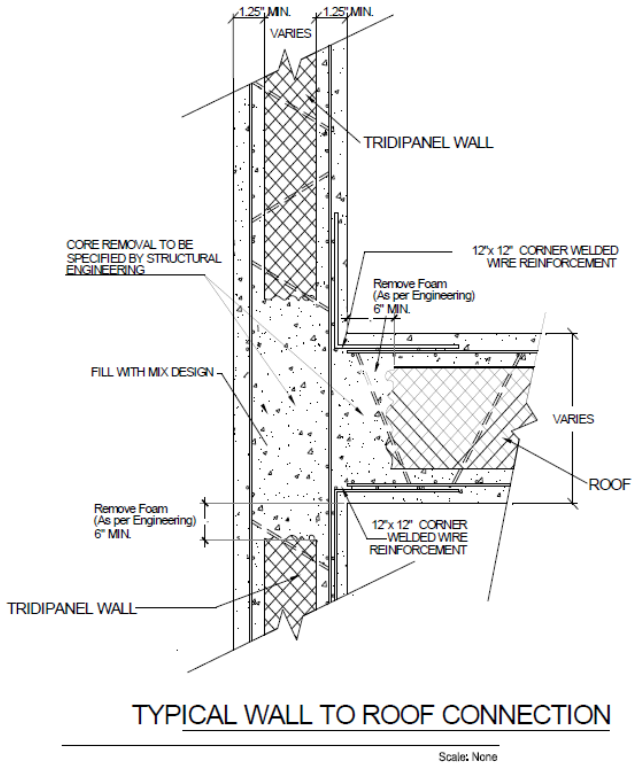

FIGURE 13—DETAIL, WALL TO ROOF CONNECTION

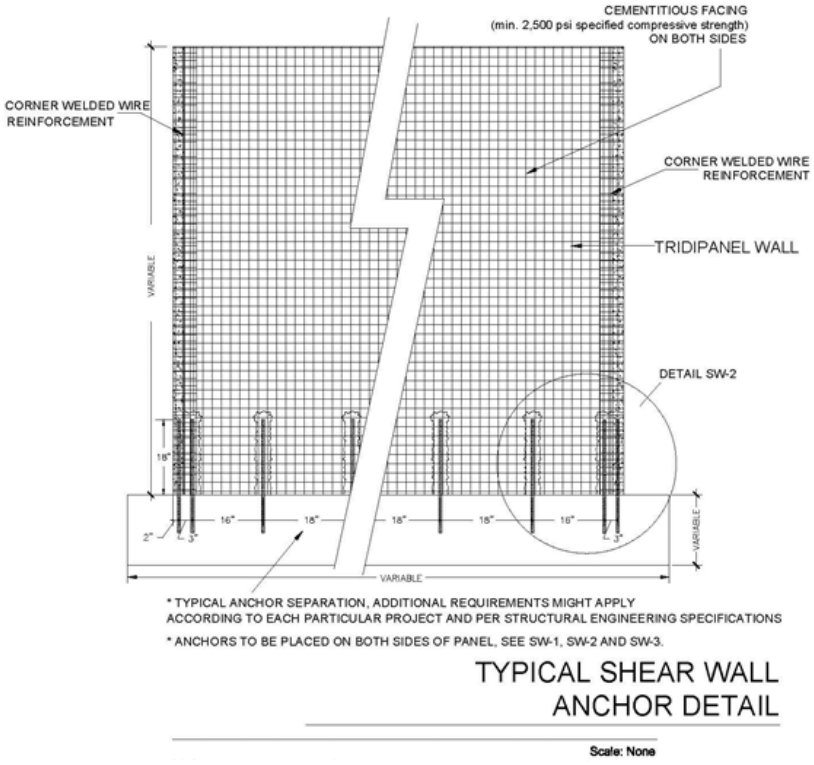

FIGURE 14—DETAIL SW-1

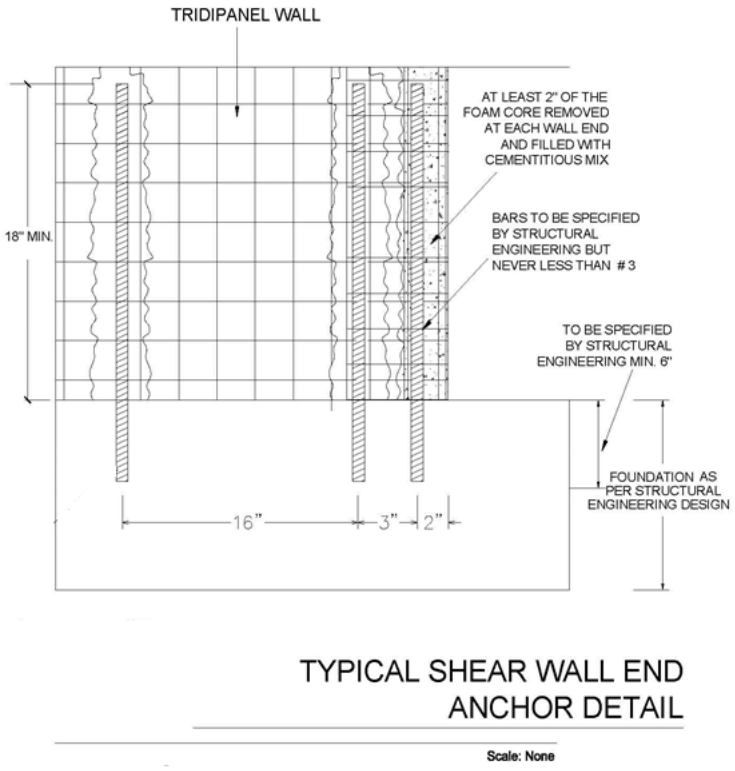

FIGURE 15—DETAIL SW-2

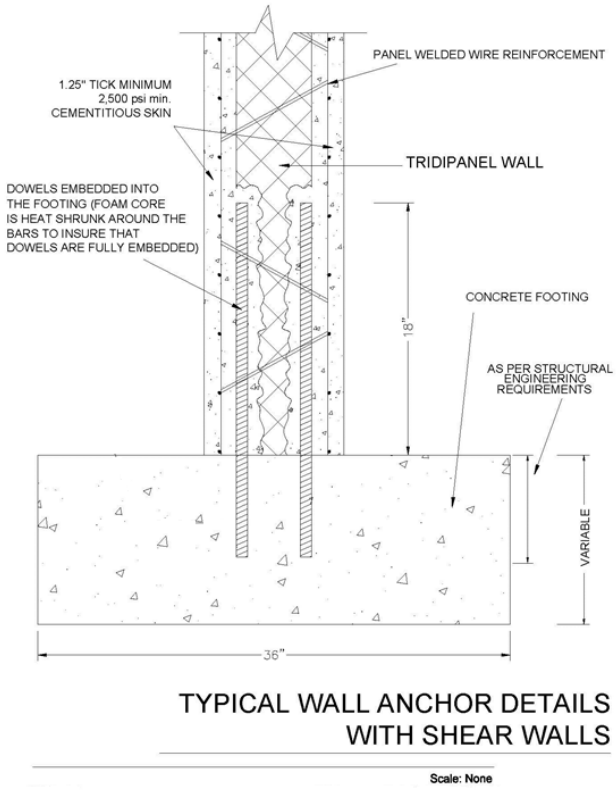

FIGURE 16—DETAIL SW-3

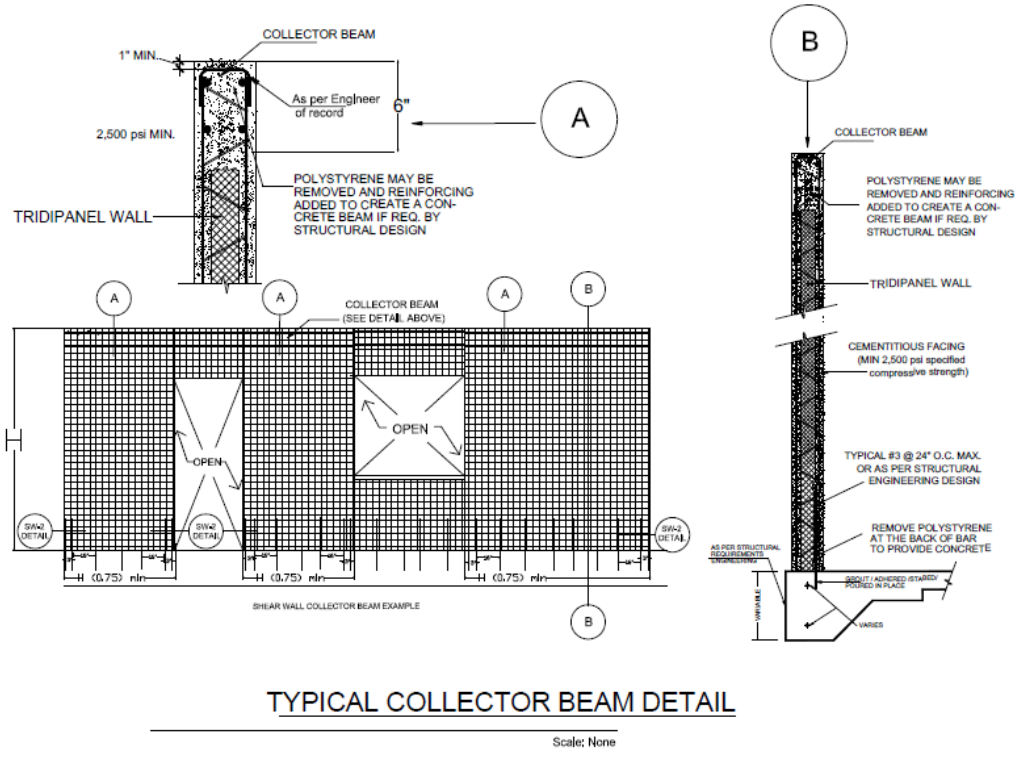

FIGURE 17—DETAIL SW-4