ICC-ES Evaluation Report

ESR-5267

Issued August 2024

Subject to renewal August 2025

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DIVISION: 03 00 00 - CONCRETE Section: 03 41 00 – Precast Structural Concrete Section: 03 47 00 – Site-cast Concrete	REPORT HOLDER: SIGMA DG CORPORATION, INC.	EVALUATION SUBJECT: X-PIN SHEAR CONNECTORS	

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2021, 2018 and 2015 *International Building Code®* (IBC)
- 2021, 2018 and 2015 *International Residential Code®* (IRC)

Property evaluated:

- Physical
- Environmental
- Structural

2.0 USES

The X-Pin Shear Connectors are used to transfer the shear flow induced by composite action between two concrete elements subjected to flexural bending in one or more directions.

3.0 DESCRIPTION

3.1 General: The connector configuration comprises two glass fiber reinforced polymer (GFRP) bars, called pins, installed into a rigid insulation board, forming an "X" pattern at a 90-degrees. The length of each pin measures approximately 7.80 inches (198.12 mm) long and 0.40 inches (10.16 mm) in diameter for the 2-inch X-Pin configuration, and 10.60-inch (269.24 mm) long and 0.40-inch (10.16 mm) for the 4-in X-Pin configuration. The height of the X-Pin shear connectors is based on its configurations and insulation thickness. Height ranges from 5½-inch to 7½-inch (139.7 mm to 190.5 mm). Dimensions are shown in Figure 1.

3.2 Concrete: Normal-weight concrete must conform to Sections 1903 and 1905 of the IBC, as applicable, and comply with the compressive strength requirements in Table 1.

3.3 Insulation: Foam insulation board must have a minimum compressive strength of 10 psi of either EPS or XPS conforming to ASTM C578, faced polyisocyanurate rigid insulation conforming to ASTM C1289, or unfaced polyisocyanurate rigid insulation conforming to ASTM C591.

4.0 DESIGN

4.1 Physical and Material Properties of the Connectors: Design must be based on the physical and mechanical properties listed in Table 1 and 2.

4.2 Shear Strength of the Connector (v_n): The nominal shear strength (lbs) of the X-Pin connector depends on the insulation thickness and connector length. The nominal shear strength values of the X-Pin connectors are shown in Table 1.

4.3 Stiffness of the Connector (K): The stiffness (lbs/inch) of the X-Pin connector depends on insulation thickness and connector length. The stiffness of the X-Pin connectors are shown in Table 1.

4.4 Strength Reduction Factors:

The following strength reduction factors are applicable for the design of the insulated concrete panel construction with connectors.

- A strength reduction factor of 0.75 must be used to determine the nominal design shear strength (v_n).

$$\phi v_n = 0.75\, v_n$$

- For the design of the insulated concrete panels for sustained loads, an additional strength limit factor of 0.15 must be used to determine the nominal design shear strength (q_n).

$$\phi v_n = 0.15\, v_n$$

4.5 Stiffness: Designing the deflections of insulated concrete panels using the construction method under consideration must be based on a combination of flexural deformation and shear deformation. The total deformation is the sum of the long-term flexural deformation and the long-term shear deformation. The total deformation must be based on the following:

$$\left(\delta_F \lambda_\Delta + \delta_S \xi\right) = \delta_{LongTerm}$$

where

δ_F = the flexural deflection of the panel due to moment applied to the panels by sustained gravity loads

λ_Δ = long-term load flexural deformation creep factor due to sustained loads as defined in Section 4.5.1.

δ_S = the shear deflection of the panel due to shear in the panel due to the sustained gravity loads

ξ = the shear deformation creep factor due to sustained loads as defined in Section 4.5.2.

4.5.1 Flexural Deformations: Long-term load flexural deformation calculations must follow a rational method. The long-term load flexural deformation creep factor is defined as λ_Δ and can be determined in accordance with Section 24.2 of ACI 318-19 (2021 IBC) or ACI 318-14 (2018 and 2015 IBC).

4.5.2 Shear Deformations: Long-term load shear deformation calculations must follow a rational method. The long-term load shear deformation creep factor is defined as ξ and can be determined in accordance with Section 24.2 of ACI 318-19 (2021 IBC) or ACI 318-14 (2018 and 2015 IBC).

5.0 INSTALLATION:

5.1 General:

Connector orientations and locations must comply with this report and the plans and specifications approved by the code official. X-Pin shear connectors must be installed in accordance with the instructions provided by Sigma DG Corporation, Inc.

The minimum embedment, edge distance, connector spacing, and minimum concrete thickness must comply with Tables 1 and 2 of this report.

After the bottom layer of concrete is placed, code-compliant of rigid insulation foam per Section 3.3 in widths of 2-inch or 4-inch-thick layer preinstalled equivalent X-Pin shear connectors are placed over the concrete while the concrete is in a plastic state. Concrete consolidation around the connectors must be conducted in accordance with the manufacturer's installation instructions. The top layer of concrete is then placed and consolidated over the insulation board, engaging the connectors. Panels must be cured in accordance with the manufacturer's installation instructions.

5.2 Special Inspection:

Installations must be made under special inspection in accordance with Section 1704 of the IBC. The special inspector must be in the manufacturing facility continuously during connector installation to verify connector type, connector dimensions, cleanliness, embedment depth, concrete type, concrete compressive strength, edge distances, connector spacings, concrete thickness, concrete consolidation and concrete curing.

6.0 CONDITIONS OF USE:

The X-Pin Shear Connectors described in this report are suitable alternatives to what is specified in the codes listed in Section 1.0 of this report, subject to the following conditions:

6.1 Connector sizes, dimensions, and installation must comply with this report and the Sigma DG Corporation, Inc. published installation instructions. In case of a conflict between this report and other documentation, this report governs.

6.2 Calculations and details demonstrating compliance with this report must be submitted to the code official for approval. The calculations and details must be prepared by a registered design professional where required by the statues of the jurisdiction in which the project is to be constructed.

6.3 Nominal shear strength and stiffness must be as noted in Table 1. The values shall be adjusted in accordance with Section 4.4 of this report. The values may be interpolated for intermediate insulation sizes not shown.

6.4 Connectors are not evaluated for use in conjunction with fire-resistance-rated construction.

6.5 Use of connectors to resist seismic loads is outside the scope of the evaluation report.

6.6 Short-term loads due to product manufacturing, transportation, and handling is outside the scope of the evaluation report.

6.7 Qualification testing, as described in Section 4.4 of AC422 of this criteria, is needed for each insulated concrete panels manufacturing facility. The testing must justify that the nominal shear strength and stiffness, as applicable, of the connectors is applicable to the insulated concrete panels manufactured at that panel manufacturing facility.

6.8 Special inspection shall apply to the installation of the connectors. Special inspection shall conform to Section 1704 of the IBC.

6.9 Since an ICC-ES acceptance criteria for evaluating the performance of composite connectors in cracked concrete is unavailable at this time, the use of the connectors is limited to use in uncracked concrete. Cracking occurs when $f_t > f_r$ due to service loads or deformations.

6.10 Since an ICC-ES acceptance criteria for evaluating data to determine the performance of connectors subjected to fatigue or shock loading is unavailable at this time, the use of these connectors under these conditions is outside the scope of the report, as defined by ACI 318.

6.11 Minimum number of X-Pin connectors shall not be less than two (2) per concrete wythe.

6.12 Connectors are manufactured under a quality control program with inspections by ICC-ES.

7.0 EVIDENCE SUBMITTED

Data in accordance with the ICC-ES Acceptance Criteria for Semicontinuous Fiber-Reinforced Grid Connectors Used in Combination with Rigid Insulation in Insulated Concrete Panel Construction (AC422), dated June 2023.

8.0 IDENTIFICATION

8.1 The ICC-ES mark of conformity, electronic labeling, or the evaluation report number (ICC-ES ESR-5267) along with the name, registered trademark, or registered logo of the report holder must be included in the product label.

8.2 In addition, the connectors are identified in the field by dimensional characteristics and packaging. The packaging label indicates the Sigma DG Corporation, Inc. name and address, the type of connector. Each connector box is stamped with the lot number.

8.3 The report holder's contact information is the following:

SIGMA DG CORPORATION, INC.
5019 NW 127 STREET
VANCOUVER, WASHINGTON 98685
(360) 859-3170
www.sigmadg.com

TABLE 1 – NOMINAL SHEAR STRENGTH AND STIFFNESS VALUES

CONNECTOR CONFIGURATION	INSULATION[2], inch (mm)	MINIMUM CONCRETE STRENGTH[1], psi (kPa)	NOMINAL SHEAR STRENGTH, lbs (kN)	STIFFNESS, lbs./in (kN/mm)
2-in X-PIN	2 (50.8)	4,851 (33,446)	3,820 (16.99)	101,894 (17.84)
4-in X-PIN	4 (101.6)	6,250 (43,092)	4,058 (18.05)	93,939 (16.45)

For **SI**: 1 inch = 25.4 mm; 1 psi = 6.89 kPa; 1 kN = 224.81 lbf; 1 kN/mm = 5710 lbs/inch
[1]Minimum concrete wythe thickness is 2 inches (50.8 mm), excluding reveals and rustications or greater.
[2]Values for intermediate insulation thicknesses may be interpolated.

TABLE 2 – INSTALLATION DIMENSIONS OF X-PIN SHEAR CONNECTORS[1,2]

PARAMETER	VALUE
Minimum embedment	1.83 inches (46.48 mm)
Minimum edge distance – Longitudinal	12 inches (304.8 mm)
Minimum edge distance – Transverse	6 inches (152.4 mm)
Minimum connector spacing – Transverse[3]	12 inches (304.8 mm)
Minimum connector spacing – Longitudinal[3]	12 inches (304.8 mm)

[1]See Figure 1 and 2 for exact dimensions and lay-out.
[2]Longitudinal – parallel to load direction; transverse – perpendicular to load direction.
[3]Measured from one center of X-Pin to another center.

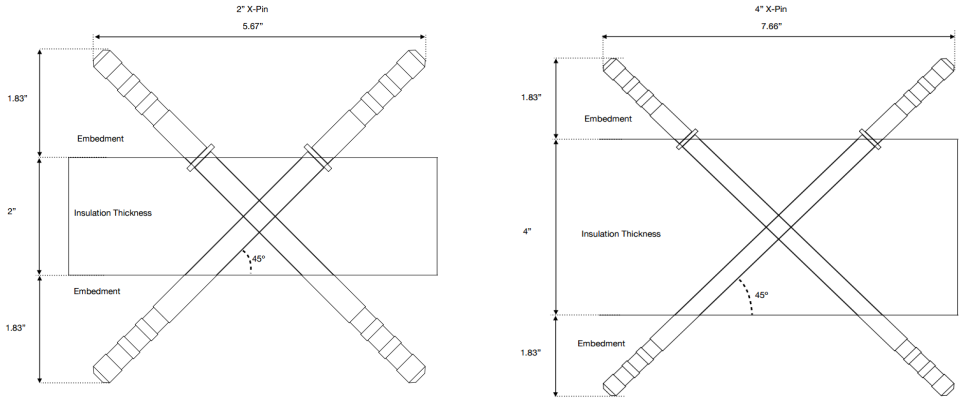

FIGURE 1—X-PIN CONFIGURATION

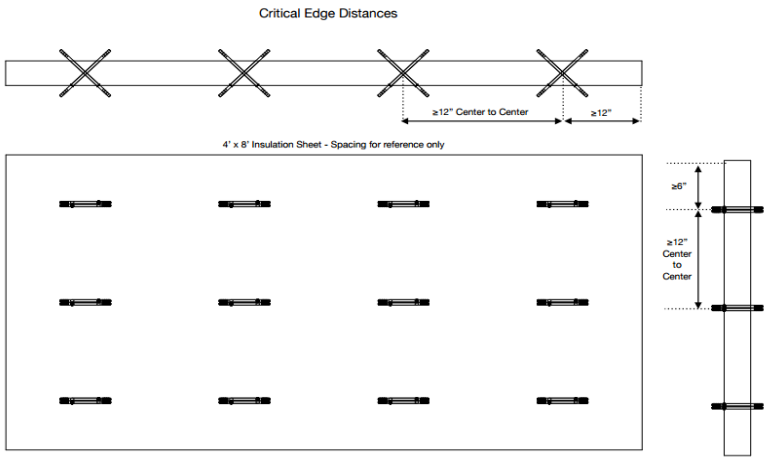

FIGURE 2—X-PIN INSTALLATION DIMENSIONS