ENCLOSURE SOLUTIONS PRECAST INSULATED CONCRETE DESIGN GUIDE

ES-CO-11

FOAMULAR® & FOAMULAR® NGX™ EXTRUDED POLYSTYRENE INSULATION IN PRECAST SANDWICH PANELS

Precast Concrete Panels

Precast concrete panels are an efficient assembly option to maximize performance and construction timelines. These panels are manufactured in a controlled environment facility prior to shipping to the job site for erection. Benefits of precast sandwich panels include:

- Protection of the panel during manufacture
- Quality-controlled components, including the concrete, reinforcement, insulation, attachments, and finishes
- Variety of finish and strength options
- Protection from fire exposure
- Faster installation
- Lower construction costs

Sandwich Panels

A subcategory of precast concrete panels is sandwich panels, which incorporate insulation between two wythes of concrete. These panels create an energy-efficient, unitized solution for designers to address thermal performance.

Protection from UV

Protection from fire

Fast install

Lower cost

This guide discusses select best practices in precast panel design and installation as well as performance requirement of the International Building Code (IBC) and recommendations of the Precast Concrete Institute (PCI) and Architectural (ACI).

(Image, lower left) Cite: *Universal Forest Products (UFP)*

XPS vs. EPS vs. Polyiso

Three types of foam plastic insulation may be used for precast panels: XPS, EPS, and Polyiso. Of the three, XPS has the highest water resistance and for two primary reasons. First, XPS insulation has a continuous closed-cell structure, unlike expanded polystyrene (EPS) that has open spaces between the individual beads that comprise EPS, or polyisocyanurate, which has larger irregular, interconnected cells. See Figures 1, 2, and 3. Second, the XPS molecule is hydrophobic, meaning that the polystyrene molecule is not attracted to the water molecule. These two characteristics cause FOAMULAR® & FOAMULAR® NGX™ XPS to reject water instead of absorbing it, making it ideal for resistance to moisture following manufacture of the panel. It should be noted that the hydrophobic nature of attachment accessories play a fundamental role in optimizing the flexural and compressive strength of XPS versus EPS, which will be discussed later. For more information regarding differences between XPS, EPS, and Polyisocyanurate, please see the following technical bulletins: **FOAMULAR® Science Doesn't Lie, XPS vs EPS Technical Bulletin**, **FOAMULAR® XPS vs EPS Technical Bulletin**

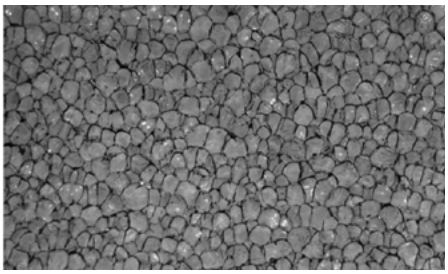


Figure 1:
Magnified section of XPS insulation showing no gaps between cellular structure.

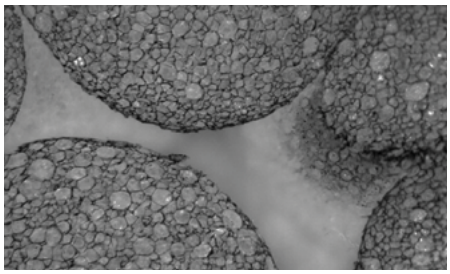


Figure 2:
Magnified section of EPS insulation showing gaps between cellular structure.

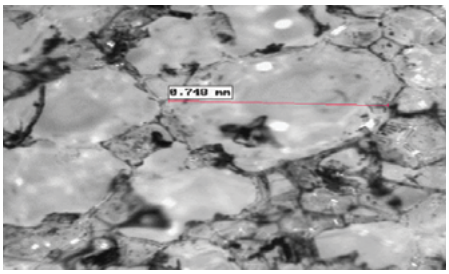


Figure 3:
Magnified section of Polyisocyanurate insulation showing irregular cellular structure.

XPS R-value & Thermal Performance

Extruded polystyrene insulation has a thermal resistance value (R-Value) of R-5 per inch thickness. By combining XPS into the concrete wythes, an overall U-Value of the wall is commonly modeled by manufacturers for code compliance.

XPS Dimensions

XPS Dimensions FOAMULAR® & FOAMULAR® NGX™ XPS are available in multiple configurations and compressive strengths suited to precast sandwich panels. Compressive strengths range from 15-100 PSI and thicknesses from 0.5" - 4". Consult your local Owens Corning representative for length options that might be available to meet design needs.

FOAMULAR® & FOAMULAR® NGX™ 250 XPS

Click here for data sheet

THICKNESS	Thermal Resistance,[1] R-Value, hr•ft²•°F/Btu (RSI, °C•m²/W)
1"	5
1.5"	7.5
2"	10
2.5"	12.5
3"	15
3.5"	17.5
4"	20

Highlighted thicknesses most commonly required and available for precast applications.

Note: Higher compressive strengths available if required. Please contact Owens Corning.

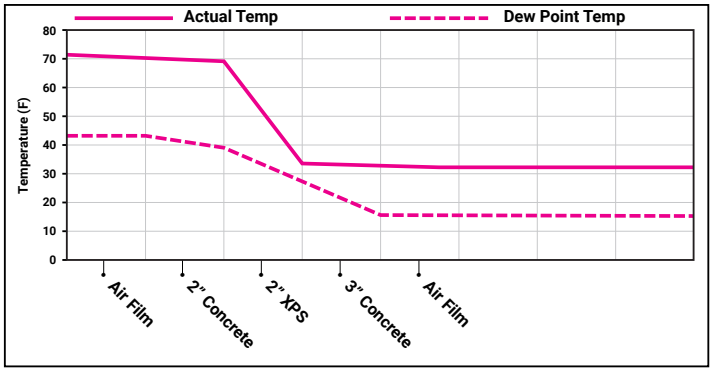
Additional dimensions may be available. Please contact Owens Corning.

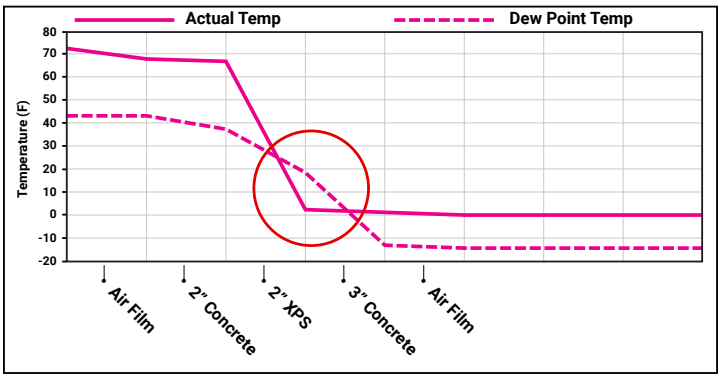
[1] R means the resistance to heat flow; the higher the value, the greater the insulation power. This insulation must be installed properly to get the marked R-value. Follow the manufacturer's instructions carefully. If a manufacturer's fact sheet is not provided with the material shipment, request this and review it carefully. R-values vary depending on many factors, including the mean temperature at which the test is conducted and the age of the sample at the time of testing. Because rigid foam plastic insulation products are not all aged in accordance with the same standards, it is useful to publish comparison R-value data. The R-value for FOAMULAR® & FOAMULAR® NGX™ XPS insulation is provided from testing at mean temperatures of: -4°C (25°F), 4.4°C (40°F), and 24°C (75°F) and aging techniques of 180-day real-time aged (as mandated by ASTM C578) and accelerated aging "Long-Term Thermal Resistance" (LTTR) per CAN/ULC S770-03. The R-value at 180-day real-time age and 75°F mean temperature is commonly used to compare products and is the value printed on the product.

Preventing Condensation

Adequately addressing thermal performance is key in preventing condensation on or in a precast wall. The most common type of brief analysis to validate adequate insulation is a dew point calculation that may be provided by the manufacturer or performed by the designer of record. In this analysis, exterior and interior temperatures are considered along with humidity levels, and the thermal performance of the different "layers" of the pre-cast wall are analyzed to ensure that a temperature at which the humidity — or gaseous content of water — would not trigger a phase change to a liquid — or condensation — within the wall or to the interior of the wall. This is indicated where a dew point line would intersect a temperature line in the example below.

If further analysis is required — such as quantifying moisture build-up over time, building envelope consultants may be engaged for additional analysis, such as WUFI and THERM.





The amount of insulation combined with environmental conditions such as temperature and humidity indicate potential for condensation to form in undesirable areas of the wall. The image on the right indicates condensation potential as the dew point line intersects with the ambient temperature line.

Structural

Composite vs. Non-Composite

Concrete wall panels can be categorized by structural configuration as either composite or non-composite. Composite walls require wythes of concrete to exhibit structural properties resisting loads and forces while non-composite walls are made up of a structural wythe attached to a non-structural wythe and may include a layer of insulation. See figures 4 & 5.

Figure 4

Figure 5

Attachment

It is recommended to contact the proposed precast manufacturer regarding attachment solutions and limitations. However, there are a variety of solutions available for both composite and non-composite applications.

Considerations when selecting attachments for joining panels on the site would include weather conditions, corrosion, thermal protection, air infiltration, water protection, and availability of tools and expertise for welding versus mechanical attachment, for example.

Installation

XPS insulation is embedded into the concrete wythes during the pouring and curing process. There are many attachment and reinforcement options to ensure transfer of loads securing the wythes and insulation to each other to achieve the required flexural and compressive strength. Size and spacing shall be determined by the manufacturer.

Best practices include casting XPS in interior facilities away from heat and UV exposure. The manufacturing, storage, and installation should be sequenced to protect the XPS from exposure to UV and moisture.

Fire

Documentation of many fire assembly types may be required for a particular project. While the licensed design professional should determine needs based on a project's individual details, precast concrete sandwich panels demonstrate successful testing or may be included in IBC exceptions in multiple assemblies, such as

- **NFPA 285: Standard Fire Test Method for Fire Evaluation of Fire Propagation Characteristics of Exterior Wall Assemblies Containing Combustible Components**
  The 2015 and later versions of the IBC provide an exception for foam plastic insulations protected on both sides with a minimum of 1 inch masonry or concrete and no air space. Therefore, this can provide an exception, exempting precast sandwich walls. See the **Owens Corning Enclosure Solutions NFPA 285 Design Guide** for more information.

- **ASTM E119: Standard Test Methods for Fire Tests of Building Construction Materials**
  Fire-rated wall assemblies may be required due to occupation type or lot configuration. These are available with precast concrete walls, typically through engineering judgment, and example assemblies may be identified on UL 263 listings at **UL Product IQ**.

- **NFPA 286: Standard Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Roof Fire Growth**
  If the panel is designed for interior exposure, foam plastic would be protected behind adequate concrete to help prevent the spread of fire in interior applications. If instead foam plastic insulation is installed in a furred wall to the interior of the precast wall, it must have a 15-minute thermal protective barrier that meets an exception, allowing exposure in attics and crawlspaces based on NFPA 286.

- **ASTM E2307: Perimeter Fire Containment**
  Where a floor/ceiling assembly intersects an exterior wall, sealing and protecting the joint prevents the spread of fire and smoke. The ASTM E2307 test exposes the joint to fire from the room of fire origin, and the exterior wall to fire from both interior and the exterior as the fire plume exits the room. When the floor/ceiling is required to be rated, this same period of time that the perimeter fire containment system will limit flame penetration through the opening between the exterior wall assembly and the floor assembly will be reported in the appropriate listing per ASTM E2307. See **UL Product IQ** for more information.

- **ASTM E1966 / UL 2079**
  ASTM E1966 / ANSI / UL 2079 test methods evaluate the ability of a fire resistive joint system to undergo movement without reducing the fire rating of the adjacent fire separating elements, and the duration for which test specimens will contain a fire and retain their integrity. Among the characteristics evaluated is the durability of the joint system through movement cycles, the ability of the joint system to prohibit the passage of flames and hot gases, and transmission of heat through the joint system. The test methods also include optional air leakage tests to determine the rate of air leakage through joint systems resulting from a specified air pressure difference applied across the surface of the joint systems.

Protection

Moisture

XPS should be protected from vapor pressure. In a precast wall, vapor from concrete is allowed to diffuse outward from wythes of concrete. Storing in standing water may force the polystyrene to absorb water when no relief of pressure is provided. Therefore, care should be taken to protect panels from water during manufacture, storage, and installation.

Once installed, sealant should be installed to protect the building from water intrusion.

Heat/Solar

Foam plastic insulation should be protected from both heat and UV exposure. Installation should be sequenced to be covered as soon as possible to limit exposure to mechanical damage and to solar heat that may result in distortion. FOAMULAR® & FOAMULAR® NGX™ XPS insulation have a maximum service temperature of 165°F. Taking simple precautions during construction can minimize the potential for heat-related damage. Install only as much FOAMULAR® & FOAMULAR® NGX™ XPS insulation as can be covered in the same day. For horizontal applications, turn print side down when possible so the black print does not show to the sun, which may at times act as a solar collector, raising the temperature of the foam under the print to an unacceptable level. Provide a final finish covering or temporary white opaque covering to avoid possible damage when dark (non-white) surfaces are used over FOAMULAR® & FOAMULAR® NGX™ insulation. Do not cover FOAMULAR® or FOAMULAR® NGX™ XPS insulation either stored (factory-wrapped or unwrapped), or partially installed, with dark-colored (non-white) or clear (non-opaque) coverings and leave it exposed to the sun. If improperly covered, and exposed to the right combination of sun, time, and temperature, FOAMULAR® & FOAMULAR® NGX™ insulation deformation damage may occur rapidly. See **Heat Buildup Due to Solar Exposure Technical Bulletin** for more information.

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