XPSA
EXTRUDED POLYSTYRENE FOAM ASSOCIATION

Technical INSIGHTS

Technical Insights: PMRA - 04

Guide to Specifying XPSA for Protected Membrane Roof Assemblies

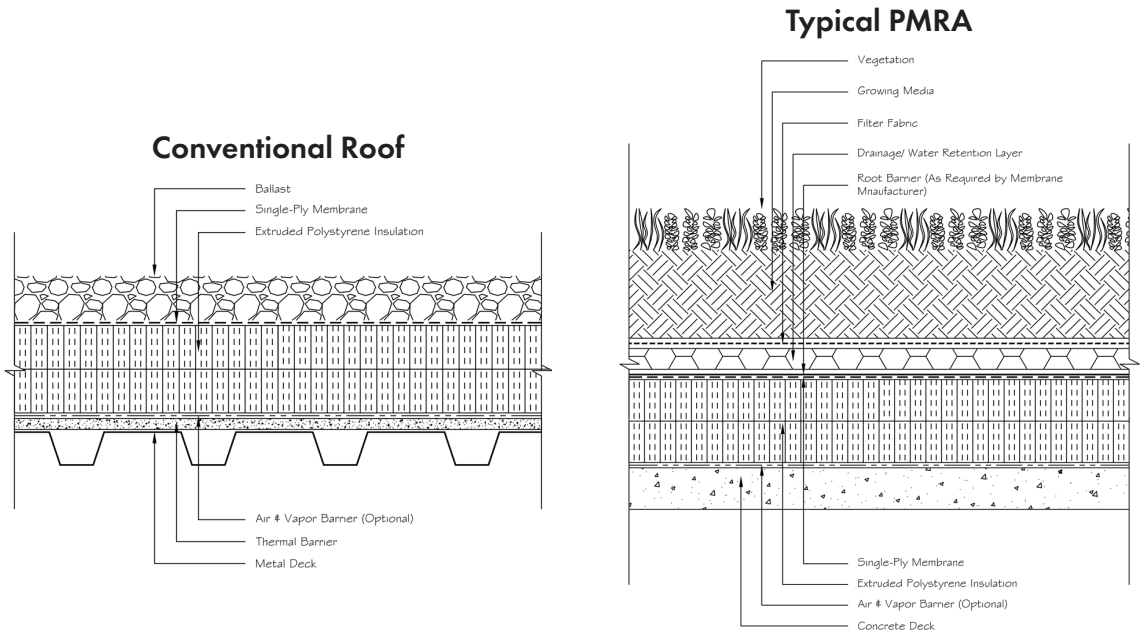

Figure 1 — A PMRA is sometimes referred to as a "upside down" roof assembly because XPS insulation boards are placed on top of the roofing membrane. Here a conventional single ply roof assembly on a metal deck (left) is compared with a PMRA (right) including vegetative roof layers. Line drawings courtesy of Owens Corning.

The choice of XPS "Type" for Protected Membrane Roof Assembly systems is dictated by the compressive strength that is required for the PMRA application to withstand the loads expected on the roof. These dead and live loads may include auxiliary equipment and vegetation as well as foot traffic and vehicular traffic.

XPS is classified by ASTM C578 [1] and CAN/ULC-S701.1 [2] into Types by compressive strength. PMRA system designers need to specify XPS Type(s) with compressive strengths high enough to withstand the expected loads.

The properties of XPS insulations can be varied by the manufacturing process. By varying the cell wall thicknesses between internal cells, the density and strength of the extruded polystyrene foam can be varied over quite a large range.

It is interesting that for many Types of extruded polystyrene insulation the moisture absorption and R-value per inch are not affected much by the ASTM Type. For example, Types IV, V, VI and VII all have the same R-Value per inch and the same low moisture absorption value.

Yet their densities and strength vary quite a lot.

As classified in ASTM C578 and measured by ASTM C303 [3], the minimum densities of XPS Types are as follows, in pcf (kg/m^3):

Type IV – 1.45 (23)
Type VI – 1.80 (29)
Type VII – 2.20 (35)
Type V – 3.00 (48)

As classified in ASTM C578 and measured by ASTM D1621 [4], the minimum compressive strengths of XPS Types are as follows, in psi (kPa):

Type IV – 25.0 (173)
Type VI – 40.0 (276)
Type VII – 60.0 (414)

Figure 2 — XPS insulation used in a PMRA for a building being constructed in Washington, DC. Heavy pavers are used to ballast the XPS insulation. Photo courtesy of Kingspan.

As a rule, higher density correlates with higher strength in XPS insulation board. Types VII and V are suitable for applications that may have high point loads, e.g., applications with raised pavers or PV arrays. Type V is capable of withstanding high loads such as may be experienced with vehicles parking on the building's rooftop.

XPS Types IV, VI, VII or V each would be suitable for a typical ballasted PMRA. More ballast or ballast securement may be required for high wind zones and hence also higher compressive strength. The International Building Code (IBC) requires ballast designs be in accordance with ANSI/SPRI RP-4 [5].

A roof assembly's fire classification is a very important factor. The discussion of roof assembly fire classification is beyond the scope of this article. Specifiers are referred to ASTM E108 [6] or UL790 [7] for more about fire classification.

There are many considerations in the design of PMRA: structural performance, wind uplift resistance, means of egress for occupiable roofs, and other factors. Fortunately, much knowledge and experience has accumulated in recent years and more and more contractors and building materials suppliers are knowledgeable of standards and best practices.

Published guidance has been developed about PMRA and is still evolving. The interested architect or designer is encouraged to contact one or more of the XPS manufacturers for recommendations on designing a PMRA that will provide maximum durability and performance.

Thermal Resistance and Structural Integrity

Specifiers of the components of PMRAs must balance form and function utilizing a high degree of knowledge of PMRA components.

1. Below the insulation, the roof covering must be correctly installed to the roof deck with a suitable drainage system which regulates the water retention.

2. The insulation itself must be thick enough to provide the desired amount of thermal resistance.

3. Above the insulation, the ballast holds down the XPS, which must be strong enough to withstand the weight of the ballast as well as variable loads such as rainfall and human or vehicular traffic.

XPS floats on water. If there are several inches of water on the roof because of a sudden downpour, then hydrostatics requires that the weight of the volume of displaced water be countered with at least that weight in ballast. Hydrostatics tells how much ballast is necessary to keep the XPS from floating.

However, buoyancy is not the only factor in determining the ballast requirement. Ballast is used to provide uplift resistance for roof assemblies that are not adhered or mechanically attached to the roof deck. The PMRA must meet standards relating to wind uplift resistance. The height of the parapet wall surrounding the PMRA has a striking effect on wind uplift. For a detailed discussion of ballast design requirements, see ANSI/SPRI RP-4 [5].

References

1. ASTM C578 – 19, Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation https://www.astm.org/Standards/C578.htm

2. CAN/ULC-S701.1:2017 Standard for Thermal Insulation, Polystyrene Boards. https://www.scc.ca/en/standardsdb/standards/28922

3. ASTM C303 - 21 Standard Test Method for Dimensions and Density of Preformed Block and Board–Type Thermal Insulation https://www.astm.org/Standards/C303.htm

4. ASTM D1621 - 16 Standard Test Method for Compressive Properties of Rigid Cellular Plastics https://www.astm.org/Standards/D1621

5. Ballast ANSI/SPRI RP-4 Wind Design Standard for Ballasted Single-Ply Roofing Systems. https://www.spri.org/wpfb-file/ansi_spri_rp-4-wind-design-standard-for-ballasted-sinlge-ply-roofing-systems_corrected-pdf/

6. ASTM E108: Standard Test Methods for Fire Tests of Roof Coverings https://www.astm.org/Standards/E108.htm

7. UL790 Standard for Standard Test Methods for Fire Tests of Roof Coverings https://standardscatalog.ul.com/ProductDetail.aspx?productId=UL790

Figure 3 — Examples of PMRAs. Photos courtesy of DuPont.