XPSA

EXTRUDED POLYSTYRENE FOAM ASSOCIATION

Technical INSIGHTS

Winter-Spring 2020 | Below Grade Series, Number 1

New Data Confirms Superior Performance of XPS versus EPS in Cold Regions, Below Grade Applications

Cold regions within Alaska and Canada as well as high elevation mountain regions have thousands of miles of roadways and airfields that are susceptible to frost heave and permafrost thaw. A real world, in-field study was conducted on the performance of below grade insulation which is invaluable when considering insulation for such applications. A new report by Billy Connor, P.E., for the Alaska University Transportation Center, University of Alaska Fairbanks (the Connor report) concludes XPS is far superior in below grade applications when compared to EPS.

Connor extracted 15 samples of polystyrene insulation from three different below grade locations in cold climate regions of Alaska. He merged these 15 data points with 25 data points from two earlier similar studies. A clear picture emerges of the relative stability of high R-value per inch XPS samples compared to the relative instability of the lower R-value per inch EPS samples.

HIGHER THICKNESS RATIO

The Final Project Report of the Connor study leads to the following conclusions:

- To deliver the same in-service R-value in cold regions, below grade applications, EPS needs to be 1.5 to 2 times thicker than XPS.
- The new results indicate that the previous studies underestimated the decrease in EPS thermal resistance over time.
- Small-scale laboratory comparative tests used to classify EPS and XPS products do not fully account for the actual long-term R-values realized in the field.
- Newer EPS products do not translate to improved R-value performance evaluated after field extraction and years of exposure below grade.
- Moisture absorption with EPS has a much greater negative impact on in-service R-value than moisture absorption and aging with XPS.

COMBINED DATA, MULTIPLE SITES

Insulation samples extracted from multiple sites allow performance to be examined across a wide range of conditions with a sample size sufficient to reveal longer-term trends. During these long periods of time in service, the polystyrene insulation samples were exposed to the effects of aging, moisture absorption and drying, and compressive forces. Combining data from all three studies, the EPS and XPS sample sizes are 19 and 21, respectively; and the oldest of these EPS and XPS samples were in service for 21 and 31 years, respectively.

The conclusions of R-value performance are shown in Figure 1.

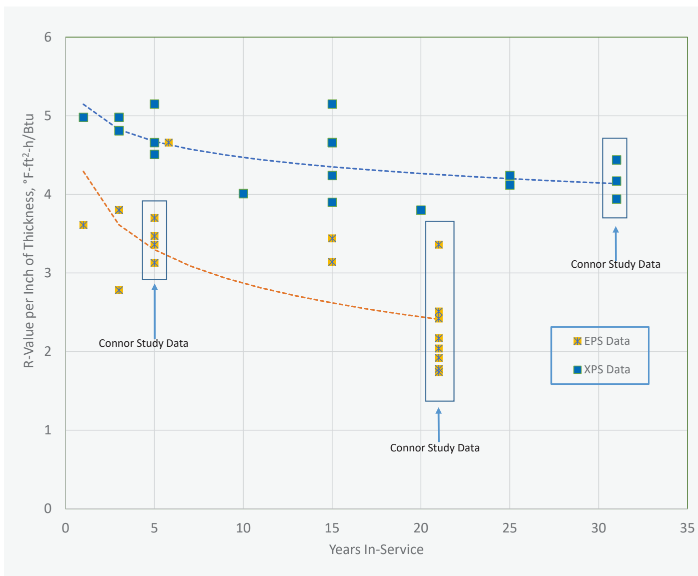

Figure 1 — Thermal resistance (R-value per inch in units of °F hr ft² / Btu) versus Years in Service. This graph plots the data points that were presented by Connor in tabular form.

XPS OUTPERFORMS EPS

The test results indicate a rapid drop in R-value per inch for EPS in the first five years in service (with in-service R-values ranging from 3.13 to 3.70 per inch). By comparison, the R-values per inch for XPS only gradually dropped after five years in service on previously measured XPS samples (with R-values per inch ranging from 4.51 to 5.15). Furthermore, the Connor study showed the R-values per inch for XPS decreased gradually, levelling out to an average value of about 4.1 after 31 years in service. By comparison, R-values per inch for EPS decreased rapidly, levelling out to an average value of about 2.2 after 21 years in service.

MOISTURE ABSORPTION

An important finding of the Connor study points to the drawbacks of using small-scale moisture absorption testing as a predictor of in-service performance. Besides measurements of R-value per inch, moisture absorption was measured on all of the samples. The Connor study sought to correlate "Water by Volume" data points with the R-value per inch data points. One EPS product claimed to have the same moisture absorption as XPS based on small-scale laboratory testing (as required by ASTM C578) yet the in-service performance was substantially different.

The improved EPS small-scale moisture absorption test results on average did not lessen the already rapid EPS R-value degradation due to moisture absorption in service.

THE LAST WORD ON RESILIENCE

Through scientific study and empirical evidence, the resilience of XPS has been reaffirmed in below-grade applications in cold regions. Nonetheless, a field study in one region of the country may not accurately predict the same performance in all regions of the country, considering the different climates and soil conditions. Fortunately, these three studies examined multiple climates with severe freeze/thaw cycling. The studies provide critical long-term data, whereas the small-scale testing methods used to classify polystyrene foam insulation are not indicative of long-term performance. Specifiers are responsible to ensure this research data is applicable to their climatic regions.

The Connor study suggests that small-scale tests used to classify products per material standards ASTM C578 or CAN/ULC S701.1 do not account for the actual reductions in thermal performance of both EPS and XPS in below-grade applications in cold regions. Moisture absorption with EPS has a much greater negative impact on R-value in-service than moisture absorption and aging with XPS. In these harsh below-grade applications, the research indicates that after moisture absorption very little drying of EPS and XPS occurs in-service.

As the most recent of three such studies, the Connor study confirms the higher thermal resistance of XPS compared to EPS, which is attributed to the lower moisture absorption of XPS compared to EPS; furthermore, the Connor study recommends applying an EPS-to-XPS thickness ratio of 1.5 to 2.0 to account for this in-service difference in R-value.

"[...] a clear trend indicates that R-value decreases over time. EPS decreases more rapidly than XPS and appears to be asymptotic to a value of 2.2 at about 30 years. XPS becomes asymptotic to a value of about 4.1 after 30 years. [...] the ratio of the thickness of EPS to XPS would be 1.86 [...]."

— Billy Connor, P.E., author of the Connor study.

REFERENCES

1. Billy Connor, April 2019. "Comparison of Polystyrene Expanded and Extruded Foam Insulation in Roadway and Airport Embankments". Alaska University Transportation Center, University of Alaska Fairbanks, (INE/AUTC 19.08). http://autc.uaf.edu/projects/2019/comparison-of-polystyrene-expanded-and-extruded-foam-insulation-in-roadway-and-airport-embankments/

2. Rob Brooks, Barbara Fabian, Jeremy Smith, Guy Titley and John Woestman, "Extruded Polystyrene Delivers Higher R-Values than Expanded Polystyrene in Below-Grade Applications," XPS Insulation Performance, Below Grade Series ID: IP-BG-01 (2019). http://xpsa.com/pdf/XPSA-IP-BG-01