Legacy Case Study from Dow Building Solutions

Styrofoam™ Brand Insulation: Shrinkage Case Studies

Introduction

Does foam shrink? This is a question that is occasionally asked, generally when exposed aged foam and gaps between foam boards are discovered during remodeling projects. Lstiburek (2012) and Holladay (2010) describe examples where gaps have been discovered and potential performance differences between various types of rigid board foam exist. Although there are cases where the history of the foam and installation are well known and documented, it is more often the case that the discovery is made by a different person than the original installer and the timing and climate conditions are unknown. Thus, it is a challenge to know with certainty if the foam was originally installed with gaps or if the gaps occurred over time.

Three case studies are described in this report where initial conditions of installation are generally well known. The first case is an examination of test wall assemblies after 5 years of test exposure in a climate research laboratory. The second case is an instrumented multi-story building in the Pacific Northwest where foam movement was monitored over several years. Finally, the third case study is an examination of a 10 year old single-family residential home in Climate Zone 5.

CASE STUDY 1:

Analysis of Styrofoam™ Brand Insulation Joint Dimensional Stability

5 Year In-Use Study

Midland, Michigan Wall Assembly Research Lab

Wood framed wall assemblies sheathed with a 1" layer **Styrofoam™ Brand Insulation** are included as experimental, long term wall exposure samples installed on the Wall Assembly Research Building located in Midland, Michigan. Four wall assemblies, installed on each cardinal direction were available for inspection during late 2015. The wall specimens were constructed in a lab environment in late 2010 and installed shortly after into the research building.

The wall cladding consists of manufactured stone installed on the lower half of the wall sample and vinyl siding on the upper half. Several board joints were included in each sample in order to measure the performance of the taped joints used as a weather resistive barrier (WRB). The vinyl siding was removed for the inspection of board gaps and the condition of the construction tape used to seal the joints creating the WRB. Normally, when gaps are found, even small gaps such as those observed in these wall samples, foam shrinkage is claimed as the root cause. Fortunately, rigorous photo documentation of starting and ending conditions facilitated comparison of before and after photos. Before and after exposure photos of all four wall sections are below.

Careful inspection of the before and after assembly photos shows similar spacing. It is clear from these photos that no opening of board joints has occurred during this test exposure period. The construction tape was still strongly adhered to the foam boards with no evidence of loss of adhesion performance through this five year period

North Wall Assembly 3C

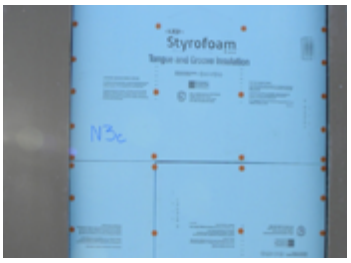

Photo 1a
Initial N Wall Assembly December 2010

Photo 1b,
Aged N Wall Assembly Sept 2015

East Wall Assembly

Photo 2a
Initial E Wall Assembly December 2010

Photo 2b
Aged E Wall Assembly Sept 2015

South Wall Assembly

Photo 3a
Initial S Wall Assembly December 2010

Photo 3b,
Aged S Wall Assembly Sept 2010

West Wall Assembly

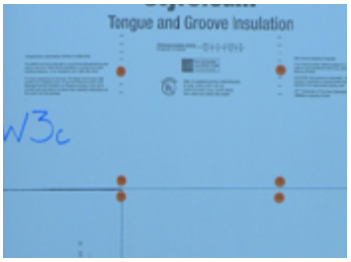

Photo 4a
Initial W Wall Assembly December 2010

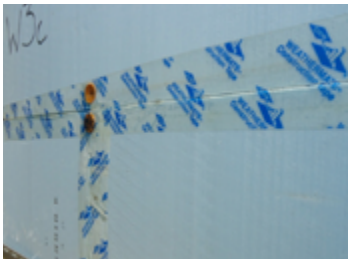

Photo 4b
Aged W Wall Assembly Sept 2015

CASE STUDY 2:

Vancouver Housing Complex
Vancouver, Canada

During a multi-story cladding rehabilitation project in Vancouver, British Columbia, there was an opportunity to install instrumentation to monitor movement within the retrofit wall system. The building is a 64-unit social housing complex in a seven story reinforced concrete structure, with steel stud infill walls and commercial space on the first floor. The original envelope assemblies included cement stucco on steel-stud-infill walls, exposed mass concrete, brick at the first floor front elevation, and built-up roof systems on main and terrace-level roofs.

The new wall assembly includes three inches of **Styrofoam™ Brand insulation** with a nominal R-value of R15. The rain screen cavity is achieved by fastening the paperback lath on the outside face of the metal Z girt over which a three coat stucco is traditionally applied.

Photo 5a
North Elevation After Repairs

Photo 5b
Galvalume Z-girts on 3" rigid XPS

Building Measurements

Building position measurements were taken on the south and north façades of the building, with sensors located on the second, fourth and sixth floors. Locations of measurement panels are indicated by the red squares in Figure 1 for the south location. North instruments were similarly located directly across the building.

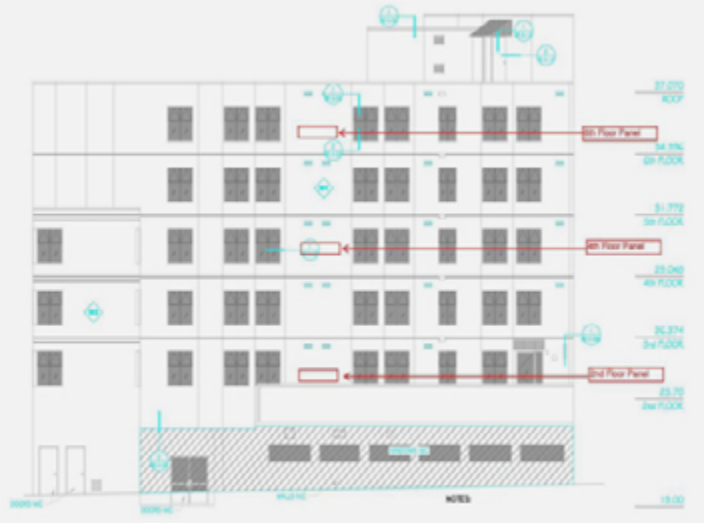

Figure 1. Measurement Panel Locations (S)

Analysis of X Direction Displacement

An example of board length movement relative to the building structure reference bracket is shown in Figure 2. Displacement is measured in millimeters. An increasing value for displacement indicates an increase in distance between the sensor and the reference bracket and indicates shrinkage of the board length. Since the X-direction sensors are oriented on opposite ends of the insulation board, both sensor values simultaneously increasing would indicate opposite board ends becoming closer together and the foam insulation board shrinking. These conditions are not observed in the monitored data at any of the six building locations and the maximum movement range is approximately 0.5 mm.

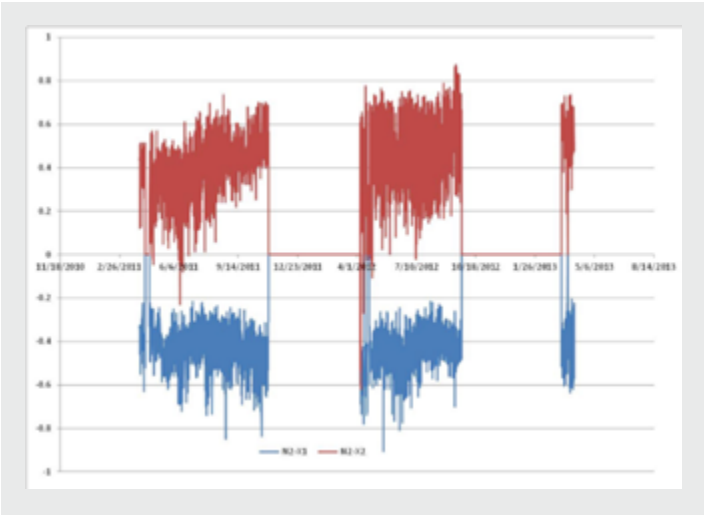

Figure 2. Length move of North elevation 2nd floor foam board

The sensors were installed along foam board joints to monitor foam displacement relative to the structural steel of the building via an external bracket directly attached to the interior steel studs. Sensor locations on an insulation board are shown in Figure 3. This attachment facilitated foam movement relative to the steel structure to be measured. To monitor shrinkage, each panel included two side sensors (X axis). Position data was collected every two hours and transmitted via wireless data acquisition units to the network analysis software.

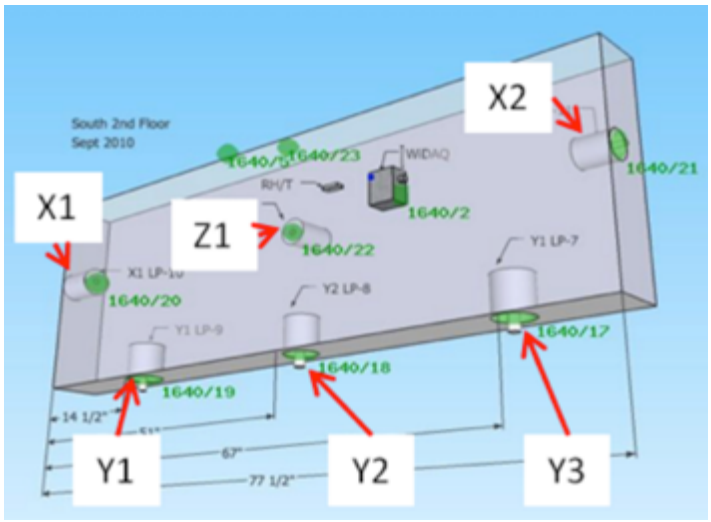

Figure 3, Sensor locations on foam board

CASE STUDY 3:

Single-Family Residential Home
Midland, Michigan

Inspection of foam condition was conducted in early summer 2016 of a single-family residential dwelling located in Midland, Michigan prior to the addition of a room. The house was constructed during the summer of 2006 by Midland County Habitat for Humanity. The 1" foam layer was applied direct to studs using cap nails with construction tape on seams as the WRB. Although initial construction photos and measurements are not available, it is possible to measure current dimension in the width direction on three of the boards where the factory edges were still intact.

Photo 6a
wall prior to vinyl removal

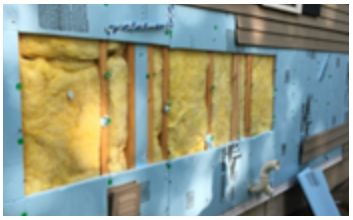

Photo 6b
cavity inspection after vinyl removal

Photo 7
condition of taped seam

Photos 8 a, b, c show the width dimension of the three exposed boards with intact factory edges. Each measured board is slightly over 48", which indicates that although slight gaps are present that the boards remain at the manufacturing design dimension, in fact slightly wider. The cap nail does not show signs of pull through or sliding in the foam that could also indicate board movement. Again this is an indication that boards have not shrunk in the width dimension. It can be concluded from the combination of tape condition, lack of fastener drag and current board dimension that board gaps resulted from installation.



Photo 8a, b, c; width dimension measurement of three boards with intact factory edges

Since no wood sheathing was used in construction of the wall system, it was possible to inspect cavity conditions for signs of deterioration and water intrusion. Photo 9a is of the back of one removed piece of **Styrofoam™ Brand Insulation** and is found in clean condition with no signs of water anywhere on the board, including around fasteners and board edges. Photos 9b and 9c show the conditions within the cavity including the bottom plate and subfloor below the bathtub located at the interior of the inspected cavity. Again, there are no signs of moisture or deterioration in either location.



Photo 9a, back side of foam

9b, bottom plate

9c, subfloor beyond cavity

Summary

While it is typically assumed the cause of gaps is believed to be shrinkage of the foam, these three case studies indicate that shrinkage is not necessarily the cause of gaps.

On another positive note, the long term exposure indicates that tape performance is sound after multiple years of building use and continues to perform well as a WRB.

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Styrofoam™ Brand Extruded Polystyrene Foam Insulation

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