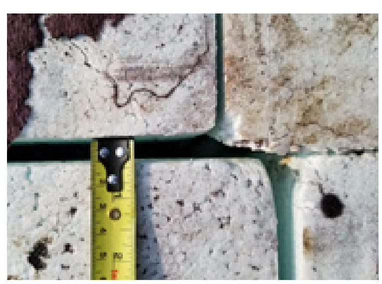
INSULATION

WRINKLED ROOF MEMBRANES: MATERIAL DIMENSIONAL STABILITY

SUMMARY OF THE PAPER BY JUN TATARA AND LORNE RICKETTS OF RDH BUILDING SCIENCE INC., PRESENTED AT THE 15TH CANADIAN CONFERENCE ON BUILDING SCIENCE AND TECHNOLOGY IN VANCOUVER (NOVEMBER 2017) AND AT THE RCI 2018 INTERNATIONAL CONVENTION IN HOUSTON (MARCH 2018).

Field observations have recently noted problems with wrinkling of 2-ply styrene-butadiene-styrene (SBS) modified bituminous roof membranes. Wrinkling of roof membranes can be indicative of undue stress on the membrane and may lead to premature failures such as opening of laps, abrasion of the raised surface, and ponding of water.

Initial investigations of these issues found that wrinkling frequently correlates with the presence of expanded polystyrene insulation within the roof assembly, and when exploratory openings are made, gaps between insulation boards and between insulation boards and parapets are common. To investigate this issue further, a laboratory based research study was undertaken.

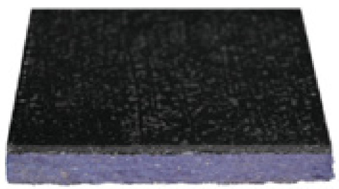


This research was completed in partnership with RDH Building Science Inc.

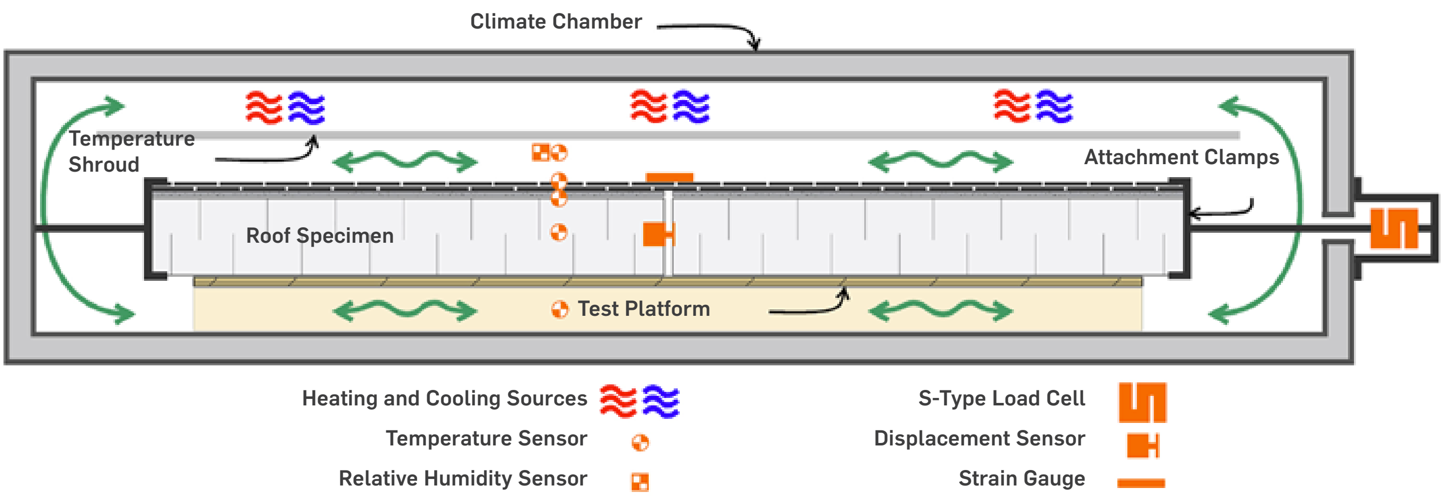
METHODOLOGY

Based on the initial theory that dimensional stability of materials in the roof system may be a potential cause of the observed wrinkling, this initial phase of testing focused on whether it is possible to reproduce wrinkles in a laboratory test that are similar to those observed in the field. To do this, a range of 4' x 8' (1.2 m x 2.4 m) roof assembly test specimens were constructed with varying components so that the impact of each could be assessed. These included:

- Membrane reinforcement (polyester and composite)
- Cover boards (slip sheet (no board), asphaltic, and fiberboard)
- Insulation type (mineral wool (MW), expanded polystyrene (EPS), and polyisocyanurate (ISO)), and
- Attachment methods (mechanically fastened, ribbon adhered, and mopped)



These roof specimens were placed into a climate chamber which was used to uniformly expose them to hot temperatures up to approximately 90°C (194°F) and cold temperatures down to approximately -15°C (5°F). These temperatures were intentionally selected as extreme so as to simulate a worst-case scenario and accelerate the potential impacts of experimental exposure, thus verifying initial feasibility of the methodology to replicate wrinkles from this mechanism and rule out parameters which do not cause wrinkling under these conditions.



FINDINGS

Testing of the various combinations of roof assembly components found that wrinkles were only created during the laboratory testing when EPS insulation was included in the roof specimen (page 3, top right). It was also noted that while all of the specimens experienced some change in the size of the gap between insulation boards during testing, the roof specimens with EPS experienced significantly larger changes in gap size, in particular at high temperatures, and that these changes were permanent with the EPS not returning to its original condition upon completion of the testing when returned to room temperature (page 3, bottom).

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FINDINGS (continued)

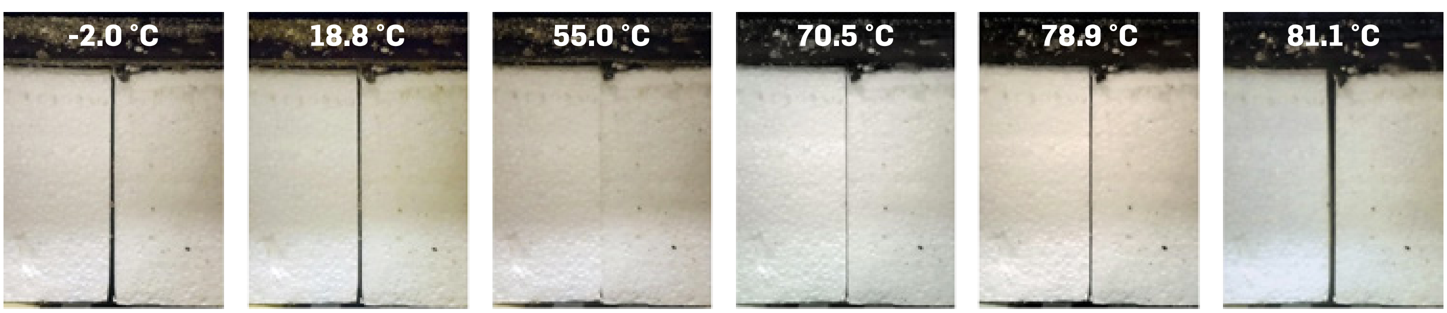
More rigid coverboards (fiberboard) were shown to be a successful method in reducing roof membrane wrinkling; however, insulation was still observed to move beneath the coverboard which can potentially lead to convective looping within the insulation layer and also create thermal bridges. While both mechanically fastened and ribbon adhered systems were observed to potentially wrinkle when used with EPS insulation, the ribbon adhered method appeared to provide a more direct bond between the insulation and the cover board, leading to wrinkles even when an asphalt coverboard is used, whereas the mechanically attached system did not wrinkle with this coverboard. The type of reinforcing scrim used in the SBS membrane had no apparent impact on the performance of the test specimens with respect to wrinkling.

EPS Roof Specimen after Heating

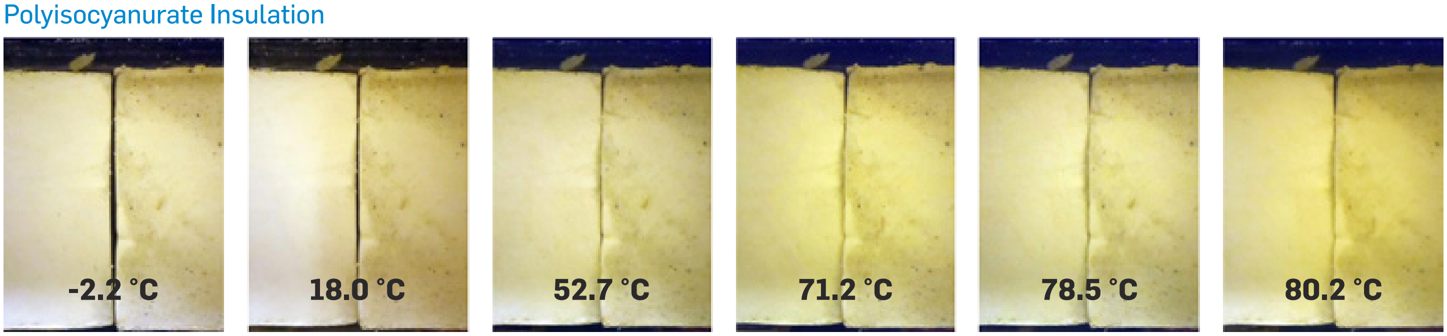
Mineral Wool Roof Specimen after Heating

It is important to note that this initial testing used intentionally extreme conditions on small scale laboratory specimens to determine the feasibility of materials within the roof assembly creating wrinkles in the membrane. Furthermore, exposure to uniform temperature is not a realistic representation of in-service conditions. The next phase of testing worked to address this. For the second phase of testing the climate chamber was modified to circulate room temperature air (approximately 21°C [70°F]) beneath the specimen and insulation was used to seal around the edges of the specimen. This allowed for the creation of a temperature gradient across the roof specimens, which is more consistent with in-situ conditions for roofs that typically separate interior and exterior environments. This testing environment was used to assess the impact of using a hybrid insulation solution (i.e. one type of insulation over top of another type) as a way of buffering the impact of extreme temperatures on potentially temperature sensitive insulation products.

EPS Insulation



Polyisocyanurate Insulation



Photographs of the gap between insulation boards during exposure to uniform heating and cooling of the roof specimens.

WORKING TOWARDS A SOLUTION

When tested using a temperature gradient across the specimens, none of the roof specimens (including those with EPS) experienced wrinkling in one cycle of testing. However, the specimen which was all EPS did demonstrate a ratcheting effect when heated multiple times. That is, each time it was heated, the gap between insulation boards increased, potentially indicating an effect due to duration or frequency of exposure.

Prior to this research, Soprema identified a need to address the issue of wrinkling membranes, and based on the limited information available at the time issued Technical Bulletin 0714CE which requires that expanded and extruded polystyrene insulation be covered with 50 mm (2 in) of MW or ISO insulation. To test the effectiveness of this technique, testing was also performed on hybrid insulation assemblies with 50 mm (2 in) of MW or ISO insulation on top of 50 mm (2 in) of EPS. This testing found that protecting the temperature sensitive insulation from extreme temperatures reduced the movement, and also prevented wrinkling in the laboratory condition.


Before Heating


After Heating

CONCLUSIONS

Key conclusions that can be drawn from the research work completed so far include the following:

- At high temperatures above ≈80°C (176°F), EPS insulation experiences significant permanent shrinkage and it is possible for the force of this shrinkage to wrinkle 2-ply SBS modified roof membranes.
- While rigid coverboards and mechanically fastening the roof assembly may help to limit membrane wrinkling, movement of the insulation can occur beneath the membrane potentially creating gaps between insulation boards.
- The use of more thermally dimensionally stable insulation products to protect temperature sensitive products from extreme temperatures proved to be an effective method for reducing the potential for wrinkling, while still accommodating various insulation types within the assembly which may be desirable for various reasons including cost.
- Wrinkling of the roof specimens did not occur when exposed to a temperature gradient rather than uniform heating; however, a ratcheting effect was noted when using EPS, with gap size increasing with each heating cycle.

While research to date has demonstrated a potential link between the dimensional stability of roof components and the observed wrinkling of SBS roof membranes, recent field investigations have pointed toward additional potentially contributing or causal factors such as quality of the installation, method of insulation and membrane securement, and climate. Further testing and field measurements are underway to continue to investigate the cause of the observed wrinkling in the field.

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If you have any questions about this research, please contact your SOPREMA representative.

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