Building Envelope FORUM

THE ANATOMY OF AN ICE DAM

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Introduction

An ice dam at the edge of a sloped roof is a common occurrence in Canadian buildings. Leakage of water through sloped roofs, when ice dams occur, is an old problem but the corrective measures frequently recommended never seem to quite correct the problem. The corrective measures include eave protection under the shingles for about three feet up slope under roof shingles. The eave protection may be constructed with building paper, elastomeric membranes and even sheet metal. Other corrective measures include better soffit ventilation, more ventilators such as goosenecks, ridge vents, gable vents, and turbine vents. Sometimes, as a last resort, electrical de-icing cables may be installed but most frequently the roof is shoveled clear of snow and ice. Even with all of the above remedial measures, the ceiling leaks reappear at times in winter to the dismay and frustration of the owners and builders alike.

Case Study

In a recent investigation of an ice dam problem at a 48 unit Coop Housing Project, the Coop owners, of the three-storey wood framed buildings, had applied various corrective measures to the roofs over a period of about 15 years at mounting costs but without success. Some years, milder than usual, the ice dam problem appeared to be solved. Then during the next winter when a prolonged cold spell occurred followed by a mild day, the ceiling leak problems reoccurred in well over 50% of the units.

The roofs of the Coop Housing buildings comprised a wood scissors truss with a modest slope, plywood sheathing, sheet metal eave protection, 2 metres up slope under asphalt shingles. Each roof was vented at the soffits, had several goose neck vents, a ridge vent, and a turbine vent. The typical attic was insulated with R32 insulation, had a polyethylene vapour retarder and a gypsum board interior finish. The houses were electrically heated.

Field Observation

One winter day, following a few days of warmer temperature, water was reported dripping under a ceiling bulkhead in several Coop units. Several days later when the temperature dropped back into the deep freeze, the investigator entered the attic of one Unit late one evening. He crawled over the insulation between the trusses to examine the underside of the roof sheathing. The following observations were noted.

Starting at the top of the attic, it was noted that the turbine vent was clear and free of obstructions. At first the underside plywood appeared clean and dry but then as the investigator crawled lower into the truss cavity, towards the outside wall, a band of frost was noted under the plywood sheathing, about 1.5 meters wide. Further down into the attic cavity below the frost, the plywood sheathing was found wetted for about another 1.5 meters. Further down again, the plywood sheathing was found clean and dry at the truss connection to the outside wall. While probing with his hand, the investigator noted warm air rising at the exterior wall over the underside of the roof sheathing. The most startling observation was the discovery of inverted icicles and ice patties on the surface of the roof insulation. These were found mostly below the frosted area almost directly under the nails of the roof singles (see Figure).

Analysis

The anatomy of this type of water leak appears to be as follows. During cold nights, at or below -20^{o}C, when stack effect is strong due to a large temperature difference, air exfiltrates into the attic through all the cracks and holes of the outside wall cavity to leak into the attic. The warm exfiltration air rises to wash over the plywood sheathing to melt some of the snow on the roof surface while losing some of its heat (1). Then, as the exfiltration air drift up toward the vent, it is further cooled by the plywood sheathing and now deposits condensation for about 1.5 meters up slope (2). Drifting

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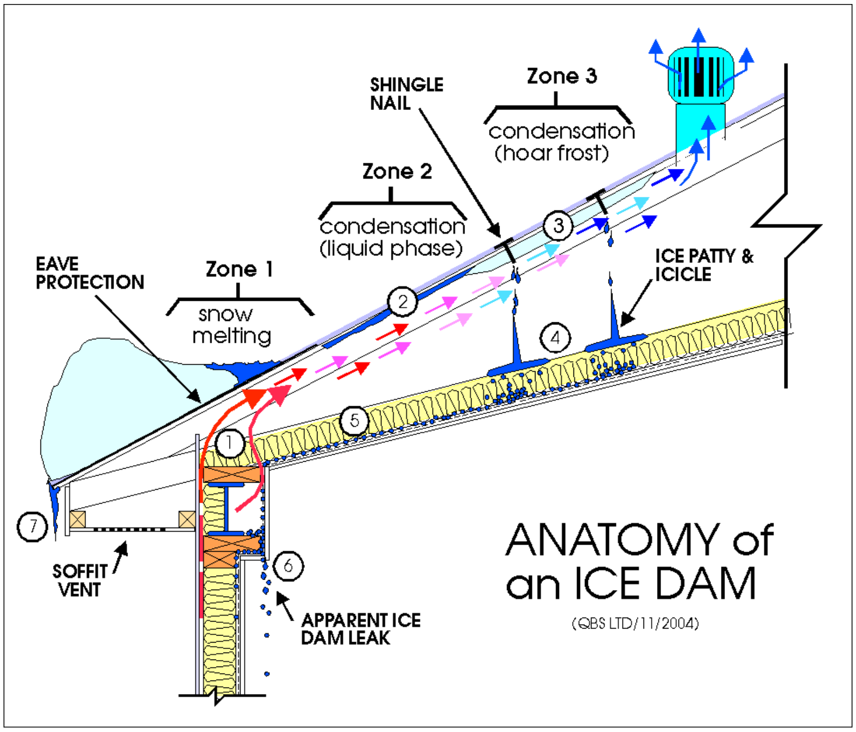
Anatomy of an Ice Dam, continued from page 1



further up slope of the sheathing, the exfiltration air now deposits its remaining moisture as frost for about another 1.5 meters. Beyond this point, the air exfiltrates through the turbine vent completely dehydrated and dry (3).

The next part of the cycle takes place in the daytime when the outside temperature rises slightly but not above freeing. On clear, cold sunny days, the sun warms the black exposed shingles and plywood on the up slope portion of the roof where there is little snow. This causes the underside frost to melt and to drain downward to a roof nail and then to drip down over the insulation below. Because the surface temperature of the insulation is still well below freezing, the dripping water splashes into a patty of ice with an inverted icicle forming above (4). There were well over 20 such patties of ice observed on the surface of the insulation that night.

The last part of the cycle takes place when the outdoor temperature rises well above freezing. Generally, the attic temperature also rises above freezing and the ice patties begin to melt. The melt water then drains into the fibre insulation and onto the polyethylene sheet below.

In turn this water flows downward and into the ceiling bulkhead to penetrate to the inside of the building through polyethylene lap joints, tears and fastener holes and then through the gypsum board joints. This leakage typically continues for 2 to 3 days.

Lastly, because these buildings had sheet metal eave protection for about 2 metres up slope, the melting snow of the ice dam drained over the edge of the roof to form the icicles indicated in the diagram. It is important to note that the ice dam water did not penetrate to the inside in these buildings.

Conclusions

From the above observations, the ice dam water leaks were finally demystified. The actual cause of the roof/ceiling water leaks was not the external moisture of snow and ice but rather the accumulation condensation in the attic from the exfiltration of indoor air and the subsequent melting of frost and leakage of water to the inside.

The ice dam problem is first and foremost an air exfiltration problem. This is the cause of most ice dam water leak problems. Unless our industry undertakes to research and apply better ways of correcting air leakage into attics, the ice dam water leak problems will continue to occur haphazardly while the most frequently recommended remedial measures, except eave protection, will continue to be costly ineffective wasted efforts.

In a future article, we will present the remedial repair undertaken to correct the ice dam problem at this Coop Housing Project.