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September 3, 2009

Ric Boyd, Public Works Director
Ketchikan Gateway Borough
344 Front St.
Ketchikan, AK 99901

RE: Ketchikan Gateway Borough – Mike Smithers Pool
Roof Observations and Intrusive Inspections

Dear Ric,

Trinity | ERD received a commission from Ketchikan Gateway Borough to carry out an inspection and an infrared scan of the composition shingle roof at the Mike Smithers Community Pool ('the Pool') located in Ketchikan, AK. Trinity | ERD was informed that the Pool was re-roofed in 1999. At the time of the re-roof, an addition to the pool structure was constructed at the northeast elevation of the building.

The current roof, deck and waterproofing assembly consists of the following components:

- Log beam framing;
- 8" x16" wood purlins;
- A composite panel consisting of 3/8" plywood at the base, 5/8" plywood at the top and foam polyurethane insulation core;
- 5/8" OSB sheathing nailed to the top surface at the composite panel;
- One layer of ASTM D226 Type I (15#) roofing felt; and,
- Architectural composition roofing nailed to the OSB sheathing.

Maintenance personnel reported that repairs to the roof have been made continually over the past two years. These include some 'deck' repairs where extruded polystyrene has been used to replace the original polyurethane foam within the composite panel. The repairs have been conducted with component by component replacement. Newly installed repair materials do not form a composite, resulting in reduced structural loading capabilities. Shingles have been blowing off in high winds. In addition, birds have removed shingles, as well as wet and decayed pieces of the OSB sheathing. It is hypothesized that these materials are taken by birds and used as nesting materials. The bird issues are reported to be most significant in the spring months.

Roof Investigation

On August 5, 2009, Trinity | ERD traveled to the site to carry out a visual and intrusive investigation of the interior and exterior of the roof to identify physical damage and sources of moisture. In addition, Trinity | ERD conducted an infrared scan to evaluate the extent of water in the assembly. At the time of the inspection, it had not rained in Ketchikan for approximately three weeks.

Moisture readings taken within the OSB sheathing and plywood surface of the composite panels were taken with a TRAMEX MRH moisture meter. Twenty-four readings were taken on the North and South planes of the roof. Readings were taken in the top surface of the OSB sheathing and the top surface of the plywood panel. The moisture readings are marked on the roof plan below, along with the locations of test cuts in the roof. In summary, the OSB and composite panels are consistently wet throughout the roof area.

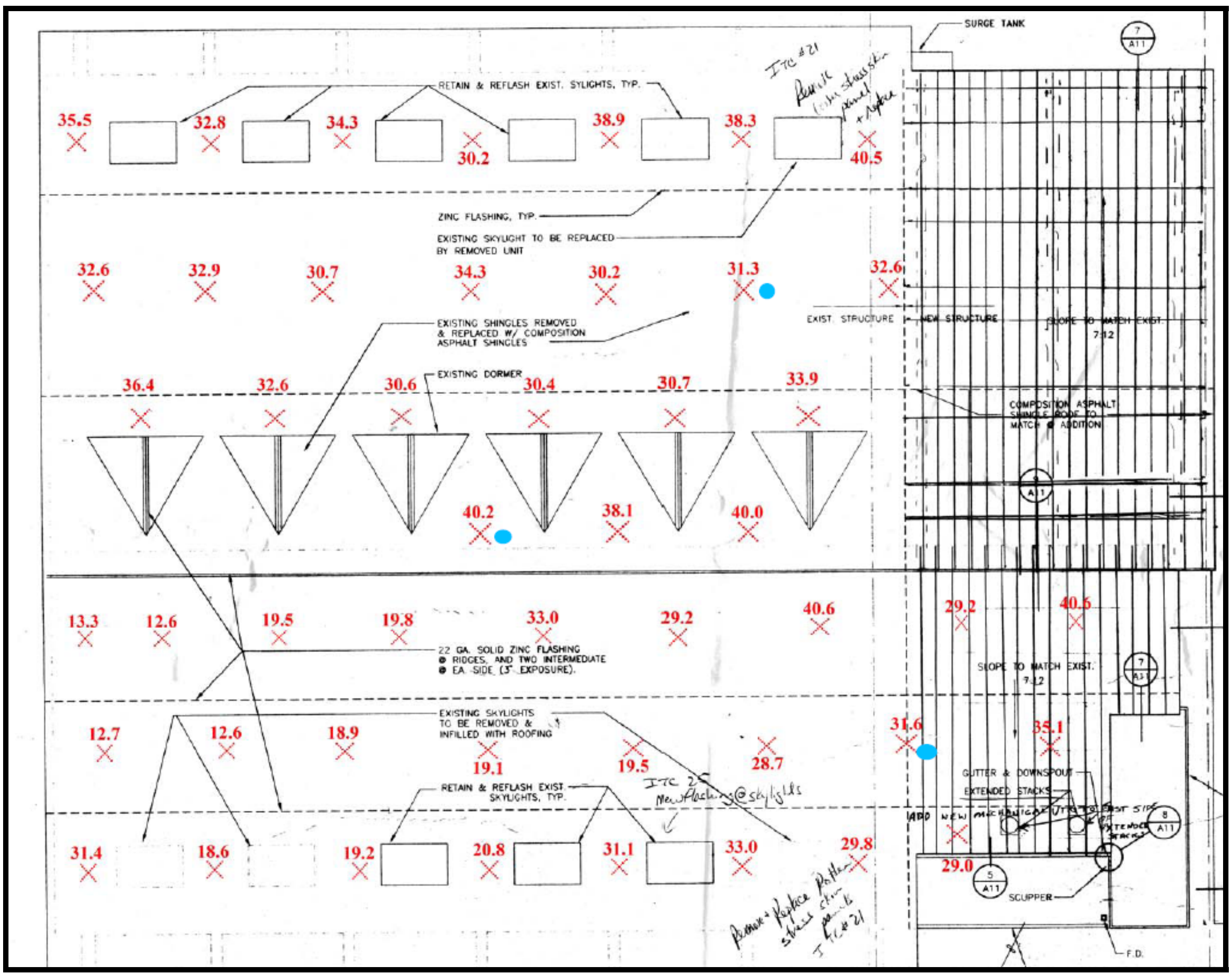

Figure 1 – Roof Map Showing Moisture Meter Readings (Red X's) and Roof Cut Locations (Blue Dots)

Inspection of the North face of the roof revealed OSB sheathing that is decayed, soft and swollen. Foot traffic completely breaks up the OSB surface. The structural integrity of the OSB sheathing has been compromised by water and can no longer hold the shingle nails. Shingles pull away and slide under light pressure. The roof assembly and substrate have failed. The bond of the composite material has also failed in many areas observed, impacting the structural loading capabilities of the decking assembly.

The OSB sheathing is swelling and lifting the shingles, creating a gap between overlaying shingles. These gaps allow wind and wind driven rain to get under the shingles. The water then passes through the underlayment by way of the nail holes and seepage through the saturated underlayment. In some cases, total saturation of the underlayment was observed as a result of constant exposure to water. There are also limited areas of moss and mushroom growth between shingles. Additional organic growth was observed between the shingles and roofing felt and between the roofing felt and OSB sheathing.

Two areas of exposed, decayed plywood on the composite panels were observed during the inspection. In these areas, the shingles have either blown off, or been pulled off, and the OSB and plywood sheathing has completely decayed, exposing the insulation. Maintenance personnel conveyed that all that can be done to temporarily repair these areas is to cover the exposed area in roofing mastic and stick shingles in place. This type of repair provides minimal protection and can be a danger for any foot traffic.

Conditions are similar on the South face of the roof. The East half is particularly wet. Shingles removed in this area revealed severely decayed, soft, and swollen OSB sheathing. Again, areas of sheathing gave way under foot traffic.

Three intrusive cuts were made in the roof assembly, at the locations identified on the roof plan above. Only one sample was retained from these cuts; at the other two locations, the materials removed simply crumbled during removal and were no longer suited for further analysis due to their advanced state of deterioration.

In the interior of the building, there is evidence of moisture running down the plywood walls on the interior side of the vent dormers. Significant water staining was observed at these locations. It was noted that the mechanical unit draws air from the interior and exhausts the air to the exterior through these vents.

Also noted in the interior were significant cracks in the log beam framing of the roof. In addition, there is severe blistering of the interior paint at the transition between the original building and the addition. Leaks are evident at dormers as a result of water running under the underlayment by passing the flashings at the roof-to-wall transitions.

Photo- 1 Overview of the North Roof

Photo- 2 Overview of the South Roof

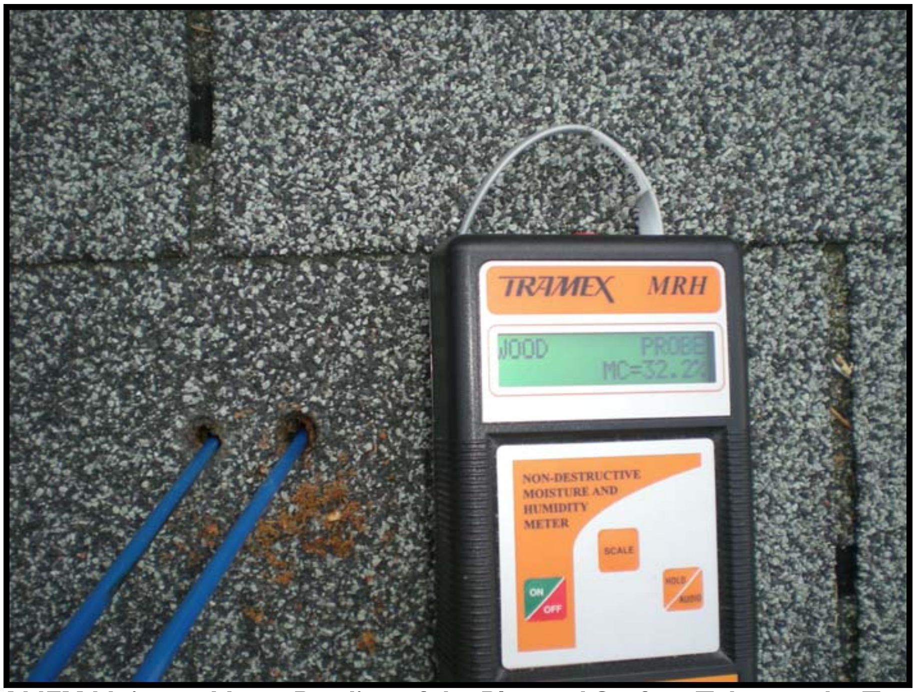

Photo- 3 TRAMEX Moisture Meter Reading of the Plywood Surface Taken at the Top Sufrace of a Composite Panel - 32.2%

Photo- 4 Example of Area of Exposed OSB Sheathing

Photo- 5 Example of Missing and Damaged Shingles

Photo- 6 Example of Bird Damage Resulting in Exposed OSB and Plywood

Photo- 7 Example of Moss and Mushroom Growth

Photo- 8 Shingles Lifted Revealing Wet Roofing Felt

Photo- 9 Shingles Lifted to Expose Wet and Decayed OSB Sheathing

Photo- 10 Decayed and Flaking OSB Sheathing

Photo- 11 Roof Deflection as a Result of Decayed and Deformed OSB Sheathing

Photo- 12 Roof Deflection as a Result of Decayed and Deformed OSB Sheathing

Photo- 13 Organic Growth Between Shingles and Roofing Felt

Photo- 14 Organic Growth Between Roofing Felt and OSB Sheathing

Photo- 15 Intrusive Opening in Composite Panel Revealing Wet Plywood and Extruded Polystyrene Insulation – This Area is Assumed to be a Repair Based on the Change in Insulation, the Materials Replaced do not Form a Composite

Photo- 16 Leakage Observed in Dormers on South Face of Roof

Photo- 17 Water Staining on the Interior of the Dormer Housing the Mechanical Vent

Photo- 18 Leaking and Staining at and Around an Interior Vent

Photo- 19 Paint Blistering at the Transition Between the Addition and the Existing Building

Photo- 20 Example of Cracking of the Log Beams

Photo- 21 Example of Cracking of the Log Beams

Infrared Scan

On the evening of August 5, 2009, an infrared scan of the roof was carried out using a FLIR infrared camera.

Both the North and South faces of the roof revealed significant evidence of moisture within the roof assembly when viewed with the infrared camera. Moisture levels were consistently high across the entire roof plane. The roof protecting the addition did not reveal any significant moisture accumulation. Moisture accumulation within the main roof is clearly significant as evidenced by these results.

Figure 2 Infrared Photo of Northwest Corner of the Roof

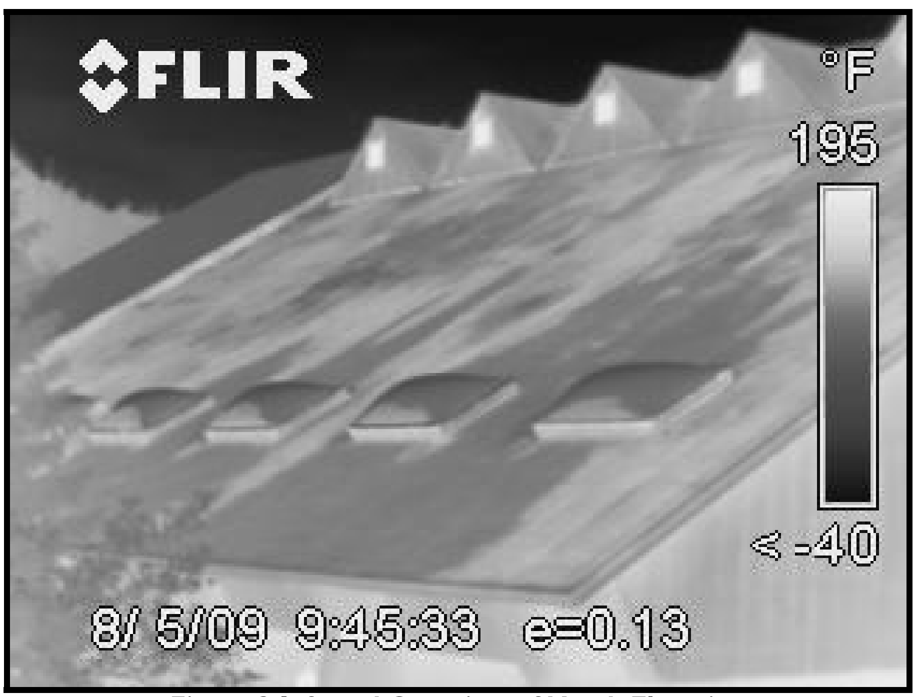

Figure 3 Infrared Overview of North Elevation

Figure 4 Infrared Overview of North Elevation – Note Addition Roof is Dry

Figure 5 South Elevation Roof Above the Boiler Room

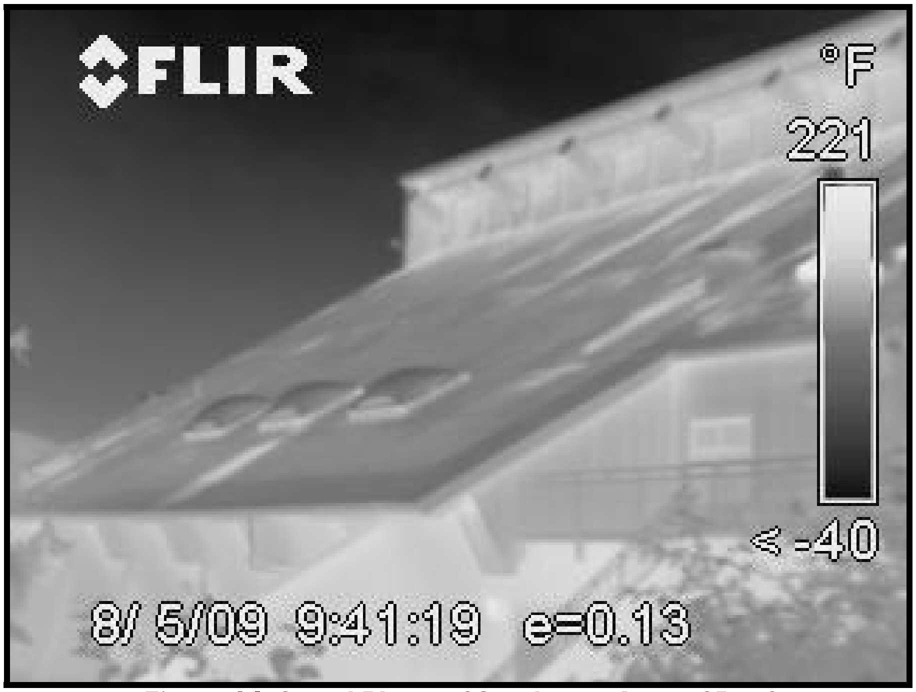

Figure 6 Infrared Photo of Southwest Area of Roof

Interior Conditions

The building interior is a moist environment that is controlled by a dehumidification system. It is not known what temperature and humidity levels are maintained within the building interior; however, data from the maintenance staff indicates temperatures are in the mid-80s Fahrenheit and the relative humidity is maintained at around 50%.

Since the roof is made up of a pre-manufactured composite panel, there is no vapor retarder within the panel or on the interior surface. The paint does not appear to be vapor retarder paint or primer; however, no testing of the paint has been carried out. The paint and primer should be sampled to determine if any vapor retarding qualities are present. Even if a vapor-retarding paint has been applied, there are gaps, breaks and open transitions in the roof panels that allow vapor transfer into the joints of the panels. The foam is an open cell foam which does not have any significant vapor retarding qualities. Joints in the panels have been trimmed with dimensional lumber and do not have effective seals to stop water vapor.

Discussion

The pool building was originally designed by Architect Kenneth W. Brooks and Structural Engineers Esvelt & Sexton. The plans show the composite panel as a structural component of the insulated deck. Copied below is the section of the roof panel described in Detail 3 on Sheet S3 of the structural plans.

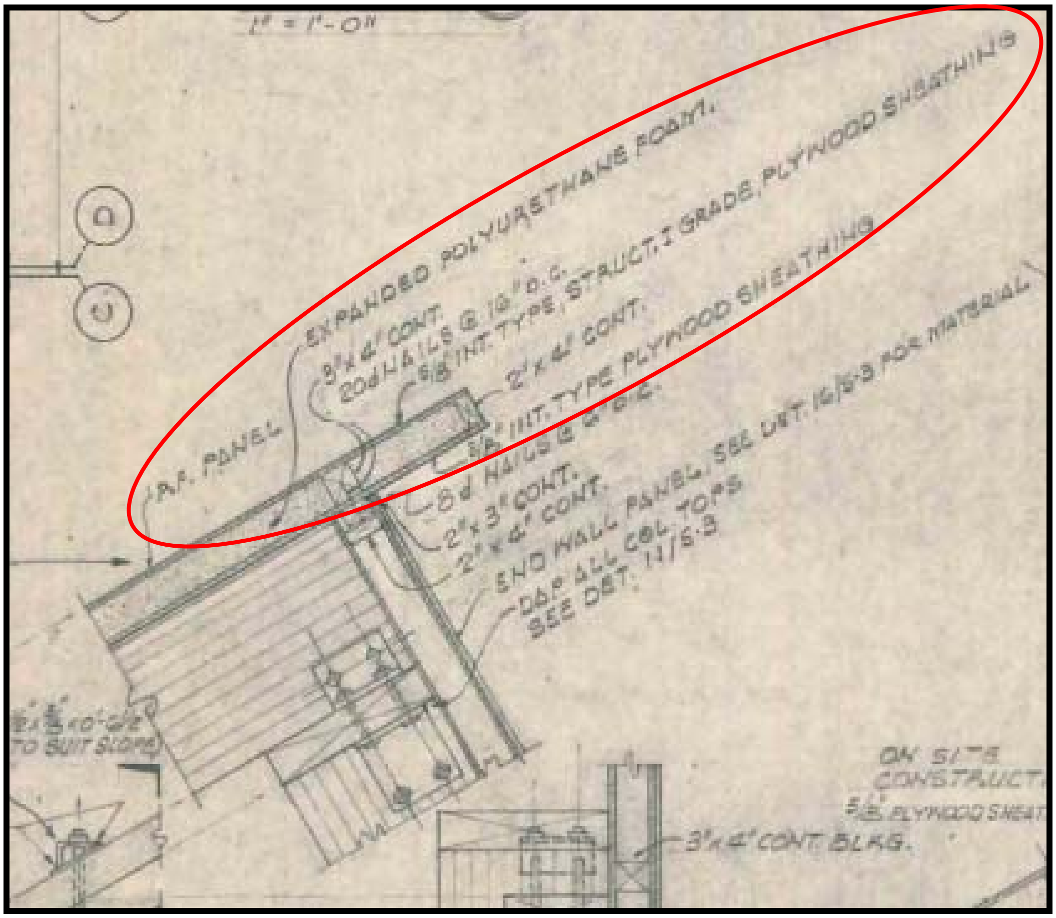

Figure 7 – Detail 3 on Sheet S3 of the Structural Plans

This panel is an 'early day' example of Structural Insulated Panels ('SIPS'), which were first designed using polyurethane foam. They became common in engineered post and beam homes and recreational structures such as natatoriums. Panel manufacturers subsequently changed to the use of expanded polystyrene to form the core for a variety of technical reasons. The Structural Insulated Panel Association ('SIPA') only publishes data for expanded polystyrene core panels.

The bonds between the three components, forming the composite, are critical to the structural performance of the panel. The capabilities of the panel to resist loads is dependent on the bonds between all three elements. The loss of bonds and the deterioration of the top plywood panel have greatly reduced the load bearing capabilities of the panel. The load tables below show the standard allowable loading for SIPS panels as provided in the NTA Evaluation Report commissioned by the SIPA in 2009. Note these tables do not directly represent conditions on the project; however, they provide a general view of performance when the components are fully laminated.

The report provides loading values for a variety of panel thicknesses. Based on the detail above, the composite panels were approximately four inches thick. The closest thickness the report provides is 4 5/8 inches thick, which is relatively similar, but not exact to the industry specifications. Further, the industry specification in the report calls for expanded polystyrene insulation only.

Table 3: Allowable Uniform Transverse Loads[1, 4]						
Panel Length (ft)	4-5/8-inch Thick SIP Deflection Limit[2]			6-1/2-inch Thick SIP Deflection Limit[2]		
	L/180	L/240	L/360	L/180	L/240	L/360
8 WAB[3]	50.8	44.6	29.7	75.8	71.0	47.3
8	76.4	57.3	38.2	104.8	94.0	62.7
10	50.4	37.8	25.2	80.6	64.5	43.0
12	34.6	26.0	17.3	61.0	45.8	30.5
14	24.6	18.4	12.3	44.5	33.4	22.3
16	--	--	--	33.2	24.9	16.6
18	--	--	--	25.3	19.0	12.7

Figure 8 – Excerpt from NTA Evaluation Report SIPA120908-10

Table 5: Allowable Axial Loads (plf)[1,2,3,4]			
Lateral Brace Spacing (ft)	Panel Thickness		
	4-5/8-inches	6-1/2-inches	8-1/4-inches
8 WAB[5]	2420	2580	2650
8	3700	4080	4230
10	3370	3930	4140
12	2990	3730	4020
14	--	3500	3890
16	--	3240	3720
18	--	2960	3540
20	--	--	3340

Figure 9 - Excerpt from NTA Evaluation Report SIPA120908-10

As noted, data provided by maintenance personnel indicate a typical temperature of 85-90 degrees Fahrenheit and 45%-50% relative humidity at the deck level and 92 degrees Fahrenheit and 50% relative humidity at the catwalk level. Higher temperatures and greater moisture saturation in the air can be expected at the top of the structure.

Water entry into the panels is from both the interior and exterior conditions; water vapor is condensing within the panels at joints and cracks and water is breaching the shingle layer from above. Based on temperature and humidity data received, the dew point ranges from the insulation core to within the plywood and OSB surfacing. Water vapor is condensing in the noninsulated joints at the underside of the decks on colder days and within the joints when the temperature is slightly warmer. Within the foam panels, water vapor is condensing within the foam and at the interface between the two plywood panels.

The sources of water from above are obvious. The roof has failed and the underlayment is saturated. The degree of roof and roof deck deterioration is substantial and is likely at a point of structural impairment. Combined dead and live loads, especially with a load of snow, could overload the panels considering the level of deterioration observed. In addition, the degree of cracking and checking of the structural log beams is a further concern as to the ability to carry anticipated live loads.

It is strongly recommended that a structural analysis be carried out as soon as practical to determine the current structural capabilities of the composite panels and the ability to carry anticipated snow loads this coming winter.

A new roof and decking assembly must be designed in conjunction with the interior mechanical system. Temperature and humidity must be maintained within a specified range for the roof deck and insulated roof assembly to perform correctly.

It is strongly suggested that an alternate to a composite panel be considered. Based on current structural design, a car deck or 'Potlach' decking system could be installed over the wood purlins with a vapor retarder and a nail base insulation installed in two layers. The insulation should be a minimum of R-38. The shingles should be installed with six nails per shingle and should be tested for wind resistance to 110 mph. The underlayment should be two layers, with ice dam protection at eaves, valleys, and ridges in compliance with ARMA cold weather recommendations.

Conclusions

Visual, intrusive, and infrared investigation of the roof, deck and weathering surface at Mike Smithers Community Pool has revealed evidence of significant moisture damage as a result of water intrusion from both the interior and exterior. Moisture was identified beneath the shingles on the roofing felt, OSB sheathing, and within the structural insulated panel system.

Based on the infrared scan, the water intrusion appears to be systemic throughout the roof except at the addition constructed in 1999. As noted above, the investigation took place following a period of three weeks without rain, yet many of the underlying materials within the roof system were still very wet. There is evidence of significant leakage into the interior of the building, as supported by water stains and trails along the interior surface of the roof. Some of the leakage is a result of condensed water from the interior.

The cause of the water intrusion is a combination of factors. The exterior surface of the roof has clearly been damaged by high winds and birds, creating avenues for water entry from rain and snow. Also, the high humidity environment within the building can result in condensation within the roof assembly. Considering there is no effective vapor retarder, this moisture has condensed within the assembly and contributed to the damage. In addition, the exhaust of interior air through the dormer vents has resulted in significant condensation localized around those vents, resulting in leaks to the interior and into the roof assembly.

In many areas, it appears that this combination of factors has saturated the OSB sheathing and limited its ability to secure the shingles. This in turn has led to further deterioration, including exposure of the plywood surface of the structural insulated panels.

Due to the severity of the damage to the shingles and OSB sheathing, these components will likely require complete replacement. Damage is a combination of loss of lamination and water damage to the panels. The lack of a vapor retarder render the panels useless in a any future design unless a new interior ceiling system is designed to hide a vapor retarder.

Additional structural investigation of the log beam framing is strongly suggested to evaluate the impact of the cracks over the service life of the structural members. It may well be the log beams are over-designed for the anticipated load bearing; however, this should be confirmed.

Please contact our office with any questions.

Sincerely,

TRINITY | ERD

BUILDING SCIENCE RESEARCH | DESIGN | CONSULTATION

Colin Murphy, RRC, FRCI, LEED® AP

for the firm