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CRREL ROOF MOISTURE SURVEY
Building 208
Rock Island Arsenal

C. Korhonen, T. Dudley and W. Tobiasson

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The roof of building 208 at Rock Island Arsenal was surveyed for wet insulation using a hand-held infrared camera. Areas of wet insulation were marked with spray paint on the roof and 3-in.-diam core samples of the built-up membrane and insulation were obtained to verify wet and dry conditions. Roof defects uncovered during a visual inspection were also marked with spray paint. The majority of the wet areas detected are associated with flashing flaws, which are considered responsible for the wet insulation. Recommendations

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20 Abstract (cont'd).

for maintenance of this roof are based on information derived from the infrared survey, core samples and visual examinations.

PREFACE

This report was prepared by Charles Korhonen, Research Civil Engineer, Timothy Dudley, Civil Engineering Technician, and Wayne Tobiasson, Research Civil Engineer, Construction Engineering Research Branch, Experimental Engineering Division, U.S. Army Cold Regions Research and Engineering Laboratory.

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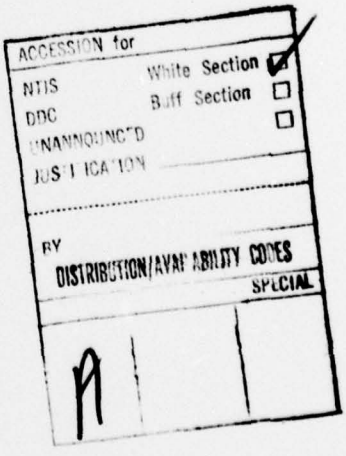
This report was technically reviewed by E.F. Lobacz, Chief, Construction Engineering Research Branch.



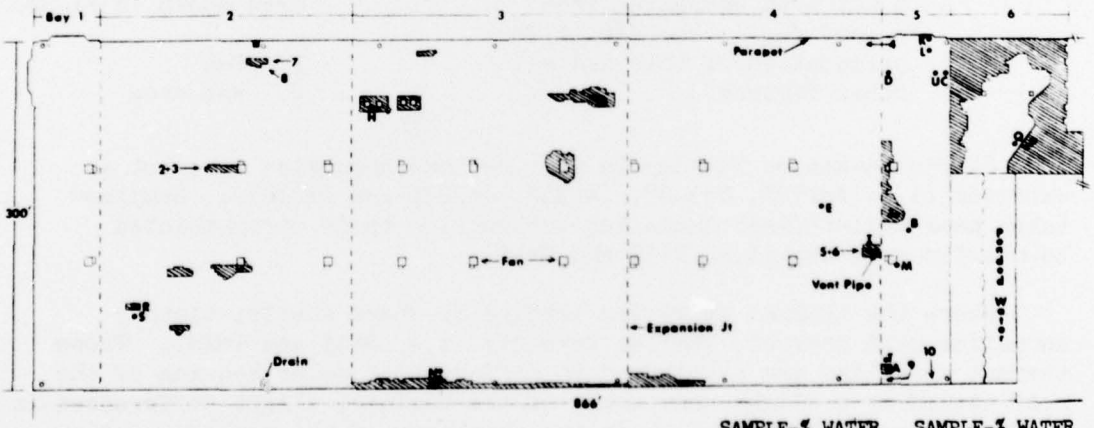
CRREL ROOF MOISTURE SURVEY - BUILDING 208, ROCK ISLAND ARSENAL

Charles Korhonen, Timothy Dudley and Wayne Tobiasson

INTRODUCTION

The roof of building 208 at Rock Island Arsenal consists of six bays separated either by expansion joints or parapets as shown in Figure 1. Bay 6 is at a lower elevation than bays 1 through 5. The total area of the roof is approximately six acres. A gravel-covered built-up membrane overlies 1-3/4-inch-thick wood-fiber insulation on a metal deck. The roof slopes to internal drains near the parapets.

This roof was surveyed for wet insulation with an AGA Thermovision 750 infrared scanner during the nights of 25 and 26 July 1977. Wet areas appear as bright anomalies on the viewing screen of the AGA unit. Thermograms (Polaroid photos of the thermal image on the viewing screen) and conventional daytime photos were taken of the anomalies. During the daytime, the roof was examined visually and defects were marked with white spray paint. Three-inch-diameter core samples were also obtained during the daytime to determine the moisture content of the insulation and to examine the membrane in cross section. Insulation water contents cited in this report represent the weight ratio of water to dry insulation. Water contents were obtained by weighing the samples before and after oven drying at 110°F. The cross-hatched areas in Figure 1 represent areas of the roof containing wet insulation. Such areas were outlined with white spray paint.



SAMPLE	% WATER	SAMPLE	% WATER
A	170	L	2
B	3	M	3
C	4	N	3
D	5	O	318
E	2	P	216
G	398	Q	5
H	235	R	155
I	435	S	3
J	223	T	4
K	1	U	2

Figure 1. Plan view of building 208. The cross-hatched areas indicate wet insulation. Arrows indicate the viewing direction of objects in Figures 2 through 10.

DEFINING WET AREAS

Many thermal anomalies were detected during the first evening survey. Of these, some were well-defined and quite likely moisture-related. A photograph and thermogram of a well-defined anomaly are shown in Figures 2 and 3 respectively. Many other anomalies were detected that were subtle and had boundaries that were difficult to define. Our common procedure is to outline all detected anomalies with spray paint, but because of the number of subtle anomalies encountered during Monday night, we only marked sample locations at that time.

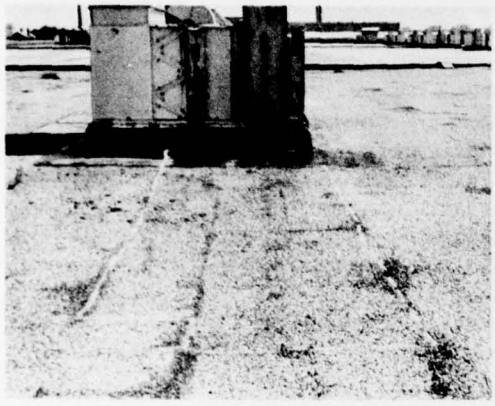


Figure 2. White spray paint outlines a wet area emanating from a roof fan. (See Fig. 1 for orientation of this and all other figures.)

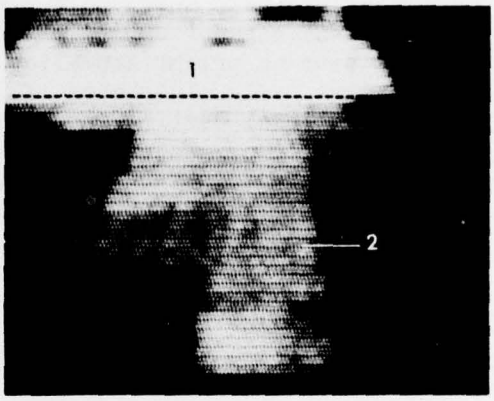


Figure 3. Thermogram of the wet area shown in Figure 2.

1. Fan
2. Wet area

Samples taken on Tuesday in well-defined anomalies were wet as expected (i.e. A=170%, G=398%, I=435%, J=223% and O=318%). Samples taken near well-defined anomalies but outside their spray-painted boundaries were dry (i.e. N=3% and T=4%).

Where the thermal image was mottled or where subtle, blotchy anomalies were present, samples were dry (i.e. B=3% and E=2%). These thermal anomalies are attributed to differential solar heating of the roof caused by a slight unevenness of the surface, slight differences in surface color, and variations in the thickness of the membrane and gravel cover.

Samples C, D, K, L and U were obtained in Bay 5 (Fig. 1) to determine the cause of subtle thermal anomalies along the parapet walls and along the expansion joints. Because of flashings, built-up membranes are normally thicker at the edges of a roof, and subtle thermal anomalies

unrelated to moisture are frequently encountered there. The anomalies detected in these areas appeared to be of this nature, except that their inside boundary was quite irregular (Fig. 4), which is uncommon. Since anomalies with irregular boundaries are often moisture-related, samples were taken. All insulation samples associated with these types of anomalies were dry (i.e. C=4%, D=5%, K=1%, L=2% and U=2%). The membrane was thicker within these anomalies. This is believed to be the cause of their thermal signature.

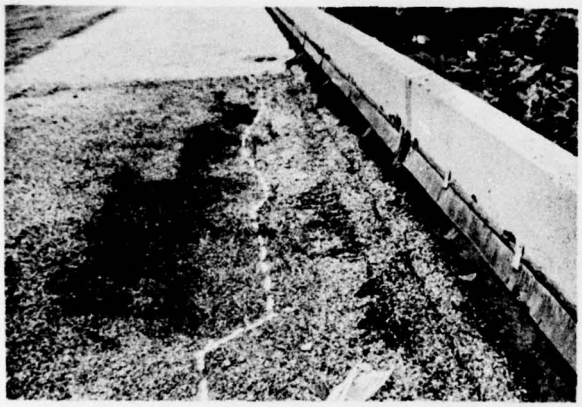


Figure 4. Spray painted boundary of an irregular thermal anomaly along the parapet.

Sample M was taken within a subtle anomaly, typical of those that surround most roof fans. This sample also had a low water content of 3%, and again the membrane was extra thick. However, in bays 2, 3 and 5 bright thermal anomalies of a different size and shape than the anomalies associated with sample M were located adjacent to six fans. Sample H, taken in a typical bright anomaly, had a water content of 235%. Based on sample H it is concluded that these six bright anomalies were moisture-caused.

Those anomalies that proved to be wet during the Tuesday sampling program were outlined in white spray paint during the Tuesday night infrared survey. As a further check, four more sample locations were marked on Tuesday night. Those samples were taken on Wednesday. Areas expected to be wet were wet (i.e. P=216% and R=155%) and areas expected to be dry were dry (i.e. Q=5% and S=3%).

SOURCES OF MOISTURE

The majority of the wet areas shown in Figure 1 are associated with membrane penetrations. Quite likely water has entered the insulation through the flashings at these penetrations. For example, the flashing collar was loose at the base of a vent pipe. The collar would move relative to the pipe when someone walked nearby. Figures 5 and 6 show the well-defined wet area surrounding this vent pipe. The collar was not loose at an identical vent pipe nearby and the thermal image was

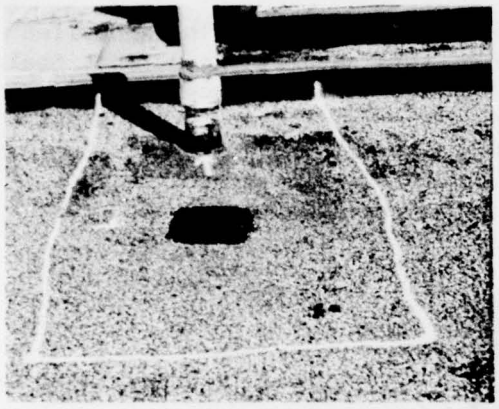


Figure 5. Daytime photograph of a wet area outlined with white spray paint. The arrow points to the loose collar flashing. The built-up membrane contained a 3-in.-diam hole which was subsequently patched (black square).

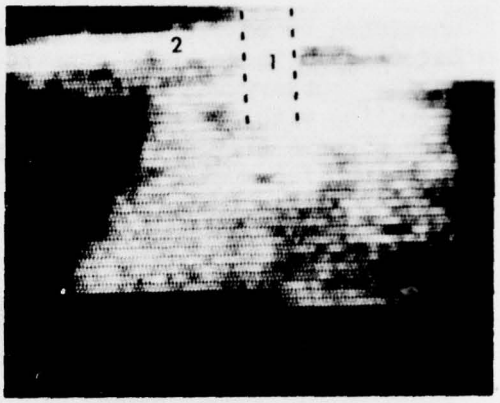


Figure 6. Thermogram of the area shown in Fig. 5. The moisture probably entered around the vent pipe.

1. Vent pipe
2. Expansion joint

uniformly dark there. Within the wet area shown in Figure 6 a 3-in.-diam hole was discovered in the membrane. Sample I, taken from the exposed insulation, had a water content of 435%. Prior to completion of this survey the hole was patched as shown in Figure 5.

Other wet areas were associated with roof patches as shown in Figures 7 and 8. It's not possible to determine when moisture entered this area - before or after the patches were installed.

Figure 7. Daytime photograph of a patched area with a wet area outlined in white spray paint.

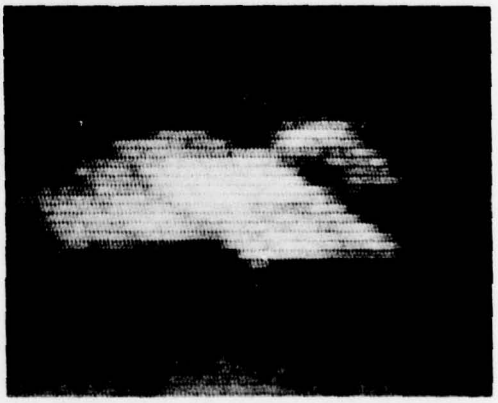


Figure 8. Thermogram of the wet area shown in Fig. 7.

Visual examinations conducted during the daytime (26 and 27 July) revealed that the entire roof membrane contained numerous blisters. Although blisters are potential moisture entry points no wet areas were directly associated with blisters. While the flashings and expansion joints were being examined, defects were marked with white spray paint, as shown in Figures 9 and 10. Repairs should be made in such areas.

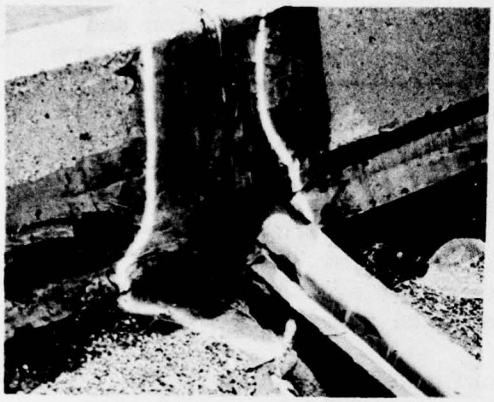


Figure 9. White spray paint was used to mark defects.

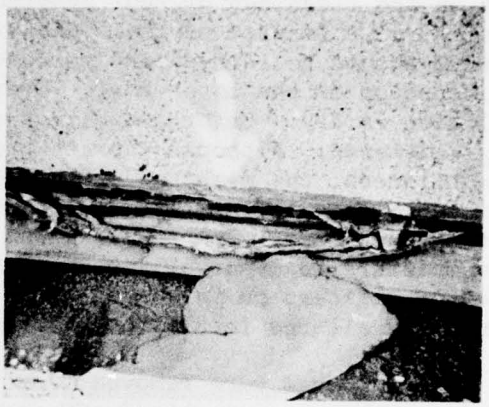


Figure 10. Flashing defect marked with white spray paint.

It is understood that this roof leaks every time it rains and repeated patching attempts, based on visual examinations, have failed to correct these leaks. The number of defects currently present on this roof suggest that prior visual examinations and subsequent repairs have not been that comprehensive. It is suggested that a comprehensive visual examination be conducted at each of the cross-hatched areas shown in Figure 1. It is possible that moisture-entry points will be located. (A single hole in the membrane could produce leaks some distance away in the building as water can travel along the channels provided by the metal decking.)

The eastern half of the southern portion of Bay 6 was covered by ponded water as shown in Figure 1. Because of the ponded water an infrared survey could not be conducted in this area. Ponding of water is a problem and better drainage should be provided. The western half of this southern portion was not water-covered and appeared to be free of wet insulation as no thermal anomalies were detected.

Much of the northern portion of Bay 6 contains wet insulation. New built-up roofing and insulation are needed there. Careful attention should be directed toward installation of new wall flashings as it is quite likely that flashing flaws destroyed this portion of the roof.

CONCLUSIONS

New insulation and a built-up membrane are needed for the northern portion of Bay 6. Better drainage should be provided in the southern portion of this bay.

Current problems in Bays 1-5 are quite likely caused by localized flaws on the flashings of roof membrane penetrations. The infrared and visual surveys located several areas where the existing insulation and membrane should be removed and replaced. These problem areas are a very small portion of the total roof. Over the remainder of the roof, the insulation is dry. Unfortunately, the membrane over most of the roof is badly blistered. Although current problems are not directly related to these blisters, the membrane probably has only a few more years of serviceable life left in it. Blisters accelerate deterioration of built-up membranes. Foot traffic and snow loads can open blisters and allow moisture to eventually soak the insulation below. Because of the number of blisters on this roof such a sequence of events could ruin essentially all the insulation. Action should be taken to prevent this.

If all gravel were removed from the roof and blisters in the existing membrane were sliced off, a new membrane could be placed over the remains of the existing membrane. It would not be possible to eliminate all small air voids between the old and new membranes. Consequently, it is expected that the new membrane would rapidly acquire blisters. About the only way to prevent reflective blistering in the new membrane would be to install a ventilating layer between the old and new membranes. This might consist of a ventilating felt spot-mopped to the existing membrane and vented at the edges of the roof. Conventional breather vents alone are not considered capable of preventing reflective blistering in this case.

A second alternative that may be worth investigating further is the complete removal of the old blistered membrane, removal of the few small areas of wet insulation, addition of dry insulation in these areas, addition of insulation over the entire roof to meet current insulation standards, and the application of a new gravel-covered built-up membrane.

A third alternative would be to remove and replace the existing membrane and all existing insulation. New insulation should meet current insulation standards. This alternative is expected to be the most expensive but also the most reliable in this particular case.