ROOFER: A Management Tool For Maintaining Built-Up Roofs

by:
David M. Bailey
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This paper describes ROOFER, a roofing maintenance management system for built-up roofs being developed by the U.S. Army Construction Engineering Research Laboratory with the assistance of the U.S. Army Cold Regions Research and Engineering Laboratory and the U.S. Army Engineering and Housing Support Center. ROOFER provides building managers with a practical tool for evaluating built-up roofs, determining maintenance priorities, and selecting repair strategies that ensure the maximum return on investment.

ROOFER comprises procedures for dividing the building roof into manageable sections, collecting and managing inventory information, inspecting and evaluating condition, and managing networks and projects.

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FOREWORD

This article is reprinted with permission from the Proceedings of the 9th Conference on Roofing Technology, "Putting Roofing Technology to Work," May 4-5, 1989, Gaithersburg, Maryland.

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ROOFER: A MANAGEMENT TOOL FOR MAINTAINING BUILT-UP ROOFS

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The U.S. armed services have a very large inventory of buildings with bituminous built-up roof membranes. Millions of dollars are being spent annually to repair or replace these roofs. In the past this has been done using inconsistent management schemes. There was a need for a systematic procedure to evaluate these roofs, to determine priorities and to select repair strategies that would insure the maximum return on investment.

To respond to this need, the U.S. Army Construction Engineering Research Laboratory (USACERL), with the assistance of the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) and the U.S. Army Engineering and Housing Support Center (USAESHC), is developing ROOFER, a roofing maintenance management system for built-up roofs. This work has been a team effort involving roofing experts from industry as well as from other branches of the military in an "on the roof" dynamic process involving more than 50 buildings at seven locations. ROOFER provides building managers with a practical decision-making procedure that will identify problem roofs and select maintenance and repair strategies for roofs with bituminous membranes.

ROOFER comprises procedures for dividing the building roof into manageable sections, collecting and managing inventory information, inspecting and condition evaluation, network management and project management. It utilizes many of the highly successful concepts developed by USACERL for the PAVER pavement maintenance management system.

NETWORK vs. PROJECT

Network management is defined as the process of making decisions regarding the management of a group of roof sections, such as all roof sections on a military installation or all roof sections on a specific building type such as barracks. Project management is the process of making decisions regarding the maintenance and repair of individual roof sections. When there are just a few roofs to manage, they can be kept track of on a project basis. When there are hundreds or thousands of roofs to manage, initial decisions should not be made on a project by project basis but on a network basis. ROOFER provides the tool for network decisions as well as the information needed to initiate projects. Network level management includes managing all of the roofs on an installation, in a geographic area or even service-wide. Management decisions are made in a general way and do not require the same amount of information that a project-level decision requires. What is needed is a way of comparing the condition of all of the roofs in the network using a consistent evaluation technique. Network level information is used to develop a rational means of repairing or replacing problem roofs within the network to meet specific performance levels. Short- and long-term plans can be developed that will respond to actual or anticipated needs rather than employing crisis management or spending money on roofs in less need than others.

DIVIDING A ROOF INTO SECTIONS

Building roofs are divided into identifiable sections in order to increase management efficiency. Managing roofs at the section level provides a better means of evaluating conditions and determining maintenance and repair needs. For example: A roof section that is in poor condition will not detract from the condition of a roof section in good condition on the same building, and conditions indicating replacement of one section would not necessarily indicate replacement of the entire building roof.

Roof sections are generally delineated by firewalls, expansion joints or area dividers. Areas having different roofing systems, different amounts of roof traffic and/or rooftop equipment or significantly different occupancies below the roof are designated into separate sections.

INVENTORY AND DATA MANAGEMENT

The roof inventory is the foundation of ROOFER. It provides the information needed by engineering personnel to select repair techniques and to determine the suitability of replacement systems. A well maintained inventory will provide a history of each roof section and a record of roof performance that can be used to determine which built up roof systems are the most suitable for use on a particular building type or occupancy.

For each building, general information concerning building name, number, location and occupancy are collected. A building roof plan is developed that shows overall dimensions and identifies each roof section. This information, along with contract drawings, specifications, submittals and as-built drawings, is also collected and stored in a building folder.

For each roof section, data are collected on the type of structural frame, deck, vapor retarder, insulation, membrane and flashing. Worksheets with checklists are used to ensure uniformity in reporting. A roof section plan is drawn to scale on the roof inspection worksheet, showing all physical features, including perimeter conditions, rooftop equipment

*The views of the authors do not purport to reflect the position of the Department of the Army or the Department of Defense.
4. **Determine component condition rating.** The condition rating is determined from Table 2.

**NON-DESTRUCTIVE MOISTURE EVALUATION**

A complete evaluation of an insulated roofing system requires that the insulation be inspected to determine if excessive moisture is present. Moisture reduces the thermal value of the insulation and may also reduce the bond between it and the membrane or deck. Water in insulation adds to the weight of the structural system and may cause corrosion of fasteners and deterioration of the roofing system.

By using non-destructive moisture evaluation techniques such as infrared (IR), nuclear or capacitance, areas of probable wet insulation can be determined. Core samples must be taken to verify the probable wet areas and to determine the moisture content of the insulation. Knowing the type and amount of wet insulation and its moisture content, the insulation condition index (ICI) for a section can be calculated.

**ROOF CONDITION INDEX**

The membrane, flashing, and insulation condition indexes are combined to determine the roof condition index (RCI). This provides a useful method of evaluating the overall condition of a roof section and a method of comparing conditions between roof sections. The RCI allows the user to rank individual roof sections according to their ability to perform.

The three component indexes (MCI, FCI, and ICI) have a direct relationship to determining the needs for maintenance and repair (M&R) of a roof section. Similarly, the RCI provides an overall indication of M&R needs.

Like the component indexes, the RCI is based on the same scale of 0 to 100, with 100 indicating that only routine maintenance is needed. It is calculated by giving the greatest weight to the component with the lowest condition index and a lesser weight to the remaining indexes. For a roof section with insulation, the lowest of the three indexes has 70 percent of the weighting and the other two indexes each have 15 percent of the weighting. Table 3 lists the qualitative condition ratings associated with the RCI.

**NETWORK MANAGEMENT**

Network management uses the collected information to develop long-range budget projections and work requirements for the network.

The ROOFER program can generate a series of reports for making network management decisions. These reports include:

**Section Inventory List**

The section inventory list report (Figure 4) provides a list of the surveyed roof sections. For each section, the type of membrane insulation, and deck as well as roof slope and area are provided.

**Inspection Scheduling**

The inspection schedule report is used to prepare a plan for scheduling future ROOFER inspections for roof sections based on the RCI. The report produces a plot and list of the roof sections to be inspected during the next three years for all of the roof sections of a particular building use, membrane type or section area.
Condition Frequency
The condition frequency report informs management of the current condition of the roof network and helps plan for future maintenance and repair. The roof sections included in the report can be selected by building use, membrane, insulation and/or deck type, roof slope, section area or age. The report lists, by section and area, the number and percentages for the different RCI ranges and provides a graphical plot of the frequency of occurrences. Figure 5 is a typical report for a group of buildings at a military installation.

Using the different selection options, the effects of conditions such as deck type, insulation type or slope on overall condition can be examined.

Roof Condition Index
The roof condition index report (Figure 6) lists roof sections and component indexes in order of increasing RCI. The report can be sorted based on building use, membrane, insulation, deck type, roof slope, section area or age to provide management with the background information needed to select and prioritize roof sections for maintenance and repair. The RCI, building use and age, as well as available budget, provide the criteria for project selection.

Project Management
Project management uses the three component condition indexes and distress data that were determined for a section to provide valuable information regarding the condition of the roof section and required maintenance and repair. This information when combined with life-cycle predictions can be used to identify M&R alternatives.

Field Tests
Field tests of the ROOFER program were performed at Ft. Meade last year, and preliminary findings indicate that the system works well. The forms used for data collection and the microcomputer program for analyzing the data provided the planning for long-range repair and replacement of the built-up roof network at Ft. Meade. They did not present any problems to the contractor performing the work.

CONCLUSIONS
This paper has described a comprehensive management system for built-up roof systems. The procedures presented are being programmed for microcomputer use as part of the ROOFER program. Inventory, inspection, condition evaluation and network management techniques have been developed, and the system has been designed to enable the incorporation of other low-slope roofing systems in the future ROOFER will be available to private industry through a nongovernment distribution agency.

REFERENCES


ACKNOWLEDGMENTS
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<thead>
<tr>
<th>Flashing</th>
<th>Membrane</th>
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</thead>
<tbody>
<tr>
<td>Base Flashing</td>
<td>Blisters</td>
</tr>
<tr>
<td>Metal Cap Flashing</td>
<td>Ridges</td>
</tr>
<tr>
<td>Embedded Edge Metal</td>
<td>Splits</td>
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<tr>
<td>Flashed Penetrations</td>
<td>Holes</td>
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<tr>
<td>Pitch Pans</td>
<td>Surface Deterioration</td>
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<tr>
<td>Drains and Scuppers</td>
<td>Slippage</td>
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<tr>
<td></td>
<td>Patching</td>
</tr>
<tr>
<td></td>
<td>Debris and Vegetation</td>
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<tr>
<td></td>
<td>Equipment Supports</td>
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<tr>
<td></td>
<td>Ponding</td>
</tr>
</tbody>
</table>

Table 1 Built-up roofing distresses
Condition Index | Rating
--- | ---
86 - 100 | Excellent
71 - 85 | Very Good
56 - 70 | Good
41 - 55 | Fair
26 - 40 | Poor
11 - 25 | Very Poor
0 - 10 | Failed

Table 2 Condition ratings

<table>
<thead>
<tr>
<th>RCI</th>
<th>Roof Condition Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>86 - 100</td>
<td>Routine Maintenance</td>
</tr>
<tr>
<td>71 - 85</td>
<td>Minor Repairs Needed</td>
</tr>
<tr>
<td>56 - 70</td>
<td>Moderate Repairs Needed</td>
</tr>
<tr>
<td>41 - 55</td>
<td>Major Repairs Needed</td>
</tr>
<tr>
<td>26 - 40</td>
<td>Replacement Probable</td>
</tr>
<tr>
<td>11 - 25</td>
<td>Replacement Needed</td>
</tr>
<tr>
<td>0 - 10</td>
<td>Replacement Critical</td>
</tr>
</tbody>
</table>

Table 3 Maintenance and repair recommendations

BLISTERS

Description: Blisters are round or elongated raised areas of the membrane that are filled with air.

Note: Blisters and ridges are difficult to differentiate at the low and medium severity levels. The rating error will be insignificant because of the similarity in the deduc curves. At high severity, however, it is important to distinguish between the two distresses due to their different leak potentials.

Severity Levels:

Low:
1. The raised areas are noticeable by vision or feel. The surfacing is still in place and the felts are not exposed.

Medium:
1. The felts are exposed or show deterioration.

High:
1. The blisters are broken.

Measurement:
1. Measure the length and width of the blister in linear feet and calculate the area (length times width). If the distance between individual blisters is less than 5 feet, measure the entire affected area in square feet.
2. When large quantities of this problem are present (especially on large roofs), the representative sampling technique can be used.

Density:

\[
\text{Problem Density} = \frac{A \times 100}{B}
\]

where:
- \(A\) = total area of membrane blisters (sq ft)
- \(B\) = total area of roof section being rated (sq ft)

Note: The problem density is calculated for each existing severity level.

Figure 1 Distress description and severity levels for blisters

Figure 2 Deduc value curve for blisters
Figure 1: Corrected deduct values for membranes

Figure 2: Correction factors for deducts

Figure 3: Corrected total deducts

Figure 4: Section inventory report

Figure 5: RCI frequency plot

Figure 6: RCI report
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