PLANNED MAINTENANCE FOR COMMERCIAL ROOFING

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The basic role of the roofing system portion of the building envelope is to protect the interior from intrusion of moisture from exterior sources. There is no argument that an unreliable roof is one of the most aggravating problems of building ownership. It can also be the most potentially destructive of the building's value. Moisture that finds its way into the roof system or into the interior of a building can not only destroy ceilings, walls and furnishings but can decrease the efficiency of thermal insulation, resulting in needless waste of heat energy. A reliable roof is essential to protect the building owner's investment.

The relative cost of the roofing system as a percentage of the cost of the building has risen dramatically, from 1 percent to 2 percent before 1973, to 3 percent to 6 percent today. One reason for this rise was the Arab oil embargo, which increased the cost of asphalt by 300 percent overnight. Another factor was the cost of insulation included in the roof system to provide thermal protection from loss of heating energy. Before 1973 insulation was generally used as a part of the roofing system to provide a level surface over steel decking. With the increase in cost of energy for heating and cooling, the roof system is now relied upon to provide a major part of the thermal efficiency of the building envelope.

The ownership of commercial real estate has been further impacted by the Tax Reform Act of 1986. Depreciation of all building components has been placed on the same schedule, regardless of the components' useful life. Roofing, which before could be totally written off in eight years, now must be depreciated over 31 ½ years. The design life of most commercial roofing systems is considered to be about 20 years, so this arbitrary change in the tax law requires the depreciation life of a roof to exceed its design life by 10 ½ years or 57 ½ percent. Obviously, there is no longer a tax advantage to premature roof replacement. On the contrary, it is now incumbent upon the building owner to develop a plan that will extend the roof's useful life through comprehensive maintenance.

Comprehensive preventive maintenance provides the building owner with a program that will help protect the investment in the roofing system as well as provide an opportunity to extend the useful life of the roof to term and beyond.

GOAL OF PREVENTIVE MAINTENANCE

In my opinion, roofing systems installed from the late 1950s through the middle 1970s, a period of approximately 25 years, typically failed in about half of their design life. In addition, if the roofing system did not fail entirely, it was also typical that there were many problems associated with the roof that caused leaks and consequential damage to property and building components. The underwriters of designers' errors and omission coverage reported to NRCA that nearly 50 percent of claims were attributable to roof defects.

The purpose of roofing system preventive maintenance programs is twofold:

- to promote satisfactory, trouble-free performance of the roof system; and
- to assure that the term of performance of the roof system is extended to its design life and beyond.

A preventive maintenance program will prescribe what is necessary to minimize problems occurring due to roof defects. If the roof leaks, the preventive maintenance program has failed in its first task—to prevent moisture from penetrating into and through the roof system and into the building.

The second purpose is to extend the service life of the system. Preventive maintenance anticipates the stresses on the system that will require repair or replacement of system components to bring the roof back to serviceability.

BASIC PREVENTIVE MAINTENANCE

Virtually everything requires some measure of maintenance if it is to provide satisfactory long-term performance. No one would expect a new automobile to provide satisfactory performance without regular maintenance. Planned maintenance of roofing is just as important to protect the owner's investment in a building's roof.

The basic elements of a preventive maintenance program for roofs are:

- regular visual inspections to determine the current condition of the roof membrane and flashings;
- immediate repair of any defect discovered before it allows moisture to enter the roof system or the building interior; and
- non-destructive moisture detection to determine if moisture has infiltrated into the insulation in the roof system.

A vital part of the condition of the roof system is whether or not the insulation remains dry. A roof may appear to be in excellent condition from the surface but have areas of saturated insulation, which severely affect the thermal efficiency of the roof.

Non-destructive moisture detection of roof systems has developed into a sophisticated technique that provides accurate analysis of the thermal insulation for intrusion of moisture either from the exterior through the roof membrane or from interior humidity condensation. Two commonly used systems are infrared thermography and nuclear meter. Infrared may be done either on the roof surface or aerially from a helicopter or fixed-wing aircraft. The nuclear system is done on the surface of the roof.

Visual inspection by a trained person is the key to a successful program. Using a systematized inspection technique, each component of the roof system is investigated to deter-

mine its current condition and what maintenance may be required to assure its satisfactory performance through its design life.

IMPLEMENTING PREVENTIVE MAINTENANCE

Ideally, preventive maintenance on roofing should begin when the roof system is new. Within the first year after completion, an inspection should be made to determine how well the system is performing.

An infrared scan can assist in evaluating whether moisture was built into the roof system during installation, and visual inspection may reveal defects in workmanship and provide some assurance that the materials used are likely to give suitable performances for the design life of the system. After a roof has had a year of exposure to its environment, the inspector may be able to determine if there are design defects that must be corrected to allow the roof to provide satisfactory long-term performance. Non-destructive moisture detection should be employed in the maintenance program at least once every two years.

The material manufacturer and the roofing contractor normally would guarantee the roof for the first two years. Any repairs necessary due to material defects or improper or careless workmanship should be then taken care of by the responsible party.

If the implementation of preventive maintenance is delayed until the roof has been in service for several years, it may be necessary to develop a plan to bring the roof system back to a level of maintainability. Deferred maintenance can reduce the roof system serviceability until the cost of restoration cannot be justified in terms of expected service life. Unrepaired defects may saturate insulation and each rainfall can destroy more of the thermal value of the system. If the moisture-saturated insulation extends to a third of the roof area, but is isolated to one or two areas, it is probable that the affected insulation can be removed and replaced and the roof brought to a state of maintainability. If, however, one-third of the roof area contains wet insulation and the areas of wet insulation are scattered, the roof system then should be considered non-maintainable and scheduled for replacement. However, if the cost to restore the roof system to a maintainable condition divided by the estimated extension of roof life through restoration is equal to or less than the average cost per year of the roof (cost of installation plus cost of maintenance divided by design life of the system) then restoration should be considered a good investment.

An example of the formula to make this determination would be:

Where A = cost to restore
B = estimated additional roof life due to restoration
C = cost to replace entire roof system
D = aggregate cost to maintain over life of roof
E = design life of roof system

$$\frac{A}{B} \leq \frac{C + D}{E}$$

ROOF MAINTENANCE MANAGEMENT

Assuming that the owner recognizes the need to systematize the maintenance of the investment in roofing, the extension of basic preventive maintenance into roof maintenance management will provide the greatest benefit measured in cost per year of useful roof life.

A roof maintenance management system includes elements beyond the basic preventive maintenance program that enhance the ability of the owner to realize the maximum benefit from the roofing investment.

ROOF INVENTORY AND DATA BASE

There is some information that is essential to the function of a managed roof maintenance program. Building roofs in the program may be divided into sections if areas are separated by parapet walls, change elevations, contain expansion joints or other delineation, or if the roof area is too large for management efficiency. Generally, 40,000 square feet should be considered maximum size for a roof section. Each section is treated as a separate case with its own information data base. The first task is to complete the information search. A worksheet is prepared with all information items included in the data base. A copy of the worksheet is used for each section of roof to be inspected. This data is collected only on the first inspection, but will be reviewed and updated on successive inspections. Figure 1 is an example of a roof section inventory worksheet. The information required may be difficult to obtain, depending on the records kept on the roof by the owner. Some information may need to be obtained with test cuts or by other investigative means.

INSPECTION PROCEDURE

If non-destructive moisture detection is scheduled, it should be performed prior to the visual inspection. The interpretation of the roof scan is important information for the visual inspector.

Suspected moisture must be verified by test cuts, and if substantiated, the cause of the moisture entrapment must be determined. Figure 2 is an example of an infrared thermogram taken from an altitude of 1,000 feet above the roof. Light areas of the thermogram are from higher levels of heat radiation than from adjoining dark areas and therefore indicate possible moisture infiltration into the insulation underlying the roof membrane. In this thermogram there is an area of suspected wet insulation measuring approximately 40 feet by 50 feet. The two small white spots to the right of the wet area are roof drains.

The visual inspection should be a structured procedure developed in such a way that all components of the roof system—base flashing, metal cap flashing, metal termination flashings, drains and membrane—are examined thoroughly and in the same manner each time an inspection is performed. Consistency is necessary if reliable survey results are to be achieved. The inspector must be objective in the assessment of the condition of the roof components. Subjectivity leads to faulty condition reports and maintenance management based on unreliable information.

Consistency is improved if each component of the system is given a rating so that the condition rating of the roof is a composite of the rating of each component of the system. An example of such a rating system can be found in "Roofer,"[1] a maintenance management system developed by the U.S. Army Construction Engineering Research Laboratory for survey of built-up roofing systems on military bases.

The procedure recommended for the inspector is to develop a routine that will be followed on each roof section every time an inspection is performed.

The next step is to develop a small scale roof section plan. If the owner has kept a set of the original building plans, the roof section plans can be drawn from the as-built records. If, however, plans are not available, the roof section plans must be drawn from measurements obtained during the inspection.

A rough working plan is drawn showing all penetrations and roof mounted equipment. The file copy is drafted to scale when the inspector returns to the office.

The record copy of the small-scale roof plan should include only the physical features of the roof such as dimensions, penetrations, roof mounted equipment, etc. It should be a maximum of 8½" x 11" in size for ease of use during inspections. That size can be easily duplicated on any office copier.

All roof defects are indicated on the roof section plan by location and coded to type of defect and maintenance required. Inspection of each component type is completed before moving to the next component type. For example, all base flashing is inspected before moving to metal cap flashing. Figure 3 is a small-scale roof plan with field notes identifying roof defects found during visual inspection. Each defect is identified as to its location.

REPORTS AND RECORD KEEPING

Inspection reports furnished to the building owner must provide sufficient information to make decisions on maintenance and repair to preserve the investment in the roof system. It is not enough to report to the owner that something is wrong without also telling the owner what must be done to correct it; nor will the owner be able to make economic decisions without budget figures for maintenance. The report should be simple and concise but include documentation of inspection findings. All recommended maintenance should include current cost for each item of work and an estimate of the effect of the work on future life of the roof. The report should also include the replacement cost of the roof in current dollars and an estimate of the date total replacement will be necessary. With the information listed above, an economic decision can be made.

The information developed for each roof section is arranged into a permanent record file. The roof section inventory and the record copy of the small-scale roof plan provide all of the statistics pertinent to the roof area and make up the statistical data section of the records.

The second section of the permanent records are the nondestructive moisture detection reports, together with the gravimetric laboratory verification reports of wet core samples.

The third section contains the visual inspection reports with budget figures for all defect repair and preventive maintenance.

Finally, a complete record of all completed work orders with the cost of all repairs should be included.

The permanent records may be in loose file folders, threering binders or in an electronic computer data base. Availability of the information for use in management of maintenance of the roofing system is key to success of the program.

CONCLUSION

Roof systems which today are expected to provide key thermal protection as well as waterproofing of the structure have more than doubled as a percentage of the cost of building construction. Detection of potential problems before major damage has occurred keeps the cost of maintenance at a minimum and extends the useful life of the roof.

REFERENCE

[1]Shahin, M.Y., Bailey, D.M. and Brotherson, D.F., "Membrane and Flashing Condition Indexes for Built-Up Roofs," Volume II: *Inspection and Distress Manual*, Technical Report M-87/13, U.S. Army Construction Engineering Research Laboratory (USA-CERL), September 1987

ROOF SECTION INFORMATION

OWNER
ADDRESS
DATE / BLDG NO: SECTION ID: AREA SQ FT
OCCUPANCY YEAR ORIG. CONST YEAR LAST REPLACE
GENERAL
PERIMETER: ACCESS:
PARAPET FT AREA DIVIDER FT
ROOF EDGE FT ADJ WALL FT
EXP JOINT FT OTHER FT
STRUCTURAL FRAME
TYPE
ROOF DECK
TYPE
DESIGN LOAD SLOPE: DRAINAGE:
LIVE PSF IN 12
DEAD PSF
VAPOR RETARDER
TYPE
INSULATION:
TYPE
PHYSICAL PROPERTIES R-VALUE:
BOARD STOCK FILLS
THICKNESS (in.) ATTACHMENT
NO. OF LAYERS
APPLIED
MEMBRANE
PRODUCT
WARRANTY (Y/N) Term Expiration PROTECTED MEMBRANE (Y/N)
MANUFACTURER DESCRIPTION
SPECIFICATION NO
TYPE ATTACHMENT REINFORCEMENT
SURFACING WALKWAYS:
FLASHING
BASE FLASHING FLASHING ADHESIVE COUNTERFLASHING:
FLASHING TYPES
REMARKS

Figure 1

Figure 2

ROOF INSPECTION WORKSHEET JOB NUMBER 062-89
OWNER R.L.T. CORPORATION DATE FEB 21, 1989
ADDRESS SCOBEY, MONTANA INSPECTOR MCELE
BUILDING NUMBER 002 SECTION NUMBER A

ROOF AREA 20,025 SF COUNTERFLASH 684 CURBS 3
BASE FLASH 720 LF PARAPET CAP 684 SCUPPERS 10
ROOF EDGE --- LF PIPE PENETR. 3 PITCH PANS 2
EXP. JOINTS --- LF ROOF DRAINS 10 REGLETS 684

IDENT NO	PHASE CODE	PLAN COMMENTS	QUANTITY
1	203	/	609'
2	246	/	42'
3	501	3	32'
4	161	/	/
5	553	/	10
6	375	4	200.25
7	720	/	350 SF
8	141	/	2
9	167	5	560 SF

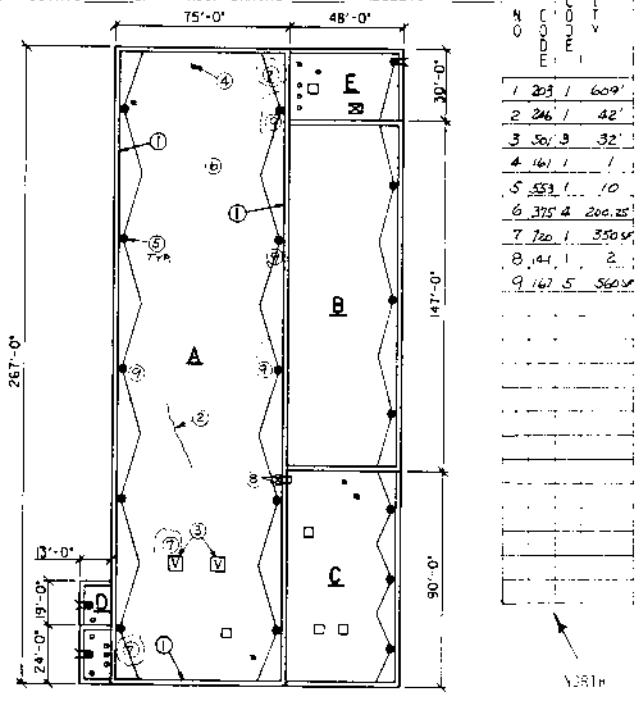

Figure 3