



NBSIR 85-3239

Roof Management Programs

Walter J. Rossiter, Jr.*
William C. Cullen**
Robert G. Mathey*

*U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
National Engineering Laboratory
Center for Building Technology
Gaithersburg, MD 20899

**William C. Cullen Associates
Potomac, MD 20854

November 1985

Prepared for:
U.S. Postal Service
Design Management Division
Real Estate and Buildings Department
Washington, DC 20260-6415

QC
100
.U56
85-3239
1985

NBS
RESEARCH DESIGN
CENTER

26
100
1070
1020 1070
10

NBSIR 85-3239

ROOF MANAGEMENT PROGRAMS

Walter J. Rossiter, Jr.*
William C. Cullen**
Robert G. Mathey*

*U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
National Engineering Laboratory
Center for Building Technology
Gaithersburg, MD 20899

**William C. Cullen Associates
Potomac, MD 20854

November 1985

Prepared for:
U.S. Postal Service
Design Management Division
Real Estate and Buildings Department
Washington, DC 20260-6415



U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, *Secretary*
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT	iv
LIST OF TABLES	v
LIST OF FIGURES	vi
1. INTRODUCTION	1
1.1 Background	1
1.2 Objectives.....	6
1.3 Scope of the Study	6
2. ROOF MANAGEMENT PROGRAMS	7
2.1 Purposes of Roof Management	7
2.2 Essential Elements	8
3. TYPICAL ROOF MANAGEMENT PROGRAMS	10
3.1 Total Roof Management	11
3.2 Management of Roofing Design and Construction	23
3.3 Maintenance Management of Existing Roofs	24
4. DISCUSSION	29
4.1 Cost of Roof Management Programs	29
4.2 Effectiveness of Roof Management Programs	29
4.3 Responsibility	32
5. SUMMARY	38
6. REFERENCES	43
7. ACKNOWLEDGMENTS	45
APPENDIX A. ORGANIZATIONS CONTACTED REGARDING ROOF MANAGEMENT	A-1
APPENDIX B. EXAMPLE OF CONTRACT DOCUMENTS USED IN NEW ROOFING MANAGEMENT	B-1
APPENDIX C. REPRINT OF THE AIR FORCE QUALITY CONTROLLER APPOINTMENT FORM	C-1

ABSTRACT

Roof management programs are used by private and public sector organizations in the United States to help assure that low-sloped roofing systems will perform as intended over their intended service lives. This report reviews those programs. Three general types of roof management programs are identified and discussed. For the most part, the structure and format of these programs have not been formally published. A notable exception is the U.S. Air Force program. The three types of roof management program currently conducted are: (1) total roof management which treats the design, construction, and maintenance of new and existing roofing; (2) new construction management dealing with design and installation; and (3) maintenance management which considers the maintenance and repair of existing roofs. Four elements are considered essential to an acceptable roof management program: (1) the roof system criterion, (2) quality assurance, (3) quality control, and (4) responsibility. In addition to the roof management programs that have been developed in the private and public sectors, several companies have organized to provide owners with total or partial roof management services. Although the increased roofing costs associated with new construction and total roof management programs have not been studied, estimates for such programs range from increases to 5 to 25 percent above the costs for roof construction without management. Many individuals in the industry using roof management programs believe that improved roofing performance results and that the increased costs are justified.

Key Words: construction; design; low-sloped roofing; maintenance; management; review; roofs

LIST OF TABLES

	<u>Page</u>
Table 1. Types of Roof Management Programs and the Time Span in the Roof Service Cycle for Which Each Type is Applicable	12
Table 2. Elements of Roof Management Programs and Associated Activities for Roofing Design and Construction or Renovation	41
Table 3. Elements of Roof Management Programs and Associated Activities for Roofing Maintenance and Repair	42

LIST OF FIGURES

Page

Figure 1. Quality Assurance of Roofing - A Diagram of the Construction and Service Cycle of Roofs Depicting the Parties Involved and Steps in the Cycle 3

1. INTRODUCTION

1.1 Background

Most industrial and commercial buildings have low-sloped roof systems with slopes generally less than four percent. Because of the low slope, the water-proofing is provided by a continuous membrane. Until the mid-1970s, most low-sloped roof systems had bituminous built-up membranes. Over the last decade the use of single-ply membranes has increased and in 1983 accounted for about 40 percent of the membranes installed [1]. In addition to the membrane, the major components of a low-sloped roof system are structural deck, thermal insulation and, in some cases, a vapor retarder.

Although the majority of the installed low-sloped roof systems have performed acceptably, experience has shown that premature failures often occur. Griffin [2] has indicated that roofing deficiencies constitute a major problem for industrial and commercial buildings. A 1983 survey of building owners, including private companies as well as state and local government agencies, found that roof leaks were one of the most common problems experienced with buildings [3]. Cash [4] has reported that, although built-up membranes are often referred to as having a twenty year service life, membranes fabricated with organic felts have no greater than a 50 percent probability of lasting 20 years before replacement is needed.

Low-sloped roof systems are complex, and the component materials should interact compatibly to achieve successful performance. According to Griffin [2], factors contributing to premature roof failures may be listed as follows:

- o The extraordinary rigors of roof-performance requirements
- o Proliferation of new materials

- o Complexity of roof-system design
- o Expanding roof dimensions
- o Field application deficiencies
- o The modern trend toward more flexible buildings

The design and construction of any low-sloped roof system should include a consideration of the factors listed above.

It has long been recognized [5] that four essential elements contribute to assuring acceptable roofing performance: (1) sound design, (2) suitable materials, (3) good workmanship, and (4) proper and timely maintenance. Thus, the construction and long-term performance of a low-sloped roofing system involves numerous steps and interactions between various professions. This is illustrated in figure 1 which shows the steps in the process, factors contributing to the successful completion of each step, and the parties involved in the process. As is evident from figure 1, as the construction process moves from the design stage (including materials selection) through installation and completion of the roof, the factors to be considered vary considerably. For example, the design factors concern performance, durability, material compatibility, costs, and performance criteria and standard specifications for materials. In contrast, during construction the emphasis shifts to logistics, application and installation methods, workmanship, and on-site quality control of construction practices. Finally, the completed roof must be properly maintained over its service life.

QUALITY ASSURANCE OF ROOFING

THE CONSTRUCTION AND SERVICE CYCLE

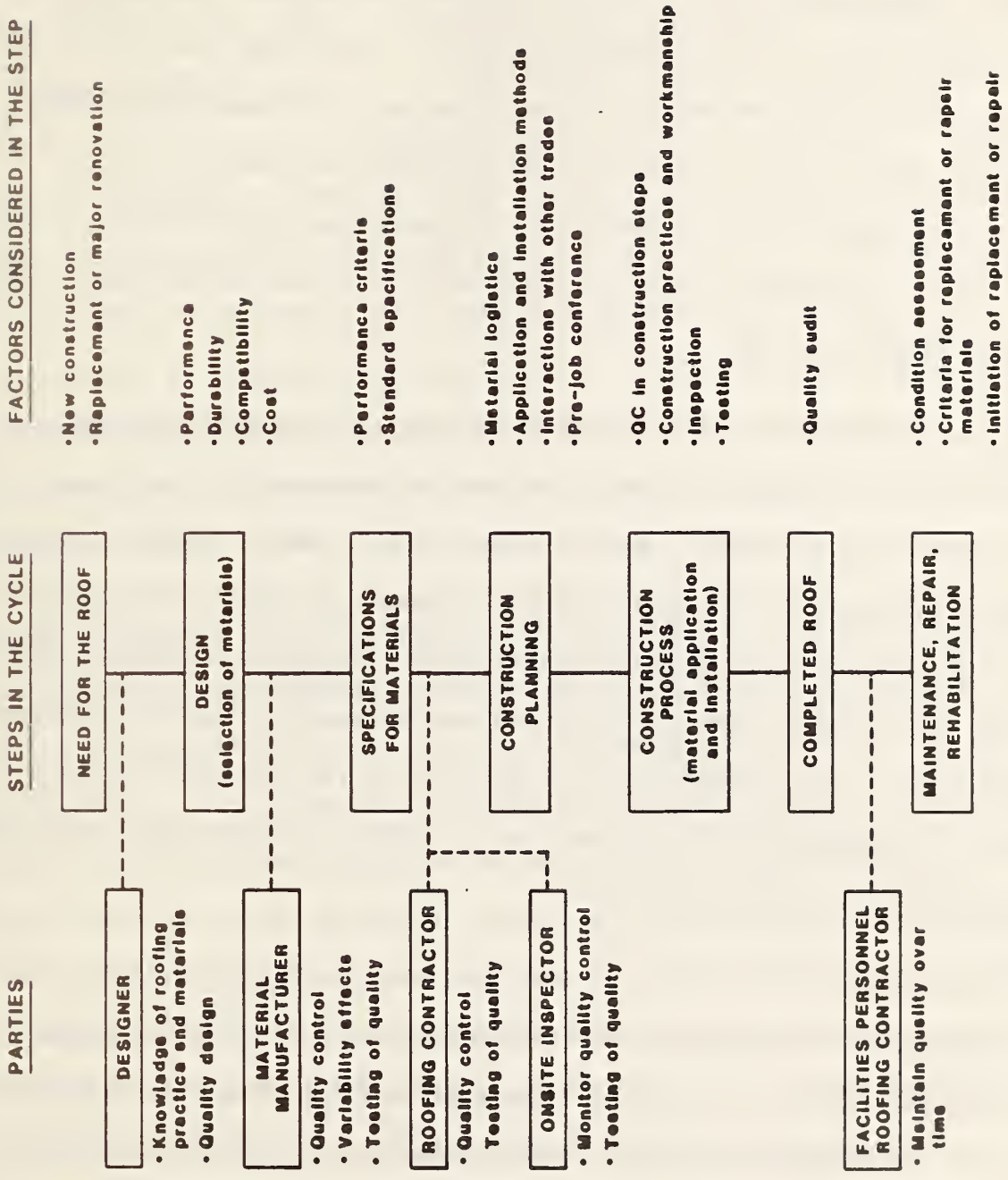


Figure 1. Quality Assurance of Roofing - A Diagram of the Construction and Service Cycle of Roofs, the Parties Involved, and the Steps in the Cycle.

The professions of the parties who contribute directly to the roof construction process vary widely. They include designers (e.g., architect, engineer, roof consultant), material manufacturers, the roofing contractors, the on-site inspectors, and building maintenance personnel. In addition, the general contractor and various sub-contractors are involved. Although the knowledge, experience, and expertise of each of the parties may be specific to their own area of responsibility, it cannot be overlooked that they form part of the total process. Coordinated interactions between these professions must occur to have successful roofing.

Although the professions and factors contributing to successful completion of each step in the roofing construction process and service cycle vary widely, an examination of figure 1 shows a common link: namely, quality must be considered and ensured at each step of the process. If error is introduced into any of the steps, the risk of unsatisfactory long-term performance will increase. For example, good materials and good workmanship will not overcome a design error. When considering the complexity of the process, it is not difficult to understand why low-sloped roof systems have experienced unacceptably high incidences of premature failure.

It is often stated that roofing failures are system failures, resulting from poor combinations of materials, lack of understanding of the roof assembly as a multi-component system, or improper field practices [6]. The roofing industry has long been considered as being fragmented among the various professions which contribute to the construction and service cycle. No single profession involved has taken total responsibility for the job. This limited responsibility or fragmentation among professions was described in a report issued

by the U.S. General Services Administration (GSA) in 1970 as "compartmentalized responsibility" [6]. The description was intended to imply that none of the parties involved, e.g., owner, architect, general contractor, roofing contractor, and materials manufacturer, was in a position to control the entire design and construction process. In examining reasons for premature roofing failures, the GSA report indicated that the lack of total control among the professions in roof construction was a significant factor. Based on that examination, it was recommended to GSA that a roof management program be established [7]. Roof management is the process whereby proper control and responsibility are assigned for every phase of the construction process including design, construction, and maintenance, and steps are taken to assure that the control is exercised fully.

Although the concept of roof management for low-sloped roofing is not new, it has not been put into widespread practice in the United States. Recently there has been increased interest in roof management programs. In the most notable example, the U.S. Air Force initiated a program in the late 1970s [8]. A number of private organizations which own and operate many buildings at numerous locations across the United States have also initiated roof management programs. This report presents the results of a study reviewing roof management programs in the United States and discusses the major elements comprising roof management programs. A benefit of the study for the National Bureau of Standards (NBS) was assistance in identifying roofing research needs.

This study was conducted at the request of the U.S. Postal Service (USPS) which is among the Nation's largest users of buildings with an inventory of over 30,000. The total roof area of the buildings used by USPS is estimated to be

about 200 million square feet. The majority of these buildings are protected with low-sloped roofing systems. Like many organizations with a large stock of buildings and high incidence of roofing problems, USPS has serious concerns about roofing performance. A conservative estimate of USPS annual roofing costs is for new construction, repair, and replacement \$30 million. A roof management program, aimed at improving the performance of USPS roofing, offers potential for significant savings in roofing costs through increasing roof service life.

1.2 Objectives

Because of the potential cost savings and performance benefits to be gained through the development and implementation of a roof management program, the USPS requested the National Bureau of Standards (NBS) to study the content and effectiveness of some current roof management programs. This report describes the results of the study. The objectives of the report are to identify the essential elements of an effective roof management program and to review current roof management programs conducted in the United States by both private and public sector organizations.

1.3 Scope of the Study

This report describes one phase of a two-phase study undertaken to assist the USPS in improving its roofing performance. In the other phase of the study, a review of USPS roofing activities and practices was conducted. The results of the other phase are available in a report entitled "USPS Roofing Practices" [9]. A comparison of currently accepted roof management practices with the roofing activities and practices of the USPS will provide the basis for recommendations to improve USPS roofing performance.

Information concerning roof management programs was obtained primarily from discussions held with those knowledgeable in the field. The discussions were complemented by published information, although few reports are available on the subject of roof management. Contacts were made with building owner representatives, consulting architecture/engineering (A/E) firms, manufacturers, roofing contractors, and roofing technologists to determine the manner in which large organizations deal with the construction, maintenance, and repair of roofs. A review of the policies and procedures of several large organizations, public and private, was included. In general, the large organizations were multi-regional with large stocks of multi-purpose buildings such as the USPS. Examples of the contacts made are included in Appendix A.

The study was limited to low-sloped roofing. Steep roofing which is normally found on residential buildings, and to a lesser extent, on small commercial and industrial buildings was beyond the scope of the study. Significantly fewer problems are encountered with steep roofing as compared to low-sloped roofing. Also, the scope of work for the project did not include addressing economic considerations directly. However, they are extremely important when considering roof management, since a major reason for improving roof management is economics.

2. ROOF MANAGEMENT PROGRAMS

2.1 Purposes of Roof Management

A roof management program is defined as a set of procedures for assuring that roofing systems will perform as intended over their anticipated service lives. As stated by Bradford [10], a roof management program is put into effect with a view towards treating the roofs of buildings as a financial asset to the building owner and maximizing the benefits of good roofing performance.

Maximum benefits from an owner's investment in the roof will not be achieved if the roof fails prematurely whether due to poor design, construction, or maintenance. Within a roof management program, steps are taken to assign responsibility and control for all steps involved in the construction and service cycle of the roof. A roof management program is undertaken by an organization to fit its particular roofing needs, taking into consideration the organizational structure, number of buildings, their location and serviceability, and personnel.

2.2 Essential Elements

The elements essential of a roof management program are: 1) a roofing system criterion; 2) a quality assurance plan; 3) a quality control plan; and 4) assignments of responsibility.

1. Roofing System Criterion - This encompasses the selection of plans, specifications, standards, guidelines, and the like which are commensurate with the quality of the roofing system desired by the owner. The criterion considers the design, material, application, and perhaps, maintenance of a roofing system, as well as the costs associated with these factors. Whether or not maintenance is included depends upon the particular roof management program undertaken by the owner. As will be seen in section 3.3 of this report, certain roof management plans are confined to the design and construction phase of the roof; while others are limited to roof condition, maintenance, repair, and eventual re-roofing. In either case, documents should spell out directly, completely, and in easy-to-follow terms the roof system desired by the owner. If the owner wishes to use different types of

roof systems and materials, depending upon the given circumstances, reference to all allowable systems and materials should be included. Since changes in technology are occurring rapidly in the roofing industry, means should be provided to review and perhaps update the roofing system criterion periodically.

2. Quality Assurance - Quality assurance is a planned, systematic pattern of all actions required to provide confidence that the roof system will conform to the established requirements of the owner as defined by the Roofing System Criterion. It is the owner's mechanism by which the required quality is assured in each step of the roof construction and service cycle. The steps to be taken to assure quality must be defined completely and in detail. These may include actions such as review of design and drawings, certification, testing, and inspection. When quality assurance is achieved in design, materials, and construction phases of a roofing system, the end result is a high quality roofing system.

3. Quality Control - Quality control is the designer's, manufacturer's, and applicator's implementation of the quality assurance plan for each of their respective contributions to the roof system. Actions are undertaken to insure that the roofing system and its design, materials, and construction conform to the owner's requirements defined by specific items in the Quality Assurance Plan. In general, quality control is the responsibility of those parties who are conducting the various steps in the construction. However, in some roof management programs, quality control may be monitored by an owner's representative

who is a third party to the roof construction process. In this case, the parties who are conducting the various steps of the construction are not relieved of the responsibility to maintain acceptable quality control.

- 4) Assignment of Responsibility - The assignment of responsibility among the many parties contributing to the production of the end product (which is the completed roof) has a direct impact on the quality obtained. These responsibilities must be well defined from the initial stages to the end of the intended service life of the roofing system. Those who are assigned key responsibility must have the experience and training necessary to carry out their roles satisfactorily. The chain of responsibility between the individuals must be clearly defined. In some roof management programs, emphasis is placed on identifying a single source to have responsibility for assuring that the design, materials, and installation are satisfactory.

3. TYPICAL ROOF MANAGEMENT PROGRAMS

This section of the report presents a synopsis of roof management programs which are being conducted in the United States. The information is a synthesis of that obtained from discussions with personnel of organizations actively engaged in roof management (Appendix A). In collating the results of the various discussions held during the study, it became apparent that most of the organizations active in roof management were conducting programs which could be classified according to one of three modes of operation:

- 1) Total Roof Management - The program is intended to manage the entire construction process and service cycle of the roof including design, materials selection, application, and maintenance as well as quality control aspects.
- 2) Design and Construction Management - The program is intended to manage new roof construction, reroofing, and major renovation. The maintenance of the completed roof is not included.
- 3) Maintenance Management - This program is the complement of design and construction management in so far as it deals primarily with the maintenance and repair of completed roofs.

The major features of these three types of roof management programs are reviewed in the following sections. Table 1 illustrates the relationship between the type of roof management program and its applicable time span in the roof service cycle.

3.1 Total Roof Management

As mentioned above, total roof management concerns the entire service cycle of the roof from design through maintenance. Two major types of roof management programs have been identified: those in the public sector and those in the private sector. These are described in this section of the report.

3.1.1 The Public Sector - USAF Manual 91-36

The concept of total roof management is best typified by the program of the U.S. Air Force (USAF), described in USAF Manual 91-36, "Built-Up Roof Management Program" [8] which was published in 1980. Since then, major revisions

Table 1. Types of Roof Management Programs and the Time Span in the Roof Service Cycle for Which Each Type is Applicable

Roof Management Programs

Type	Time Span
1) Total Roof Management	Roof conception to end of service life
2) Design and Construction Management	Roof conception to acceptance of the built roof
3) Maintenance Management	Acceptance of the roof to end of service life

to the criteria for selecting thermal insulations have been made as reported by Courville and Kolb [11]. The USAF Manual is one of the most extensive documents written on the subject of roof management. Several major private corporations in the United States conduct roof management programs similar to that described in USAF Manual 91-36. The USAF Manual 91-36 was designed to be applicable to maintenance, repair, and replacement activities for built-up roofs on Air Force facilities. However the key concepts included in the manual have been applied to new construction as well as low-sloped roofing using other than multi-ply bituminous membranes.

The USAF Manual is divided into six chapters which outline the program. The topics are:

- 1) General Information Including Scope and Responsibility
- 2) Roofing Data Base
- 3) Rating the Serviceability of Existing Roofs and Treatment Alternatives
- 4) Repair Procedures
- 5) Design Including Specifications and Drawings
- 6) Construction Management

The contents of the six chapters are described in the following sections.

3.1.1.1 General Information Including Scope and Responsibility

The first chapter outlines the scope of the program, and sets responsibility for its development and operation. The scope of the program deals with two major areas:

- an in-house preventive maintenance area for cataloging and quantifying roof serviceability, and conducting roof repairs.
- an area dealing with contracts showing how to determine best solutions and prepare construction documents that define quality control and set accountability for suppliers in the process.

Program responsibility is assigned to two individuals at the facility level who have been designated as the roof engineer (RE) and the roof technician (RT). The roof engineer has responsibility primarily for developing a data base or inventory of existing roofing, inspecting and periodically rating the roofs, designing roofing projects, and verifying contractor compliance with the plans and specifications. The roof technician's responsibilities center around maintenance and include activities such as periodic inspection, the development of a list of repair materials and the proper techniques for in-house use. This chapter emphasizes the benefits of training, indicating that those knowledgeable with the program will be better able to accomplish the program objectives.

3.1.1.2 Roofing Data Base

This activity in the USAF roof management program concerns the development of a data base which includes the type, amount, and condition of roofing which must be managed. Tasks included in the development of the data base are:

- development of a listing of all roofs
- development of a roof inspection priority list and identification of problems on suspect roofs
- development of a folder (file) for each building which contains:

- a completed form summarizing essential information on the roof construction and its performance
- roof plan drawings
- inspection and condition-rating worksheets
- documents relating to work done on the roof such as work orders, contractors' submittals, construction records, contract specifications, test results, and the like.

Information in the data base is to be used to assure that needed repair and other work is conducted in a timely and acceptable manner. The data base is, of course, updated and revised as necessary.

3.1.1.3 Rating Existing Roofs and Treatment Alternatives

The chapter describes how to inspect and rate a roof to determine its condition and useful life. The inspection and rating are conducted jointly by the roof engineer and roof technician. Instructions for conducting the inspection and a list of needed equipment are given. The types of BUR roofing problems are clearly defined so that those involved in the solutions can communicate precisely.

During an inspection, a determination is made of existing problems, their severity and density (which considers the amount of roof area affected). Using the information from the inspection, a procedure is given for estimating the anticipated useful life of the roof. In developing the USAF program, it was realized that the rating system had a large subjective element. One purpose of the rating system was to provide a tool to identify needed repairs and establish priorities for completing them. Although the rating system was

insufficient for performance prediction it was considered to be a first step towards an objective, quantitative means for rating a roof. It was intended that the rating system should be revised as feedback from the inspections and ratings became available. It was recommended that once a roof was rated, re-rating should occur about 3 years later in normal circumstances.

The information obtained from the inspection and rating procedure is used to recommend needed work on the roof, whether repair or re-roofing. The alternatives described for such treatment are: (1) cold repair, (2) hot repair, (3) recover existing membrane, and (4) removal and replacement. The risks and benefits, as well as economic considerations, are discussed.

3.1.1.4 Repair Procedures

The authors of the USAF Manual recognized that substantial roof repair work on Air Force bases might be conducted by in-house personnel. Because of the importance of doing repair work correctly and promptly, the USAF roof management program devotes considerable detail to in-house repairs. The topics covered include basic roof construction, maintenance materials, and procedures for emergency and permanent repairs.

3.1.1.5 Design Including Specification and Drawings

This chapter concerns the development of contract documents for built-up roofing projects. It is primarily intended for the roof engineer who has responsibility for contracting work which will not be conducted in-house. However, it is emphasized that, if contract documents are to be prepared by an A/E firm, all the requirements given in the USAF Manual regarding specifications and drawings must be included as a condition of the A/E contract.

This chapter has three parts:

- o A discussion of the technical aspects of roofing including materials systems, and work practices.
- o The development of contract documents based on a master or standard specification.
- o The development of contract drawings based on a series of standard roof drawings and details.

The master specification is quite comprehensive, although limited in scope to built-up roofing systems. One author of the AF Manual indicated that this limitation is, for the most part, based on the concept that some built-up membrane material manufacturers will provide a warranty for the system, and not just the membrane. Items in the master specification include:

- o the construction contract including two items which are controversial within the roofing industry: (1) the appointment of a quality control inspector who is responsible to the contractor; and (2) an agreement that the contractor is responsible for fixing defects or problems with the roof for 5 years.
- o basic quality control requirements for the roofing including acceptable tolerances.
- o a listing of 23 quality control work items that the contractor or inspector must follow during construction.
- o a listing of materials and products acceptable for the contract and applicable standards.
- o execution of the work according to the requirements of the contract.

3.1.1.6 Construction Management

The final chapter of the USAF program deals with construction management. This reflects the belief that the successful completion of all construction projects requires an accurate understanding of the contract obligations by the parties to the contract. The contract obligations clearly define the roles and responsibilities of the parties involved in the contract. Thus, a chapter in the USAF Manual describes the basic concepts underlying the development of the master specification, particularly regarding quality control, inspection by the contractor-appointed quality controller, and the agreement by the contractor to fix leaks and defects for a five year period after completion of the job. In addition, the role of government inspectors is explained with regard to pre-construction conferences, auditing the contractor's quality control, and evaluating laboratory reports on test cuts taken during construction.

Paraphrasing the text in the Air Force Manual, the contractor is held responsible for installing the roof as specified in the contract. The government performs its own audits and tests to determine whether the terms of the contract are met. The USAF program includes the following provisions as part of the contract:

- o the manufacturer's requirements concerning materials, and where and how to install them; included is a certification that the manufacturer has reviewed the project requirements and indicates that the system is proper for the project.
- o minimum acceptable standards for materials.
- o a manufacturer's certification that the roof contractor is qualified to apply the material.

- o quality assurance provisions regarding the level of quality the contractor is to achieve during construction and methods to measure that level of quality; included here is the contractor appointed quality controller.
- o the authority of the government inspector.
- o mandatory sampling of the finished roof membrane, methods of testing penalties for nonconformance, and acceptance of the membrane.
- o the contractor's responsibility to repair leaks and other defects for 5 years.

The contractual obligations that the manufacturer review the project requirements concerning materials and certify that the contractor is qualified to apply them are steps taken to overcome the fragmented responsibility which historically has dominated roofing construction projects. These obligations are intended to identify a single source of responsibility for the design, materials manufacturer, and installation of the roofing. As stated in the USAF manual, "the manufacturer acknowledges that its products are put to their proper use." Appendix B includes a copy of the manufacturer's contract submittal which the USAF program requires for design review and contractor approval.

3.1.2 The Private Sector

Many organizations in the United States either own or lease many buildings of varying size and use across the country. Examples of these organizations are department stores; food chains; manufacturers of automobiles, building products, and textiles; and chemical producers. These organizations have concern for the performance of the roofs on the buildings they occupy. In many cases, the amount of roofing is considerable and the organizations realize that it is economically feasible to carry out roof management programs to minimize premature

failure and maximize the return in the monetary investment in the roofs. Contacts were made with several of these organizations to discuss their roof management programs and to learn their views and experiences concerning their program's successes, failures, advantages, disadvantages, and limitations. From the information provided by these organizations, it was seen that the roof management programs generally fall into one of two categories. The first type mirrors closely the concepts of the USAF program, although the actions taken to carry out the program may differ. The second involves contract not management whereby a firm contracts with the building owner to manage the owner's roofing.

3.1 2.1 Private Sector Programs Managed within the Organization

Private sector programs include the major elements of a roof management program: (1) a roofing system criterion, (2) quality assurance, (3) quality control, and (4) assignment of responsibility. In this regard, the salient features of the programs include:

- o Designation of individuals within the firm as being responsible for roofing. These individuals plan and coordinate major roofing activities, maintain a level of training and expertise, and often interact with roofing industry organizations such as ASTM, NRCA, (National Roofing Contractors Association) and RIEI (Roofing Industry Educational Institute). In many, but not necessarily all cases, these individuals utilize the assistance (through contractual arrangements) of roofing consulting firms.
- o Development of master specifications for the firm's specific roofing needs. Depending upon the company, the master specification may be

- broad in its reference to materials and systems, or it may be restricted to the use of materials and systems with which the organization feels comfortable, has extensive experience, and satisfactory performance. The master specifications are intended for use by in-house architects responsible for roof design, or for use as guidelines by contract architects and engineers performing design services for the organization. In the latter case, the individual responsible for the organization's roofing or the designated roofing consultant reviews the design to check that it is in accord with the master specification.
- Requirements that manufacturers of materials review the design specifications and drawings and indicate approval that the design is compatible with the intended use of the material. In many cases, the manufacturer is asked to provide a list of contractors approved for application of the material and eventual certification that the contractor who receives the bid is approved by the material manufacturers. As is the case with the USAF program, this aspect is intended to designate single source responsibility for the design, materials manufacture, and installation. In other cases, some private firms will only hire contractors whom they have found through experience to be satisfactory.
 - Guidelines for the selection of the materials used in their roofing. In most cases, the selection is based upon an in-house analysis of material properties and performance history.
 - Techniques for controlling the quality of the installed roofing. These techniques often include field inspection during construction,

provided either by an in-house inspector or a contract consultant, and sampling and testing of the installed membrane.

- Development of maintenance and inspection programs for the completed roof. In this case, unlike the Air Force program, necessary repair work identified during inspections is not normally handled in-house, but by roofing contractors. Sometimes, firms will have contractual arrangements with roofing contractors to provide routine inspection and maintenance.
- Contractual requirements. Some roof management programs in the private sector will incorporate contractual agreements (similar to those in the Air Force program) which delineate the responsibilities of all parties involved in the construction process.

3.1.2.2 Contract Roof Management

With this type of program, a firm such as a roofing material manufacturer or a consulting engineering company specializing in roofing provides, under contract and for a fee, complete roof management. In this case, the firm takes responsibility for design, construction, and maintenance and repair, and includes warranties to keep the roof leak-free and defect-free for periods of time ranging from 15 to 20 years. As an example, one roofing material manufacturer provides a warranty of 20 years for built-up roofing and 15 years for single-ply systems. In the type of program under the direction of a roofing materials manufacturer, the materials used to construct the roofing system (including membrane, insulation, and accessories) would generally be from the product line of the manufacturer. Thus, if the manufacturer's product line includes built-up and polymer modified bituminous membranes, and certain generic types

of single-ply roofing, there would be a choice of materials available to the owner. If the roofing products sold by the manufacturer do not encompass a wide range of materials, then the owner's choice may, of course, be limited. This approach to roof management by a materials manufacturer differs from the traditional role it has played in the roof construction and service cycle. Traditionally, the material manufacturer has taken responsibility for the quality of the materials only, and deferred responsibility for design and installation to the designer, and contractor, respectively. In this type of roof management program, the design is accomplished by architects or roofing specialists employed by the material manufacturer. Installation is done by roofing contractors under agreement with the manufacturer who also provides for construction inspection. The agreement between the manufacturer and contractor details the responsibilities and liabilities of the two parties regarding the installation, maintenance, and repair of the roof, as well as the in-service performance of the roofing materials. However, the material manufacturer has sole responsibility through a contract with the owner to assure that the roof performs as intended over its service life. Generally if a problem occurs with the roof, the owner would first contact the material manufacturer for its solution. It is intended that problems be fixed as quickly as possible regardless of which party was responsible for the problem. Such a determination of responsibility would be settled, with arbitration if necessary, after the repair is completed.

3.2 Management of Roofing Design and Construction

Roof management programs for roofing construction are also conducted by large organizations with multi-purpose buildings throughout the United States. In

many cases, these organizations have a construction division at the corporate level and located at the company's headquarters. The construction division is responsible for the organization's new construction and may, in some cases, be involved with major renovation and repair of existing buildings. It is the construction division which conducts the roof management program. In general, these types of roof management include the basic controls associated with the design and construction aspects of total roof management programs including:

- o designation of responsibility,
- o development of master specifications,
- o use of approved roofing contractors,
- o guidelines for the selection and limitation of materials, and
- o control of the quality of the installed roofing.

The major difference between a roof management program for new roofing construction and one of total management is that the new construction program has no elements of maintenance management at the headquarters level of the company. The construction division of the company has responsibility for the building up to the time construction is completed, and the building is then turned over to the appropriate division of the company for operation and maintenance. Thus, the maintenance of the roof becomes the responsibility of those using the building. The roof may or may not receive adequate maintenance but, in either case, those responsible for its proper design and construction are divorced from its maintenance.

3.3 Maintenance Management of Existing Roofs

This type of roof management is concerned primarily with the maintenance of roofs. As such, it complements a management program for new roof construction. However, it was often found that this type of roof management program was not directly connected to new construction management.

In recent years, there has been a growth in the number of firms which provide specialized maintenance management programs for building owners. One reason offered for this growth is that an increased number of building owners have become aware of the benefits of maintaining the serviceability of their roofs and maximizing the value of their investment in the construction of the roofing system.

An overview of the major steps which have been incorporated in maintenance management programs is summarized below. It is noted that most of the steps are comparable to those described for roof maintenance in the USAF Manual [8] or in the RIEI roof maintenance guidelines [12]:

- Make an inventory of the the number and type of low-sloped roofs which need to be managed.
- Identify the condition of each roof using a survey report which includes the results of visual inspections and test cuts. At this step, defects are also identified and options for repairs are recommended. The results of nondestructive evaluation (NDE) of the moisture content of the insulation may be included in identifying roof condition. The use of NDE methods in assessing roof condition is not consistent among all firms practicing maintenance roof management. At least one organization contacted purchased its own infrared thermography equipment and uses it routinely on every roof being evaluated. Other firms engaged in roof management only use NDE when it is believed that the roof condition cannot be adequately evaluated without NDE.

- Prepare an accurate small-scale roof plan. Repairs to be conducted on the roof may be identified on the plan. When a work order is drawn up for repairing the roof, the plan may be attached to help clarity with regard to areas of the roof to be repaired. A small roof plan may be readily copied for distribution to individuals involved with maintaining the roof.
- Prepare scale drawings of the metal and flashing details of each roof. The dimensions of the drawings should be exact so that, if replacement metal pieces are needed for repair, a sheet metal worker can make the replacements without a visit to the roof. (This step would not be necessary if accurate details existed.)
- Prepare a roof survey report which describes in narrative form the condition of the roof. Separate roof areas (for example, different levels of the building) are normally treated as single entities and have separate reports. The reports should use standard industry language for precision in communication.
- Complete a "budget" report for the roof. This report contains an item-by-item description of the problems and defects of the roof and an estimated cost for repairing them. The needs for maintenance repair and their costs are categorized as to the time frame when they are to be done. A common categorization includes the following: (1) immediate needs (those which must be done without delay to keep water out of the roof system and building); (2) short-term future needs (those which must be done soon to maintain and extend serviceability); and (3) long-term future needs (a subjective estimate of when the roof may need to be replaced). The budget report enables a comparison

of the cost of projected maintenance and repair versus replacement costs. It also provides a planning document for the orderly allocation of funds to complete needed repairs and replacement. It is intended that the budget report be revised and updated whenever the roof is surveyed or has work done on it. Budget reports are often maintained on computer-based data management systems.

- Prepare a master file on each roof. This file is used to follow the performance of the roof. It generally would contain the historical information regarding construction, designer, contractor, specifications, and drawings. Survey reports, work orders, repairs, roof plan, and similar documents would be maintained in the master file. If a master file were set up on an existing roof for which the historical information was not readily available, such information, in all likelihood, would be omitted because of the costs and time involved in searching for it. Some master files may contain an aerial photograph of the roof.
- Set up a bid package for necessary repairs and maintenance work to be done for each roof. The bid package provides the building owner with a determination of the costs of labor and materials, and a scope of the work which is to be done.

Roof maintenance management may be provided to an owner in three main ways. The owner may set up an in-house program to conduct all steps within the organization. In the second, an owner may contract with a firm which provides maintenance management services and have all maintenance and repairs done by the contracting firm. And in a third case, the owner may handle some maintenance

management activities internally and contract for others. In any case, the owner would designate someone within the organization as having the responsibility for roof maintenance. This individual should have basic training in roofing technology. Examples of the duties are:

- keep inventories of the roofs and records regarding maintenance, repair, and performance.
- schedule roof surveys (either in-house or by contract).
- coordinate survey reports with all involved in carrying out necessary repairs and assure that repairs are performed; schedule maintenance and repair in a timely fashion.
- prepare budget reports and submit them to those responsible for providing allocations.
- provide drawings and specifications for work to be done either in-house or by contract. If done outside, review the drawings and specifications for adequacy; assure that needed revisions are completed.
- arrange for the contractor and work with the procurement office so that materials and labor are obtained as intended.
- arrange, as necessary, for consulting assistance and laboratory testing.
- provide for on-the-job quality control during installation and acceptance of roof installation in the case of roof replacement.
- provide guide recommendations for techniques for use in the repair and maintenance of existing roofs.

4. DISCUSSION

4.1 Cost of Roof Management Programs

As mentioned earlier in this report, an analysis of the economic considerations of roof management programs was beyond the scope of this study. Nevertheless, it would not be attractive to a building owner to undertake a roof management program unless it was economically justifiable. Reports on the economics of roof management were not found during the course of this study. Discussions with those involved with roof management programs indicated that increased initial expenses were not quantified. Rough estimates of the added costs were often given in the range of about 5 to 25 percent of the conventional costs of new or replacement roofing construction. The added costs were described as varying depending upon the type and extent of the roof management. For example, individuals involved with the USAF program indicated there has been no appreciable increase in bids for the construction of Air Force roofing. They also indicated that the contractor may add 5 to 10 percent for the 5-year performance agreement. It was pointed out that a major contribution to the added costs due to roof management is the use of full-time inspectors or quality controllers during roofing installation. The review of a designer's specifications and drawings for conformance to the owner's requirements was often relatively low in cost. Those individuals who discussed the increased expense of roof management agreed that the added costs were beneficial in achieving improved roof performance.

4.2 Effectiveness of Roof Management Programs

As was the case with costs, reports are not available which document the effectiveness of roof management programs in providing improved long-term

roofing performance. The major source of information on effectiveness is the opinions of those practicing roof management who were contacted. They are very positive that their approaches to roof management have resulted in more trouble-free and longer-lasting low-sloped roofing systems. In particular, the representative of one national firm which has had a roof management plan akin to that of the USAF for 13 years indicated that roofs designed and constructed during that time have performed extremely well with few problems. According to roofing program director for this firm, the result of the roof management program "... has been zero roof failures and virtually cost-free maintenance" [13]. Before initiating its program, this firm had estimated that its built-up roofs were lasting, on the average, 12 years. Since the roof management program has only been in place 13 years, it has not been possible to compute a revised average lifetime, but it is clearly going to be well over 13 years.

Representatives of the U.S. Air Force and consultants responsible for assisting the USAF have also spoken favorably about improved roofing performance. Again, the evidence is anecdotal, since no studies of USAF experience have been reported.

The State of Illinois has been managing the design and construction of its roofing systems for about 4 years. The emphasis of its program is on control of design through review processes and installation through tight pre-qualification of roofing contractors. One representative of the program, when asked about the effectiveness, responded that "he could not say enough about how well it was working." It was indicated that premature failures in the first few years of a roof life have been avoided since initiation of the program.

In another case where testimony was provided on the effectiveness of roof management, the representative of a large national organization indicated that his firm used to manage new roof construction very effectively in the early to mid-1970s. However, because of the added costs associated with roof management and a downturn in the economy, the roof management program was allowed to slip away. Emphasis was then placed on first costs on roof construction and not long-term roof performance. In this case, the firm found that the performance of its low-sloped roofs deteriorated. Thus, it is presently considering a return to a roof management program for design and construction.

Fricklas [14] recently discussed the advantages of contract maintenance management. He indicated that such programs assure that roofs receive prompt and continuous attention, while relieving building owners of the worry of routine roof maintenance management. He also pointed out that it is difficult to measure the cost-effectiveness of such programs, but reported that in his opinion, there is a consensus that contract maintenance management is worth the costs involved. He endorsed the concept of contract maintenance management and suggested that such a program begin on a roof after the expiration of the roof warranty.

Although most discussions concerning roof management programs provide evidence of their effectiveness, the authors of this report have been associated with one poor experience with new roof management. In this case, the design and construction of a relatively large low-sloped roof ended in application of system which has not performed satisfactorily. A roofing specialist had been placed under contract to provide design assistance, review of specifications and drawings, and also full-time inspection during installation. Investigation

of the problem indicated that the roof in question experienced poor performance associated with design, materials selection, and installation practices, in spite of the use of the roofing specialist. This points out that caution must be exercised and that roofing consultants and specialists, selected to provide owners roof management assistance, should be carefully chosen after review of their qualifications.

4.3 Responsibility

4.3.1 Design and Construction

A key element of a successful roof management program is the assignment of responsibility to those involved in the roofing process. As mentioned earlier in this report experience has shown that, traditionally within the roofing industry, responsibility for design, construction, and maintenance of roofs has been fragmented among the parties involved. The fragmented responsibility has not been in the best interests of successful roof performance. In recognition of this fact, roof management programs attempt to define clearly the responsibility of each party before the construction begins, thus providing the control so that the owner will obtain the desired roof system with a minimum risk.

An owner normally assigns responsibility by one of two methods. First he may appoint an individual(s) in the organization to watch over the roofing program. For example, in the USAF program for design and construction, the role is filled by the designated roof engineer at the base level. The USAF also has an engineer assigned at each major command, as well as an overall coordinator for all AF roofing and structural problems. Second, the owner may hire a roof carry out the same duties or assist someone within the organization.

For roofing construction, the assignment of responsibility is primarily intended to assure that those conducting design, materials selection and manufacture, and application are clearly aware of the tasks which they are to carry out. The individual having the responsibility monitors the designer, materials manufacturer, and roofing contractor to assure that they complete their part in the process as intended by the owner and that the three parties fulfill their assignments compatibly. This is primarily done by the owner (or his representative) assuring that: the design is according to acceptable practice; the selected materials are compatible with the design; and the contractor has the experience and capability for installing the selected materials. This latter point is often taken into consideration by using contractors who have been "approved" by manufacturers for installing their materials. The success of this approach to control the quality of workmanship is, of course, very dependent upon the level of ability to properly install materials as determined by the manufacturer. Very often the roof management program incorporates full-time inspection of the installation.

A novel approach incorporated in some roof management programs requires by contract that the material manufacturer also review the design specifications and drawings. Then, upon review, the manufacturer certifies that its requirements for design are met or notes exceptions. It is also certified that, when the system is installed by an "approved" roofing contractor, the roof will perform as intended and a warranty will be issued for the system by the material manufacturer. Under this warranty, the material manufacturer will make, or be responsible for another party making, necessary future repairs to the roof for a specified period of time. In these cases, the system includes materials

from the deck up as certified in the design review: membranes, flashings, insulation, vapor retarder, fasteners and adhesives.

An example of this approach to tying together the design, materials manufacture, and roofing installation in a contract document is given in Appendix B. Included in the material manufacturers certification from the USAF Manual. This appendix also includes documents used by the State of Illinois: (1) the Roofing System Manufacturer's Certification (RSMC) and (2) the Roofing System Manufacturer's Warranty (RSMW). As described in the RSMW, the warranty is for ten years and includes the system from the deck up. Exclusions to the warranty include a provision that materials supplied by an entity other than the manufacturer are not included except where such materials were part of the specified roofing system certified by the manufacturer prior to bidding the roofing work.

Connecting design, materials, and installation by the material manufacturer certification of design review and installation is intended to provide the owner a single source of recourse in the event of future problems. The approach is controversial and not totally accepted by all material manufacturers. For example, in discussing the Illinois program with a state representative, it was indicated that not all manufacturers of roofing materials would participate in the program and sign the Illinois documents. Those who have signed include both built-up roofing and single-ply manufacturers.

One major manufacturer indicated that a manufacturer only has responsibility for roofing materials, and not design, installation, and other factors such as

misuse, and abuse. In the opinion of this manufacturer, the design and contracting professions have responsibility for those aspects of roof construction and it is not the intent of the manufacturer to remove that responsibility from them. Thus, this particular manufacturer will not, as a matter of policy, routinely sign the owner's certification. However, the manufacturer will sign the certification if, after review, it is found that the design meets the company's published specifications and recommendations. The manufacturer will only provide the warranty if it is also in line with the company's warranty policy for its materials and systems.

4.3.2 Quality Control During Roof Installation

Inadequate workmanship during roofing installation has often been cited as a major factor resulting in premature roofing failure. For example, the Federal Construction Council (FCC) found that the majority of responses to a questionnaire on roof performance issued to its members listed poor workmanship among the primary causes of premature failure of federal roofing projects [15]. As a result, the FCC recommended that "federal agencies should provide for very thorough inspection of roof installations to ensure strict compliance with project specifications." It is noted that this recommendation assumed that the project specifications were prepared in accordance with acceptable roofing practice.

The importance of adequate workmanship and the use of inspection during roofing installation has recently been emphasized by the Claims Coding Subcommittee of the American Institute of Architects (AIA) Architects Liability Committee [16]. This subcommittee reviewed many insurance claims regarding roofing and found that in nearly all of the claims analyzed, architectural inspection and

general-contractor control of the roof installation were neglected. As a consequence, the subcommittee recommended to the AIA that roofing specialists be used during construction, since most of the problems analyzed were believed to have been preventable, if an expert had supervised construction.

Consistent with the belief that poor workmanship is often responsible for premature failures, roof management programs involving design and construction often emphasize the need for quality inspection. In most cases, such inspection is conducted by the owner's representative who is a member of the company or a roofing specialist hired by the owner. Among those contacted during this study, almost all agreed that providing inspection during installation results in improved roofing. Third party inspection does not relieve the roofing contractor from his responsibility to apply the roof properly as specified.

It is also generally indicated that continuous, full-time inspection, can be costly. Moreover, in some cases involving the Federal or State governments, shortages of available personnel and budget restrictions prohibit the use of inspectors during installation. Considering these factors, in a different approach to providing inspection, the USAF roof management program developed the concept of the roof quality controller. Here, an individual is hired by the contractor and is designated by the contractor to monitor the installation quality. The quality controller has no additional activities regarding roofing other than the responsibility to assure that the customer receives what is required by the contract. The appointment of the quality controller is handled by contractual agreement between the roofing contractor and the Air Force. The roofing material manufacturer is not involved in this agreement. A copy of the submittal from the contractor is given in Appendix C. Note that

the quality controller has the authority, in principal, to order a job stopped if it is not proceeding in conformance to the contract specifications and requirements.

The assignment of responsibility to control installation quality by an individual hired by the roofing contractor is, as may well be imagined, a controversial subject in the roofing industry. The concept was developed on the basis that when an industry produces a product, it also provides in-house quality control of the product. On the roof, the roofing contractor is the "manufacturer of the roofing system," and thus, it is argued, should have the primary responsibility for quality control. Regarding the workability of the concept, one point of view is that it will not succeed. The contractor-appointed quality controller is too close to the contractor and thus must be biased to monitor the quality of the installation effectively. The situation has been equated to one where "the cat protects the mouse." On the other hand, some individuals connected with the USAF program indicate that the concept is workable and is working. They cite examples where the quality controllers have actually shut down roofing jobs until steps were taken to improve the quality of the installation.

Two major national organizations using a roof management program akin to that of the USAF also have used the contractor-appointed quality controller on installations for a number of years. Individuals from these companies related some experiences which had been satisfactory and some which had been disappointing. In one case, it was indicated that the concept worked where large industrial building constructions, including roofing, were underway. In these cases, the company had construction project managers available at the job site who were engineers and could keep control of the construction, including the roof. The

use of the contractor-appointed quality controller did not work in jobs where construction project managers were not involved. Both of these national organizations recently changed their method of conducting inspections during construction, because of the number of times that it did not work. The quality controller is now a person from an accredited laboratory and trained in roofing technology. The quality controller may still be hired by the contractor as part of the job contract but, under this program, reports to the owner or his representative. The quality controller is selected from an approved list assembled by the owner. In other cases, the quality controller is hired directly by the owner.

5. SUMMARY

This report reviews current roof management programs used by private and public sector organizations in the United States to help assure that low-sloped roofing systems will perform as intended over their intended service lives. In recent years, roof management programs have increased in popularity with building owners as awareness of the economic benefits of maintaining the servicability of their roofs increased. Three general types of roof management programs are identified and discussed. For the most part, the structure and format of these programs have not been formalized in publication. A notable exception is the USAF program. The three types of roof management program are:

(1) total roof management which treats the design, construction, and maintenance of new construction and existing roofing; (2) roofing design and construction management dealing with design and installation; and (3) maintenance management which considers the maintenance and repair of existing roofs. In addition to the roof management programs which have been developed and used by organizations

in both the private and public sectors, several companies have organized themselves to provide owners with either total or partial roof management assistance.

Four elements are essential to an acceptable roof management program. These are:

- 1) The Roof System Criterion - This determines the quality of the roofing system desired by the owner and deals with the selection of plans, specifications, standards, guidelines, and criteria.
- 2) The Quality Assurance Plan - This is the planned, systematic pattern of all actions required to provide confidence that the roof system will conform to the requirements of the Roof System Criterion.
- 3) The Quality Control Plan - This is the implementation of the Quality Assurance phase.
- 4) Assignment of Responsibility - This defines the individuals who are responsible for the tasks carried out in a roof management program.

Roof management programs are intended to provide the mechanism for the construction and maintenance of low-sloped roofing systems over their intended service lives. In principle, the tasks conducted to reach this goal are generic to all roof management programs. In practice, some roof management programs are broader in scope and activity than others. A reason for the limitation of some programs is the limited resources available to those conducting the program. Tables 2 and 3 present, respectively, a summary of the four essential elements of roof management and a summary of the activities associated with each for roofing design and construction, and maintenance and repair.

Studies have not been reported which indicate the added costs for design, construction, and maintenance of roofs associated with roof management programs. Estimates from individuals in the industry involving new construction with total roof management programs have been placed the cost increase in the range of 5 to 25 percent. A majority of those contacted in the study firmly believe that the benefits of roof management in improved roofing performance justify the added costs. The higher initial costs are believed by those contacted to result in improved roofing performance and considerable savings over the service lives of the roofs.

Table 2. Elements of Roof Management Programs and Associated Activities for Roofing Design and Construction or Renovation

Element	Sub-Element	Activity
1) Roof System Criterion (Materials and design)	o master specification	- implement in-house - adopt industry document - prepare guidelines for specific details such as slope, thermal resistance, placement of roofing top equipment, etc.
	o master details	- implement in-house - adopt industry documents
	o acceptable materials and systems	- prepare list of acceptable materials and limitations of use - conform to consensus standards - conform to industry standards
	o application	- prepare guidelines for acceptable application practice - hold pre-bid, pre-job, and pre-work conferences
	o final acceptance	- implement final inspection procedures
	o warranty	- obtain warranty that satisfied owner's requirements
2) Quality Assurance	o owner's requirements	- develop plan to assure that owner's requirements are satisfied
3) Quality Control	o design	- review specification including details
	o materials	- certification - testing
	o application	- handling and storage - inspection - sampling and testing
4) Responsibility	o roof system criterion	- assigned as appropriate for the activities listed for elements 1, 2, and 3
	o quality assurance	- assigned as appropriate
	o quality control	- assigned as appropriate

Table 3. Elements of Roof Management Programs and Associated Activities for Roofing Maintenance and Repair

Element	Sub-Element	Activity
1) Roof System Criterion	o condition assessment	- train personnel - implement instructions for conducting condition assessment - implement guidelines for assessing the condition of the roof - report condition of the roof including recommendations for maintenance or repair
	o repair and maintenance techniques	- select mechanism for maintenance and repair either in-house, or by contract - implement guidelines for carrying out satisfactory maintenance and repair
	o warranty	- obtain warranty that satisfies owner's requirements
2) Quality Assurance	o owner's requirements	- develop plan to assure that owner's requirements are satisfied
3) Quality Control	o procedures	- review maintenance and repair scope of work
	o materials	- assure that materials conform to appropriate specifications - assure that repair materials are compatible with existing roofing
	o workmanship	- assure that maintenance and repair are conducted in accordance with acceptable roofing practice
4) Responsibility	o roof system criterion	- assigned as appropriate for the activities listed for elements 1, 2, and 3
	o quality assurance	- assigned as appropriate
	o quality control	- assigned as appropriate

6. REFERENCES

1. Cullen, W. C., "Survey Compares Practices to Problems," *Roofing Spec* (October 1984), pp. 37-40.
2. Griffin, C. W., "Manual of Built-Up Roof Systems," 2nd Edition, McGraw-Hill, New York, Chapter 1 (1982), pp. 1-6.
3. "Opinion of Building Owners on the Construction Industry," Report to Wagner-Hohns-Inglis, Prepared by Fleishman-Hillard, Inc. (September 1983), 53 pages.
4. Cash, C. G., "Durability of Bituminous Built-Up Roofing Membranes," First International Conference on the Durability of Building Materials and Components, ASTM Special Technical Publication 691 (1980), p. 752.
5. Cullen, William C., Rossiter, Walter, J. Jr., Mathey, Robert G., and Clifton, James R., "Low-Sloped Roofing Research Plan," National Bureau of Standards (U.S.), Special Publication 659 (July 1983), p. 2.
6. "Roof and Waterproof Deck Systems Study," Report to the General Services Administration (U.S.), Prepared by Construction Consultants, Inc. (May 1970), p. 13.
7. *Ibid.*, p. 30.
8. "Built-Up Roof Management Program," Air Force Manual AFM 91-36, Department of the Air Force (3 September 1980).
9. Rossiter, Walter, J., Jr., Cullen, William C., and Mathey, Robert G., "USPS Roofing Practices," NBS Report, In Preparation.
10. Bradford, John, "Preventive Maintenance Can Help Extend Roof Life," *AIPE Facilities Management, Operations, and Engineering*, Vol. 11, No. 6 (November/December 1984), pp. 39-41.
11. Courville, G. E. and Kolb, J. O., "Economic Analysis of Insulation Materials Used in Low-Slope Built-Up Roof Systems," Oak Ridge National Laboratory, ORNL/TM-9004 (June 1984) p. 1-1.
12. "Roof Maintenance," The Roofing Industry Educational Institute, R-102 (1980), 27 pages.
13. Thomas, Rose, "The Pros and Cons of Roofing Consultants," *Building Design and Construction* (February 1985).
14. Fricklas, R. L., "Contract Maintenance -- Its Time Has Come," *Roofing/Siding/Insulation* (January 1985), p. 8.
15. "Low-Slope Roofing Problems," Transactions of the Federal Construction Council for 1979-80, Federal Construction Council, Washington, D. C., pp. 21-27.

16. AIA Memo, "Roofing Problems," (May 24, 1985), p. 2.

7. ACKNOWLEDGMENTS

This study was sponsored by the United States Postal Service (USPS), Design Management Division, Real Estate and Buildings Department. Mr. Warren L. Walker, Project Manager, USPS, provided technical liaison between NBS and USPS. His assistance and encouragement during the course of the study were appreciated. The authors also acknowledge with thanks those individuals in the roofing industry who gave their time to discuss the elements, concepts, and functions involved with conducting roof management programs.

Special thanks are given to those individuals who took time to provide valuable comments and suggestions regarding this report: J. Bradford (Bradford Roofing and Insulation), G. Frohnsdorff (NBS), D. Furman (USAF), H. Marien (USAF), F. Potasnik (Construction Consultants, Inc.), and E. Schrieber (Construction Consultants, Inc.). Finally thanks are expressed to J. Clifton (NBS) for his assistance in developing the diagram on the roof service cycle.

APPENDIX A. ORGANIZATIONS CONTACTED REGARDING ROOF MANAGEMENT

This appendix includes a listing of organizations contacted during the study regarding roof management. The organizations were selected based on the experiences of the authors of this report. Some of the organizations owned many multi-purpose buildings located across the U.S. and had initiated programs of total management of design, construction, and maintenance. Other organizations concentrated on a limited area such as maintenance management. Also, some of the organizations listed here were not owners of buildings, but rather firms which provided a roof management service. Information obtained during discussion with individuals representing the organizations listed formed the basis for the information presented in this report.

- Armstrong International
- Baltimore County Public Schools, Maryland
- Berrymen and Associates, Advanced Roof Management
- Bickerdike Allen Partners (United Kingdom)
- Bradford Roof Management
- Charles Brandt Goldsmith and Associates
- Construction Consultants, Inc.
- Eastman Kodak
- E. I. du Pont de Nemours
- General Motors Corporation
- Manville Products Corporation, National Accounts Group
- Montgomery County Public Schools, Maryland
- Montgomery Ward
- Owens Corning Fiberglas Corp.
- Proctor and Gamble

- Prospect Industries
- Roof Engineering, Inc.
- Safeway Stores
- Sverdrup and Parcel
- State of Illinois
- U.S. Air Force

APPENDIX B. EXAMPLE OF CONTRACT DOCUMENTS USED IN NEW ROOFING MANGEMENT

This appendix contains some documents used in the design, construction, and procurement of roofing. The documents are presented for illustration purposes only. Included is a copy of the material manufacturer's certification regarding design review and contractor's approval which has been taken from the USAF Manual on Roof Management. Two other documents used by the state of Illinois are also given. They are entitled, "Roofing System Manufacturer's Certification (RSMC)" and "Roofing System Maufacturer's Warranty (RSMW)".

SUBMITTAL 1

BURS Manufacturer Certification:

The following statement is required from each BURS Manufacturer:

_____ (Name) is accredited as
an authorized and approved applicator of our roofing system.

We have reviewed the project requirements in the contract;
Reference, Project No.: _____ and believe our system or sys-
tems are proper for this project. Our system or systems most
suitable for the buildings in this project are:

<u>Building Number</u>	<u>Roofing System Designation</u>
(From the contract)	(As appropriate for each building)
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

BURS Manufacturer Firm Name _____

Address _____

Authorized Representative's Signature _____

Printed or Typed Name _____

Date _____



CAPITAL DEVELOPMENT BOARD
 3rd. Floor, Wm. G. Stratton Bldg.
 Springfield, IL 62706

RSMC

Roofing System Manufacturer's Certification

Date: _____

TO: Architect/Engineer

CDB Project No. _____

Title _____

Location _____

CDB Proj. Mgr. _____

Our technical staff has examined the Architect/Engineer's drawings, specifications and required warranty for the roofing work on this project.

We do not wholly or partially endorse the building design or any materials or services not part of our advertised roofing system.

CERTIFICATION

We hereby certify that:

1. All materials we will furnish and deliver to the project will be of good merchantable quality, will meet or exceed the specification requirements and will, if properly applied by one of our approved roofing applicator firms in accord with our instructions, provide a sound weather/watertight roofing system.
2. Upon completion of the installation in accord with the drawings and specifications and our recommended installation procedures, we will issue the warranty specified in the project specifications, Roofing System Manufacturer's Warranty, CDB Form RSMW. (Attached)
3. The drawings and specifications follow the recommendations of our roofing manual for this type of roofing system with:
 - No exceptions.
 - The following exceptions: (Approval will be given upon correction of documents in accord with these recommendations.)

ROOFING SYSTEM MANUFACTURER _____

By: _____

Title _____

Date: _____

Direct Dial Telephone Number: () _____

cc: Manager, Technical Services, Capital Development Board, 3rd Flr. Wm. G. Stratton Bldg. Springfield, IL 62706

CDB-RSMC-16 NOV 81



State of Illinois
CAPITAL DEVELOPMENT BOARD
 3rd. Floor, Wm. G. Stratton Bldg.
 Springfield, IL 62702

RSMW

Roofing System Manufacturer's Warranty
 Effective Date: _____

Roofing System Manufacturer: _____	CDB Project No. _____
Name: _____	Building Owner _____
Address _____	Owner Address _____
Roof Area _____	Building Name _____
Roof Specification _____	Building Address _____
Lin. Ft. Flashing _____	Rofer Name _____
Lin. Ft. Expansion Joint Covers _____	Address _____
Insulation Type _____	Telephone _____

I. WARRANTY

A. The Roofing System Manufacturer, identified as _____
 _____, a _____ Corporation
 with its principal office at _____

he "Manufacturer" warrants to the Building Owner named above, hereinafter called "Owner" that, subject to the provisions of this document, the Manufacturer will, as its owner expense, make or cause to be made all repairs necessary to maintain the roofing system in a watertight condition for a period of ten years from the date of accepted substantial completion of the roofing system.

B. System includes:

1. Membrane(s).
2. Flashings (except metal or composite metal components not furnished by the Manufacturer as part of its advertised system).
3. Insulation.
4. Vapor retarder.
5. Fasteners and adhesives.

C. Limitation: The Manufacturer's liability under this Warranty shall be limited to (\$ _____) which is the Owner's original cost of the installed roofing system.

II. OWNER'S RESPONSIBILITY. The Owner will notify the Manufacturer if repairs covered by the Warranty are required. The notice will be sent by Certified Mail, return receipt requested, to the Manufacturer's office specified in the Manufacturer's Maintenance Manual within 30 days of discovery of leaks or other defects in the roofing system. The Owner will provide the Manufacturer free access to the building during regular business hours over the life of the Warranty. The Owner acknowledges that the Manufacturer has provided its Roofing Maintenance Manual, including instructions necessary for the Owner to inspect and maintain the roofing system during the warranty period.

III. EXCLUSIONS.

A. The following are excluded from this Warranty:

1. Roof maintenance for corrections of conditions other than leaks.
2. Damage to any part of the building (other than the roofing system) or to its contents.
3. Damage resulting from repairs made to the roofing system without the Manufacturer's prior authorization.
4. Damage resulting from any one of the following:
 - a. Settlement, expansion, contraction, cracking, warping, deflection or movement of roof deck, walls, coping structural members or building foundation.
 - b. Natural disasters (i.e., windstorm, hail, flood, hurricane, cyclone, lightning, tornado or earthquake).
 - c. Changes in building usage; new installations on, through or adjacent to the roofing system made after the effective date of this Warranty, unless the Manufacturer has given prior written approval of such changes in building usage or new installations.
 - d. Accidents, vandalism or other uncontrollable events.
 - e. Lack of positive drainage (standing water) except where the Manufacturer has certified acceptance of standing water as part of the roofing system design.
 - f. Chemical attacks on the membrane from sources unknown or not present at time of roofing system installation.
 - g. Falling objects, misuse or abuse of the roofing system, traffic, recreational activities or storage of material on the roofing system.
 - h. Infiltration or condensation of moisture in, through or around walls, copings, building structure or underlying or surrounding areas.
 - i. Movement or deterioration of metal components adjacent to the roof (except where such components are a part of the Manufacturer's advertised roofing system).
 - j. Failure of materials supplied by others (except where such materials are a part of the specified roofing system certified by the Manufacturer prior to bidding the roofing work).
 - k. Tests of test cuts not authorized by the Manufacturer.
 - l. Failure of the Owner to provide maintenance in accord with the Roofing Maintenance Manual.
 - m. Failure of the Owner to notify the Manufacturer of leaks or other defects within 30 days of discovery.

B. THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED.

In Witness Whereof, Manufacturer and Owner have caused this Warranty to be duly executed on the above date.

MANUFACTURER

OWNER

By _____

By _____

Title _____

Title _____

Date _____

Date _____

APPENDIX C. REPRINT OF THE AIR FORCE QUALITY CONTROLLER APPOINTMENT FORM

The U.S. Air Force in its roof management program uses a contractor-appointed quality controller to monitor the quality of the roofing installation. The contractor identifies the quality controller through a submittal to the Air Force which accompanies the work contract. This appendix includes a copy of that submittal form.

SUBMITTAL 2

Appointment of Quality Controller:

_____ (Name) is appointed as quality controller on Project _____ with the authority to regulate the quality of the work so that it conforms to the contract. The quality controller is authorized to order discontinuance of any operation causing non-conforming work and is directed to report to an officer of this firm. The quality controller is not subordinate to the foreman, job superintendent, or project manager.

The quality controller is a registered roofing journeyman or has at least 5 years prior experience in the supervision and inspection of BURS construction similar to that required in this contract. The quality controller understands all requirements of these specifications.

Name of Firm _____

Address _____

Telephone _____

Authorized Representative's Signature _____

Printed or Typed Name _____

Date _____

I acknowledge receipt of this letter.

Quality Controller's Signature _____

Printed or Typed Name _____

Date _____

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET <i>(See instructions)</i>	1. PUBLICATION OR REPORT NO. NBSIR - 85 / 3239	2. Performing Organ. Report No.	3. Publication Date DECEMBER 1985
4. TITLE AND SUBTITLE <p style="text-align: center;">Roof Management Programs</p>			
5. AUTHOR(S) <p style="text-align: center;">Walter J. Rossiter, Jr., William C. Cullen, Robert G. Mathey</p>			
6. PERFORMING ORGANIZATION <i>(If joint or other than NBS, see instructions)</i> NATIONAL BUREAU OF STANDARDS DEPARTMENT OF COMMERCE WASHINGTON, D.C. 20234		7. Contract/Grant No.	8. Type of Report & Period Covered
9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS <i>(Street, City, State, ZIP)</i> U.S. Postal Service Design Management Division Real Estate and Building Department Washington, D.C. 20260-6415			
10. SUPPLEMENTARY NOTES <input type="checkbox"/> Document describes a computer program; SF-185, FIPS Software Summary, is attached.			
11. ABSTRACT <i>(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)</i> <p>Roof management programs are used by private and public sector organizations in the United States to help assure that low-sloped roofing systems will perform as intended over their intended service lives. This report reviews those programs. Three general types of roof management programs are identified and discussed. For the most part, the structure and format of these programs have not been formally published. A notable exception is the U.S. Air Force program. The three types of roof management program currently conducted are: (1) total roof management which treats the design, construction, and maintenance of new and existing roofing; (2) new construction management dealing with design and installation; and (3) maintenance management which considers the maintenance and repair of existing roofs. Four elements are considered essential to an acceptable roof management program: (1) the roof system criterion, (2) quality assurance, (3) quality control, and (4) responsibility. In addition to the roof management programs that have been developed in the private and public sectors, several companies have organized to provide owners with total or partial roof management services. Although the increased roofing costs associated with new construction and total roof management programs have not been studied, estimates for such programs range from increases to 5 to 25 percent above the costs for roof construction without management. Many individuals in the industry using roof management programs believe that improved roofing performance results and that the increased costs are justified.</p>			
12. KEY WORDS <i>(Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)</i> construction; design; low-sloped roofing; maintenance; management; review; roofs			
13. AVAILABILITY <input checked="" type="checkbox"/> Unlimited <input type="checkbox"/> For Official Distribution. Do Not Release to NTIS <input type="checkbox"/> Order From Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. <input checked="" type="checkbox"/> Order From National Technical Information Service (NTIS), Springfield, VA. 22161		14. NO. OF PRINTED PAGES <p style="text-align: center;">61</p> <hr/> 15. Price <p style="text-align: center;">\$ 9.95</p>	

