

QUALITY ASSURANCE FOR BUILT-UP ROOF CONSTRUCTION

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Quality assurance for roofing, like health and safety, is an extremely important subject but is not often addressed in the technical literature. This paper reviews a current U.S. Air Force quality assurance program dealing with the application phases of built-up roofing. Further, it gives the advantages and limitations of the quality assurance/quality control process with respect to the performance of the roofing system. Next, it deals with common problems of built-up roofing and how they are related to quality assurance measures. Finally it suggests some of the essential elements in planning a quality assurance program and, more importantly, it emphasizes realistic, sound procedures for implementing the plan through the quality control process during application.

QUALITY CONCEPTS

The quality of a roofing system is the ability of the system to perform as intended for its projected service life under in-service conditions. Simply stated quality means "fitness for use".¹

Quality assurance is defined as a planned, systematic pattern of all actions required to provide adequate confidence that a roofing system will conform to established requirements.

Quality control is the implementation of the quality assurance plan by actions necessary to bring the roofing system into conformance with established requirements.

In brief, quality assurance is the plan; quality control is the implementation of the plan.

The application of these concepts to roofing through sound, realistic quality assurance programs relating to the material, design and application aspects of the roofing process will result in improved roofing performance. Conversely, overly strict quality control practices, as evidenced by some now in use in the United States, which demand precision and accuracy greater than is possible at the present state of the technology, may have a strongly negative impact on roof performance. These positive and negative aspects will be developed.

PROBLEM CONSIDERATIONS

Quality assurance is largely problem-driven so we must begin by surveying the problems that occur in built-up roofing in some detail. Next we respond to the problems on which, we believe, a significant impact can be made through quality assurance programs. The 1983 "Project Pinpoint" results² of the National Roofing Contractors Association reporting on some 500 problem roofs indicated that membrane splitting accounted for about 20 percent of all defi-

ciencies reported. Membrane blistering was reported on 15 percent of the problem roofs. Wind blow-offs and flashing deficiencies ranked at approximately 5 percent each, followed by membrane slippage. A large proportion, 48 percent of 500 problem jobs, were reported as experiencing a combination of two or more deficiencies. Problem identification is relatively easy but cause and, hence, elimination is more difficult to establish.

Premature deficiencies in roofing systems such as those reported can often be traced to the material, design, application and maintenance aspects of roofing. The divided responsibility among the designer, materials manufacturer, contractor and owner is a contributing factor. The responsibilities of each party must be considered in the quality assurance plan. Unfortunately, the blame for problems is often shifted (finger-pointing) from one party to another. It might be well if each responsible party would apply the old axiom, "When looking for fault, use a mirror, not a telescope."

Roofing deficiencies can have a positive effect on roofing performance through the quality assurance plan. The identification of on-the-job problems and the establishment of their causes through research often leads to improved material standards and job specifications as well as application techniques. Improved standards and specifications monitored by realistic quality control procedures in all phases of the roofing process results in improved roofing performance.

ESSENTIAL ELEMENTS OF A QUALITY ASSURANCE PLAN

Adequate material standards; design and application specifications commensurate with strength, safety and durability of the roofing system; and quality control to bring the roofing system into conformance with established requirements are the essential elements of a quality assurance plan.

ASTM develops and promulgates consensus standards for most materials and components of the built-up roofing system from the structural deck to the mineral aggregate used to surface the roof. It is generally agreed that these, like most consensus standards, are minimum standards and should be considered as such.

Roofing material manufacturers publish recommended specifications for the design and application of their materials in a roofing system. The NRCA published *The NRCA Roofing and Waterproofing Manual* in 1980, the most comprehensive document of its kind in the area of application procedures.³ It covers areas of roofing materials application and includes some 16 arrangements for the more

conventional roofing systems as well as 26 construction details which have a history of good performance. A revised edition is expected to be available in 1985. In 1981 NRCA published the *Handbook of Accepted Roofing Knowledge (HARK)*.⁴ The document is intended to provide guidance in good roofing practice to all segments of the industry. It contains information pertinent to the material, design, application and inspection (quality control) phases of the roof construction process. The basis of the document is the consensus opinion of NRCA member roofing contractors throughout the United States.

The National Bureau of Standards suggested preliminary performance criteria for bituminous membrane roofing in 1974.⁵ This document defines the performance requirements of multi-ply bituminous membranes in quantitative terms without reference to materials or how they are manufactured or applied, a first step in the application of the performance approach for the U.S. roofing industry. Although it is frequently used and referenced throughout the world, the criteria have not been generally accepted, especially by some of the manufacturing segment of the industry.

In 1983 the Asphalt Roofing Manufacturers Association (ARMA), the trade association of bituminous roofing material manufacturers, undertook a difficult and challenging task to develop a "Built-Up Roof System Performance Standard." It is an attempt to define the performance of the complete roofing system in terms not related to materials or how they are manufactured and applied. The deck, vapor retarder, thermal insulation, membrane flashings, as well as requirements for the whole roofing system are to be included. When it becomes available this document will provide another giant step forward in performance-oriented standards for roofing technology in the United States.

In 1983 the Midwest Roofing Contractors Association (MRCA) published recommended performance criteria for roofing membranes using polymer-modified bituminous products.⁶ This document contains a mixture of prescriptive and performance requirements defining various classes of available materials in terms of both their physical properties and performance characteristics.

The above standards, specifications and guidelines are but a few examples of the wealth of technical information that is available to define and specify bituminous roofing systems which will perform adequately for their intended service lives. Therefore, it appears that the first essential elements toward consummating a good quality assurance plan for quality roofing are readily available to the roofing community of the United States.

The implementation of the plan comes through the quality control phase, which insures that the specified requirements of the plan are met.

QUALITY CONTROL

In 1980 the U.S. Air Force defined the "Built-Up Roof Management Program"⁷ which covers several areas in providing roof construction quality assurance, including a master specification for design assurance, a contractor QA plan which stipulates responsibilities and accountabilities and the owner's (USAF) quality assurance functions. In 1981 Berryman and Toriello⁸ presented a detailed description of the USAF program to an international audience in Brighton, England. The plan is perhaps a model plan except

for certain controversial aspects which detract from its usefulness in completely fulfilling its intended function to provide serviceable, economical, quality roofing systems.

Among the more controversial issues is the restrictiveness relating to acceptable materials as implied by the master specification. For example, the program stipulated the exclusive use of fibrous glass insulation and, for flat roof, coal-tar membranes. This appeared to be an arbitrary and capricious decision on the part of the USAF which often resulted in higher material costs with little if any improvement in performance of the end product. This opinion (the authors) was substantiated by an ORNL study sponsored by the USAF⁹ which recommended that the Air Force consider the use of all insulations judged in the study to be competitive on a qualified basis. For economical reasons it would be prudent for the Air Force to adopt this recommendation. Next, the inclusion of low-slope roofing asphalt (ASTM D-312, Type I and II) as optional materials to the coal tar products should be considered by the USAF as a further step toward reduced roofing cost through the competitive bidding process without sacrificing in-service performance of bituminous built-up roofing. This suggestion is based on strong arguments resulting from the performance history of "low-slope" asphalts as compared to coal tar products as pointed out by the author in 1982.¹⁰ This observation was further substantiated by an analysis of problem job data from NRCA's "1983 Project Pinpoint" survey which indicated that equal, if not better, performance was obtained using asphalts rather than coal tar products.²

The quality control portion of the USAF roof management program also has several controversial issues which should be addressed and clarified. These involve the USAF definition of what I believe to be unreasonable application tolerances. First, the sampling procedure involving a small test cut is, in all probability, not representative of any one day's application because of the many variables, both human and environmental, that are encountered on the job. A case in point involves the results of a Koppers Co./NRCA joint field research program to study the relationship between bitumen temperature and viscosity and weight of bitumen applied under closely controlled conditions. This study clearly demonstrated that it is highly unlikely that one could meet the USAF interply mopping weight tolerance of plus or minus 15 percent.¹¹ Further, the highly scientific approach to laboratory analysis and reporting on samples is not appropriate for evaluating built-up roofing. The precision and accuracy of such an analysis has not been established and any conclusions drawn on this basis are highly questionable. One must always remember that built-up roof application is still an art, not a science, and must be treated as an art in every aspect of a good quality control program.

The contractor segment of the industry has the expertise to define realistic variations to be expected under normal application practices. NRCA has published the results of a two-year effort describing anticipated variations in the construction of built-up roofing membranes.¹² The major conclusion categorically stated that "the most effective means to evaluate quality installation is by thorough, continuous, visual examination at the time of application, conducted by a competent inspector, knowledgeable in roofing technology and good workmanship practices." Further, the document states that test cuts are an unrealistic basis for drawing conclusions about the entire roof. However, when test cuts are

required by job specification NRCA recommends the sampling be done in accordance with ASTM method D 3617-83,¹³ which calls for an on-site, field evaluation before surfacing bitumen and aggregate are applied. NRCA strongly feels that ASTM method D2829¹⁴ should not be used to evaluate the quality of workmanship as it is predominantly based on laboratory analysis, the precision and accuracy of which has never been published.

COMMENT

A sound, realistic quality assurance program involving material consensus standards, proven specification and adequate on-site quality control measures will result in improved roof performance to the benefit of all parties involved. However, overly strict quality control procedures involving few test cuts and laboratory analysis which demand precision and accuracy greater than is attainable at the state-of-the-art may well have an adverse effect on roofing performance. The USAF built-up roof management plan has a bit of flavor of each of these viewpoints. On the positive side, the NRCA and others are working with the USAF to bring them the benefit of contractor experience in roof application and performance to their roof management program. When the differences are resolved through compromise, I am confident that the "USAF Built-Up Roof Management Program" will be a Model Quality Assurance program for the roofing industry to emulate. Until this occurs, our experience indicates that quality of application should be judged on: 1. on-site observation, 2. visual inspection and on-site measurement of test-cuts as outlined in ASTM method D3617¹³ when job specifications call for test cuts, and 3. sound engineering judgment.

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