Summary

New roofing systems, including those using single-ply polymeric and polymer-modified bituminous membranes, have made dramatic inroads in the roofing industry during the past 10 to 15 years. The development of standard testing procedures, the understanding of failure mechanisms, and the accumulation of practical test data have not kept pace. All of these are required if useful performance standards are to be produced.

The symposium on which this publication is based was designed to begin filling this knowledge gap. This volume offers papers on the presentation and interpretation of laboratory testing and field observations, as well as on the development of needed test procedures, primarily for sheet-applied elastomeric, thermoplastic, and polymer-modified bituminous membranes and systems.

The following is an overview of the papers presented in this volume:

*Cullen* in “The Role of Research in the Standards Development Process” cites the low level of roofing research in the United States and its restraint on the development of timely consensus standards. This situation obtains in spite of the fact that the United States has seen a proliferation of new roofing materials and technology in recent years and has a $7.5 billion roofing industry employing over 4 million people.

In contrast, Cullen points out the activities that many European countries share in their roofing research, testing, and evaluation of materials and construction practices, conducted largely by governmental laboratories. Under the organization called the European Union of Agreement (UEAtc), product acceptance is based on laboratory tests and on reports from on-site investigations, from which come the resulting performance directives. He suggests that the United States consider some of these European experiences.

*Burch, Shoback, and Cavanaugh* in “A Heat Transfer Analysis of Metal Fasteners in Low-Slope Roofs” demonstrate, by the use of various finite-difference mathematical models, the thermal effects of steel fasteners that attach glass-fiber insulation as part of a roofing system over a metal or wood deck. In addition to fastener penetration through the entire insulation thickness and the use of metal caps, variations in the model include fastener penetration of a lower insulation thickness and the use of plastic caps. Very significant thermal effects produced by the variations in fastener use, insulation thickness, and type of deck were illustrated by these models. Some comparisons were made with the Johannesson and Chang-Busching lumped parameter modeling methods.

The models demonstrated in this paper provide a sound basis for further study. One subject in which the roofing community is particularly interested is the effect of metal fasteners on water condensation problems in roofing systems, particularly in colder climates.

*Koontz* in “A Comparative Study of Dynamic Impact and Static Loading of One-Ply Roofing Assemblies” describes a testing program for dynamic and static loading of elastomeric, thermoplastic, and modified bitumen single-ply membranes on several insulation substrates. The results of four static and four dynamic established test methods are discussed. Many of the conclusions will prove very useful for future development of roofing load tests. One conclusion particularly gratifying to ASTM Committee D-8 on Roofing, Waterproofing, and Bituminous Materials is the close approximation of results between the falling dart test recommended by the ASTM Test for Impact Resistance of Bituminous Roofing Systems (D 3746–85) and the highly regarded hail gun test developed by the U.S. National Bureau of Standards.
Rossiter in “Tests of Adhesive-Bonded Seams of Single-Ply Rubber Membranes” presents the results of lap shear tests on adhered joints of five commercially available reinforced and nonreinforced rubber membrane materials using neoprene-based adhesives. These tests were run through a range of ambient temperatures and load speeds. One nonreinforced EPDM was subjected to a T-peel test at room temperature and at a load rate of 5 cm/min (2 in./min). Finally, all four of the nonreinforced samples were strained in the lap-shear configuration at constant 15 and 30% elongation at room temperature for a maximum of 15 months.

Rossiter concludes that, when considering methods of testing to evaluate performance of adhesive-bonded seams in single-ply rubber membrane materials: (1) the test temperature and rate of loading must be considered; (2) the ultimate strength and elongation of a lap-shear specimen cannot be used as a direct measure of the in-service performance of a seam; and (3) the T-peel test may be more appropriate than the lap-shear test for evaluating adhesive-bonded seams.

It would be interesting to see how the results of this testing program would compare with results from similar tests on field-aged seams.

Irwin in “Analysis of Asphalt-Containing Mixtures by Nuclear Magnetic Resonance” describes a method for determining the percentage of mineral stabilizer content in asphalt coatings used in the production of asphalt shingles and other roofing products; he does this, conversely, by measuring the asphalt content. He also compares the nuclear magnetic resonance (NMR) method with specific gravity, calcination, and extraction techniques. Later, in his paper, Irwin characterizes his use of the NMR method to analyze asphalt-saturated felts for percentage of asphalt saturation and compares this technique with the extraction method.

The test procedures are portrayed in some detail and the causes of error of some of the methods are described.

Irwin concludes that the NMR method provides the most accurate and precise measurements of the stabilizer contents of filled coatings when compared with other test methods. He also concludes that the NMR method provides the shortest analysis times when measuring the stabilizer contents of filled coatings and the percent saturation of asphalt in roofing felts.

Dutt, Ashton, and Laaly in “Measuring Adhesion and Cohesion of Rubberized Asphalts” describe toughness-tenacity tests on four samples of rubberized asphalt. These tests involve the pulling of heads from embedment in solidified rubberized asphalts. These tests were done at various speeds. Three differently configured heads were compared. They are the original hemispherical head developed by Benson; the “standard head,” which is a threaded rod with a gently rounded bottom, developed by Laaly; and a tapering threaded rod. Modifications of the standard head were used in attempts to minimize the influence of adhesion and to improve the ability to distinguish between different rubberized asphalts.

Comparisons were made between the toughness-tenacity test and separate measurements of adhesion (related to tenacity) and cohesion (toughness). Adhesion was measured by a pull-off test using brass as a substrate. Cohesion was measured using a ductility test with specially designed pulling clips to eliminate the effects of adhesion.

The conclusion of this paper is that for rubberized asphalts and other similarly used materials, it is preferable to measure adhesion and tensile properties separately. The combined measurements of more than one property in one basically empirical test method leads to results that do not isolate important properties, are invariably imprecise, and often do not agree with known behavior or performance.

Dupis and Lee in “Coefficient of Expansion Values for Modified Bitumen Roof Membranes” tested several samples of SBS and APP modified bitumen sheets, reinforced with combinations of glass and polyester mats, to determine their coefficients of thermal expansion. The testing apparatus
houses the specimen in a controlled-temperature chamber. A constant preload tensile force of 1.73 kg/mm (0.15 lb/in.) is applied to maintain alignment of the sheet. As the temperature in the chamber is lowered, thermal contraction of the specimen is measured indirectly by a dial gage.

Good correlations were made with earlier testing programs. It was generally found that APP modified bitumen sheets generally had higher coefficients of expansion than the SBS modified bitumen sheets. Also, it was determined that the modified bitumen matrix has a significant influence on the coefficient of expansion in spite of the reinforcement.

This program generated very valuable data on the thermal expansion properties of new modified bitumen membranes. Similar tests run on field-aged membranes may be a logical extension to this study.

Burnett and Howson in "Performance Testing of Fully Adhered Polymer-Modified Bituminous Roofing Membranes" describe a test method that simulates fully adhered membranes subjected to movements of substrate joints or of cracking ice formed on top of the membrane. They argue that such a test method is better suited than the commonly used tension test to observe the behavior of membranes as they would behave under field conditions.

The membrane specimen is adhered to two butted, linearly aligned substrate segments. These segments are pulled apart in a testing machine, simulating the opening of a joint in the membrane substrate. The segments are kept aligned by guides. The load per unit width of membrane sample versus elongation at the joint is recorded. The authors call this the joint-bridge test.

Both the joint-bridge and standard dogbone tension tests were run on unreinforced APP and reinforced SBS at 0°C and on reinforced APP at -18 and 20°C. Probably the most significant of the several stated conclusions was that there appears to be no consistent relationship for maximum loads between the two test methods.

Perhaps the joint-bridge test could develop into an ASTM standard test method that would reflect roof membrane tensile failure mechanisms in the field.

Schumacher and Scherp in "Cold-Laid, Exposed, Two-Ply Modified Bitumen Roofing Systems" describe what they consider to be the advantages of a modified bitumen roofing system using a cold-applied, solvent-based, modified bitumen adhesive. The advantages the authors cite are safety when compared with hot-applied or flame-applied systems; simplicity, when compared with two-component systems; and less dependence on weather during application.

Results of several tests on components of one cold-applied roofing system are presented. These include tests for softening point, penetration, extensibility, peeling resistance, solvent effects on polystyrene, viscosity, and cold bending and tensile strength of the membrane. Of particular interest is the rapid loss of peeling resistance from zinc sheeting as the temperature decreases. Also illustrated is the increase of peeling resistance with time after the membrane is applied and then submersed in water. The effects of one concentration of various solvents and several concentrations of one solvent on foam polystyrene are described.

Methods of construction and application techniques of the cold-applied system are characterized.

Finally, the paper illustrates the construction of a self-adhesive polymer-modified cap sheet system. Its properties and application are described.

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