A BASIS FOR SELECTING ROOFING MEMBRANES

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ABSTRACTS

The development and world-wide distribution of nearly 500 new roofing and waterproofing membranes during the past two decades has caused a serious headache for some architects, engineers and designers. Limited availability of impartial data has made the selection and use of new roofing and waterproofing materials a rather difficult and cumbersome task. The need for a rational and scientific approach towards the selection of new roofing and waterproofing materials has never been so great.

This paper is written in plain language in order to guide and assist the roofing project manager in selecting the most suitable, cost-effective membrane for the job. Two appendices, consisting of a list of selected publications and a reference to existing compilations of tabulated data, will guide the reader to additional sources of information.

Conventional roofing materials and systems have been used for centuries and their application techniques are well established. New roofing and waterproofing materials, hot- or cold-applied, thermoplastic, elastomeric and modified bituminous membranes are less well known and only recently have found world-wide acceptance. The selection of these materials requires considerable effort, painstaking research, and time-consuming literature reviews. But, according to recent surveys, almost 45 percent of all flat roofs are covered with one of the nearly 500 new roof membranes.

The most frequent question I have been asked is: "Which one of these membranes is best?" Unfortunately, there is no simple answer. Several papers by R. Dupuis and others have addressed this question. Because the need for guidance in selecting a roofing material still exists, this paper is intended to communicate the message without trying to impress anyone in the process.

If someone asked me, "What type of clothing do you like most?" My answer would be, "It depends on the occasion." If I am asked, "What season of the year do I enjoy most?" I would answer, "I like all seasons of the year, because each offers its own opportunity for certain activities and pleasures."

By the same token, if someone asked me, "Would you prefer to use bituminous built-up roofing or one of the new single-ply membranes?" my answer would be, "It depends on, just to name a few:

- the type of building;
- the type of deck;
- the location and geographical area;
- the environment to which it will be exposed;
- the design of the roof structure;
- the budget limitations;
- the expected service life; and
- the availability of materials."

Thirty years ago the answers to these questions were much simpler. Today, the availability of new roofing materials, various types of insulating systems, and unlimited design possibilities make several thousand roofing systems possible.

In an era where cars, high-speed trains and airplanes have replaced the horse and wagons, where landing on the moon and returning to earth has become a reality, and where television and electronic equipment have changed our way of life, it is not surprising that the roofing industry uses computers for cost estimation and even the selection and design of roofing components. Some progress has been made already. However, improvements are in progress and necessary software is being developed.

The selection of roofing requires, first of all, education in fundamentals of roofing science and continual updating of acquired knowledge in a fast growing technology. No one can afford to say, "I have made up my mind, don't confuse me with facts." The last 20 years have been very educational. A few years ago in the United Kingdom, a published compilation of roofing failures was entitled: "Encyclopedia of Roofing Problems." Now the second volume must be published. It should be called, "Encyclopedia of Solutions for Roofing Problems." Thousands of research reports, technical papers, results of investigations and evaluations of roofing materials and systems have been published during the last two decades. The proceedings of several national and international conferences reflect our combined knowledge and the state of the art in roofing and waterproofing science and technology.

Architects, engineers and designers cannot limit themselves only to materials that they knew 20 years ago. It is their professional and moral duty to update their knowledge and not unintentionally deprive owners of the benefits of the latest technology.

This paper is written in plain language in order to make the situation clear for those who have the responsibility and the privilege of selecting the roof membrane for a project. Industrial jargon and complicated technical data have been avoided in order to make the selection process as easy as possible. For those who desire to go deeper and expand their knowledge, a selection of published literature and a compilation of information sources are presented as appendices. After independent investigation, one also has the option of consulting the authors of these publications for further information.

BACKGROUND INFORMATION

In 1925, a book entitled *Roof Coverings—Their Manufacture and Application,* was written by E.G. Blake and published by Chapman and Hill, Ltd., London. At that time, this book was considered to be a descriptive treatise on the origin and the method of fixing the various materials and substances that were used to cover the roofs of all classes of buildings. The classifications included: thatch, organic, metallic, mineral, asbestos cement, bituminous felts, asphalt glass, and cement concrete roof coverings.

During the six decades since then, many new roofing materials and systems have been developed and introduced to the roofing industry. While the classic materials such as bituminous built-up roofing (BUR), asphalt shingles, clay tiles, and metallic roofs are still being used and will continue to be used, new roofing and waterproofing membranes are being continually added to the list.

C.W. Griffin, being open-minded and receptive to the innovative ideas, has devoted a chapter to "Synthetic Single-Ply Membranes" in the second edition of his 1982 book entitled, *Manual of Built-up Roofing Systems.* The *NRCA Roofing and Waterproofing Manual,* 1984/1985 edition, also includes single-ply membranes.

In 1977, H.O. Laaly prepared a table of "New Roofing and Waterproofing Materials," as a reply to thousands of inquiries on single-ply membranes. This compilation consisted of manufacturers' names and products and the primary composition and classification of the following product groups:

1. hot-applied rubberized asphalt;
2. cold-applied liquid membranes;
3. prefabricated elastomeric membranes;
4. flexible polyvinylchloride (PVC); and
5. prefabricated, reinforced, modified bituminous membranes.

The number of products being used in Canada at that time was 120.

Today, the materials in use world-wide are close to 500, and, like other commercial goods, they are traded from one country to another.

At the beginning this was a frustrating situation, because adequate test methods and standards were not available. Architects, engineers and designers were justifiably confused. Some, unable to cope with so many products, chose to resist any innovative product. Now, as a result of the dedication of several individuals and groups, the situation has changed.

The organization of National and International Symposia in North America and Europe, and the closer cooperation among scientists at industrial, government and academic levels have been extremely fruitful.

Several institutions have compiled tabulated information on single-ply membranes that facilitates the selection process for architects and designers. Among them, the NRCA *Roofing Materials Reference and Guide* has been very helpful in providing uniform test methods for comparing the properties of similar materials from different manufacturers. This publication, which is updated regularly, covers 450 products of from 134 manufacturers of BUR and single-ply materials. It also includes technical data on 146 roof board insulating materials. Several other commendable efforts also provide badly needed information, and, to a certain degree, complement each other. Anybody dealing with the task of selecting roofing materials, should have at least several of the references listed in Appendix A handy on his desk.

Paralleling the above publications, the proceedings of several national and international conferences and symposia have published hundreds of useful technical reports on roofing materials and systems. These publications represent the present state of the art in roofing materials, science and technology.

Also contributing to roofing knowledge are papers and reports which have appeared in magazines such as:

- *Roofing/Siding/Insulation*
- *Roofing Spec*
- *Roofer Magazine*
- *Architectural Record*
- *Progressive Architecture;* and
- *Construction Specifications.*

There has also been progress in the field of standards and test methods. In Canada the relevant technical committees of the "Canadian General Standard Board" are working hard to develop or improve the CGSB-37GP-50 to 37GP-70 series of standards. In the United States the ASTM Technical Committee D8-18 finally is introducing performance criteria for PVC, elastomers and modified bituminous roofing membranes. Similar progress is being made in Switzerland and West Germany.

In the United Kingdom, the Agreement Board is the governing body for issuing certificates for the quality of the individual roofing membranes and systems upon the request of the manufacturer. Undoubtedly many efforts are being duplicated, perhaps due to national pride or lack of coordination.

However, since April 1983 the RILEM-CIB Joint Committee on Single-Layer Roofing, with members from 20 industrial countries, is working hard to agree on test methods, minimum requirements for various membrane properties and the development of performance criteria for various classes of single-ply membranes.

It is gratifying to see the efforts of scientists in different countries being coordinated. As a result, architects and engineers have more confidence in new roofing materials and systems.

THE PROCESS OF MEMBRANE SELECTION

Assuming that an architect or specifier has studied some of the relevant literature and has accepted the fact that each of the materials that meets the specified requirements is suitable for a given roof design, the actual selection process can begin.

The selection procedure is similar to hiring a new employee. When a personnel manager receives the resumes of 100 applicants for a vacant position, he reduces the candidates to a choice between two or three, based on the applicants' education, professional experience, salary demand and the applicant's potential. Then he hires the most suitable applicant.

The factors involved in selecting the most suitable roofing membranes are:

1. initial price of materials and application costs;

2. life cycle cost;
3. the guarantee on materials and labor;
4. laboratory evaluation of membranes to meet the minimum requirement level of the specified standard;
5. proof of field performance in a similar climate and environment through inquiry and research;
6. economic status of the supplier;
7. critical study of product data sheets;
8. the materials' limitations and disadvantages;
9. the technical and personal capability of the supplier when a problem arises and help is needed;
10. compatibility of the membrane with other roofing components;
11. method of application, tools and required equipment;
12. conformance with regional fire and wind regulations.

There are more than 50 physical, chemical and mechanical properties of membranes which should be taken into account. Fortunately, not all of those tests have to be performed on each material. Based on design considerations, 10-15 tests usually are selected and the minimum requirements specified. Below are a few examples:

- In a garden roof design, the root resistence and soil burial characteristics are most important considerations.
- In an inverted roof system, the UV resistance is not so important, because the membrane is protected from solar radiation.
- In an industrial environment, the chemical resistance and the effect of pollutants are key factors for long service life of the membrane.
- If traffic is envisaged, one should either select a membrane with good puncture resistance or provide traffic panels for the area where traffic is expected.
- Each class of materials requires a certain substrate surface preparation. It is advisable to follow the recommendation of the membrane producer.
- In roofing and re-roofing, the structural deck load bearing capacity should be known.

When all of these factors are considered, one decides on a class of material. Then one should compare the different suppliers and make the most economical, final selection of a given brand for a specific roof design.

One final point should be added to these steps: consultation with knowledgeable and impartial people and institutions who have been involved in assessing the properties of these materials. They might be able to refine the final decision to improve its economy or performance.

Selecting a roofing membrane requires a deep knowledge of roofing science and design principles. For example:

1. A membrane with a given stress-strain property may perform satisfactorily in hot and mild climates, but its application in cold regions may be disastrous.
2. If a membrane has to be applied with aluminum bars or other mechanical fastening devices, one should remember that high elongation could be a disadvantage, especially where high velocity winds could lead to surface suction force, ballooning of the membrane and premature failure of roofing systems.
3. The fire rating of the membrane alone is not adequate to judge its performance on the roof. Rather the total roofing system, deck, insulation, surfacing and slope, determines the fire rating.
4. Make sure that the material delivered on the jobsite is exactly the same as that shown by the supplier's representative during the negotiation. Keep some samples for testing and future reference.
5. Workmanship, application details and quality control are as important as the material itself. Inspection during and after completion of the job is a key factor for any sound roof.
6. After all calculations are made, include at least 20 percent to 50 percent safety factor in the important engineering properties of the membrane. Materials which barely meet minimum requirements may not be adequate for a given job.
7. If the roof is expected to perform in an environment, such as chemical laboratories, textile and paper mills, where specific pollutants are vented, chemical resistance to that particular pollutant requires special attention.
8. If a white or reflective membrane has been selected to conserve cooling energy, the retention of reflectivity after several years' exposure should be known.
9. While the properties of a new roofing membrane are important, changes in those properties after natural and accelerated weathering is equally important.

It is our hope that these guidelines, along with the information contained in appendices "A" and "B" provide assistance toward the wise selection and successful use of roofing materials and systems.

APPENDIX A

A compilation of tabulated information on single-ply roofing membranes

1. NRCA *Roofing Materials Reference and Guide,* Vol. 5, August 1984, National Roofing Contractors Association, 8600 Bryn Mawr Ave., Chicago, Ill. 60631 USA.
2. *Dach-und Dichtungsbahnen aus Kunststoffen,* (Plastic Roofing & Waterproofing Membranes), Bauen mit Kunststoffen, 3/77, pp. 2-14, published by: IBK, Osann Str. 37 D-1600 Darmstadt, West Germany.
3. "Table of New Roofing & Waterproofing Materials," a private compilation by H.O. Laaly, 1977, National Research Council of Canada, Division of Building Research, Ottawa, Ontario, Canada, K1A OR6.
4. *Kunststoff Verzeichnis* (Anwendung in Bauwesen) Band 2, Part 16. pp 135-177 sponsored by the Federal Ministry of Urban and Housing (Bundes Ministerium fur stadtebau und Wohnunswesen) Bonn-Bad Gadesberg, West Germany, 1978.
5. *A Standard for Manufacture and Code of Practice* for installation of flexible membrane roofs, published by: Flexible Roofing Association; 125 Queens Road, Brighton Sussex BN13YW, England, Issued April, 1980.
6. *Hochpolymerbahnen fur Abdictungen in Bauwesen,* (Highpolymers for the waterproofing of buildings), published by: Bauen mit Kinststoffen, Osann Str. 37, D-1600 Darmatadt West Germany, March, 1983, pp. 3-17.
7. *A Professional's Guide to Single-Ply Roofing Specifications,* 1984, published by Single-Ply Roofing Institute, (SPRI), 1800 Pickwick Ave., Glenview, Ill. 60025, USA.

8. *RSI Trade Directory,* 1984: A Harcourt Brace Jovanvich Publication; *Roofing/Siding/Insulation* Circulation Department, P.O. Box 6039, Duluth, Minn. 55806-9739, USA.
9. *Single-Ply Systems*—Index, 1984, published by: *Roofer* Magazine, D & H Publication, Inc., P.O. Box 06253, Fort Myers, Fla. 33906, USA
10. *1984 Handbook of Single-Ply Roofing Systems,* published by: *Roof Design* Magazine RSI Circulation Dept., P.O. Box 6039, Duluth, Minn. 55806-9739, USA.

APPENDIX B

Selected papers for further reading

Baker, M.C. "BUR still at the top," p. 19 Canadian Roofing Contractor's Association, 1984 Directory, Suite 710, 116 Albert St., Ottawa, Ontario, Canada K1P 5G3.

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Dupuis, R. "Guidelines for Specifying single-ply roofing roof designs." Volume 1, Number 1, March 1983, p. 20. A publication of *RSI* magazine.

Edwards, R.M. "The selection of components for the construction of flat roofs." Proceedings of the International Symposium on Roofs and Roofing. Brighton, 1981.

Erbenshade, H. "The single-ply revolution." *Roofing Spec.,* May 1979, p. 18.

European Union of Agreement. "General directive for the assessment of roof waterproofing systems." No. 27, 1983 Secretariat: 4 Avenue due Recteur Poincare, 75782 Paris Cedex 16, France.

Fricklas, R.L., "Choosing the right roofing system." *RSI,* December 1982, p. 10.

Fricklas, R.L. "Selecting the appropriate roofing system." The Roofing Industry Educational Institute, 6851 S. Holly Circle, Englewood, Colo. 80112.

Gardener, J.B. "Roofing in transition: Implications of a new technology." *Architectural Record,* May, 1983, p. 134.

Gardener, J.B., "Roofs that work: when everybody observes the rules." *Architectural Record,* July, 1983, p. 136.

Good, Bill "Comment on Single-Ply Revolution." *Roofing Spec,* June, 1982, p. 6.

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Hoher, K. *Environmental and Climatic Factors in the Specification of Roofing Membranes,* Sarnafel, Inc., P.O. Box 380, Canton Commerce Center, Canton, Mass. 02021.

Karp, B.J. "Evaluating the design of roof systems." *Roofing Spec,* June, 1982, p. 30.

Kirby, P.C. "The selection of membrane materials for the distribution and allied applications." Distribution Division, Water Research Centre, Medmenham Laboratory, Henley Road, Medmenham. P.O. Box 16, Marlow, Bucks, SL7 2HD. Technical Report TR113, May. 1979.

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NRCA. "Elastomeric roof membrane system." *RSI Handbook of Single-Ply Roofing Systems,* 1982, p. 31.

NRCA. "Recommended performance criteria for PVC systems." *RSI Handbook,* 1982, p. 42.

"Radical Roofing." *Progressive Architecture,* August 1983, p. 109.

Rakhra, A. "Building and life-cycle costing." CBD 212, National Research Council of Canada, Division of Building Research, Ottawa, Ontario, Canada, K1A DR6, July, 1980.

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"Single-ply roofing study." *An Architectural Record Research Report,* New York, NY: 1983.

"Singling out the single-ply." *RSI,* November, 1977, p. 62.

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Strong, A.G. "Selecting polymeric waterproofing membranes." Polysar Ltd., Sarnia, Ontario, Canada N7T 7M2, 1982.

Thomas, R. "Roofing options becoming more complex." *Building Design and Construction,* November, 1979.