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Single-Ply Roofing Membranes

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Abstract

New synthetic roofing materials, including prefabricated sheet-applied membranes and liquid-applied membranes, are described. Their properties, advantages and disadvantages are discussed.

Introduction

Synthetic roofing and waterproofing materials, generally known as single-ply membranes, were introduced in Canada in the early sixties as an alternative to conventional built-up roofing (BUR). In recent years, they have become viable alternatives because of the rising cost of labour and petroleum-based bituminous materials, the improvement in polymeric materials, and the need for pliable and easily adaptable membranes for unusual roof configurations.

Synthetic roofing materials have desirable performance properties, including durability. Most of them are produced in sheet form. Others are produced for liquid application. They are made from different combinations of bitumens, polymers, fillers, plasticizers, stabilizers and other additives. A reinforcing scrim or mat of polyester or glass fibers is usually incorporated as well.

In general. the application of membranes, as well as the equipment for application, is simple. A common method of application is basically to lay the membrane loosely over the insulation and provide ballast on top to prevent wind uplift. The insulation may also be loosely laid on the deck. In a partially attached system, the membrane and the insulation are attached to the deck with fasteners or adhesives at intervals. In a totally adhered system, adhesives are used to bind the membrane to the insulation and the insulation to the deck. In a protected membrane roof assembly, insulation is loosely laid over the membrane and ballasted. In all loosely laid systems, the structure must adequately carry the load of ballast.

Field operations, such as lap-jointing between sheets and attachment at flashings and roof penetrations, need special care for proper sealing. Particular attention to the perimeter attachment is also required since this is where wind uplift failures have been known to originate. Most membranes can be applied under a wide range of temperatures and they require less labour than BUR.

In the past decade, hundreds of new roofing and waterproofing materials have appeared on the market.[1] Their classification can be done in different ways. In this Digest they are grouped in generic classes that have been used for preparing material and application standards.

Hot-applied rubberized asphalt membranes

Rubberized asphalt is basically a compound of virgin or reclaimed rubber dispersed in asphalt. The rubber gives improved flexibility at low temperatures and controls flow or creep at high temperatures. Oil is used as a plasticizer, clay or limestone powder is used as a filler, and a stabilizer protects the rubber from deterioration. A small amount of synthetic rubber (styrene butadiene styrene, SBS) is sometimes added to optimize the mechanical properties of the mixture.

The material is produced in the form of cakes wrapped in low-density polyethylene that can be stored tor a long time. On the job site, the package is melted in a kettle. The polyethylene wrapping melts with the rubberized asphalt, improving its physical properties. Generally, a temperature limit of 230 °C (450 °F) and a heating period of not more than six hours are considered safe. The application temperature should not be less than 177 °C (350 °F).

Hot rubberized asphalt is applied with a squeegee to the roof deck to form a seamless membrane with an average thickness of 4.5 mm. Application surfaces should be dry and free from dust, grease. and oil. Rubberized asphalt can be applied to concrete decks or to gypsum board or plywood installed over steel decks. Concrete surfaces are primed with a suitable asphaltic solution. In plywood, joints are covered with a layer of hot material and a strip of reinforcing fabric is pressed into it before the membrane is applied. In the case of gypsum board, the joints are taped and a reinforcing fabric is installed between two layers of rubberized asphalt. This type of membrane is recommended only for protected membrane systems in which a separation sheet of asphalt-saturated felt or a polyethylene film is placed on top of the membrane, then covered with insulation and paving slabs, or landscaping. Protection boards are placed above the membrane where needed.

Cold-applied liquid membranes

Cold-applied liquid membranes are polymeric compositions with one or more ingredients, such as modified asphalt or coal tar pitch, and various resins or elastomers, such as polyurethane, dibromobutadiene, silicone or acrylic. The membranes are available in the form of emulsions or solutions. White pigment or aluminum flakes are sometimes added to reflect solar radiation. Mineral granules or sand may be introduced into the wet coating to improve slip resistance in areas of light traffic and to provide protection from solar radiation. In other cases, the insulation and ballast of an inverted roof system provides protection.

This class of material has an advantage over hot-applied systems since no kettle is required and the product can be applied with a spray gun, spreader or roller. It requires more time for drying or curing, but its versatility is an advantage in retrofit, repair or reroofing jobs. Generally, the membranes are applied in one or two coats to a total thickness of 1.5 mm. They can also be applied in one or more layers with glass or synthetic fibre or fabric as reinforcement. They are less labour-intensive than prefabricated membranes, especially in the case of steep and irregular-shaped roofs.

With thin membranes such as these, adhesion to substrates is critical. Favourable weather conditions are therefore essential during application. Failure to use a primer on a concrete deck can result in poor adhesion and subsequent detachment under wind uplift forces and premature tearing when subjected to traffic. During curing, the membranes must be protected from physical impact.

Prefabricated elastomeric membranes

Prefabricated elastomeric membranes are generally referred to as synthetic rubbers and are obtained by the vulcanization or molecular crosslinking of various plastic-like materials or polymers. The predominant elastomers used in this class of materials are ethylene propylene diene monomer (EPDM) and polyisobutylene (PIB). Other rubber and rubberlike materials used are chlorinated polyethylene (CPE), chlorosulfonated polyethylene (CSPE, trade-named Hypalon), and polychloroprene (Neoprene). These membranes, produced in sheet form. have a nominal thickness of 1 to 2 mm, and may be reinforced with fibre or a fabric laminate. Nonwoven fibres used as backing protect the membrane against punctures when it is applied over a rough substrate. The elongation and strength of reinforced membranes depend on the type and amount of reinforcement. Polyester fabric reinforcement, with its high elasticity, helps the membrane resist the effect of wind uplift forces in partially adhered systems.

Elastomeric membranes containing carbon black or coated with special paints to screen out ultraviolet (UV) radiation can usually be exposed to the sun without serious deterioration. However, they are adversely affected by some oils and chemical contaminants sometimes found on roofs. Some are attacked by ozone. Specially formulated, semi-cured or uncured rubber sheets are heat formable and used mainly for flashings.

The lap joints of prefabricated elastomeric membranes are sealed with a rubber-based contact adhesive or a double-sided adhesive tape. The membrane material is chemically stable and does not provide a good bonding surface for many adhesives. The strength of the lap joint is therefore a critical factor in achieving satisfactory performance. Proper preparation of the joining areas (usually 75 to 125 mm in width) is of paramount importance in developing sufficient bond strength. The joining technique is specified by the manufacturer, depending on the job requirements. The talc or mica dust applied to the surface during production to prevent sticking is removed with a solvent during splicing. Sometimes adhesion promoters (special primers) are used. Excessive amounts of adhesive can cause swelling and, thus, weaken the lap joint.

This type of membrane can be fully adhered, partially attached or loosely laid and ballasted. It can be used in conventional or protected membrane roof systems.

Flexible polyvinyl chloride (PVC) membranes

Polyvinyl chloride (PVC) is one of the most versatile polymeric compounds for industrial and commercial applications. It is basically a semi-rigid material, but plasticizers, stabilizers and other ingredients impart flexibility, stability and other required properties. PVC was first introduced in North America in the early Seventies. Early problems of shrinkage and embrittlement due to the loss of plasticizers have now been largely rectified by incorporating more stable plasticizers and glass or polyester fibre reinforcement. Lap joint failures have also been reduced as a result of the use of hot air welding (from an electrically powered hot-air gun) instead of a solvent for adhesion, although solvents are still in use.

Like other single-ply membranes, PVC sheets can be fully adhered, partially attached, or loosely laid and ballasted. The membranes can be exposed to solar radiation without undue deterioration since they contain pigments and UV absorbers. PVC-coated sheet metal can be used for flashings and other architectural details due to the ease with which PVC can be heat sealed. These features allow PVC membranes to be used in a wide variety of roof configurations. They are also available with a foam or non-woven polyester fabric backing, which acts as a cushion to accommodate the roughness of the substrate.

The PVC membrane should not come into contact with bitumen or coal-tar pitch if it is applied over an old BUR. The plasticizer in the PVC migrates into the bituminous layer, causing the PVC to become brittle and fail prematurely. Several types of separation sheets or underlays can be used to avoid this problem.

Prefabricated, reinforced, modified bituminous membranes

Although bitumen is a generic term applied to asphalt and coal tar pitch, most of the modified bituminous roofing materials are asphalt-based. Bitumen is thermoplastic and the temperature range over which the material remains viscoelastic is limited. Modifying the bitumen by adding polymers greatly extends this range.

There are a number of polymeric modifiers that, in combination with bitumens and other ingredients, give the desired characteristics including weatherability. Commonly-used polymers are styrene butadiene styrene (SBS) and atactic polypropylene (APP). Woven or nonwoven fabrics of glass, polyester, nylon or natural fibers, used singly or in combination, are incorporated in the membranes for reinforcement.

In composition and method of application. this class of materials is similar to conventional bituminous BUR. However, membrane thickness is between 2 and 4 mm as compared to BUR which is 6 to 10 mm thick. The reduction in thickness and the absence of gravel reduce dead load on the structural deck. The modified bituminous membrane is adhered to the roof deck or the insulation by applying a suitable asphalt adhesive or by melting the underside of the membrane, as it is unrolled, with a multiple-nozzled propane torch. Some membranes have self-adhering pressure-sensitive backings. This class of material can be applied as a single-ply membrane or as the top ply of a two-ply system in which the first ply is a mopped unsurfaced sheet that is often thinner and lighter than the cap sheet. The edges of the laps are finished with a trowel and a hand-held torch or contact cement to ensure adhesion and prevent water penetration.

Its weatherability is about the same as that of regular bitumen. To prevent deterioration caused by ultraviolet light, the membrane is surfaced with mineral slate or granules, or given a special coating or reflective facing such as embossed aluminum, copper or stainless steel. Granules lost by erosion and freeze-thaw cycles increase the area of exposed bituminous surfaces. As part of an annual inspection and maintenance program, the granules should be replaced by torch-heating the exposed areas.

If an incompatible asphalt has been used for adhesion, joint delamination may occur due to the brittleness of deteriorated materials, This can also occur with torched joints that are overheated. Lap joints can slip if excessive asphaltic adhesive has been applied or if the adhesive is too soft.

Standards and specifications

The performance of roofing membranes depends on the design, the properties of the materials, the workmanship at the site and the exposure conditions. Current material standards are prescriptive and define the physical characteristics considered necessary for proper in-situ performance and durability of the products. Application standards on the other hand attempt to ensure that the products are applied as intended on site. Architectural specifications define the end product and the performance objectives in order to provide a basis for the selection of materials.

There are correlations between the changes in the chemical, physical and mechanical properties of the materials and the environments to which they are exposed. The results from laboratory testing[2] and on-site observations assist in the development of material standards and performance criteria.

In establishing these criteria many tests have been developed to obtain qualitative and quantitative results for the assessment of the effects of stresses that are encountered during manufacture, application and the service life of roofing membranes. Some tests are designed to measure strength, elongation and flexibility, others measure resistance to puncturing, tearing, surface erosion and water vapor transmission. Special tests determine the effect of unusual in-service environments. Such tests, aimed at ensuring the satisfactory performance of materials and achieving intended service life, form part of the standard requirements.

Although several European standards dealing with many new roofing and waterproofing materials exist, they are not directly applicable in Canada because of different weather conditions. A number of material and application standards for synthetic roofing and waterproofing materials have been published in Canada and others are in preparation. Information about current standards can be obtained from the Canadian General Standards Board, Supply and Services Canada, Ottawa, Ontario, K1A 1G6.

Concluding remarks

Synthetic roofing membranes have desirable properties but there are some limitations. With continuing improvements in materials and practices, it is reasonable to expect that their use will increase. The variety of materials having different properties offers a wide choice for roof designs and different exposure conditions, whether it is for new roofing, reroofing or repair. When reroofing, the compatibility of the current material with the proposed roofing membrane, as well as the moisture condition in the roof system. must be known. Proper selection of a membrane, combined with correct roofing details and application procedures, is necessary for the roof to function properly through its service life.

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