COMPOSITE CARRIERS FOR MODIFIED BITUMEN MEMBRANES

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Several types of roof membranes, including modified bitumen roll roofing, require the use of high-performance reinforcement carriers to meet application demands. Starting with a characterization of roll roofing requirements, this paper will review the carrier properties needed for good roof performance in lightweight single-layer systems and the effect of these properties on roof performance. Special attention will be paid to the shrinkage forces involved on the roof, the importance of dimensional stability in these types of roofing systems, and the role of new composite carriers in minimizing these forces.

KEYWORDS

Composite carrier, membranes, roofing, shrinkage forces, single layer, stability.

INTRODUCTION

Traditionally, bituminous roof membranes have been applied in multilayer systems in Western Europe, often using both glass- and polyester-reinforced membranes as the separate layers. In fact, double-layer systems are still most common practice, giving security and a minimal risk of failure. Of course, such double-layer systems are also rather expensive, mainly because of higher installation costs.

In fact, a single-layer system of superior quality could also do the job and would be more economical. That is the reason why modified bitumen membranes tend to be applied in single-layer systems that must, of course, meet the most severe performance requirements.

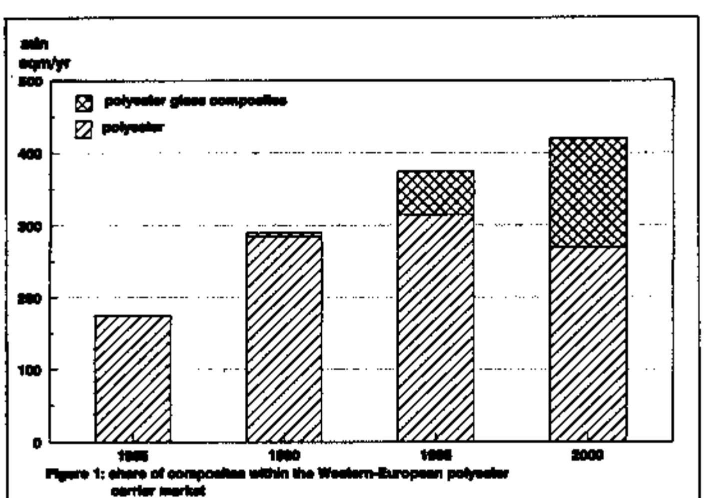

Figure 1. Share of composites within the Western European polyester carrier market.

As will be shown, these requirements can be met most efficiently today by applying a composite carrier of glass and polyester, making use of the good properties of both materials. The market share of composite carriers is growing quite fast, especially in Western Europe (Figure 1).

Three basic types of composite carriers have been introduced on the market in the past five years:

- A combination of a polyester nonwoven with a glass scrim (e.g., as a trilaminate polyester/glass scrim/polyester, for example, glass scrim: 1 cm by 1 cm by 34 tex [0.4 inch by 0.4 inch by 30 den]).
- A combination of a polyester nonwoven with glass warp threads, again as a trilaminate (e.g., glass warp yarn: 68 tex, distance 0.7 cm [60 den, distance .03 inches]).
- A combination of a polyester nonwoven with a wetlaid glass fleece, either a bilaminate or (preferably) again as a trilaminate to avoid asymmetrical shrinkage forces (e.g., glass fleece: 50 g/m² [0.16 ounces/square foot], including binder).

The last combination not only gives a highly stable roof membrane (like the other combinations), but also provides a certain fire resistance that makes it easier to comply with the national standards on this aspect. This combination also can replace the two different carriers in a dual-carrier membrane (with separate polyester and glass fleece carriers), eliminating the frequently occurring wrinkling problems with this type of product.

Requirements for Single-Layer Modified Bitumen Membranes

Because single-layer membranes are sometimes only mechanically fixed to the roof, they should be sufficiently strong and tear-resistant to withstand wind uplift forces during stormy weather.

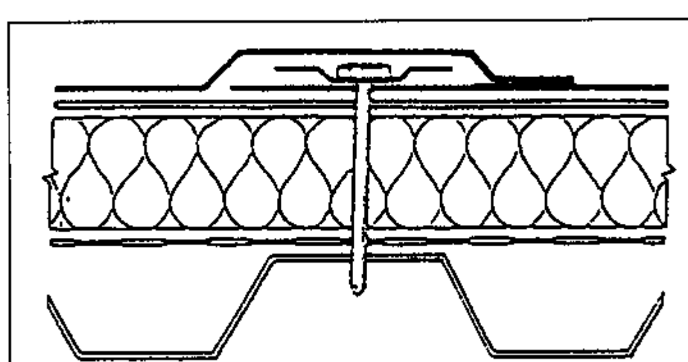

Figure 2. Mechanical fixation membrane.

The overlapping bitumen joint should also withstand these wind uplift forces plus possible shrinkage forces in the membrane.

A low level of potential shrinkage forces should be considered one of the most important requirements to avoid problems on the roof.

The membranes should also have a high puncture resistance to minimize damage caused by traffic or falling objects on the roof. They should be flexible and lightweight for easier handling and an economic use of materials. Preferably, they should also have fire-resistance properties, an issue that is becoming more and more important.

Roof membrane	Proposed carrier characteristics
*Flexible high-quality layer (100% modified bitumen)	* Open structure, easy to impregnate for modified bitumen
* Highly dimensionally stable[1]	* Composite polyester/ glass
* High strength/tear strength (mech. fixing, storm resistant)	* High filament strength, not brittle.
* Elastic behavior (following construction displacements)	* Sufficient elongation at break, like polyester.
* Puncture resistant	* Sufficient fiber toughness fiberdensity
* Fire resistant properties[2,3]	* Composite polyester/glassfleece

Figure 3. Essential requirements for single-layer bituminous membranes.

In Figure 3, the requirements for the membrane have been summarized and translated to proposed carrier characteristics.

For a high-quality membrane, the use of 100 percent modified bitumen is preferred above the use of oxidized bitumen as impregnation bitumen, covered by modified bitumen. This to avoid unnecessarily thick membranes and to avoid delamination problems between the different bitumen layers.

To facilitate impregnation, using only modified bitumen and for high production speeds, a rather open carrier with high filament diameters is appropriate and also will give better tear strength.

Dimensional Stability and Shrinkage Forces

As has been stated before, dimensional stability at elevated temperatures is one of the most important requirements for a safe application of single-layer modified bitumen membranes. This is because if shrinkage of the fixed membrane occurs, meaning that the shrinkage forces exceed the overlapping joint strength, the roof could leak.

UEAtc[1] requires a free shrinkage, less than 0.3 percent at 80°C (175°F), but experience has shown that for single-layer membranes, mechanically fixed, a free shrinkage of less than 0.2 percent would be a safer criterium.

Instability can be generated if, during the bituminizing process, a deformation of the polyester carrier occurs (elongation) and this deformation is not relaxed before cooling of the roofing sheet. When the membrane, later on, is heated up [e.g., 80°C (175°F) on the roof], it tends to shrink to its original length.

To simulate these phenomena on the polyester carrier, a test has been used in which a 1-m- (3.35-foot-) wide carrier is heated to 180°C (365°F), during 15 minutes, under a load of 500 N/m (33 lbs./ft.). After cooling down, the deformation in length is measured. This test simulates the bituminizing process under severe conditions.

Then, the same carrier is (unloaded) heated up to 80°C (175°F) for 24 hours, then cooled down to room temperature, and the free shrinkage is measured.

Or a membrane produced with a certain carrier is (unloaded, but pretensioned to a standard pretension of 100 N/m [6.5 lbs/ft.]) fixed between a fixed point and a load cell

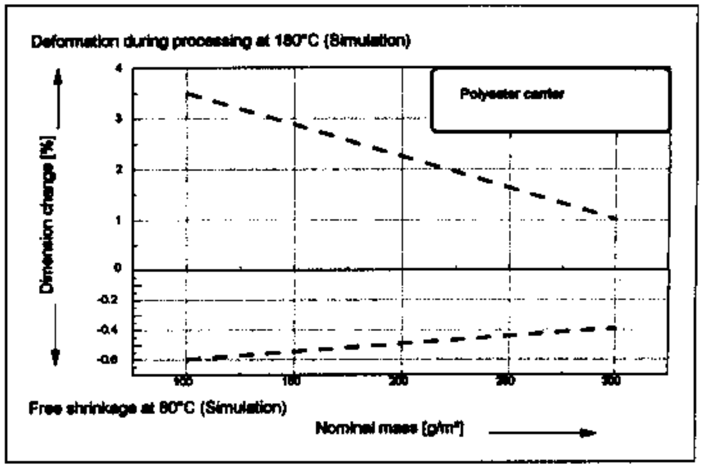

Figure 4. Simulation of the behavior of the carrier.

arrangement. Then, the membrane is heated up to 80°C (175°F) for four hours and cooled down again to room temperature, measuring the shrinkage force during this process. This test simulates the situation on the roof during a temperature cycle.

Figure 4 shows a simulation of both deformation at 180°C (365°F) and the resulting free shrinkage at 80°C (175°F) of the carrier at different weights. A rather high tension at 180°C (365°F) has been used in the test, higher than normally used in the bitumen line, to more clearly show the effect.

Undesired deformations of the carrier during processing can be avoided or minimized by applying a glass-reinforced polyester carrier. The high modulus of the glass, even at bitumen temperature, takes care of the processing tensions in machine direction. Of course, also preventing excessive necking-in.

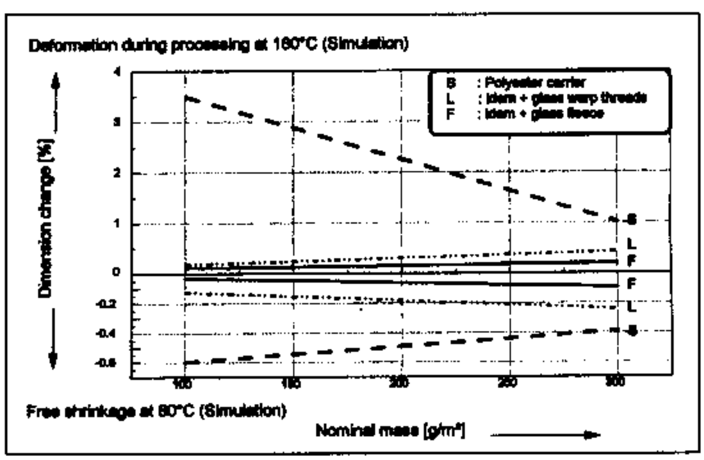

Figure 5. Simulation of the behavior of the carrier.

Figure 5 shows the simulated effect of deformation during processing of different polyester carriers with and without glass reinforcement. The result of the glass-reinforcement is a much lower deformation of the carrier during processing and, thus, a much lower free shrinkage, when the carrier in a second step is heated up again to 80°C (175°F).

But free shrinkage of the carrier, after being tensioned at 180°C (365°F) and heated up again to 80°C (175°F), is just

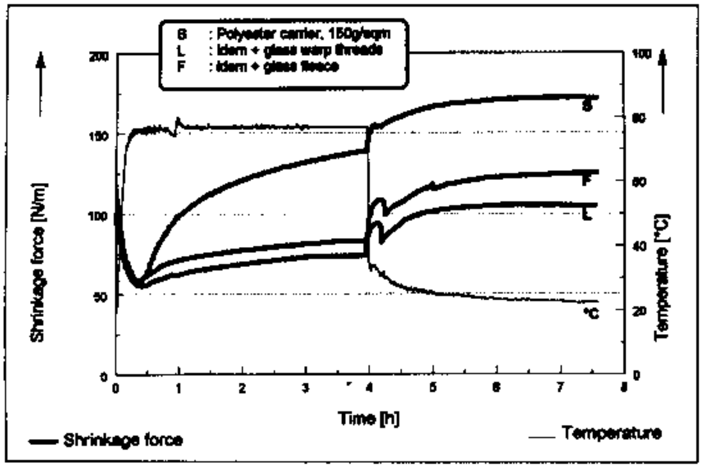

Figure 6. Shrinkage force of roof membranes with different carrier types.

one way to judge the stability. Even more important is the shrinkage force in the membrane itself when fixed and heated to 80°C (175°F) and cooled down again, thus simulating the behavior on the roof (Figure 6).

The highest shrinkage forces occur after the membrane has been heated up and then cooled down again. The normal thermal expansion, which causes the tension dip during heating up, is followed by shrinkage and is reversed when cooling the membrane; this causes the peak force.

The membranes with the glass-reinforced polyester carriers show the lowest shrinkage forces, not exceeding or only marginally exceeding the pre-tension used in the test. Such shrinkage forces are generally far below the tensions that the overlapping membrane joints can withstand.

CONCLUSION

From the shown results, it is clear that using glass-reinforced polyester carriers is a very effective way to get a highly stable, low-shrinkage modified bitumen membrane almost independent from the carrier weight. The desired mechanical properties, such as tear strength and puncture resistance, alone can thus define the required polyester carrier weight, making lower weights (and high processing speeds) often perfectly feasible.

Furthermore, it will also be clear that the concept of glass warp threads is a cost-effective way to achieve such stable membranes. Only 10 g/m^2 (0.03 ounce/square foot) glass is sufficient in practice, the costs of which often can be compensated by a lower weight of polyester.

Finally, if also fire-retardant properties are desired, the polyester glass-fleece combination would be an appropriate solution for a single-layer system.

REFERENCES

1. UEAtc special technical Guide for the assessment of single layer roof waterproofing.
2. DIN 4102, part 7, "Fire behavior of building materials."
3. Nordtest method NT Fire 006, 1985-11, Edition 2.