FLOATING AND SINKING GLASS FIBER FELT PLIES IN COAL-TAR PITCH BUILT-UP ROOFING MEMBRANES

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Floating and sinking glass fiber felt plies in coal-tar pitch built-up roofing membranes have been widely reported. This paper expands on the work regarding glass fiber felt porosity, discusses the reasons for floating or sinking felts, for the incompatibility reactions observed, and recommends the action required to avoid these problems.

KEYWORDS

Built-up, coal-tar pitch, felts, floating, glass fiber felts, incompatibility, roofing, sinking.

INTRODUCTION

This paper expands on the work regarding glass fiber felt porosity previously reported.[1] The author has observed "floating" (where the felt plies come to the top of the membrane) or "sinking" (where the felt plies sink to the bottom of the membrane) glass fiber felt plies on built-up roofs composed of asphalt coated glass fiber felts and coal-tar pitch. These roofs all required replacement (the best option) or roofing over (re-cover) to solve the problems that usually appeared after the first summer of exposure. The problems were observed in Connecticut, Illinois, and Tennessee.

FLOATING PLIES

The first "floater" reported to me was in the summer of 1991, on the manufacturing building of a major farm equipment manufacturer located in the northern, midwestern United States. A four-ply, asphalt-glass felt, coal-tar pitch roofing membrane that appeared to be properly installed the day before, now had bare, unadhered plies. Analyses of samples in our laboratory showed part of the coal-tar pitch seeped through the porous glass felts, to soak into the perlite insulation and to accumulate between the base ply and the insulation. The remaining 603 g/[m^2 x ply] (12.4 lb/[100 $ft.^2$ x ply]) of interply pitch was insufficient to adhere the plies together—up to 74 percent of the interply area was unadhered. The felts have a specific gravity of 1.00 (compared to 1.00 for water and 1.22 to 1.34 for coal-tar pitch), and a porosity (water flow through) of 12,480 mL/[s m] (1,270 gal./[h x 100 ft.]) per ply. The felts tend to bob upward in the warm pitch because of their lower specific gravity, and their movement is permitted by the porosity of the glass felts.

BITUMEN VISCOSITY

The low apparent viscosities (see Table 1) of coal-tar pitches, and dead level asphalt, are beneficial in that the flow characteristics of these bitumens allows the relief of internal thermal strains. These same low viscosities, however, permit the porous glass fiber felts to move within the membrane both upward, due to the stiffness (i.e., memory—where the applied felt is corrugated) and the low specific gravity of the glass fiber felts, and downward, from the weight of the aggregate surfacing.

FELT POROSITY

The felt porosity was measured by weighing the distilled water passing through the membrane in an arbitrary fixed period, due to a constant head of water. This test is currently being refined to be used as a quality control test for glass fiber felts.

The porosity of glass fiber felts (see Table 2) is many times greater than asphalt-organic felts (and probably much higher than coal-tar organic felts that were not measured). This high porosity has positive and negative effects. On one hand, the porosity of the glass fiber felts tends to reduce interply blistering by liberating trapped moisture and air during installation; on the other hand, it also permits the penetration and flow-through of low viscosity bitumens. The felt porosity is highly variable and uncontrolled. It varies with the manufacturer, with the felt type, and even within a single roll. Since porosity has not been standardized, the roofing membrane designer cannot specify felts with low porosities.

In response to the weight of the aggregate surfacing, the felts can be pressed to the bottom of the membrane if the temperature and porosity of the felts is high. The roofing membrane with sinking felts then becomes unbalanced, with all the reinforcement at the bottom of the membrane, and subjects an excessively thick unreinforced bitumen layer to the weather where mud cracking or alligatoring becomes evident.

HEAT AGING LABORATORY PREPARED MEMBRANES

Table 3 shows the quantity of ASTM Types I and III pitch at each level of an aggregate surfaced four asphalt-glass ply membrane, before and after 32 days at 66°C (150°F), black bulb temperature under infrared bulb (Photo 1). Each membrane sample is approximately 300 x 300 mm (2 x 2 ft.); constructed on fiberglas insulation, without joints.

Table 3 shows there is no significant difference between the degree of felt settling shown by Type I or Type III coal-tar pitch. The "lost bitumen" in each case flowed onto the laboratory bench, where it was recovered and weighed, or was absorbed by the insulation under the test membranes (observed as an increase in insulation weight).

GLASS FIBER FELT SINKING SPEED

Some of the conditions that influence the sinking speed of the felts are:

- the weather—the felts will sink faster if warm,
- the mass of the surfacing aggregate—the felts will sink slower under the lower application rate of pea stone or slag required to cover the surface, than under conventional built-up roofing aggregate (i.e., ASTM D 1863, #7),
- the viscosity of the bitumen—lower viscosity increases the felt migration speed, and
- the porosity of the felts used—higher porosity increases the felt migration speed.

One of the first signs of this sinking felt is the darkening of the surface of the roof due to the bitumen flowed up around each piece of aggregate. Photo 5 shows the vivid contrast between the sloped roof area where steep interply asphalt was used, and the flat areas where coal-tar pitch interply was used (both used asphalt coated glass felt for reinforcement).

CONTACT INCOMPATIBILITY

Roofing membranes with sinking felts composed of coal-tar pitch interply bitumen and asphalt-coated glass fiber felts have the additional problem of contact incompatibility, that destroys the colloidal structure of the bitumens. The reaction rate is temperature dependent. The coal-tar pitch picks up some of the asphalt coating from the glass fiber felts on its way to the top of the membrane, and becomes a greasy, foamed mass (consistent with a contact incompatibility reaction) that permits water to leak through the membrane (Photo 2). Incompatible bitumen staining was observed on some of the gravel used in the laboratory heat exposure test (Photo 3); both of the bitumens left a stain on filter paper (Photo 4), characteristic of an oily incompatibility reaction. While incompatibility is seldom reported from the field, the author suspects it is more because incompatibility has been relatively rare, and aggregate hides many of the warning signs.

Some of the warning signs of incompatibility that you may observe in the field include:

- areas where the top coating and gravel are easily spudded off the membrane in warm weather,
- areas of greasy feeling top coating, and
- marked darkening and oily staining of the roofing aggregate.

In the later stages of deterioration, the dull, greasy product of the incompatible bitumen reaction cracks and can easily be displaced and scraped from the surface of the membrane (Photo 6).

Coal-tar pitch has been used with asphalt-coated organic felts with few signs of incompatibility. The incompatibility observed with the asphalt-coated glass fiber felts and coal-tar pitch is probably encouraged by the large and intimate contact area between the bitumens when the pitch flows through the felt plies.

CONCLUSIONS

The following conclusions are based on field and laboratory work.

The problems of glass fiber built-up roofing felt mobility and contact incompatibility are severe, but can be avoided by the use of only Types III and IV asphalts as the interply adhesive with asphalt-glass fiber felts, because they have a high enough viscosity to resist felt migration and the coating on the felt and the interply asphalts are compatible.

Do not use coal-tar pitch with asphalt-coated fiber glass built-up roofing felts because of felt mobility and incompatibility reactions.

The average porosity of the one coal-tar felt-coated glass fiber felt sample tested is half the porosity of the same type and manufacturer of the asphalt-coated glass fiber felt used in several troubled roofs, and used in the laboratory heat aging tests. The author is therefore concerned that the porosity of the coal-tar pitch coated glass fiber felt is still too high to prevent migration of the felt plies. If you must use coal-tar pitch, use coal-tar organic felts for reinforcing.

If a contractor is requested to use glass fiber felts with coal-tar pitch, provide a written objection to the designer, agreeing to the application at the owner's or designer's risk, citing this paper.

No significant difference was found in the viscosity at performance temperatures between the Type I and the Type III coal-tar pitches.

The roofing industry should standardize and minimize the porosity of glass fiber felts used in built-up roofing.

ACKNOWLEDGMENTS

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REFERENCES

[1] Cash, C.G., "Porosity of Glass Fiber Felts Used in Built-up Roofing," *Roofing Research and Standards Development: 2nd Volume*, ASTM STP 1088, Wallace, Thomas J. and Rossiter, Walter J. Jr., Eds., American Society for Testing and Materials, Philadelphia, Pa., 1990.

Bitumen	ASTM Type	23°C (73°F)	40°C (104°F)	60°C (140°F)
Coal-Tar Pitch	D 450, I	670,000	2,200	15
Coal-Tar Pitch	D 450, III	1,200,000	2,500	12
Dead Level Asphalt	D 312, I	370,000	4,500	73
Flat Asphalt	D 312, II	48,000,000	64,000	190
Steep Asphalt	D 312, III	40,000,000	245,000	2,000
Super Steep Asphalt	D 312, IV	230,000,000	5,700,000	130,000

Table 1 *Apparent viscosities of bitumens used in built-up roofing, Kilopoises. (Random samples measured by Simpson Gumpertz & Heger Inc., using ASTM D 4989, "Test Method for the Apparent Viscosity of Roofing Bitumens Using the Parallel Plate Plastometer.")*

(Source), Type	Mass g/m^2 (lb/100 ft.^{2})	Absolute Density Mg/m^3 (lb/ft.^{3})	Porosity mL s^{-1}m^{-2} (gal h^{-1} 100 ft.$^{-2}$) 1 ply	2 plies	3 plies
(A) Asphalt-Organic ASTM D 226, I	635 (13)	not tested	0.43 (0.04)	0.37 (0.04)	0.32* (0.03)*
(B) Asphalt-Glass ASTM D 2178, IV	not tested	not tested	240 (25)	14 (1.4)	6.7 (0.68)
(B) Asphalt-Glass ASTM D 2178, VI	not tested	not tested	6,980 (712)	1,960 (200)	1,110 (113)
(C) Asphalt-Glass ASTM D 2178, IV	327 (6.7)	1.32 (83)	13,100 (1,330)	7,120 (727)	2,670 (273)
(C) Asphalt-Glass ASTM D 2178, VI	615 (13)	1.17 (73)	3,580 (365)	3,400 (347)	2,940 (300)
(D) Coal-Tar-Glass ASTM D 4990, I	591 (12)	0.99 (62)	3,420 (349)	1,550 (158)	843 (86)
(E) Asphalt-Glass ASTM D 2178, IV	586 (12)	1.25 (78)	2,280 (233)	1,215 (124)	477 (49)
(E) Asphalt-Glass ASTM D 2178, VI	not tested	not tested	7,600 (775)	3,060 (312)	2,020 (206)
(F) Asphalt-Glass ASTM D 2178, IV	650 (13)	1.25 (78)	11,840 (1,210)	6,570 (670)	4,560 (445)
(G) Asphalt-Glass ASTM D 2178, IV	635 (13)	1.00 (62)	12,480 (1,270)	7,910 (807)	4,360 (445)
* = Value calculated.					

Table 2 *Mass, density and relative porosity of BUR felts.*

Pitch Type	ASTM D 450,	Type I	ASTM D 450	Type III
Material	**Mass Applied g/m² (lb/100 ft.²)**	**Mass Recovery g/m² (lb/100 ft.²)**	**Mass Applied g/m² (lb/100 ft.²)**	**Mass Recovery g/m² (lb/100 ft.²)**
Gravel	19,450 (398)	19,420 (398)	19,970 (409)	19,970 (409)
Top coating	3,850 (79)	4,840 (99)	3,980 (82)	5,060 (104)
Interply plies 1 & 2	1,660 (34)	780 (16)	1,660 (34)	635 (13)
Interply plies 2 & 3	1,510 (31)	880 (18)	1,560 (32)	780 (16)
Interply plies 3 & 4	1,465 (30)	780 (16)	1,320 (27)	680 (14)
Interply ply 4 & insulation	1,710 (35)	1,025 (21)	1,760 (36)	780 (16)
Interply Mean	1,590 (32)	870 (18)	1,570 (32)	730 (15)
Loss on lab bench	0	195 (4)	0	146 (3)
Loss into insulation	0	1,270 (26)	0	1,710 (35)
Total Bitumen check (incl. losses)	10,190 (209)	9,770 (200)	10,280 (211)	9,800 (210)

Table 3 *Type I and III coal-tar pitch mass applied and recovered after 32 days @ 66°C (150°F). (Simpson Gumpertz & Heger Inc., laboratory tests.)*

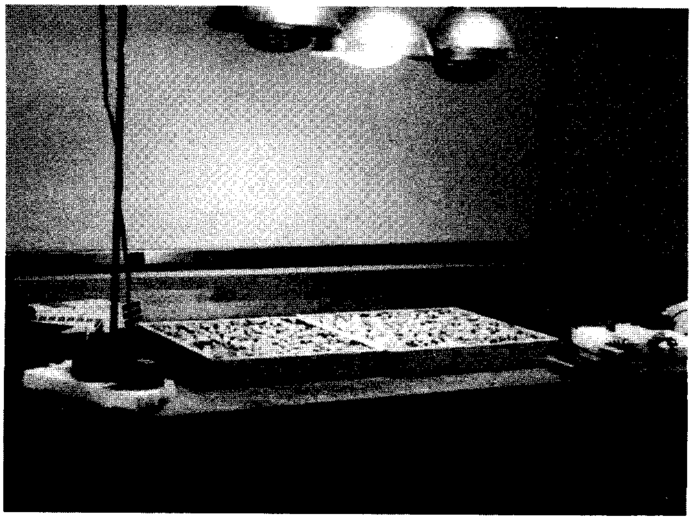

Photo 1 *Laboratory prepared membranes aging under heat lamps.*

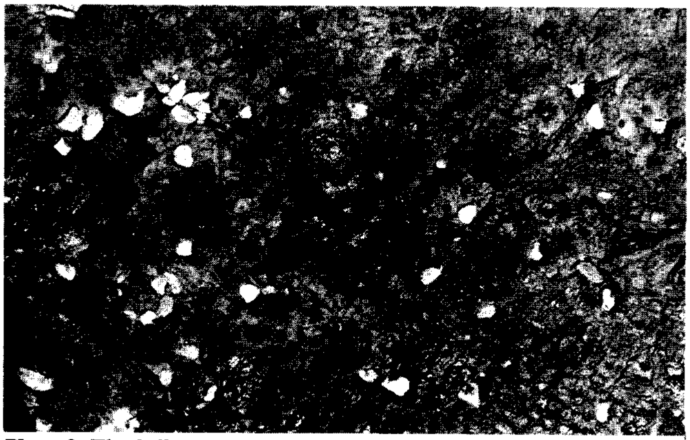

Photo 2 *The dull greasy surface of a four-year-old asphalt-glass fiber reinforced coal-tar pitch membrane.*

Photo 3 *Oil stains the aggregate after 32 days of heat lamp exposure.*

Photo 4 *Phase separation of the greasy bitumen on filter paper.*

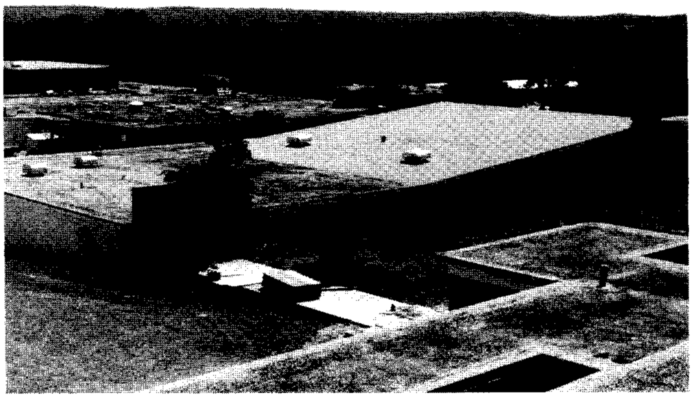

Photo 5 *The arrow points to the juncture between asphalt-glass fiber reinforced coal-tar pitch and steep asphalt membranes.*

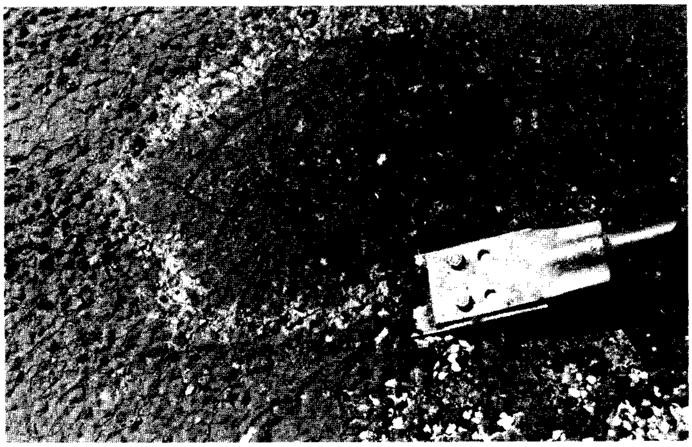

Photo 6 *The incompatible bitumen-aggregate mix is easily spudded off the membrane.*