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Effect of moisture on the strength characteristics of built-up roofing felts

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EFFECT OF MOISTURE ON THE STRENGTH CHARACTERISTICS OF BUILT-UP ROOFING FELTS

by
H.O. Laaly

American Society for Testing and Materials
Special Technical Publication 603
August 1976
10p.

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SOMMAIRE

L'auteur compare les propriétés de contrainte-defromation, à la température ambiante et 50% d'humidité relative, des feutres orgniques, d'amiante it saturés de bitume de type 15. Il évalue la vitesse de sorption d'eau du feutre orgnique plongé pendant 520 heures dans de l'eau distillée à la température ambiante ainsi que l'effet de l'humidité sur ses caractéristiques de résistance. La morphologie ,du feutre orgnique non saturé et les caractéristiques d'entrelacement des fibres sont examinées à l'aide du microscope électronique à grille.

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H. O. Laaly[1]

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Effect of Moisture on the Strength Characteristics of Built-Up Roofing Felts

REFERENCE: Laaly, H. O., "**Effect of Moisture on the Strength Characteristics of Built-Up Roofing Felts,**" *Roofing Systems, ASTM STP 603*, American Society for Testing and Materials, 1976, pp. 104–113.

ABSTRACT: Stress-strain properties of Type 15 asphalt-saturated, organic, and asbestos felts are compared at room temperature and 50 percent relative humidity. The rate of water sorption by asphalt-saturated organic felt immersed for 520 h in distilled water at room temperature and the effect of moisture on its strength characteristics are assessed. The structure of unsaturated organic felt and the interlocking characteristics of the fibers were examined by a scanning electron miscroscope.

KEY WORDS: roofing, moisture, strength, felts, asphalts

The use of asphaltic roofing materials in North America can be traced as far back as 80 years, and during the past three decades much research has been carried out on various aspects of built-up roofing (BUR). In spite of extensive knowledge on the causes of ridging, blistering, splitting, and delamination, it is estimated that 10 to 15 percent of all flat roofs still fail prematurely [*1*].[2]

There are more than a thousand publications dealing with the causes of premature failure of BUR; among these are papers by Abraham [*2*], Hoiberg [*3*], Zakar [*4*], Barth [*5*], Traxler [*6*], and Pfeiffer [*7*]. Other current publications include the results of a large number of field investigations and technical discussions with roofers, designers, and scientists [*1,8,9*]. In all, there has been a very real attempt to provide the information necessary for a sound roofing practice. The Roofing Manual of the National Roofing Contractors Association (NRCA) [*10*], the Handbook of the Canadian Roofing Contractors Associations [*11*], Standards of the Canadian Govern-

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[2] The italic numbers in brackets refer to the list of references appended to this paper.

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ment Specifications Board (37-GP series 1 to 39) [12], Canadian Standards Association publications (A.123, 1 to 17) [13], and the specifications published by the roofing manufacturers are some of the most important publications providing the technical background for current roofing practice.

Although the interaction of fibers and various polymers in reinforced plastics has been studied extensively, that of the bituminous matrix with organic (cellulosic) or inorganic (asbestos and glass) fibers is still not adequately understood. Asphalt is hydrophobic if not overheated, but organic felt is hydrophilic and No. 15 asphalt-saturated felt absorbs more than 60 percent by weight of water if submerged at room temperature for three weeks.

In recent studies of asphalt mixtures, Yaeger and Wood [14] found that moisture reduced their dynamic modulus appreciably. Soaking a 4 by 8-in. cylindrical specimen of asphalt concrete for four days in water at 122° F (50° C) markedly reduced the dynamic modulus for a particular aggregate type and minimized the binding role of asphalt.

Because of these demonstrated effects of water on roofing materials, it was decided to investigate the effect of moisture content on the tensile properties of two asphalt-saturated single felts at room temperature. This paper presents the results of the study. It is part of a research program recently initiated at the Division of Building Research, National Research Council of Canada.

Experimental

Materials

The following three proprietary roofing felts were used in this investigation: two sources of Type 15 asphalt-saturated organic felt (tension test) and one Type 15 asphalt-saturated asbestos felt (tension test).

Procedure

Tension tests were based on the procedures described in ASTM Recommended Practice for Testing Load-Strain Properties of Roof Membranes (D 2523-70); six specimens of each sample were tested whenever possible.

Instrumentation

Tensile—A tension testing machine (Tinius-Olsen) was used with the following instrumental conditions: (*a*) rate of pull: 1 percent/min, and (*b*) temperature of the specimens: 25 + 2° C (unless otherwise specified).

Scanning Electron Microscope—Cambridge Stereo Scan Model Mark 2A.

Specimen Conditioning

Specimens of felts were kept in a constant-temperature room (50 ± 5 percent relative humidity and 25 ± 2°C) for 24 h prior to test unless otherwise indicated. This is termed a "dry" felt in this paper in connection with tension test.

Moisture

Specimens were immersed for 520 h in a bath of distilled water at room temperature and gently agitated until the weight gain and dimensional change had almost ceased. These specimens are termed "wet," and their moisture content excludes that already present in the dry felt, as just described.

Temperature

The felt specimens were subjected to the tension test at 25 ± 2° C.

Results and Discussion

The first objective was to investigate whether two similar rolls of Type 15 asphalt-saturated organic felt provided by two different sources would exhibit similar stress-strain properties. Figures 1 and 2 show the stress-strain curves in both the machine direction and cross-machine direction. Six specimens from the same roll of felt showed fluctuations in the results. The first felt (Fig. 1) had a higher stress/strain ratio in both directions than the second roll (Fig. 2).

The second objective of the investigation was to establish whether a correlation exists between the strength of saturated roofing felt and its moisture content. In the course of the experimental work, the effect of type of fiber was also studied.

Figure 1 also shows that the ultimate strength of asphalt-saturated organic felt in the machine direction is three times greater than its strength in the cross direction. The ultimate strength of asphalt-saturated asbestos felt in the machine direction is also three times its strength in the cross direction, as may be seen in Fig. 3. The strength of the asphalt-saturated organic felt in both directions, however, is approximately 30 percent higher than that of asphalt-saturated asbestos felt.

The effect of water absorption on the tensile strength of one of the Type 15 asphalt-saturated organic felts in both the machine and cross-machine directions is shown in Fig. 2. It is evident that moisture reduces the strength of asphalt-saturated organic felt by a factor of about six for both the machine and cross direction.

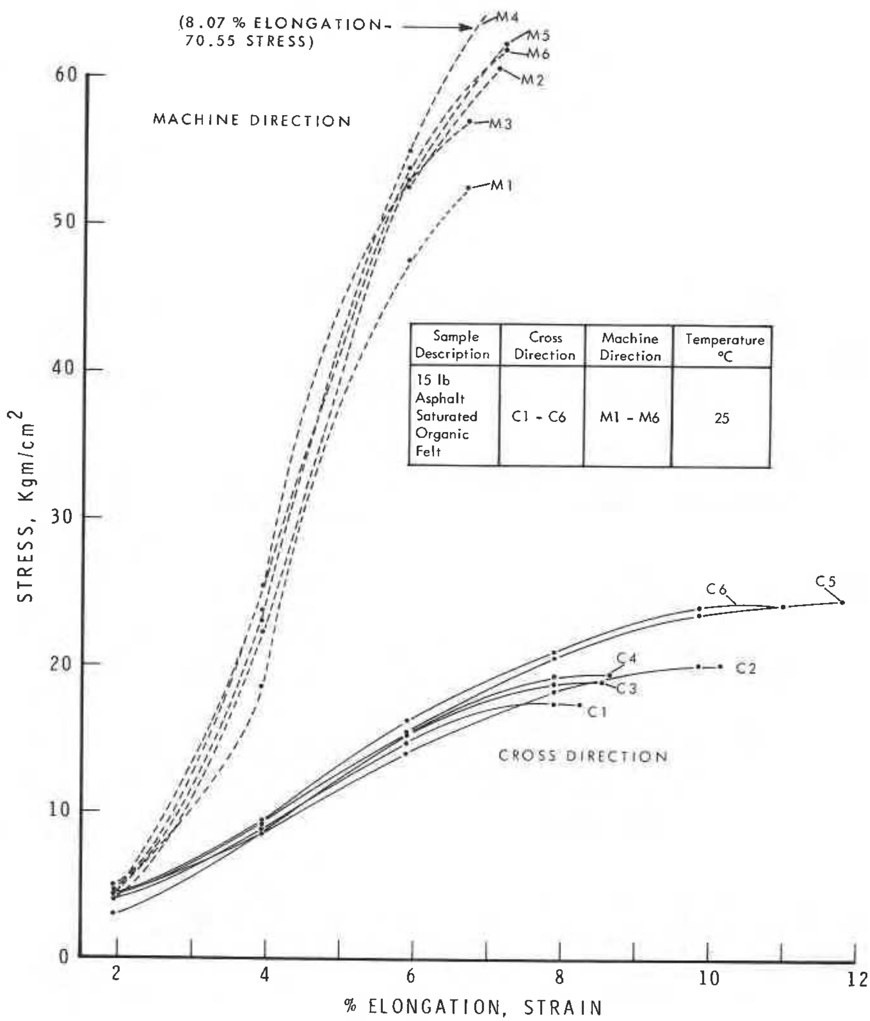


FIG. 1—*Tensile properties of one-ply, Type 15, asphalt-saturated organic felt at room temperature.*

Figure 4 presents the rate of water penetration of Type 15 asphalt-saturated organic felt during 520 h of immersion in distilled water at room temperature. Most of the water is sorbed during the first three to four days.

Figures 5 and 6, micrographs of unsaturated (dry) organic felt, indicate that a large number of voids and pores in the felt act as ideal locations for moisture absportion or condensation. The shape and length-to-diameter (L/D) ratio are such that there is very little mechanical interlocking of fibers, with the result that any contribution to the tensile properties of the fibrous component (roofing felt) is small.

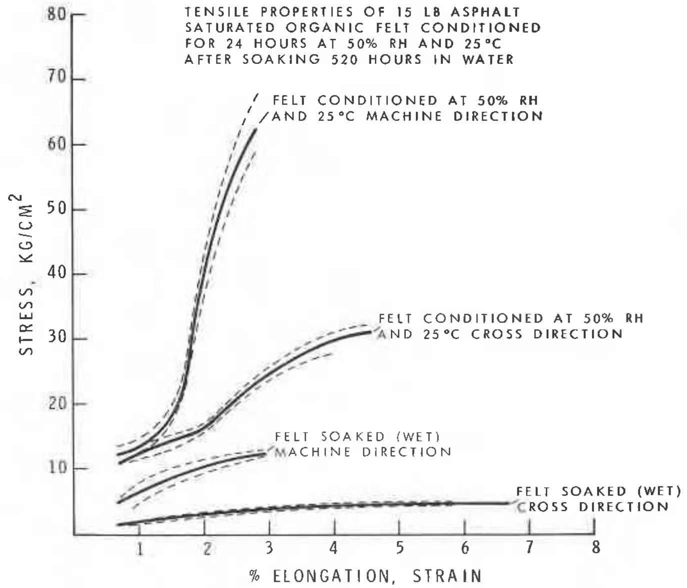
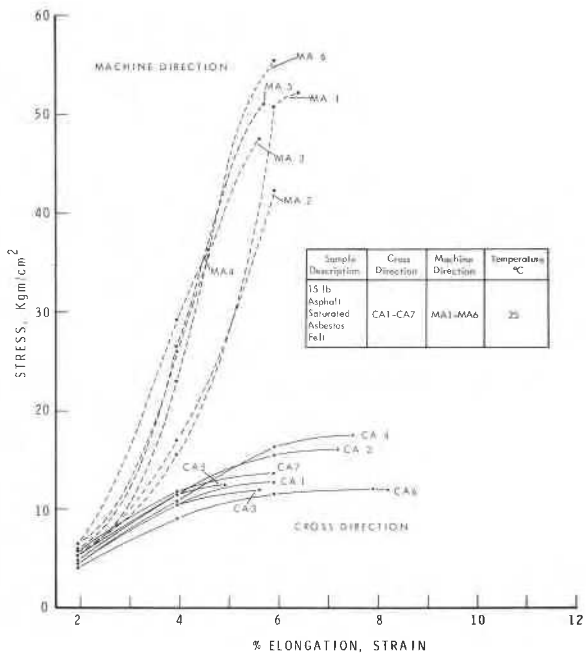


FIG. 2—*Effect of moisture on the tensile strength of Type 15 asphalt-saturated organic felt.*



Sample Description	Cross Direction	Machine Direction	Temperature °C
15 lb Asphalt Saturated Asbestos Felt	CA1-CA7	MA1-MA6	25

FIG. 3—*Tensile properties of one-ply, Type 15, asphalt-saturated asbestos felt at room temperature.*

Conclusion

The following conclusions can be drawn:

1. Asphalt-saturated organic felt, Type 15, absorbs up to 60 percent by weight of water at room temperature, and this reduces the tensile strength to 16 percent of its original strength.

2. Both the asphalt-saturated organic and asbestos felts tested had tensile strength in machine direction three times that in the cross direction.

3. The strength of Type 15 asphalt-saturated organic felt conditioned at 50 percent relative humidity and 25°C for 24 h is approximately 30 percent higher than the equivalent type of asbestos felt conditioned under the same conditions, probably owing to the shorter fiber length of the latter.

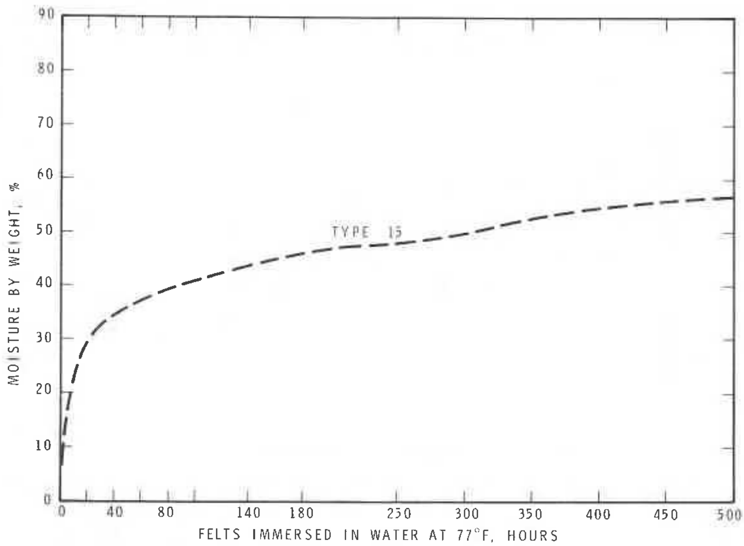


FIG. 4—*Rate of water penetration in Type 15 asphalt-saturated organic felt during 520 h of immersion at room temperature.*

FIG. 5—*Top surface of dry organic felt.*

4. Figures 5 and 6 show the presence of fibers of wide range of L/D ratio, some fibers being less than 2 μm in diameter. Consequently, in those fibers, asphalt (with high molecular weight) cannot easily get access to all voids. Hence water, having a high dipole and small molecular diameter, can still be absorbed to a great extent even in the asphalt-saturated specimens (Fig. 4).

Now that the considerable effect of moisture on the strength of a single ply of asphalt-saturated roofing felt has been shown, the important question to ask is whether the same effect will be reflected on the strength of four- to five-ply BUR membranes, and what the combined effect of temperature and moisture will be on the tensile strength of the membrane system. Future research will be undertaken to answer these questions. Meanwhile, the fundamental work of Jones [*15*] remains a useful source of information in this field.

Acknowledgment

The author wishes to express his sincere thanks to P. J. Sereda, head, Building Materials Section, for valuable advice, fruitful discussion, and constructive suggestions. Thanks also are due to K. K. Karpati for her interest and cooperation in the evaluation of some of the results and to H. E.

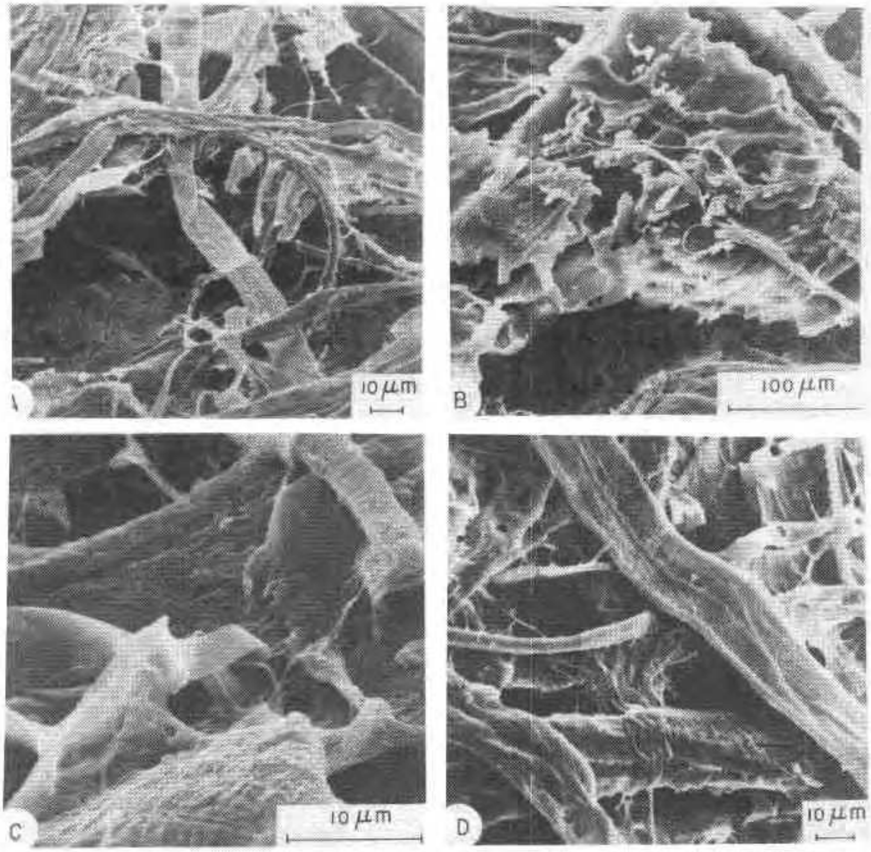


FIG. 6—*Photomicrograph of unsaturated organic felt, showing voids and spaces and poor* L/D *ratio.*

Ashton for help in preparing the paper. The experimental work was carried out by C. C. Barrett, whose assistance is also appreciated.

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DISCUSSION

M. D. Keller[1] *(written discussion)*—I would like to ask Mr. Laaly the following question: If you take rolls of felt and you have them out in a heavy rain; then you allow them to dry over a couple of weeks; will the felts than be weaker than if they had been maintained dry?

H. O. Laaly (author's closure)—The following results of a study at the Division of Building Research, National Research Council are offered as an answer to this question.

Based on the ASTM Recommended Practice D 2523, 20 specimens from one roll of bitumen-saturated Type 15 organic roofing felt were prepared in machine direction and 20 specimens from the same roll of felt in cross

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machine direction. They were divided into four groups consisting of five specimens each, as follows:

1. Original specimens before wetting.
2. Soaking for a period of three days in water at room temperature, drying 90 min at 55°C.
3. Soaking for a period of seven days in water at room temperature and drying at room temperature until they regained their original weights.
4. Soaking for a period of ten days in water at room temperature and drying at room temperature until they regained their original weights.

The amount of water absorption increased from 31 percent by weight after three days up to nearly 40 percent after ten days immersion in water. It was found that the rate of drying of wet felt in a condition room (50 percent relative humidity and 23 ± 2°C temperature) is much slower than rate of water absorption when immersed. Dog bone specimens were tested using a tension testing machine (Instron Universal) at room temperature and 50 percent relative humidity with a crosshead speed of 1 percent/min, and the results are given in Table 1.

One cycle of wetting and drying decreases the breaking strength of Type 15 asphalt saturated organic felt as shown in Table 1.

TABLE 1—*Dog bones tested at room temperature and 50 percent relative humidity with a crosshead speed of 1 percent/min.*

Specimen Series and Conditions of Treatment	Machine Direction		Cross Machine Direction	
	Actual Load at Break, kg	Loss of Strength, % of Original	Actual Load at Break, kg	Loss of Strength % of Original
a	13.63	...	4.92	...
b	11.98	12.1	4.74	3.7
c	11.61	14.8	4.51	8.3
d	10.92	19.9	3.97	19.3