Reprinted from *ISI Bulletin*; Vol. 34, No. 2; P 56-58 & 68 (1982)

Waterproofing of flat roofs with tar felts has not been found to be very effective over long periods. The author makes a comparative study of the specifications laid down in India, British and ASTM standards on tar felt in regard to their raw material, bonding material and physical requirements, and suggests modifications to the concerned Indian standards in the light of work done elsewhere and investigations that may be carried out in this country — Ed.

Performance Standards for Tar Felt

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■ Tar felts are commonly used as waterproofing membranes over flat roofs. If these felts are prepared on the basis of correct specifications, laid in accordance with the standard code of practice and properly maintained, they can last a sufficiently long time. However, it has been observed in this country that many of them fail much earlier than anticipated. The failure occurs usually through shrinkage, splitting, ridging, blistering and delamination. The more important causes of these failures have been listed as moisture, heat, sunlight, freezing, thawing, etc. While the former three factors are vitally important for tropical and equatorial type of climates, the latter two are more relevant to temperate countries.

Extensive research work is reported in the literature[1-8] on the causes of failure of tar felts in different climatic conditions. Tar felts manufactured in India meet the performance requirements laid down in the Indian standard specifications for bitumen felts for waterproofing and damp-proofing[9] and glass fibre base coal tar pitch and bitumen felts[10] yet, it is observed, they fail prematurely in outdoor performance. Where do things go wrong? What could be done to overcome this problem? To find an answer to these questions, efforts were made to scrutinize Indian and other important national standards laid down for this product and determine the areas in which further work is essential so that performance standards could be modified to reflect the actual performance of tar felts in the field with special reference to tropical climate in India. Standards on tar felts[9-19] were analyzed with respect to their classification, raw material specification and physical requirement as also specification of the bonding material. Studies already reported on performance evaluation of these felts, especially in tropical climate, were also reviewed to determine the gap between requirements laid down in different standards and actual field performance of the product.

ANALYSIS OF STANDARDS

The standards referred to in this analysis are Indian standards[9-11], British standards[12,13] and ASTM standards[14-19]. A comparison of these standards reveals that there is much divergence in the selection of parameters as well as specifications. This may be due to different climatic and geographical conditions of the countries adopting these standards. However, some of their important features are summarized in the following paragraphs.

Classification

The Indian Standards Institution has grouped the tar felts into three types, based on fibres, namely, organic fibre-based, hessian-based and glass fibre-based. These are of saturated as well as self-finished (coated) types. On the other hand, the British Standards Institution (BSI) specifies four types of felts, namely, organic fibre-based, asbestos fibre-based, fluxed-pitch and flax. Of these, only the first two are bitumen-based while the latter two are based on coal tar pitch. ASTM has grouped tar felts into three types, namely, organic fibre-based, asbestos fibre-based and glass-matt. It is interesting to note that in India, apart from glass fibre-based felts, ISI has specified organic fibre-based and hessian-based felts both of which happen to be cellulosic fibres with very poor decay resistance. It has not specified asbestos fibre-based felt which is more suitable to Indian climate.

Raw Material Specifications

Specifications for three important raw materials, that is, base fibre, saturant and coatant are as under:

Fibres — ISI and ASTM give weight and ash requirements for all the fibres while BSI does not specify these parameters. BSI, however, prescribes a minimum of 80 percent asbestos, the rest in the asbestos felt being organic fibres.

Saturant — The saturant has to be a soft grade of bitumen which can penetrate well into the felt. BSI specifies a softer grade of bitumen (penetration, 140-220) than that prescribed by ISI (penetration not less than 80). ASTM does not specify any hardness requirement for the saturant. It, however, specifies more bitumen loading (140 percent) in the organic fibre-based felt than ISI (110 percent) while BSI specifies 110-120 percent for this type of felt. For asbestos fibre-based felt, ASTM and BSI specify not less than 40 percent and between 40 and 55 percent saturant respectively.

Coatant — The coatant has to be a blown grade of bitumen which possessed better weather resistance. ISI specifies a bitumen (softening point not less than 105°C and penetration not less than 7) harder than that specified by BSI (softening point 80-100°C). ASTM does not specify any physical requirement for the coatant but specifies instead its weight limits (135 percent minimum of dry felt weight in the case of organic fibre-based felts and 82 percent minimum in the case of asbestos fibre-based felts).

Physical Requirements

Indian standards prescribe a number of physical requirements for finished tar felts while ASTM standards prescribe limits for only breaking strength, pliability, openness of perforations, loss on heating and moisture content at the point of manufacture. Surprisingly, British standards do not specify any physical or performance requirement for felts. The breaking strength specified by ISI for its three types of felts (both in warp-way and weft-way) is much higher than that specified by ASTM for any of the six types of felts classified by it. Openness of perforations and loss on heating at 105°C are not specified by ISI; it specifies instead maximum limits for water absorption and some special tests, such as storage sticking test, heat resistance test and pressure head test. None of these tests, however, simulates the outdoor exposure conditions of temperature, humidity, sunlight, etc. For example, the breaking strength test, pliability test, storage sticking test, heat resistance test and pressure head test require conditioning of the felt at 27±2°C for 48 hours, at 5°C for 3 hours, at 35±2°C for 18 hours, at 68±2°C for 3 hours, and at 68±2°C for 3 hours respectively. Relative humidity values have not been specified in any of these cases. However, during the actual service of the felt, it is exposed to daily cycles of heating and cooling apart from the direct effect of rain and photochemical degradation of the binder as well as the fibrous matrix.

Bonding Material

Blown bitumen is used as an adhesive for bonding different layers of felts and the roof in making the waterproofing membrane. The selection of this bitumen has to be done judiciously as performance of the membrane depends to a great extent on this bonding material. ISI has specified the use of bitumen with a penetration not more than 40 in all the cases irrespective of climatic conditions, the slope of the roof or position of the bitumen in the inter-layer adhesion. However, ASTM and Canadian standards specify different grades of bitumen depending upon the slope of the roof (*see* Tables 1 and 2). The arbitrary use of bitumen (penetration ≯ 40) may result in slippage and other forms of roof failure due to the tropical climate of this country.

SALIENT COMPARATIVE FEATURES

While there are large variations in the specifications of different national standards, a few salient points are as under:

a) Compared to Indian standards, British and ASTM standards specify lower softening point and higher penetration values for saturants and coatants, keeping in view the cold climate of those countries;

b) ISI does not cover asbestos fibre-based felt though it is well established that asbestos fibre-based felts are better suited to tropical climate;

c) A penetration of not less than 80 for saturant in Indian conditions seems to be on the higher side;

d) For bonding material, softening point has not been specified by ISI though it is supposed to be a very important property in the service of the felt. Other standards recommend different softening points for

TABLE 1 PHYSICAL REQUIREMENTS OF ASPHALT IN ROOFING (ASTM D 312-1978)

Sl No.	Property	Type I Min	Type I Max	Type II Min	Type II Max	Type III Min	Type III Max	Type IV Min	Type IV Max
1	Softening point, °C	57	66	70	80	85	96	99	107
2	Flast point, °C	225	—	225	—	225	—	225	—
3	Penetration at								
	0°C	3	—	6	—	6	—	6	—
	25°C	18	60	18	40	15	35	12	25
	46°C	90	180	—	100	—	90	—	75
4	Ductility at 25°C, cm	10	—	3	—	2·5	—	1·5	—
5	Recommended slope, percent	—	4·17	4·17	12·5	8·3	2·5	16·7	50
6	Susceptibility to flow	Susceptible		Moderately susceptible		Relatively non-susceptible		Non-susceptible	

TABLE 2 SOFTENING POINT OF ASPHALT IN ROOFING

MATERIAL Asphalt	SOFTENING POINT, °C	RECOMMENDED SLOPES
Type 1	60-65·5	0 to 1 : 16
Type 2	74-79·5	1 : 16 to 1 : 8
Type 3	88-96	Greater than 1 : 8
Coal tar pitch	60-68	0 to 1 : 25

TABLE 3 COMPARATIVE PERFORMANCE OF VARIOUS TYPES OF FELTS EXPOSED TO OUTDOOR WEATHERING IN MELBOURNE

SL No.	TYPE OF FELT	PERFORMANCE
1	Unsaturated organic fibre felt	After two weeks began to pucker and blister, after 4 weeks began to disintegrate
2	Saturated organic fibre felt	After 4 weeks began to pucker and blister
3	Coated organic fibre felt	After 9 months began to develop small postules or blisters
4	Unsaturated asbestos felt	After 4 weeks began to pucker and then disintegration started
5	Saturated asbestos felt	After 12 months began to pucker
6	Coated asbestos felt	No data are given
7	Glass fibre matt	Even after 18 months no fault was visible

various slopes of roofs (*see* Tables 1 and 2); and

e) None of these standards prescribes any accelerated weathering test for determining the weathering behaviour of tar felts.

PERFORMANCE OF TAR FELT IN TROPICAL CLIMATE

Performance studies on tar felts in Indian climate have not been carried out systematically. However, extensive research work is reported from the National Bureau of Standards (USA), National Research Council (Canada), Building Research Establishment (United Kingdom) and Commonwealth Scientific and Industrial Research Organization (CSIRO) (Australia). Work done at the first three organizations deals mostly with the performance of tar felts in temperate climate. However, extensive work done at CSIRO[1-4] may be useful in this country as the studies there were carried out in tropical climate. Martin[8] compared the durability of untreated, saturated and coated felts made from organic fibres (cellulosic wastes), asbestos fibres and glass fibres (*see* Table 3). As expected, the performance of these felts was found to improve in the order of untreated, saturated and coated felts. Glass fibre felts were found to possess better weather resistance, but their poor bitumen absorption was found to result in poor waterproofing property.

It can be clearly inferred from these investigations that asbestos-based felts perform better than the organic fibre-based (cellulosic) felts. This is due to the latter's high dimensional movement to moisture variation and poor decay resistance. The poorly saturated felts showed more swelling and shrinkage. Since textile wastes and waste paper are normally used for making organic fibre felt, it is difficult to exercise strict quality control in the preparation of these felts. Further, if the felts are not well protected by an impermeable layer, the surface becomes permeable within a few months. Asbestos fibre felts, on the other hand, possess lower capacity to absorb moisture, greater dimensional stability to moisture movement, smaller change in tensile strength from dry to wet conditions and higher resistance to photochemical degradation of the exposed fibres.

It is, however, not known whether the exhaustive work carried out by CSIRO is reflected in the form of a revised standard specification or code of practice for tar felt. This is important if national standards are to be used for evaluating the performance of felts in outdoor weathering.

CONCLUSIONS

The above analysis shows that the performance requirements for tar felts specified in different national standards do not adequately reflect their expected durability. Emphasis on the specification of various raw materials does not seem to be very relevant to the climatic requirement. The tests do not simulate the changes in moisture content and cumulative effect of moisture, ultraviolet radiation and temperature changes. Indian standards do not cover asbestos fibre-based felt which has been proved to perform much better in tropical climate.

There are no tests whatsoever in the national standards on the evaluation of durability of tar felts. A suitable accelerated weathering test on the lines of ASTM D 529-1976[10] requires to be developed and incorporated in the Indian standards to allow the felts to be tested for their durability. This, however, needs some modifications as the whole waterproofing membrane is a multi-layered system and its durability depends not only on the life of the top layer of felt but on many other factors, such as primary and secondary layers of felts, quality of bonding bitumen, method of laying, and mineral and gravel dusting.

Since it is not clear whether the failure of Indian tar felts in temperate climate is due to substandard specifications, non-compliance of the use of specified raw materials or use of a poorly framed code of practice, it would be worthwhile to carry out further investigations which would help in pinpointing the gaps between the specified physical requirements and actual field performance. These studies could help in deciding on the steps necessary to make the Indian standard specification for tar felts more useful. These could be:

a) Upgrading the physical requirements for tar felts to make them match their outdoor performance;

b) Revision of specification for raw materials as well if outdoor weathering performance of the felts is not satisfactory even after using the specified raw materials; and

c) Suitable changes in the standard code of practice (IS : 1346-1976) recommending specific properties of bonding bitumen depending upon the climatic conditions in this country.

ACKNOWLEDGEMENT

The author wishes to thank the Director, Central Building Research Institute, Roorkee, for his permission to publish this paper.

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