From the NRCA/NBS PROCEEDINGS OF THE SYMPOSIUM ON ROOFING TECHNOLOGY, Sept 1977 PAPER NUMBER 23

EXPANSION-CONTRACTION EFFECTS ON ALUMINUM COATED ASPHALT BUILT-UP ROOFING

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Asphalt-based materials age by losing their oils in the same way as the mud of a river bed, which, after it has lost its water, undergoes a substantial contraction, causing cracks. Asphalt that has lost oils breaks up by undergoing the same phenomenon of mud-curling.

A roofing felt, therefore, must be protected on the surface by flakes of slate or by granules of ceramic, but this protection is not impervious to oil vapors and this sealing coat can itself crack, in those cases where the roofing felt has failures or a bad choice of asphalt.

On the other hand, the material is preserved if the surface is protected by a metal, whether it be aluminum, copper, or rust-proof steel. In fact, a covering 0.08 mm in thickness totally forestalls the problems of evaporation of the oils of the bitumen.

It is, in fact, very easy to glue a thin skin of aluminum onto a roofing felt, but when this felt is placed in position on a roof, there is a risk that the metallic protective film may expand and form creases if it is subjected to severe differences in temperature, which is always the case when the roofing is applied on thermal insulation (annual temperature ranges attaining 90°C.)

The explanation for this phenomenon was brought to light in 1963-64. We can graph the elongation of a metal sheet as a function of the temperature (Fig. 1). If the metal is free (unglued), it expands and contracts according to the diagonal MN, since nothing interferes with the expansion, which is itself proportional to the temperature.

If the metal is glued to the asphalt, the temperature, being raised from O to A, expands the metal sheet, but there cannot be full expansion since the asphalt is too hard and does not permit it. From A to B, the metal becomes loose on the asphalt, which is softer, and rejoins its expansion curve at point B.

If it is cooled, the metal first contracts on the hot, soft asphalt. It then follows diagonal MN, and as the asphalt hardens more and more, the metal cannot contract. It stays at a permanent length OD. The phenomenon begins again the next cycle.

This phenomenon can be reproduced in the laboratory. The apparatus consists of an extremely rigid, hollow support, of the following dimensions:

- Length: 2 meters
- Width: 0.20 meters
- Cold water circulates inside the support during the entire experiment.

One has then an immobile support insensitive to temperature variations to which the test pieces are submitted.

On this support a 10 mm thick insulating panel is affixed to the asphalt. This insulating sheet is placed in eight pieces, each 25 cm. in length, glued to a frame one after another.

On the uncovered surface of the insulating sheet, test pieces are glued to the asphalt. The test pieces were self-protected by metal foil, and were tested in the form of strips two meters in length.

Points of reference fixed on the frame at the two extremities of these test pieces allow one to measure, by means of a micrometer, the movement of the aluminum to the nearest 1/100th of a mm.

The surface of the test pieces is painted with black varnish and the heat is provided by infra-red lamps uniformly spaced at 40 cm. from the surface.

This apparatus was entirely to our satisfaction. At each end of the test piece we measured the extension of the aluminum by means of an optical comparator.

If one places our sample on this thermal shock bench and reproduces several cycles of heating and cooling, one establishes that the aluminum film undergoes a series of cumulative daily expansions reaching one-third of a mm. in only six days (Fig. 2).

In 1963 and 1964, several samples were exposed simultaneously to many cycles: the extension appears on the ordinates of the table, while the number of cycles appears on the coordinates (Fig. 3).

The first sample (the dotted line) attained an extension of close to 7 mm. in 45 days.

A second sample with an improved roofing felt – the structure having been placed very close to the metallic protection (the third line in bold face from the top of Fig. 3) in such a way as to stop the sliding of the metal – only attained an extension of 3.5 mm. in 40 days.

It is evident that in less than one year the same extension of 7 mm. was attained or even surpassed. A series of improvements allowed the extension to be kept within 2 mm. in 40 days (a group of 3 curves practically intermixed).

But this improvement was not decisive since in one year alone the metal extended and formed seriously large creases.

Returning to the work at hand, these extensions were then reduced by creases, which create leaks, especially in the curious and well-known case of creepage from East to West.

The Case of a Projected Shadow

In the case where the heat is produced in an assymetrical manner, the surface shifts towards the West, the asphalt on its sliding plane. With displacement of aluminum from East to West, the coating of the East side is 0.60 meters to the maximum point (there is no incline; the incline of the roof being North-South at about 2%).

Explanation of this Phenomenon:

As we have just seen, when the materials are glued to the asphalt they expand and do not return to their original size. The projected shadows thus create permanent distortions. The sun rises in the East and starts to heat part A in the morning. Part A lengthens, part O being in the shade on the cold, hard asphalt. The sun, in the evening, drops to the horizon and the projected shadow cools down, making firm the part that was stretched in the morning. The product then contracts more and more, as the shadow grows, but this time it is point O which is displaced, since at this moment in the evening the sun is hot on the soft asphalt while the part extended in the morning is now rigid from the evening shadow. (Fig. 4).

We have seen this phenomenon very clearly twice, but it is produced in a concealed manner in numerous classic cases, i.e., sheds, wide gutters, etc.

A decisive improvement was made in 1964 to suppress all movement of extension from the metallic protection. The last two curves at the bottom of Fig. 3 show not only veritable non-existant extensions, but even a slight contraction due to the fact that the metallic protection film glued under tension undergoes a slight contraction in its installation in the workshop. The experiment has been carried out for five years, which represents 1850 cycles.

We find a remarkable difference between a covering manufactured before 1964, where the aluminum had undergone accumulated everyday extensions, and the covering manufactured after 1964, which stays perfectly stable.

How did we arrive at such a result? By a process called "self-compensated extension" (Fig. 5). The aluminum is corrugated transversely every 12th mm. At the right angle of each groove, the surface of the aluminum glued to the hard asphalt, which constitutes the covering, floats in a film of asphalt (straight run), which is perpetually soft, even at low temperatures, in such a way that the grooves can close when here and there the flat parts expand, and can reopen when the flat parts contract again, even if the surrounding temperature had lowered substantially.

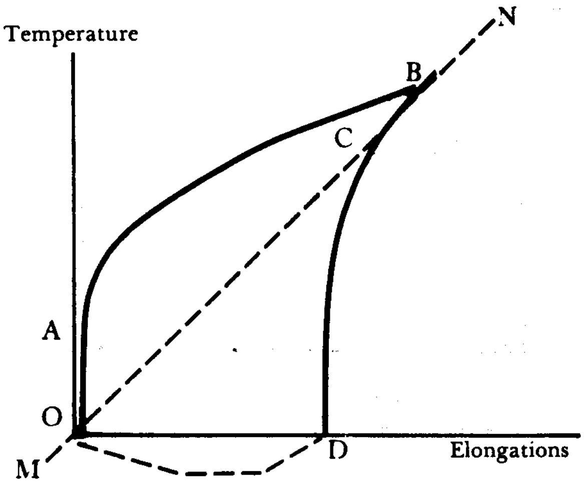

FIGURE 1

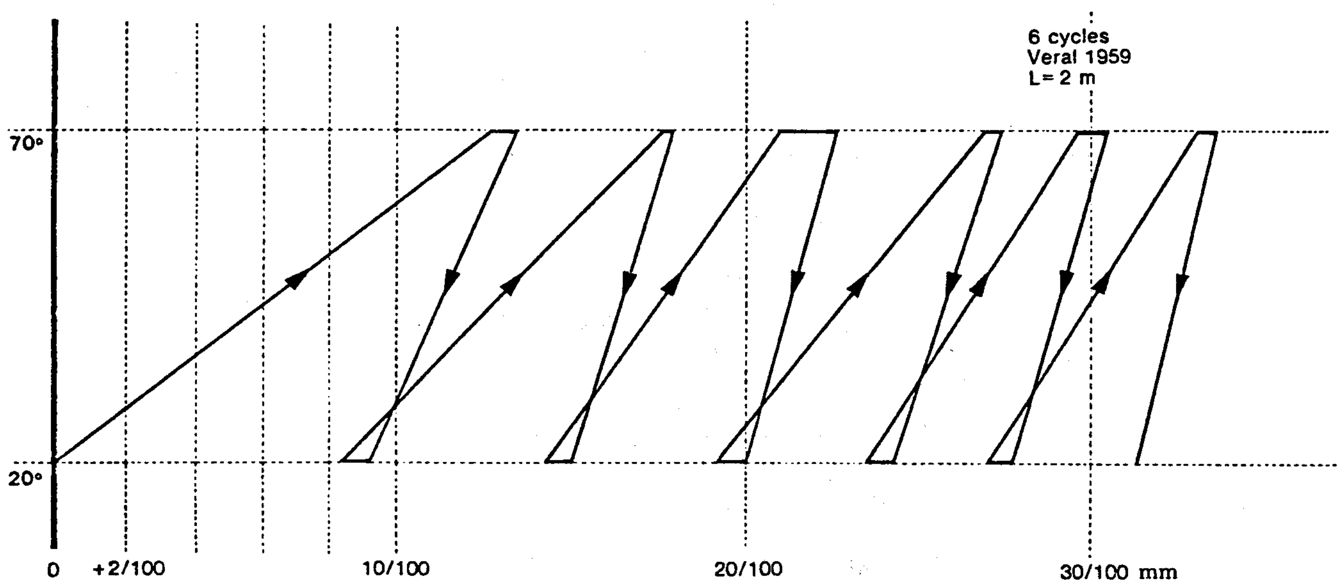

FIGURE 2