

Thin Overlay Bituminous Macadam for the Control of Reflex Cracking

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•REFLEX CRACKING in pavement overlays has been an extensive problem, often with an unsatisfactory solution. This problem is brought about by attempts to correct another far-reaching problem—old pavement in need of rehabilitation. Both problems now exist in practically all pavements.

Determination of a satisfactory solution to these problems has been one of the most pressing demands on airport owners and the Aeronautics Commission in Maine for the past 10 years.

Pavements in concern, for the most part, have been over 20-years-old, have retained their general shape, but are severely cracked. The cracks commonly prevail in two directions—longitudinally with a reasonably consistent pattern and straight alignment, and transversely with a very irregular pattern and irregular alignment. The width of the cracks is most often from $\frac{1}{2}$ to $\frac{3}{4}$ in.

PREVIOUS METHODS

One method used extensively to rectify badly cracked pavements was to clean the cracks with a router, or by some other means, and then fill them by successive applications of asphalt and sand. This often was followed by a seal coat or bituminous concrete overlay 1 to 2 in. in thickness.

Another method used to some extent was, after routing, to fill the cracks with a rubber asphalt or synthetic and then apply a seal coat or bituminous concrete overlay.

A third method was to fill the cracks with either asphalt and sand, rubber asphalt or synthetics and then apply a bituminous concrete overlay, 1 to 3 in. in thickness, underlain with wire mats.

For each of these methods results were unsatisfactory. It was common to have a great many of the original cracks reappear the following year as reflex cracks.

NEW APPROACH

Because of the dissatisfaction with previous methods, in 1959 the decision was made to use a 3-in. course of bituminous macadam pavement to rehabilitate an extreme case of old, badly cracked bituminous concrete runway pavement. It was predicted that the large 2-in. base stone of the macadam would bridge the existing cracks and therefore would resist or actually eliminate reflex cracking. It was further theorized that because of this expected bridging action, the existing pavement cracks would not have to be pretreated.

In the summer of 1959, a typical 3-in. bituminous macadam overlay course was placed over 1 of the 2 runways at the Eastport Airport, Eastport, Maine. Inspections during the next 4 years revealed no evidence of reflex cracking. During the fifth year one crack occurred, but it had actually healed itself. Obviously the $2\frac{1}{2}$ gal./yd² of flexible asphalt used in this macadam course added greatly to its ability to resist cracking; when cracking did take place, the asphalt was a great asset in rehealing it. The actual material description, amounts and order of application used on the Eastport project, is described in Table 1. Pavement conditions before and after this project are shown in Figures 1 and 2.

TABLE 1
EASTPORT AIRPORT, MAINE,
BITUMINOUS MACADAM OVERLAY

Order of Application	Amount of Material per Square Yard	Material Description
1	225 lb	Stone— $2\frac{1}{2}$ in. minus
2	1, 60 gal.	Asphalt cement
3	35 lb	Stone— $\frac{3}{4}$ in. minus
4	0, 60 gal.	Asphalt cement
5	25 lb	Stone— $\frac{1}{2}$ in. minus
6	0, 15 gal.	Asphalt cement
7	15 lb	Stone— $\frac{1}{4}$ in. minus

Because the first bituminous macadam project produced such satisfactory results, macadam was used again when, in 1964, another badly cracked runway pavement was scheduled for rehabilitation. A major adjustment adopted, however, primarily for economy, was to reduce the pavement thickness from 3 in. to $1\frac{1}{2}$ in. The specifications that were used generally followed the Maine State Highway specifications for bituminous macadam surface course, except for the adjustments described in Table 2.



Figure 1. Eastport Airport before bituminous macadam overlay.



Figure 2. Eastport Airport after a 3-in. bituminous macadam overlay.

The construction of the 1½-in. macadam course generally followed typical macadam construction, with minor exceptions. Equipment that was used was an Adnun paver, a modern bituminous distributor truck, chip spreader, 6-ton roller, and a broom drag.

Two conditions were encountered that had not been anticipated. It was found that a 12-ton, 3-wheel tandem roller that had originally been brought to the job was too heavy and tended to push the stone up in a wave in front of the rollers. This condition was corrected by replacing this larger roller with a smaller 7-ton, 2-wheel roller. Some difficulty was encountered in obtaining the desired uniform covering of Keystone and Chip Stone. This problem was attributed to an extensively used and worn tail gate type chip spreader. This spreader was condemned on this project and, on another similar job, a more modern spreader was used with very good success.

A 1½-in. macadam overlay pavement was placed on runways at 2 different airports. One was at Caribou, Maine, and the other at Dexter, Maine. Pavement conditions before and after the Caribou project are shown in Figures 3 and 4.

TABLE 2
CARIBOU AIRPORT, MAINE,
BITUMINOUS MACADAM OVERLAY

Order of Application	Amount of Material per Square Yard	Material Description
1	100 lb	Stone—¼ in. minus
2	0.75 gal.	Asphalt cement
3	15 lb	Stone—½ in. minus
4	0.50 gal.	Asphalt cement
5	10 lb	Stone—¾ in. minus
6	0.25 gal.	Asphalt cement
7	15 lb	Stone—¾ in. minus

An unfortunate condition that prevailed during the Dexter construction was unusually cold weather. This proved somewhat of a deterrent in gaining the desired adherence of Keystone and Chip Stone to the asphalt.

However, even though it was our first experience with a 1½-in. thin overlay bituminous macadam, we found its placement progressed very satisfactorily, with few unexpected or unusual problems. Actually, its construction is very much like that of the more common 3-in. bituminous macadam surface course.

Observations in May 1965 of both the Caribou and the Dexter projects revealed



Figure 3. Caribou runway before bituminous macadam overlay.



Figure 4. Caribou runway after a $1\frac{1}{2}$ -in. macadam overlay.

that they were holding up very well, and most importantly, that reflex cracking was practically nonexistent. Therefore, we now believe that thin overlay bituminous macadam is the most economical and practical approach to the control of pavement reflex cracking that we have tried, observed, or researched to date.

Opinions offered by some paving specialists state that macadam does not provide a satisfactory wearing course for some purposes. They suggest that, in these cases, the macadam could and should be used first to provide an insulation course to prevent reflex cracking, but then the macadam should be overlaid with a thin course of bituminous concrete. We can only say that this sounds as if it may have merit and that we would be greatly interested to hear of results from anyone that may experiment with it.

Discussion

CHARLES F. PARKER, Chairman, Subcommittee on Penetration Macadam, Committee on Bituminous Aggregate Bases—There are several items that I would like to discuss regarding this method, which has been so ably presented by Robert D. Johnson. The resident engineer employed on much of this work is a retired engineer who devoted the greater part of his career to the construction of macadam pavements. I worked many years with this man and have a great deal of respect for his ability. His name is David A. Smith.

In an interview Dave Smith stated, "Macadam is a good type of pavement but lacks research If one-half of the research had gone into macadam as for other types, it would be a popular type of construction today."

With this type of thin overlay using penetration grade asphalt, the penetration does not go through the stone. For that reason there is positively no bond between the overlay and the old pavement. Furthermore, there is a thick coating of asphalt on the stone and this adds greatly to the flexibility and aging characteristics of the overlay pavement.

Emulsified asphalt or cutback types would probably not be as successful, as there would be greater penetration and bonding of the overlay to the old pavement and less flexibility due to a thinner coating.

Relative to the compaction, it is my understanding that on one project, with greater than normal grades, they experienced some difficulties in rolling and changed to a lighter type roller. Probably larger diameter rolls or pneumatic-tire rolling would have been helpful in this case.

Weather could be quite a controlling factor. I was interested in one case about which Johnson may give us more details. It appears that on one of these projects there was a severe shower shortly after the application of the penetration, which prevented the application of the stone chips. As the field was being used, it was necessary to spread the chips before the pavement dried. Later, when the chips did dry, they rolled the pavement again and obtained a good bond. It would, of course, be necessary to have clean, well-graded stone chips.

The resident engineer attributed the smooth riding qualities to the long-wheelbase stone spreader used; they received many complimentary reports from visiting aircraft. With this type of construction, it is my understanding that they took out irregularities ranging from 1 to 1½ in. The thickness of this overlay, as reported by Johnson, seems adequate for the normal traffic on these airfields. The author might give his opinion as to the use of increased thicknesses for heavier traffic.

Proof of aging characteristics of macadam pavement using penetration grade asphalt has been observed many times. There are many cases in which macadam pavement over 30 years old, when excavated, showed the asphalt in thick layers still bright and sticky with a minimum amount of oxidation.

There is a considerable amount of skill required in the construction of macadam pavements. This is undoubtedly a contributing factor to its apparent decrease in popularity.

ROBERT D. JOHNSON, Closure—Based on knowledge gained primarily from actual experience, in order to develop a satisfactory macadam pavement, some of the important conditions that should be met are:

1. Provide for appropriate equipment;
2. Provide for competent supervision;
3. Make sure that stone is sufficiently hard, is not susceptible to excessive stripping by bituminous binders, does not consist of an excessive amount of elongated particles, is satisfactorily clean, and does not contain an excessive amount of moisture;
4. Call for a bituminous binder that will adequately fulfill its intended function; and
5. Actually construct the pavement only in satisfactory weather.

Another important point is that macadam has some outstanding favorable characteristics, one of which is flexibility. Because of these characteristics, macadam, in many instances would be the pavement that best fulfills the requirements established. Unfortunately, macadam has been substantially neglected by research and suffers from a tremendous amount of careless, unproven and unwarranted criticism. A modern research program, specifically oriented to clear up many of macadam's uncertain influencing factors, is very much in order, and actually long overdue.