The Use of a Crack Relief Layer to Reduce Reflective Cracking on Arkansas Highways

Norman D. Pumphrey, P.E.
District Engineer
Arkansas Highway and Transportation Department

In the very beginning and for several thousand years there were no engineers nor contractors, no suppliers and no problems. The people followed game trails or foot paths.

Then, around 700 B.C., we find that Isaiah, the prophet, writes in Chapter 40:3

“The voice of him that crieth in the wilderness, Prepare ye the way of the Lord, make straight in the desert a highway for our God. Every valley shall be raised up, and Every mountain and hill shall be made low: And the crooked shall be straight, and the rough places smooth . . . for the mouth of the Lord hath spoken it.”

And there was born the highway engineering profession and the highway construction industry.

Since that day highway engineers, contractors and administrators have worried, cajoled, cursed and cried for money, materials and methods to build, preserve and maintain those highways.

As the highways were upgraded the Arkansas Highway and Transportation Department (AHTD) began surfacing with Portland cement concrete and later with asphalt concrete. As these highways were subjected to more and more and heavier and heavier loads the surfaces began to crack.

Those cracked surfaces were covered over with asphalt mixes and the cracks came through the new surface, allowing the infiltration of water into the subbase and subgrade. This development of new cracks was given the name “reflective cracking”.

Early in the 1960’s the AHTD felt that something must be done to prevent or reduce reflective cracking in our pavements if we were to preserve the investment in our state highway system.

We tried asphaltic concrete hot mix surface course (ACHM) alone, ACHM binder and ACHM surface, asbestos asphalt and rubberized asphalt. The cracks came through.

In the latter half of the 60’s, we heard about a cobblestone overlay which had been moderately successful in reducing reflective cracking.

Cracks develop along paths of least resistance. The key to the suc-
cess of crushed stone bituminous concrete base (AHTD specifications), very simply, is building in 'paths of least resistance'.

Figure 1 is a typical section of overlay. Over the cracked surface, a course of crushed stone bituminous concrete base (crack relief overlay) is placed, topped with ACHM binder and ACHM surface.

The crack relief overlay is a very open graded aggregate which contains numerous large voids. As the crack from the old surface attempts to reflect into the new surface it is dissipated by the voids and does not readily penetrate through the binder and surface course — Figure 2.
Two types of mix were developed:

<table>
<thead>
<tr>
<th>Type I</th>
<th>% Retained</th>
<th>Sieve Size (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0 - 5</td>
<td>2-1/2</td>
</tr>
<tr>
<td>30 - 70</td>
<td>1-1/2</td>
<td></td>
</tr>
<tr>
<td>85 - 100</td>
<td>3/4</td>
<td></td>
</tr>
<tr>
<td>98 - 100</td>
<td>3/8</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Type II</th>
<th>% Retained</th>
<th>Sieve Size (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0 - 25</td>
<td>1-1/2</td>
</tr>
<tr>
<td>30 - 50</td>
<td>3/4</td>
<td></td>
</tr>
<tr>
<td>80 - 92</td>
<td>#4</td>
<td></td>
</tr>
<tr>
<td>95 - 100</td>
<td>#100</td>
<td></td>
</tr>
</tbody>
</table>

Both types of the open graded aggregates were to contain 3-4% 20, 30 or 40 viscosity grade asphalt cement.

After developing the initial specifications, a contract was let in 1969 to overlay a severely cracked asphalt road in south central Arkansas.

Traffic was to be maintained throughout the 13-1/2 miles of the project. Type I (350 lb/sy) was used on 13 miles and Type II (350 lb/sy) was used on a 1/2-mile section.

The contract was let and the work order was issued. After about 45 days, the contractor had worked up enough nerve to begin.

Some minor problems developed in the beginning with the Type I aggregate. The larger aggregate broke off the mixer paddles and pugmill lining. These areas were strengthened and the lay-down operation began.

The specifications called for the intermediate roller to be a pneumatic of a certain psi bearing pressure. The first real problem developed at this point. After the pneumatic roller finally got onto the top of the mat, it began to spread the large aggregate from a mat to individual rocks!

Being a rational individual, the engineer realized that something was amiss and the pneumatic roller was removed. It is no longer required in the specifications for this material.

The contractor got some mat down and it cooled to the point that traffic could be routed onto the newly placed material. The edges ravelled, the quarterpoints ravelled, the center ravelled and the beginning and the end of the run ravelled!

The mix was being made with 3% AC. Thinking it needed more asphalt to stick it together, the AC content was upped to 3-1/2%.

The ravelling didn't improve and it was found that an excessive
amount of AC in a mix this open allows the AC to run down into the bottom of the truck beds, making it necessary to clean the beds after each load.

The AC content was dropped back to 3% and the mat behind the finish roller was watered to make it cool faster. This helped the ravelling problem until about mid-morning following the day of placement. As soon as the air temperature warmed enough, traffic began picking up the smaller aggregate, thereby ravelling the previously laid mat.

An attempt was made to solve this problem by lowering the laying temperature and to cast sand on to the mat behind the finish roller before it had a chance to cool. To make a long story short, this didn't work either!

As all good government agencies do when confronted by complex problems, the operation was halted in order to study the problem. The upshot of the study was to cover the Type I open graded mix with ACHM surface course the same day it was placed.

This provided the opportunity for the contractor to obtain an additional asphalt plant, train a crew to run it, provide an additional lay-down machine, and train a crew to run it.

There was some necessary delay after finish rolling the open graded mix before the surface course could be applied. This was brought about by the trucks displacing the coarse aggregate, allowing the lay-down machine to become stuck in the mix.

The surface was finally placed on the project and the department received rave notices from all over the State of Arkansas from everyone who had travelled this section of highway. No one could understand how it could take so long to take a section of highway that was smooth, and only cracked, and make it into one of the roughest pieces of road within 100 miles! An additional ACHM surface course (165 lb/sy) was placed immediately. This section of highway served 11 years before it was overlaid with ACHM surface (165 lb/sy) in 1981.

Since this initial project, the AHTD has constructed numerous projects throughout the state with, generally, very satisfactory results.

The aggregate specifications for both types have not been changed but the asphalt content has been changed to allow 2%-4% and in some special conditions has been reduced to 1.7% (when using a very hard aggregate with low absorption).

Projects on the Primary and Interstate Systems are generally constructed to the following typical section:

Crushed stone bituminous concrete base - 300 lb/sy
ACHM binder - 385 lb/sy
ACHM surface - 165 lb/sy

On two projects which utilized this typical section, Interstate 55 in
northeast Arkansas and Interstate 30 in central Arkansas, some unique problems developed.

Rutting problems developed on the I-55 project. In an effort to determine the cause of this problem a section was removed through to the underlying PCC pavement. It was determined that the rutting was in the binder course and not in the crack relief layer.

The high percentage of trucks (30%) and depth of binder (7 1/2 in.) were considered to be contributing factors to the rutting.

The I-30 project experienced what at first was a mystifying problem. A bump appeared at many of the joints in the old PCC pavement. With the very high summer temperatures and the presence of moisture, hydro-static pressure caused a puffing at the joints in the old PCC pavement.

There are a number of items which we have learned to carefully consider during the period of 12-15 years the AHTD has been designing and constructing crack relief overlays.

The design is covered quite adequately in the Asphalt Institute Publication IS No. 177. Some of the more important design considerations are:

1. Type II Aggregate (-2 in.) should be used if the crack relief layer must carry traffic prior to its being covered by a Binder Course.

2. Type I Aggregate (-3 in.) gives the greatest protection against reflective cracking and should be used if traffic can be rerouted.
   Both of these mixes should be covered with both ACHM binder and ACHM surface courses.

3. Interstate and Primary highways with a high volume of truck traffic and with any movement of the PCC pavement which is to be overlaid could need pressure grouting to stop the movement of the concrete slabs.
   This was done on the I-30 project by detecting movement with a 25-ton proof roller. In those areas where movement was detected, a drilling pattern was marked on the pavement and holes were drilled through the concrete.
   Grout was then pumped beneath the slab until slab movement was detected. No attempt was made to correct deviations in grade.

4. The crack relief layer should be taken underneath the shoulder to daylight on the slope for drainage.
5. In areas with severe ground water problems, parallel and lateral drainage of the existing pavement should be provided.

In the construction of a crack relief overlay, some seemingly minor details can be recognized early and corrective measures taken which will ease some of the heart break on a project of this type.

1. Both the Type I and Type II mix use the same type of equipment that is used for ACHM surface and binder courses but you must convince yourself, and your people, that this is not asphaltic concrete hot mix and that is must be handled differently.

2. The mix may be hauled to the lay-down machine in conventional trucks, however, care should be exercised in dumping into the lay-down machine hopper. The truck bed needs to be raised as high as safely possible before tripping the tailgate. This reduces segregation of material and helps clean the truck bed.

3. Some attention must also be given to the hauling units prior to beginning. A truck with a short distance between the rear wheels and the end of the tailgate will not dump into the lay-down machine hopper far enough to prevent spillage. When spillage in front of the lay-down machine occurs, because of the weight of the material, the quickest method to clean it up is with a small front end loader.

A truck with the bed extending well back of the rear wheels with an extension welded to the bed will prevent the spillage, provided the trucker will hold the rear wheels in contact with the push rollers on the lay-down machine.

4. Rolling is accomplished by steel wheeled rollers. No minimum nor maximum weight is specified. When beginning to roll this type material, convince yourself that it is not ACHM. It doesn't lay the same. If it is too hot or contains excess asphalt, the asphalt will lubricate the aggregate and rolling will be delayed an unusually long time (possibly until the next day) or the roller may sink into the mix.

5. Hold the temperature of the mix as low as possible within the specifications to assist in early rolling. The best laying temperature with the aggregate currently in use is around 250° with the roller held back about two hours depending upon the air temperature.

6. Control the stockpile of aggregate and the plant so that the mix you receive on the roadway is as uniform as possible.
7. Provide a method of cleaning truck beds after every two or three loads. Use a detergent or something that is not detrimental to the asphalt mix.

8. Keep the asphalt content of the mix high enough to coat the aggregate but low enough to prevent excess runoff both while in the truck beds and also after the mix is placed on the roadway.

9. Do not attempt to obtain density, only some stability.

10. Cover the crack relief layer with binder course as soon as possible.

It can be concluded from this discussion that the open-graded mixes are hard to lay and that they are tough on your equipment. Both are true. Crack relief layers are not a cure-all to reflective cracking and there are still problems, but it is the best solution the AHTD has found to reduce reflective cracking.