EXPERIMENTAL PAVEMENTS WITH CURTISS-WRIGHT'S COAL-MODIFIED, COAL-TAR BINDER (FIRST YEAR'S PERFORMANCE)

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Introduction

At last year's Kentucky Highway Conference, Mr. W. B. Drake, Associate Director of the Research Division of the Kentucky Department of Highways, discussed the Curtiss-Wright coal-tar binder project. His paper was concerned with the selection of test sites, the construction of test and control sections, and the laboratory investigation performed before and during the construction period. In order to inform those that did not hear or read last year's presentation and to review those that did, I will quickly summarize the history of this study before I get into the evaluation of the first year's performance.

This project started in April, 1959, when the Curtiss-Wright Corporation announced the development of a new and superior road-paving binder utilizing bituminous coal. The development was the result of their research program conducted in an effort to find new uses for coal and coal products.

The material had been subjected to a variety of laboratory tests. Some of the tests followed Standard ASTM Procedures, and others were developed to emphasize proposed desirable properties. The materials were produced in 1-gallon batches; and, therefore, no quantities were available for any road tests.

Kentucky officials became quite interested in the material partly because of its reported volume uses of bituminous coal. The Commissioner of Highways and members of the engineering staff visited the Research Division Laboratories of the Curtiss-Wright Corporation at Quehanna, Pennsylvania. The material and its laboratory testing were discussed in detail. It was reasoned that the bituminous binder would need to be produced on a larger scale and that pavements would have to be placed and tested under traffic and weather to substantiate the laboratory tests.

The Commissioner of Highways entered into an agreement with the Curtiss-Wright Corporation, by which Curtiss-Wright would design, build, and operate a pilot plant to produce 3,000 gallons per day of Curtiss-Wright Binder. Kentucky agreed to place approximately 150,000 gallons of experimental binder in bituminous concrete test-road projects under the same conditions as asphalt cement. The producers were attempting to supply a binder that would have the same hot-mix plant production temperature relations as asphalt cement.

The contract was signed with the Curtiss-Wright Corporation on June 22, 1959. It was decided that because of the time involved and other factors that it would be necessary to arrange for change orders on existing bituminous concrete paving projects. Altogether, 50 projects were considered by means of using available data in the Department of Highways' files and by visual surveys. They were studied for design variables such as traffic count, roadway classification and system, existing pavement design, soil and geologic areas, aggregates specified, and asphaltic cement materials specified. Of the original 50 projects reviewed, 13 sections were selected.

The test sites are scattered over much of the state. Also, special attention was given to the selection of test projects in the eastern and western coal
producing regions of the state where the interest in this work was very high. Eleven of the projects selected were re-surfacings; two were initial treatments.

For each section of roadway selected to be used as a test for the Curtiss-Wright Binder, a comparable section—in base, traffic, etc.—was selected on which either PAC-5 or PAC-7 asphaltic binder mix was used according to the original contract. This control section was for comparison in the field evaluations of the experimental material.

The projects constructed were located in 12 counties and contained 13 test sections. Ten and two-tenths miles of pavement were placed using the experimental binder. A total of 11,030 tons of material containing 150,900 gallons of the CW Binder and 4,700 gallons of RT-12 was involved.

Two interesting control sections actually developed as the construction progressed. A section containing 1200 gallons of RT-12, the raw material used in the Curtiss-Wright Binder, was placed on one of the initial treatments. One-fourth mile sections of RT-12 and 2-component CW Binder were placed on one of the resurfacings. The 2-component binder was made by combining RT-12 with powdered coal; the high-boiling point creosote oil was not included.

Performance Studies and Results

During the year since construction of the test sections, the Research Division of the Kentucky Department of Highways has been continuously evaluating the binder. Tests in the laboratory and field have been run to support the information gained from visual surveys. Movie films and still photographs have been made before and immediately after paving. Also, additional still photos were made six months and one year after paving.

The most reliable data that we have collected on this project are monthly visual performance surveys. These surveys were made before paving and each month after paving for both the test and control sections for the first year. In every case, the failures on the test section were more plentiful and more severe than those on the control section. Remembering the fact that a special effort was made to have traffic, base, and design equal, you can visualize that there is a great difference in the performance. It should be pointed out that most of the failures in the experimental material are progressive. There is very little "healing" of blemishes in CW Binder mixes as compared to those in asphaltic binder mixes.

We have noted that a large number of the failures on the test sections seem to be caused by the brittleness of the mix made from CW Binder. This is emphasized in that cracks and defects soon reflected from the previous pavement onto the new surface. To illustrate this, Fig. 1 shows cracking in one of the test sections prior to surfacing with the Curtiss-Wright Binder, and Fig. 2 shows reflection cracking through the CW Binder test section on the same project.

The brittleness property of the material is again noted by the large amount of edge cracking over all of the CW Binder test sections. Cracks, such as shown in Fig. 3, have already formed where the new pavement was extended over the old surface. Only a very small amount of this type of failure has been observed on the control sections.

Another problem experienced with this experimental paving mix when prepared at temperatures comparable to those used in asphaltic construction is that the fines tend to wear or ravel away from the surface rapidly leaving a coarse, rough texture. Figure 4 is a close-up texture photograph of a control section after six months of service. There appears to have been a minimum loss of aggregate.

Figure 5 is a close-up of a test section containing Curtiss-Wright Binder after six months of service. There has been considerable loss of aggregate through the abrading action of traffic. This loss of surfacing material is very noticeable in the wheel tracks of the higher traffic volume test sections. This factor is evident in that in a number of places the CW Binder mix has worn through to the original surface.

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Another point worthy of mention is that the construction joints—both longitudinal and transverse—in the CW Binder test sections have opened and raveled much more than the control section joints. Some of these were hot joints made through the use of tandem pavers. This raveling tendency that is especially prominent at the start of a day’s work or when the paver switches to a different lane has made it necessary to patch several areas. The quick set of this material—although an advantageous characteristic in letting the traffic on the new mix quickly—appears to have a lot to do with the bad joints. Raking or handwork just cannot be done successfully even immediately back of the paver.

Of the other tests that we have performed on this project, two will be discussed here. One is skid resistance, and the other is roughness. These properties have become very important in building safe and comfortable highways and definitely must be considered in this type of evaluation.

Surface and friction measurements have been made on the test and control sections by a skewed wheel method. These readings were taken immediately after paving, six months after paving, and one year after paving.

Table 1 is a summary of the skewed wheel friction tests on wet pavement surfaces. The data represent averages of several readings on each test section, and all sections of each type are grouped. Note that the mixes from all the binders had approximately the same friction values immediately after paving, but that the CW Binder mixes have lower readings than the standard binder mixes for the last two testing cycles. Again this is typical data rather than the exception.

**TABLE 1: SKEWDE WHEEL TEST**

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<td>St.</td>
<td>0.78</td>
<td>0.72</td>
<td>0.67</td>
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<tr>
<td>CW</td>
<td>0.78</td>
<td>0.71</td>
<td>0.64</td>
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<tr>
<td>2-Comp.</td>
<td>0.75</td>
<td>0.71</td>
<td>0.57</td>
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<tr>
<td>RT-12</td>
<td>0.79</td>
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The roughness tests, taken at the same time intervals as the friction readings, show that the CW Binder sections are deteriorating—in regard to roughness—much more rapidly than the standard mixes. The poor riding quality of most of these sections is evident to the average driver even though he has no special measuring devices. Vehicle tires make a “singing” sound when they travel over a CW Binder surface.

**Conclusions**

The Research Division of the Kentucky Department of Highways has observed the construction and evaluated the first year’s performance of 10.2 miles (13 test sections) of roadway using the experimental CW Binder mix and 11.5 miles (13 control sections) of pavement surfaced with standard asphaltic binder mixes.

The following is a list of characteristics of the material observed during construction:

1. The CW Binder coated the aggregate exceptionally well.
2. Traffic could be permitted on a pavement that had been paved with CW Binder mix very early without apparent damage.
3. Fumes given off by the CW Binder hot mix created a hazardous and difficult working condition for the construction personnel.
4. The Curtiss-Wright Binder mix was difficult to finish after initial cooling. However, the densities of the mix on the test and control sections taken one year after construction and tested in the laboratory were about the same for both the experimental and standard materials.

5. A tar-type tack coat would probably be more compatible with the experimental binder than the cut-back or emulsified asphalt tack used.

The following is a list of characteristics of the material observed during the period of the first year's performance:

1. The experimental material lacked flexibility: edge cracking developed rapidly; old surface and base failures soon reflected through it; and raveling of the fine aggregate produced a rough textured surface.
2. The CW Binder mix did not bond with itself or other paving mixes after the set-up; and, therefore, the cold centerline and transverse joints soon opened.
3. Raking and handwork on the surface and approaches were difficult and ineffective.
4. Surfaces made with CW Binder mix have a tendency to become more slippery than those made with standard asphaltic mixes, but the actual magnitude of the difference in coefficients of friction is very small.
5. CW Binder mix deteriorates, in regard to roughness, more quickly than standard asphaltic binder mixes.

Some of the above difficulties have been observed in the standard asphaltic binders but have not developed to such a severe degree in a one-year period.

The RT-12 binder and 2-component CW Binder were not used in quantities large enough to accurately compare them with the materials already discussed. They seem to have some of the same brittleness characteristics that caused most of the troubles encountered in the 3-component CW Binder, but further observations will be necessary to confirm this.

Additional advantages and disadvantages of this new material may show up in the next few years. In order to fully evaluate the CW Binder, the Research Division plans to observe the performance and continue the field and laboratory testing as required. But the movie films, still photographs, visual surveys, and laboratory and field tests all taken as part of the first year's performance study, indicate that the experimental binder, as tested in the 13 old installations, has not compared favorably with the control asphaltic binder sections. In making this conclusion, it is significant to again state that the CW Binder sections were prepared with the same equipment, temperatures, and aggregation gradation used for the asphaltic binder control sections.

A report covering the Research Division's work in collecting and evaluating the data taken during the first year's observation of roads using the experimental CW Binder has been prepared and will be released later this month.
Fig. 1—Area of Transverse Cracking on Nelson County Test Section (Before Paving).

Fig. 2—Transverse Cracks Reflecting Through CW Binder Mix on Nelson County Test Section (One Year After Paving).
Fig. 3—Edge Cracking Common to Rowan County Test Section (One Year After Paving).
Fig. 4—Close-up View of Texture of Hopkins County Control Section (Six Months After Paving).

Fig. 5—Close-up View of Texture of Hopkins County Test Section (Six Months After Paving).