"KENTUCKY'S BITUMINOUS PAVEMENT RESEARCH ON MODIFIED COAL TAR"

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Introduction

In April, 1959, the Curtiss-Wright Corporation announced the development of a new road paving binder material. The following is from literature distributed by the company describing their development. Quote:

> "CURTISS-WRIGHT ROAD PAVING BINDER: The first of these new products, which has been developed and extensively tested in the laboratories of Curtiss-Wright at Quehanna, is an improved coal-based binder for hot-mix, hot-lay bituminous concrete highway and airport surfaces. The process under investigation is an adaption (patents applied for) of one in which coal is digested at high temperature in products derived from coal tar produced by the carbonization of coal.
>
> Laboratory tests have demonstrated that the new Curtiss-Wright binder material offers many advantages over present blacktop paving materials. Without resorting to unusual aggregate gradations, operating temperatures, etc., the improved binder can be used in existing hot-mix plants, and results in the construction of a durable and skid-resistant highway and airport surface that will not be adversely affected by water, jet fuels, gasoline or lubricating oils; will be resistant to shoving or rutting at elevated temperatures and to cracking at low temperatures; will not soften excessively under jet-blast conditions and will not harden appreciably due to oxidation, evaporation or molecular changes within the binder during its service life" end of quote.

The material had been subjected to a variety of laboratory testing. Some of the tests were Standard ASTM procedures and others were developed to emphasize proposed desirable properties. The materials were produced in one 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 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 Department of Highways entered into an agreement with Curtiss-Wright Corporation, by which Curtiss-Wright would design, build and operate a pilot plant to produce 3000 gallons per day of Curtiss-Wright binder. Kentucky agreed to pay Curtiss-Wright invoice costs for all materials used in production and to place the approximate 150,000 gallons of Curtiss-Wright binder in Bituminous concrete test road projects.

The Research Division was designated to administer the contract and to select the roads for test installation. The transportation of the material from Frankfort to the projects, the use of the material, the compiling of the construction records, and the performance surveys and evaluations were included in the administration of the project.

Project Selection

The contract was signed with 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 in order to complete the test installation during the pilot plant production period (August 21 to October 31).

The material involved was experimental and of course, not covered by approved Kentucky Highway Department Specifications. This meant that the material could not easily be incorporated in Federal Aid Porjects and would therefore have to be placed on projects involving only state funds. All existing construction projects containing bituminous concrete surfacing or re-surfacing in this category were reviewed. Projects programmed through September 1959, lettings were also studied for possible suitability.

The projects 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 primary importance was the construction status of the projects and the possibility of scheduling the test paving without undue delay to the contractors. Originally some seventy projects were available and these were reduced to fifteen.

The Construction Division arranged for conference with the Contractors on these projects. The bituminous plant mix contractors were exceedingly cooperative for every single project. Agreements involving change orders were worked out through the Construction Division Office to the satisfaction of the Department and the contractors to use the Curtiss-Wright binder in lieu of asphaltic cement on one half or one mile test sections of existing paving projects. Only one scheduled project had to be dropped from the program because of material production scheduling. A substitute project was used and the original number of projects were paved. Figure 1 shows the distribution of the projects

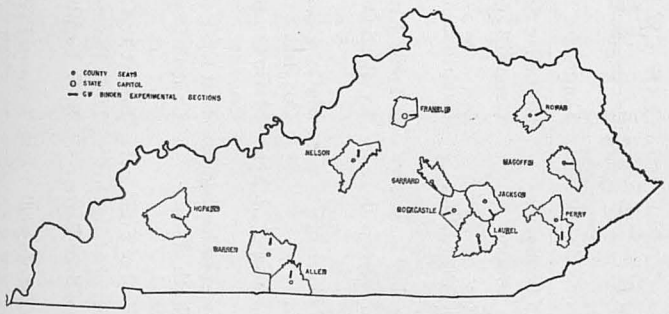

Fig. 1.—Distribution of test locations by counties.

by counties. The location of the test pavements are spread from Perry to Hopkins and from Rowan to Laurel. Existing interstate highways and streets are included. Initial treatments with Class I modified base and resurfacing on the secondary and primary system were selected. Table 1 shows plant location, contractor, traffic and type of construction. The traffic range was from 50 VPD to 14,150 VPD. All but two of the projects were resurfacings. These two were initial treatments with Class I modified-base type surfacing.

Production andTransportation

The agreement with Curtiss-Wright stipulated production to begin within 60 days or on August 21st. The site for the pilot plant was picked at the Daily Avenue, Franklin County Maintenance lot just east or the Central Garage on the

TABLE I: LIST OF CW-BINDER TEST SECTIONS

Group No.	County	Approx. Location	Contractor	Location of Plant	Traffic ADT	Type Construction
S.P. Gr. 6	Allen	Ky. 101 in Scottsville	McLellan Stone Co.	Scottsville	1025 (57)	Class I Surface–1½"
S.P. Gr. 11 Urban	Laurel	U.S. 25 in London	Cantrill Constr. Co., Inc.	London	14150 (58)	Class I Surface–1½"
S.P. Gr. 11 Rural	Laurel	U.S. 25 North of Lily	Cantrill Constr. Co., Inc.	London	11000 (59)	Class I Surface–1½"
S.P. Gr. 16	Garrard	Ky. 39 South of Lancaster	E'Town Paving Co., Inc.	Mt. Vernon	1070 (59)	Class I Surface–1½"
S.P. Gr. 18	Magoffin	Ky. 114 in Salyersville	Ky. Road Oiling Co.	Pomp (near West Liberty)	1075 (59)	Class I Surface–1½"
S.P. Gr. 31	Nelson	U.S. 31-E North of Bardstown	MaGo Construction Co., Inc.	Bardstown	2825 (58)	Class I Surface–1½"
S.P. Gr. 32	Jackson	U.S. 421 South of McKee	MaGo Construction Co., Inc.	Near McKee	1350 (59)	Class I Surface–1½"
S.P. Gr. 37	Rowan	U.S. 60 East of Morehead	East Ky. Paving Corp.	Olive Hill	2407 (59)	Class I Surface–1½"
S.P. Gr. 38	Perry	Ky. 699 North of Leatherwood	Cantrill Constr. Co., Inc.	Leatherwood	1125 (59)	Class I Surface–1½"
S.P. Gr. 45	Franklin	U.S. 460 East of Frankfort	Robert L. Carter Co.	Frankfort	1435 (59)	Class I Surface–1½"
S.P. 51-140	Hopkins	Ky. 70 East of Madisonville	Dixie Pavers, Inc	Henderson	2660 (57)	Class I Surface–1½"
I.T. Gr. 14	Warren	Ky. 185 South of Barren River	R. E. Gaddie, Contractor	Bowling Green	50 (58)	Class I (modified) 2¾"
I.T. Gr. 22	Rockcastle	Ky. 618 East of Quail	E'Town Paving Co., Inc.	Mt. Vernon	75 (58)	Class I (modified) 2¾"

same location. Figures 2 and 3 show the pilot plant before production was begun. The plant was constructed and the first batch actually taken from the pilot plant on August 19th. This material was processed through a hot-mix bituminous paving plant and placed on Daily Avenue in Frankfort on August 19, 1959. About 700 feet of two lane pavement 1¼ inches thick was constructed. It was found thereby,

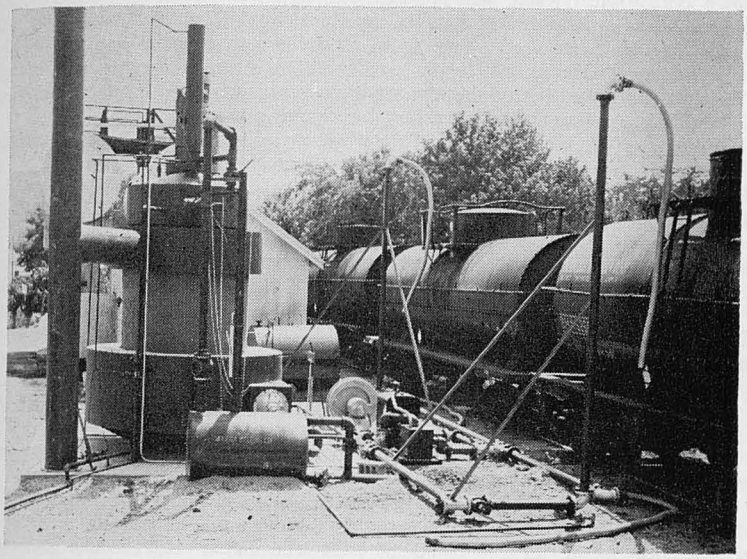

Fig. 2.—End view of pilot plant for production of Curtiss-Wright Binder. The primary unit is a vertical tank with oil fired heaters. Note pump and pipe installation for material handling.

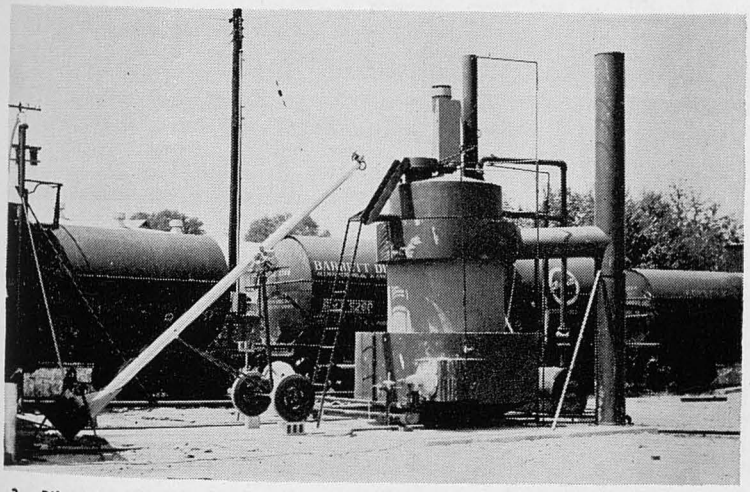

Fig. 3.—Pilot plant digestor tank with oil heater unit at base. Screw-type conveyor was used to charge digestor with powdered coal.

that the Curtiss-Wright binder would mix with aggregate in the plant and could be spread with conventional pavers. The compaction also appeared to be obtained with normal effort. The first section was not part of the planned test program, but rather a shake down for the benefit of Curtiss-Wright and the paving contractors on the test projects.

The pilot plant was a vertical-type, oil heated tank with a mechanical agitator. Cooling coils, with water and pumps for material handling were included. Storage of raw material and finished product was in railroad tank cars with normally four cars required. Two were used for raw material and two for the finished product. A tank car heater was used. A steam generator was required for heat on pipes and materials. An air-compressor was used to purge the lines. Coal handling equipment was necessary for charging the digester.

The binder production involved digesting powdered coal in products derived from coal tar. The primary raw material used at the pilot plant was RT-12. A high-boiling cresote oil was added in amounts of 10 to 15 percent by volume. From seven to ten percent by weight of the raw material batch was powdered bituminous coal. The coal was digested in the tar at temperatures of near 600° F. Volitals in the digestion up to the final temperatures were condensed and removed from the material.

Marshall stability design tests were performed for Class I type B surface mix and binder. It was found that maximum stability was obtained with about the same volume of Curtiss-Wright tar binder as was required for the asphalt cement. The specific gravity of the Curtiss-Wright binder was near 1.25 which meant that a somewhat higher bituminous content by weight was needed when the tar was used.

Standard penetration test, softening point, thin film oven weathering and other tests were performed on the material.

The Curtiss-Wright binder was stored at the pilot plant site in Frankfort in one or two railway tank cars. It was highly desirable and practically necessary to keep the temperatures of the stored materials above 300° F. The Curtiss-Wright binder was transported from the pilot plant to the various hot mix plants in insulated trailers (see figure 4) with butaine heaters for more or less emergency heating. Liquid Transportators, Inc., Louisville, Kentucky, supplied the trans-

Fig. 4.—Truck trailer units loading for transportation of Curtiss-Wright binder to hot-mix bituminous plants. Note pilot plant digestor at left of photograph.

portation required. Three 5500 gallons tandum axle trailers were used. One of the trailers was spotted at the hot-mix plant and used in lieu of storage tanks. The other two trailers were used to haul to the spotted trailer. By this method, normally only two tractors were needed. On the longer hauls, three tractors were used at times. The transportation service proved to be a most excellent arrangement and there was very little lost motion in moving from one project to the next.

On Labor Day weekend, after the pilot plant had been in production for just over two weeks, a fire destroyed the powdered coal in storage. The fire occurred at night and apparently started in the stacked bags of powdered coal. The plant was not damaged but approximately 54 tons of coal was destroyed. Additional coal was obtained without serious loss in production.

Construction

It was mentioned previously that change orders were arranged for each project selected for tests. The change orders provided that the contractor would substitute Curtiss-Wright binder in place of an equal volume of asphalt cement for a specified length of the road being surfaced. The aggregates, plant operations, construction specifications, and procedures were not to be changed. The only difference in the test section and its control section was the type of bitumen. An equal quantity of Curtiss-Wright binder was substituted for the asphalt cement. On each project, a length of road was selected to be paved with Curtiss-Wright binder and an equal length of normal asphalt cement pavement was designated for a control section. The test and control sections were selected to be as nearly uniform throughout the lengths involved as possible. A photographic record for the entire length of control and test sections was made before paving. This record was made on 16MM movie film. A similar record was made immediately following the paving operation.

At each hot-mix plant, the stationary or supply trailer was connected by flexible hose directly to the feed line to the plant. Both continuous and batch type plants were used. In some installations, it was possible to use a return loop to circulate the binder material. This was not absolutely necessary but we believe that it was helpful in keeping even temperatures in the supply systems and to prevent the filler material from settling out of the Curtiss-Wright binder.

In one instance, on a large "Barber Green Batch-O-Matic" plant, it was found that the pump from the supply reservoir could not be allowed to run continuously on the automatic position. With the pump running, it was found that the Curtiss-Wright binder appeared to coke or reduce back to solids since the pump was pumping air on the off-cycle. The solids clogged the jets in the pump, thereby, stopping the supply of bitumen to the pugmill. This pump was cleaned and placed on manual operation which eliminated the air pumping cycle and no further difficulties were observed.

As long as the temperatures were maintained, the Curtiss-Wright binder seemed to pump and handle very much like asphalt cement. No particular problems were observed in the mixing either in the batch or continuous mix plants. The bitumen appeared to coat the aggregate exceptionally well for the normal mixing time.

Haul distances varied from practically nothing to about 40 miles. Temperature records were made both at the plant and on the road. On one project, a round of trucks was delayed two to three hours unloading because of a rain shower. All of the material was placed without any particular difficulty. Figure 5 shows the paving operation.

The Curtiss-Wright binder mix had somewhat higher Marshall stabilities and this, of course, caused the material to be somewhat stiffer under the roller. The material appeared to be brittle in some instances and possibly crack under the rollers.

One of the objectionable features of the Curtiss-Wright binder was the presence of noxious fumes at the hot-mix plant and on the road at the pavers.

Fig. 5.—Paving operation on U.S. 60 in Rowan County. Conventional paving equipment and standard aggregate mixtures were used throughout the test projects.

The paver operators were the men most affected. The paving crews were not accustomed to the use of heavy grades of tar and this might have cause some of the difficulties. It was necessary to use hand and face creams to soothe the irritations.

The projects constructed were located in 12 counties and contained 13 test sections. Ten and two tenths miles of pavement were placed on the projects. A total of 11,029.31 tons of material containing 150,900 gallons of the Curtiss-Wright binder and 4,700 gallons of RT-12 was involved. Table II lists some of the construction data.

Two interesting control sections actually developed as the construction progressed. On Warren County IT Group 14, a section containing 1,700 gallons of RT-12 was placed to finish out a test project. Some difficulties developed at the Frankfort pilot plant after a batch in the digester had foamed and boiled over, causing a minor fire. The pilot plant operation had to be closed down for some period of time. In order to finish the test section, it was decided to use standard RT-12, the raw material used in the Curtiss-Wright binder. The material was handled in the same manner as the experimental Curtiss-Wright binder.

The Laurel County rural section was the last project to be paved and contained two variables not originally programmed. Approximately one fourth of a mile of pavement was placed with RT-12 for the bitumen. Curtiss-Wright Corporation requested that they be permitted to produce 3,000 gallons of two component Curtiss-Wright binder. This material contained only RT-12 and powdered coal. The third component high-boiling point cresote oil was not included. This section was the southern most one-fourth mile section of the Laurel County Rural test pavement and has been adequately marked by signs on the shoulder.

Performance Studies

The photographic record, taken on movie film immediately after paving, began the actual performance survey. Monthly visual inspections have been programmed with photographic records where significant changes are noted. A complete photographic record has not been rescheduled and would not be expected before late spring or early summer, and then only if the performance warrants.

TABLE II. CONSTRUCTION DATA—CW BINDER TEST SECTIONS

Group No.	County	Approx. Location	Length (mi.)	Mix (tons)	CW Binder (gal.)	RT-12 (gal.)	Date(s) Constructed (1959)
SP Gr 6	Allen	Ky. 101 in Scottsville	0.5	920.39	13,500		Oct. 12, 13 and 14
SP Gr 11 (Urban	Laurel	US 25 in London	0.5	831.80	13,000		Nov. 4 and 6
SP GR 11 (Rural)	Laurel	US 25 north of Lily	0.0	947.23	10,600 (3,000 gal. was 2-comp.)	3,000	Nov. 6 and 7
SP Gr 16	Garrard	Ky. 39 south of Lancaster	0.9	944.35	12,000		Sept. 24 and 25
SP Gr 18	Magoffin	Ky. 114 in Salyersville	0.8	665.01	9,500		Sept. 18
SP Gr 31	Nelson	US 31-E north of Bardstown	1.0	1,017.38	14,300		Oct. 21 and 22
SP Gr 32	Jackson	US 460 south of McKee	1.0	1,026.78	13,500		Sept. 29
SP Gr 37	Rowan	US 60 east of Morehead	0.9	802.00	11,500		Sept. 1
SP Gr 38	Perry	Ky. 699 north of Leatherwood	1.1	995.87	13,500		Oct. 6 and 7
SP Gr 45	Franklin	US 460 east of Frankfort	0.6	626.15	9,000		Sept. 9
SP 54-140	Hopkins	Ky. 70 east of Madisonville	1.0	916.31	13,500		Oct. 15 and 16
IT Gr 14	Warren	Ky. 185 south of Barren River	0.5	658.59	8,000	1,700	Oct. 1 and 2
IT Gr 22	Rockcastle	Ky. 618 east of Quail	0.5	677.45	9,000		Sept. 21
		TOTALS	10.2	11,029.31	150,900	4,700	

Surface friction measurements were taken on each of the test sections and its control shortly after placement. No significant differences were observed with the coefficients of friction averaging about 0.7 which is normal for new bituminous concrete pavements with Kentucky Class I Type B surface mix containing natural sand. Additional friction measurements are planned for this summer.

A series of rebound measurements by the swiss-rebound hammer method was taken in the late fall. Additional measurements are planned for early summer. These measurements may evaluate any tendency of the pavements to become brittle.

We believe that with the wide range of design variables in the thirteen test installations that the Curtiss-Wright binder material can be properly evaluated. Service life records for the control and the test installations should certainly answer the questions as to the comparability of the materials under test.

One item that has not been discussed thus far is the economics of the materials. Of course, pilot plant operation is not comparable to full scale production and the actual costs on these projects would of necessity be exceedingly high. The cost of the raw materials used in the production of the binder are listed here for information only and are of course subject to change. The RT-12 was delivered to the Department of Highways in Frankfort at $0.21 per gallon. The high-boiling cresote oil cost $0.60 per gallon delivered to Frankfort.

The powdered coal was delivered at the pilot plant for $57.50 per ton or $0.03 per pound. The approximate cost per gallon of the raw materials used to produce one gallon of Curtiss-Wright binder was $0.26. It is planned to develop service life data so that estimated future costs of the Curtiss-Wright binder can be compared with other surfacing materials on annual cost basis.