B. E. KING

COMMISSIONER OF HIGHWAYS

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
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H-2-8

MEMORANDUM TO: J. R. Harbison
State Highway Engineer
Chairman, Research Committee

SUBJECT: Research Report; "Experimental Sand-Asphalt Surface;" KYHPR-64-8; HPR- 1(6), Part II

In my submittal of a report on "Pavement Slipperiness Studies," May 8, 1970, I dutifully remarked that the problem of pavement slipperiness continues to be unresolved in a completely satisfactory manner. Class I, Type A, asphaltic concrete surface courses are not providing the desired assurances against slipperiness because the limestone aggregates therein polish too readily. The specifications for the fine aggregate admit sands which do not have good skid-resistant qualities. The term "Natural Sand" and its definition (Section 611, Standard Specifications..., 1965) no longer suffices. It has become apparent also that qualifying sands cannot compensate fully for losses in skid-resistance attributable to limestone coarse aggregates. Conceptually, the alternative is to relegate the limestone aggregates to bituminous concrete structural layers and to employ skid-resistant sands in a relatively thin (0.5 inch), sand-asphalt wearing course on top.

The first research measure of these qualities of pavement surfaces in Kentucky was made in 1953 in cooperation with the Tennessee Highway Research Program. [cf. "A Study of the Properties and Performance of Kentucky (Natural Sandstone) Rock Asphalt," Reports of HMRL, Vol XI, 1956]. Kentucky Rock Asphalt has always been praiseworthy for its skid-resistance. From the early 1900's until the 1950's, Rock Asphalt was used extensively

in Kentucky and was regarded as a premium-type surfacing material; however, it became unreliable in other qualities and passed out of use. Attempts to restore full confidence in it from the standpoint of other qualities have not been successful. Nevertheless, in that interim, Kentucky--whether intently or not--minimized slipperiness by using this material in resurfacing and earlier in new construction. In the 1950's, eastern Kentucky sandstones appeared to have good skid-resistant qualities; and for a few years, sandstone was invited as an alternate to limestone in asphalt resurfacing, etc. In the latter part of the 1950's, we undertook the development of a more generic and inclusive surfacing mixture--namely, a sand-asphalt. Conceptually, there, full reliance for skid-resistance would be given to sharpness and angularity of quartz sand--this was a recognizable and specific attribute of Rock Asphalt and sandstone aggregates excelling in skid-resistance. In this schema, the surface course (nominally 0.5 inch) would be regarded as being sacrificial but renewable. The wear-rate was an important factor. At the outset, it seemed important to demonstrate stability and permanence rather than premature wear. Blends of quartz sand with crushed limestone sands were admitted for that purpose. At that time, there was persuasive evidence that some limestone in sand-sizes would not affect skid-resistance significantly if the wear-rate was good. Unfortunately, it appears now that such a balance is unachievable. Some trials based on such premises have proven to be inferior in skid resistance to Class I, Type A surfaces. Summarily speaking, it appears that half-measures are to no avail and that the original concept was the correct one. The objective remains compelling if high assurances against slipperiness are considered a degree of excellence in highway safety.

Densely-graded sand-asphalts such as described in Special Provision 22-A suffer severe losses in coefficient of friction in relationship to increasing speed. Those mixtures ranged between 8 and 12% voids. This decrease in traction seems to be related to the "hydroplaning phenomenon" arising from insufficient, internal drainage. Optimization of all factors resolves into three guiding considerations, as follows:

1. Quality of sand--angular, sharp quartz
2. Maximization of Voidage--approximately 15%
3. Low Penetration Bituminous Binder--PAC-3

Optimumized sand-asphalt surfaces may not provide a high order of tractive resistance for vehicles traveling at high speed, during a rain--when water stands on the pavement. Many drivers reduce speed because of poor visibility--unfortunately, some seem

to feel privileged to abuse the posted speed limit regardless of the conditions. The apparent alternatives would be: 1) to make reduced speeds more compelling or advisable or 2) resort to coarse-textured, knobby, surface courses. These coarse surfaces are known to be noisy and disquieting; whereas sand surfaces generate a minimum of tire noise. Surely, the sand-type surface would command the greater admiration and provide due assurance against slipperiness.

The development of sand-asphalts to operational status has not been fully achieved; the report submitted here documents the several projects which are being studied. Materials, mixture designs, construction, and performance records were purposefully recorded. Some skid-resistance measurements have been included. They are automobile coefficients determined in the decelerating (skid) mode between 30 and 20 mph. Those values are generally higher than the 40 mph, steady-state, trailer values. More complete discussions of these data are given in our report of March 1970, on "Pavement Slipperiness Studies." A succeeding report will include more definitive ratings of surface types. However, there are certain issues which cannot be deferred further. Commentaries on those matters follow.

There are obvious, economical reasons for using locally indigenous sands in pavements. They occur abundantly in all areas of Kentucky--but less in the Inner Bluegrass. Selectivity in terms of composition, particle shape, and gradation imposes exclusions. A specific exclusion would be the glacial outwash sands from the Ohio River usually between Louisville and Cincinnati. Sands from the Carrollton-Warsaw areas contain carbonates in considerable proportion and do not qualify as skid-resistant material. Some other deposits consisting predominately of quartz would not qualify if the particles were rounded and polished. The desired shape is readily discernible visually (with magnification) but is not easily describable in specification terms. Photographic standards are being considered.

As mentioned previously, here, the term Natural Sand and its definition given in Section 611 permits but does not assure skid-resistant materials. Undoubtedly, some Class I surfaces have become more slippery than others. Prior to June 5, 1970, the definition did not permit the inclusion of crushed oversize siliceous material from conglomerate deposits in the sand product. Since the above date, the following permissive note has been included in proposals:

> Conglomerate Sand shall consist of natural material processed to recover desired sizes and may include materials produced by crushing oversize particles indigenous thereto.

Concurrent with the above action, an attempt was made to define skid-resistant fine aggregate for all uses where the uncertainties in the existing definition of natural sands cannot be allowed. The text follows:

> Skid-Resistant fine aggregate for surface courses and surface treatments, when specified, shall consist of mineral quartz particles, or other materials of equal or greater hardness, which have sufficient angularity in shape and (or) roughness of texture to assure maximum tire-pavement tractive frictional resistance when wet. Fine aggregates qualifying as mineral quartz shall contain at least 90% quartz particles by visual count or 94% SiO_2 by chemical analyses. Particle shape and texture shall be evaluated visually (magnified as necessary) and in comparison to reference materials having a proven performance history. Materials produced by crushing quartz sandstones, quartz pebbles, or quartz gravels may qualify separately as fine aggregate or as blending fractions. The percentage of rounded or adversely-shaped particles in the final product shall not exceed 15%. Products of other compositions, natural or synthetic, shall be subject to pre-qualification as an equivalent alternate hereto in advance of bidding. Pre-qualification, here, means prior approval of the Engineer.
>
> The proposal cited above remains pending.

The report does not confront the issues described here--because these are overviews which the authors were not privileged to offer.

We are not aware of any instance, historical or current, wherein Kentucky Rock Asphalt or comparable sand-asphalt surfaces have proven to be slippery. Sand-asphalts in the Frankfort area (1966) appear to have alleviated the problem of slipperiness which existed there previously. No complaints of slipperiness have arisen from the Muldraugh Hill area of US 31-W since resurfacing with Rock Asphalt (1967). Two sand-asphalt resurfacings have been disappointing. They are identified below:

SP 44-16, Green Co., Ky 61 from US 68 in Greensburg to Ky 88; completed July 11, 1969. An epidemic of accidents followed. Skid tests were requested by the District Engineer; a Skid Number of 34 was reported in October 1969. Early in December 1970, additional tests were requested; the value reported thereafter was 28. The aggregate composition was 55% natural sand and 45% limestone sand. Further characterization of the sands and mixture will be forthcoming.

SP Gr. 7, Meade Co., US 31-W from junction of US 60 at Tip Top to beginning of Rock Asphalt surface at Muldraugh (Ky 1638); completed June 1970. Complaints and skidding accidents have been persistent. SN values determined in December 1970 were: outside lanes, 34; inside lanes 37. At this site, the aggregate consisted of 80% natural sand and 20% limestone sand. Further characterization of the sands and mixture will be undertaken.

To update project records, there is appended hereto a tabulation of sand-asphalt surfaces constructed during 1970.

In final summary, definition of desired particle shape involves visual judgment; limestone sands cannot be admitted--except possibly as fine mineral filler (maximum of 10%); blending of sands qualifying in shape and composition should be permissive; sand-asphalt surfacing may be specified on new construction or deferred until needed; the implementation of sand-asphalt into resurfacing work involves leveling of the existing surface; the cost per ton is expected to be approximately twice that of the cost of Class I; plant capacities far exceed laying rates. The reliability of Class I surface, from the standpoint of skid-resistance, would be enhanced through the use of skid-resistant sands.

Specific recommendations concerning immediate changes needed in Special Provision 22-A, with regard to gradation, will follow soon.

Respectfully submitted,

Jas. H. Havens

J. H. Havens
Director of Research

Attachments:

cc: Research Committee

Assistant State Highway Engineer, Research and Development
Assistant State Highway Engineer, Planning and Programming
Assistant State Highway Engineer, Pre-Construction
Assistant State Highway Engineer, Construction
Assistant State Highway Engineer, Operations
Assistant State Highway Engineer, Staff Services
Assistant Pre-Construction Engineer
Assistant Operations Engineer
Executive Director, Office of Computer Services
Executive Director, Office of Equipment and Properties
Director, Division of Bridges
Director, Division of Construction
Director, Division of Design
Director, Division of Maintenance
Director, Division of Materials
Director, Division of Photogrammetry
Director, Division of Planning
Director, Division of Research
Director, Division of Right of Way
Director, Division of Roadside Development
Director, Division of Rural Roads
Director, Division of Traffic
Division Engineer, Federal Highway Administration
Chairman, Department of Civil Engineering, University of Kentucky
Associate Dean for Continuing Education, College of Engineering, University of Kentucky
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JHH/rp

KENTUCKY ROCK ASPHALT HOT-MIX SURFACES
KENTUCKY DEPARTMENT OF HIGHWAYS PROGRAM (1965-1970)

Prepared by Jerry G. Rose
January 11, 1971

Route	County	Project Limits	Length (Miles)	Const. Date	1969 ADT	Contractor	Thickness (in.) Width (Lanes)
KY 728	Edmonson	From: Jct. KY 259 near Kyrock To: Demumbrun's Store (The Nolin Dam Road)	8.664	Sept-Nov 1965	530	W. G. Reynolds & Associates	1 1/2 inch 2 lanes
US 31W-US 60	Meade-Hardin	From: 550 north of KY 868 in Muldrough To: South end of Salt River Bridge in West Point (The Louisville-Elizabethtown Road)	5.180	Aug-Sept 1966	22320	Middle West Roads (Warren Brothers)	7/8 inch 4 lanes
US 41	Henderson	From: 0.311 mile south of KY 54 in Henderson To: Jct. KY 136 at Anthoston (The Henderson-Sebree Road)	5.089	Oct 1966	5290	Dixie Pavers	7/8 inch 2 lanes
US 68-KY 80	Christian	From: The Todd County line To: 0.7 mile east of Jct. US 41 in Hopkinsville (The Hopkinsville-Elkton Road)	9.356	Nov 1966	2070	Dixie Pavers	7/8 inch 2 lanes
US 31E	Barren-Hart	From: North City Limits of Glasgow To: Larue County line (The Glasgow-Hodgenville Road)	31.848	Sept 1966-July 1967	1880	Henry Farris	7/8 inch 2 lanes
US 31W-US 68	Warren	From: South end of Barren River Bridge in Bowling Green To: Jct. of US 31W and US 68 (The Bowling Green - Cave City Road)	6.456	Oct 1966-June 1967	8070	R. E. Gaddie	7/8 inch 4 lanes
KY 80	Adair-Metcalfe	From: New West City Limits of Columbia To: Jct. of US 68 in Edmonton (The Columbia-Edmonton Road)	21.507	May-June 1967	1422	Marion Contracting	7/8 inch 2 lanes
US 127	Russell	From: Jct. KY 619 near SCL of Jamestown To: Jct. KY 55 south of Sewellton (The Jamestown-Albany Road)	5.150	June 1967	1710	R. E. Gaddie	7/8 inch 2 lanes
KY 101-KY 259	Warren-Edmonson	From: Jct. US 31W-KY 101 north of Bowling Green To: Jct. KY 70 south of Brownsville (The US 31W-Brownsville Road)	8.291	June 1967	1875	R. E. Gaddie	7/8 inch 2 lanes
US 79	Todd	From: The Logan County line To: 405 feet southwest of Hadenville (The Russellville-Guthrie Road)	6.673	June-July 1967	1230	Kapco Inc.	5/8 inch 2 lanes
KY 70	Barren	From: Jct. US 31W in Cave City To: East City limits of Hiseville (The Brownsville-Sulphur Well Road)	8.550	Aug 1967	1455	Henry Farris	5/8 inch 2 lanes
US 31E	Nelson	From: Forrest Street in Bardstown To: Cox's Creek (The Bardstown-Louisville Road)	5.300	Aug 1967	6900	Mago Const.	5/8 inch 2 lanes
KY 105	Breckinridge	From: Jct. US 60 in Cloverport To: Jct. KY 992 (The Cloverport-McQuaddy Road)	7.394	Aug 1967	400	Charles R. Allen	5/8 inch 2 lanes
KY 54	Daviess-Ohio	From: 0.234 miles northwest of Whitesville To: West city limits of Fordsville (The Owensboro-Fordsville Road	10.116	Sept 1967	2177	Corum and Edwards (by subcontract from State Contracting)	5/8 inch 2 lanes
US 431	McLean	From: Northeast CL of Island To: East CL of Livermore (The Central City-Owensboro Road)	3.107	Oct 1967	2715	Corum and Edwards (by subcontract from State Contracting)	5/8 inch 2 lanes
US 231	Butler	From: Old Northwest city limits of Morgantown To: Warren County Line (The Morgantown-Bowling Green Road)	11.331	June 1968	3050	R. E. Gaddie	5/8 inch 2 lanes
US 27	Pulaski	From: 4.5 miles north of Jct. US 27 & KY 80 in Somerset To: Northerly 1.5 miles to 1000 ft. north of Jct. KY 1247 (The Somerset-Stanford Road)	1.500	Aug-Sept 1968	8720	R. E. Gaddie	1/2 inch 2 lanes

SAND ASPHALT HOT-MIX SURFACES
KENTUCKY DEPARTMENT OF HIGHWAYS PROGRAM (1970)

Prepared by Jerry G. Rose
January 13, 1971

Route	County	Project Limits	Sands and Sources	Asphalt Content	Combined Silica Content	Length (mile) Width (ft.)	Const. Date & Special Provision	1969 ADT	Contractor
US 25- US 42	Boone (S.P. 8-10)	From: Kenton County Line To: Jct. US 25 & US 42 in Florence (The Covington-Lexington Road)	80% Coarse River Sand Appalachian Stone, Belleview 20% Fine Pit Sand Appalachian Stone, Belleview	7.5%	58%	0.900 ?? ft.	June 1970 22A	18,690	F.M.D. Covington
10th Street Newport	Campbell (S.P. GR. 9)	From: York Street To: West end of bridge over C&O RR	80% Coarse River Sand Appalachian Stone, Belleview 20% Fine Pit Sand Appalachian Stone, Belleview	8.0%	58%	0.500 40 ft.	July 1970 22A	-	F.M.D. Covington
11th Street Newport	Campbell (S.P. GR. 9)	From: Brighton Street To: York Street	80% Coarse River Sand Appalachian Stone, Belleview 20% Fine Pit Sand Appalachian Stone, Belleview	8.0%	58%	0.600 40 ft.	July 1970 22A	-	F.M.D. Covington
Main Street Hopkinsville (US 41)	Christian (S.P. GR. 4)	From: Ninth Street To: South end of Little River Bridge	63% Natural Mortar Sand Henderson Mats., Henderson 9% Pit Sand ?????? 23% Limestone Sand Hopkinsville Stone, Hopkinsville 5% Mineral Filler Hopkinsville Stone, Hopkinsville	8.8%	59%	0.460 43 ft.	Aug. 1970 22A	-	Dixie Paving
N. Virginia St. Hopkinsville (US 41)	Christian (S.P. GR. 4)	From: Ninth Street To: 144 feet south of First Street	63% Natural Mortar Sand Henderson Mats., Henderson 9% Pit Sand ?????? 23% Limestone Sand Hopkinsville Stone, Hopkinsville 5% Mineral Filler Hopkinsville Stone, Hopkinsville	8.8%	59%	0.320 43 ft.	Aug. 1970 22A	-	Dixie Paving
Ninth Street Hopkinsville (US 68)	Christian (S.P. GR. 4)	From: Main Street To: Seventh Street	63% Natural Mortar Sand Henderson Mats., Henderson 9% Pit Sand ?????? 23% Limestone Sand Hopkinsville Stone, Hopkinsville 5% Mineral Filler Hopkinsville Stone, Hopkinsville	8.8%	59%	0.318 43 ft.	Aug. 1970 22A	-	Dixie Paving
US 62	Hardin (S.P. GR. 7)	From: Old NECL of Elizabethtown To: The Kentucky Turnpike (The Elizabethtown-Bardstown Rd.)	45% Natural Sand Lucas Bros., Mauckport, Ind. 43% Pit Sand E'town Paving, Hart Co. Pit 12% Limestone Sand Waters Quarry, E'town	8.1%	71%	0.984 48 ft.	Aug. 1970 22A	-	E'town Paving
US 31W- US 60	Meade (S.P. GR. 7)	From: US 60 Jct. at Tip Top To: Rock Asphalt Surface at Muldraugh (The Elizabethtown-Louisville Road)	80%+ Natural Sand Lucas Bros., Mauckport, Ind. 20%- Limestone Sand Osborne Bros. #1, Hart Co. Pit	8.4%	56%	2.100 48 ft.	June 1970 22A	22,320	Middlewest Roads
Main Street Madisonville (US 41A)	Hopkins (S.P. GR. 3)	From: Lake Street, northerly To: North Street	48% Natural Sand Caseyville Mats., Caseyville 31% Natural Mortar Sand Henderson Mats., Henderson 21% Ag. Lime Cedar Bluff Stone, Princeton	8.2%	67%	0.944 44 ft.	Aug. 1970 22A	-	Corum & Edwards
Center Street Madisonville (US 41A)	Hopkins (S.P. GR. 3)	From: Main Street, easterly To: End of new const. approx. 110 feet west of Park Avenue	48% Natural Sand Caseyville Mats., Caseyville 31% Natural Mortar Sand Henderson Mats., Henderson 21% Ag. Lime Cedar Bluff Stone, Princeton	8.2%	67%	0.662 36 ft.	Aug. 1970 22A	-	Corum & Edwards

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EXPERIMENTAL SAND-ASPHALT SURFACE

KYHPR-64-8;HPR-1(6), Part II

FINAL REPORT

by

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Former Research Engineer
and
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Research Engineer

Division of Research
DEPARTMENT OF HIGHWAYS
Commonwealth of Kentucky

In cooperation with the
U. S. Department of Transportation
Federal Highway Administration

October 1970

INTRODUCTION

Wearing surfaces of Kentucky rock asphalt applied in thin layers were used extensively in Kentucky for many years. Sand asphalts, which generically include rock asphalt, are now a reemergent generation of surfacings to be investigated (1,2,3). An interim report (4) related the construction and interim performance of trial surfacings in Logan County. Two bridge deck sand-asphalt surfacings have been reported (5). This report covers sand-asphalt construction and performance since 1966. Pertinent project data and comments are contained in Appendix A. The several Special Provisions are included in Appendix B.

Interest in sand-asphalt wearing surfaces issues from the skid-resistant qualities which are inherent in angular (unpolished) quartz sands. Blends of quartz sands together with crushed limestone sands have been employed experimentally to obtain strength and durability--and to evaluate the effect of limestone or carbonate sands on skid-resistance. Quartz concentrations in the order of 50 percent of the combined sand have not provided the desired assurances of persistent skid resistance; therefore, recourse to mixtures richer in quartz has become imperative. Experimental work is continuing in that direction.

CONSTRUCTION AND PERFORMANCE PROBLEMS

Major problems encountered during placement of the sand-asphalt overlays were:

1. tearing of the sand-asphalt mat,
2. unevenness of existing surface,
3. inexperience,
4. traffic, and
5. instability and scaling.

Tearing of Mat

Tearing of the mat by the paver screed may be attributed to the following:

1. lack of silicone additive in the asphalt cement,
2. low temperature of material,
3. low ambient temperature,
4. uneven or deeply rutted surface,
5. sand-asphalt laid too thin, or
6. warp and tilt of screed.

Silicone was initially added to the asphalt cement to reduce foaming during heating. It was later noted that incidence of tearing was greatly reduced with silicone in the mixture.

Tearing was also concurrent with low plant production temperatures. When the temperature was increased to the 310°F to 325°F range and silicone was being used, tearing was virtually eliminated.

Experience indicates that tearing is reduced through the use of harder grades of asphalt cement.

Low ambient temperatures resulted in a cool surface temperature of the original pavement. Low pavement temperatures undoubtedly caused rapid cooling of the sand-asphalt mixture to a temperature such that tearing became noticeable. Production temperatures were increased to the highest allowable limit in order to compensate for the rapid heat loss at the construction site.

Unevenness of Existing Surface

Several surfaces overlaid had been deeply rutted by traffic; and as a result, the sand asphalt was not of uniform thickness. On later projects, the situation was remedied by placing a leveling course of Class I asphaltic concrete prior to the sand-asphalt surfacing.

Experience

On a few projects, it seemed that the sand asphalt was placed too thin and that this caused the tearing. However, when the surface being overlaid is smooth and even and is uniformly "tacked", it is possible to lay courses less than 1/2-inch in thickness--without blemishes. Adjustments in the tilt of the screed, pull-points, tampers and heat may be needed to achieve good results. "Up-tilted" screeds tend to climb or ramp up and then subside--causing unevenness and roughness. Usually, a reverse tilt or nearly flat screed suffices.

Contractors inexperienced with sand-asphalt mixtures tended to apply the normal construction practice for Class I mixtures by operating the breakdown roller close to the paver. The procedure proved detrimental to sand-asphalt mixtures since the plant production temperature for sand asphalt is considerably higher than for Class I. Higher temperatures allow the roller to displace, squeeze, or shove the sand asphalt. Shoving produces a differential thickness and longitudinal marks which cannot be erased by additional rolling. Allowing sand-asphalt mixtures to cool to temperatures normally encountered for Class I breakdown compaction minimized both surface pickup and longitudinal marking. A simple remedy was to operate the breakdown roller considerably farther behind the paver than for normal Class I construction. Another solution was to utilize two-wheel tandem rollers for breakdown. Longitudinal marking was significantly decreased in comparison to three-wheel rollers.

Hand finishing should be minimized. Prior to compaction, the density of hand-finished or raked material is less than that of material placed by pavers. Subsequent rolling produces porous depressions in the surface. Material broadcast or scattered over screeded areas rarely blends in very well.

Traffic

Traffic presents several problems. Tracking of the tack coat onto the freshly placed and compacted sand asphalt tended to glaze the new surface. In some instances, traffic was forced to stop on freshly compacted surfaces, and this caused tire markings. In addition, tire treads picked up loose aggregate from shoulders and parking lots--these aggregates were then pressed into the sand asphalt and remained in the surface. On the Pulaski County project on US 27, limestone aggregate used later to build up the shoulders was somehow scattered onto the surface and became imbedded--thereby increasing slipperiness.

Guide cones and escort vehicles were effective means of disciplining one-way traffic. Traffic should not be permitted on the sand asphalt until evening or preferably the following morning. Sand asphalt is more susceptible to damage than is Class I asphaltic concrete. In any case, traffic should not be allowed to stand on the newly compacted sand-asphalt layer.

Construction projects which have developed a glazed surface appearance under traffic are principally located in the Covington area. All of those sand-asphalt mixtures contained fly ash as a mineral filler to fulfill gradation requirements. Fly ash was used because it was available locally and was relatively cheap. The surfaces have developed a glazed appearance in the wheel tracks, and these mixtures do not have the stability nor the endurance of a normal sand asphalt mix. These deficiencies are attributed to the fly ash particles. Test results have not shown the glazed appearance to affect skid resistance. Stability is also reduced.

Instability and Scaling

The Pulaski County project on US 27 was the only one involving scaling. Vehicles were forced to stop on these experimental sand asphalt mixtures. Scaling was evidenced only in the wheel tracks. The two sections (Sections 2A and 5A) where scaling was predominant utilized mixtures that had a very low stability and did not contain portland cement filler. The two companion sections (Sections 2B and 5B) which did not scale contained portland cement filler.

Crusts 1/8 to 1/4-inch thick could be lifted from the surface with a knife blade during winter periods. The crust could be removed in the direction of traffic but not transversely. Inspection of the bottom of the crust revealed a layer of sand grains from which asphalt had been stripped. The edges of the scaled areas were nearly vertical. The combination of traffic and warmer temperatures has erased the vertical edge. The shear plane has also healed.

This scaling phenomenon plus lateral movement, ripple patterns, hair cracking, sanding, rutting and shoving, pickup, and tire tracking are described in detail in a report (6) on a rock asphalt pavement. Failure mechanics were discussed in a previous report (7). The conclusion drawn is failure observed in rock asphalt is not a property of the natural material alone, but also of gradation, particle size, and bitumen content. Moisture definitely adds to scaling and pickup. Moisture may come from either surface drainage or from the aggregate. To illustrate that scaling is unique to sand-type mixtures, the following is quoted(6):

> ". . .Sanding resulted from surface abrasion of mixtures having very low cohesion and usually occurred when moisture contents were quite high and cohesion at a minimum. . .Rutting and shoving were induced by loading in excess of the inherent ability of the materials to resist. In some cases the shear was along a horizontal plane and in others along a concave surface. . .Pickup by vehicle tires occurred principally when moisture contents were high. It was observed in a few instances when the mixture was dry and vehicles were required to stop in one place for even a few minutes. . .Scaling resulted from differential movement of the crust which formed as a hardened layer 1/8 to 1/4-inch thick on most of the steamed rock asphalt. The hardening itself apparently results from exposure to air and light; consequently, underlying material is insulated by the surface crust and tends to remain soft and uncured. Whether produced during construction or by traffic afterwards, a weakened plane highly susceptible

to scaling failure is created, and the entry of water along the planes of separation fulfills the requirements of scaling failure. . ."

Other observed failures in Pulaski County and other projects are also explained in the report (6).

Stability became a problem on the Pulaski County, US 27, project for two mixtures--the particle sizes and gradations being such that the mixtures had very low stabilities. Consequently, 2.6 percent portland cement was added to act as a mineral filler to stiffen the mixtures. This proved to be fairly successful; however, while the stability did increase, the desired strengths were not achieved. Placement of these two mixtures was critical because traffic could not be detoured during construction. The two mixtures remained very tender for 24 hours or longer. Successful placement of low stability sand-asphalt mixtures would require that traffic be detoured during construction and for at least two days thereafter.

SUMMARY

Preparation of the old pavement is most important and should include

1. a Class I asphalt concrete leveling course for deeply rutted pavements, and

2. a tack coat of sufficient quantity and uniform coverage (diluted SS-1h is preferred) for adhesion of the sand asphalt to the older surface.

Experience has shown that an uneven coverage of the tack coat may cause loosening of the sand asphalt under traffic.

Mat tearing was a major problem on earlier construction projects. Considerable reduction of the mat tearing was accomplished by one or more of the following:

1. addition of silicone to the asphalt cement at the rate of one ounce per 5000 gallons of asphalt cement,

2. keeping the mixture production temperature between 310°F and 325°F,

3. use of harder grades of asphalt cement, and

4. placement of the sand asphalt when the ambient temperatures were above 70°F.

Stability of the mixture was a problem on only one project. The use of a hard grade asphalt cement and the addition of portland cement as a filler helped to overcome the difficulty. It was noted that keeping the initial breakdown roller well back from the paver prevented shoving and longitudinal marking since the mixture had time to cool sufficiently to minimize the difficulty.

Scaling is considered as a defect inherent in this type of aggregate-bitumen mixture. This defect has been noted in a rock asphalt mixture having approximately the same gradation and bitumen content as that of sand asphalt. Mixtures containing fly ash as mineral filler have not performed as well as overlays constructed

with normal sand asphalt. The surface deterioration and glazed appearance are so severe it is recommended that fly ash not be used in a sand-asphalt mixture.

LIST OF REFERENCES

1. Strunk, L.H., "Bridge Resurfacing With Silica Sand-Asphalt Mixture", Kentucky Department of Highways, December 1958.

2. Florence, R.L., "The Design of Thin, Silica Sand-Asphalt Wearing Surfaces for Highways and Bridge Decks", Kentucky Department of Highways, July 1959.

3. Florence, R.L., "Bridge Resurfacings With Silica Sand-Asphalt Mixture", Kentucky Department of Highways, March 1961.

4. Florence, R.L., "Construction And Interim Performance of Silica Sand-Asphalt Surfacing, Kentucky Department of Highways, February 1965.

5. Hughes, R.D. and Scott, J.W., "Concrete Bridge Decks: Deterioration and Repair, Protective Coatings, and Admixtures", Kentucky Department of Highways, June 1966.

6. Havens, J.H. and Williams, E.G., "A Study of the Properties and Performance of Kentucky (Natural Sandstone) Rock Asphalt", Kentucky Department of Highways, February 1956, pp. 44-47.

7. Havens, J.H. and Williams, E.G., "A Preliminary Report on the Performance of Kentucky (Natural Sandstone) Rock Asphalt", Kentucky Department of Highways, April 12, 1955, pp. 2-8.

APPENDIX A

Project Data

PROJECT DESCRIPTION

Location	Boone-Kenton Counties, KY 236, Greater Cincinnati Airport to US 25 & US 42 in Erlanger
Number	SP 8-270-5, SP 59-3215-4
Date Constructed	June 22-23, 1966
Contractor	Eaton Asphalt Paving Co., Sanfordtown, Kentucky
Special Provision	22

AGGREGATE

Type	Percent by Weight	Source
Natural sand	83	Cookes Aggregates, Petersburg, Kentucky
Mineral filler (fly ash)	4	Dayton Fly Ash, Dayton, Ohio
Limestone sand	13	Geoghegan-Mathis, Butler, Kentucky

Combined aggregate gradation

Sieve	1/4 inch	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Percent passing	100	95.9	82.5	67.8	31.1	8.6	5.3

Fineness modulus — Extracted 2.13

Equivalent silica content 58%

ASPHALT

Type and source	PAC-5					
Content	Design	8.5%	Extracted	8.5%	Marshall	8.5%
Silicone oil added	Yes					
Tack coat	RS-1, fogging application					

MARSHALL TEST

Compaction effort	50 blows
Compaction temperature	275 - 300°F
Unit weight	135.6 pounds per cubic foot
Marshall stability	620 pounds
Flow	7.3

EQUIPMENT

Paver Barber-Greene

REMARKS

Coefficient of friction 1966: 0.50 1967: 0.46 1968: 0.50

The RS-1 tack coat was applied by fogging to a coarse-textured, very "dry" asphalt pavement in a non-uniform coverage pattern.

Because the Greater Cincinnati Airport is located on the western end of this project, the traffic volume was very high during construction hours. The high traffic volume, a non-uniform coverage of the tack coat, a midrange production temperature, and absence of silicone in the mix combined to produce mat tearing and blemishes caused by traffic. This was especially noticeable near the airport entrance, as shown in Figures 1 and 2. Traffic caused the wheel tracks to obtain a slick appearance (Figure 1). The mat tearing and traffic blemishes were reduced by increasing the production temperature from 300°F to 325°F and the addition of silicone to the asphalt cement.

Visual inspections have revealed:

1. edge cracking which may be caused by the sand-asphalt extending beyond the old pavement,
2. joint and diagonal cracks which are reflections from the old surface,
3. an uneven thickness longitudinally with the pavement,
4. approximately 16 square feet of the mat has been removed entirely, and
5. one to three longitudinal cracks have been observed within a six-inch width at the centerline of the pavement.

Items 3 and 4 may have been caused by snow removal equipment and/or the lack of a leveling course before the sand asphalt was laid. Item 5 may be an indication of structural weakness.

Figure 1. Greater Cincinnati Airport Road.
The flushed appearance in the wheel tracks is attributed to the fly ash mineral filler.

Figure 2. Greater Cincinnati Airport Entrance.
Note the raveled surface in the foreground. A midrange production temperature, fly ash mineral filler, and absence of silicone in the asphalt cement combined to produce a mixture susceptible to damage by traffic.

PROJECT DESCRIPTION

Location	Anderson County, US 62 & US 127, from Main Street in Lawrenceburg extending westerly to New US 127 US 62, from 0.169 mile west of ECL of Lawrenceburg to west end of Tyrone Bridge Old US 127, from SCL of Lawrenceburg extending southerly to New US 127
Number	SP GR 8
Date Constructed	July 13-14, 1966
Contractor	Mago Construction Co., Tyrone, Kentucky
Special Provision	22

AGGREGATE

Type	*Percent by Weight*	*Source*
Natural mortar sand	58	Standard Materials, Carrolton, Kentucky
Limestone sand	42	Kentucky Stone Co., Tyrone, Kentucky

Combined aggregate gradation

Sieve	*1/4 inch*	*No. 8*	*No. 16*	*No. 30*	*No. 50*	*No. 100*	*No. 200*
Percent passing	100	99.2	87.1	65.2	29.2	11.3	7.1

Fineness modulus *Design* 1.90 - 2.30 *Extracted* 2.08

Equivalent silica content 37.5%

ASPHALT

Type and source	PAC-5, Chevron Asphalt Co., Louisville, Kentucky
Content	*Design* 8.5 and 9.0% *Extracted* 8.7% *Marshall* 8.5%
Silicone oil added	Yes, added to tank truck load of asphalt cement
Tack coat	RS-1, fogging application

MARSHALL TEST

Compaction effort	50 blows
Compaction temperature	260 - 270°F
Unit weight	137.4 pounds per cubic foot
Marshall stability	2415 pounds
	(High stability values may be due to sample having been reheated more than once)
Flow	8
Bulk specific gravity	2.201

PRODUCTION TEMPERATURE

Plant production temperature 320 - 325°F

REMARKS

Leveling mix 1 inch of Class I Asphalt Concrete

The combination of very little traffic, the mix production temperature near the 325°F limit, silicone additive in the asphalt cement, and a good leveling course on a uniform tack coat produced a very nice sand-asphalt mat with very few tears occurring behind the paver. Most of the sand asphalt contained 8.5 percent bitumen, however, the section containing 9.0 percent is located between Stations 69+50 and 89+00 in the westbound lane.

One very unusual observation has been noted during the August 1969 inspection. At the time of construction, asphalt was tracked onto the sand asphalt from the Fairgrounds entrance (Figures 3 and 4). Since that time, traffic has tracked aggregate onto the sand asphalt and the aggregate stuck to these tracked areas and became embedded in the sand asphalt. The wheel track areas are now raised approximately 1/16th of an inch above the remaining sand asphalt. The larger aggregate has polished and is much slicker than the adjacent, uncontaminated sand asphalt.

Figure 3. Lawrenceburg Fairgrounds Entrance on US 62 (looking east). Asphalt was tracked from the fairgrounds onto the sand-asphalt surface.

Figure 4. Lawrenceburg Fairgrounds Entrance on US 62 (looking west). Asphalt was tracked from the fairgrounds onto the sand-asphalt surface.

PROJECT DESCRIPTION

Location	McCracken County, US 68, from ICRR overpass near junction with US 60 to the Marshall County Line
Number	SP 73-72-12
Date Constructed	July 25-26, 1966
Contractor	Harry Berry Inc., Paducah, Kentucky
Special Provision	22

AGGREGATE

Type	*Percent by Weight*	*Source*
Natural sand	60	Federal Materials, Paducah, Kentucky
Pit sand	25	Ed DeBuke Pit, Leadbetter, Kentucky
Limestone sand	12	Three Rivers Quarry, Smithland, Kentucky

Combined aggregate gradation							
Sieve	*1/4 inch*	*No. 8*	*No. 16*	*No. 30*	*No. 50*	*No. 100*	*No. 200*
Percent passing	100	94.8	84.0	64.6	37.7	15.4	3.4

Fineness modulus *Design* 1.75 - 2.15 *Extracted* 2.04

Equivalent silica content 70%

ASPHALT

Type and source	PAC-5, Delta Refining Co., Memphis, Tennessee
Content	*Design* 8.0-9.0% *Extracted* 8.3% *Marshall* 8.5%
Silicone oil added	Yes, at the terminal
Tack coat	SS-1H

MARSHALL TEST

Compaction effort	50 blows
Compaction temperature	245 - 255°F
Unit weight	136.4 pounds per cubic foot
Marshall stability	575 pounds
Flow	8

EQUIPMENT

Plant Standard Steel, 5000-pound Batch

REMARKS

Coefficient of friction 1967: 0.45

The sand asphalt was laid directly on an old Rock Asphalt pavement after being fog tacked with diluted SS-1H. The contractor said that silicone had been added at the terminal prior to shipment of the asphalt cement. Considering the amount of mat tearing and screed dragging that was experienced, it is doubtful if the silicone was indeed added. If the silicone was added, then the defects must have been caused by the lack of a leveling course. Excess moisture was blamed for the "rich" appearance of the surface at the time of construction.

Inspections have been made annually. Pop-outs have been attributed to moisture collecting between the rock asphalt and the sand asphalt (Figures 5 and 6). Base failure has also caused alligator cracking in local areas as seen in Figure 5. Reflection cracks appeared the day after the sand asphalt was laid. The cracks produced rough riding characteristics which became worse until 1968 (Figures 7 and 8). The August 1969 inspection indicated that the reflection cracks were not as severe as in 1968.

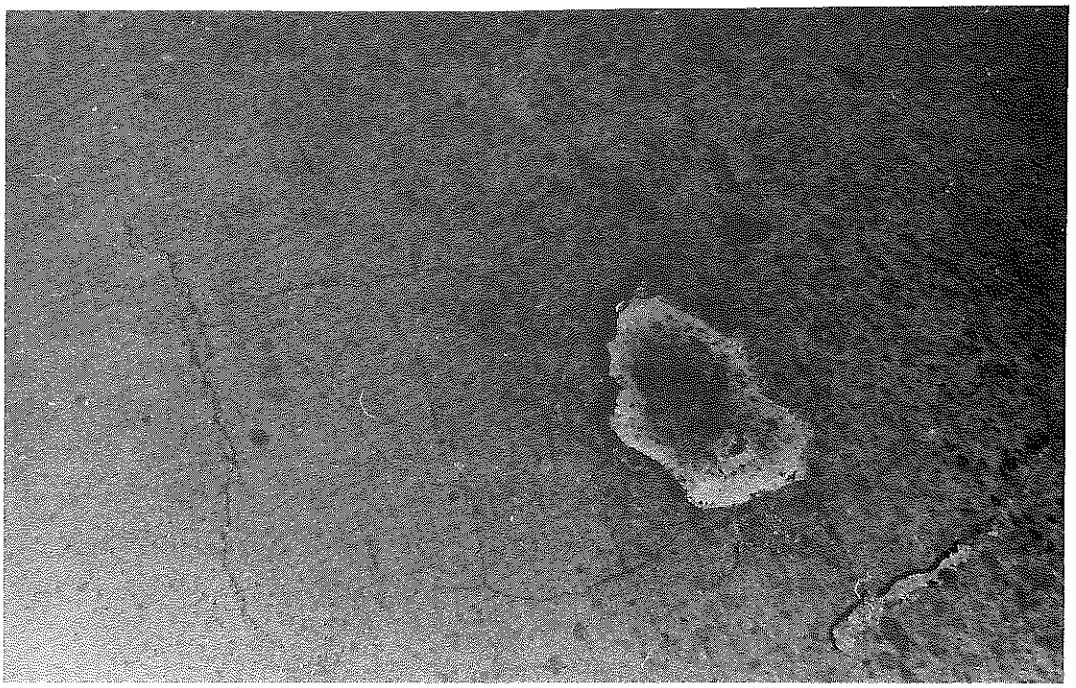


Figure 5. US 68, McCracken County.
Note alligator cracks and sand-asphalt pop-out.

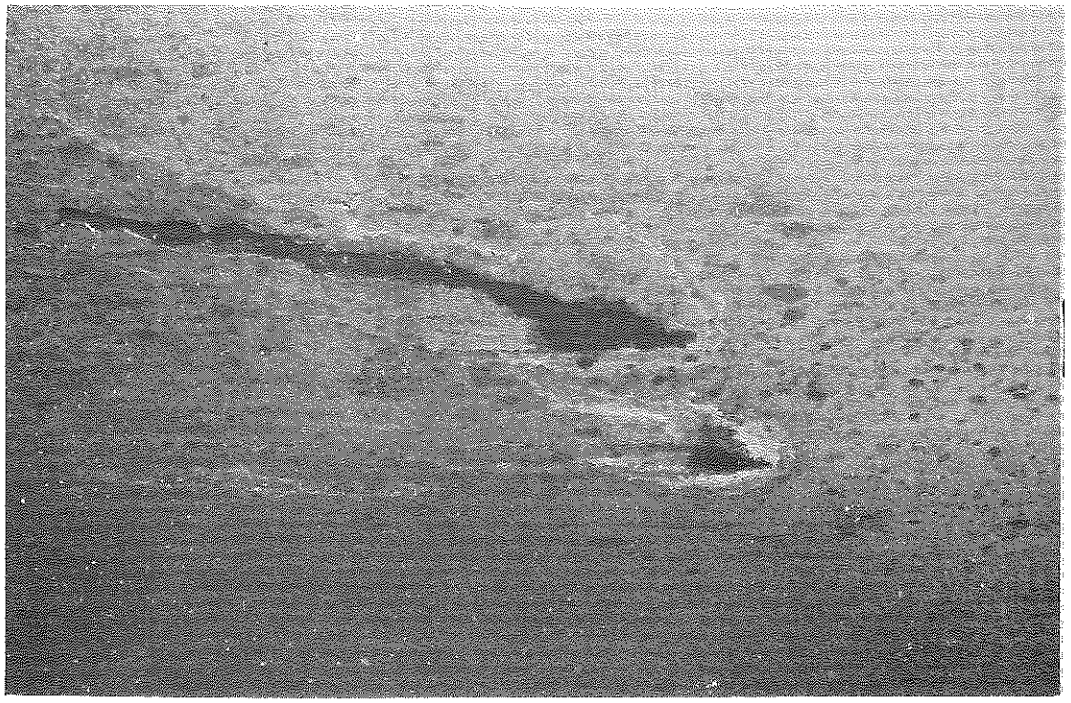


Figure 6. US 68, McCracken County.
Note pop-out areas in sand asphalt.

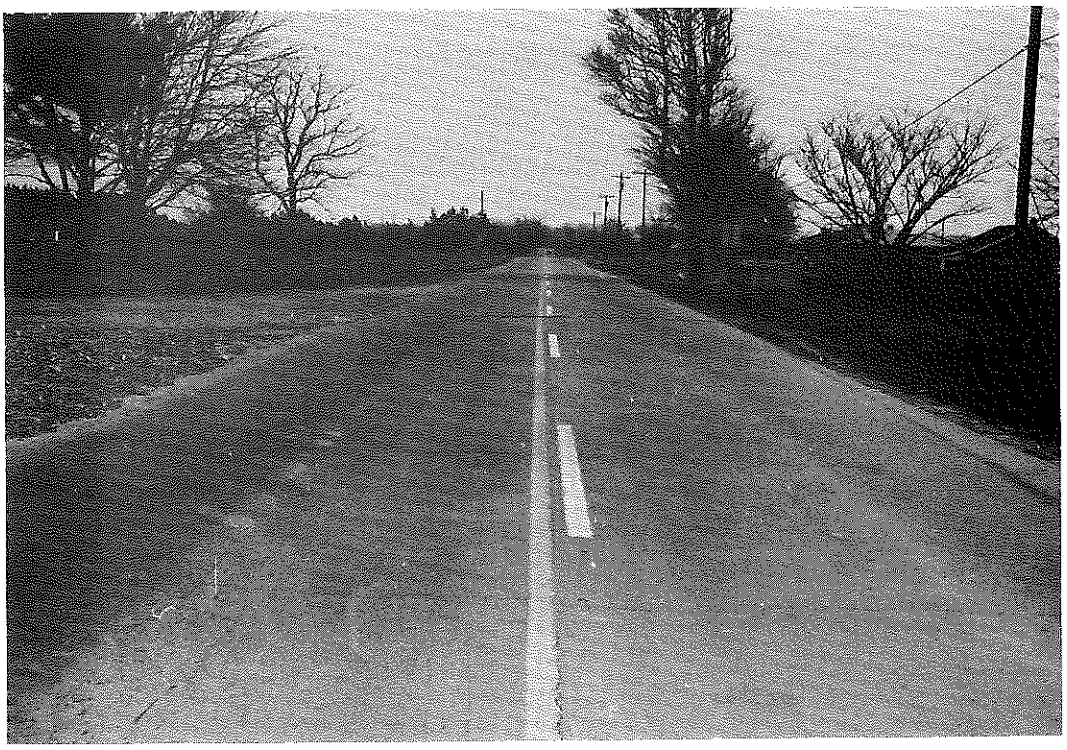


Figure 7. US 68, McCracken County.
Reflection cracking in the surface was observed the day after the sand asphalt was placed.

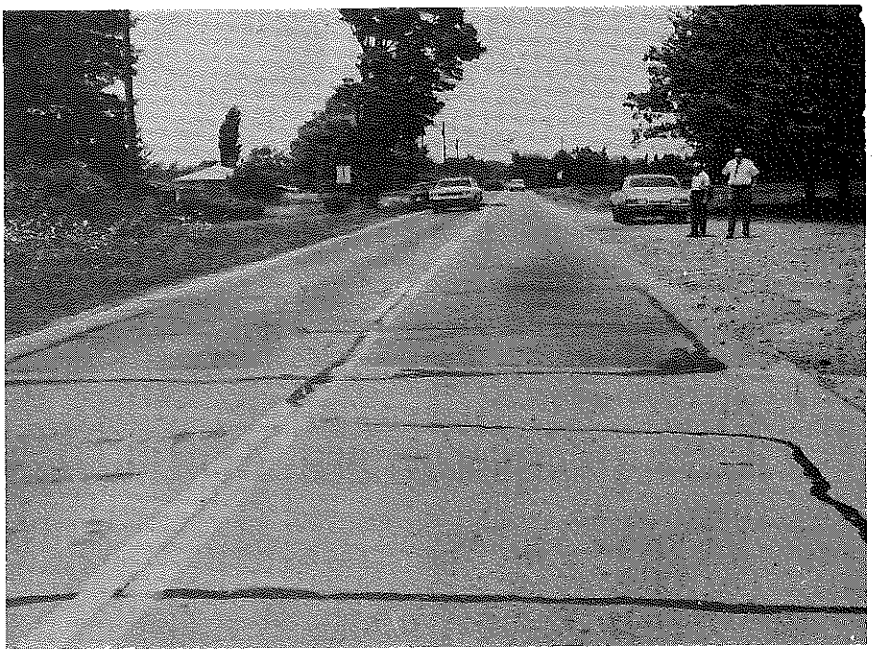


Figure 8. US 68, McCracken County.
The same area (shown in Figure 7) one year later.

PROJECT DESCRIPTION

Location	Franklin County, Mix "A", US 60 west, from Capitol Avenue to Lafayette Drive and Shelby Street and from Second Street to Rockland Court
Number	SP GR 17
Date Constructed	August 22 - September 13, 1966
Contractor	R. L. Carter, Frankfort, Kentucky
Special Provision	22

AGGREGATE

Type	Percent by Weight	Source
Kentucky River natural sand	68	Gilley Co., Lexington, Kentucky
Limestone sand	32	Falls City Quarries, Frankfort, Kentucky

Combined aggregate gradation

Sieve	1/4 inch	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Percent passing	100	99.5	91.7	79.2	35.1	9.5	5.6

Fineness modulus — Design 1.65 - 2.05 — Extracted 1.85

Equivalent silica content 58%

ASPHALT

Type	PAC-5		
Content	Design 9.0%	Extracted	9.0%-Shelby St.;8.5%-US 60 West Marshall 9.0%
Silicone oil added	Yes		
Tack coat	Diluted SS-1H		

MARSHALL TEST

Compaction effort	50 blows
Compaction temperature	285°F
Unit weight	128.0 pounds per cubic foot
Marshall stability	955.0 pounds

(High stability values may be due to sample having been reheated more than once)

Flow 9

REMARKS

Coefficient of friction

	1966	1967	1968
W. B. Outer Wheel Track	0.32	0.42	0.47
W. B. Inner Wheel Track		0.51	0.61

Very few problems were encountered with the mix. Minor fluctuations in the mix gradations at the plant occurred when a much finer limestone was mistakenly hauled to the plant. Other minor production problems were eliminated.

This mix was laid on US 60, west from Capitol Avenue to Lafayette Drive and Shelby Street from 2nd Street to Rockland Court, both of which were comparatively level and did not require a leveling course. Very little mat tearing was noted and that which did occur was easily eliminated by rolling. The silicone additive combined with light traffic enabled these two sections to be the best of the series included in the overall project.

PROJECT DESCRIPTION

Location	Hopkins County, US 41, from end of US 41 By-Pass to SCL of Hanson
Number	SP 54-20
Date Constructed	September 22-24, 1966
Contractor	Dixie Pavers Inc., Henderson, Kentucky
Special Provision	22

AGGREGATE

Type	Percent by Weight	Source
Natural sand	56.4	Hopkinsville Stone Co., Hopkinsville, Kentucky
Blow sand	10.3	Vincennes, Indiana
Limestone sand	28.3	Henderson Materials, Henderson, Kentucky
Mineral filler	5.0	

Combined aggregate gradation

Sieve	1/4 inch	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Percent passing	100	97.3	83.6	60.8	26.8	9.7	4.8

Fineness modulus — Design 2.00 - 2.40 — Extracted 2.22

Equivalent silica content 52%

ASPHALT

Type and source: PAC-5, Lion Oil Company

Content — Design 8.5% — Extracted 8.6% — Marshall 8.8%

Silicone oil added: Yes, to production of second and third days only

Tack coat: RS-1, spray bar application

MARSHALL TEST

Compaction effort	50 blows
Compaction temperature	260°F
Unit weight	136.5 pounds per cubic foot
Marshall stability	605 pounds
Flow	6.7

PRODUCTION TEMPERATURE AND EQUIPMENT

Mix production temperature	310 - 315°F
Roller	Three-wheel and Tandem

REMARKS

Leveling mix	Class I Asphalt Concrete
Coefficient of friction	1967: 0.40

During the first construction day, silicone was not added to the asphalt cement. The pit sand was wet and would not properly feed into the pug mill, resulting in a lower pit-sand content than desired. This moisture also became a problem upon being laid because it would bubble to the surface in the westbound lane. There was considerable mat tearing and mix segregation near the center and outside of the lane requiring extensive hand work repairs (Figures 9 and 10). Addition of silicone to the asphalt cement on the second day practically eliminated all of the above problems.

Skid tests were performed the next year and the outside wheel track of the northbound lane was slick. This was attributed to asphalt being tracked onto the sand asphalt from the built-up shoulder (Figure 11). It was also observed that the lane without the silicone was much rougher riding than the lane containing silicone. Surface polishing of the aggregate was noted in the August 1969 inspection.

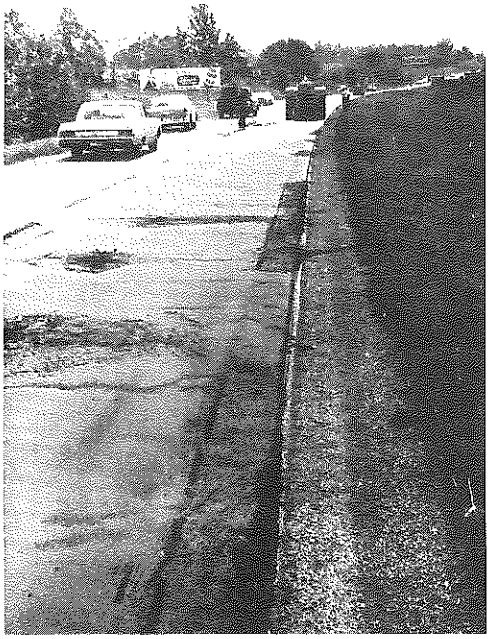


Figure 9. US 41, Hopkins County.
The lack of silicone and high moisture content in the aggregate combined to cause bubbles, mat tearing, and segregation in the sand asphalt. Considerable handwork repairs were required.

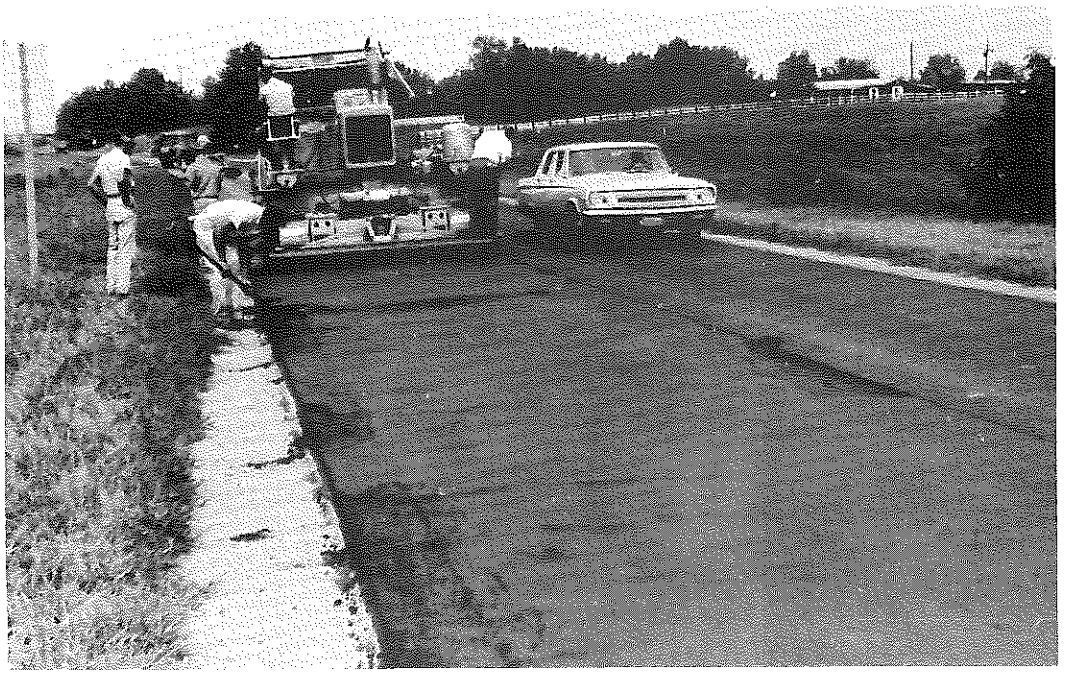


Figure 10. US 41, Hopkins County.

Figure 11. US 41, Hopkins County (looking north).
The slick appearance is attributed to tracking of the asphalt from the built-up shoulders.

PROJECT DESCRIPTION

Location	Kenton County, KY 17, Scott Street in Covington from 4th Street to SCL of Covington at Latonia Avenue KY 8, 4th Street in Covington from Court Avenue to east end of Licking River Bridge KY 8, 5th Street in Covington from Garrard Street to Ramp G of I 75 Interchange KY 8, from Main Street in Covington along 4th Street, Philadelphia Street and 3rd Street to ECL of Bromley KY 8, Garrard Street in Covington from 5th Street to 4th Street
Number	SP GR 12
Date Constructed	June 30 - July 17, 1967
Contractor	Northern Kentucky Asphalt Paving Co., Covington, Kentucky
Special Provision	22A

AGGREGATE

Type	*Percent by Weight*	*Source*
Natural sand	95	Standard Materials, Carrolton, Kentucky
Mineral filler (fly ash)	5	Dayton Fly Ash, Dayton, Ohio

Combined aggregate gradation

Sieve		*1/4 inch*	*No. 8*	*No. 16*	*No. 30*	*No. 50*	*No. 100*	*No. 200*
Percent passing	(7.8%)	100	95.5	80.2	56.8	21.7	8.4	5.7
	(8.3%)	100	98.3	87.0	64.8	21.1	7.9	5.1

Fineness modulus *Design* 2.00 - 2.40 *Extracted* (7.8%)-2.39 (8.3%)-2.19

Equivalent silica content (7.8% A.C.) 61-67

ASPHALT

Type and source PAC-5

Content *Design* 7.8 and 8.3% *Extracted* (7.8%)-8.0% *Marshall* (7.8%)-8.6%
(8.3%)-8.5% *Marshall* (8.3%)-8.6%

Silicone oil added Yes, 1 ounce per transport load of asphalt cement

Tack coat SS-1H

MARSHALL TEST

	7.8% A.C.	8.3% A.C.
Unit weight, pounds per cubic foot	135.7	132.1
Marshall stability, pounds	663	440
Flow	5	3
Voids in mix, percent	7.2	9.5

PRODUCTION TEMPERATURE

Mix production temperature 290 - 320°F

REMARKS

Leveling mix Class I, Type A modified

The same comments made under "City Streets in Newport" apply to this project. Again the wheel tracks had a glazed appearance and was attributed to the fly ash filler.

PROJECT DESCRIPTION

Location	Breckinridge-Meade Counties, US 60 from KY 448 in Irvington to KY 144 approximately 1.4 miles SE of Garrett
Number	SP 14-333-3, SP 82-423-3
Date Constructed	September 29 - October 11, 1966
Contractor	Mago Construction Co., Irvington, Kentucky
Special Provision	22

AGGREGATE

Type	Percent by Weight	Source
Natural sand	70	Lucas Bros., Mauckport, Indiana
Pit sand	12	R&W Pit, Louisville, Kentucky (Dirty pit sand)
Limestone sand	18	Kentucky Stone Co., Irvington, Kentucky

Combined aggregate gradation

Sieve	1/4 inch	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Percent passing	100	94.3	84.6	70.2	26.5	9.7	4.2

Fineness modulus — Design 1.80 - 2.20 — Extracted 2.15

Equivalent silica content 58%

ASPHALT

Type and source	PAC-5, Chevron Asphalt, Louisville, Kentucky
Content	Design 8.7 (8.2-9.2)% Extracted 8.7%
Silicone oil added	Yes
Tack coat	RS-1

EQUIPMENT AND PRODUCTION TEMPERATURE

Plant production temperature	300 - 320°F
Plant	Barber-Greene, 845 L Continuous Mix
Paver	Cedar Rapids
Rollers	Three-wheel and Tandem

REMARKS

Coefficient of friction	Breckinridge - 1967: 0.56
	Meade - 1967: 0.59

Feeding of the fine pit sand in the mixing plant was the only construction problem. This was overcome and did not present any paving problems. The overall appearance of the project at the time of construction was good and generally improved as construction progressed. As of August 1969, the surface still had a good appearance. No defects were noted.

PROJECT DESCRIPTION

Location	Campbell County, US 27, from SCL of Newport extending along Monmouth and Third Streets to intersection of Third and Saratoga at the L&N Bridge approach
Number	SP 19-11-16
Date Constructed	November 9-15, 1966
Contractor	Northern Kentucky Asphalt Paving Co., Covington, Kentucky
Special Provision	22

AGGREGATE

Type	Percent by Weight	Source
Natural sand	75	Cookes Aggregates, Petersburg, Kentucky
Mineral filler (fly ash)	4	Dayton Power and Light Co., Dayton, Ohio
Limestone sand	21	Geoghegan-Mathis, Butler, Kentucky

Combined aggregate gradation Sieve	1/4 inch	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Percent passing	100	98.1	87.0	72.5	34.5	8.7	4.8
Marshall Test 1	100	95.8	84.6	72.1	34.6	7.9	4.5
Marshall Test 2	100	98.6	87.0	74.0	34.5	11.3	7.2**

Fineness modulus — Design 1.80 - 2.20; Extracted 1.99; Marshall Test 1 2.05; Marshall Test 2 1.95

Equivalent silica content 54%

ASPHALT

Type and source	PAC-5, Ashland Oil Co., Covington, Kentucky				
Content	Design 8.0 - 9.0%	Extracted 8.6%	Marshall (1)	8.44%	
			Marshall (2)	9.09%**	
Silicone oil added	Yes, 2 ounces per 4000 gallons of asphalt cement				
Tack coat	RS-1				

**Out of job-mix tolerances

MARSHALL TEST

	Mix 1		Mix 2	
	No. 1	No. 2	No. 1	No. 2
Compaction effort, number of blows	50	75	50	75
Compaction temperatures, °F	275	270	280	275
Unit weight, pounds per cubic foot	131.7	132.7	135.3	136.1
Marshall stability, pounds (High stability values may be due to sample having been reheated more than once)	680	770	920	1100
Flow	8	8.5	9	10

EQUIPMENT

Plant	Cummer, 4000-pound Batch
Paver	Barber-Greene and Blaw-Knox
Roller	Tandem

REMARKS

The main surface that was paved was US 27 through downtown Newport, Kentucky. This is a four-lane, undivided, and heavily traveled thoroughfare having in excess of 20,000 vehicles, of which trucks comprise a large percentage. The old rutted and corrugated surface was leveled with a Class I mix applied over a RS-1 tack coat. A tack coat was not used between the leveling and sand-asphalt layers.

An excellent sand asphalt mat was laid with a Barber-Greene paver on November 9, 1966, despite a light rainfall. On November 14, 1966, a Blaw-Knox paver was utilized simultaneously with the Barber-Greene and observers noted that there was considerably more mat tearing behind the Blaw-Knox than the Barber-Greene. However, these tears were no worse or more frequent than had been observed on earlier projects. The use of the tandem roller did not completely eliminate the tears, which were still noticeable in August 1969.

PROJECT DESCRIPTION

Location	Calloway County, KY 121, from Graves County line to NWCL of Murray
Number	SP 18-123-552
Date Constructed	June 19-21, 1967 and June 26, 1967
Contractor	Warren Bros., Lake City, Kentucky
Special Provision	22A and 26

AGGREGATE

Type	Percent by Weight AE-60	Percent by Weight PAC-5	Source
Natural sand	40	36	Federal Materials, Paducah, Kentucky
Pit sand	20	27	Reed Pit, Gilbertsville, Kentucky
Limestone sand	40	37	Reed Stone, Gilbertsville, Kentucky

Combined aggregate gradation

Sieve	1/4 inch	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Percent passing	100	96.6	84.2	66.7	27.6	8.6	4.2

Fineness modulus — Design 1.90 - 2.30 — Extracted (AE-60) 2.16

Equivalent silica content 60.1%

ASPHALT

Type and source	(a) AE-60, Emulsified Asphalt Sales, 1/2 project length (b) PAC-5, Kentucky Asphalt Sales, 1/2 project length
Content	Design (a) 8.2% base asphalt (b) 8.9 % Extracted (a) 8.2% (AE-60)
Silicone oil added	Yes, in the PAC-5 section

PRODUCTION TEMPERATURE AND EQUIPMENT

Mix production temperature	250 - 270°F
Plant	Barber-Greene Batch-Pac
Roller	Tandem

REMARKS

Coefficient of friction 1967: 0.45

The PAC-5 section starts at the Murray By-Pass and KY 121 intersection and extends westward on KY 121 for 4.5 miles. The remaining 4.5 miles westward is the AE-60 section.

While producing the emulsion mix, considerable steam was emitted from the plant and apparently affected the emulsion scales, because the bitumen content tended to be high. A few "cold" loads were produced in the morning, causing pulling and ragged edges in the mat.

It was reported that the PAC-5 mix presented more difficulties than the AE-60 mix, but the nature of the troubles was not specified. The present condition of the surface is good except for five full-width patch repairs caused by base failures.

PROJECT DESCRIPTION

Location	Kenton County, KY 17, from Court Street to Sterret Avenue
Number	SP 59-635-4
Date Constructed	June 23, 1967
Contractor	Eaton Asphalt Paving Co., Sanfordtown, Kentucky
Special Provision	22A

AGGREGATE

Type	Percent by Weight	Source
Natural sand	96	Cooke Aggregates, Petersburg, Kentucky
Mineral filler (fly ash)	4	Dayton Fly Ash, Dayton, Ohio

Combined aggregate gradation

Sieve	1/4 inch	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Percent passing	100	96.4	86.9	72.2	36.1	7.8	3.4

Fineness modulus: Design 1.8 - 2.2

ASPHALT

Type and source	PAC-5
Content	Design 8.5% Extracted 8.5% Marshall 8.3%
Silicone oil added	Yes, 1 ounce per transport load of asphalt cement

MARSHALL TEST

Compaction effort	50 blows
Compaction temperature	310°F
Unit weight	133.5 pounds per cubic foot
Marshall stability	1377 pounds
(High stability values may be due to sample having been reheated more than once)	
Flow	10.1
Bulk specific gravity	2.140

PRODUCTION TEMPERATURE AND EQUIPMENT

Mix production temperature	290 - 300°F
Plant	Barber-Greene, 5000-pound Batch-Pac
Paver	Barber-Greene
Roller	Tandem

REMARKS

KY 17 is routed along Greenup, Scott, and Wallace Streets in Covington, Kentucky. At the time of construction, observers noted minor tears, a tender mix near curb lines, and a flushed appearance after traffic had been routed over it (Figure 12). By August 1969, Wallace and Greenup Streets were still in good condition. However, on Scott Street, surface soft spots and a noticeably poorer surface appearance were noted. The soft spots were attributed to oil and gasoline spillage.

Figure 12. KY 17, Covington.
The slick appearance in the wheel tracks is attributed to the fly ash mineral filler.

PROJECT DESCRIPTION

Location	Franklin County, Frankfort, Capital Avenue, from Second Street to Todd Street
Number	SP 37-85
Date Constructed	June 23, 1967
Contractor	Frankfort Materials, Frankfort, Kentucky
Special Provision	22A

AGGREGATE

Type	Percent by Weight	Source
Natural sand	70	
Limestone sand	30	

Combined aggregate gradation

Sieve	1/4 inch	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Percent passing	100	98.7	88.0	69.8	24.5	9.4	5.4

Fineness modulus — Design 1.85 - 2.25 — Extracted 2.096

Equivalent silica content 58.1 %

ASPHALT

Type and source	PAC-5			
Content	Design	8.5%	Extracted	8.7%
Silicone oil added	Yes			
Tack coat	RS-1			

PRODUCTION TEMPERATURE and EQUIPMENT

Mix production temperature	320°F
Plant	10,000-pound Barber-Greene Batch-Pac
Paver	Cedar Rapids
Roller	Three-wheel and tandem

REMARKS

Leveling mix Class I Asphalt Concrete

No particular problems occurred in either production or placement of the sand asphalt mix on this job. Inspection in August 1969 revealed some reflection cracking, otherwise, the pavement was in good condition.

PROJECT DESCRIPTION

Location	Newport City Streets, US 27, Third Street in Newport from Monmouth Street to Central Bridge Approach at York Street US 27, York and 11th Street in Newport from Third Street to Monmouth Street KY 8, Fourth Street in Newport from Monmouth Street to Patterson Street KY 8, Fifth Street in Newport from Patterson Street to Monmouth Street
Number	SP GR 10
Date Constructed	June 23, 1967
Contractor	Northern Kentucky Asphalt Paving Co., Covington, Kentucky
Special Provision	22A

AGGREGATE

Type	Percent by Weight	Source
Natural sand	95	Standard Materials, Belleview, Kentucky
Mineral filler (fly ash)	5	Dayton Fly Ash, Dayton, Ohio

Combined aggregate gradation

Sieve	1/4 inch	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Percent passing	100	98.5	84.3	59.5	22.9	8.0	5.4

Fineness modulus — Design 2.00 - 2.40 — Extracted 2.27

ASPHALT

Type and source	PAC-5, Ashland Oil Co., Covington, Kentucky
Content	Design 7.7 - 8.7% — Extracted 8.5% — Marshall 7.9%
Silicone oil added	Yes, 1 ounce DC-200 per transport of asphalt cement

MARSHALL TEST

Compaction effort	75 blows
Compaction temperature	320°F
Unit weight	136.0 pounds per cubic foot
Marshall stability	1212 pounds
(High stability values may be due to sample having been reheated more than once)	
Flow	7.5
Bulk specific gravity	2.179

PRODUCTION TEMPERATURE AND EQUIPMENT

Mix production temperature	300°F
Plant	Cummer, 4000-pound Batch
Paver	Blaw-Knox

REMARKS

Two Blaw-Knox pavers were used in tandem. Scrubbing of the surface was noted while the screeds were still cool. However, the worst damage occurred when traffic sank into the mix immediately behind the rollers. The wheel tracks appeared to be flushed; however, Marshall tests indicated there was 7 to 10 percent void content. The slick appearance has been attributed to fly ash particles migrating to the surface and becoming oriented in the horizontal plane.

PROJECT DESCRIPTION

Location	Mountain Parkway, Ten Superelevated Curves between Campton and Presconsburg
Number	EKE 129
Date Constructed	August 28, 1967
Contractor	Gaines Wilson and Son
Special Provision	22A

AGGREGATE

Type	Percent by Weight	Source
Natural sand	65	Rockcastle Creek
Limestone sand	35	Magoffin-Morgan-Johnson Stone Co.

Combined aggregate gradation

Sieve	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Percent passing	100	99.6	92.1	78.2	35.8	9.1	4.0

Fineness modulus — Design 1.60 - 2.00 — Extracted 1.57

Equivalent silica content 56%

ASPHALT

Type and source	PAC-5, Kentucky Asphalt Sales				
Content	Design 9.0%	Extracted	8.8%	Marshall	9.5%
Silicone oil added	Yes, 1 ounce per transport load				
Tack coat	SS-1H				

MARSHALL TEST

	Lab.	Plant
Compaction effort, blows	35	35
Compaction temperature, °F	310	
Unit weight, pounds per cubic foot	125.7	123.9
Marshall stability, pounds	379	1086
(High stability values may be due to sample having been reheated more than once)		
Flow	9.2	11.9
Bulk specific gravity	2.299	2.310
Voids in mix, percent	12.4	14.1

EQUIPMENT

Plant	Standard Steel, 5000-pound Batch
Paver	Cedar Rapids
Roller	Three-wheel and Tandem

REMARKS

Leveling mix Class I Binder

Sand asphalt was used to raise the superelevations on ten curves of the Mountain Parkway (Figure 13). As of August 1969, the surfaces look good with a few minor exceptions. Defects that were observed were:

1. failure at the outer edge on one curve,
2. 1/8th-inch pull in one small area,
3. a steel wheel rut on the curve, and
4. on one curve, the sand asphalt was 3/4 inch higher at the joint with the Class I surface.

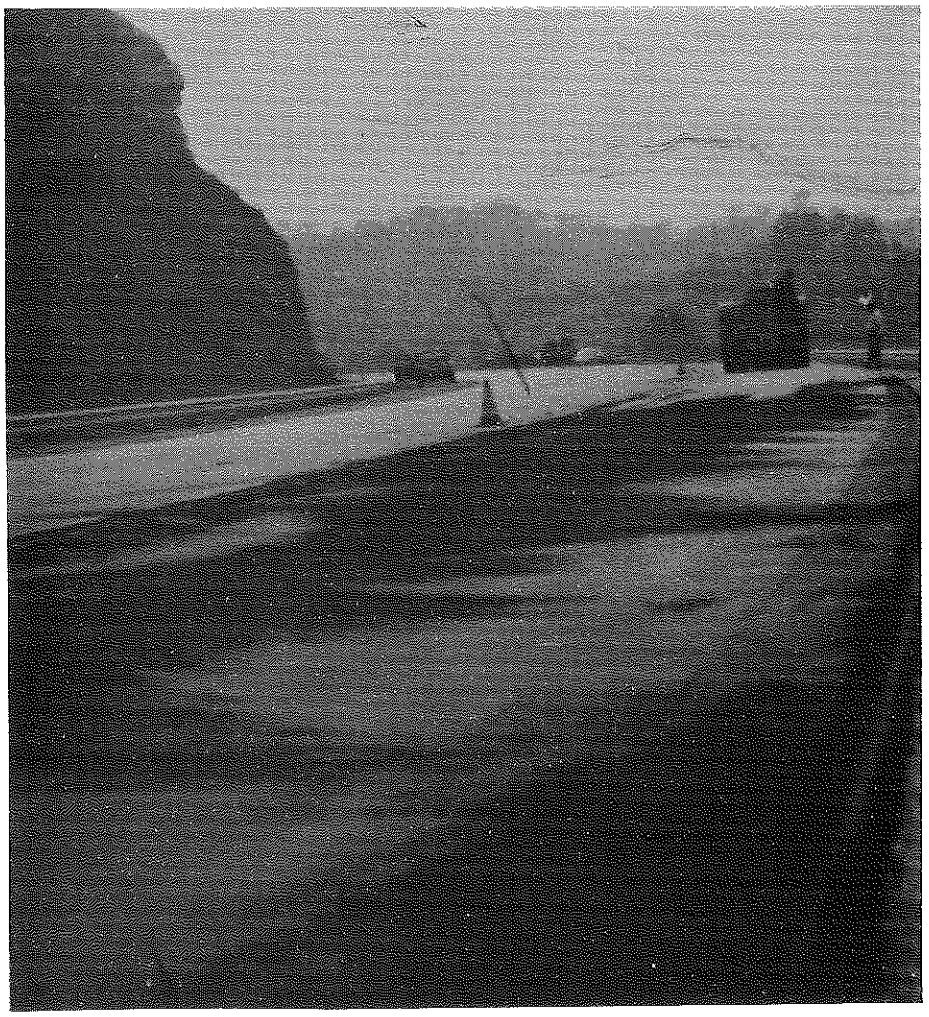


Figure 13. Superelevated Curve on Mountain Parkway.
Note the considerable extent of handwork.

PROJECT DESCRIPTION

Location	Warren County, US 68 & US 31W, Bowling Green By-Pass, from Chestnut Street to State Street
Number	SP GR 30 (SP 114-6328-4S1)
Date Constructed	May 29 - June 4, 1968
Contractor	McLellan Stone Co., Bowling Green, Kentucky
Special Provision	22A

AGGREGATE

Type	Percent by Weight	Source
Natural sand	60	
Limestone sand	40	

Combined aggregate gradation

Sieve	1/4 inch	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Percent passing	100	97.3	85.5	71.9	30.1	6.9	4.2

Fineness modulus — Design 1.90 - 2.30 — Extracted 2.08

Equivalent silica content 59%

ASPHALT

Content — Design 8.7% — Extracted 8.8% — Marshall 8.8%

Tack coat SS-1H

MARSHALL TEST

Compaction effort	75 blows
Unit weight	132.7 pounds per cubic foot
Marshall stability	475 pounds
Flow	9
Bulk specific gravity	2.35
Voids in mix	9.2%

PRODUCTION TEMPERATURE AND EQUIPMENT

Mix production temperature	300 - 315°F
Plant	Barber-Greene Batch-Pac

REMARKS

The only construction problem stemmed from traffic tracking the tack coat from one lane onto the completed sand-asphalt mat in the next lane (Figures 14 and 15). Subsequently, traffic picked up the sand asphalt resulting in a marred surface appearance (Figure 16). The August 1969 inspection revealed that traffic had smoothed these surface defects and the pavement has been rated excellent.

Figure 14. US 31-W, Bowling Green By-Pass.
Tack coat was tracked onto the sand asphalt.

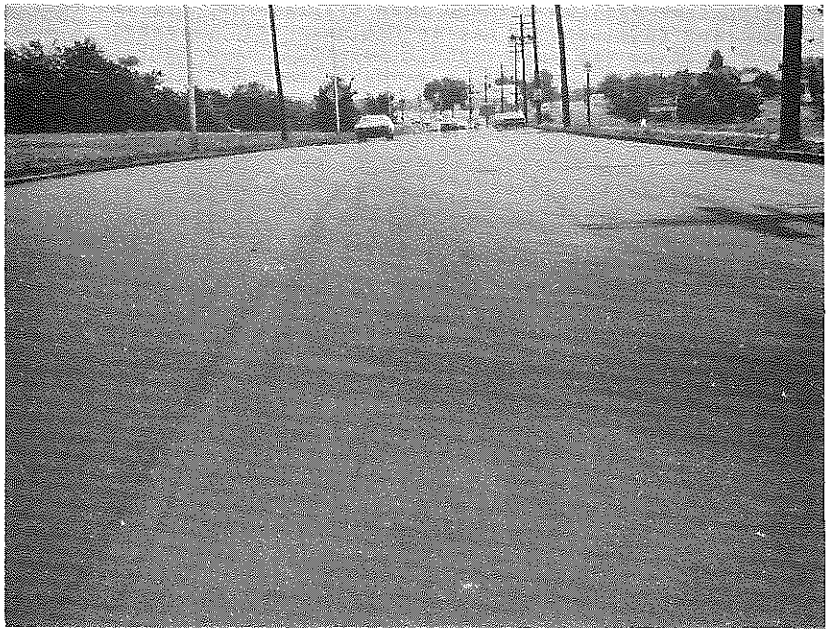


Figure 15. US 31-W, Bowling Green By-Pass.
Tack coat was tracked onto the sand asphalt.

Figure 16. US 31-W, Bowling Green By-Pass.
Traffic picked up track coat and then the top crust of the sand asphalt.

PROJECT DESCRIPTION

Location	Kenton County, 12th Street, Covington, from junction of 12th Street & I 75 on Ramp E of I 75 to west end of Licking River Bridge
Number	SP 59-7995-1
Date Constructed	June 27, 1968
Contractor	Northern Kentucky Asphalt Paving Co., Covington, Kentucky
Special Provision	22A

AGGREGATE

Type	Percent by Weight	Source
Natural sand	95	Cookes Aggregates, Petersburg, Kentucky
Mineral filler (fly ash)	5	Louisville Fly Ash Co., Louisville, Kentucky

Combined aggregate gradation							
Sieve	1/4 inch	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Percent passing	100	98.6	92.3	82.8	44.5	6.1	3.5

Fineness modulus	Design	1.60 - 2.00	Extracted	1.77
Equivalent silica content	58.9%			

ASPHALT

Type and source	PAC-5, Ashland Oil Co., Covington, Kentucky					
Content	Design	8.4%	Extracted	8.4%	Marshall	8.4%
Silicone oil added	Yes					

MARSHALL TEST

Compaction effort	75 blows
Unit weight	131.6 pounds per cubic foot
Marshall stability	194 pounds
Flow	8.5
Bulk specific gravity	2.364
Voids in mix	12.2%

PRODUCTION TEMPERATURE AND EQUIPMENT

Mix production temperature	290 - 305°F
Plant	Cummer, 4000-pound Batch
Paver	Blaw-Knox
Roller	Tandem

REMARKS

Surface defects particularly noticeable on this project, partially due to traffic using the mat upon completion of rolling, were:

1. damage due to power steering and truck parking (Figure 17),
2. frequent dragging of the paver screed (Figure 18),
3. bubbles in the mat, and
4. traffic entering from side streets (Figure 19).

Extensive pulling of the mat was observed in August 1969.

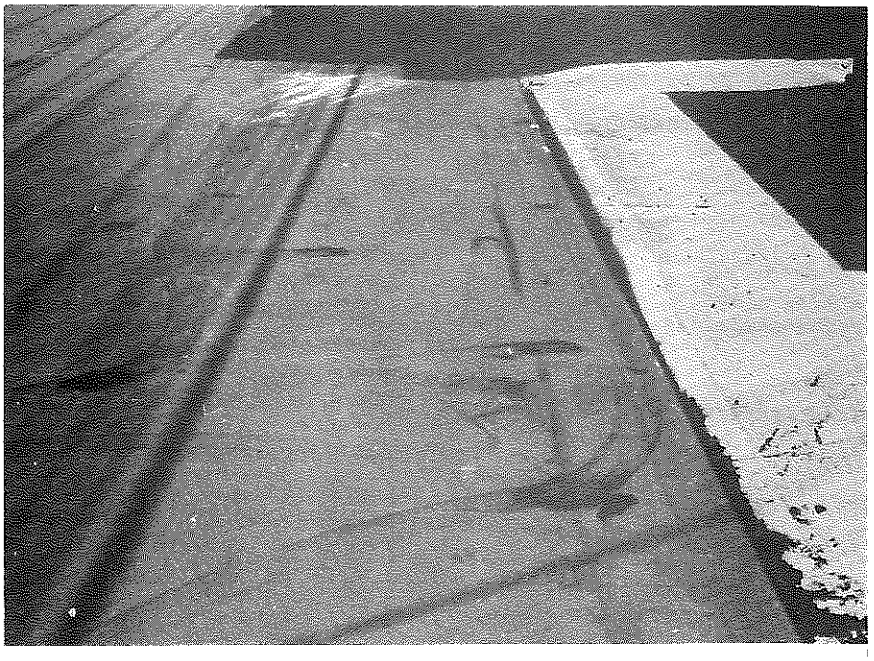


Figure 17. 12th Street in Covington.
Surface marred by tire abrasion in parking area.

Figure 18. 12th Street in Covington.
Mat tears caused by dragging paver screed.

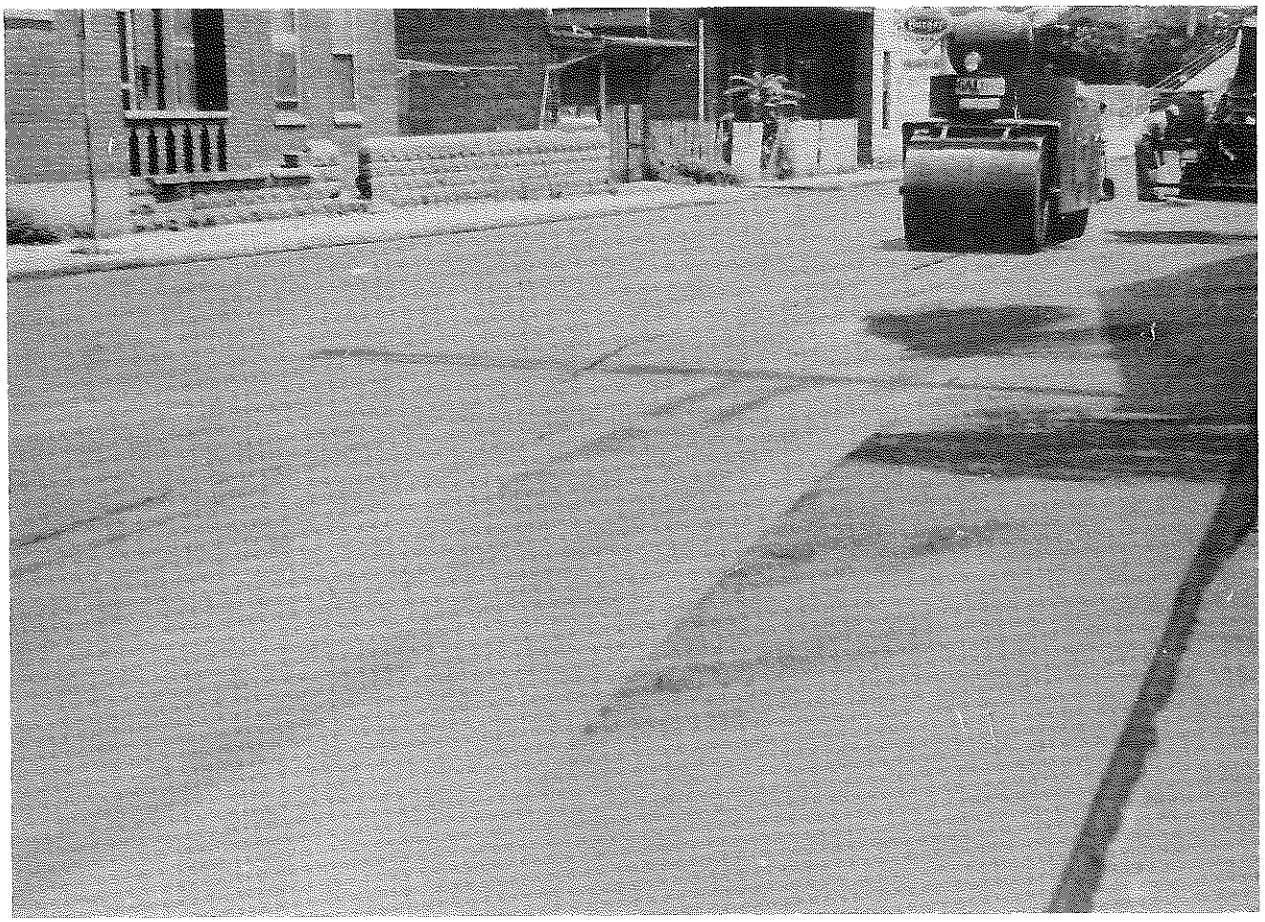


Figure 19. 12th Street in Covington.
Surface defects caused by traffic from side street.

PROJECT DESCRIPTION

Location	Franklin County, Lafayette Drive, from US 60 to Shelby Street
Number	SP 37-5105-13
Date Constructed	July 3, 1968
Contractor	R. L. Carter, Frankfort, Kentucky
Special Provision	22A

AGGREGATE

Type	Percent by Weight	Source
Silica sand	70	Kentucky River Sand, Frankfort, Kentucky
Limestone sand	30	Lehigh Cement, Frankfort, Kentucky

Combined aggregate gradation

Sieve	1/4 inch	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Percent passing	100	98.7	87.0	65.3	21.5	7.1	3.6

Fineness modulus — Design 2.00 - 2.40 — Extracted 2.21

Equivalent silica content 51.7%

ASPHALT

Type and source	PAC-3, Chevron Oil Co.					
Content	Design	8.6%	Extracted	8.5%	Marshall	8.6%
Silicone oil added	Yes					
Tack coat	SS-1H					

MARSHALL TEST

Compaction effort	50 blows
Unit weight	127 pounds per cubic foot
Marshall stability	634 pounds
Flow	7.5
Bulk specific gravity	2.343
Voids in mix	12.7%

PRODUCTION TEMPERATURE

Mix production temperature	265 - 310°F
Plant	Barber-Greene, 10,000-pound Batch-Pac

REMARKS

Leveling mix — Class I Asphalt Concrete

Initial construction inspection reports noted areas which apparently received a very poor roller coverage, if indeed they were rolled at all (Figures 20 and 21). Figure 22 shows parking areas which exhibited asphalt leaching due to gasoline spillage. Inspectors felt that very little pride in workmanship was exhibited during this paving operation. The above defects, plus reflection cracks, were noted in August 1969.

Mat tears occurred behind the paver.

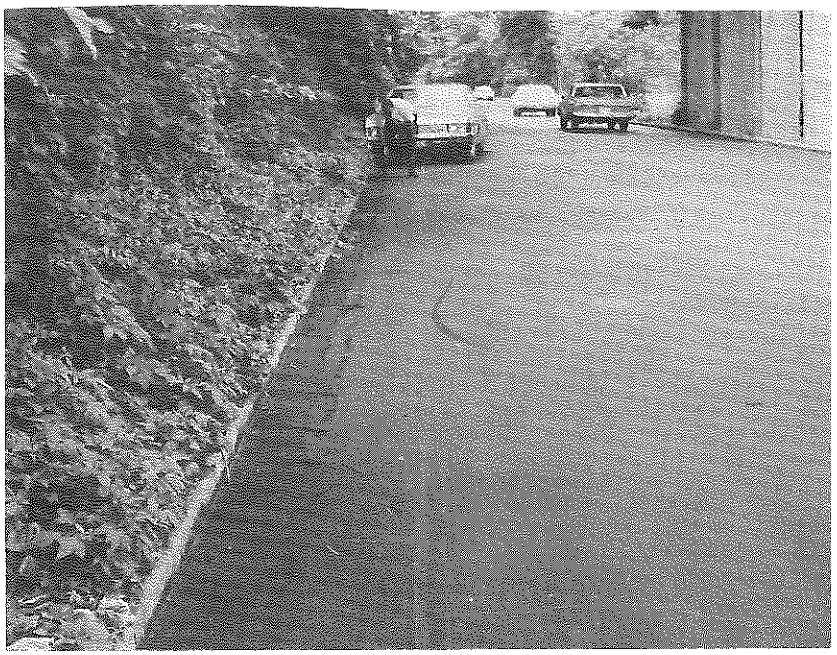


Figure 20. Lafayette Drive in Frankfort.
Area next to curb appears to have been hand compacted.

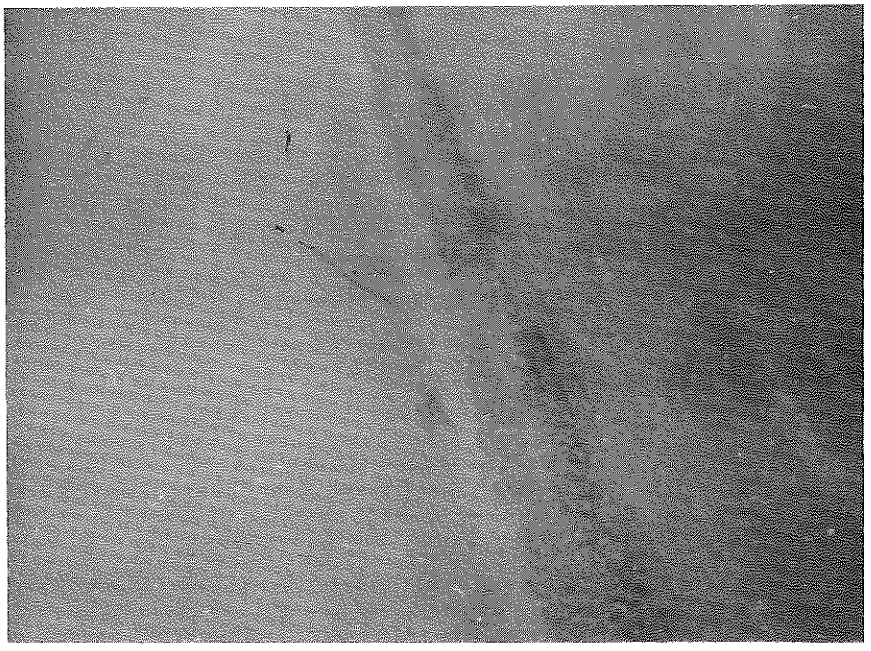


Figure 21. Lafayette Drive in Frankfort.
Surface defect caused by poor compaction procedure.

Figure 22. Lafayette Drive in Frankfort.
Leaching of asphalt in the parking lane was due to gasoline spillage.

PROJECT DESCRIPTION

Location	Pulaski County, US 27, Section 1, from junction of KY 80 for 1.5 miles north
Number	SP 100-535
Date Constructed	August 28 - September 12, 1968
Contractor	R. E. Gaddie, Columbia, Kentucky
Special Provision	22A

AGGREGATE

Type	Quantities	Percent by Weight	Source
Natural sand (cover)	44 tons		
Class I, Type A, scratch course	1463 tons		
Sand asphalt mixture	580 tons		
Fine conglomerate		44	Green River Sand Co., Jonesville, Kentucky
Coarse conglomerate		20	Green River Sand Co., Jonesville, Kentucky
Limestone		36	Shamrock Stone Co. (Butler Quarry) Columbia, Kentucky

Combined aggregate gradation

Sieve	1/4 inch	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Division of Research	100	92.5	75.7	62.9	39.1	6.9	3.1
Division of Materials							
Lab mix	100	93	82	70	34	8	4.0
Field mix	100	92	77	64	33	6	3.0

Fineness modulus (Division of Materials) Lab mix Extracted 2.15
Field mix Extracted 2.29

ASPHALT

Type and source	PAC-3, Ashland Oil and Refining Co., Louisville, Kentucky			
		Division of Research	Division of Materials	
Content	Design 7 - 10%	Extracted 8.9%	Marshall:	Lab 8.4%
		Effective 7.5%		Field 8.7%
Silicone oil added	Yes, 1 ounce per transport of asphalt cement			
Tack coat	SS-1H, 2220 gallons			

MARSHALL TEST

	Division of Research	Division of Materials Lab Mix	Division of Materials Field Mix
Unit weight, pounds per cubic foot	135.4	127.2	132
Marshall stability, pounds	868	275	400
Flow	7	12	10
Bulk specific gravity	2.169		
Voids in mix, percent	9.16	12.4	9
Voids in mineral aggregate, percent	25.43	28	26

EQUIPMENT

Plant	Hetherington Berner, 4000-pound batch
Paver	Cedar Rapids
Rollers	Three-wheel and Tandem

REMARKS

Coefficient of friction 1968: 0.61

The mix designed at the plant differed considerably from the laboratory mix because the contractor wanted to use only the two conglomerate sands and the limestone sand, thus eliminating the mortar sand. Very few problems were encountered with this mix, either during production at the plant or in the paving operation on the job. Better paving results were obtained with this mix than with any of the other mixes. This section was still in excellent condition as of August 1969.

PROJECT DESCRIPTION

Location	Pulaski County, US 27, Section 2A from 1.5 miles north of junction of KY 80 for 0.25 miles north, thence Section 2B for next 1.25 miles north
Number	SP 100-535
Date Constructed	August 28 - September 12, 1968
Contractor	R. E. Gaddie, Columbia, Kentucky
Special Provision	59

AGGREGATE

Type	Quantities	Percent by Weight	Source
Natural sand (cover)	40 tons		
Class I, Type A, scratch course	1463 tons		
Sand asphalt mixture	580 tons		
Fine conglomerate		58.4	Green River Sand Co., Jonesville, Kentucky
Coarse conglomerate		39.0	Green River Sand Co., Jonesville, Kentucky
Mineral filler (cement) (Section 2B only)		2.6	Kosmos Cement Co., Louisville, Kentucky

Combined aggregate gradation

Sieve	1/4 inch	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Division of Research							
Section 2A	100	94.8	93.0	90.2		3.4	0.5
Section 2B	100	88.1	84.7	81.1		4.4	1.4
Division of Materials							
Lab mix	100	90	86	83	52	4	0.5
Field mix	100	91	89	86	48	5	2

Fineness modulus (Division of Materials) — Lab mix, Extracted 1.88; Field mix, Extracted 1.82

ASPHALT

Type and source	PAC-3, Ashland Oil and Refining Co., Louisville, Kentucky				
		Division of Research		Division of Materials	
Content	Design 7 - 10%	2A Extracted	8.9%	Marshall: Lab	9.0%
		2A Effective	8.4%	Field	9.0%
		2B Extracted	9.5%		
		2B Effective	9.0%		
Silicone oil added	Yes, 1 ounce per transport of asphalt cement				
Tack coat	SS-1H, 2220 gallons				

MARSHALL TEST

	Division of Research Sect. 2A	Division of Research Sect. 2B	Division of Materials Lab Mix	Division of Materials Field Mix
Unit weight, pounds per cubic foot	119.4	123.0	122.0	122.0
Marshall stability, pounds	40.5	39.5	35	45
Flow	8	5	13	11
Bulk specific gravity	1.913	1.971		
Voids in mix, percent	17.41	14.68	15.2	15
Voids in mineral aggregate, percent	33.84	32.43	31	31

EQUIPMENT

Plant	Hetherington Berner, 4000-pound batch
Paver	Cedar Rapids
Rollers	Three-wheel and Tandem

REMARKS

Coefficient of friction 1968: 2A - 0.63
2B - 0.64

At the time of construction, the paving performance of this mix was satisfactory; however, more tearing of the mat was noted than in Sections 1 and 3. Performance to date has been erratic. On Section 2A, the southern 1/4 mile which did not contain portland cement, scaling in both wheel tracks in both lanes had increased from 125-foot length in December 1968 to the full 1/4-mile length by the February 19, 1969 inspection. In addition, there was one small spot where the sharp vertical edges (Figure 23) of the scaled areas had been feathered out by traffic.

For Section 2B, the last 200 feet on the north end of the section has scaled in the southbound lane only. It is felt that the geometrics of the site causes a continual wetting problem. The geometrics involve a superelevated curve, no ditch for 500 feet, high access traffic from a used car lot, a gasoline station, and a restaurant-truck rest stop complex. Water seems to be continually draining across this scaled area. A small piece of the overlay was removed and was wet at the stratification plane.

Figure 23. US 27, Somerset.
Note scaling in the wheel track of southbound (left) lane.

PROJECT DESCRIPTION

Location	Pulaski County, US 27, Section 3, from 3.0 miles north of junction KY 80 for next 1.5 miles north
Number	SP 100-535
Date Constructed	August 28 - September 12, 1968
Contractor	R. E. Gaddie, Columbia, Kentucky
Special Provision	S8

AGGREGATE

Type	Quantities	Percent by Weight	Source
Natural sand (cover)	48 tons		
Class I, Type A, scratch course	1524 tons		
Sand asphalt mixture	585 tons		
Fine conglomerate		20	Green River Sand Co., Jonesville, Kentucky
Coarse conglomerate		16	Green River Sand Co., Jonesville, Kentucky
Mortar Sand		31	Lucas Sand & Gravel, Mauckport, Kentucky
Limestone		33	Shamrock Stone Co. (Butler Quarry) Columbia, Kentucky

Combined aggregate gradation

Sieve	1/4 inch	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Division of Research	100	91.5	74.9	63.0		4.3	1.9
Division of Materials							
Lab mix	100	93	81	69	30	5	1.0
Field mix	100	92	78	65	30	6	2

Fineness modulus (Division of Materials) Lab mix Extracted 2.24
Field mix Extracted 2.30

ASPHALT

Type and source	PAC-3, Ashland Oil and Refining Co., Louisville, Kentucky		
		Division of Research	Division of Materials
Content	Design 7 - 10%	Extracted 9.2%	Marshall: Lab 8.7%
		Effective 7.8%	Field 8.7%
Silicone oil added	Yes, 1 ounce per transport of asphalt cement		
Tack coat	SS-1H, 2,200 gallons		

MARSHALL TEST

	Division of Research	Division of Materials Lab Mix	Division of Materials Field Mix
Unit weight, pounds per cubic foot	132.66	126.5	132
Marshall stability, pounds	782	225	375
Flow	3.5	10	10
Voids in mix, percent	10.29	12.2	8
Bulk specific gravity	2.126		
Voids in mineral aggregate, percent	26.88	29	26

EQUIPMENT

Plant	Hetherington Berner, 4000-pound batch
Paver	Cedar Rapids
Rollers	Three-wheel and Tandem

REMARKS

Coefficient of friction 1968: 0.60

Minor production problems were involved in maintaining the gradation within the specification limits. In general, the southbound lane met the gradation specification while the northbound lane gradation was more like that of Section 1. The general performance has been very good and is the second best of the five sections.

PROJECT DESCRIPTION

Location	Pulaski County, US 27, Section 4, from 4.5 miles north of junction of KY 80 for next 1.5 miles north
Number	SP 100-205
Date Constructed	August 28 - September 12, 1968
Contractor	R. E. Gaddie, Columbia, Kentucky
Special Provision	24B

AGGREGATE

Type	Quantities	Percent by Weight	Source
Natural sand (cover)	46 tons		
Class I, Type A, scratch course	1595 tons		
Sand asphalt mixture	610 tons		
Lean Kentucky rock asphalt		100	Gripstop Corp., Brownsville, Kentucky

Combined aggregate gradation

Sieve	1/2 inch	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Division of Research	100	95.9					9.1	
Division of Materials								
Lab mix	100	98	94	92	88	43	10	4.8
Field mix	100		90	88	82	38	10	4.0

ASPHALT

Type	PAC-3				
		Division of Research		Division of Materials	
Content	Design 8 - 11%	Extracted	9.5%	Marshall: Lab	9.3%
		Effective	8.6%	Field	9.3%
Silicone oil added	Yes, 1 ounce per transport of asphalt cement				
Tack coat	SS-1H, 2,320 gallons				

MARSHALL TEST

	Division of Research	Division of Materials Lab Mix	Division of Materials Field Mix
Unit weight, pounds per cubic foot	125.89	127.4	125
Marshall stability, pounds	903	875	445
Flow	8	11	11
Bulk specific gravity	2.017		
Voids in mix, percent	10.48	12.0	12.5
Voids in mineral aggregate, percent	27.83	31.0	31.0

EQUIPMENT

Plant	Hetherington Berner, 4000-pound batch
Paver	Cedar Rapids
Rollers	Three-wheel and Tandem

REMARKS

Coefficient of friction 1968: 0.69

The only production problem that was encountered was uniform plant production due to large lumps of the crushed aggregate. It is not known whether the lumps were formed in the producer's stockpile or in the contractor's stockpile.

Some mat tearing and pulling were noted during the paving operation which may have been caused by the lighter than normal application rate of 50 pounds per square yard. Application rates for other sites had been either 60 or 85 pounds per square yard. As of August 1969, the pavement was in good condition.

PROJECT DESCRIPTION

Location	Pulaski County, US 27, Section 5A from 6.0 miles north of junction of KY 80 for 0.25 miles north, Section 5B for next 1.25 miles north
Number	SP 100 - 205
Date Constructed	August 28 - September 12, 1968
Contractor	R. E. Gaddie, Columbia, Kentucky
Special Provision	60

AGGREGATE

Type	Quantities	Percent by Weight	Source
Natural sand (cover)	46 tons		
Class I, Type A, scratch course	1595 tons		
Sand asphalt mixture	610 tons		
Fine conglomerate		97.4	Green River Sand Co., Jonesville, Kentucky
Mineral filler (cement)		2.6	Kosmos Cement Co., Louisville, Kentucky

Combined aggregate gradation

Sieve	1/2 inch	1/4 inch	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Division of Research	100		99.4					4.6	0.9
Division of Materials									
Lab mix	100	100		100	96	93	48	4	0.5
Field mix	100	100		99	98	95	55	5	2

Fineness modulus (Division of Materials) — Lab mix: Extracted 1.59; Field mix: Extracted 1.49

ASPHALT

Type	PAC-3				
Content	Design 7 - 10%	Division of Research		Division of Materials	
		Extracted	9.9%	Marshall: Lab	10.0%
		Effective	9.4%	Field	10.0%
Silicone oil added	Yes, 1 ounce per transport of asphalt cement				
Tack coat	SS-1H, 2,320 gallons				

MARSHALL TEST

	Division of Research	Division of Materials Lab Mix	Division of Materials Field Mix
Unit weight, pounds per cubic foot	120.5	119.3	118
Marshall stability, pounds	57	30	30
Flow	7.7	15	20
Bulk specific gravity	1.924		
Voids in mix, percent	16.25	16.0	16.5
Voids in mineral aggregate, percent	34.33	34.0	34.0

EQUIPMENT

Plant	Hetherington Berner, 4000-pound batch
Paver	Cedar Rapids
Rollers	Three-wheel and Tandem

REMARKS

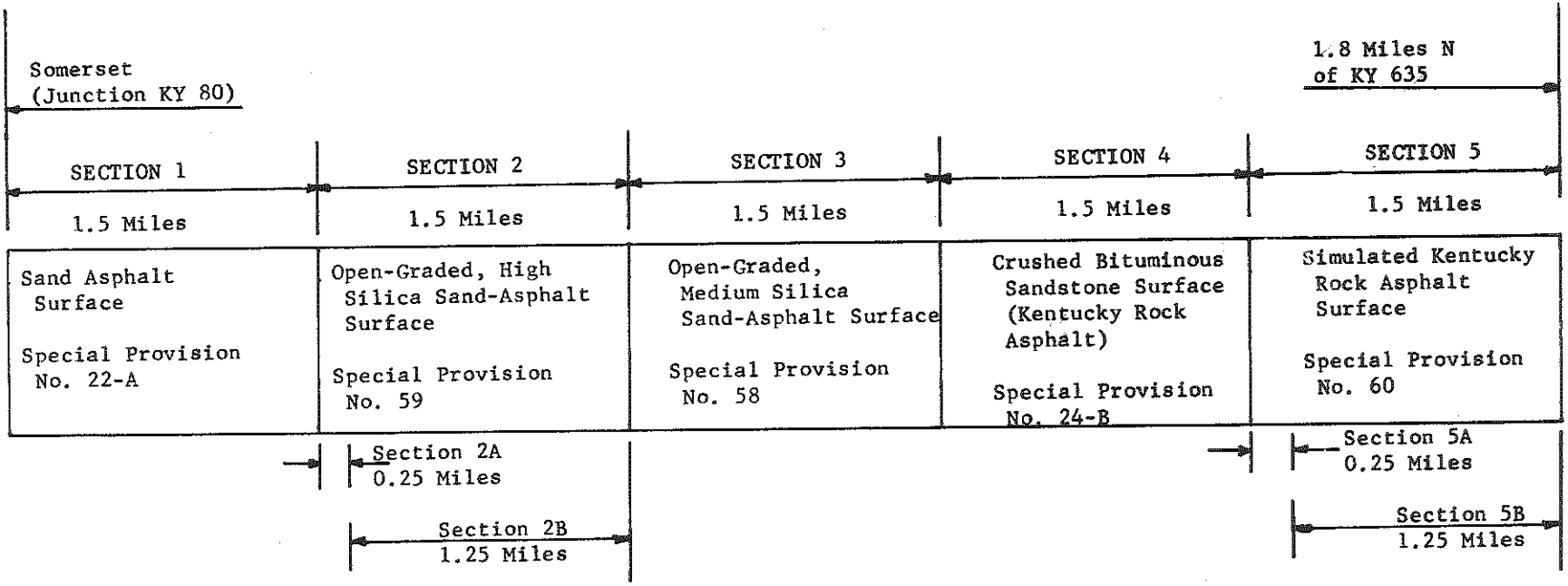
Coefficient of friction — Section 5A 1968: 0.62; Section 5B 1968: 0.59

This section has the poorest construction performance history of the five sections. This section has been intended to simulate Section 4; however, a blending of the mortar sand and portland cement was used in the mix. The use of only the fine conglomerate sand may have been the cause of the poor workability of the mix. Considerable pulling and tearing of the mat was experienced (Figure 24). The mix remained very tender for a considerable number of hours, and in some areas, extended until the next day. Perhaps one of the most detrimental features was allowing traffic to stand on the newly laid mix, leaving tire marks and depressions. Some of these defects can be seen in Figures 25 and 26.

Scaling of both wheel tracks of both lanes had become rather severe by February 1969.

PULASKI COUNTY

SP 100-535, SP 100-205



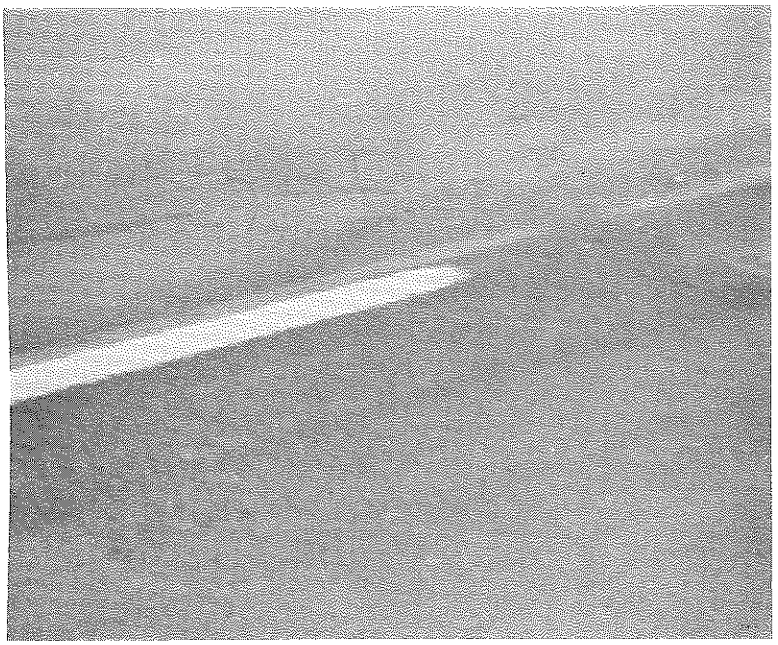


Figure 24. US 27, Somerset.
Badly pulled area near centerline.

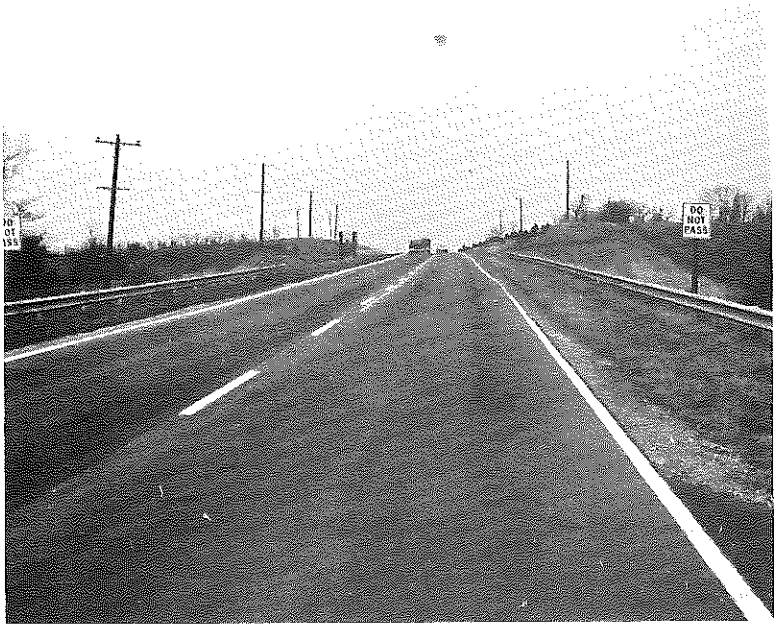


Figure 25. US 27, Somerset.
Note prominent scaling in the wheel tracks just three months after construction.

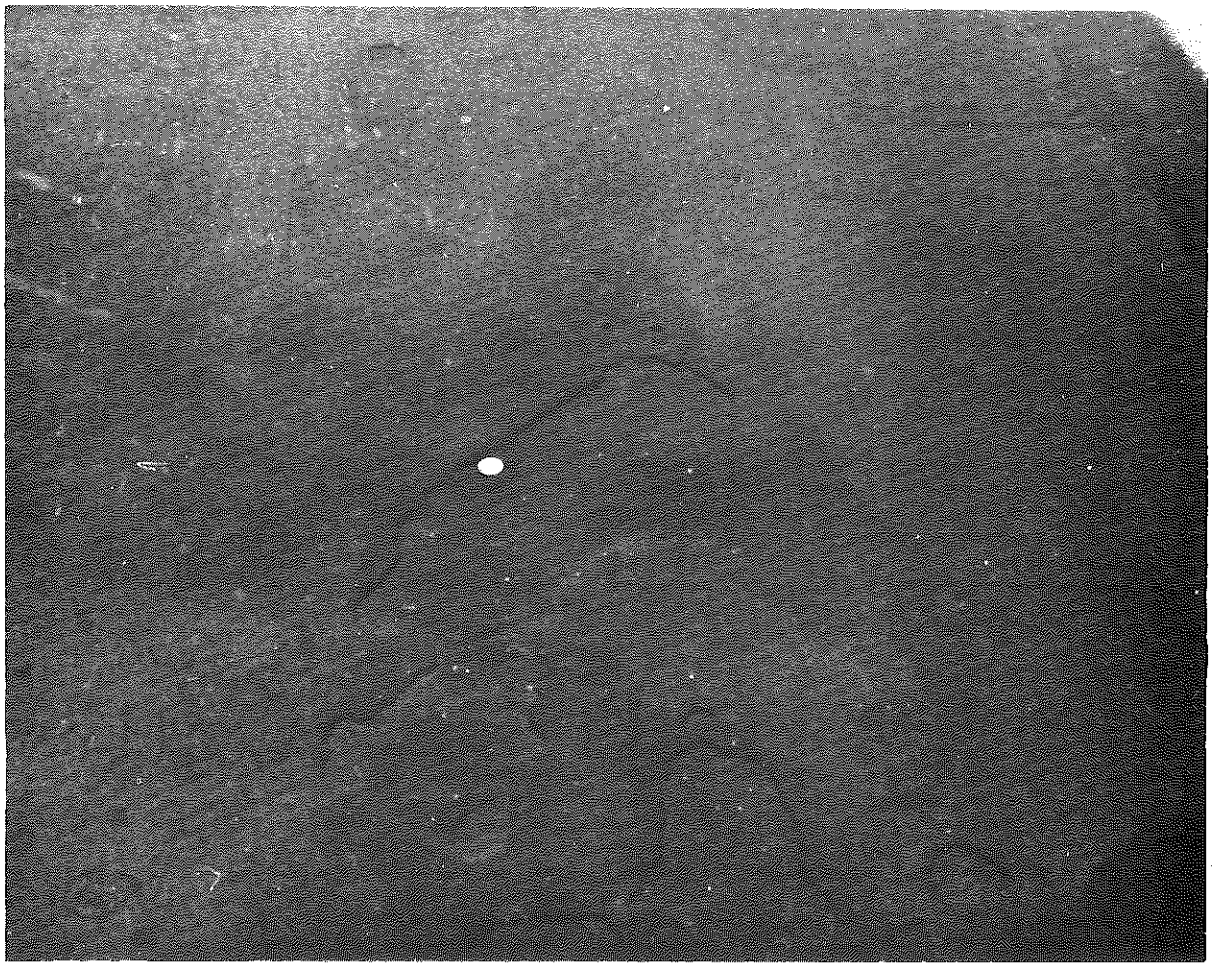


Figure 26. US 27, Somerset.
A close-up of a scaled area taken December 1968. Note the sharp vertical walls of the scaled area. By August 1969, the summer heat and traffic had produced feathered edges.

PROJECT DESCRIPTION

Location	Green County, KY 61, from US 68 in Greensburg to KY 88 NW of Greensburg
Number	SP 44-16
Date Constructed	July 11, 1969
Contractor	Nally-Gibson, Greensburg, Kentucky
Special Provision	22A

AGGREGATE

Type	Percent by Weight	Source
Natural sand	55	Green River Sand Co., Jonesville, Ky.
Limestone sand	45	Nally-Gibson, Greensburg, Kentucky

Combined aggregate gradation

Sieve	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Percent passing	99.8	92.2	79.0	67.9	39.2	8.6	4.4

Fineness modulus — Design 2.07 — Extracted 2.18

Equivalent silica content — 53%

ASPHALT

Type and source	PAC-5, Ashland Oil Company
Content	Design 8.5% — Extracted 8.5% — Marshall 8.5%
Silicone oil added	Yes
Tack coat	SS-1H

MARSHALL TEST

Compaction effort	50 blows
Compaction temperature	260°F
Unit weight	135.3 pounds per cubic foot
Marshall stability	488 pounds
(High stability values may be due to sample having been reheated more than once)	
Flow	11.3
Theoretical maximum specific gravity	2.357
Voids in mix, percent	8.0

PRODUCTION TEMPERATURE AND EQUIPMENT

Mix production temperature	280 - 300°F
Plant — Continuous Mix	Continuous Mix, 80 tons per hour

REMARKS

Leveling mix — Class I Asphalt Concrete

Two miles of KY 61 were paved with sand asphalt. No defects were noted in August 1969.

PROJECT DESCRIPTION

Location	Franklin County, Mix "B", US 60, from 100 feet east of junction of US 60 & US 127 at Capitol Avenue to new concrete at Jerry's Drive-In Main Street from High Street to Ann Street US 460 from junction US 60 & US 421 to end of four-lane section
Number	SP GR 17
Date Constructed	August 22 - September 13, 1966
Contractor	R. L. Carter, Frankfort, Kentucky
Special Provision	22

AGGREGATE

Type	Percent by Weight	Source
Natural mortar sand	60	Standard Materials, Carrolton, Kentucky
Pit sand	13	Louisville Sand and Gravel, Louisville, Kentucky
Limestone sand	27	Falls City Quarries, Frankfort, Kentucky

Combined aggregate gradation

Sieve	1/4 inch	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
Percent passing	100	99.7	94.4	74.8	32.5	11.2	5.2

Fineness modulus — Design 1.70 - 2.10 — Extracted 1.88

Equivalent silica content 57%

ASPHALT

Type and source	PAC-5, Sinclair, Louisville, Kentucky
Content	Design 8.5% Extracted 8.5% Marshall 8.5%
Silicone oil added	All but US 60,east section
Tack coat	RS-1

MARSHALL TEST

Compaction effort	50 blows
Compaction temperature	265°F
Unit weight	131.7 pounds per cubic foot
Marshall stability	650 pounds
Flow	6

EQUIPMENT

Plant Barber-Greene, 10,000-pound Batch-Pac
Paver Cedar-Rapids

REMARKS

Leveling mix Class I Asphalt Concrete

Mix B was laid on the following locations:

1) US 60 east from the Capitol Avenue Bridge to Jerry's Drive-In,

2) US 460 east from US 60 and US 421 to the end of the four-lane section, and

3) Main Street from Ann Street to High Street.

Practically anything that could go wrong with a sand asphalt mix occurred on these three sections, including:

1) lack of silicone additive to the mix,

2) a poor tack coat that actually came out as globs on some pavement areas,

3) pickup of sand asphalt due to attempting to roll while the mix was still too hot,

4) improper operation of the paver causing large transverse humps of sand asphalt left by the screed,

5) tack coat being lifted by truck traffic,

6) poor roller compaction near curbs,

7) lack of a leveling course on US 60 East left large deep ruts in the pavement which

The east hill on US 60 East, better known as East Main Street, had deep ruts and the sand asphalt was too thick in these areas. The roller appeared to roll additional roughness into the pavement. Mat tearing and some shoving were observed. Unfortunately, due to the remaining limited curb height left by this overlay, a leveling course followed by another sand asphalt overlay could not be tolerated.

The area of Versailles Road, US 60 East, that could tolerate additional thickness was from Lyons Drive to Jerry's Drive-In. On this stretch there was excessive longitudinal rutting and transverse bumps. Rolling efforts seemed to increase the roughness of the first sand-asphalt overlay. Three attempts were made to correct this problem. First, and probably the most significant, was the addition of the silicone additive to the asphalt cement (the contractor had run out of the additive without telling Division of Construction personnel). Because the Construction personnel were unaware of the lack of silicone in the mix, the temperature was lowered, worsening the aggregate moisture problem. To overcome this, the bitumen content was lowered from 8.5 to 8.0 percent, compounding the problems. The mix production temperature was then raised to 315°F, which helped considerably. Of course, the problems were virtually eliminated when the silicone was finally added to the asphalt cement. Even so, the contractor was required to apply a Class I leveling course followed by another sand-asphalt overlay to the area from Lyons Drive to Jerry's Drive-In.

The above experiences resulted in the contractor applying a Class I leveling course followed by the sand asphalt overlay to Main Street (downtown) and US 460 with satisfactory results.

Hand work along the curbs and at intersections was generally poor because the mix was allowed to become too cool before hand work was begun and too few passes were made by the roller.

APPENDIX B

Special Provisions

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS

SPECIAL PROVISION NO. 22

FOR

SAND ASPHALT SURFACE

This Special Provision covers the material requirements and construction methods for Hot-Mixed, Hot-Laid, Sand-Asphalt, Surface Course and shall be applicable to individual projects only when indicated on plans, proposals, or bidding invitations; and, when so indicated, it shall supersede all conflicting provisions of the Department's current Standard Specifications for Road and Bridge Construction. References herein are to the Department's Standard Specifications and approved addenda thereto.

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I. DESCRIPTION

Hot-Mixed, Hot-Laid, Sand-Asphalt is intended to provide a fine-textured, skid-resistant, wearing surface for pavements and bases. At least 50 per cent of the sand therein shall consist of quartz (SiO_2). A proportion of the sand may consist of crushed limestone or slag sand. The sand, bituminous material, and the mixing and application thereof shall be in accordance with the respective requirements hereinafter described. The mixture shall be applied to the nominal, compacted thickness indicated on the plans or in the proposal; and the finished surface shall conform with the lines and grades shown on the plans or proposals.

II. MATERIALS

A. Requirements

1. Bituminous Materials. The asphalt cement to be mixed with the sand shall be of the grade specified on plans or proposals and shall meet the particular requirements of Section 621. The quantity of asphalt cement used shall be as directed by the Engineer.

Bitumen for the tack coat shall meet the requirements of Section 621 for the particular type and grade specified on the plans or proposals.

2. Aggregate. The aggregate shall consist, by weight, of not less than 50 per cent quartz (SiO_2). Quartz, to fulfill this requirement, shall be obtained from crushed sandstone, conglomeratic sand, bank sand, river sand or combinations thereof. The remaining portion of aggregate shall consist of quartz sand, limestone sand, slag sand, or blends thereof. Unless otherwise provided, mineral filler meeting the requirement of Article 611.5.0 may comprise not more than 5 per cent of the aggregate combination. The total combined aggregate, including mineral filler, shall have a minimum Sand-Equivalent value of 35, as determined by AASHO T 176. Deleterious substances retained on the No. 200 sieve shall not exceed the following percentages by weight of the total combined aggregate.

	Per Cent by Weight
Clay lumps.	None
Other deleterious substances such as, but not limited to, alkali, mica, shale, coated grains, soft and flaky particles.	1.0

3. Approval of Materials. Article 306.2.2

III. CONSTRUCTION METHODS

The construction methods shall comply with the applicable requirements of Article 306.3.0, except as otherwise provided hereinafter and on the plans or in the proposals.

A. Composition of Mixtures. The sand and asphalt cement shall be combined in such proportions that the composition of the mixture by weight shall be within the general limits given in the following table. A job-mix formula, within the specified composition limits, shall be established by the Engineer for each project; and the proportions and gradings so set shall be maintained within the tolerances specified hereinafter. The percentages passing all sieve sizes shall be determined by dry sieving. These permissible tolerances from the job-mix formula shall not permit the use of any mixture which will be outside the specified composition limits. Once the job-mix formula has been established, it shall remain in effect until changed in writing by the Engineer. Deviations from the job-mix formula shall not exceed 0.5 percentage points in the asphalt content, 0.2 in fineness modulus of the sand gradation, and 1.5 percentage points in the amount of material passing the No. 200 sieve.

Composition Limits

Sieve	Per Cent Passing
1/4-inch	100
No. 8	90-100
No. 16	75-100
No. 30	50-95
No. 50	25-65
No. 100	7-30
No. 200	2-10
Per Cent Bitumen	7-10

B. Preparation of Aggregates. If sands from two or more sources are blended, they shall be metered from individual cold bins in such proportions that will yield a product having the specified gradation. The sand shall be uniformly dried and heated to a temperature of not less than 225 degrees F. nor more than 325 degrees F. If mineral filler is used, it shall be weighed or metered into the mix from a separate bin.

IV. METHOD OF MEASUREMENT

The sand asphalt will be weighed in accordance with Article 1.9.1. Bituminous material, except that used in the sand-asphalt mixture, will be measured in gallons as specified in Section 621.

V. BASIS OF PAYMENT

The quantities thus measured and accepted, complete and in place, will be paid for at the contract unit price bid per gallon for "Bituminous Materials," per ton for "Sand-Asphalt Mixture;" which payment shall be full compensation for cleaning surface, for furnishing, hauling, and placing all materials, and for all labor, equipment, tools, and incidentals necessary to complete the work.

APPROVED February 15, 1966

D. H. BRAY
STATE HIGHWAY ENGINEER

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS

SPECIAL PROVISION NO. 22-A

FOR

SAND ASPHALT SURFACE

This Special Provision covers the material requirements and construction methods for Hot-Mixed, Hot-Laid, Sand-Asphalt, Surface Course and shall be applicable to individual projects only when indicated on plans, proposals, or bidding invitations; and, when so indicated, it shall supersede all conflicting provisions of the Department's current Standard Specifications for Road and Bridge Construction. References herein are to the Department's Standard Specifications and approved addenda thereto.

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I. DESCRIPTION

Hot-Mixed, Hot-Laid, Sand-Asphalt is intended to provide a fine-textured, skid-resistant, wearing surface for pavements and bases. At least 50 per cent of the sand therein shall consist of quartz (SiO_2). A proportion of the sand may consist of crushed limestone or slag sand. The sand, bituminous material, and the mixing and application thereof shall be in accordance with the respective requirements hereinafter described. The mixture shall be applied to the nominal, compacted thickness indicated on the plans or in the proposal; and the finished surface shall conform with the lines and grades shown on the plans or proposals.

II. MATERIALS

A. Requirements.

1. Bituminous Materials. The asphalt cement to be mixed with the sand shall be of the grade specified on plans or proposals and shall meet the particular requirements of Section 621. The quantity of asphalt cement used shall be as directed by the Engineer.

Bituminous material for the tack coat shall meet the requirements of Section 621 for the particular type and grade specified on the plans or proposals.

2. Aggregate. The aggregate shall consist, by weight, of not less than 50 per cent quartz (SiO_2). Quartz, to fulfill this requirement, shall be obtained from crushed sandstone, conglomeratic sand, bank sand, river sand or combinations thereof. The remaining portion of aggregate shall consist of quartz sand, limestone sand, slag sand, or blends thereof. Unless otherwise provided, mineral filler meeting the requirements of Article 611.5.0 for quality may comprise not more than 5 per cent of the aggregate combination. Each aggregate, except mineral filler, shall have a minimum Sand-Equivalent value of 10 as determined by AASHO T 176, and the total combined aggregate, including mineral filler, shall have a minimum Sand-Equivalent value of 35. Deleterious substances retained on the

No. 200 sieve shall not exceed the following percentages by weight of the total combined aggregate.

	Per Cent by Weight
Clay lumps.	None
Other deleterious substances such as, but not limited to, alkali, mica, shale, coated grains, soft and flaky particles.	1.0

3. Admixture. A moisture controlling admixture such as silicone fluid (dimethyl siloxane polymer) shall be furnished by the Contractor to be blended with the mix when and as directed by the Engineer.

B. Approval of Materials. Silicone shall be of a type approved by the Department and shall be from a source approved by the Department.

At least one week prior to commencing production, the Contractor shall notify the Engineer that the aggregates, including blended natural sand if used, have been stocked at the job site. Prior to notification, at least 500 tons or one-half the anticipated project requirement, whichever is least, of each aggregate shall be stocked.

III. CONSTRUCTION METHODS

The construction methods shall comply with the applicable requirements of Article 306.3.0, except as otherwise provided hereinafter and on the plans or in the proposals.

A. Seasonal and Weather Limitations. No sand asphalt surface as defined by this special provision shall be laid between September 30 and May 1, nor when the temperature is below 60 degrees F., except by written permission of the Engineer, nor when the underlying course is wet, nor when other weather conditions are unsuitable.

B. Preparation of Mixture.

1. Composition of Mixture. The sand and asphalt cement shall be combined in such proportions that the composition of the mixture by weight shall be within the general limits given in the following table. A job-mix formula, within the specified composition limits, shall be established by the Engineer for each project; and the proportions and gradings so set shall be maintained within the tolerances specified hereinafter. The percentages passing all sieve sizes shall be determined by dry sieving. These permissible tolerances from the job-mix formula shall not permit the use of any mixture which will be outside the specified composition limits. Once the job-mix formula has been established, it shall remain in effect until changed in writing by the Engineer. Deviations from the job-mix formula shall not exceed 0.5 percentage points in the asphalt content and 0.2 in fineness modulus of the sand gradation.

Composition Limits

Sieve	Per Cent Passing
1/4 inch	100
No. 8	88-100
No. 16	70-95
No. 30	50-90
No. 50	20-65
No. 100	5-20
No. 200	1-8
Per Cent Bitumen	7-10

2. Preparation of Aggregates. If sands from two or more sources are blended, they shall be metered from individual cold bins in such proportions that will yield a product having the specified gradation. The sand shall be uniformly dried and heated to a temperature of not less than 280°F nor more than 325°F. If mineral filler is used, it shall be weighed or metered into the mix from a separate bin.

3. Temperature Requirements. Unless otherwise approved by the Engineer, the temperatures of the materials and the mixtures, in degrees Fahrenheit, shall be maintained within the ranges given in the following table:

Mixing and Laying Temperatures

Aggregates.	.Min. 280 - Max. 325
Asphalt Cement.	.Min. 265 - Max. 325
Mixture at Plant.	.Min. 280 - Max. 325
Mixture When Laid	.Min. 280 - Max. 310

C. Spreading and Finishing.

1. Paver Speed. Unless otherwise directed by the Engineer, the paver when placing the surface mix shall maintain a speed of 22 feet per minute, plus or minus 8 feet per minute.

2. Continuous Paver Operation. The plant production and the paver speed shall be synchronized in such a manner which will permit the paver to travel in a uniform continuous forward speed within the limits as required hereinbefore. The paver shall engage the hauling trucks while traveling forward. Every effort shall be made to keep the paver moving continuously. The paver should be permitted to stop only when a plant or paver breaks down or when some emergency or unavoidable condition exists.

3. Entrances and Crossovers. Entrances, crossovers, and other areas inaccessible to the paver which must be spread by hand, whether constructed of sand asphalt or other surface mixture, shall be constructed as a separate operation. The material for these areas shall be placed directly from the trucks. The paver shall not be stopped, side plates removed, and the material for these areas allowed to spill out to the side, or the paver shall not be stopped and material for these areas shoveled from the hopper.

4. Pavement Samples. Samples shall not be cut from the pavement unless directed by the Engineer.

5. Compaction. Unless otherwise directed or permitted by the Engineer, compaction, including breakdown rolling, shall be accomplished with a 3-wheel roller or a tandem roller weighing not less than 8 tons. Entrances, crossovers and other inaccessible areas spread by hand shall be compacted with roller weighing not less than 3 tons.

6. Leveling and Patching. Leveling and patching shall be performed in a manner, with the designated equipment and with the materials, as prescribed on the plans or in the proposal.

IV. METHOD OF MEASUREMENT

The sand asphalt will be weighed in accordance with Article 1.9.1. Bituminous material, except that used in the sand-asphalt mixture, will be measured in gallons as specified in Section 621.

V. BASIS OF PAYMENT

The quantities thus measured and accepted, complete and in place, will be paid for at the contract unit price bid per gallon for "Bituminous Materials," per ton for "Sand-Asphalt Mixture;" which payment shall be full compensation for cleaning surface, for furnishing, hauling, and placing all materials, including the silicone fluid, and for all labor, equipment, tools, and incidentals necessary to complete the work.

APPROVED March 7, 1967

A. O. NEISER
STATE HIGHWAY ENGINEER

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS

SPECIAL PROVISION NO. 24-B

FOR

CRUSHED BITUMINOUS SANDSTONE SURFACE (KENTUCKY ROCK ASPHALT)

This Special Provision shall be applicable only when indicated on the plans, in the proposal, or in the bidding invitation and, when so indicated, shall supersede any conflicting requirements of the Department's 1965 Standard Specifications for Road and Bridge Construction, and is complemented with the applicable provisions of Section 306 thereof.

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I. DESCRIPTION

This work shall consist of furnishing and placing paving mixtures complying with the material requirements and processed as hereinafter described, without alternate types of materials or processes, for use in the construction of surface courses on existing bases or pavements as set forth by the plans, proposal, or bidding invitation. The mixture shall consist essentially of crushed bituminous sandstone (Kentucky Rock Asphalt), enriched with an optimum quantity of asphalt cement. Construction procedures and finished work shall conform with the further stipulations listed herein.

The work shall also include the surfacing of approaches at road and street intersections and approaches or aprons at entrances, when and as directed by the Engineer. If not specified and unless otherwise directed by the Engineer, the bituminous mixture for this work shall be Bituminous Concrete Surface, Class I, which shall conform to Section 306. Fine aggregate for the bituminous concrete may be natural, crushed, or conglomerate sand meeting the requirements of Section 611 for quality.

II. MATERIALS

A. Aggregate. The aggregate shall consist of crushed, bituminous, quartzy sandstone having uniform quality and hardness. It shall be free of dirt and debris and shall meet the following requirements:

1. Bitumen Content: The raw aggregate shall contain not less than 3.5 per cent of natural bitumen by weight. Bitumen content shall be determined on the aggregate as produced (without additional crushing or fracturing) by extraction with trichloroethylene used as the solvent.

2. Gradation: The size-gradation of the extracted aggregate shall comply with the following requirements:

Sieve Size	Per Cent Passing
1/2 inch	100
No. 4	40-100
No. 100	0-15

3. Silica: The extracted aggregate shall contain not less than 90 per cent Silica (SiO_2) as determined by chemical analysis.

B. Asphalt Binder. Asphalt cement enrichment shall consist of PAC-5 (Article 621.4.0) as specified on the plans or in the proposal.

C. Bituminous Tack Coat. Tack coats shall be of the type and in the quantities designated on the plans or in the proposal for the work and shall be applied in the manner described in Section 301 and as prescribed by the Engineer.

D. Admixture. A moisture controlling admixture such as silicone fluid (dimethyl siloxane polymer) shall be furnished by the Contractor to be blended with the mix when and as directed by the Engineer. The silicone shall be of a type approved by the Department and shall be from a source approved by the Department.

III. CONSTRUCTION METHODS

A. Seasonal and Weather Limitations. No crushed bituminous sandstone surface shall be placed between September 30 and May 1, nor when the air temperature is below 60°F, except by written permission of the Engineer; neither shall it be placed when the underlying course is wet or when other weather conditions are unsuitable.

B. Plant and Equipment. Article 306.3.2, except as noted below:

1. Screens: Only one screen, a scalping screen of the necessary size, will be required.

2. Bins: The plant shall include a storage bin of sufficient capacity to supply the mixer, when it is operating at full capacity, with no undue periods of waiting for aggregate. The outlet gate on the bin shall cut off quickly and completely and shall be designed and constructed so there will be no leakage when closed.

3. Thermometric Equipment: Article 306.3.2-C-8, excluding paragraphs c. and d., which are replaced with the following paragraphs:

   c. A certified thermometer, visible to the plant operator responsible for controlling the aggregate temperature, shall be installed at the aggregate discharge from the drier.

   d. A recording thermometer or pyrometer shall be installed with the actuator at the aggregate discharge from the drier and the recording device mounted free of vibration.

4. Dust Collectors: The plant shall be equipped with an effective dust collector. Material collected must be returned to the mix unless wasting is permitted by the Engineer.

5. Field Laboratory: Article 306.3.2-I. In addition, each field laboratory where rock asphalt will be tested shall be provided with a hood and exhaust fan arrangement to remove harmful solvent fumes and to provide adequate ventilation.

C. Preparation of Mixture.

1. Composition of Mixtures: The rock asphalt aggregate and asphalt cement shall be combined in such proportions that the total bitumen content will be not less than 8 per cent and not more than 11 per cent. The asphalt cement enrichment shall be not less than 4 per cent nor more than 6 per cent. No direct payment shall be made for the asphalt cement enrichment. A minimum total bitumen content within the specified limits shall be established by the Engineer for each project. Mixtures which contain less than the minimum total bitumen content as established by the Engineer shall be adjusted by increasing the asphalt cement enrichment.

2. Preparation of Aggregate: The rock asphalt aggregate shall be deposited in the cold elevator at a rate to insure correct and uniform temperature control of the heating and drying operation. The aggregate shall be heated to a uniform temperature between 240°F and 325°F as measured at the point of discharge from the drier. Any aggregate heated in excess of 325°F shall be rejected.

3. Preparation of Asphalt Cement: Article 306.3.3-C.

4. Preparation of Mixtures: Article 306.3.3-D as applicable.

5. Temperature Requirements: Article 306.3.3-E.

D. Preparation of Base. The existing surface shall be swept clean of all foreign material by means of hand brooms and mechanical sweepers. Patching, wedging, and leveling courses of bituminous concrete (Class I) shall be applied as directed by the Engineer and in the quantities as stated on the plans or in the proposal. Bituminous tack coat shall be applied in accordance with Section 301.

E. Spreading and Finishing. Spreading and finishing shall be in accordance with Article 306.3.6, except as hereinafter provided.

1. Continuous Paver Operation: The plant procedure and the paver speed shall be synchronized in such a manner which will permit the paver to travel in a uniform continuous forward speed. The paver shall engage the hauling trucks while traveling forward. Every effort shall be made to keep the paver moving continuously. The paver should be permitted to stop only when

a plant or paver breaks down or when some emergency or unavoidable condition exists.

2. Entrances and Crossovers: Entrances, crossovers, and other areas inaccessible to the paver which must be spread by hand, whether constructed of crushed bituminous sandstone or other surface mixture, shall be constructed as a separate operation. The material for these areas shall be placed directly from the traveling trucks. The paver shall not be stopped to remove the side plates to allow the material for these areas to spill out the side, neither shall the paver be stopped and material for these areas shoveled from the hopper.

F. Compaction. Compaction shall be in accordance with Article 306.3.7, as applicable, except that entrances, crossovers, and other inaccessible areas spread by hand may be compacted with a roller weighing not less than three tons.

G. Leveling and Patching. Leveling and patching shall be performed in a manner, with the designated equipment and with the materials, as prescribed on the plans or in the proposal, or as directed by the Engineer.

H. Surface Tolerances. Surface tolerances shall be in accordance with Article 306.3.9 as applicable.

I. Maintenance and Protection. Maintenance and protection shall be in accordance with Article 306.3.10.

IV. METHOD OF MEASUREMENT

The crushed bituminous sandstone and bituminous concrete mixtures shall be weighed in accordance with Article 1.9.1.

The bituminous tack material shall be measured in gallons as specified in Section 621.

V. BASIS OF PAYMENT

The accepted quantities thus measured will be paid for at the contract unit price per ton for "Bituminous Concrete Mixture" for patching, wedging, and leveling and for "Crushed Bituminous Sandstone Mixture" for the surface course, complete in place, and per gallon for "Bituminous Tack Material," which payment shall be full compensation for furnishing, hauling, and placing all materials; for cleaning and all necessary preparations of base; for the making of proper joints; for the disposal of all surplus materials; for furnishing, processing, placing and rolling of the bituminous mixtures and materials; and for all labor, equipment, tools and incidentals necessary to complete the work specified.

APPROVED August 15, 1967

A. O. NEISER
STATE HIGHWAY ENGINEER

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS

SPECIAL PROVISION NO. 26

FOR

SAND-ASPHALT SURFACE

(Experimental: AE-60, Asphalt Emulsion)

This Special Provision covers the material requirements and construction methods for Hot-Mixed, Hot-Laid, Sand-Asphalt, Surface Course and shall be applicable to individual projects only when indicated on plans, proposals, or bidding invitations; and, when so indicated, it shall supersede all conflicting provisions of the Department's current Standard Specifications for Road and Bridge Construction. References herein are to the Department's Standard Specifications and approved addenda thereto.

I. DESCRIPTION

Hot-Mixed, Hot-Laid, Sand-Asphalt is intended to provide a fine-textured, skid-resistant, wearing surface for pavements and bases. At least 50 percent of the sand therein shall consist of quartz (SiO_2). A proportion of the sand may consist of crushed limestone or slag sand. The sand, bituminous material, and the mixing and application thereof shall be in accordance with the respective requirements hereinafter described. The mixture shall be applied to the nominal, compacted thickness indicated on the plans or in the proposal; and the finished surface shall conform with the lines and grades shown on the plans or proposals.

II. MATERIALS

A. Requirements.

1. Bituminous Binder. Emulsified Asphalt, AE-60, shall conform to the requirements tabulated below. The test requirement for settlement may be waived when the emulsified asphalt is used in less than 5 days time; or the Engineer may require that the settlement test be run from the time the sample is received until it is used, if the elapsed time is less than 5 days.

Viscosity, Saybolt-Furol, at 77° F., sec.	100-500
Distillation to 260° C. (500° F.), pct. distillate by wt., not more than.	30
Oil Distillate, pct. by vol	0-6
Modified sand-coating test.	Shall Pass
Settlement, 5 days, not more than, pct.	5
Tests on Residue when distilled to 260° C. Penetration at 77° F.	50-80

Float Test at 140° F., not less than, sec.	1200
Solubility in Carbon Tetrachloride, not less than, pct.	97.5
Ash by Ignition, not more than, pct	2.0

A representative sample of not less than one gallon shall be submitted in clean, air-tight, sealed containers. The containers shall be glass, black iron, or polyethylene.

Testing shall be in accordance with the American Association of State Highway Officials Standard Methods of Sampling and Testing for the following designations:

Testing Emulsified Asphalts T-59

Float Test. T-50

Except that the minimum variation of 4 seconds for two determinations shall not be required. Any sample or samples shall be considered as passing when the float period is more than 1200 seconds.

Modified Sand Coating Test. T-59

Except that the mixture of air-dry test aggregate and asphalt emulsion shall be mixed vigorously with a spatula for 5 minutes in an iron or enamelware pan. The blade of the spatula shall have a length of approximately 4 inches and a width of approximately 1-1/4 inches. The pan shall have an average diameter of approximately 8 inches and a depth of approximately 4 inches. Immediately after the mixing period, the mixture shall then be thoroughly wetted with approximately twice its volume of distilled water at room temperature, after which the aggregate shall be at least 90 percent coated with asphalt film. The test aggregate shall be a combination of 90 percent concrete sand and 10 percent portland cement. The amount of asphalt emulsion to be used shall be 10 percent by weight of the aggregate.

2. Bituminous Tack Coat. Bitumen for the tack coat shall meet the requirements of Section 621 for the particular type and grade specified on the plans or proposals.

3. Aggregate. The aggregate shall consist, by weight, of not less than 50 percent quartz (SiO_2). Quartz, to fulfill this requirement, shall be obtained from crushed sandstone, conglomeratic sand, bank sand, river sand or combinations thereof. The remaining portion of aggregate shall consist of quartz sand, limestone sand, slag sand, or blends thereof. Unless otherwise directed, mineral filler meeting the requirement of Article 611.5.0 may comprise not more than 5 percent of the aggregate combination. The total combined aggregate, including mineral filler, shall have a minimum Sand-Equivalent value of 35, as determined by AASHO T 176. Deleterious substances retained on the No. 200 sieve shall not exceed the following percentages by weight of the total combined aggregate.

	Percent by Weight
Clay lumps	None
Other deleterious substances such as, but not limited to, alkali, mica, shale, coated grains, soft and flaky particles	1.0

B. Approval of Materials. Article 306.2.2

III. CONSTRUCTION METHODS

The construction methods shall comply with the applicable requirements of Article 306.3.0, except as otherwise provided hereinafter and on the plans or in the proposals.

Note: The plant mixing-unit should be suitably covered and draft exhausted to protect the operator from steam emitted by the asphalt emulsion.

A. Composition of Mixtures. The sand and asphalt emulsion (AE-60) shall be combined in such proportions that the composition of the mixture by weight shall be within the general limits given in the following table. A job-mix formula, within the specified composition limits, shall be established by the Engineer for each project; and the proportions and gradings so set shall be maintained within the tolerances specified hereinafter. The percentages passing all sieve sizes shall be determined by dry sieving. These permissible tolerances from the job-mix formula shall not permit the use of any mixture which will be outside the specified composition limits. Once the job-mix formula has been established, it shall remain in effect until changed in writing by the Engineer. Deviations from the job-mix formula shall not exceed 0.5 percentage points in the asphalt content, 0.2 in fineness modulus of the sand gradation, and 1.5 percentage points in the amount of material passing the No. 200 sieve.

Composition Limits

Sieve	Percent Passing
1/4-inch	100
No. 8	90-100
No. 16	75-100
No. 30	50-95
No. 50	25-65
No. 100	7-30
No. 200	2-10
Percent Bitumen (Base Asphalt)	7-10

B. Preparation of Aggregates. If sands from two or more sources are blended, they shall be metered from individual cold bins in such proportions that will yield a product having the specified gradation. The sand shall be uniformly dried and heated to a temperature of not less than 240° F. nor more than 400° F. If mineral filler is used, it shall be weighed or metered into the mix from a separate bin.

C. Preparation of Emulsified Asphalt. The emulsified asphalt binder shall be of pumpable consistency of 140° F; it may be warmed to, but not exceeding, 160° F.

D. Preparation of Mixtures. The applicable provisions of Article 306.3.3 shall govern, except that the Engineer may increase the time of mixing as deemed necessary to reduce the moisture content to the limits allowed. The maximum allowable moisture content of the mixture at the time of discharge from the mixer shall be not more than 0.5 percent by weight.

E. Temperature Requirements. The temperature of the mixture at the time of laying shall be not less than 220° F. nor more than 240° F.

IV. METHOD OF MEASUREMENT

The sand-asphalt mixture shall be weighed in accordance with Article 1.9.1. Bituminous material, except that used in the sand-asphalt mixture, shall be measured in gallons as specified in Section 621.

V. BASIS OF PAYMENT

The quantities thus measured and accepted, complete and in place, will be paid for at the contract unit price bid per gallon for "Bituminous Materials", per ton for "Sand-Asphalt Mixture"; which payment shall be full compensation for cleaning surface, for furnishing, hauling, and placing all materials, and for all labor, equipment, tools, and incidentals necessary to complete the work.

APPROVED _____

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A. O. NEISER
PROJECT MANAGEMENT ENGINEER

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS

SPECIAL PROVISION NO. 58

FOR

OPEN-GRADED, MEDIUM SILICA
SAND-ASPHALT SURFACE

This Special Provision covers the material requirements and construction methods for Hot-Mixed, Hot-Laid, Sand-Asphalt, Surface Course and shall be applicable to individual projects only when indicated on plans, proposals, or bidding invitations; and, when so indicated, it shall supersede all conflicting provisions of the Department's current Standard Specifications for Road and Bridge Construction. References herein are to the Department's Standard Specifications and approved addenda thereto.

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I. DESCRIPTION

Hot-Mixed, Hot-Laid, Sand-Asphalt is intended to provide a fine-textured, skid-resistant, wearing surface for pavements and bases. Fifty percent of the sand therein shall consist of quartz (SiO_2). The remaining proportion of the sand shall consist of crushed limestone. The sand, bituminous material, and the mixing and application thereof shall be in accordance with the respective requirements hereinafter described. The mixture shall be applied to the nominal, compacted thickness indicated on the plans or in the proposal; and the finished surface shall conform with the lines and grades shown on the plans or proposals.

II. MATERIALS

A. Requirements.

1. Bituminous Materials. The asphalt cement to be mixed with the sand shall be PAC-3 and shall meet the particular requirements of Section 621. The quantity of asphalt cement used shall be as directed by the Engineer.

Bituminous material for the tack coat shall be SS-1h meeting the particular requirements of Section 621. The SS-1h shall be prepared for application by dilution with an equal volume of potable water.

2. Aggregate. The aggregate shall consist, by weight, of not less than 50 percent quartz (SiO_2). Quartz, to fulfill this requirement, shall be obtained from crushed sandstone, conglomeratic sand, bank sand, river sand or combinations thereof. The remaining portion of aggregate shall consist of limestone sand. Unless otherwise provided, mineral filler meeting the requirements of Article 611.5.0 for quality may comprise not more than 3 percent of the aggregate combination. Each aggregate, except mineral filler, shall have a minimum Sand-Equivalent value of 10 as determined by AASHO T 176, and the total combined aggregate, including mineral filler, shall have a minimum Sand-Equivalent value of 35. Deleterious substances retained on the No. 200 sieve shall not exceed the following percentages by weight of the total combined aggregate.

	Percent by Weight
Clay lumps.	None
Other deleterious substances such as, but not limited to, alkali, mica, shale, coated grains, soft and flaky particles.	1.0

3. Admixture. A moisture controlling admixture such as silicone fluid (dimethyl siloxane) shall be furnished by the Contractor to be blended with the mix when and as directed by the Engineer.

B. Approval of Materials.

Silicone shall be of a type approved by the Department and shall be from a source approved by the Department.

At least two weeks prior to commencing production, the Contractor shall notify the Engineer that the aggregates, including blended natural sand if used, have been stocked at the job site. Prior to notification, at least 500 tons or one-half the anticipated quantity requirement, whichever is least, of each aggregate shall be stocked.

III. CONSTRUCTION METHODS

The construction methods shall comply with the applicable requirements of Article 306.3.0, except as otherwise provided hereinafter and on the plans or in the proposals.

A. Seasonal and Weather Limitations. No sand-asphalt surface as defined by this special provision shall be laid between September 30 and May 1, nor when the temperature is below 60 degrees F, except by written permission of the Engineer, nor when the underlying course is wet, nor when other weather conditions are unsuitable.

B. Preparation of Mixture.

1. Composition of Mixture. The sand and asphalt cement shall be combined in such proportions that the composition of the mixture by weight shall be within the general limits given in the following table. A job-mix formula, within the specified composition limits, shall be established by the Engineer for each project; and the proportions and gradings so set shall be maintained within the tolerances specified hereinafter. The percentages passing all sieve sizes shall be determined by dry sieving. These permissible tolerances shall not permit the use of any mixture which will be outside the specified composition limits. Once the job-mix formula has been established, it shall remain in effect until changed in writing by the Engineer. Deviations from the job-mix formula shall not exceed 0.5 percentage points in the asphalt content and 0.2 in fineness modulus of the sand gradation.

Composition Limits

Sieve	Percent Passing
1/4 inch	100
No. 8	88-100
No. 16	80-100
No. 30	60-95
No. 100	1-20
No. 200	0-3
Percent Bitumen	7-10

2. Preparation of Aggregates. If sands from two or more sources are blended, they shall be metered from individual cold bins in such proportions that will yield a product having the specified gradation. The sand shall be uniformly dried and heated to a temperature of not less than 280°F nor more than 325°F. If mineral filler is used, it shall be weighed or metered into the mix from a separate bin.

3. Temperature Requirements. Unless otherwise approved by the Engineer, the temperatures of the materials and the mixtures, in degrees Fahrenheit, shall be maintained within the ranges given in the following table:

Mixing and Laying Temperatures

Aggregates.	.Min. 280 - Max. 325
Asphalt Cement.	.Min. 265 - Max. 325
Mixture at Plant.	.Min. 280 - Max. 325
Mixture When Laid	.Min. 280 - Max. 310

C. Spreading and Finishing.

1. Paver Speed. Unless otherwise directed by the Engineer, the paver when placing the surface mix shall maintain a speed of 22 feet per minute, plus or minus 8 feet per minute.

2. Continuous Paver Operation. The plant production and the paver speed shall be synchronized in such a manner which will permit the paver to travel in a uniform continuous forward speed within the limits as required hereinbefore. The paver shall engage the hauling trucks while traveling forward. Every effort shall be made to keep the paver moving continuously. The paver should be permitted to stop only when a plant or paver breaks down or when some emergency or unavoidable condition exists.

3. Entrances and Crossovers. Entrances, crossovers, and other areas inaccessible to the paver which must be spread by hand, whether constructed of sand asphalt or other surface mixture, shall be constructed as a separate operation. The material for these areas shall be placed directly from the trucks. The paver shall not be stopped, side plates removed, and the material for these areas allowed to spill out to the side, or the paver shall not be stopped and material for these areas shoveled from the hopper.

4. Pavement Samples. Samples shall not be cut from the pavement unless directed by the Engineer.

5. Compaction. Unless otherwise directed or permitted by the Engineer, compaction, including breakdown rolling, shall be accomplished with a 3-wheel roller or a tandem roller weighing not less than 8 tons. Entrances, crossovers and other inaccessible areas spread by hand shall be compacted with a roller weighing not less than 3 tons.

6. Leveling and Patching. Leveling and patching shall be performed in a manner, with the designated equipment and with the materials, as prescribed on the plans or in the proposal.

IV. METHOD OF MEASUREMENT

The sand asphalt will be weighed in accordance with Article 1.9.1. Bituminous material, except that used in the sand-asphalt mixture, will be measured in gallons as specified in Section 621.

V. BASIS OF PAYMENT

The quantities thus measured and accepted, complete and in place, will be paid for at the contract unit price bid per gallon for "Bituminous Materials," per ton for "Sand-Asphalt Mixture," which payment shall be full compensation for cleaning surface, for furnishing, hauling, and placing all materials, including the silicone fluid, and for all labor, equipment, tools, and incidentals necessary to complete the work.

APPROVED October 10, 1967

A. O. NEISER
STATE HIGHWAY ENGINEER

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS

SPECIAL PROVISION NO. 59

FOR

OPEN-GRADED, HIGH SILICA
SAND-ASPHALT SURFACE

This Special Provision covers the material requirements and construction methods for Hot-Mixed, Hot-Laid, Sand-Asphalt, Surface Course and shall be applicable to individual projects only when indicated on plans, proposals, or bidding invitations; and, when so indicated, it shall supersede all conflicting provisions of the Department's current Standard Specifications for Road and Bridge Construction. References herein are to the Department's Standard Specifications and approved addenda thereto.

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I. DESCRIPTION

Hot-Mixed, Hot-Laid, Sand-Asphalt is intended to provide a fine-textured, skid-resistant, wearing surface for pavements and bases. At least 85 percent of the sand therein shall consist of quartz (SiO_2). No portion of the sand may consist of crushed limestone or slag sand. The sand, bituminous material, and the mixing and application thereof shall be in accordance with the respective requirements hereinafter described. The mixture shall be applied to the nominal, compacted thickness indicated on the plans or in the proposal; and the finished surface shall conform with the lines and grades shown on the plans or proposals.

II. MATERIALS

A. Requirements.

1. Bituminous Materials. The asphalt cement to be mixed with the sand shall be PAC-3 and shall meet the particular requirements of Section 621. The quantity of asphalt cement used shall be as directed by the Engineer.

Bituminous material for the tack coat shall be SS-1h meeting the particular requirements of Section 621. The SS-1h shall be prepared for application by dilution with an equal volume of potable water.

2. Aggregate. The aggregate shall consist, by weight, of not less than 85 percent quartz (SiO_2). Quartz, to fulfill this requirement, snall be obtained from crushed sandstone, conglomeratic sand, bank sand, river sand or combinations thereof. Unless otherwise provided, mineral filler meeting the requirements of Article 611.5.0 for quality may comprise not more than 3 percent of the aggregate combination. Each aggregate, except mineral filler, shall have a minimum Sand-Equivalent value of 10 as determined by AASHO T 176, and the total combined aggregate, including mineral filler, shall have a minimum Sand-Equivalent value of 35. Deleterious substances retained on the No. 200 sieve shall not exceed the following percentages by weight of the total combined aggregate.

	Percent by Weight
Clay lumps.	None
Other deleterious substances such as, but not limited to, alkali, mica, shale, coated grains, soft and flaky particles.	1.0

3. Admixture. A moisture controlling admixture such as silicone fluid (dimethyl siloxane) shall be furnished by the Contractor to be blended with the mix when and as directed by the Engineer.

B. Approval of Materials.

Silicone shall be of a type approved by the Department and shall be from a source approved by the Department.

At least two weeks prior to commencing production, the Contractor shall notify the Engineer that the aggregates, including blended natural sand, if used, have been stocked at the job site. Prior to notification, at least 500 tons or one-half the anticipated quantity requirement, whichever is least, of each aggregate shall be stocked.

III. CONSTRUCTION METHODS

The construction methods shall comply with the applicable requirements of Article 306.3.0, except as otherwise provided hereinafter and on the plans or in the proposals.

A. Seasonal and Weather Limitations. No sand-asphalt surface as defined by this special provision shall be laid between September 30 and May 1, nor when the temperature is below 60 degrees F, except by written permission of the Engineer, nor when the underlying course is wet, nor when other weather conditions are unsuitable.

B. Preparation of Mixture. The sand and asphalt cement shall be combined in such proportions that the composition of the mixture by weight shall be within the general limits given in the following table. A job-mix formula, within the specified composition limits, shall be established by the Engineer for each project; and the proportions and gradings so set shall be maintained within the tolerances specified hereinafter. The percentages passing all sieve sizes shall be determined by dry sieving. These permissible tolerances from the job-mix formula shall not permit the use of any mixture which will be outside the specified composition limits. Once the job-mix formula has been established, it shall remain in effect until changed in writing by the Engineer. Deviations from the job-mix formula shall not exceed 0.5 percentage points in the asphalt content and 0.2 in fineness modulus of the sand gradation.

Composition Limits

Sieve	Percent Passing
1/4 inch	100
No. 8	88-100
No. 16	80-100
No. 30	60-95
No. 100	1-20
No. 200	0-3
Percent Bitumen	7-10

2. Preparation of Aggregates. If sands from two or more sources are blended, they shall be metered from individual cold bins in such proportions that will yield a product having the specified gradation. The sand shall be uniformly dried and heated to a temperature of not less than 280°F nor more than 325°F. If mineral filler is used, it shall be weighed or metered into the mix from a separate bin.

3. Temperature Requirements. Unless otherwise approved by the Engineer, the temperatures of the materials and the mixtures, in degrees Fahrenheit, shall be maintained within the ranges given in the following table:

Mixing and Laying Temperatures

Aggregates.	.Min. 280 - Max. 325
Asphalt Cement.	.Min. 265 - Max. 325
Mixture at Plant.	.Min. 280 - Max. 325
Mixture When Laid	.Min. 280 - Max. 310

C. Spreading and Finishing.

1. Paver Speed. Unless otherwise directed by the Engineer, the paver when placing the surface mix shall maintain a speed of 22 feet per minute, plus or minus 8 feet per minute.

2. Continuous Paver Operation. The plant production and the paver speed shall be synchronized in such a manner which will permit the paver to travel in a uniform continuous forward speed within the limits as required hereinbefore. The paver shall engage the hauling trucks while traveling forward. Every effort shall be made to keep the paver moving continuously. The paver should be permitted to stop only when a plant or paver breaks down or when some emergency or unavoidable condition exists.

3. Entrances and Crossovers. Entrances, crossovers, and other areas inaccessible to the paver which must be spread by hand, whether constructed of sand asphalt or other surface mixture, shall be constructed as a separate operation. The material for these areas shall be placed directly from the trucks. The paver shall not be stopped, side plates removed, and the material for these areas allowed to spill out to the side, or the paver shall not be stopped and material for these areas shoveled from the hopper.

4. Pavement Samples. Samples shall not be cut from the pavement unless directed by the Engineer.

5. Compaction. Unless otherwise directed or permitted by the Engineer, compaction, including breakdown rolling, shall be accomplished with a 3-wheel roller or a tandem roller weighing not less than 8 tons. Entrances, crossovers and other inaccessible areas spread by hand shall be compacted with a roller weighing not less than 3 tons.

6. Leveling and Patching. Leveling and patching shall be performed in a manner, with the designated equipment and with the materials, as prescribed on the plans or in the proposal.

IV. METHOD OF MEASUREMENT

The sand asphalt will be weighed in accordance with Article 1.9.1. Bituminous material, except that used in the sand-asphalt mixture, will be measured in gallons as specified in Section 621.

V. BASIS OF PAYMENT

The quantities thus measured and accepted, complete and in place, will be paid for at the contract unit price bid per gallon for "Bituminous Materials," per ton for "Sand-Asphalt Mixture;" which payment shall be full compensation for cleaning surface, for furnishing, hauling, and placing all materials, including the silicone fluid, and for all labor, equipment, tools, and incidentals necessary to complete the work.

APPROVED October 10, 1967

A. O. NEISER
STATE HIGHWAY ENGINEER

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS

SPECIAL PROVISION NO. 60

FOR

SIMULATED KENTUCKY ROCK ASPHALT SURFACE

This Special Provision shall be applicable only when indicated on the plans, in the proposal, or in the bidding invitation and, when so indicated, shall supersede any conflicting requirements of the Department's 1965 Standard Specifications for Road and Bridge Construction and is complemented with the applicable provisions of Section 306 thereof.

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I. DESCRIPTION

This work shall consist of furnishing and placing paving mixtures complying with the material requirements and processed as hereinafter described, without alternate types of materials or processes, for use in the construction of surface courses on existing bases or pavements as set forth by the plans, proposal, or bidding invitation. The mixture shall consist of crushed non-bituminous sandstone aggregate -- essentially identical to the asphalt-impregnated sandstone aggregate to be supplied under Special Provision No. 24-B on a companion section of this project, but containing no natural bitumen -- and an optimum quantity of refinery asphalt. Construction procedures and finished work shall conform with the further stipulations listed herein.

The work shall also include the surfacing of approaches at road and street intersections and approaches or aprons at entrances, when and as directed by the Engineer. If not specified and unless otherwise directed by the Engineer, the bituminous mixture for this work shall be Bituminous Concrete Surface, Class I, which shall conform to Section 306. Fine aggregate for the bituminous concrete may be natural, crushed, or conglomerate sand meeting the requirements of Section 611 for quality.

II. MATERIALS

A. Aggregate. The aggregate shall consist of crushed, non-bituminous sandstone, as described above, having uniform quality and hardness. It shall be free of dirt and debris and shall meet the following requirements:

1. Gradation: The size-gradation of aggregate samples shall comply with the following requirements:

Sieve Size	Percent Passing
1/2 inch	100
No. 4	40-100
No. 100	0-15

2. Silica: The aggregate shall contain not less than 90 percent Silica (SiO_2) as determined by chemical analysis.

B. Asphalt Binder. Asphalt cement enrichment shall consist of PAC-3 (Article 621.4.0) as specified on the plans or in the proposal.

C. Bituminous Tack Coat. Bituminous material for the tack coat shall be SS-1h meeting the particular requirements of Section 621. The SS-1h shall be prepared for application by dilution with an equal volume of potable water.

D. Admixture. A moisture controlling admixture such as silicone fluid (dimethyl siloxane) shall be furnished by the Contractor to be blended with the mix when and as directed by the Engineer. The silicone shall be of a type approved by the Department and shall be from a source approved by the Department.

III. CONSTRUCTION METHODS

A. Seasonal and Weather Limitations. No surface mixture shall be placed between September 30 and May 1, nor when the air temperature is below 60°F, except by written permission of the Engineer; neither shall it be placed when the underlying course is wet or when other weather conditions are unsuitable.

B. Plant and Equipment. Article 306.3.2, except as noted below:

1. Screens: Only one screen, a scalping screen of the necessary size, will be required.

2. Bins: The plant shall include a storage bin of sufficient capacity to supply the mixer, when it is operating at full capacity, with no undue periods of waiting for aggregate. The outlet gate on the bin shall cut off quickly and completely and shall be designed and constructed so there will be no leakage when closed.

3. Thermometric Equipment: Article 306.3.2-C-8.

4. Dust Collectors: The plant shall be equipped with an effective dust collector. Material collected must be returned to the mix unless wasting is permitted by the Engineer.

C. Preparation of Mixture.

1. Composition of Mixtures: The crushed sandstone aggregate and asphalt cement shall be combined in such proportions that the bitumen content will be not less than 7 percent and not more than 10 percent.

2. Preparation of Aggregate: The aggregate shall be deposited in the cold elevator at a rate to insure correct and uniform temperature control of the heating and drying operation. The aggregate shall be heated to a uniform temperature between 280°F and 325°F.

3. Preparation of Asphalt Cement: Article 306.3.3-C.

4. Preparation of Mixtures: Article 306.3.3-D as applicable.

5. Temperature Requirements: Unless otherwise approved by the Engineer, the temperatures of the materials and the mixtures, in degrees Fahrenheit, shall be maintained within the ranges given in the following table:

Mixing and Laying Temperatures

Aggregates.	.Min. 280 - Max. 325
Asphalt Cement.	.Min. 265 - Max. 325
Mixture at Plant.	.Min. 280 - Max. 325
Mixture When Laid	.Min. 280 - Max. 310

D. Preparation of Base. The existing surface shall be swept clean of all foreign material by means of hand brooms and mechanical sweepers. Patching, wedging, and leveling courses of bituminous concrete (Class I) shall be applied as directed by the Engineer and in the quantities as stated on the plans or in the proposal. Bituminous tack coat shall be applied in accordance with Section 301.

E. Spreading and Finishing. Spreading and finishing shall be in accordance with Article 306.3.6, except as hereinafter provided.

1. Continuous Paver Operation: The plant procedure and the paver speed shall be synchronized in such a manner which will permit the paver to travel in a uniform continuous forward speed. The paver shall engage the hauling trucks while traveling forward. Every effort shall be made to keep the paver moving continuously. The paver should be permitted to stop only when a plant or paver breaks down or when some emergency or unavoidable condition exists.

2. Entrances and Crossovers: Entrances, crossovers, and other areas inaccessible to the paver which must be spread by hand, whether constructed of this type of surface mixture or other designated surface mixtures, shall be constructed as a separate operation. The material for these areas shall be placed directly from the traveling trucks. The paver shall not be stopped to remove the side plates to allow the material for these areas to spill out the side, neither shall the paver be stopped and material for these areas shoveled from the hopper.

F. Compaction. Compaction shall be in accordance with Article 306.3.7, as applicable, except that entrances, crossovers, and other inaccessible areas spread by hand may be compacted with a roller weighing not less than three tons.

G. Leveling and Patching. Leveling and patching shall be performed in manner, with the designated equipment and with the materials, as prescribed on the plans or in the proposal, or as directed by the Engineer.

H. Surface Tolerances. Surface tolerances shall be in accordance with Article 306.3.9 as applicable.

I. Maintenance and Protection. Maintenance and protection shall be in accordance with Article 306.3.10.

IV. METHOD OF MEASUREMENT

This surfacing mixture shall be weighed in accordance with Article 1.9.1.

The bituminous tack material shall be measured in gallons as specified in Section 621.

V. BASIS OF PAYMENT

The accepted quantities thus measured will be paid for at the contract unit price per ton for the surface course, complete in place and per gallon for "Bituminous Tack Material," which payment shall be full compensation for furnishing, hauling, and placing all materials; for cleaning and all necessary preparations of base; for the making of proper joints; for the disposal of all surplus materials; for furnishing, processing, placing, and rolling of the bituminous mixtures and materials; and for all labor, equipment, tools and incidentals necessary to complete the work specified.

APPROVED October 10, 1967

A. O. NEISER
STATE HIGHWAY ENGINEER