
Research Report
KTC-92-5

KENTUCKY ROCK ASPHALT (KYROCK)
ROAD SURFACING MATERIAL

Preliminary Investigation

by

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16. Abstract This report documents a preliminary investigation of Kentucky Rock Asphalt (Kyrock) - as a road surfacing material. The indigenous bituminous impregnated sandstone was widely used as a premium quality skid resistant surfacing material during the first half of this century. Redevelopment efforts gained momentum during the 1960's, but for the last twenty years interest has waned. Laboratory tests were conducted on the Kyrock to determine its applicability in bituminous surface mixes by blending Kyrock with virgin materials in a similar manner as adding recycled asphalt pavement. The findings indicated it was feasible to blend Kyrock and a continuation proposal was presented.					
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I. INTRODUCTION AND BACKGROUND

Early Uses

Natural rock asphalt from the west-central Kentucky area was used during the late 1800's and early 1900's, prior to the development of the petroleum refining industry, for some of the first asphalt roads in this country. The material was obtained from extensive deposits of natural bitumen (asphalt) - impregnated sandstones (mineral matter approximately 98 % SiO₂) commonly referred to as Kentucky Rock Asphalt or "Kyrock". Reserves in western Kentucky are estimated at more than 500 million tons of stripable rock asphalt, according to a 1976 Kentucky Geological Survey report (1).

During the early years the richer material, with an asphalt content of 7 % or greater, was selectively quarried, crushed to pass a number four (approx 1/4 in.) sieve, steamed to soften the material for workability, and generally applied as cold-rolled paving. The natural asphalt was inherently somewhat softer than paving-grade asphalt cements since it contained varying amounts of volatile and light non-volatile oils which made it tacky and required aging or curing before it could be subjected to traffic. The natural asphalt had to cure (harden) on the road so that necessary stability and therefore acceptable durability could be obtained. Handling and placement on the road required softening which was usually accomplished by injecting steam into the Kyrock.

Kyrock was used extensively in Kentucky and other states from 1900 until the 1950's. Between 1890 and 1957 approximately twenty different companies were engaged in quarrying and processing Kyrock for highway paving. Peak production

occurred in 1927 when 344,000 tons were produced. It was widely regarded as a premium grade paving material with a sand textured, long wearing, highly skid-resistant surface. However, a growing tendency to regard it as a perfected, self-contained, all-purpose paving material resulted in mishandling and misuse. Between the mid-1940's and mid-1950's, Kyrock surfaces began to scale, strip and rut due to low stability. The tender mix containing soft asphalt and possessing low stability could not withstand the immediate high volume traffic.

During 1940, a research group at Purdue University (2) conducted exploratory investigations on the general physical characteristics of Kyrock and the performances of the material, both in the laboratory and the road, under different conditions of curing. This was followed by a combined laboratory, production and field study by the Kentucky Department of Highways (KDOH) resulting in a comprehensive 1956 report (3). Both studies recognized the variable nature of the asphalt coating on the sand grains and consistency of the asphalt which ranged from extremely soft to relatively hard. The KDOH investigation included field studies of test sections utilizing dry heat rather than steam to soften the Kyrock. Steam was not used to heat the Kyrock. The dry heating process hardened the natural asphalt to a consistency similar to paving grade asphalt cements produced by typical petroleum refining operations. Performances of the dry-heated sections were superior to the steam-heated sections.

The KDOH study clearly indicated, that if Kyrock was to regain its position as a high-type, road surfacing material, either the rich (approximately 7% asphalt) natural material or the lean (approximately 4% asphalt) natural material enriched

with petroleum asphalt cement would have to be pre-cured by dry heating prior to being placed on the road. This should enhance its performance on the road and solve certain curing and handling problems while decreasing production costs. However by the mid-1950's, most states had discontinued the use of this once highly regarded material. In 1957, the last remaining and most prolific producer, the Kentucky Rock Asphalt Company, ceased operations.

The collapse of the industry was attributed to: 1) the inability of the slow curing Kyrock to perform under modern traffic--because of the softness of the natural bitumen and moisture induced by steaming the material, 2) high production costs--because of selective quarrying and special handling in transportation and preparation, 3) growth of the more reliable plant-mix asphalt industry, 4) lack of intensive testing of composition design criterion, 5) lack of experimentation directed toward information needed for establishing tolerance limits for production and construction practices, and 6) lack of emphasis on the need for skid-resistant pavements.

1960's Redevelopment

During the early 1960's, efforts were made to use the lean Kyrock as dust-free, traffic-bound base materials for stage construction of rural roads. The trials and experiments produced varying degrees of performances.

Plans were made by KDOH in 1965 to use a modified Kyrock surface and a lean Kyrock base on the recently constructed Nolin Dam Road in Edmonson County. Experimentation on the previously constructed test sections had indicated that

improved performance was gained by using an appreciable thickness of lean traffic-bound Kyrock base with a modified and enriched Kyrock surface to protect the base from water intrusion and traffic abrasion. Exploratory laboratory tests and favorable results from the 1955 study (3) indicated that dry heated, lean Kyrock could be enriched with asphalt cement to produce a high-type surface. Therefore, the road was paved with a lean Kyrock base course and a hot-mix enriched Kyrock surface course. A typical hot-mix asphalt plant was used to heat the lean Kyrock and add the asphalt cement. Due to poor subgrade support and lack of binding and stability of the base, many cracked and failed areas resulted; however, no failures were attributed to deficiencies in the composition or construction of the surface.

Based on the promising results achieved with the hot mix enriched Kyrock (termed modified Kyrock) surface, interest in the material for high type surfacing and resurfacing was renewed. A company was formed in 1966 under the name of Gripstop Corporation and a large capacity crushing plant was placed in a former rock asphalt quarry in Edmonson County. During the late 1960's, the KDOH surfaced by contract some 150 miles of state maintained roadways with the modified Kyrock as part of the normal resurfacing program. Smaller amounts were utilized in several other states. (4,5)

The experimental surfaces were placed in accordance with Special Provisions No. 24 and No. 24-A. Application rates ranged from 85 lbs/yd² (7/8 in. thick) to 50 lbs./yd² (1/2 in. thick). A later Special Provision--No. 24-B--did not contain the "experimental" clause.

It was decided that pre-curing could best be accomplished by dry heating the

rock asphalt in the contractor's asphalt plant dryer. This would volatilize the light oils, and at the elevated temperature the natural asphalt would flow and better coat the sand grains. By necessity, in order to circumvent handling problems due to sticking, a lean rock asphalt (containing approximately 4% natural asphalt) was quarried. The lean rock asphalt was then enriched with approximately 5% paving-grade asphalt cement at the contractor's pugmill in the normal manner. It was applied to the roadway and rolled while maintaining a temperature at about the same level as used for conventional hot-mix asphaltic concrete paving.

These modifications did not lower the inherently and well-known high skid resistant qualities of Kyrock. The same sharp, angular, high-silica sand was used and mix design calculations indicated that the high air-voids content (approximately 15%) of old Kyrock was not altered. The properties of the hard angular sand and the high voids content of the mix along with a slowly breaking away of sand grains under traffic thus constantly revealing the renewing surface, had long been considered primary factors contributing to the high, long-lasting skid resistance of Kyrock surfaces. The substitution of paving grade petroleum asphalt for a portion of the natural asphalt did not adversely affect the skid resistance.

Although the modifications were made primarily to produce a more durable, long-lasting surfacing material, the issue that still remained to be answered was whether the material would be durable enough for modern high-speed, high-volume traffic.

A condition and performance evaluation was conducted in 1973 on the 150 miles of Kentucky highways resurfaced with the modified Kyrock material. These

surfaces had provided wearing surfaces for periods ranging from 5 to 6½ years. The findings and conclusions from the report (6) follow:

1. The modification of dry-heating lean Kyrock has resulted in a very durable road surfacing material. This represents a significant improvement when compared to the former, self-contained Kyrock surfacing material.
2. No stripping, scaling, excessive wear or low stability was noticeable on the modified Kyrock roads. These factors had contributed to the demise of the former Kyrock surfacing process and material.
3. Mining of lean Kyrock, dry heating it in an asphalt plant dryer and enriching it with asphalt cement have not altered the initially high, long lasting skid resistance that was such a well established fact of former Kyrock material. The same hard, sharp, well-cemented silica sand grains, high void contents in the mix, and slow wearing or attrition of the surface--which provided the inherent skid resistance of Kyrock surfaces--still exist in the modified surfaces.
4. Of the sixteen different projects on which modified Kyrock was used, nine projects contained adequate bases to withstand superimposed loadings; the surfaces on these roads are in essentially perfect condition and for all practical purposes have been maintenance-free. Three of the surfaces were placed on bases that, although rather thick and structurally adequate, contained many cracked and faulted areas--particularly expansion-joint portland cement concrete pavement. The

performance of the surface on these roads is somewhat variable, but generally comparable to that which would have been expected from conventional resurfacing material. Four of the surfaces were placed on bases that were inadequate in strength and thickness to carry the superimposed loads; these surfaces have required patches and other maintenance operations to smooth and level the riding surfaces.

5. The surfaces remain very black and do not "bleach-out".
6. The high void content and fine-textured surfaces provide for a very low noise level and smooth-riding surface.
7. Modified Kyrock--if used primarily for its skid resistant qualities--should be placed only on high-type roadways with bases capable of sustaining the superimposed loadings.
8. High traffic volumes do not materially polish the surfaces nor decrease durability. The performance of the material is not related to traffic volumes.

Therefore, the modified Kyrock surfacing material was durable and did maintain its inherent skid resistant properties. However, certain handling problems associated with processing the material increased costs and adversely affected environmental conditions.

The first several thousand tons of lean Kyrock crushed by the Gripstop Corporation in 1966 were taken from boulders discarded by previous quarrying operations. These boulders had asphalt contents too low (lean) for previous production. Fortunately, the natural asphalt had hardened sufficiently over the years

in the exposed condition of the quarry so that the Kyrock could be crushed and handled without the individual fragments sticking together. However, when the Kyrock was subjected to the elevated temperatures and direct flame of the contractors' asphalt plant dryers, considerable smoke, fumes, light petroleum fractions and particulate matter evolved. Some contractors experienced the heated material sticking together during handling, coating and plugging ducts, and plugging bag house filters. Air pollution and handling problems began to become major concerns.

As the Gripstop Corporation exhausted the supply of weathered lean boulders, quarrying began in 1967. The freshly quarried Kyrock contained much softer asphalt than had been present in the weathered boulders. After crushing, the individual particles would agglomerate in the quarry stockpile adversely affecting handling and shipping. Also, the contractors' handling, plant operations and air pollution problems were increased due to the lighter, softer hydrocarbons present in the freshly quarried Kyrock.

Subsequently, the Gripstop Corporation erected an asphalt plant dryer in the quarry. The freshly crushed Kyrock was dry heated to pre-hardened it and thus reduce handling problems. Air pollution at the quarry was severe. The contractors' air pollution remained significant. It became impracticable to heat the softer Kyrock in a conventional asphalt plant dryer. Production ceased about 1970. A stockpile of dry heated Kyrock remained at the quarry site. The crushing plant and asphalt plant/dryer were dismantled. No further efforts were made to revive the use of Kyrock until the present study was instigated.

II. RECENT INVESTIGATIONS

Objectives

A Transportation Cabinet research needs survey in early 1991 indicated the desirability of re-evaluating Kyrock, or a modified Kyrock, as a highway surfacing material. A quick response study was initiated with the following general objectives:

- To determine if recent designs for asphalt mix plants would be more amenable for processing (heating) Kyrock than those in existence in the 1960's and before,
- To determine if the previously known and assumed benefits of Kyrock were still applicable, and
- To determine by laboratory studies whether certain properties of petroleum asphalts could be enhanced by blending natural asphalt with them.

Processing Developments

It is obvious in the 1990's, with the air pollution controls now in effect, and which will probably get more stringent in the future, that any means to process Kyrock must meet environmental regulations. As mentioned earlier, handling (sticking) and air pollution problems associated with dry heating Kyrock in batch and continuous asphalt mix plants greatly increased costs and contributed to both the economic and technical impracticalities of using Kyrock.

During the past ten to twenty years, major changes have occurred in the design and operations of asphalt mix plants. The primary developmental change has been the extensive use of drum mix plants. These are largely replacing batch and

continuous mix plants. Drum-mix plants routinely operate at larger capacities, produce less air pollution and handling problems, and are more amenable to processing recycled asphalt pavement (RAP) material. The RAP does not come in direct contact with the flame. Millions of tons of RAP are currently being recycled and added to virgin aggregates and asphalt cement in drum mix plants, and possibly some batch plants, which have been refitted to accommodate the RAP.

Since RAP contains asphalt cement, direct applications of the flame will produce air pollution. RAP is normally heated by indirect methods in drum mix plants using conduction principles to transfer heat to the RAP.

Kyrock is similar in nature to RAP since it contains both aggregate and asphalt. The follow-up study, discussed in Section IV of this report, proposed to process a limited quantity of Kyrock in a drum mix plant designed to accommodate RAP.

It does appear technically feasible to process Kyrock in mix plants designed to accommodate RAP. The consistency (viscosity) of the virgin petroleum asphalt cement could be specified so that the combined viscosity of the virgin asphalt cement and natural asphalt would meet typical specification limits. The size and grading of the virgin aggregate could be selected to blend with the Kyrock so that an optimum aggregate grading would meet specifications for specific mixes.

It should be stressed that the technology had not been developed in the 1960's for processing RAP nor were the drum mix plants available at that time. It seems that the handling and pollution control problems experienced during the 1960's could largely be alleviated using today's available technology.

Previously Known and Assumed Benefits

The primary attribute of Kyrock in highway surfacing applications is the inherent skid resistant properties of the material. The effect of the proposed blending of Kyrock with virgin aggregate could have some effect on skid resistance. The extent of the effect cannot be determined at this time. Obviously, the Kyrock should have a positive influence.

Blending Kyrock with locally available aggregates to provide a skid-resistant surfacing material would likely be more economical than the costly importation of skid-resistant aggregates from out-to-state to meet requirements.

Since Kyrock contains a percentage of asphalt, less virgin asphalt cement would be required in a blended mix than in a 100% virgin material mix. This would decrease the amount of virgin petroleum asphalt cement for paving thus extending asphalt supply while conserving energy supplies and decreasing material costs. A means to utilize a Kentucky product would be developed.

Evaluation Plan

The primary effort of this study was directed toward determining whether certain properties of petroleum asphalt and mixes could be enhanced by blending the natural asphalt with petroleum asphalt. Possible benefits considered included:

- 1) reduction in mixture stripping tendency to improve pavement durability,
- 2) increase in mixture stability to reduce pavement rutting, and
- 3) reduction in oxidation and hardening rates (aging susceptibility) to improve pavement durability.

These studies are described in the following section.

III. LABORATORY STUDIES

Initial contacts were made with the W.G. Reynolds family, owners of the bulk of the former Kyrock properties and promoters of the Gripstop Corporation during the 1960's. Permission was obtained to tour sites in the Brownsville area of Edmonson County and to secure samples for laboratory analyses. All samples were obtained from the former Indian Creek quarry, approximately five miles north of Brownsville, near Sweeden.

Sampling

Three different types of Kyrock materials were sampled. The first was a stockpile of dry-heated crushed material, produced during the late 1960's, labeled as Processed. The stockpile, containing 4,500 tons, is shown in the overview of the quarry, Figure 1. The material was easily excavated and was readily available for mixture evaluations and chemical analyses. Figure 2 depicts the sampling process. Figure 3 is a close-up view of the material.

The second product sampled was a pile of uncrushed boulders, termed Ledge form, which had not been crushed or processed, but had been discarded as being "too lean" some forty or more years ago. The pile of boulders is shown in Figures 4 and 5. The boulders were fractured to obtain samples.

The third product sampled was representative of reasonably recent excavations and labeled as Face samples. These excavations were made about 1970. Samples were obtained from the richer appearing boulders. Figures 6 and 7 depict the sampling area.



Figure 1. Indian Creek Quarry and Stockpile of Dry Heated, Crushed Kyrock



Figure 2. Sampling the Stockpile



Figure 3. Dry Heated Kyrock



Figure 4. Pile of Lean Ledge Boulders of Kyrock



Figure 5. Sampling the Lean Ledge Boulders

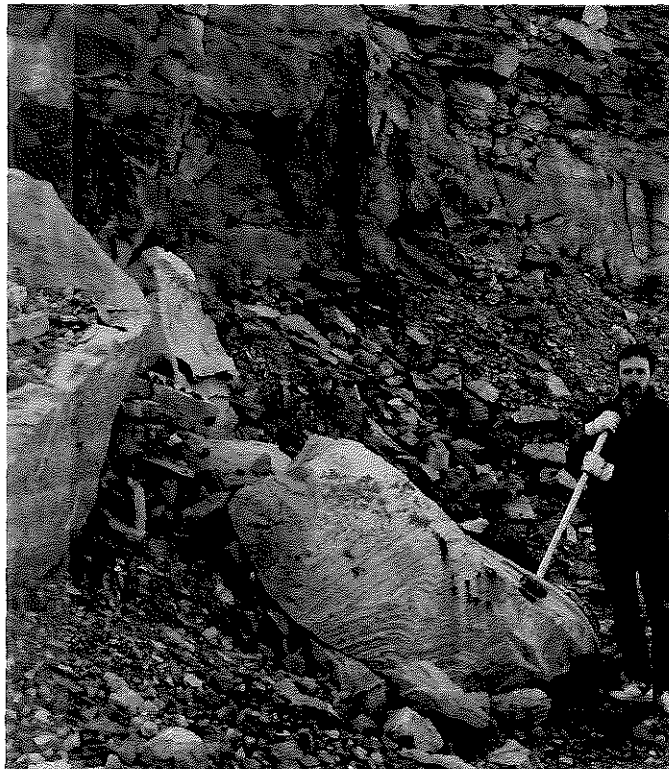


Figure 6. Face Samples of Kyrock



Figure 7. Face Sampling

Phase I Tests

The Transportation Cabinet's Division of Materials conducted extraction, gradation, and recovered asphalt properties tests on the samples. Table 1 contains data for the various samples.

Tests were conducted on the Processed material (samples P1, P2 and P3) as obtained from the stockpile. No crushing or sizing was necessary. After extracting the natural asphalt from the material, gradation analyses were performed. The gradation was predominately sand size (No. 30 to No. 100 sieve) with a top size of about 1/4 inch and 6% passing the No. 200 sieve. The natural asphalt content was low, averaging 3.3%.

Tests on the recovered asphalt indicated a very hard asphalt having penetrations ranging from 5 to 9 and extremely high viscosities. This is not surprising when considering the material had been crushed and heated in the dryer twenty plus years ago and had been subjected to weathering since then. The

Table 1. Extraction, Gradation and Recovered Asphalt Properties on the Kyrock Samples

SAMPLE	P 1	P 2	P 3	L 1	L 2	F 1	F 2	F 3
<i>SIEVE SIZE</i>	<i>% PASSING</i>	<i>% PASSING</i>	<i>% PASSING</i>	<i>% PASSING*</i>	<i>% PASSING*</i>	<i>% PASSING*</i>	<i>%PASSING*</i>	<i>% PASSING*</i>
1/2"	100	100	100	100	100	100	100	100.00
3/8"	100	100	100	92.0	91.0	93.5	91.2	92.4
# 4	94.8	94.9	94.2	78.5	76.1	78.0	75.4	75.8
# 8	92.7	92.0	91.5	74.0	71.9	73.4	70.6	71.0
# 16	90.9	89.1	88.7	70.3	68.2	70.2	67.6	68.0
# 30	87.9	86.2	85.7	67.3	65.6	66.8	63.9	64.3
# 50	44.8	40.6	43.1	48.6	46.9	41.7	39.5	39.7
# 100	12.7	11.1	12.0	15.2	14.9	13.1	12.3	12.4
# 200	7.1	5.9	6.1	7.4	7.6	7.1	6.7	6.7
Loss on Wash, % (-200 Material)	6.5	5.0	5.4	6.8	6.3	6.3	6.1	6.0
Percent Asphalt Cement	3.3	3.2	3.4	5.5	5.4	4.47	4.45	4.5
Penetration of Residue @ 25°C (77°F)	9	7	5	48	42	33	32	29
Kinematic Viscosity of Residue @ 135°C (275°F)	7,639	10,049	7,715	510	556	739	742	810
Viscosity of Residue @ 60°C (140°F)	**	**	**	5,659	5,809	12,912	13,980	15,593
Softening Point	---	128	---	133	---	---	---	---

* crushed and scalped over 1/2 in. screen prior to blending, quartering and subsequent testing

** unable to obtain results, too hard

softening point was only slightly higher than would be expected for a typical asphalt cement.

Samples L1 and L2 represent the weathered Ledge form material obtained from the boulders excavated forty plus years ago. The material was crushed and scalped over a 1/2-inch screen prior to the extraction and recovery sequence. The minus 1/2-inch material was tested. The grading is of no particular importance since the material was crushed in the laboratory. The natural asphalt content was 5.45 %, somewhat higher than the processed material. Richer pieces were selected for testing in order to obtain a larger quantity of recovered asphalt.

Tests on the recovered asphalt compare favorably with values expected for an AC 60 paving grade asphalt cement, but were several orders of magnitude softer than the processed material.

The Face samples (F1, F2 and F3) were obtained from material blasted from the face of the quarry around 1970 and represent reasonably recent excavation. The gradation tests are meaningless since the samples were crushed in the laboratory. The recovered asphalt met AC-20/AC-40 paving grade viscosity requirements. The natural asphalt in these samples was softer, as expected, than that contained in the processed and ledge samples.

Phase II Tests

Proximate and ultimate analyses were conducted on the recovered asphalt from the three Face samples at the Center for Applied Energy Research. Proximate analyses were obtained on a Dupont model 2950 TGA; C, H and N on a Leco model CHN-600; and sulfur on a Leco model Sc-432. Table 2 contains the data.

Recovered asphalt from the Face samples was submitted to the Western Research Institute (WRI) for a series of rheological and spectroscopic analyses before and after low-temperature aging. The material was determined to be highly oxidized and extremely stiff. The detailed WRI report is contained in Appendix A. It was recommended that future studies be conducted with freshly quarried materials and, at least in part, in the presence of aggregate to simulate road conditions of aging.

Table 2. Proximate and Ultimate Analyses of Natural Asphalt Recovered from Kyrock

<i>Sample</i>	<i>F 1</i>	<i>F 2</i>	<i>F 3</i>
% C	86.38	86.34	87.42
% H	9.72	9.69	9.79
% N	0.11	0.10	0.10
% S	1.97	1.98	1.94
% H ₂ O	1.73	2.38	2.29
% Volatile Matter	83.4	82.6	83.6
% Fixed Carbon	14.9	14.0	14.1
% Ash	<0.1	<0.1	<0.1

Phase III Tests

A conventional Marshall mix design was conducted on a blend of Kyrock and virgin aggregates and petroleum asphalt. Samples of No. 8 limestone, natural river sand and limestone sand were obtained from Scotty's Contracting asphalt plant in

Bowling Green for blending with the processed Kyrock from the existing stockpile in the Indian Creek quarry. The virgin asphalt cement was AC-20. Appendix B contains the design data.

The aggregate blend selected to meet the Class I surface specification was 45% No. 8 limestone, 30% limestone sand, 10% natural sand and 15% Kyrock by weight. The optimum percent of added AC-20 was 4.9%. The Marshall parameters at the design asphalt content were, as shown in Table 3.

Table 3. Marshall Design Values

Stability	3,220 lbs
Flow	9.8
Unit Weight	148.93 pcf
Air Voids	3.2%
VMA	14.3%
Max. Sp. Gr.	2.467

These meet the specifications for Class I surface.

The water susceptibility characteristics were evaluated using the "Lottman" tensile splitting strength test. A compactive effort of 20 blows on each end of the specimen produced the required air void content of about 7%. The total strength retained (TSR) was 87%. The minimum passing value is 70%. The addition of the Kyrock did not adversely affect the stripping and water susceptibility of the mix.

IV. Continuation Proposal

Based upon the findings from the preliminary study that:

- It appeared feasible to add Kyrock to a mix similar to adding RAP in a drum mix plant, thus utilizing both the natural asphalt and skid-resistant sand of the Kyrock with local virgin materials;
- The primary inherent benefit of Kyrock --- high skid resistance properties--should not be adversely affected and the blending of Kyrock with local aggregates should improve their skid resistant properties;
- Mix economics should be more attractive since this would offer an alternative to the costly importation of aggregates from out-of-state to meet skid resistance guidelines;
- The asphalt supply would be extended and energy conserved by utilizing the natural asphalt as a portion of the total asphalt demand, thereby reducing the amount of petroleum asphalt added to the mix;
- A means would be developed to utilize a Kentucky product; and
- Mix design guidelines could be met using a blend of Kyrock and local materials;

a continuation study was proposed for the 1992 FY. Appendix C contains a copy of the proposal.

Plans were made to modify a Class AK bituminous concrete surface mix being used for the rehabilitation of the a portion of the Western Kentucky Parkway in western Grayson County, approximately 20 miles north, northwest of the Kyrock source. The modifications would involve substituting approximately 20%, by weight,

of Kyrock for the aggregates proposed for the project, and adding the Kyrock in a similar manner as RAP would be added in a drum mix plant, according the Transportation Cabinet's definition of "Reclaimed Asphalt Pavement". Additional details of the proposed plan are contained a Memorandum from the Director, Division of Materials and is included in Appendix C. The proposal plan also included an evaluation of the chemical and physical properties of the natural asphalt and the blended natural/petroleum asphalt. This subtask was to be conducted by the Western Research Institute. Details are presented in Appendix C.

Paving was scheduled for the Fall, 1991. However, the owner of the Kyrock properties and the paving contractor were unable to agree on certain provisions. The project reverted back to a standard Class AK surface mix. No further investigations were conducted during FY 1992.

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APPENDIX A

FINAL REPORT

**RHEOLOGICAL AND SPECTROSCOPIC ANALYSES OF KENTUCKY ROCK
ASPHALT BEFORE AND AFTER LOW-TEMPERATURE AGING**

June 1991

Work Performed for the University of Kentucky
Department of Civil Engineering
Transportation Research Center

by The University of Wyoming Research Corporation
a.k.a. Western Research Institute
Laramie, Wyoming

EXECUTIVE SUMMARY

A sample of extracted Kentucky rock asphalt (bitumen) was received from the University of Kentucky and used to evaluate its susceptibility to low-temperature oxidative aging. The sample was highly oxidized as received; further, it contained nearly 5% volatiles as determined by a thin-film oven (TFO) test. The TFO aging gave an aging index (AI) of approximately 8, whereas the TFO plus pressurized oxidation vessel (POV) combination gave an AI of approximately 22. In both cases, there was very little change in the absolute concentrations of ketones, which are a major low-temperature oxidation product of conventional asphalt. Viscoelastic properties were determined on the as received, TFO-aged and TFO-POV aged materials. In all cases, the viscoelastic properties showed that the material had a very low viscoelastic ratio. In terms of conventional asphalts, this suggests that the material is extremely stiff. Finally, a recommendation is made to use freshly quarried materials for future studies.

INTRODUCTION

Four samples of extracted Kentucky rock asphalt (bitumen) were received by the Western Research Institute (WRI), and a limited set of material properties was determined for this material. The stated purpose for this investigation was to evaluate the low-temperature oxidation and aging characteristics of this Kentucky bitumen. The experiment was designed specifically to determine the resistance to aging, or viscosity increase, of the bitumen as it was oxidized under conditions, especially temperature, that give similar oxidation products to those observed in recovered roadways. To be clear, the term oxidation refers to measurable increases

in oxygen-containing oxidation products that are primarily ketones and sulfoxides, whereas aging refers to relative increase in viscosity as oxidation occurs. The two are not equivalent from one crude oil source to another. All four samples of the bitumen, however, were considerably oxidized already. Therefore, in consultation with the project manager at the University of Kentucky it was decided to further age the bitumen. Again, this was to evaluate how much increase in viscosity occurs for a given amount of oxidation.

Low-temperature oxidation by pressurized methods was chosen to simulate oxidation that occurs in pavement. Pressure is used to increase the absolute rate. It should be noted that although the chemical oxidation that occurs in the pressurized oxidation vessel (POV) is very similar to what occurs in a roadway, the kinetics with and without aggregate present may differ from one aggregate to another.

EXPERIMENTAL

Infrared spectroscopic analyses were obtained using a Perkin-Elmer model 983 infrared spectrophotometer. The spectra were obtained as solutions in spectrograde carbon disulfide and recorded from 4,000 to 600 cm^{-1} .

Rheological analyses were obtained using a Rheometrics RMS Model 605 mechanical spectrometer, which is operable from liquid nitrogen temperature to greater than 200°C (392°F). The spectrometer is capable from operating from 10^{-1} to 10^2 radians/sec (rad/s). The specific conditions of plate size, plate spacing, frequency, and temperature are given in the data display for each mechanical spectrum.

Pressurized oxidation was conducted in a pressurized oxidation vessel similar to that described by D. Y. Lee (Final report: Iowa Projects 7175 and 8285, HR-124, 1972). The specific conditions of time and temperature for each oxidation are reported in the results and discussion section.

Thin-film oven oxidation was conducted by standard ASTM procedure D 1754.

RESULTS AND DISCUSSION

Four samples of extracted Kentucky rock asphalt (bitumen) were received by WRI and were designated as samples 1A, 1B, 1C, and 2. The infrared spectra of all four samples were obtained. Sample 2 proved to have the least amount of oxidation; therefore, it was used for all further experiments. It was split into two parts, and one part was subjected to the standard TFO test. The TFO-aged sample was further oxidized in a pressure oxidation vessel (POV). The conditions were 300 psi of air pressure at 60°C (140°F) for 144 hours. This was applied to a 7.9-g sample spread to a uniform 1/8-inch-thick film (3.175 mm). After pressurized oxidation treatment, this sample was removed and vacuum degassed.

The infrared spectrum of the bitumen was acquired again after oxidation. The rheological properties of the material as received, the TFO-aged and the TFO + POV-aged bitumen were likewise acquired. The infrared spectroscopic and selected rheological data are listed in Table 1.

TABLE 1
Properties of Kentucky Rock (Bitumen) Sample 2 Before and After Aging

	Carbonyl Absorbance* (ketone)	Carbonyl Conc., mol/L	Viscosity, P				Tan Delta (δ), G ^m /G ^r	
			60°C (140°F)	AI	25°C (77°F)	AI	60°C	25°C
As Received	0.385	0.330	11,560	1.0**	6,867,000	1.0**	37.1	2.58
After Annealing	0.385	0.330						
After Std TFO (wt loss after TFO)	0.425 (4.91%)	0.360	91,470	7.9	-	-	12.8	
After Std TFO + POV	0.430	0.361	255,300	22.1	119,000,000	17.3	5.5	1.36

* The carbonyl absorbance results from ketones formed during oxidation.

**This AI value is defined as 1.0 since this is starting material, and no other reference point is available.

The carbonyl absorbance listed in Table 1 for sample 2 as-received, is 0.385 absorbance units, which is 0.330 moles per liter (mol/L) of ketone present in the starting material. This is a highly oxidized material similar to what is observed in a pavement after several years of asphalt aging. The thin-film oven test raised the carbonyl absorbance to 0.425 with a weight loss of 4.91%. Finally, pressurized oxidation raised the carbonyl absorbance to 0.430. Only a minor change in oxidation level occurred between the TFO and the POV suggesting that this material is relatively insensitive to further oxidation at 60°C (140°F). However, this material was already very highly oxidized as it was received. The viscosity at 60°C (140°F) increased from 11,560 P for the as-received material to 91,470 Poise upon treatment in the TFO test. This may well be accounted for by the substantial loss of 4.91% volatiles. Although the amount of oxidation increased very slightly in going from the TFO test through the pressurized oxidation (0.425 to 0.430 infrared absorbance units), note that the viscosity did increase nearly threefold, going from just under 92,000 P to more than 255,000 P between TFO treatment and POV treatment. These data suggest that this material as-received at WRI may be near its chemical oxidation limit, but that a small amount of additional oxidation will have a significant effect on the physical properties.

The viscoelastic properties, or rheological properties, were acquired as follows for the as-received material and the aged binders. The elastic modulus (G') and the viscous modulus (G'') are acquired directly by the mechanical spectrometer. The value G^* is calculated as follows:

$$G^* = \sqrt{G'^2 + G''^2}$$

Viscosity (Table 1) was calculated from G^* by dividing G^* by the frequency:

$$\eta = G^*/\omega$$

Tan delta (δ), the viscoelastic ratio, is calculated as follows:

$$\delta (\tan \delta) = G''/G'$$

It is obvious that tan delta may vary with frequency and temperature. In order to acquire values that can be related to each other, all tan delta values were acquired at a constant power input of 400 g/cm². At a fixed temperature and constant power input, there will be variations in the shearing frequency from one sample to another. In general, the stiffer a sample is, the lower the frequency for the fixed power input. Note that at 25°C (77°F), tan delta is 2.58 for the material as-received at WRI. This is already a low value. Oxidation by TFO and POV reduced this value to 1.36. On a relative basis this is an extraordinarily high elastic modulus, and, together with the 255,000 P, is an extraordinarily stiff material, especially if it is judged in terms of conventional asphalt. None-the-less, this material is somewhat resistant to change, especially when one considers that the AI before and after POV aging is less than three (AI [POV] = 2.75).

A more detailed examination of the rheological data reveals that the bitumen, as-received, shows significant shear susceptibility, and that the susceptibility increases substantially following TFO and POV aging. Figure 1 is the mechanical spectrum for sample 2, as-received, at 60°C (140°F). Note that the elastic modulus (G') shows an irregular pattern between 10⁻¹ and 2 rad/s. This suggests that microfractures (or some other similar disturbance of the microstructure of the polar materials) are forming during the scan. Above 10 rad/s, both G' and G'' diminish, suggesting that the sample is beginning to shear. This is accompanied by a

reduction in viscosity at the higher frequency. Figure 2 is the mechanical spectrum for the same material at 25°C (77°F). Both G' and G'' appear to be continuous up to 1 rad/s, but the combination shows again that viscosity decreases with increasing frequency. Figure 3 is the mechanical spectrum at 60°C (140°F) for sample 2 after TFO treatment. Note here that at about 4 rad/s, G' and G'' both decrease drastically with an accompanying loss of viscosity with increased frequency. Again, this most likely indicates significant shear (or microfracturing) and, thus, apparent loss of viscosity within the sample. Figure 4 is the mechanical spectrum for sample 2 at 60°C (140°F) after TFO and POV treatment. The same phenomenon is observed as for the TFO (only) aged material except significant shearing occurs at a lower frequency yet (as might be expected) since the absolute viscosity is about three times higher after POV aging. Finally, Figure 5 is the mechanical spectrum for sample 2 at 25°C (77°F) after TFO and POV. It is obvious that the sample begins to shear at the lowest available frequency. The data illustrated by these figures suggest that the Kentucky rock asphalt bitumen was highly aged as received. Further intentional aging increased the concentrations of oxidation products only slightly, but the stiffness and shear susceptibility increased markedly. Again, much of this may be due to the loss of 4.91% volatiles.

Historically, Kentucky tar sand has been used quite successfully for roadways; therefore, it appears that tar sand may be better judged as a pavement binder by standards other than those used for petroleum asphalt. Further credence to this notion comes from the successful use of Uintah Basin (Utah) tar sand in roadways. Uintah Basin tar sand has properties somewhat like those of the Kentucky rock asphalt.

In conclusion, it is very difficult to say what the aging susceptibility might be for this Kentucky rock asphalt were it to be evaluated starting with a freshly quarried material which had been vacuum reduced to a point where there would be very minimal volatile loss during the TFO test.

RECOMMENDATIONS

Western Research Institute recommends that future aging studies of Kentucky rock asphalt be conducted with freshly quarried materials. At least a portion of the study should be conducted with a material that is first vacuum-reduced to remove the very high level of volatiles observed in this sample. Vacuum reduction may create a new problem by generating a material with a much higher viscosity than specification-grade asphalt. Such a problem may be alleviated by diluting the whole bitumen with a higher distillate fraction, such as a 700-900 °F overhead material. Flash point and actual mixture tests will be most useful to determine whether the high volatile content is really a problem, or whether the material simply doesn't fit the petroleum standards. We recommend that the oxidative aging be carried out, at least in part, in the presence of aggregate to simulate road conditions of aging. We also recommend that the aging be studied at two or more elevated temperatures to evaluate the aging characteristics of a Kentucky rock asphalt as a function of temperature. It is clearly understood from numerous studies that high surface temperature of pavement is a major factor in promoting oxidative aging. Again, there are significant variations in aging susceptibility from one crude oil to another.

ACKNOWLEDGMENTS

Western Research Institute expresses thanks and appreciation to Professor Jerry Rose, University of Kentucky College of Engineering, who commissioned this study on behalf of the state of Kentucky, for the many helpful discussions concerning this project. Pressurized oxidations and infrared spectroscopy were conducted by P.M. Harnsberger and J.M. Wolf. Rheological measurements were obtained by H. Plancher. The interpretation was prepared by R.E. Robertson and the text typed by J.M. Greaser.

KYROCK SAMPLE #2 PAC-148 UNIV KENT DYN RATE 60C 25MM PP 2MM 50% 060

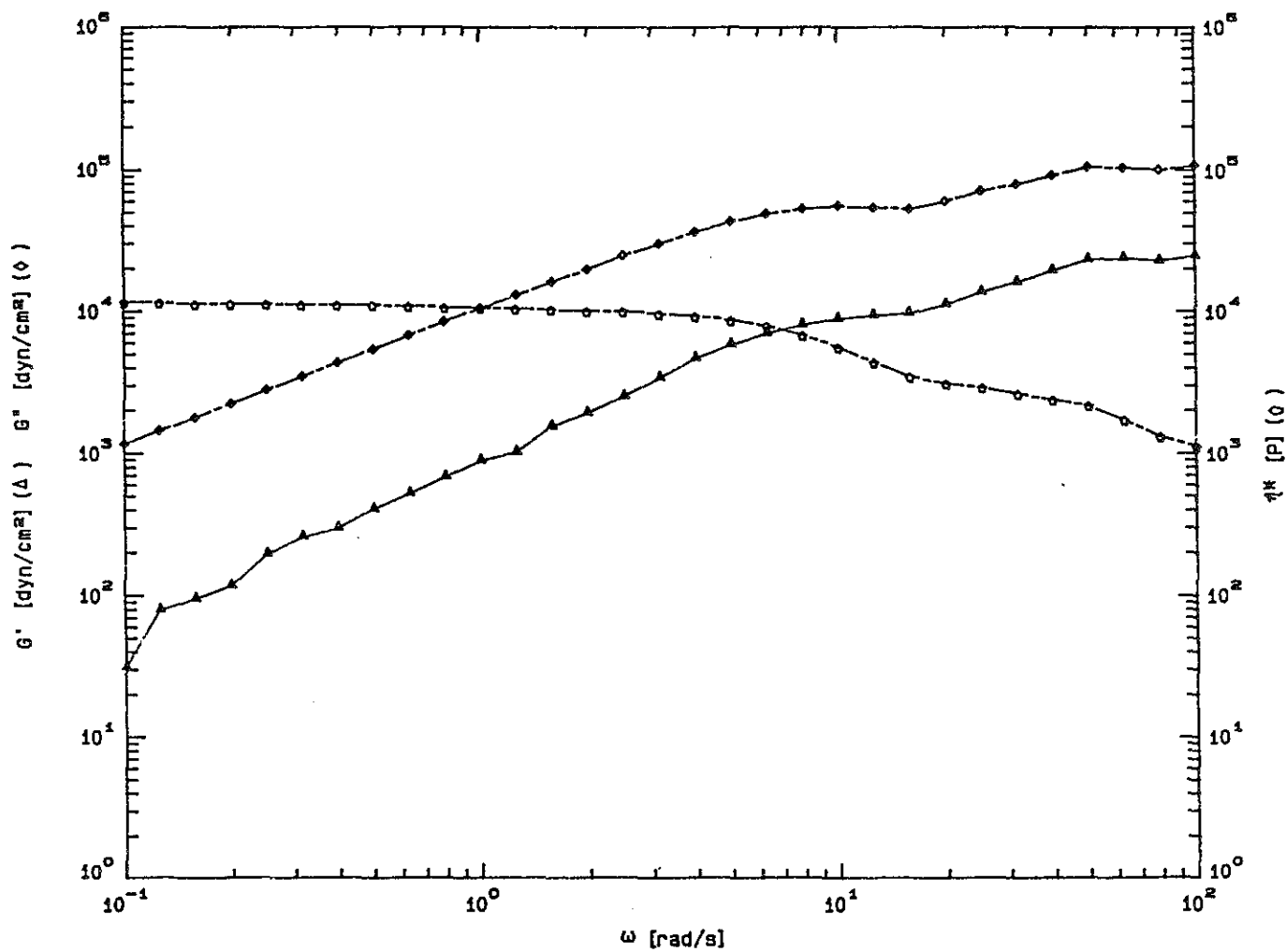


Figure 1. Mechanical Spectrum of Sample 2 As-Received at 60°C (140°F).

KYROCK SAMPLE #2 PAC-148 UNIV KENT. DYN RATE 25C 25MM PP 2MM 3% 059

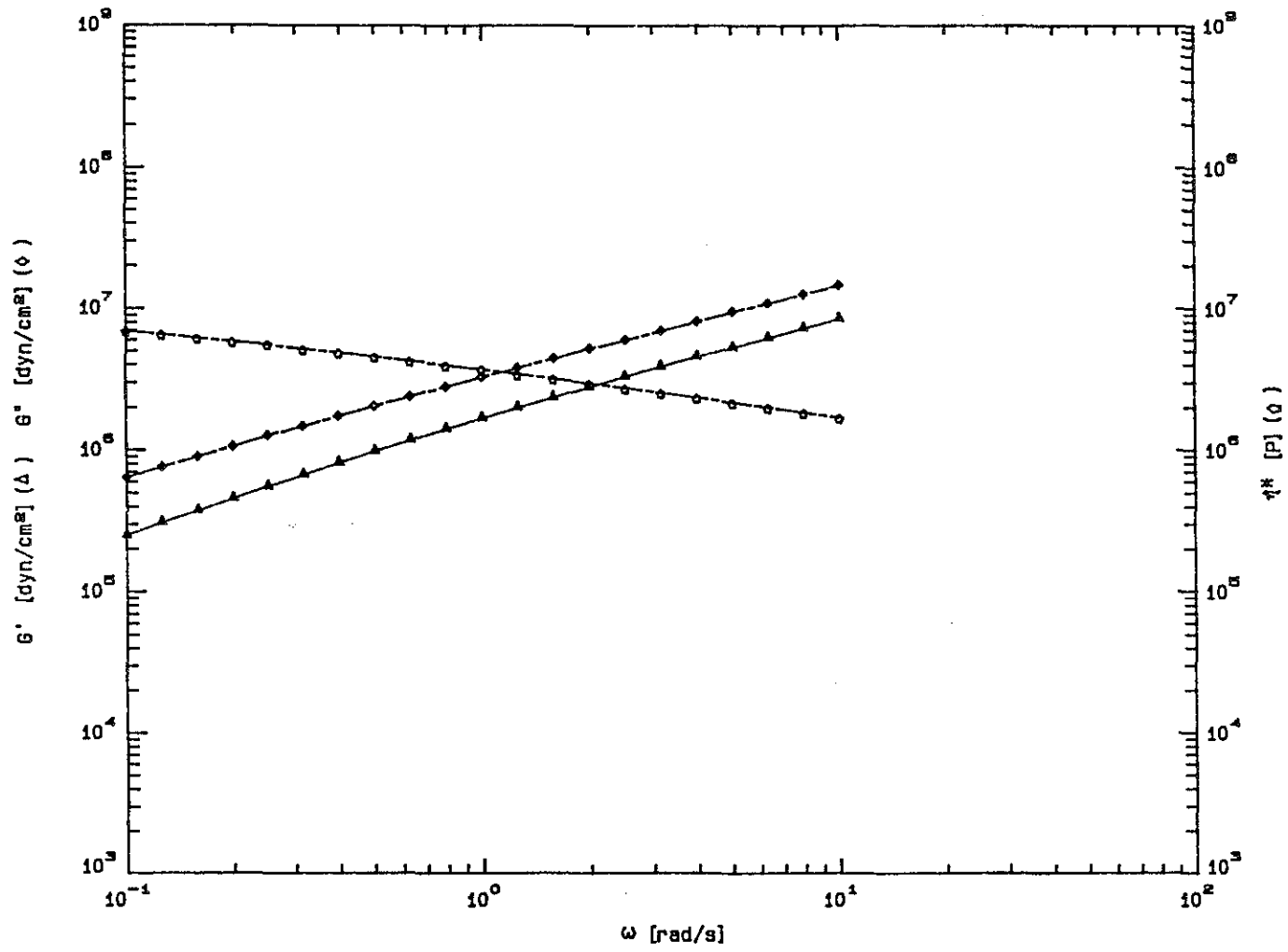


Figure 2. Mechanical Spectrum of Sample 2 As-Received at 25°C (77°F).

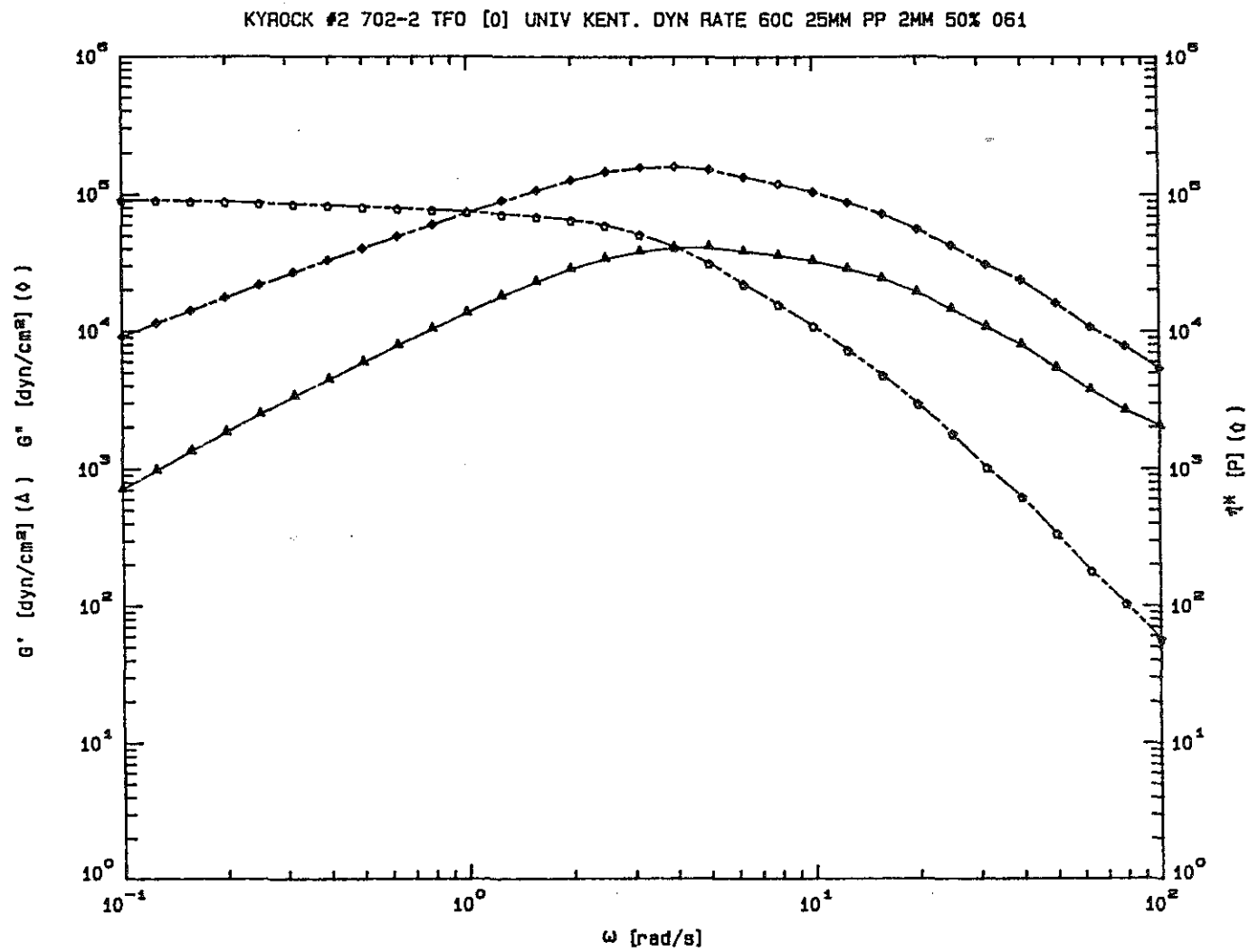


Figure 3. Mechanical Spectrum of Sample 2 After TFO at 60°C (140°F).

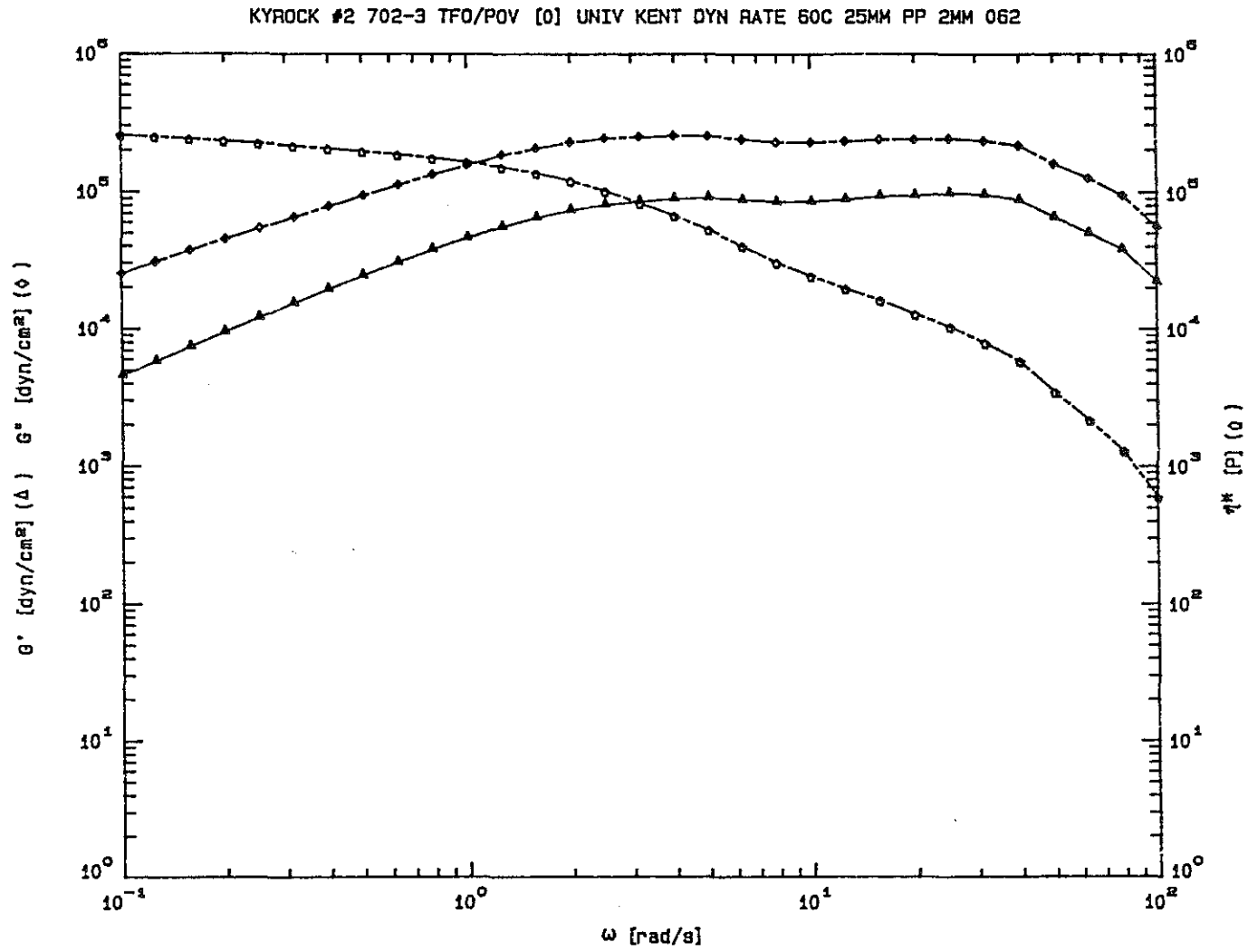


Figure 4. Mechanical Spectrum of Sample 2 After TFO-POV at 60°C (140°F).

KYROCK #2 702-3 TFO/POV [0] UNIV KENT DYN RATE 25C 25MM PP 2MM 063

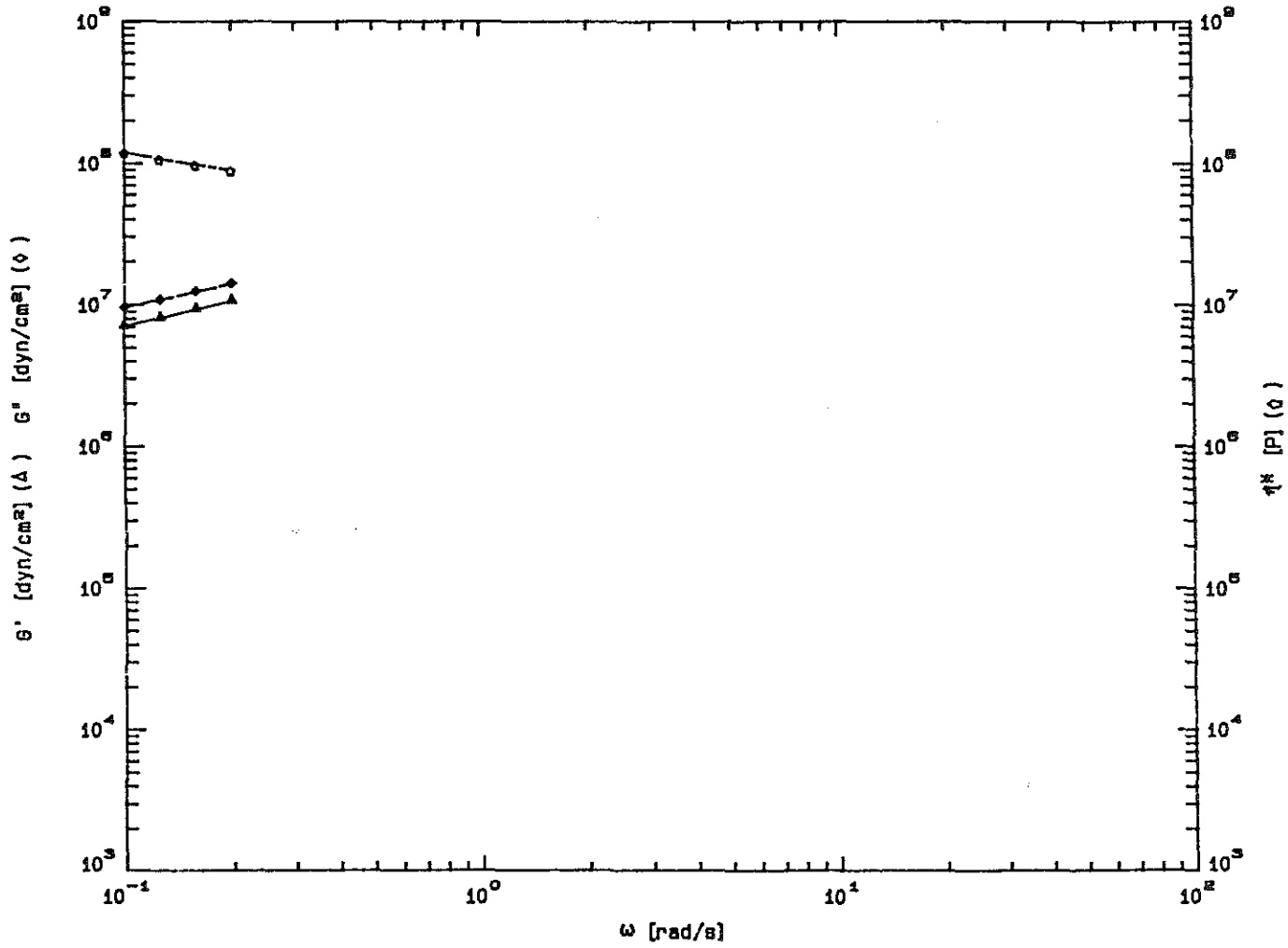


Figure 5. Mechanical Spectrum of Sample 2 After TFO-POV at 25°C (77°F).

APPENDIX B

PROJECT NUMBER:
 TYPE OF MIX:
 COUNTY:
 CONTRACTOR:

TYPE OF MATERIAL	--- LS #8's		--- LS Sand		--- Nat. Sand		--- KyRock (Processed)		COMBINED	SPECIFICATION	SIEVES
	% PASS	% BATCH	% PASS	% BATCH	% PASS	% BATCH	% PASS	% BATCH			
2"	100	45	100	30	100	10	100	15	100	100	1/2"
1 1/2"	85.2	38.34	100	30	100	10	100	15	93.34	80-100	3/8"
1 1/4"	11.1	4.995	93.4	28.02	98.8	9.88	94.6	14.19	57.085	55-80	#4
1 1/8"	5.3	2.385	64.6	19.38	85.4	8.54	92.1	13.815	44.12	35-60	#8
3/4"	1.9	0.855	45.2	13.56	71.6	7.16	89.6	13.44	35.015	22-46	#16
3/8"	1.8	0.81	33.7	10.11	54.1	5.41	86.6	12.99	29.32	10-32	#30
#20	1.7	0.765	22.6	6.78	11.6	1.16	42.8	6.42	15.125	5-21	#50
#40	1.6	0.72	15.7	4.71	1.4	0.14	11.9	1.785	7.355	3-14	#100
#80	1.6	0.72	12.1	3.63	0.7	0.07	6.4	0.96	5.38	2-7	#200

Project Number: KyRock Marshalls
 Mixture Identification: #
 Aggregate:

Type	Sp. Grav.	%
Limestone # 8's	2.650	45
Limestone Sand	2.650	30
Natural Sand	2.600	10
KyRock	2.650	15

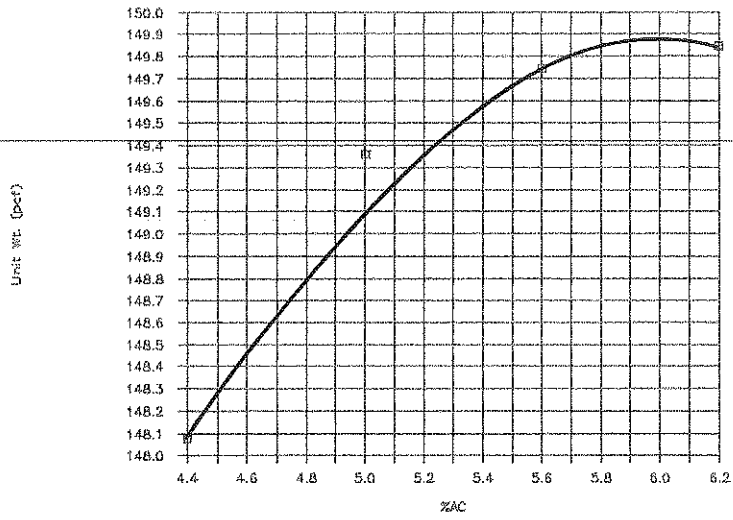
Sample #	% AC (mix)	Washed Gradation (% Passing):					Bulk Vol. (SSD)	Bulk Vol. (GFC)	Max. Spec. Gravity	Unit Wt. (GFC)	% Air Void	Height (in.)	Corr.
		3/8"	1/2"	3/4"	1"	1 1/2"							
1		1176.9	681.9	1179.6	497.7	2.359	147.8	2.45	1.03				
5		1172.9	681.4	1174.4	493.0	2.379	148.5	2.45	1.03				
9		1177.6	681.5	1178.1	496.6	2.371	148.0	2.45	1.03				
Avg	4.4					2.373	148.1	4.5			55	42	
2		1185.2	690.4	1185.8	495.4	2.392	149.3	2.44	1.04				
6		1184.6	691.4	1184.9	493.5	2.400	149.8	2.44	1.04				
10		1182.0	687.3	1182.3	495.0	2.388	149.0	2.44	1.04				
Avg	5.0					2.394	149.4	2.9			55	42	
3		1189.8	694.4	1190.3	495.9	2.399	149.7	2.45	1.03				
7		1187.7	694.3	1188.0	493.7	2.406	150.1	2.43	1.05				
11		1188.5	692.4	1188.8	496.4	2.394	149.4	2.45	1.03				
Avg	5.6					2.400	149.7	1.7			55	42	
4		1197.9	700.7	1198.3	497.6	2.407	150.2	2.45	1.03				
8		1194.0	695.6	1194.1	498.5	2.395	149.5	2.45	1.03				
12		1193.1	696.6	1193.4	496.8	2.402	149.9	2.45	1.03				
Avg	6.2					2.401	149.8	0.8			55	42	

Date: April 25, 1991

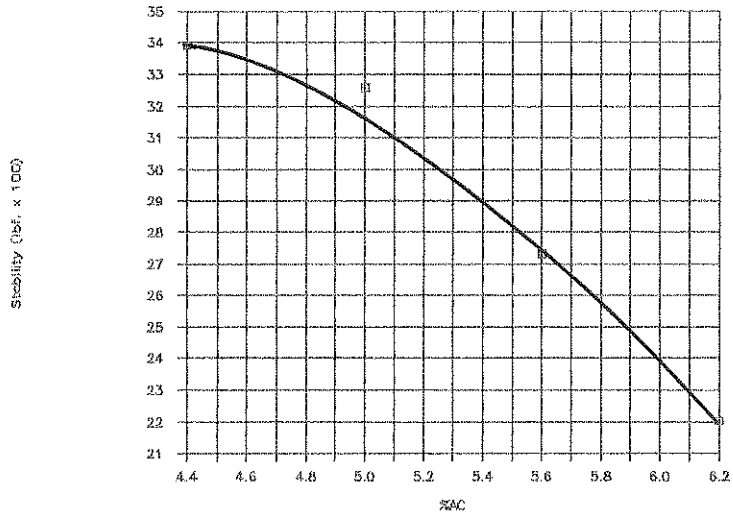
Bitumen Type: AC-20
 Type Mix: Class I Surface (KyRock)
 Compaction: Mechanical
 Temperature: Mix @ 300
 Spec. Grav. AC: 1.03
 Bulk Spec. Grav. Agg: 2.652
 Eff. Spec. Grav. Agg:
 Source: Southern States Asphalt @ Kuttawa
 Blows: 75
 Comp. @ 265

	\$16	\$30	\$50	\$100	\$200							
	34	29	17	8	5.5							
Stability (lb/ sq. ft.)			Flow (in.)	Eff. Sp. Grav. (Cagg.)	% Abs. AC (Cagg)	% Abs. AC (Mix)	% Eff. AC	ALPHA	SAE	% VMA	% VFA	Film Thickness (microns)
3330	3417	9.5								30.29	162.18	7.1
3330	3440	9.5										
3210	3316	9.0										
	3291	9.3	2.659	0.09	0.09	0.09	4.31	14.5	68.7			
3050	3172	9.5										
3340	3474	10.0										
3010	3130	9.5										
	3259	9.7	2.659	0.09	0.09	0.09	4.91	14.3	80.0			8.1
2790	2863	10.5										
2620	2743	13.0										
2520	2586	13.5										
	2731	12.3	2.659	0.09	0.09	0.09	5.51	14.6	88.1			9.2
2310	2370	13.5										
2160	2216	17.0										
1970	2022	16.5										
	2203	15.7	2.659	0.09	0.09	0.08	6.12	15.1	94.6			10.3

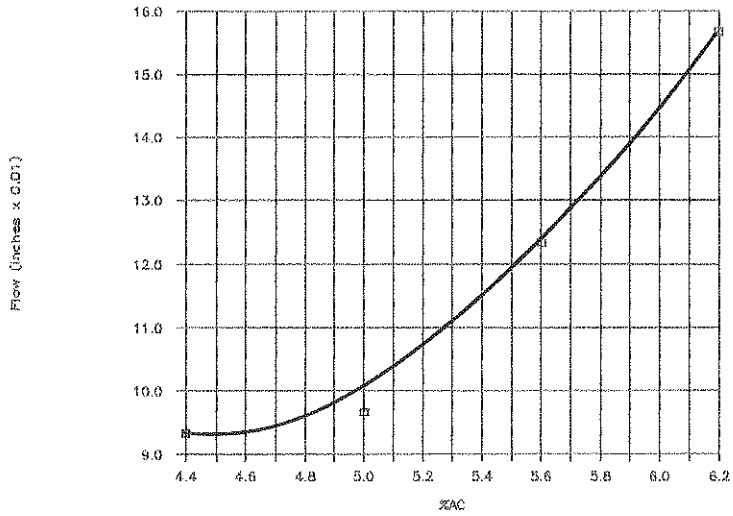
Unit Wt. vs. %AC



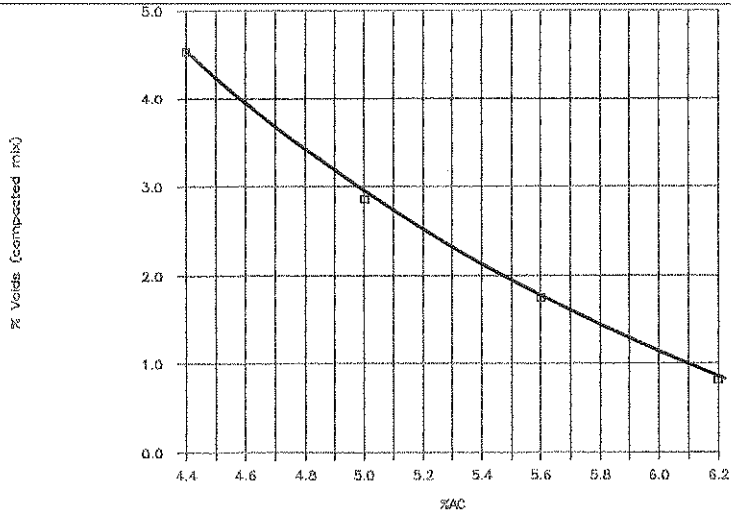
Stability vs. %AC



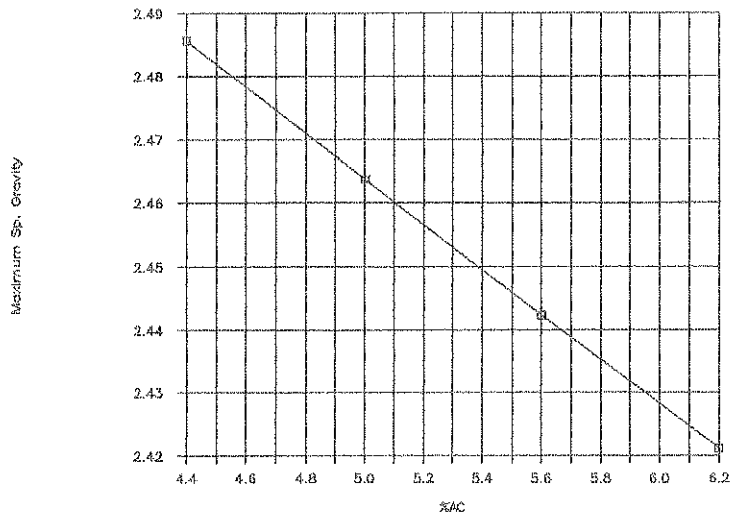
Flow vs. %AC



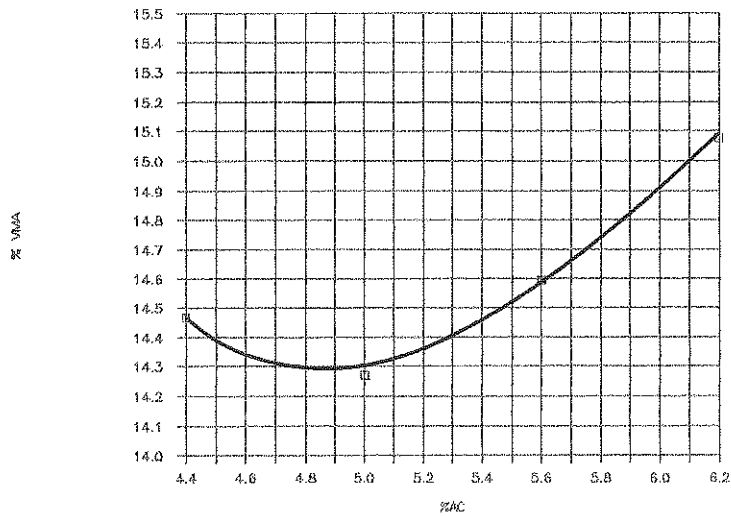
% Voids vs. %AC



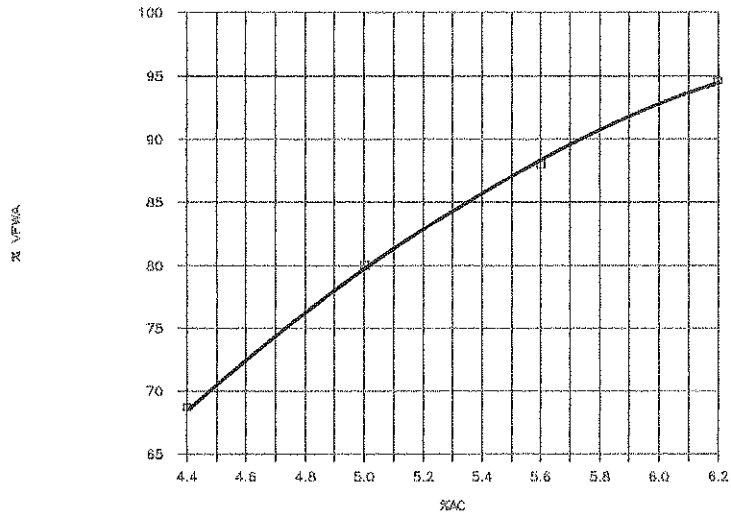
Max Sp. Grav. vs. %AC



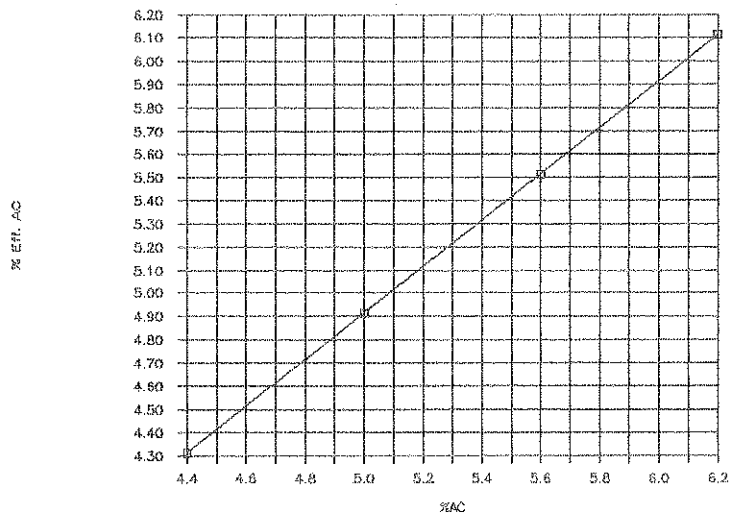
%VMA vs. %AC



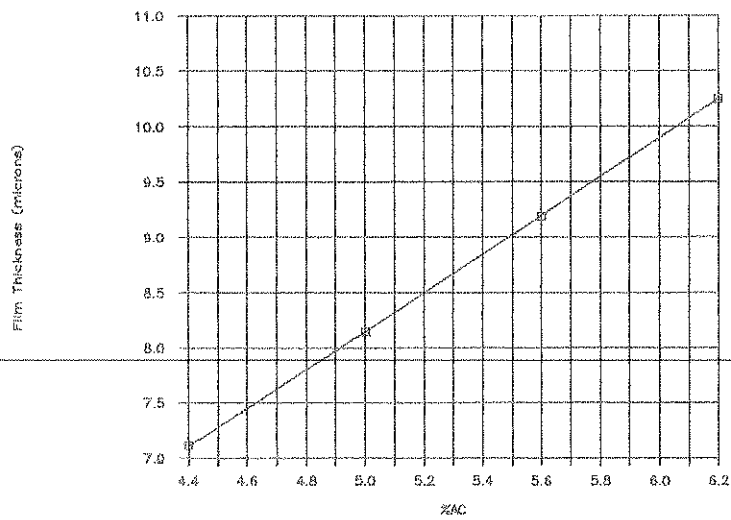
%VFWA vs. %AC



% Eff. AC vs. %AC



Film Thickness vs. %AC



LABORATORY DATA SHEET, TENSILE SPLITTING STRENGTH

State KY Project KYROCK %AC 4.9

Compaction 20 Type & Dosage of Anti-Strip None

Date Tested 4-26-91 By Steve Sheets

		C		C		C	
Sample I.D.		1	2	3	4	5	6
Diameter	D	4"					
Thickness	t	2.54	2.49	2.48	2.49	2.50	2.49
Dry Weight in Air	A	1154.0	1155.3	1154.8	1157.2	1154.7	1153.0
SSD Weight	B	1157.5	1158.3	1156.5	1158.9	1157.9	1156.0
Weight in Water	C	651.0	655.7	653.9	656.7	657.0	653.2
Volume, B-C	E	506.5	502.6	502.6	502.2	500.9	502.8
Bulk Sp.Gr., A/E	F	2.278	2.299	2.298	2.304	2.305	2.293
Max. Sp.Gr. 2.466	G						
% Air Void, 100(G-F)/G	H	7.61	6.79	6.83	6.56	6.53	7.01
Volume Air Void, HE/100	I	38.54	34.13	34.31	32.94	32.70	35.24
Load, pounds	P	1370		1345		1415	

Saturated

SSD Weight	* B'		1177.7		1177.9		1176.1
Weight in Water	C'						
Volume, B'-C'	E'						
Vol. Abs. Water, B'-A	* J'		22.4		20.7		23.1
% Saturation, 100J'/I	*		65.7		62.9		65.6
% Swell, 100(E'-E)/E							

Conditioned 24 Hrs. in 140F Water

Thickness	* t"		2.49		2.49		2.49
SSD Weight	* E"		1182.5		1182.3		1181.0
Weight in Water	C"						
Volume, B"-C"	E"						
Vol. Abs. Water, B"-A	* J"						
% Saturation, 100J"/I	*						
% Swell, 100(E"-E)/E							
Load, pounds	* P"		1195		1205		1165
Dry Strength, 2P/tD·γ	* S _{td}		85.8		86.3		90.1
Wet Strength, 2P/t"D·γ	* S _{tm}		76.4		77.0		74.5
TSR, 100S _{tm} /S _{td}	*						
Visual Stripping, 0-5							

APPENDIX C



COMMONWEALTH OF KENTUCKY
TRANSPORTATION CABINET
FRANKFORT, KENTUCKY 40622

MILO D. BRYANT
SECRETARY
AND
COMMISSIONER OF HIGHWAYS

WALLACE G. WILKINSON
GOVERNOR

M E M O R A N D U M

TO: Paul Gravely, Director
Division of Construction

FROM: Larry Epley, Director *LE*
Division of Materials

DATE: July 9, 1991

SUBJECT: Experimental Use of Kyrock
Grayson County SSP 043-9001-090-096

As you requested, I am providing information on the subject project for the experimental utilization of native Kentucky Rock Asphalt (Kyrock) in the Class AK surface mix on the subject project.

This change order provides for modifying the Bituminous Concrete Surface, Class AK, on this project by adding approximately 20 percent by weight of native Kentucky Rock Asphalt (Kyrock) quarried from the source near Sweeden in Edmonson County. The Kyrock shall be either fresh quarried material or crushed from existing boulders at the quarry. Use of the existing stockpile of processed Kyrock will not be permitted for this project.

The Class AK Surface (experimental) containing the Kyrock shall meet all requirements of the contract except:

- (1) The asphalt cement in the final mixture will be accepted as the approved blend of native asphalt with AC-20.
- (2) The Kyrock aggregate will satisfy the requirements as applicable for either polish-resistant fine or coarse aggregate on an equal substitution basis.
- (3) A JMF gradation outside the master range will be permitted providing the specified mix design criteria are met.
- (4) The Kyrock is considered to be Reclaimed Asphalt Pavement insofar as mix design, plant operation and other specification requirements are concerned.

Mr. Paul Gravely
Page 2
July 9, 1991

The project will be monitored by Dr. Jerry Rose, Kentucky Transportation Center. Dr. Rose will collaborate with the Division of Materials and the Contractor during mix design process. The Division of Materials will assist Dr. Rose in the evaluation and reporting of field operations and performance. The Contractor shall inform Dr. Rose (606) 257-4278 and the Division of Materials prior to the start of production of Kyrock at the quarry.

The Contractor is responsible for making all arrangements with the quarry owner for all operations, permits, approvals, etc. for production of the Kyrock aggregate. The Department assumes no liabilities associated with production of the Kyrock.

If at any time during the production of the Kyrock aggregate, production of Class AK surface (experimental) or construction of the experimental surface, any tests, plant operations, or construction inspections indicate (in the judgement of the Engineer) that an unsatisfactory surface will be produced or is being produced, production of the experimental surface shall be discontinued and the project shall be completed according to the original contract.

Paul, our discussions with Jim Scott did not mention a Control Section. However, Dr. Rose and Dwight have pointed out that a Control Section is highly desirable. If this can be worked out, then the following paragraph should be added to the change order:

As directed by the Engineer, the Contractor shall place a Control Section of conventional Class AK surface. The Control Section shall be placed in the outside lane, either eastbound or westbound, and shall be a minimum of one mile in length.

By copy of this memo to Cy Layson, I am also providing a copy of the research study proposal prepared by Dr. Rose. I am also designating Dwight Walker to be this division's contact for future activities on this project.

LE/ad

Attachment

cc: C. S. Layson
Gary Sharpe
Jim Stone
Dwight Walker
Jerry Rose

KYDOT RESEARCH NEEDS STUDY

PROPOSAL FOR IMPROMPTU STUDY

TITLE OF STUDY

Kentucky Rock Asphalt (Kyrock) Road Surfacing Material

OBJECTIVE

Develop a use for a highly skid-resistant sandstone containing natural asphalt to conserve resources and document mixture enhancement effects of the natural asphalt in hot mix asphalt pavement surface mixtures.

BACKGROUND

Reserves of bitumen-bearing sandstones in Kentucky are estimated at more than 500 million tons and are concentrated in the west and west-central portions of the state. There is no production currently. The materials were used extensively for surfacing roads during the early 1900's, primarily to utilize the skid resistance properties of the angular silica sand particles.

POTENTIAL BENEFITS

- A. Improvement in pavement skid resistance by blending a percentage of Kyrock with local aggregates to minimize costly importation of aggregates to meet polish-resistant aggregate requirements.
- B. Enhance properties of petroleum asphalt cements by diffusing the native asphalt within the petroleum asphalt to:
 - 1. Add body to the binder to increase stability and reduce rutting,
 - 2. Reduce oxidation and hardening rates to improve durability, and
 - 3. Reduce stripping tendency to improve durability.
- C. Decrease amount of petroleum asphalt cement added to mix thus extending asphalt supply and conserving energy.
- D. Develop means to utilize a Kentucky product.

With the advent of asphalt plants designed to process recycled materials, it is now feasible to add Kyrock to the mix similar to adding recycled asphalt pavement (RAP), thus utilizing both the sand and native asphalt.

URGENCY

A preliminary study ended June 30, 1991. Results indicate it is feasible to blend Kyrock with virgin materials using typical production facilities.

RESEARCH PLAN

1. Observe and document the excavation and preliminary processing of the Kyrock material.
2. Collaborate with the Division of Materials during the mixture design phase.
 - A. Extraction and gradation tests on the Kyrock
 - B. Properties of the recovered natural asphalt
 - C. Marshall mix design using the Kyrock as RAP
 - D. Measure of retained tensile strength (TSR)
3. Observe and document the mixture production and field paving operations.
4. Obtain samples at plant for routine mixture properties evaluations.
 - A. Extraction and gradation tests
 - B. Mold Marshall specimens for typical stability/flow and voids analyses and TSR tests
 - C. Mold resilient modulus test specimens
5. Conduct laboratory tests on reheated specimens
 - A. Loaded wheel tester
 - B. Static creep
6. Obtain plant samples and cores six month later for evaluations by Western Research Institute
 - A. Chemical properties of the asphalt
 - B. Oxidative aging tests
7. Observe performance of test section.
 - A. Skid resistance
 - B. Rutting
 - C. Visible distress (cracking, stripping, releveling, discoloration, etc.)

Note: This research project is based on the assumption that a test section will be constructed during the latter part of 1991 using Kyrock as a RAP ingredient of a bituminous surface mix.

8. Compile interim report by June 30, 1992.

ESTIMATED COST FY 1992

July 1, 1991 - June 30, 1992 - \$18,973 (detailed budget attached)

PRINCIPAL INVESTIGATOR

Dr. Jerry G. Rose
Professor of Civil Engineering
University of Kentucky

DATE SUBMITTED

July 3, 1991

AGENCY

Kentucky Transportation Center

BUDGET

*July 1, 1991 - June 30, 1992
Kentucky Transportation Center
(Kentucky Transportation Cabinet)*

"Kentucky Rock Asphalt (Kyrock) Road Surfacing Material"

Principal Investigator (Jerry G. Rose)

10% AY July 1, 1991 - June 30, 1992	\$6,000
TIAA	600
FICA	460
Insurance	115
Total	\$7,175
One-half Summer Month, July 16-31, 1991	\$3,333
TIAA	333
FICA	254
Total	\$3,920
Supplies	\$ 500
Travel	\$1,000
Subcontractor - Western Research Institute (To be approved by KTC before expending)	\$2,000
TOTAL DIRECT COSTS	\$14,595
INDIRECT COSTS 30%	\$4,375
TOTAL PROJECT COSTS	\$18,973

Note: Division of Materials will provide support during the design, testing and evaluation phases.



September 27, 1991

Dr. Jerry G. Rose, Professor
Department of Civil Engineering
212 Anderson Hall
University of Kentucky
Lexington, KY 40506-0046

Dear Dr. Rose:

Thank you for your invitation to WRI to submit a proposal to evaluate a specific set of chemical and physical properties of Kentucky rock asphalt to be used in the Western Kentucky Parkway. This proposed effort is much like what we reported to you earlier for aged K-Rock alone. We have added, as you suggested, additional areas that we feel could be beneficial in gaining an understanding of K-Rock used in pavement. Like most projects, this list could be quite extensive. We have limited it somewhat. Other subjects of interest are 1) volatility of K-Rock bitumen compared to petroleum, 2) speciation of basic materials (by quantity and basic strength) which appears to relate to adhesion, 3) chromatographic separation of K-Rock bitumen, again for comparison of chemistry to physical properties to those of petroleum, and 4) rheological evaluation of K-Rock extracted bitumen over wide temperature, shear stress and shear frequency ranges, again for comparison to somewhat well-understood petroleum asphalts. Certainly there are more subjects that could be useful. We will be happy to prepare a letter proposal on any of the above list, or yet other subjects if you wish.

We look forward to working with you on the K-Rock paving project. The use of tar sand materials in pavement seems to be an obvious match. If you have questions, please feel free to call Ray Robertson at 307-721-2325 anytime.

Sincerely,

Samuel M. Dorrence, Vice President
Office of Physical Sciences

cc: R.E. Robertson
D. Geldien

PROPOSAL

CHEMICAL AND RHEOLOGICAL ANALYSES OF SELECTED SAMPLES OF NEW AND PAVEMENT-AGED KENTUCKY ROCK ASPHALT

Western Research Institute (WRI) proposes to investigate the aging propensity of natural Kentucky rock asphalt (KRA) to be used in a road resurfacing project of approximately 16 lane miles of the Western Kentucky Parkway. Specifically WRI proposes to determine the rheology and the types and levels of functional groups that occur in new KRA, new asphalt cement (AC), KRA-AC extracted from new pavement and KRA-AC extracted from pavement after about 1 year of service. This will require extractions of new KRA, new pavement and aged pavement, with all cores to be supplied by the University of Kentucky (UKy).

Functional group analyses will be done using published infrared spectroscopic methods. Rheological analyses will be acquired using a Rheometrics 605 mechanical spectrometer at two temperatures over a wide shear frequency range. Extractions will be conducted according to methods recently developed for the Strategic Highway Research Program. This set of analyses will be applied to all four samples: new AC, new KRA bitumen, extracted new pavement binder, and extracted aged pavement binder.

The results of this study, together with all data, will be summarized into a final interpretive report to be delivered to the Principal Investigator at the University of Kentucky within ten weeks after receipt of the final sample.

This proposed effort can be conducted for a cost not to exceed \$2,000.

Additional Items of Possible Interest to UKy

- A. WRI proposes to conduct an artificial aging of the new concrete prepared from KRA and AC using a pressurized aging vessel (PAV) at 60°C (140°F) as developed for SHRP. This requires preparation of laboratory concrete samples rather than aging binder alone. The samples will be extracted after aging for 144 hr and 400 hr, and the infrared spectroscopic and rheological analyses performed. The results of this study will be compared with the results obtained from the KRA-AC aged road core to determine how well the PAV predicts the aging of this mixture. The results will be reported to UKy within two months after receipt of the aged road core.

Estimated cost for item A is not to exceed \$2,400.00.

- B. WRI proposes to determine the moisture sensitivity of the KRA-AC mix using a pedestal (freeze-thaw) test developed and published by WRI. A closely graded aggregate is used in this test to exaggerate the freeze-thaw stress placed on the asphalt-aggregate bond, and hence effect an accelerated evaluation of moisture sensitivity. The test should be run with an aggregate used in the Parkway and the control is the conventional AC. The results are expected to show what improvements in resistance to moisture damage may be expected from the presence of KRA. The data and interpretation will be submitted to the University of Kentucky within 3 months after authorization to proceed and receipt of materials.

Estimated Cost for item B is not to exceed \$1,200.00.