

Research Report
KTC-94-13

EVALUATING THE DESIGN
AND EFFECTIVENESS
OF SUBSURFACE DRAINAGE LAYERS

by

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and

Federal Highway Administration
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16. Abstract <p>In recent years, the subject of open-graded drainage layers, often referred to as "drainage blankets", has been utilized increasingly for pavement drainage. This study addresses the use of drainage blankets in Kentucky. Study efforts have focused on construction, performance, materials, and design considerations of drainage blankets.</p> <p>Study findings are that the Number 57 gradation provides the optimum drainage and structural stability of the standard gradations evaluated. Asphalt treated aggregate provides greater stability and a better working platform than untreated aggregate. Maintenance of collector system outlets is very poor. Daylighting of drainage blankets appears to be feasible. Drainage blankets can be given structural value in pavement design but the structural coefficient, especially for untreated material, has not been satisfactorily established at this time. There is no clear evidence that drainage blankets extend pavement life as constructed and maintained.</p>			
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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS					APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol	Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH					LENGTH				
in.	inches	25.40000	millimetres	mm	mm	millimetres	0.03937	inches	in.
ft	feet	0.30480	metres	m	m	metres	3.28084	feet	ft
yd	yards	0.91440	metres	m	m	metres	1.09361	yards	yd
mi	miles	1.60934	kilometres	km	km	kilometres	0.62137	miles	mi
AREA					AREA				
in. ²	square inches	645.16000	millimetres squared	mm ²	mm ²	millimetres squared	0.00155	square inches	in. ²
ft ²	square feet	0.09290	metres squared	m ²	m ²	metres squared	10.76392	square feet	ft ²
yd ²	square yards	0.83613	metres squared	m ²	m ²	metres squared	1.19599	square yards	yd ²
ac	acres	0.40469	hectares	ha	ha	hectares	2.47103	acres	ac
mi ²	square miles	2.58999	kilometres squared	km ²	km ²	kilometres squared	0.38610	square miles	mi ²
VOLUME					VOLUME				
fl oz	fluid ounces	29.57353	millilitres	ml	ml	millilitres	0.03381	fluid ounces	fl oz
gal.	gallons	3.78541	litres	l	l	litres	0.26417	gallons	gal.
ft ³	cubic feet	0.02832	metres cubed	m ³	m ³	metres cubed	35.31448	cubic feet	ft ³
yd ³	cubic yards	0.76455	metres cubed	m ³	m ³	metres cubed	1.30795	cubic yards	yd ³
MASS					MASS				
oz	ounces	28.34952	grams	g	g	grams	0.03527	ounces	oz
lb	pounds	0.45359	kilograms	kg	kg	kilograms	2.20462	pounds	lb
T	short tons (2000 lb)	0.90718	megagrams	Mg	Mg	megagrams	1.10231	short tons (2000 lb)	T
FORCE AND PRESSURE					FORCE				
lbf	pound-force	4.44822	newtons	N	N	newtons	0.22481	pound-force	lbf
psi	pound-force per square inch	6.89476	kilopascal	kPa	kPa	kilopascal	0.14504	pound-force per square inch	psi
ILLUMINATION					ILLUMINATION				
fc	foot-candles	10.76426	lux	lx	lx	lux	0.09290	foot-candles	fc
fl	foot-Lamberts	3.42583	candela/m ²	cd/m ²	cd/m ²	candela/m ²	0.29190	foot-Lamberts	fl
TEMPERATURE (exact)					TEMPERATURE (exact)				
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature	°C	°C	Celsius temperature	1.8C + 32	Fahrenheit temperature	°F

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EXECUTIVE SUMMARY

Investigations of numerous pavement failures indicate that insufficient subsurface drainage of the pavement system is a likely cause of failure. One means of correcting this problem is the construction of an open-graded drainage layer between the subgrade and pavement. Drainage blankets are typically separated from the subgrade, especially unstabilized subgrades, by a filter layer. The filter is typically dense graded aggregate (DGA), stabilized aggregate base (SAB), or fabric. Drainage blankets in Kentucky are typically Number 57 gradation aggregate either untreated or stabilized with 2% asphalt. Drainage blankets have not been assigned a structural number for use in pavement design. This interim report includes the findings of the evaluation of the design and effectiveness of drainage blankets.

Commonly used permeability test methods and apparatuses do not appear reliable. Falling head tests and small specimen dimensions do not approximate field conditions. An apparatus was constructed which allows constant head conditions, low head, and large specimen dimensions. The apparatus was tested for lower and upper limits of operation and repeatability of results and was determined to be suitable for the intended purposes.

Numerous gradations of aggregate were tested for flow rate, resilient modulus, and conformance to Kentucky Standard Specifications for Road and Bridge Construction. The currently used Number 57 gradation is the optimum standard gradation for flow rate and resilient modulus. This gradation met the gradation specification requirements when sampled from stockpiles while most other gradations did not meet specification requirements.

Asphalt treated drainage blankets constructed in Kentucky typically had densities of 105 to 110 lbs/ft³ and approximately 100 lbs/ft³ for untreated. Flow rates average about 13,000 ft/day for treated and 15,000 ft/day for untreated. Resilient modulus test results of asphalt treated drainage blanket, at these densities, indicate a structural coefficient of 0.15 to 0.16. The structural coefficient of untreated drainage blankets has not been established.

Laboratory tests indicate that stripping occurs in asphalt treated blankets. The impact of stripping on flow rate and stability have not been fully evaluated.

Field observations indicate that untreated material is difficult to pave over, daylighting is a viable alternative, and outlet systems are not maintained properly. Pavement performance histories indicate that drainage blankets may not extend pavement life significantly.

INTRODUCTION

In 1992, a proposal for investigating the performance and engineering characteristics of full width pavement drainage layers (drainage blankets) in Kentucky was approved by the Kentucky Transportation Cabinet and the Federal Highway Administration. The principle objective of the study was to develop recommendations for optimal structural and material design procedures for drainage blankets. The principle objective was to be achieved by conducting a literature search and review, field monitoring of construction practices, field monitoring of performance, and laboratory evaluation of the engineering characteristics of potential drainage blanket materials.

Some flexible pavements with drainage blankets were constructed as early as 1978. Several miles of flexible pavement with a drainage blanket were constructed in the late 1980's. Both flexible and rigid pavements with drainage blankets were constructed in the late 1980's and early 1990's. Existing pavements (long-term performance) and current projects (short-term performance and construction) have been evaluated during this study.

LABORATORY EVALUATION

Flow Rate

The first effort during the laboratory evaluation was the determination of appropriate methods and apparatuses for measuring the permeability or flow rate of the materials studied. The terms permeability and flow rate are interchangeable; but in this report, permeability is generally used in reference to materials having lower flow rates, such as filters, and flow rate is used in reference to materials having higher flow rates, such as drainage blanket materials. Materials studied were; the filter separating the drainage blanket and subgrade, various aggregates tested for possible use in the drainage blanket, bituminous concrete mixes placed on the drainage blanket, and other construction materials. Permeabilities of these materials range from less than 1 foot per day to several thousand feet per day. For materials having low permeabilities, the test method used was the falling head method developed by the Army Corp of Engineers (1).

The drainage blanket materials require a different method and test apparatus for determining flow rate. The large aggregate dimensions of some gradations require large specimen dimensions and the flow rates of such specimens far exceed the capacity of

conventional test apparatuses. Initially, an 8-inch diameter specimen was used to insure an acceptable specimen dimension to particle size relationship. As laboratory testing progressed, additional information prompted the deletion of certain gradations having larger top size aggregate and test specimens were reduced to 6 inches in diameter.

The equation used for calculating flow rate or permeability is based on Darcy's Law and is contingent upon the existence of laminar flow. Laminar flow cannot be assured for conditions of high flow rate through aggregate, but by keeping the hydraulic head very low, turbulence can be reduced and field conditions may be approximated. Initial efforts were directed toward developing an apparatus for testing flow rates of drainage blanket gradations.

The drainage and strength characteristics of a material may change with prolonged flow of water through it. These changes could be precipitated by stripping, if asphalt binder is used, or flushing of smaller particles. The changes may increase or decrease permeability or decrease strength characteristics of the material. Since long-term tests were desirable to monitor possible changes in materials, a constant head permeability test was used. Also, this type test permits the selection of low but variable hydraulic gradient (head) values to approximate field conditions.

Initially, the materials considered for use in drainage blankets ranged from Number 4 gradation (maximum particle size of 2 inches and 0 to 5 percent passing the 3/8-inch screen) to Number 610 gradation (maximum particle size of 1.5 inches and up to 40 percent passing the Number 4 screen). Based on the 2-inch particle size, an 8-inch diameter specimen size was chosen. The length to diameter ratio was reduced to 1.5 to 1 for flow rate testing. Specimens to be tested for strength maintained the 2 to 1 length to diameter ratio. Tests by other agencies indicated that a 2-inch water supply line was not sufficient for the large specimens, therefore a 4-inch water supply line was used.

The equation used to calculate flow rate and permeability is based on Darcy's Law which is:

$$k = Ql/hAt$$

where:

- k (feet/ day) = coefficient of permeability
- Q (gallons) = quantity of water discharged
- l (inches) = length of specimen
- h (inches) = hydraulic head
- t (minutes) = time to accumulate Q

Laminar flow cannot be assumed for open graded materials, but by maintaining head (h) values near anticipated field values, test results may be assumed to approximate field values.

Flow Test Apparatus

The flow test apparatus consisted of a shallow (10 inches) reservoir having a large cross section (12.5 square feet), a 4-inch supply line to the specimen, a movable specimen holder, and a manometer. The reservoir permits the establishment of a constant depth of water in the tank by having an adjustable, high volume supply (water main) to the reservoir, an overflow, and an on/off valve for the 4-inch specimen supply line. Once a specimen was in place and flow through the system began, input to the reservoir was adjusted so supply to the tank was balanced to the flow through the specimen and overflow combined.

Head was monitored by attaching one side of a manometer to the reservoir and the other side to the overflow or tail water side of the specimen. Due to changes in the specimen during testing, the flow rate and thus the head sometimes changed. The large tank cross section and overflow minimized the rate of head change and the manometer permitted precise and constant monitoring of the head. The adjustable specimen holder allowed adjustments to the head when specimens of various lengths were tested.

Flow through the specimen was monitored by directing the tail water or flow from the specimen into a calibrated container and the collection was timed with an electronic timer. A schematic of the flow test apparatus is shown in Figure 1.

Apparatus Calibration

When the basic requirements of the apparatus were determined and the apparatus had been constructed, functionality testing and calibration of the apparatus were initiated. Upper and lower functional limits were established. The upper limit was established by running the system with no specimen in place and at a maximum head of 8 inches. Under these conditions, the system permitted a flow rate of approximately 90,000 ft/day. Since some of the gradations to be tested contained significant amounts of fine material, retention screens were necessary at each end of the specimen. Frames were machined to fit inside the specimen chamber and fitted with Screen Numbers 100, 30, 10. Tests indicated that the Number 100 screen significantly reduced flow, the Number 30 screen tended to clog with time, but the Number 10 screen did not noticeably affect flow at flow rates less than 30,000 ft/day.

Since permeability of filters, subgrades, and denser asphaltic concrete may be tested by conventional methods, common concrete sand, meeting the gradation requirements of ASTM C 33 (2), was chosen to determine lower end performance characteristics of the test apparatus. Nine tests were performed with a smaller collection container and the resultant flow rate was 72 or 73 ft/day for all tests.

The apparatus was calibrated against the flow rate of various gradations published in FHWA-TS-80-224 "HIGHWAY SUBDRAINAGE DESIGN" (3). Figure 29 of the design manual charts gradations and flow rates for several filter and open graded materials. Those gradations identified as having flow rates of 6,000, 14,000, 20,000, and 36,000 ft/day were chosen for comparison. The manual does not include information on test method or specimen preparation from which the chart was constructed. A search of referenced articles did not reveal the test method and only a general statement of specimen preparation typified as "moderate" compaction.

Specimens for the calibration tests were composed of crushed limestone which was screened and recombined to the gradations indicated in Figure 29 of the design manual. Compaction was standardized at 1 minute (maximum force) on a vibration table with a 28-pound surcharge. Specimens were compacted in one lift with Number 10 retaining screens placed at both ends after compaction. Compacted specimens were between 90 and 100 lbs/ft³.

Results of the calibration flow tests indicated that the apparatus yielded values similar to FHWA's tests for gradations at flow rates of 6,000 and 14,000 ft/day. At higher flow rates, KTC values were less than FHWA values. This could be due to turbulent flow. Since KTC tests were conducted on relatively large specimens and with head conditions expected in the field, researchers have confidence that KTC laboratory flow rate test results are representative of field conditions. Results of calibration tests versus FHWA predictions are graphed and shown in Figure 2.

Since current expectations for drainage blanket flow rates are less than 20,000 ft/day and results from calibration tests were repeatable, the apparatus was used as constructed.

Flow Rate of Laboratory Gradations

Initial efforts to determine flow rates of possible drainage blanket gradations involved obtaining a quantity of crushed limestone aggregate, sizing it, and recombining to the gradation specification requirements shown in Table 1 of the Kentucky Standard Specifications for Road and Bridge Construction (4). The gradations originally selected

for testing were 57's, 610's, 67's, 68's, 710's, 78's, and 8's. Gradations were recombined to the center and fine side of the specification band. An example of the manner in which the specimens were recombined is shown in Figure 3. Compaction of specimens was the same as in the calibration specimens and a Number 10 screen was placed at both ends of the specimens.

The current drainage blanket gradation specification is a Number 57 gradation for untreated or portland cemented treated blankets and a gradation very similar to Number 57 (allows additional minus 4 material) for asphalt treated blankets. A gradation meeting specification requirements for both asphalt and portland cement treatment was prepared and specimens of each type treatment were prepared for flow tests. The Special Note for Pavement Drainage Blankets is contained in Appendix A.

Flow test results of laboratory recombined gradations indicated that the Number 57 gradation (or the gradation specified for asphalt treatment) provides the highest flow rate, 14,100 ft/day, and the Number 610 gradation provides the lowest flow rate, 4,000 ft/day. Asphalt treatment of the Number 57 gradation appears to reduce the flow rate to approximately 10,300 ft/day and Portland cement treatment appears to increase the flow rate to approximately 26,000 ft/day for the single gradation tested with these treatments. The increase in flow rate in the portland cement treated specimen was probably due to a decrease in unit weight. The portland cement specimen did not densify as much as the asphalt treated specimen under the same compaction procedure. Unit weight and flow rate data for all recombined specimens are shown in Table A.

For each gradation, the specimen prepared at the finer boundary of the gradation specification indicated decreased flow rate. Flow rates of the gradations tested are shown in Figure 4.

Supplier Gradations

Simultaneous with the flow rate testing of recombined gradations were sieve analyses of aggregate supplier gradations for adherence to specification requirements. The test method used was Kentucky Method 64-602-91 (5). Specimens were taken from the stockpiles of several central Kentucky suppliers. The gradations tested were Numbers 57, 610, 67, 68, 8 (from 2 suppliers), and 11. Test results revealed that Numbers 57 and 8 were generally within gradation specification requirements but the other gradations were not within specification requirements. In most cases the stockpiled material contained more fine material than allowed by the specifications. The gradation

specification requirements and stockpile gradation test results are shown in Figures 5 through 11.

Since the material that would be used to construct drainage blankets often did not meet gradation specification requirements, flow tests were conducted on specimen materials as-is. Quantities of the stockpiled materials were obtained and specimens were prepared with asphalt treatment, portland cement treatment, and untreated aggregate. Care was taken with material obtained for both flow rate and gradation testing to maintain representative portions for test specimens. Material obtained from stockpiles was split to specimen size portions using ASTM C702 - Method A (6).

Because some gradations are not commonly stockpiled by all suppliers, four gradations were selected for flow rate testing of treated and untreated specimens. Those gradations were Numbers 57, 67, 8, and 610. At this time it was determined that gradations having aggregate larger than 1.5 inch (Number 57 gradation) were not necessary to obtain sufficient flow rate. Specimen dimensions were reduced to 6-inches in diameter and 12-inches in length.

Flow rates of these specimens are, in some cases, different from the flow rates of laboratory prepared gradation specimens. All gradations except Number 57 indicated the highest flow rate in the untreated condition with some reduction of flow rate for asphalt or portland cement treatment. In most cases, the reduction in flow rate was 2,000 to 3,000 ft/day. Number 57 gradation, when treated with portland cement, indicated an increase in flow rate. The significant increase in flow rate appears to be related to the decreased unit weight of the portland cement treated specimens (about 97 lbs/ft³). Initial analyses of all density versus flow rate data tends to indicate a moderate correlation, i.e., an increased flow rate typically occurs at lower specimen densities as shown in Table B. It was not possible to prepare an asphalt treated Number 610 gradation specimen. The large amount of fine material in the Number 610 absorbed the asphalt and did not permit coating of the larger particles.

Flow rates of the supplier gradations varied somewhat from recombined gradations. The Number 610 gradation, which tends to have more fine material than specifications permit, decreased in flow rate to approximately 1,850 ft/day for untreated material. This was at densities that were probably far lower than would exist in the field. Greater density would decrease the flow rate further and thus eliminate the Number 610 gradation as a drainage blanket. Results of the supplier gradation flow tests are charted in Table B and graphed in Figure 12.

Field Specimens

While the evaluation of different gradations for flow characteristics continued, there were several construction projects utilizing treated and untreated drainage blankets in progress. Asphalt treated material was obtained from the spreader at one project and specimens were compacted at the site. Flow test results for these specimens further established that unit weight significantly impacts flow rate. Field specimens having unit weights ranging from 88 lbs/ft³ to 111 lbs/ft³ had flow rates ranging from 28,000 ft/day to 11,000 ft/day, respectively. Flow rate versus unit weight for these specimens is graphed in Figure 13.

During the testing of field specimens, it became obvious that the flow rate of the asphalt treated specimens tended to decrease as the specimen was subjected to longer periods of flow. After flow tests had been conducted, specimens were broken and examined. Stripping had occurred and clogging of voids was the probable cause of decreased flow rate.

Twelve asphalt treated specimens of various gradations were molded and tested for stripping. Specimens were left in the apparatus with flow through them and monitored until the flow rate stabilized. In some cases, duration of the stripping test was 200 minutes. All specimens exhibited signs of stripping with some specimens' flow rate decreasing to less than 50 percent of the initial flow rate. Neither laboratory nor field specimens contained anti-stripping agents. Change in flow rate versus time is shown graphically in Figure 14.

Permeability of Materials other than Open Graded

Permeability of pavement structure material above and below the drainage blanket was determined. A nuclear gage was used to monitor the field density of underlying filters and overlying asphaltic pavement mixes. Mix design, specifications, and in-place densities were used to prepare laboratory specimens for testing. The materials included dense graded aggregate (DGA), stabilized aggregate base (SAB), Class I bituminous base, and Class K bituminous base. Permeability of DGA was 2.0×10^{-4} cm/sec, SAB was 1.28 and 0.23×10^{-7} cm/sec, Class I was 4.78×10^{-5} cm/sec, and Class K was 3,000 ft/day. Density of the Class K base specimen was 124 lbs/ft³ as compared to field densities of 145 to 150 lbs/ft³.

Concrete sand (ASTM C 33) is often used as trench backfill for edge drain collector systems. Flow tests of concrete sand indicate a flow rate of 72 ft/day or 2.54×10^{-2} cm/sec.

Summary of Flow Tests

The apparatus constructed for testing flow rate of drainage blanket materials functioned satisfactorily. In tests involving untreated or portland cement stabilized materials, flow rate results were repeatable through dozens of measurements. The test procedure, as used, that is with Number 10 retaining screens on both ends of specimens, appears to be accurate from 30,000 ft/day to rates as low as 70 ft/day. Specimens having flow rates less than 70 ft/day were not tested in the apparatus but were tested using conventional permeability test procedures.

A series of flow tests was conducted on laboratory recombined specimens. Crushed limestone was screened and recombined to the fine limit and mid range of Kentucky Specifications gradation limits. It was determined that gradations permitting more fine material had significantly reduced flow rates at the fine limit of the specification range.

Gradation specification testing of supplier stockpiles revealed that most gradations are not within specification limits. Those that are not within specification limits, consistently contain more fine material than permitted. Since material that would almost certainly be used in constructing drainage blankets did not match laboratory recombined gradations, supplier gradations were tested for flow rate. Four gradations (57, 67, 8, and 610) were selected for testing. Each gradation was specimen from stockpiles, split using ASTM C702 - Method A, and specimens were molded from asphalt stabilized, portland cement stabilized, and untreated material.

Flow rate tests of these specimens indicated that stabilization of either type reduces the flow rate but usually by only 2,000 to 3,000 ft/day. Most of these gradations have flow rates of several thousand ft/day, therefore, stabilization was not prohibitive. Of the gradations tested, 57's had the highest flow rate at the 10,000 to 15,000 ft/day range. The 610 gradation was as low as 800 ft/day for Portland cement treated material. This was considered below the minimum necessary for a drainage blanket material.

Density of the in-place material, whether untreated blanket, stabilized blanket, or bituminous pavement, had a greater impact on flow rate than either gradation or stabilization. Flow rates of drainage blankets currently being constructed are approximately 15,000 ft/day for untreated blankets and 12,000 ft/day for asphalt stabilized blankets. Permeabilities of filter materials and Class I base range from 0.23×10^{-7} to 2.0×10^{-4} cm/sec. Satisfactory specimens of Class K base for flow rate testing

have not been produced at this time but field experience and initial laboratory data indicate that in-place Class K base could have flow rates of 2,000 ft/day or greater.

Flow rate testing revealed that asphalt stabilized materials do strip. Stripping reduces flow rate but not sufficiently to prohibit use of the more open materials.

Resilient Modulus

Resilient moduli of the various materials used in the pavement structure was evaluated in an effort to assign a structural coefficient to those materials. The standard test method (ASTM 4123) (7) was not used since several of the materials being evaluated did not lend themselves to that test method. The large voids in Class K base and most drainage blanket materials do not provide adequate sensor mounting surfaces. Non-cohesive materials such as DGA and unbound drainage blankets also present problems when the standard test method is used. Because of the nature of the materials being evaluated, the resilient modulus was determined from unconfined compression tests of cylindrical specimens with the conventional 2:1 height to diameter ratio.

All specimens were tested at room temperature and under the same conditions of confining pressure (0.0 psi) and stress (30 psi). Room temperature was normally 70° F but any variations were recorded and moduli were normalized to 70° F using data from previous research (8). The compressive load was applied with a square waveform (instantaneous load and unload) at a frequency of 1 hertz. The load time was 0.5 second and the unload time was 0.5 second. Total resilient modulus was calculated using the total recoverable strain during the unloaded portion of the cycle. The test apparatus used was an electrohydraulic, closed loop servo-valve, 10 kip capacity MTS test machine. Data were collected with an electronic load cell and both external (mounted to the specimen) and internal (test machine) LVDTs (linear variable differential transformer). Machine strain was isolated and subtracted from internal LVDT output for modulus calculations. Outputs from the sensors were recorded for all test cycles but data for modulus calculation were taken after 100 test cycles to allow for specimen conditioning.

All specimens tested for resilient modulus were molded specimens, not cores. Field tests indicate that in-place density of asphalt treated drainage blankets, in Kentucky, typically range from 105 to 110 lb/ft³. Target densities of laboratory molded specimens were within the range of in-place densities but specimens were compacted both on site and in the laboratory. Field compacted specimens did not always fall within the target density

range. Laboratory molded specimens were of various gradations while field molded specimens were of actual drainage blanket, Class K, or Class I material.

Laboratory test results indicate that, when the density is constant, resilient modulus does change greatly with the asphalt treated gradations tested. Gradation Numbers 8, 67, and 78 all averaged approximately 55,000 psi and gradation Number 57 averaged 78,000 psi. Moduli of specimens significantly outside the target density are not included in results shown in Figure 15.

SAB and DGA filter material specimens and Class I and Class K base mixture specimens were compacted in the field. Density of SAB and DGA specimens ranged from 146 to 151 lbs/ft³. Densities of Class I specimens were comparable to in place densities at approximately 146 lbs/ft³. Class K specimens were difficult to compact and densities of specimens were only 118 and 124 lbs/ft³. The low densities of the Class K specimens are reflected in moduli of 129,000 and 188,000 psi. Class I moduli ranged from 189,000 to 232,000 psi.

SAB specimens were cured 45 days before testing. Two SAB specimens were cured under damp burlap and two others were cured in water. The two specimens cured under burlap had moduli of 6,000,000 and 5,000,000 psi. while the soaked specimens had moduli of 5,600,000 and 4,800,000 psi. DGA specimens were cured 7 days and had moduli of 7,000, 13,000 and 14,000 psi. These values are low but comparable with results reported from other studies when tested with no confining pressure (8).

Specimens of the Number 57 gradation with portland cement stabilization, conforming to Kentucky Specifications, were prepared. Two specimens were cured in the mold with plastic covers and the other two were cured in the mold with damp burlap covers. One of the plastic covered specimens was damaged but the other one had a modulus of 2,000,000 psi. The wet cured specimens had moduli of 2,000,000 and 1,400,000 psi. Moduli of portland cement stabilized specimens are graphed in Figure 16.

Summary of Resilient Modulus Tests

A very limited number of specimens have been tested for resilient modulus but preliminary indications are that, for asphalt treated drainage blanket material, the Number 57 gradation yields the highest resilient modulus at approximately 78,000 psi while other gradations yield slightly lower moduli averaging 55,000 psi. Given the same quality of aggregate, the key to resilient modulus of asphalt stabilized materials appears to be density. The moduli of various drainage blanket gradations and both Class I and

Class K bases are plotted versus density in Figure 17. It can be seen that gradation apparently has less impact than density.

The resilient modulus of Class I base ranged from 189,000 to 232,000 psi at a density of 146 lb/ft³. Class K base was difficult to compact and had lower moduli of 129,000 to 188,000 psi at densities ranging from 118 to 124 lb/ft³.

While recognizing that DGA yields low moduli in an unconfined condition, all specimens were tested under the same conditions of stress and confinement. DGA specimens indicate resilient moduli significantly lower than other materials at 7,000 to 14,000 psi. SAB yields moduli of 5,000,000 to 6,000,000 psi and portland cement stabilized Number 57 gradation yields moduli of 1,400,000 to 2,000,000 psi. Wet cure versus plastic cure does not appear to significantly affect the moduli of portland cement stabilized drainage blankets.

Material Properties

Specimens of aggregate from a local supplier were used for some basic materials property tests. The specific gravity of material retained on the 3/4 inch, 3/8 inch, and Number 4 screens was determined. The specific gravities were 2.71, 2.70, and 2.72, respectively, when tested in accordance with Kentucky Method 64-707-91.

Resistance to degradation was determined using ASTM C 535-89. The material tested was Number 4 and Number 8 gradations. The percent loss was 18.0 percent and 19.4 percent, respectively.

FIELD EVALUATIONS

Field evaluations included monitoring construction of and engineering performance of subgrade, filter, drainage blanket, asphaltic pavement and portland cement pavements. Monitoring the construction of pavement systems involving drainage blankets included documenting construction problems, successes, and techniques. Monitoring engineering performance included determination of in-place densities, conducting falling weight deflectometer (FWD) tests, performing pavement distress surveys, determining rutting, rideability indices (RI), and monitoring in-place drainage. Performance and maintenance histories (up to 16 years) of pavements utilizing drainage blankets are also documented.

Sites

Several sites were included in the evaluation. Some were under construction and some were approaching 15 years of service. A variety of subgrades, filters, drainage blankets and pavements were inspected. Most sites were located in Central or North Central Kentucky as shown in Figure 18.

KY 55, Taylor County

A 5.2-mile section of Ky 55 in Taylor County containing drainage blankets was constructed in 1978. The experimental sections begin south of Campbellsville and extends to US 68 in Campbellsville. The site includes ten sections of five different designs. Figure 19 shows the site layout where four sections incorporate untreated drainage blankets and one is a control section where the drainage blanket was excluded. Location of the site in Taylor County is shown in Figure 20.

Earlier reports (9,10) document construction and performance of the site. It was concluded (9) that it is difficult to place pavement layers above untreated material, pavement deflection analysis indicates little significant difference between sections of equivalent thickness, and the drainage system functions well. Conclusions from (10) are, after 12 years of service the drainage blanket was in good condition and functioning well; however, outlet headwalls were clogged. The pavement was characterized as in generally good condition with most distress occurring in the thinner design sections.

Observation of the site during heavy rainfall in 1994 (16 years of service) revealed that the drainage system responds quickly (within minutes) after the onset of precipitation. Most outlets were clogged and need clearing to provide free drainage. Of 21 outlets inspected on northbound KY 55, 15 required maintenance for free drainage. Most of the problems were grass and debris in the headwall and rodent screens. Ponding (ditch line blockage) and displaced outlets were also observed.

The experimental section was overlaid with one inch surface in 1990. Ky 55 south of the experimental section was overlaid in 1991. The maintenance engineer responsible for Taylor County revealed that there was no significant difference in pavement condition but that fiscal factors determined the timing of the overlay. The maintenance engineer indicated that rutting or cracking was not the reason for resurfacing but that some raveling had occurred.

Louisa Bypass

The Louisa Bypass (US 23 in Lawrence County, Figure 21) was completed in July 1989. The pavement consisted of 12 inches of LSM (Large Stone Mix) base and one-inch surface course on 4-inches untreated drainage blanket (Number 57) on 4-inches DGA. Construction and short-term performance are documented in report KTC-90-16 (11).

After two years of service, significant rutting had developed in areas where loaded trucks moved slowly. Investigations in 1991 indicated that the rutting (up to 1.8 inches) was primarily in the Class K base. Measurements of pavement cores taken in the rutted wheel paths and between the ruts (Figure 21, p.46 of KTC-90-16) indicated that the rutting occurred in the top two courses (8 inches) of Class K base.

The northbound lanes developed surface irregularities that required milling and resurfacing in 1994. The irregularities were humped or domed areas, not typical distress, and were possibly due to movement of the unbound drainage blanket.

AA Highway

The AA highway (KY 546, Figure 22) extends from Alexandria in North Central Kentucky to the Ashland area of Eastern Kentucky. This highway was constructed in sections with different designs and contractors. Approximately one-half of the AA highway involved drainage blankets. The drainage blanket was either untreated 57's or asphalt treated 57's. Most of the sections were completed between 1987 to 1990.

All components of the pavement structure varied depending upon design. Subgrade conditions were either untreated, lime treated or cement treated. The base was either DGA, SAB, or deleted. Pavement thickness and mix varied. A filter fabric was used in one section and the drainage blanket was daylighted in another. The various design sections are included in Appendix B.

Monitoring of pavements having drainage blankets as used on the AA highway has consisted primarily of pavement deflection testing, pavement distress surveys, rideability indices (RI), visual surveys of drainage during and after precipitation, and outlet condition surveys.

Pavement distress surveys reveal that, after five to six years of service, the surface is generally in good condition. Rutting of the asphaltic concrete pavement typically ranges

from 1/8 inch to 3/8 inch with little difference between design sections. There is moderate cracking with the more significant cracks being longitudinal between the wheel paths. Transverse cracks are significant only in the western 3.5 miles of the AA highway near Alexandria and at Maysville in Mason County. The transverse cracking at Maysville is probably the result of higher traffic volume. Except for the Maysville section, cracking of either type is common to sections having drainage blankets and noticeably absent from sections with no drainage blanket. Raveling is present but not severe throughout much of the AA highway.

Visual surveys of the outlets revealed that there is drainage during precipitation and that the outlets on the AA highway are remarkably clear and clean when compared to other sites.

Of particular interest was the performance of the daylighted drainage blanket. It was obvious from an inspection shortly after a moderate rainfall that the daylighted section was functioning well. Side slopes in sections having edge drains and outlets were dry except below the outlets, while the side slope at the daylighted sections was damp. Concern had been expressed that the daylighted blanket would be clogged by silt and vegetation. Those concerns appear to be unwarranted after six to seven years of service. Vegetation encroachment was minimal as shown in photographs (Figures 23 and 24).

One problem with the daylighted blanket is displacement of aggregate by vehicles driving off the shoulder. In areas where there was a guardrail, the exposed blanket looked much as it did when placed. In areas with no guardrail, there were deep ruts where vehicles had driven onto the unstabilized drainage blanket (Figure 25).

FWD data were collected most years since the AA highway has been in service. These data are currently being analyzed and will be detailed in a later report.

Rideability index (RI) data for the AA Highway obtained over the last three years (1991 through 1993) have been analyzed. Rideability indices for those years are plotted in Figure 26. RI values have been determined for the western end of the AA Highway, in Campbell County, and extend through Lewis County. Most of the route exhibits good RI with some obvious decreases at sections having older pavement in Mason and Lewis Counties and a localized decrease in Bracken County. The area having a lower RI in Bracken County is apparently due to a cut/fill interface subsidence with resulting surface irregularities.

Changes in RI over time have been compared for different design sections. The AA Highway has nearly 30 design sections and many of them are identical or very similar. Contiguous design sections were grouped into five groups for comparison. Group One began at the western end and consists of sections having eleven inches of pavement on an asphalt treated drainage blanket on a lime stabilized subgrade. Group Two is similar except that the drainage blanket is unstabilized. Group Three has ten inches of pavement (+/- 0.5 inch) on an asphalt treated drainage blanket on a stabilized aggregate base. Group Four has ten to fourteen inches of pavement on DGA with Monsanto panel edgedrains. Group Five has 8.5 to 9 inches of pavement on 4 inches of either DGA or rock roadbed and no drainage system. Group One had a 10% decrease in RI from 1991 to 1992 and little change thereafter. Groups Two, Three, and Four had only slight decreases from 1991 to 1993. Group Five had a more pronounced and continuing decrease. RI values for each section were averaged for each year and plotted versus time in Figure 27.

US 127, Mercer County

The northbound lanes of US 127 in Mercer County (Figure 28) were constructed in 1992. A portion of that route was chosen for monitoring. The site chosen extends from Station 368+00 to Station 488+00. Design at the site was 11-inches bituminous concrete, four-inches untreated Number 57 gradation drainage blanket, four-inches DGA, and eight inches of lime stabilized (6%) subgrade. Deflection data were collected with a FWD on the structural layers during construction and on the pavement surface since completion.

Two problems observed during construction were maintaining the profile of the drainage blanket due to rutting or displacement and compaction of the first base course of the bituminous pavement. Blanket profile was maintained by shaping and rolling in front of the paving operation. The first course of the bituminous base tended to spread under compaction by nearly one foot on each side of the mat. While some spreading is to be expected, this appeared excessive and due in part to movement of the untreated drainage blanket.

When observed during a light rain in 1994 (two years service), the drainage system was functioning in that there was flow from the open outlets. During the visit to the site, 14 outlets were observed with seven of the 14 being effectively plugged with grass and debris. In more than one case, grass roots and film-like deposits in the rodent screen plugged the outlet so that when the screen was partially removed water spewed several inches into the air. The system obviously was under several inches of head.

After two years of service, there was no significant pavement distress observed at this site.

US 127, Franklin County

Realignment of US 127 in Franklin County was constructed in 1992. The section of US 127 from the Anderson/Franklin County line (Figure 29) extending north through the I-64 interchange comprises more than 5 miles and drainage blanket was included throughout the section. Beginning at the south end (Station 101+57.45), the design section was 9.5-inches of Class K bituminous concrete on four inches of untreated drainage blanket on 8 inches of SAB on 8 inches of lime treated subgrade. This section continued to Station 295+50. The second section extends from Station 295+50 to Station 305+50 and was the same design except that the drainage blanket was asphalt treated. Section three extends from Station 305+50 to 309+20 and has 10.5 inches of Class K on four inches of asphalt treated blanket on five inches of SAB on 8 inches of lime treated subgrade. The fourth section extends from Station 309+20 to 364+70 and has 10.5 inches of Class K on four inches of asphalt treated blanket on five inches of SAB on untreated subgrade.

Field monitoring of this site included in-place density of lime treated subgrade, SAB and asphalt treated blanket. Material was collected to remold laboratory specimens and specimens were compacted in the field for flow rate and resilient modulus testing. FWD testing was conducted on the different structure layers as construction progressed and on the surface since completion.

A visual survey of the site during a heavy rainfall in 1994 revealed that of 39 outlets inspected 21 had some obstruction to free discharge. Fifteen outlets had severe obstruction, three had some debris in the headwall and three were clear but had no discharge. The severe obstruction was usually due to ponding as a result of the outlet being nearly at the same level as the ditch. Blocking of the ditch causes, in some cases, the outlet to be submerged. The problems at the three outlets having less severe obstructions were headwalls filled with shoulder material that, when removed, allowed free drainage. The three outlets with no discharge are suspected of having construction damage. Figures 30 through 32 show some of these conditions.

I-264, Jefferson County

Construction of a rigid pavement (portland cement concrete) with an asphalt stabilized drainage blanket was monitored at two sites in Jefferson County, Kentucky. The sites

were both on the I-264 (Waterson Expressway) widening project. One site was at Breckinridge Lane and the other was a collector road on the west side of I-264 at Shelbyville Road (Figure 33). Design for both sites was 11 inches of PCC on four inches of asphalt treated blanket on four inches of DGA. At the Breckinridge Lane site, a very soft subgrade was replaced with one foot of Number 3 stone and covered with a filter fabric. At the Shelbyville Road site, the subgrade was a mixture of shot rock and soil.

FWD data were collected on the layers as construction proceeded and after the PCC pavement was cured. The high modulus (up to 1.2×10^7 psi) of the PCC pavement prohibits the use of FWD data to back calculate underlying layer moduli. Distress surveys and RI data will continue to be collected but FWD data collection will not be continued.

CONCLUSIONS and RECOMMENDATIONS

Considerable monitoring, testing, and analyses remains for this study, but some preliminary conclusions can be drawn from work performed. The effort to develop an appropriate apparatus and procedure for flow rate testing of open graded materials was successful. Test results were repeatable for flow rates ranging from 70 ft/day to more than 20,000 ft/day.

The current "Special Note For Pavement Drainage Blanket" provides for the optimum gradation for both drainage and stability in an asphalt treated drainage blanket. Asphalt treated specimens compacted to densities typical of field conditions, 105 to 110 lbs/ft³, indicate flow rates ranging from 11,000 to 14,000 ft/day. At these densities, structural stability of the blanket, as measured by resilient modulus, is approximately one third that of a Class I base which results in a structural coefficient of 0.15 or 0.16 for the asphalt treated blanket. Compaction of the asphalt treated blanket soon after placement would increase density and provide increased stability with more than sufficient drainage capability and a resulting higher structural coefficient.

Stripping of asphalt treated laboratory specimens was observed. The effect of stripping on flow rate and stability have not been fully evaluated.

Untreated drainage blankets provide good drainage (15,000 to 16,000 ft/day) but present construction problems. Structural stability or structural coefficients of untreated blankets have not been established.

Portland cement treated drainage blankets have not been used in Kentucky. Laboratory tests indicate that the drainage capability of a cement treated blanket could be greater than an untreated blanket and the resilient modulus would be much greater than bituminous pavement. Curing of cement treated blanket by either covering with plastic or misting, appears to produce similar strengths in laboratory specimens.

Pavement drainage systems are limited to the capability of the slowest draining component which, in the case of current construction in Kentucky, is the collector system. Daylighting the drainage blanket is a viable alternative to a collector system. Concerns of siltation and vegetation in the daylighted blanket appear to be unfounded based on the performance of a daylighted blanket on the AA highway. However, untreated blankets that are daylighted should be afforded some means of protection from traffic encroachment.

Collector system outlets are typically not maintained properly and are often poorly designed. Excluding the AA Highway, most outlets were not draining properly due to either siltation in the headwall, vegetation in the headwall, damage to the outlet pipe, or ponding. Ponding is sometimes due to blockage in the ditch but design at two of the sites allowed outlet headwalls to be placed level with the original ditchline elevation. Headwalls were observed with water ponded above the outlet pipe elevation. All headwalls should be at least 6 inches higher than the ditchline elevation.

While properly constructed pavement drainage systems have been observed to remove water from the pavement structure rapidly, pavement performance histories do not necessarily validate the expectations of increased pavement life. All study sites except Ky 55 in Taylor County, are fairly new and have not required rehabilitation at this time; however, distress surveys of the AA highway indicate that sections having drainage blankets might be deteriorating more rapidly than sections having no drainage blanket. The Ky 55 site was overlaid after approximately 12 years of service. The adjacent undrained section was similar condition and provided 13 years of service before being overlaid.

The literature search and review will be included in a separate report.

REFERENCES

1. US Army Corp of Engineer, 1980, Laboratory Soils Testing, Engineer Manual EM 1110-2-1069, Washington, DC.
2. ASTM C 33 - 90, "Standard Specification for Concrete Aggregates", 1990 Annual Book of ASTM Standards, Section 4, Volume 04.02, Concrete and Aggregates, American Society for Testing and Materials, Philadelphia, U.S.A.
3. US Department of Transportation, "HIGHWAY SUBDRAINAGE DESIGN". Report No. FHWA-TS-80-224, Federal Highway Administration, Washington D.C., 1982.
4. Kentucky Transportation Cabinet, Department of Highways, Standard Specifications for Road and Bridge Construction, p.650, 1994.
5. Kentucky Method KM 64-602-91, "Dry Sieve Analysis of Fine and Coarse Aggregate", Kentucky Methods for Material Testing and Control, Division of Materials, Kentucky Transportation Cabinet, Frankfort, 1991.
6. ASTM C 702 - 87, "Standard Practice for Reducing Field Specimens of Aggregate to Test Size", 1990 Annual Book of ASTM Standards, Section 4, Volume 04.02, Concrete and Aggregates, American Society for Testing and Materials, Philadelphia, U.S.A.
7. ASTM D 4123 - 82, "Standard Method of Indirect Tension Test for Resilient Modulus of Bituminous Mixtures", 1984 Annual Book of ASTM Standards, Section 4, Volume 04.03, Road and Paving Materials; Traveled Surface Characteristics, American Society for Testing and Materials, Philadelphia, U.S.A.
8. Allen, D. A., "Determination of Rutting in Asphaltic Concrete Pavements: Field Instrumentation and Laboratory Characterizations", Research Report 502, Division of Research, Bureau of Highways, Department of Transportation, Commonwealth of Kentucky, 1978.
9. Havens J. H., and Sharpe G. W.; "Water Under Pavements", Research Report UKTRP 83-13, Kentucky Transportation Research Program, University of Kentucky, July 1983.

10. Graves R. C., "Pavement Base Evaluation Ky 55 Taylor County", Research Report KTC-89-48, Kentucky Transportation Center, University of Kentucky, October 1989.
11. Mahboub K. and Fleckenstien L. J.; "Louisa Bypass Experimental Project", KTC-90-16, Kentucky Transportation Center, University of Kentucky, June 1990.

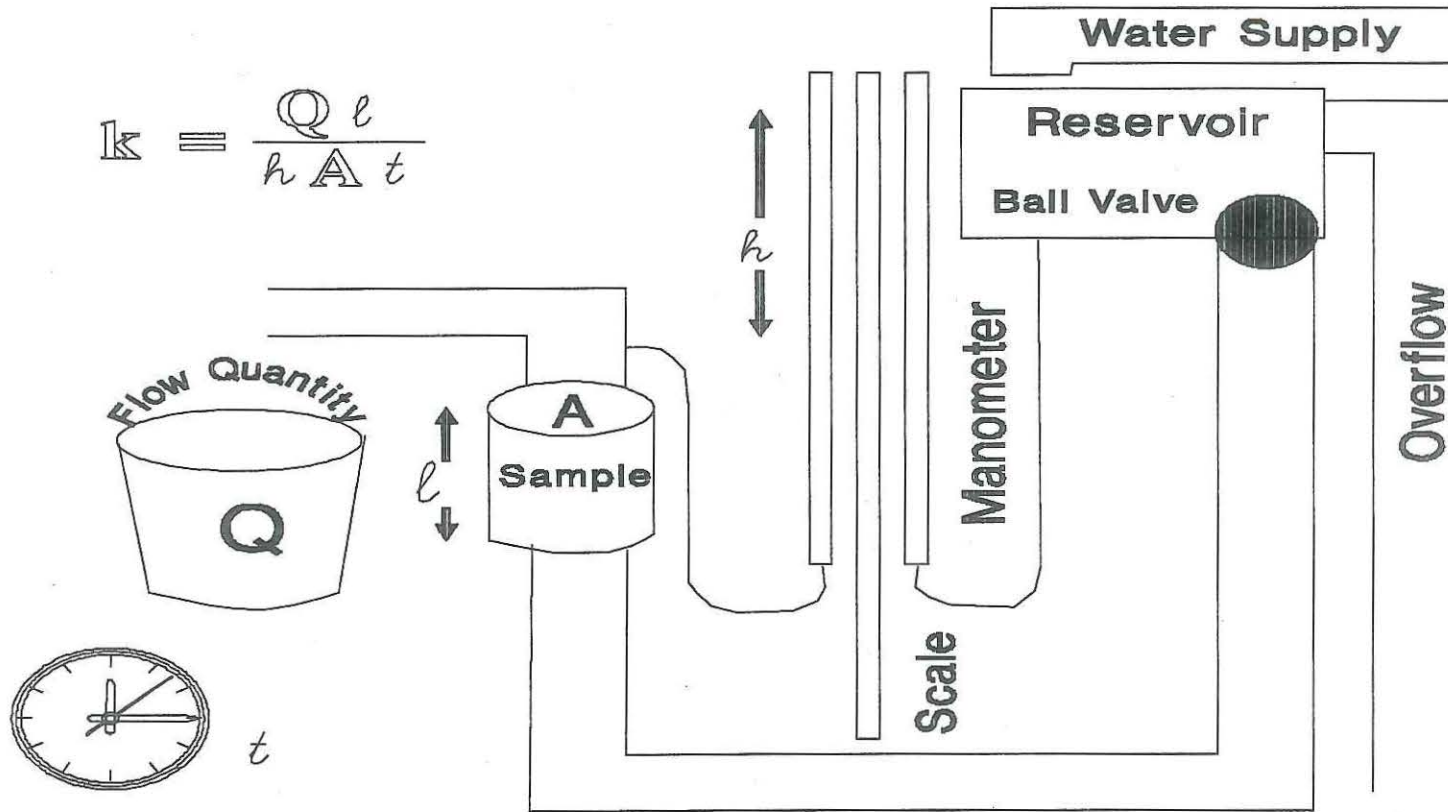


Figure 1. Schematic of Laboratory Permeability Apparatus.

KTC VS FHWA

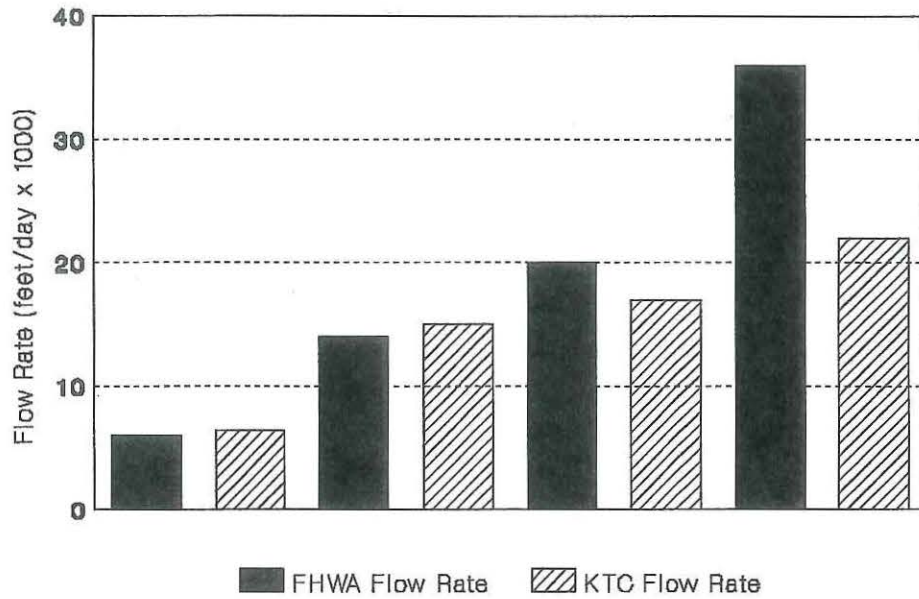


Figure 2. Comparison of KTC and FHWA Flow Rates for Open Graded Materials.

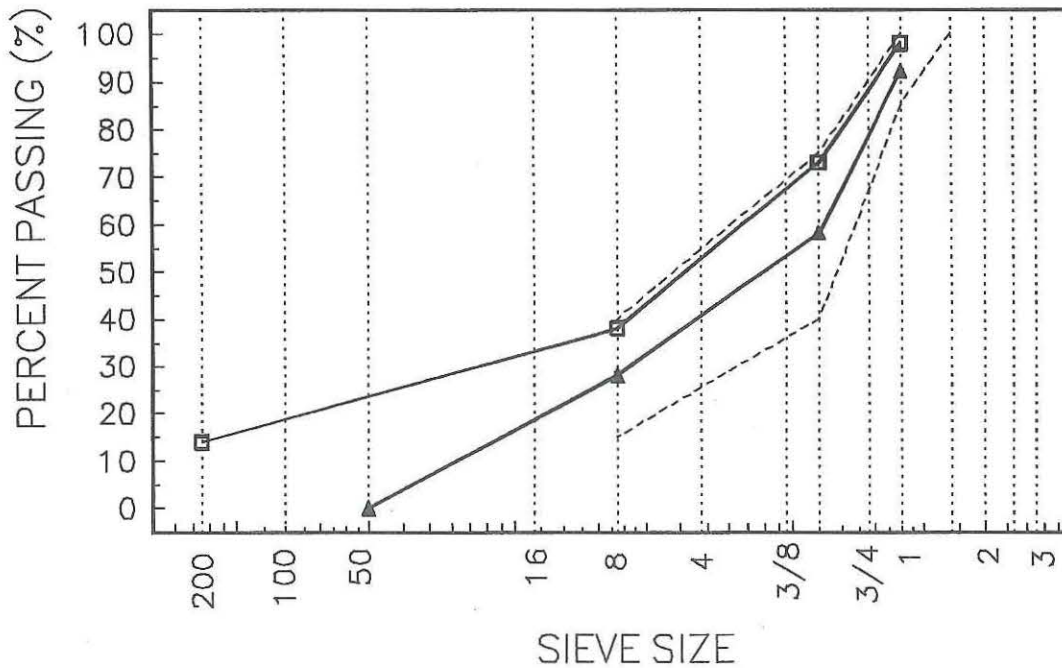


Figure 3. Laboratory Samples Were Recombined at the Center and Fine Limit of Each Gradation Specification.

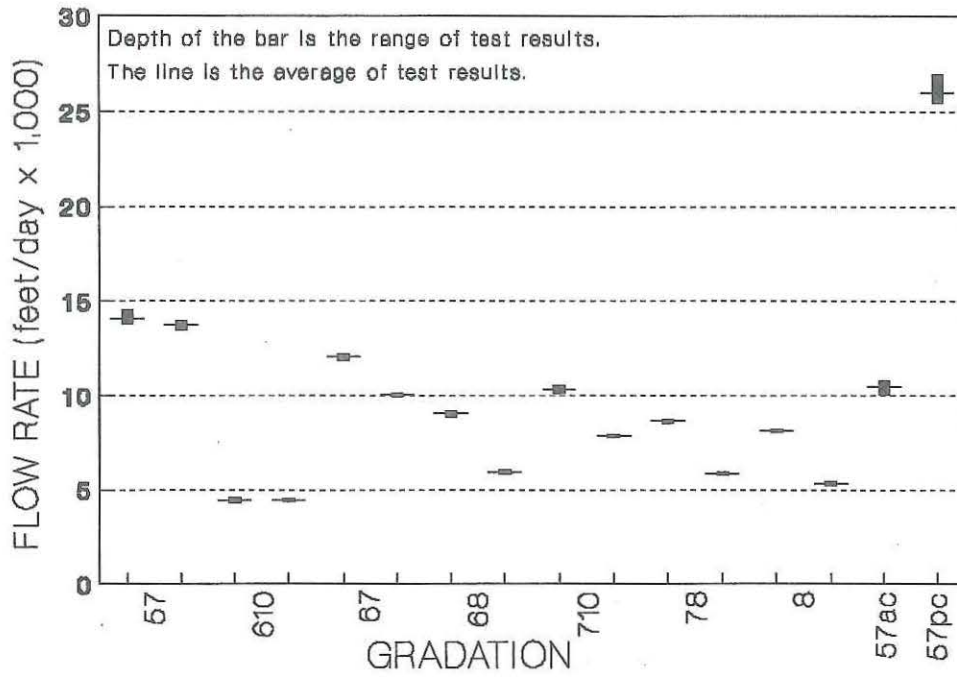


Figure 4. Flow Rate of Laboratory Recombined Samples.

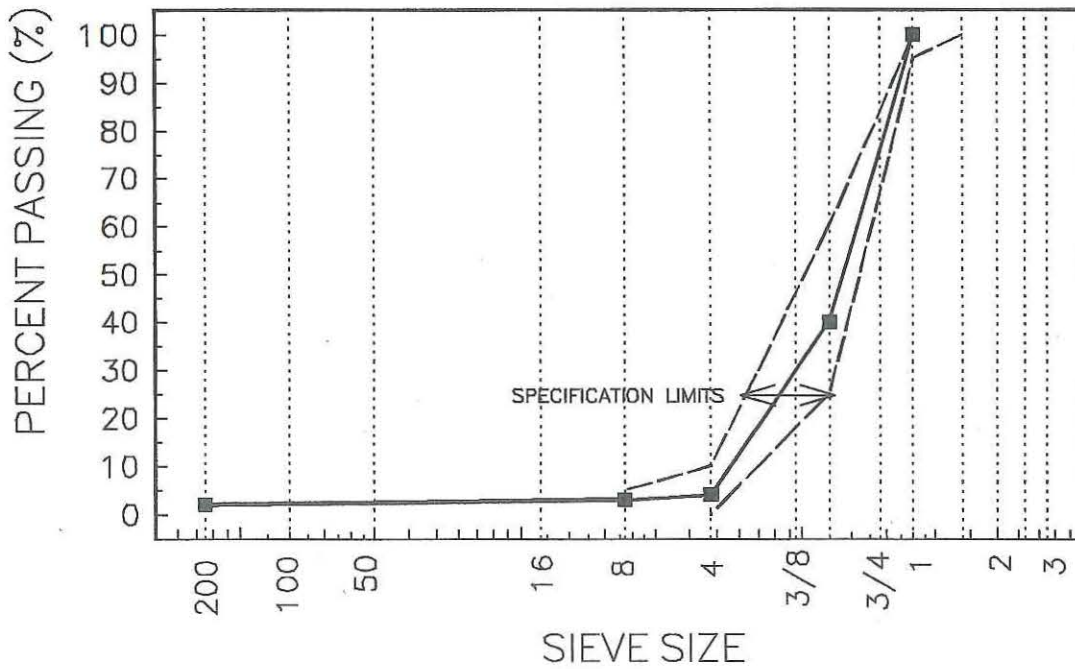


Figure 5. Distribution of Supplier Stockpiled Gradation 57.

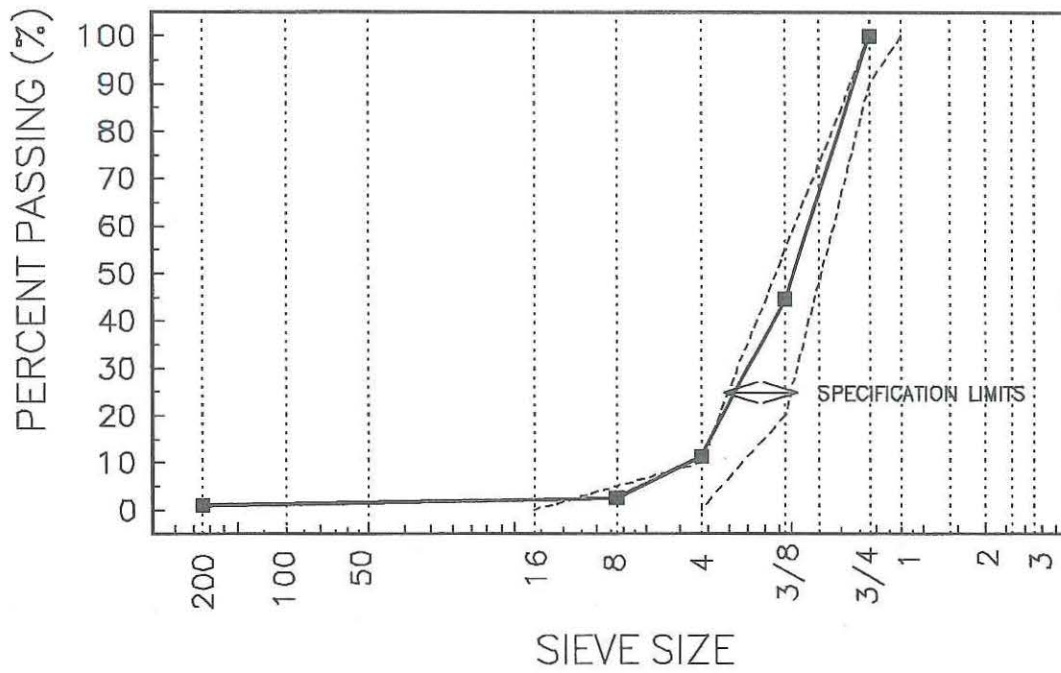


Figure 6. Distribution of Supplier Stockpiled Gradation 67.

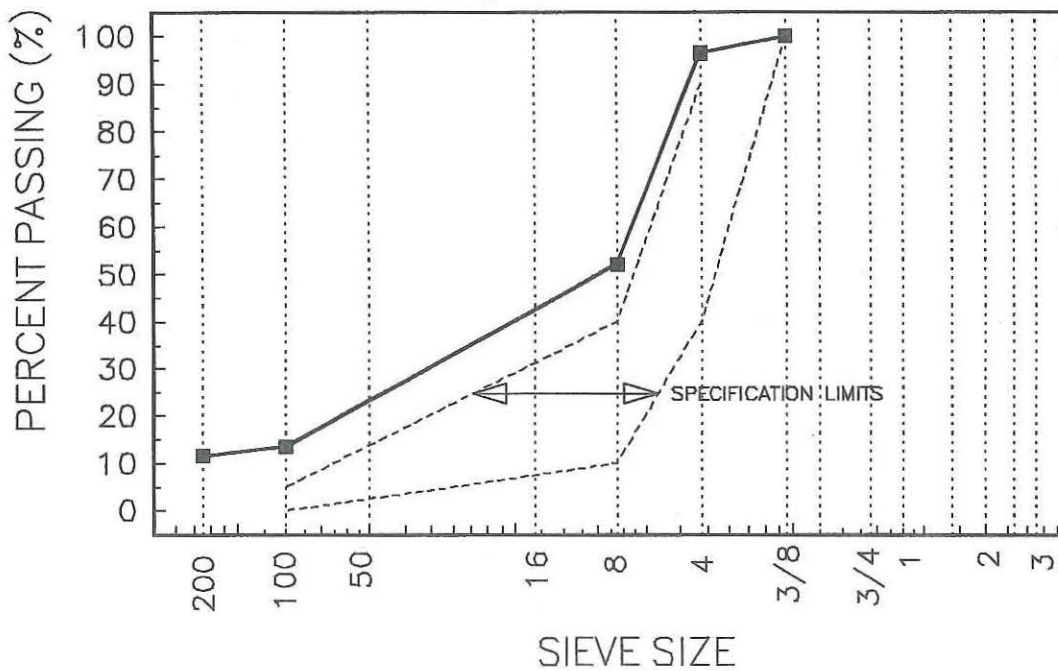


Figure 7. Distribution of Supplier Stockpiled Gradation 11.

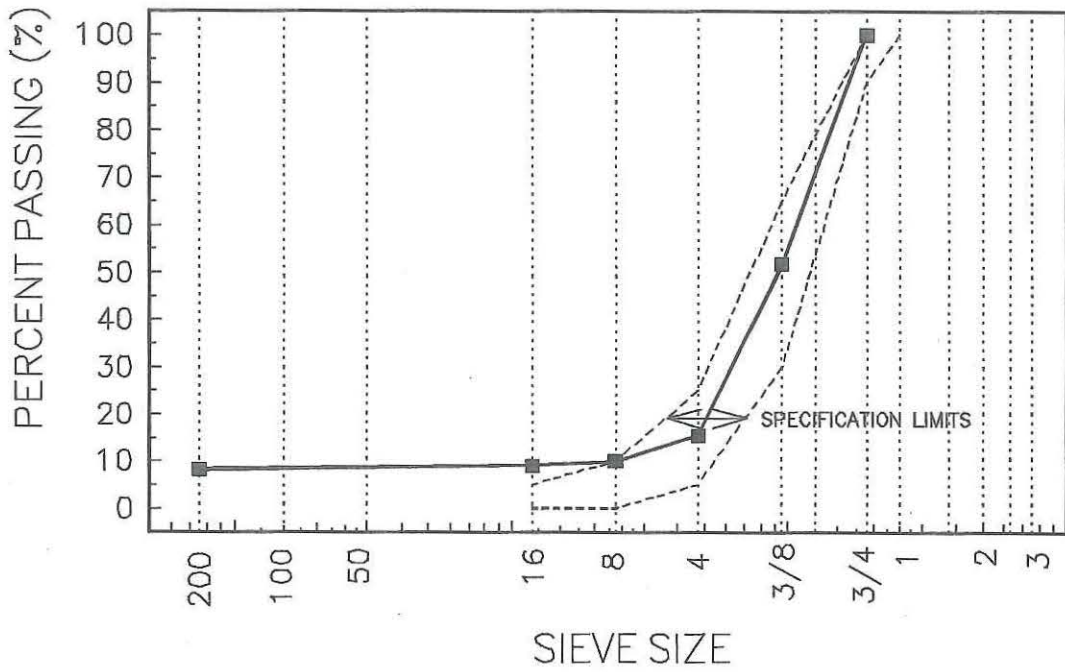


Figure 8. Distribution of Supplier Stockpiled Gradation 68.

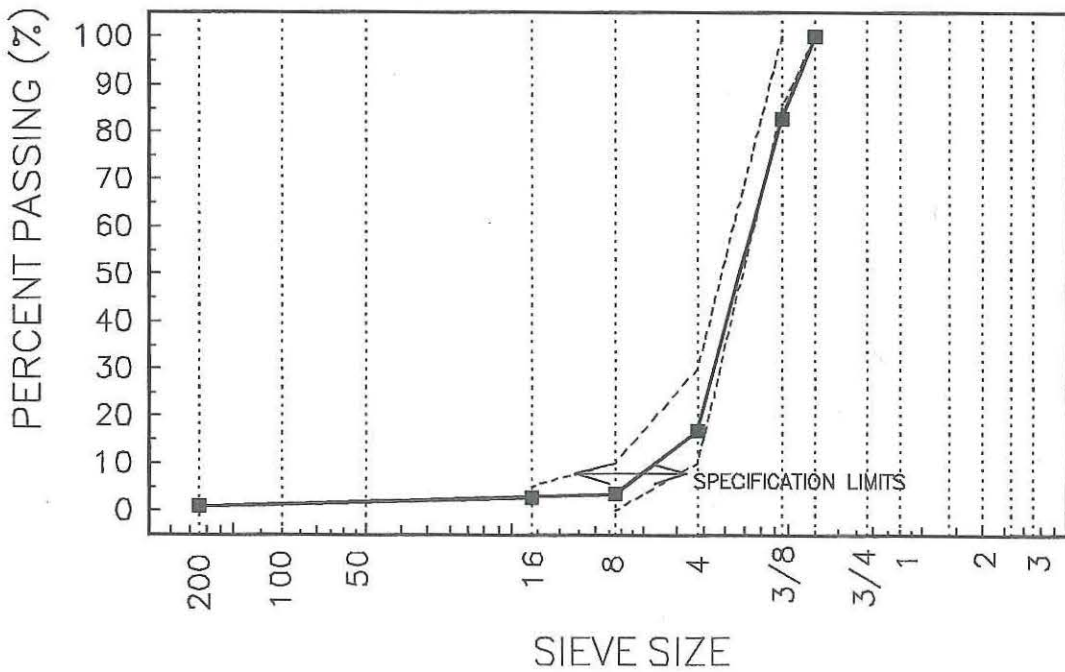


Figure 9. Distribution of Supplier Stockpiled Gradation 8.

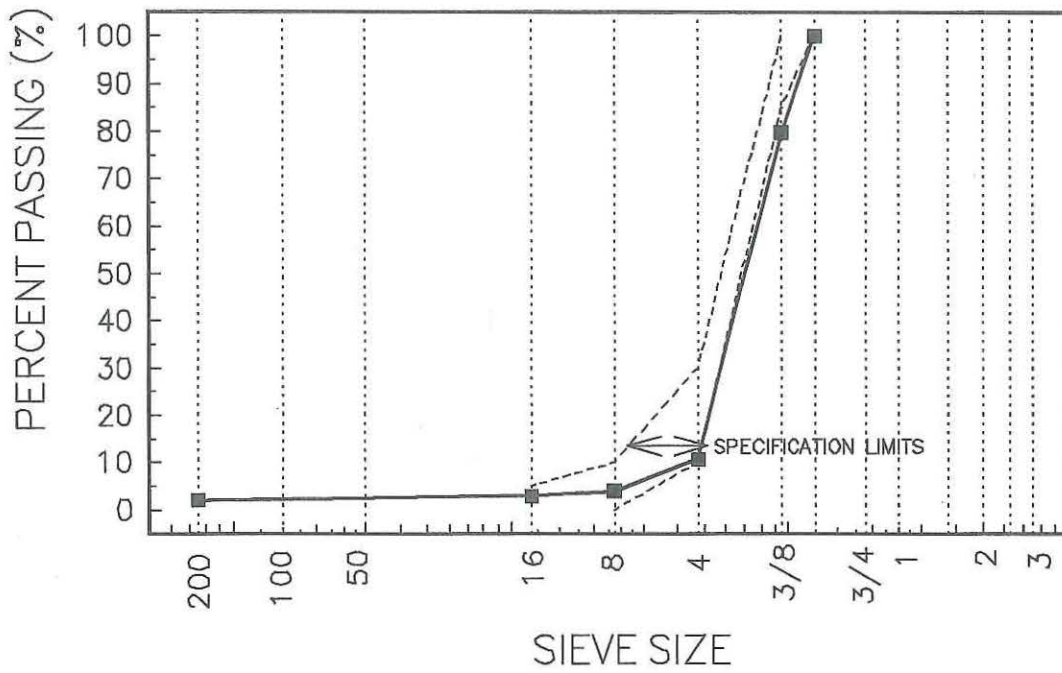


Figure 10. Distribution of Supplier Stockpiled Gradation 8 (second source).

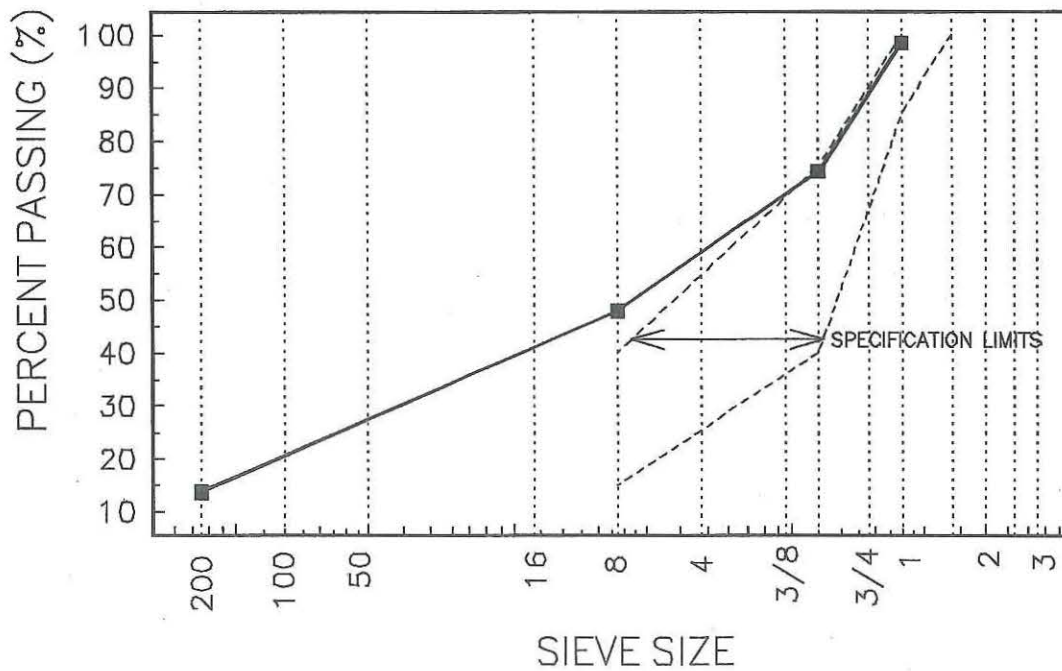


Figure 11. Distribution of Supplier Stockpiled Gradation 610.

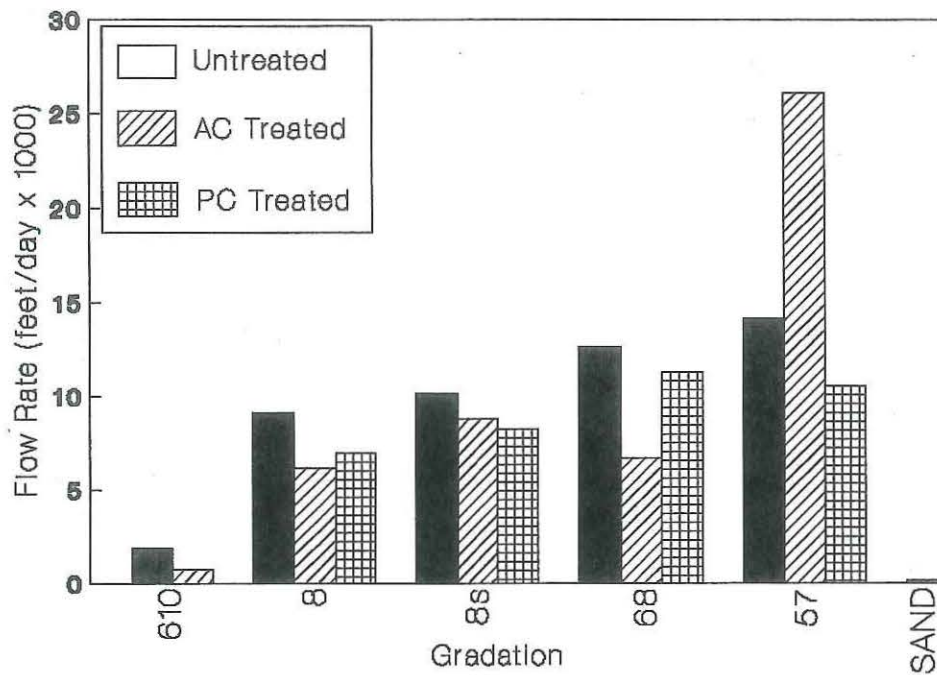


Figure 12. Flow Rate of Supplier Gradations. Samples Are Untreated, Asphalt Treated, and Portland Cement Treated.

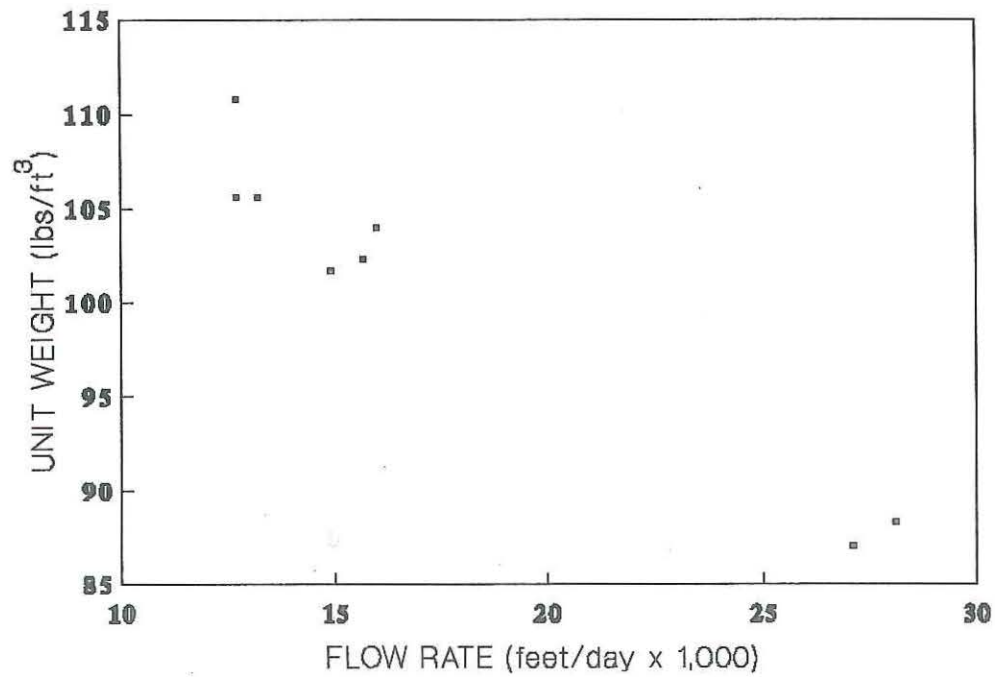


Figure 13. Flow Rate Versus Unit Weight of Field Compacted Samples. Material Is Asphalt Treated Gradation 57.

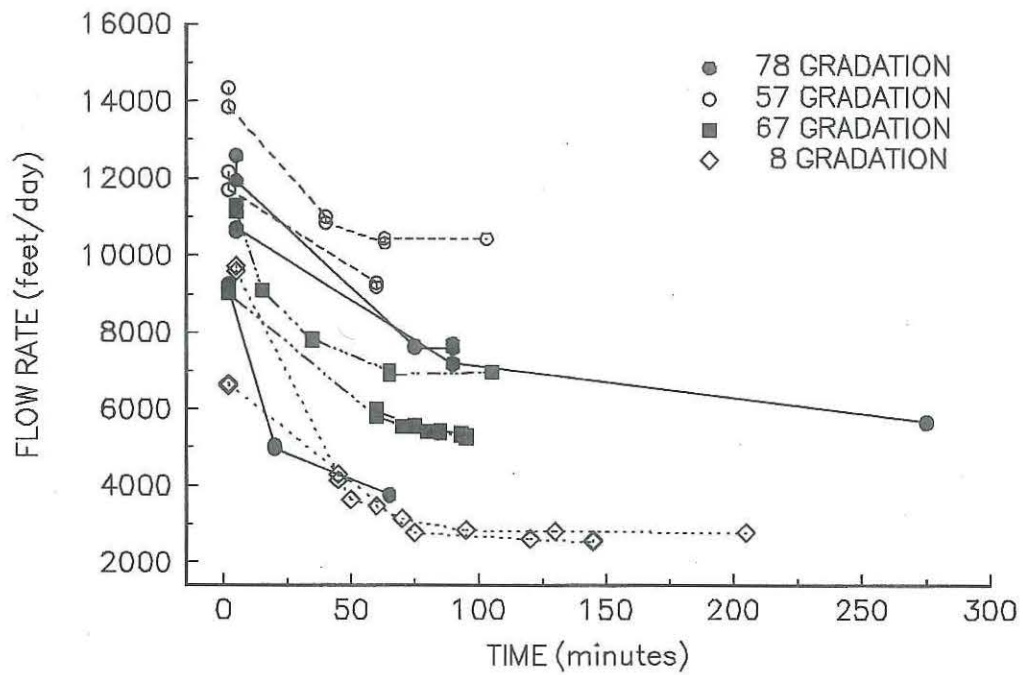


Figure 14. Flow Rate Versus Time for Asphalt Treated Samples.

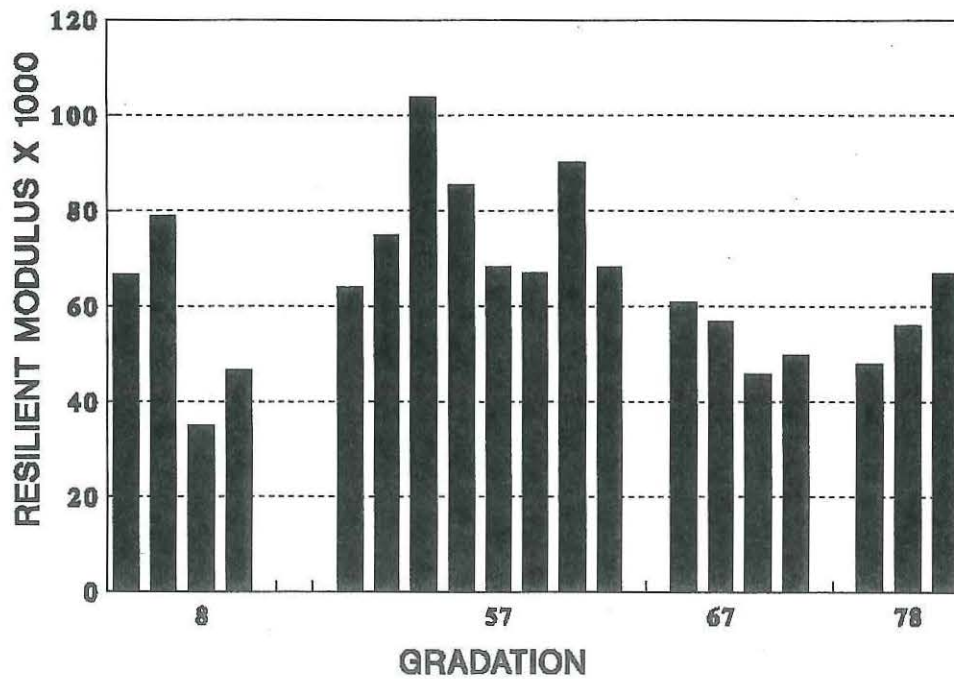


Figure 15. Resilient Modulus of Asphalt Treated Gradations.

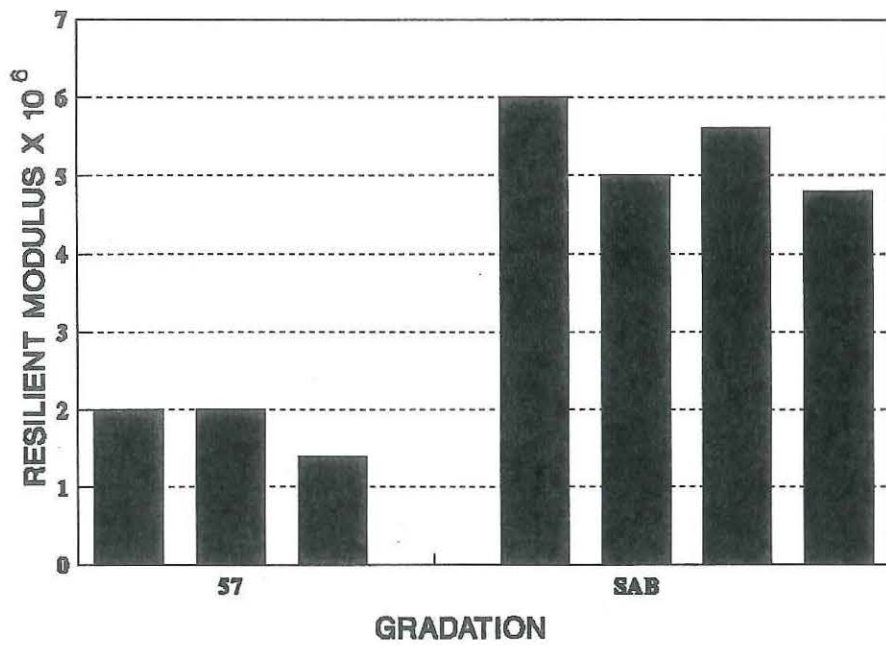


Figure 16. Resilient Modulus of Portland Cement Stabilized Materials.

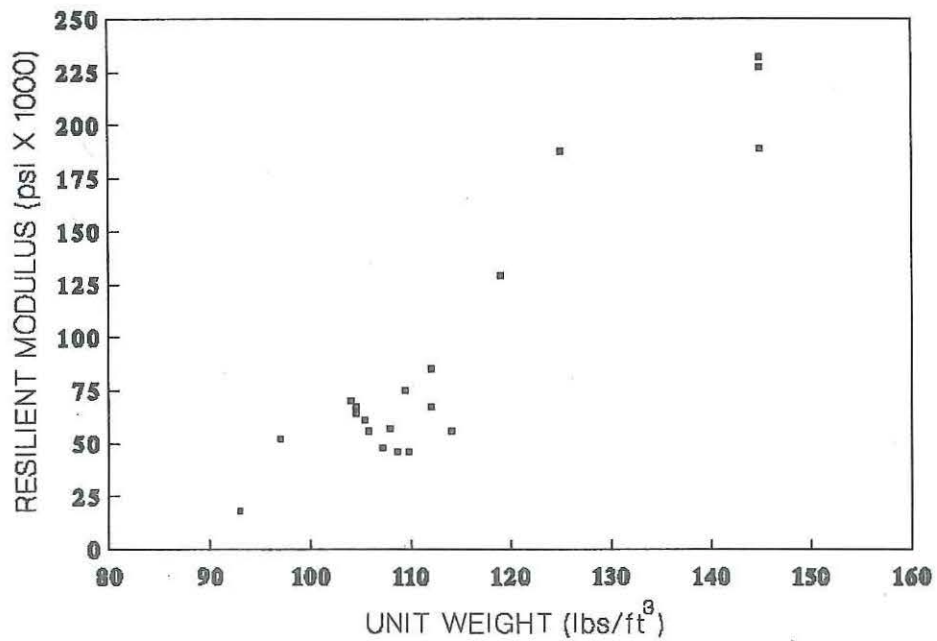


Figure 17. Resilient Modulus Versus Unit Weight of Asphalt Stabilized Materials.

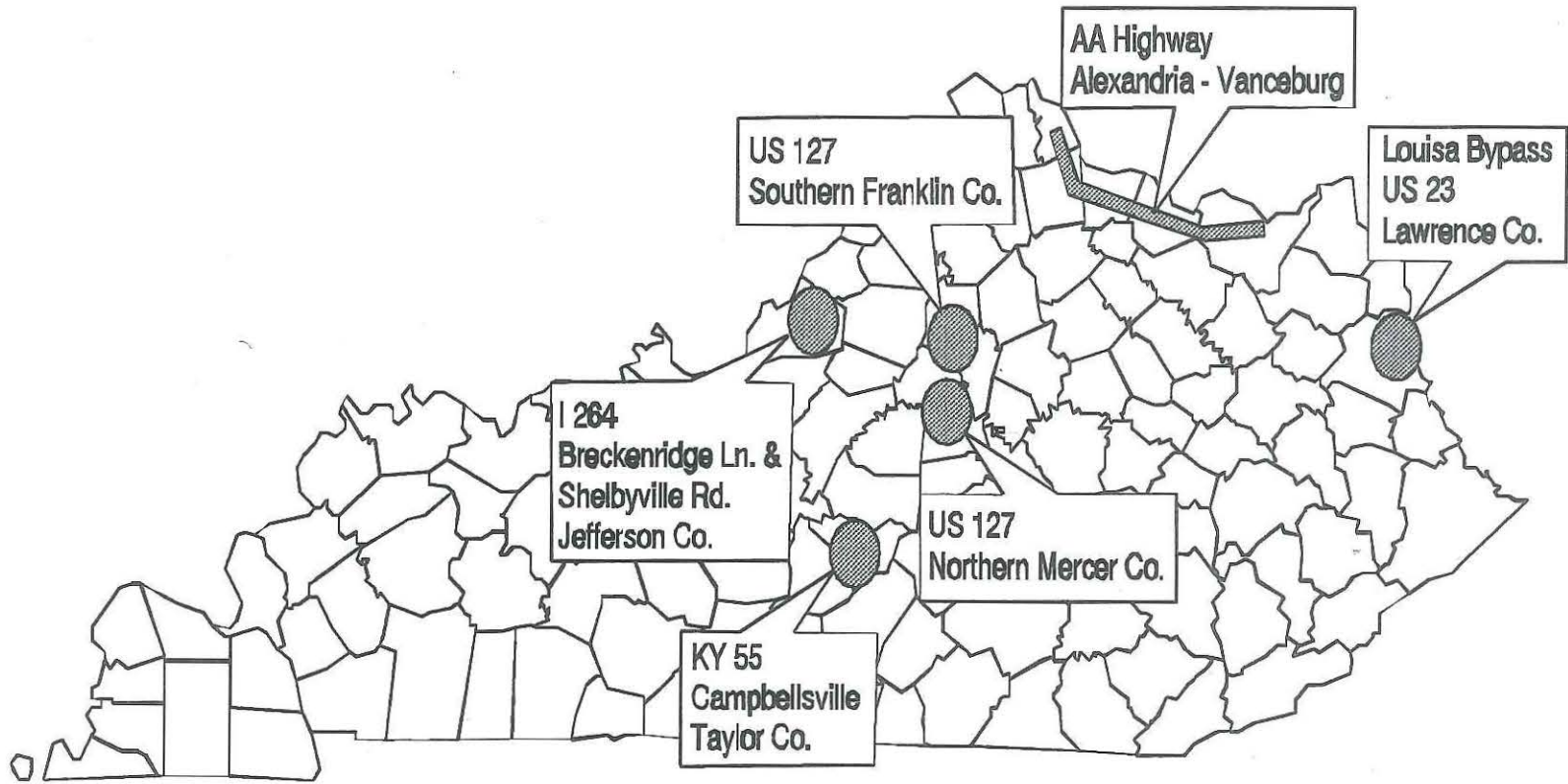


Figure 18. Locations of Monitored Pavements.

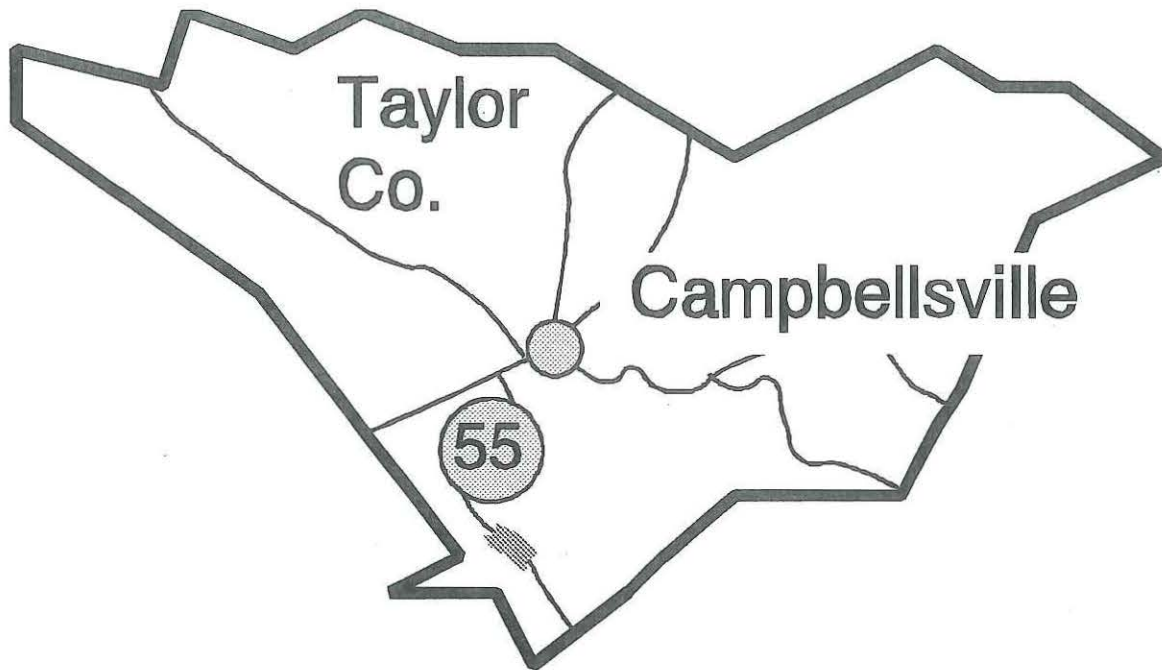


Figure 20. Location of KY 55 Site in Taylor County.

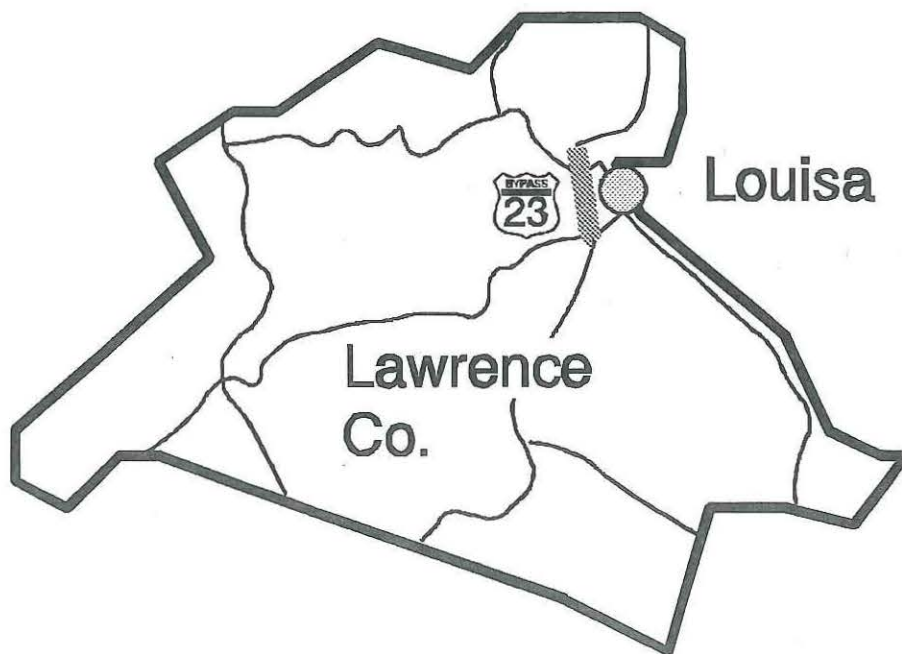


Figure 21. Location of US 23 Site in Lawrence County.

Figure 22

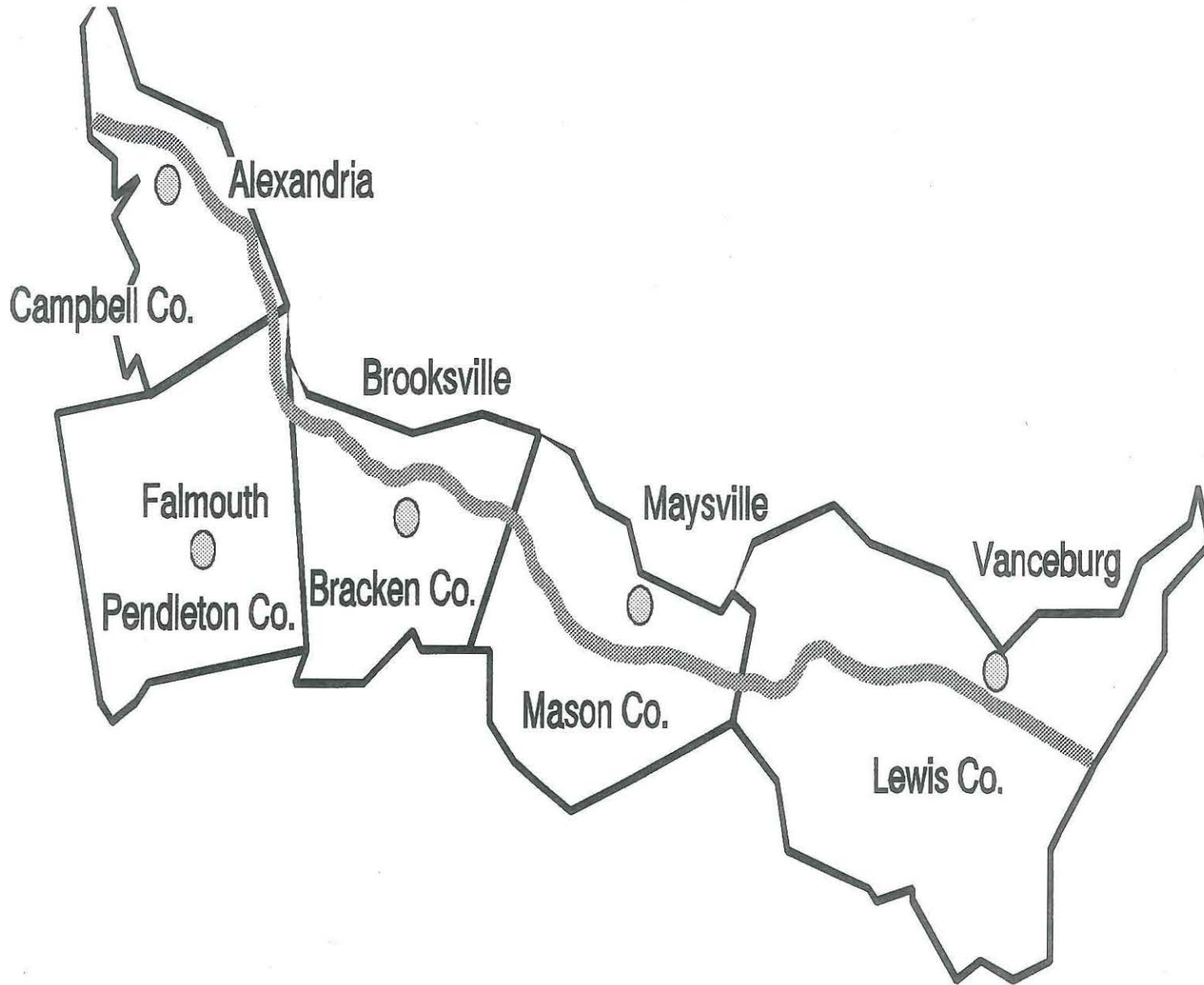


Figure 22. AA Highway in Northern Kentucky Where Pavement Included Treated Blankets, Untreated Blankets and Undrained Sections.



Figure 23. Daylighted, Untreated Drainage Blanket at AA Highway. Little Vegetation after Seven Years.



Figure 24. Daylighted, Untreated Drainage Blanket at AA Highway. Little Vegetation after Seven Years.



Figure 25. Untreated, Daylighted Drainage Blanket Displaced on Shoulders.

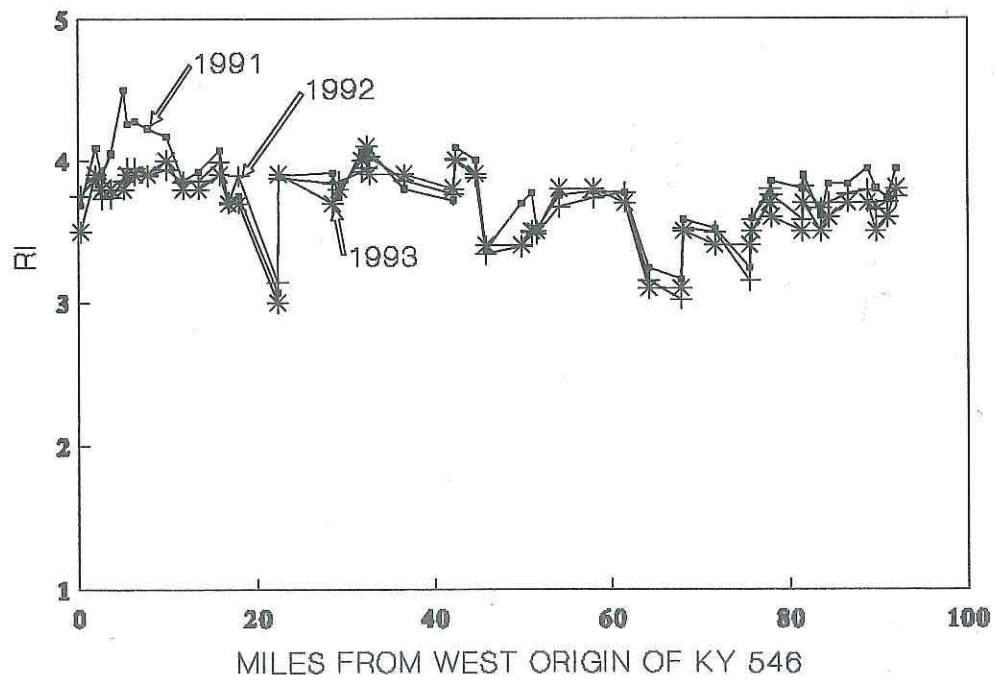


Figure 26. RI values for East Bound AA Highway.

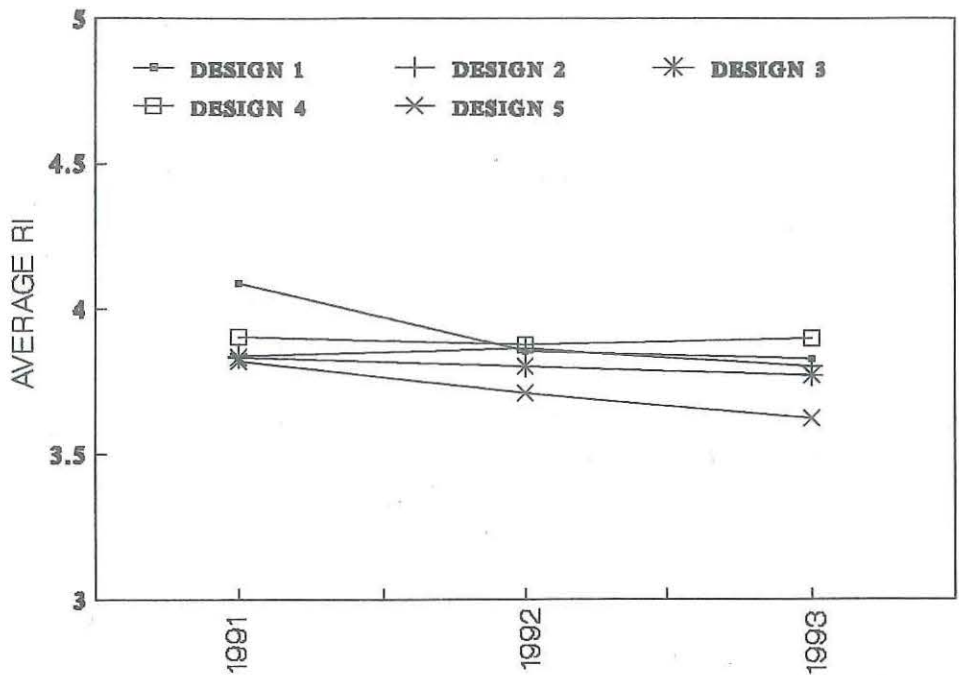


Figure 27. Eastbound AA Highway RI Values Averaged by Design Section.

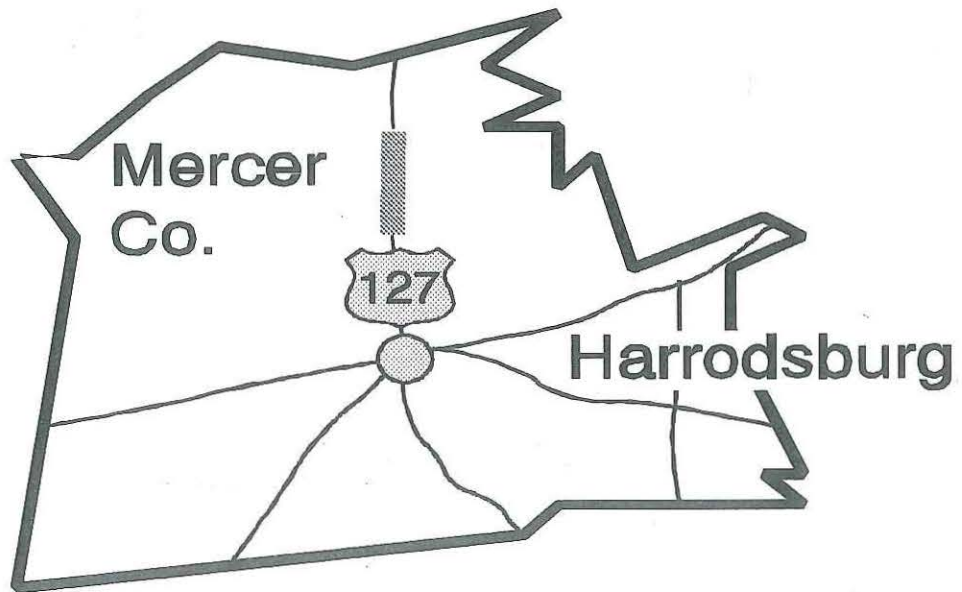


Figure 28. Location of US 127 Site in Mercer County.

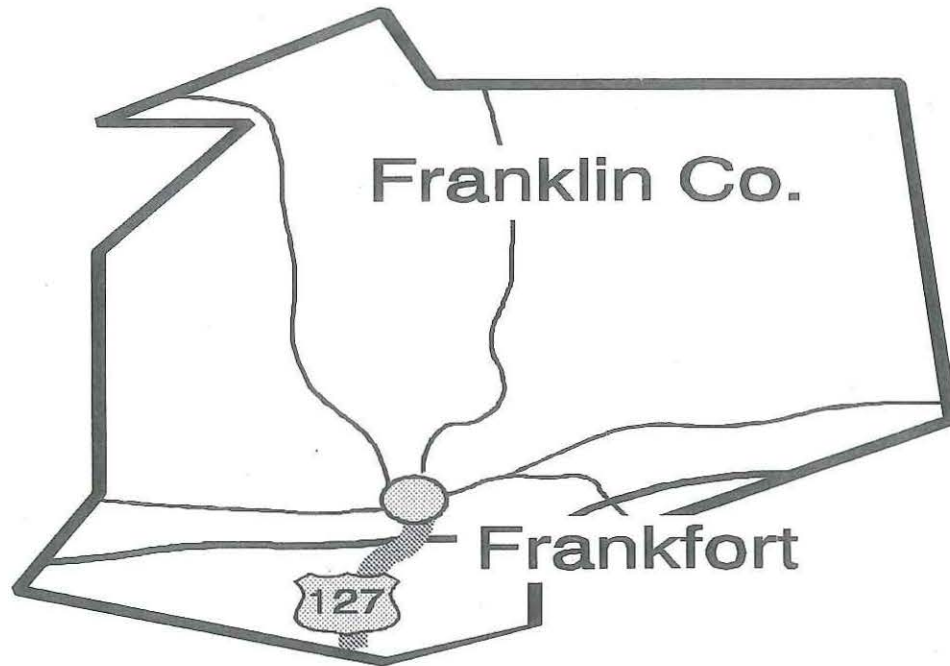


Figure 29. Location of US 127 Site in Franklin County.



Figure 30. Drainage System Outlet Plugged with Debris and Vegetation.



Figure 31. Drainage System Outlet Pipe Severed above the Headwall.



Figure 32. Drainage System Outlet Located Lower than the Ditch Line.

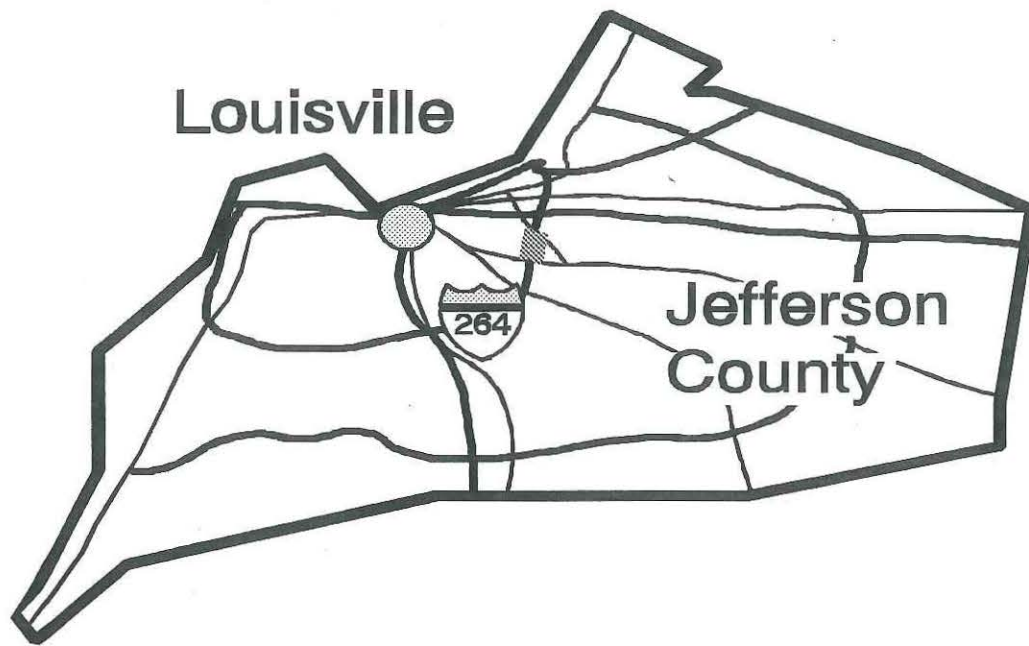


Figure 33. Location of I-264 Sites in Jefferson County.

APPENDIX A

Special Note For Drainage Blanket

SPECIAL NOTE FOR PAVEMENT DRAINAGE BLANKET

I. DESCRIPTION

This special note covers requirements for a pavement drainage blanket, constructed in accordance with the typical section specified elsewhere. The drainage blanket may be untreated, asphalt treated, or portland cement treated, as specified or permitted on the plans or in the proposal.

Section references herein are to the Department's Standard Specifications.

II. MATERIALS

A. Aggregate. Aggregate for the drainage blankets shall be crushed stone meeting the requirements of Sections 805.02 and 805.03. Size No. 57 shall be used for untreated or portland cement treated drainage blankets. Asphalt treated material shall meet the composition requirements in paragraph II.F.

B. Asphalt Cement. Asphalt cement for the drainage blanket shall be AC-20 meeting the requirements of Section 806.06.

C. Portland Cement. Portland cement shall be Type I or Type III meeting the requirements of Section 801.

D. Water Reducing Admixture. Water reducing admixture shall be Type A, D, F, or G meeting the requirements of Section 802.01.

E. Water. Water used in mixing portland cement treated material shall meet the requirements of Section 803.

F. Composition of Asphalt-Treated Mixture. The composition of asphalt treated mixture shall be as follows:

Sieve Size	Master Range % Passing by Weight
37.5 mm (1 1/2 inch)	100
19 mm (3/4 inch)	85-100
125 mm (1/2 inch)	35-65
4.75 (No. 4)	0-20
2.36 mm (No. 8)	0-10
75 m (No. 200)	0-4
JMF Asphalt Content Range	1.5-2.5%

Contrary to subsection 401.02.01, the job-mix formula tolerance for asphalt content shall be $\pm 0.5\%$. Acceptance testing will be in accordance with KM 64-405 and KM 64-406.

The Contractor shall submit aggregate samples and a proposed job mix formula to the Division of Materials for approval. The asphalt content will be established by the Engineer within the specified range, except that an increased quantity may be required for absorptive aggregate. Asphalt content will be based on visual inspection of the extent the aggregate is coated. Adjustment of payment due to adjustment of asphalt content will not be made.

After work begins, the Contractor may request adjustments in the mob-mix formula gradation if deemed necessary to increase stability of the drainage blanket, providing the revised JMF gradation and asphalt content are maintained within the specified limits.

G. Proportions for Portland Cement Treated Mixture. Mix designs shall be proposed by the Contractor and shall conform to the following requirements:

(1) Minimum compressive strength of 2.76 MPa (400 pounds per square inch) shall be attained in 72 hours \pm 6 hours. Compressive strength shall be determined in accordance with KM 64-305 except the specimen shall remain in the mold until the time of test.

(2) Cement content shall be at least 148.4 kg per cubic meter (250 pounds per cubic yard);

(3) The water/cement ratio shall not exceed 0.37; and

(4) Water reducing admixture shall be used.

The Contractor shall submit aggregate samples and a proposed cement content, and the Engineer will perform testing as necessary to determine that the proposed mix design is acceptable.

III. CONSTRUCTION REQUIREMENTS

A. General. The underlying base course or subgrade shall be constructed in accordance with specifications elsewhere in the contract. Features requiring a cure, such as chemically treated subgrades or stabilized aggregate bases, shall be completely cured before the pavement drainage blanket is placed. Each component of the drainage blanket, subsurface drainage system, and subsequent paving courses shall be constructed in accordance with the Standard Specifications and applicable special notes or special provisions, except as superseded or modified herein.

B. Untreated Drainage Blanket. The untreated drainage blanket shall be placed using self-propelled equipment that will produce a smooth, uniform layer of material ready for compaction. The material shall be compacted using a smooth-wheel roller of approximately 9.1 metric tons (10 tons). Vibrating rollers shall not be used. An offset spreader shall be used to place the drainage blanket on the shoulders, to avoid damaging or displacing the underdrain pipe. If the pipe is damaged by construction or hauling equipment it shall be replaced immediately at no cost to the Department.

The surface of the drainage blanket shall be smooth and uniform, and shall reasonably conform to the specified lines, grades, and typical section.

C. Asphalt treated Drainage Blanket. All requirements of section 401 for bituminous plant mix pavements shall apply, except as follows:

(1)Temperatures of the materials and the mixture, in degrees Celsius (degrees Fahrenheit), shall be maintained within the following ranges:

	Minimum	Maximum
Aggregate	93 (200)	127 (260)
Asphalt Cement	93 (200)	127 (260)
Mixture at Plant	93 (200)	127 (260)
Mixture when Laying	82 (180)	127 (260)

Temperature higher than those listed may cause the asphalt cement to drain from the mixture and should be avoided at all times.

(2)Minimal use of surge bins will be permitted; but, to avoid excess drainage of the asphalt cement, lengthy storage of mixed drainage blanket material (over 3 hours) will not be permitted.

(3)The drainage blanket shall be compacted using a smooth-wheel roller weighing approximately 9.1 metric tons (10 tons). Vibrating rollers shall not be used. Overrolling to the extent that aggregate particles are broken shall be avoided.

(4)The surface of the drainage blanket shall be smooth and uniform, and shall reasonably conform to the specified lines, grades, and typical section. The completed drainage blanket shall meet the surface tolerances specified in Section 401.20 for base courses. Any corrective work necessary shall be performed using hot-mixed bituminous mixtures approved by the Engineer. Procedures that might produce fine material that would tend to clog or reduce drainage will not be permitted.

(5)The asphalt treated drainage blanket shall be allowed to cure at least overnight before the subsequent course is placed.

D.Portland Cement Treated Drainage Blanket.

(1)*Plant, Mixing, and Hauling.* The batch plant, mixing procedures, and hauling equipment shall conform to the applicable requirements of either Section 302 for gravel base type III or Section 501 for portland cement concrete pavement.

(2)*Placing and Spreading.* Spreading, consolidation, and finishing equipment shall conform to the requirements of Section 501, or as otherwise approved upon demonstration of satisfactory performance on a test strip of approximately 2 508 square meters (3,000 square yards).

(3)*Compaction.* The material shall be compacted by a steel-wheeled tandem roller weighing approximately 9.1 metric tons (10 tons), unless the drainage blanket is placed by a slip form paver and the Engineer determines consolidation is acceptable without rolling. Compaction shall follow within 1/2 hour after spreading and shall consist of at least 2 complete coverages of the drainage blanket. Sufficient equipment and rollers shall be provided so that no more than 1 1/4 hours elapse between the time water is added to the combined aggregate and cement and the time final compaction is completed.

(4)*Curing.* The completed portland cement treated drainage blanket shall be cured by covering the entire surface and exposed edges with transparent or white plastic of at least 102 μ m (4 mils) thickness immediately after completion of spreading and compacting. The plastic shall be held in place by aggregate or other acceptable means for at least 3 days. Any damage occurring to the plastic during the curing period shall be immediately repaired.

(5)*Surface Finish.* The surface of the drainage blanket shall be smooth and uniform, and shall reasonably conform to the specified lines, grades, and cross section. The completed drainage blanket shall not show a deviation greater than 6.4 mm from a 3.05 m (1/4 inch from a 10-foot) straightedge, and the cross slope shall not deviate more than 4 mm in one meter (1/4 inch in 5 feet) from the specified cross slope.

Any corrective work necessary shall be performed using hot-mixed bituminous mixtures approved by the Engineer. Procedures that might produce fine material that would tend to clog or reduce drainage will not be permitted.

(6) *Weather Limitations and Protection.* Unless otherwise authorized in writing, mixing and placing the portland cement treated material shall be discontinued when a descending air temperature in the shade and away from artificial heat reaches 10°C (50°F) and shall not be resumed until an ascending air temperature reaches 7°C (45°F).

E. Bituminous Concrete Pavement.

(1) *Untreated Drainage Blanket.* When bituminous concrete pavement is constructed on an untreated drainage blanket, the first course shall be placed using a paver mounted on tracks, to minimize displacement of the drainage blanket. One or more rollers shall be operated on the drainage blanket ahead of the paver, to repair and recompact any portion of the drainage blanket displaced by hauling equipment. A grader shall be furnished if needed.

The first course of bituminous concrete base placed on an untreated drainage blanket shall be compacted to the extent possible without damage in the judgment of the Engineer, but density requirements are waived. Density requirements as specified in Section 403.04(B) shall apply to all subsequent courses of bituminous concrete base.

Contrary to Section 403.05 of the Standard Specifications, thickness of the bituminous concrete base will be controlled by controlling the rate of application when constructed on an untreated drainage blanket. The mixture shall be placed at the weight per square yard designated by the plans or proposal, or by the Engineer. The rate of application shall not exceed the designated rate by more than 5 percent. No payment will be made for any material placed in excess of this 5 percent tolerance.

The first course shall be allowed to cure for 7 days before placing the succeeding course, unless the Engineer shortens the required time due to rainy and/or cool weather. In all cases, at least 3 days curing will be required.

Extreme caution must be taken with the first course of bituminous concrete base placed on the shoulders to avoid damage to the underdrain pipe.

(2) *Treated Drainage Blankets.* When bituminous concrete pavement is constructed on a treated drainage blanket, the first course shall be placed using a paver mounted on tracks if rubber tired pavers cause displacement of the drainage blanket.

Compaction of bituminous concrete base shall be as specified in Section 403.04(B), or in accordance with other requirements that may be specified in the proposal.

The first course of bituminous concrete shall be allowed to cure overnight before placing the succeeding course.

Thickness of bituminous concrete base placed on treated drainage blankets shall conform to the requirements of Subsection 403.05.02.

Extreme caution shall be exercised when placing bituminous concrete near or over underdrains, to avoid displacing or damaging the drain.

F. Portland Cement Concrete Pavement. When portland cement concrete pavement is constructed on an untreated drainage blanket, it shall be placed by the slip form process, unless otherwise specified or permitted. Offset equipment shall be used to construct pcc shoulders.

PCC pavement constructed on a treated drainage blanket shall be constructed in reasonably close conformity with the specified lines, grades, and cross section without damage to the drainage blanket or underdrain system.

Anchor hooks used to anchor load transfer assemblies shall be of sufficient length to extend through the drainage blanket and hold the assemblies securely in place.

G. Maintenance and Protection. Traffic over the drainage blanket shall be limited to the minimum necessary for succeeding or adjacent work. Contamination of the drainage blanket by dust, dirt, or mud shall not be allowed; portions of the blanket contaminated to the extent that drainage is clogged or reduced shall be removed and replaced, at no additional cost to the Department.

It is important that the integrity of the subgrade, base courses, perforated pipe, pavement drainage blanket, and the subsequent paving course(s) be preserved; therefore, the gross weights and types of hauling vehicles shall be controlled so no component is damaged by hauling for construction of the next component.

At no time shall trucks or other equipment operate longitudinally directly over the perforated pipe.

Repair of damage to any of the various items, except damage caused by public traffic, shall be acceptably repaired at no cost to the Department.

IV. METHOD OF MEASUREMENT

The quality of Pavement Drainage Blanket of each type acceptably placed, compacted, and maintained until covered will be weighed in metric tons (tons) in accordance with Section 109 of the Standard Specifications. Bituminous mixtures used for leveling the surface of the completed drainage blanket will be measured in metric tons (tons) as Pavement Drainage Blanket. Measurement and payment for all other items of work will be as specified elsewhere in the contract.

V. BASIS OF PAYMENT

The accepted quantity of Pavement Drainage Blanket of each type will be paid for at the contract unit price per metric ton (ton), which shall be full compensation for all materials, equipment, labor, and incidentals required to construct the drainage blanket. Basis of payment of all other items will be as specified elsewhere in the contract.

No additional payment will be made for any special or extra work necessary in construction of the project due to the drainage blanket.

Payment will be made under:

<i>Pay Item</i>	<i>Pay Unit</i>
Drainage Blanket-Type I (Untreated)	Metric Ton or Ton
Drainage Blanket-Type II (Asphalt Treated)	Metric Ton or Ton
Drainage Blanket-Type III (Cement Treated)	Metric Ton or Ton

Appendix B
Design Sections of AA Highway

SECTION AA C1 AS BUILT

FROM: I 275 AND KY.RT. 9 INTERCHANGE
TO: 117' E. OF MURNAN RD.

SUBGRADE	UNCLASSIFIED
STABILIZATION	6" LIME - 5%
DRAINAGE BLANKET	4" ASPHALT TREATED
BIT. BASE	8 1/2" CLASS I
BINDER	1 1/2" CLASS I
SURFACE	1" CLASS K
EDGE DRAIN	4" PERF PIPE WITH FABRIC & SOCK

SECTION AA C2 AS BUILT

FROM: 117' E. OF MURNAN RD.
TO: 1896' W. OF EAST ALEXANDRIA PIKE

SUBGRADE	UNCLASSIFIED
STABILIZATION	6" LIME - 5%
FILTER FABRIC	GEOTEXTILE TYPE 3
DRAINAGE BLANKET	4" ASPHALT TREATED
BIT. BASE	8 1/2" CLASS I
BINDER	1 1/2" CLASS I
SURFACE	1 1/4" CLASS A
EDGE DRAIN	4" PERF PIPE WITH FABRIC & SOCK

SECTION AA C3 AS BUILT

FROM: 1896' W. OF EAST ALEXANDRIA PIKE
TO: 117' W. OF FOUR MILE ROAD

SUBGRADE	UNCLASSIFIED
STABILIZATION	6" LIME - 5%
DRAINAGE BLANKET	4" ASPHALT TREATED
BIT. BASE	8 1/2" CLASS I
BINDER	1 1/2" CLASS I
SURFACE	1" CLASS A
EDGE DRAIN	4" PERF PIPE WITH FABRIC & SOCK

SECTION AA B1-B2 AS BUILT

FROM: 117' W. OF FOUR MILE ROAD
TO: 700' E. OF KY. 1997

SUBGRADE	UNCLASSIFIED
STABILIZATION	6" LIME - 5%
DRAINAGE BLANKET	4" ASPHALT TREATED
BIT. BASE	8 1/2" CLASS I
BINDER	1 1/2" CLASS I
SURFACE	1" CLASS K
EDGE DRAIN	4" PERF PIPE WITH FABRIC & SOCK

SECTION AA B3-B4 AS BUILT

FROM: 700' E. OF KY. 1997

TO: KY. 1996

SUBGRADE	UNCLASSIFIED
STABILIZATION	6" LIME - 5%
DRAINAGE BLANKET	4" ASPHALT TREATED
BIT. BASE	8 1/2" CLASS I
BINDER	1 1/2" CLASS I
SURFACE	1" CLASS K
EDGE DRAIN	4" PERF PIPE WITH FABRIC & SOCK

SECTION AA 6A AS BUILT

FROM: KY. 1996

TO: 4900' W. OF GUBSER MILL RD.

SUBGRADE	UNCLASSIFIED
STABILIZATION	9" LIME - 4%
DRAINAGE BLANKET	4" ASPHALT TREATED
BIT. BASE	8 1/2" CLASS I
BINDER	1 1/2" CLASS I
SURFACE	1" CLASS K
EDGE DRAIN	4" PERF PIPE WITH FABRIC & SOCK

SECTION AA 6 AS BUILT

FROM: 4900' W. OF GUBSER MILL RD.

TO: 200' E. OF WASHINGTON TRACE RD.

SUBGRADE	UNCLASSIFIED
STABILIZATION	9" LIME - 4%
DRAINAGE BLANKET	4" ASPHALT TREATED
BIT. BASE	8 1/2" CLASS I
BINDER	1 1/2" CLASS I
SURFACE	1" CLASS K
EDGE DRAIN	4" PERF PIPE WITH FABRIC & SOCK

SECTION AA 7-8 AS BUILT

FROM: 200' E. OF WASHINGTON TRACE RD.

TO: 2300' W. OF PUMP STATION RD.

SUBGRADE	UNCLASSIFIED
BASE	4" STABILIZED AGGREGATE
DRAINAGE BLANKET	4" AGGREGATE NO. 57
BIT. BASE	9" CLASS I
BINDER	1 1/2" CLASS I
SURFACE	1" CLASS K
EDGE DRAIN	4" PERF PIPE WITH FABRIC & SOCK

SECTION AA 9-10 AS BUILT

FROM: 2300' W. OF PUMP STATION RD.
TO: 3400' E. OF KY. 1109

SUBGRADE	UNCLASSIFIED
BASE	4" STABILIZED AGGREGATE
DRAINAGE BLANKET	4" ASPHALT TREATED
BIT. BASE	2 1/2" CLASS I
BINDER	1 1/2" CLASS I
SURFACE	1" CLASS A
EDGE DRAIN	4" PERF PIPE WITH FABRIC & SOCK

SECTION AA 11-12 AS BUILT

FROM: 3400' E. OF KY. 1109
TO: 1844

SUBGRADE	UNCLASSIFIED
BASE	STABILIZED AGGREGATE
DRAINAGE BLANKET	4" ASPHALT TREATED
BIT. BASE	7" CLASS I
BINDER	1 1/2" CLASS I
SURFACE	1" CLASS A
EDGE DRAIN	4" PERF PIPE WITH FABRIC & SOCK

SECTION AA 12 AS BUILT

FROM: 1844
TO: KY. 19

SUBGRADE	UNCLASSIFIED
STABILIZATION	6" LIME - 6%
DRAINAGE BLANKET	4" ASPHALT TREATED
BIT. BASE	7" CLASS I
BINDER	1 1/2" CLASS I
SURFACE	1" CLASS A
EDGE DRAIN	4" PERF PIPE WITH FABRIC & SOCK

SECTION AA 13-14 AS BUILT

FROM: KY. 19
TO: INTERSECTION WITH EXISTING KY. 10
6092' E. OF KY. 435

SUBGRADE	UNCLASSIFIED
BASE	4" DGA
BIT. BASE	8" CLASS I
BINDER	1 1/2" CLASS I
SURFACE	1" CLASS K
EDGE DRAIN	MONSANTO DRAINAGE MAT

SECTION 15B-16 AS BUILT

FROM: INTERSECTION WITH EXISTING KY. 10
8676' W. OF US 68
TO: KY. 1449

SUBGRADE	UNCLASSIFIED
BASE	4" DGA
BIT. BASE	8" CLASS I
BINDER	1 1/2" CLASS I
SURFACE	1" CLASS K
EDGE DRAIN	4" PERF PIPE W/FABRIC

SECTION 17-18 AS BUILT

FROM: KY. 1449
TO: 440' W. OF KY. 57

SUBGRADE	UNCLASSIFIED
STABILIZATION	6" LIME - 6%
BASE	4" DGA
BIT. BASE	8" CLASS I
BINDER	1 1/2" CLASS I
SURFACE	1" CLASS K
EDGE DRAIN	4" PERF PIPE W/FABRIC

SECTION 19 AS BUILT

FROM: 440' W. OF KY. 57
TO: 2072' W. OF RIBOLT RD.

SUBGRADE	UNCLASSIFIED
STABILIZATION	6" LIME - 6%
BASE	4" DGA
BIT. BASE	8 1/2" CLASS I
BINDER	1 1/2" CLASS I
SURFACE	1" CLASS K

SECTION 20 AS BUILT

FROM: 2072' W. OF RIBOLT RD.
TO: INTERSECTION WITH EXISTING KY. 10
7600' E. OF POPLAR FLAT RD.

SUBGRADE	24" ROCK ROADBED
BASE	4" DGA
BIT. BASE	6 1/2" CLASS I
BINDER	1 1/2" CLASS I
SURFACE	1" CLASS K

SECTION 21A AS BUILT

FROM: INTERSECTION WITH EXISTING KY. 10
8500' W. OF HAZEL BRANCH RD.
TO: 180 E. OF KY. 59

SUBGRADE	12" CEMENT 10%
DRAINAGE BLANKET	4" ASPHALT TREATED
BIT. BASE	4 1/2" CLASS I
BINDER	1 1/2" CLASS I
SURFACE	1" CLASS K

SECTION 21B-22 AS BUILT

FROM: 180 E. OF KY. 59
TO: 65' E. OF KY. 1149

SUBGRADE	24" ROCK ROADBED
DRAINAGE BLANKET	4" DGA
BIT. BASE	6" CLASS I
BINDER	1 1/2" CLASS I
SURFACE	1" CLASS K

SECTION 23 AS BUILT

FROM: 65' E. OF KY. 1149
TO: 11,125' W. OF SPY RUN RD.

SUBGRADE	24" ROCK ROADBED
BASE	4" CRUSHED STONE
BIT. BASE	6" CLASS I
BINDER	1 1/2" CLASS I
SURFACE	1" CLASS K

SECTION 24 AS BUILT

FROM: 11,125' W. OF SPY RUN RD.
TO: 1127' E. OF SPY RUN RD.

SUBGRADE	12" ROCK ROADBED
BASE	4" DGA
BIT. BASE	6" CLASS I
BINDER	1 1/2" CLASS I
SURFACE	1" CLASS I

SECTION 25 AS BUILT

FROM: 1127' E. OF SPY RUN RD.
TO: 3715' E. OF GREENBRIER HOLLOW RD.

SUBGRADE	24" ROCK ROADBED
BASE	4" D G A
BIT. BASE	6" CLASS I
BINDER	1 1/2" CLASS I
SURFACE	1" CLASS K

SECTION 26 AS BUILT

FROM: 3715' E. OF GREENBRIER HOLLOW RD.
TO: 3463' E. OF MONTGOMERY CREEK RD.

SUBGRADE	24" ROCK ROADBED
BASE	4" DGA
BIT. BASE	6" CLASS I
BINDER	1 1/2" CLASS I
SURFACE	1" CLASS I

TABLE A. Plant Gradation Specimens

SPECIMEN IDENTIFICATION	DENSITY (lbs/ft ³)	MINIMUM FLOW RATE (ft/day)	MAXIMUM FLOW RATE (ft/day)
#8'S CEMENT TREATED	114.5	5,996	6,204
#8'S ASPHALT TREATED	105.1	6,313	7,035
#8'S UNTREATED	95.6	9,019	9,228
#610'S CEMENT TREATED	120.2	621	801
#610'S UNTREATED	107.4	1,743	1,899
SAND	120.2	72	72
#68'S CEMENT TREATED	110.6	6,568	6,817
#68'S ASPHALT TREATED	101.9	11,040	11,375
#68'S UNTREATED	103.3	12,496	12,680
#8'S NS PC BOUND	102.4	8,594	9,098
#8'S NS GLACIER GRAVEL	99.9	7,960	8,548
#8'S NS UNTREATED	98.0	9,943	10,192

TABLE B. Recombined Specimens

SPECIMEN IDENTIFICATION	DENSITY (lbs/ft ³)	MINIMUM FLOW RATE (ft/day)	MAXIMUM FLOW RATE (ft/day)
#8'S FINER	107.8	5,282	5,438
#8'S CENTER	102.2	8,069	8,197
#57'S FINER	106.6	13,556	13,940
#57'S CENTER	100.1	13,827	14,523
#610'S FINER	113.7	4,368	4,498
#610'S CENTER	117.8	4,301	4,577
#67'S FINER	108.1	9,965	10,167
#67'S CENTER	106.4	11,858	12,217
#68'S FINER	111.2	5,830	6,079
#68'S CENTER	109.0	8,895	9,178
#710'S FINER	105.7	7,809	7,915
#710'S CENTER	104.8	10,120	10,523
#78'S FINER	109.0	5,783	5,955
#78'S CENTER	105.8	8,552	8,761
#57'S CEMENT DRAINAGE BLANKET	97.5	25,399	26,937
#57'S ASPHALT DRAINAGE BLANKET	106.1	10,105	10,799