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July 6, 1972

H.2.24

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

SUBJECT: Research Report No. 331; "Skid Resistance of Pavements;" KYHPR-64-24; HPR-1(8), Part II

Our studies of pavement slipperiness seem unending. Significant improvement in the skid resistance of pavements has not been achieved. In fact, it appears that increasing traffic has magnified the problem. Studded tires have surely increased wear. Evidences of critical friction factors continue to mount. The development of skid-resistant surface courses to operational status has become more and more compelling.

It remains intuitively apparent to me that sand asphalts containing angular quartz sands offer the best, general recourse. The Rockcastle (Sharon), Buffalo, and other conglomerates are indigenous sources. The Rockcastle deposits and their western equivalents are more widespread and abundant in Kentucky than was realized heretofore. Crushed products are most desirable. Special Provision 59-B is advocated.

The report submitted herewith presents skid-resistance histories of the respective pavement types and materials in Kentucky. The analyses have been ordered according to highway classification, cumulative traffic, and test speed. The surface types which are now more or less standard diminish to marginal levels of skid resistance after about 3 to 5 million vehicles pass.

Peak (limited slip) skid numbers are significantly higher than locked-wheel values. It appears that greater stopping traction may be obtained with braking devices which prevent lockup. The report presents a brief discussion of this possible advantage in terms of stopping distance.

I submit into record some further conjectures and hypotheses, as follows:

Apparently, tread rubber in contact with the pavement undergoes tangential shear (strain) in some proportion to the tractive force. Others have noted that the tire print is displaced rearward during braking. Surely, the rubber strains considerably; this strain and recoil probably accounts for the squeal of tires on dry pavements. Thick treads would stretch or elongate more than thin treads. In a locked-wheel slide, the same tire print is being stretched and torn continuously. However, if the wheel is merely braked, the velocity of the vehicle at any instant must be the sum of the rolling velocity (rps x circumference of wheel), the true slip velocity, and that portion attributable to stretching in the tread. If the average or effective elongation is 1.25 times, this component of velocity is proportional to rps of the wheel and may be stated as a percentage of vehicle velocity if there is no slip. In this instance, it would be 13% -- that is, (1.00 - 1/1.25) x 100; 1.5 times stretching or elongation would account for 33.3% of the vehicle velocity. In any case, it seems very possible that the peak coefficient of friction (PSN/100) is also decomposable into components. The tractive resistance of the tire tread may be stated as: shear strain in the rubber x shear modulus of rubber x real contact area. This product divided by the normal force W yields a coefficient of friction. The real contact area on a dry, fine-textured surface is here considered to be a very high percentage of the apparent area; the apparent area is approximated by W/P_a, where P_a is the tire pressure. The equation hypothesized corrects for hydrodynamic or air pressure (P_h) at the interface, as follows:

$$PSN/100 = f = (\epsilon_s \times E_s \times W/P_a)\,(1 - P_h/P_a)\,/\,W$$

ϵ_s = shear strain = 1.215 in./in./in. (maximum, deduced for f = 1)
E_s = 24.65 lbs./in.^{2} (handbook value)

First, let $P_h = 0$, and $P_a = 30$ psi; W = 1000 lbs.:

$$PSN/100 = f = 1.215 \times 24.65 \times 0.033$$

$$PSN/100 = f = 1$$

Let $P_h = 15$ psi:

$$PSN/100 = f = 1.215 \times 24.65 \times 0.033 \times 0.5 = 0.5$$

The limiting value of shear strains, above, was deduced for f = 1. Assuming a tread thickness of 1/3 inch, the effect on vehicle velocity, assuming no slip, 1/3 x 1.215, or 0.405, or (1 - 1/1.405) x 100 = 29.8%. This hypothesis implies that for peak friction to develop any contact between tread rubber and the pavement surface induces maximum shear in the tread rubber in the contact area. All traction is lost when $P_h = P_a$.

Some related research activities might be mentioned also, as follows:

1. A separate report addressing the technical aspects of skid testing is pending.
2. A report on correlations between accident frequencies and skid resistance will be forthcoming in the near future. The analyses embrace the entire, rural interstate and parkway network in Kentucky.
3. Significant wear (in order of 1/4 inch) in the wheel tracks has been measured on I 75, from I 71 northward to the Ohio River.
4. Undue slipperiness developed while overlaying I 75, in Madison County, during June. Over densification and flushing occurred under immediate traffic. Adjustments were made in the mixture. A 1.3-mile section south of Clays Ferry was deslicked with sand asphalt.
5. FHWA is currently considering issuing minimum standards for skid resistance.

Respectfully submitted,

Jas. H. Havens

Jas. H. Havens
Director of Research

JHH/dw
Attachment
cc's: Research Committee

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16. Abstract

Standard pavement types and experimental surfaces on roads throughout Kentucky were evaluated in terms of skid resistance and effects of traffic, wear, and polishing. Friction-vs-speed gradients and the relationships between locked-wheel and incipient friction were determined. Class I bituminous pavements on high-speed, four-lane roads were found to be significantly more skid resistant than on two-lane highways and somewhat more skid resistant than concrete surfaces (especially those containing calcareous gravel aggregates). Sand-asphalt surfaces containing significant proportions of limestone sands showed inadequate level of friction for the traffic sustained. Several experimental sand asphalts without limestone sands exhibited greater skid resistance; Kentucky rock asphalt surfaces remain the most skid resistant of all surfaces investigated.

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SKID RESISTANCE OF PAVEMENTS

INTERIM REPORT
KYHPR-64-24; HPR-1(8), Part II

by

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Commonwealth of Kentucky

in cooperation with the
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INTRODUCTION

Traffic polishes all pavements; all pavements wear and weather. The development of slipperiness and loss of friction (traction) is closely associated with cumulative traffic. The loss of traction is most severe during the first few years. After five or six million vehicle passes, the friction value tends to stabilize. Judgements of performance of pavements are based on mature values. Some types or surface treatments, however, may exhibit low skid resistance earlier. This report presents performance histories and analyses of standard and experimental surfaces.

No single mode of testing, such as locked wheel sliding or peak friction at critical percent slip (8 to 20 percent), completely describes the traction available to a vehicle. Kentucky trailer measurements *(1)* provided both locked-wheel skid resistance, expressed as Skid Numbers, SN, and peak slip resistance, expressed as Peak Slip Number, PSN. Skid resistance of pavements decreases as speed increases; material textural differences amongst pavements result in differing friction-vs-speed relationships. Measurement at a single test speed does not fully characterize a surface. The ASTM E-274-70 standard test speed is 40 mph; at least three test speeds are needed for research purposes. By choice, tests were made at 20, 40, and 60 mph. Where the speed limit was 70 mph, this higher test speed was used. The peak slip resistance at these speeds may be a better indicator of traction available to vehicles during acceleration, deceleration, and perhaps in cornering and passing maneuvers. However, in panic braking where the driver locks wheels and skids, the Skid Number more closely reflects available traction, and it may be useful in ascertaining stopping distances or speed reduction prior to collision. Obviously, overall evaluation of pavements is not a simple task.

A previous report *(2)*, issued in March 1970, discussed the polishing characteristics of various pavements and deslicking and surface treatments used in Kentucky. Several pavement types have been monitored continually. All data are presented in the Appendix.

CLASS I BITUMINOUS CONCRETE

Limestone remains the predominant coarse aggregate in surface courses. Most, if not all, limestones are susceptible to polishing. Surface courses contain limestone coarse aggregate and natural or conglomerate sand in the proportion of not less than 40 percent of the combined aggregate. Natural sand is defined in Section 611 of the **Standard Specifications...***(3)*. Mineral composition, gradation and particle-shape requirements for sand, however, were not specified. The evolutionary refinements in the design for bituminous surface-course mixtures were reported in September 1966 *(4)*.

In-service performance of Class I, Type A, and Type A, Modified surfaces on US and KY routes is shown in Figure 1. Only 40-mph test data are shown. The cumulative traffic per lane was calculated from ADT data. No weighting factors for trucks as opposed to automobiles were considered.

Scatter of data, on the basis of available information, could not be explained. Percentages of various aggregates and asphalt contents bore no relationship to deviations from the regression curve. Practically all of the surfaces contained the following:

Intermediate Grade Limestone (No. 9 or No. 8)	40%
Limestone Filler	20%
Natural, Siliceous Sand	40%
Asphalt Content	5.3% — 5.6%

A few surfaces varied in relative proportions of the two limestones, but all contained at least 40 percent natural (river or pit) sand. These sands usually contained a large percentage of well-rounded particles.

Performance of Class I, Type A and Type B, Modified (six projects) surfaces on interstate and parkway roads is shown in Figure 2. At 70 mph, and for the same cumulative traffic, lower values were found in the outer lanes. Traffic density appears to be the affecting factor. A limited number of these projects was tested at 40 mph to obtain a relationship between the two test speeds. An equivalent SN_{40} curve, derived from the correlation given in Figure 3, is also shown in Figures 1 and 2. Surprisingly, the SN_{40} values interpolated from Figure 3 failed to match the SN_{40} values measured on two-lane roads. These differences are shown in Figure 1. No satisfactory explanation for the differences has been found. Inaccuracy of ADT information, density and composition of traffic, environmental factors, and variables associated with the test may obscure the precise influence of traffic. Hardness and wear characteristics of limestone and(or) sand aggregates from different sources most likely affected the skid resistance to some extent. The possibility remains that the style of road is the most important factor.

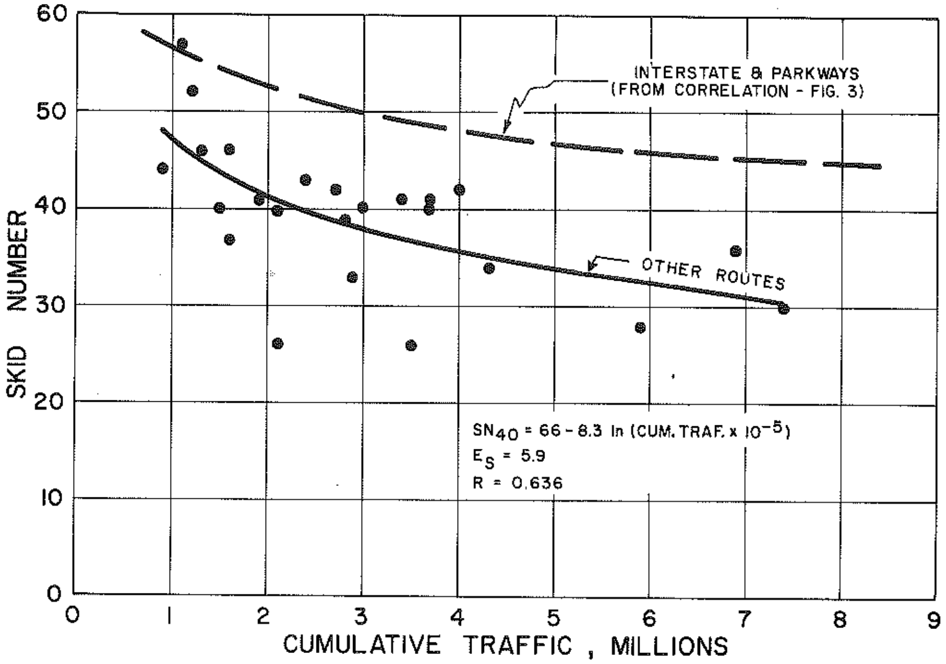


Figure 1. Effect of Traffic on Class I, Type A, Bituminous Surfaces; US and KY Routes.

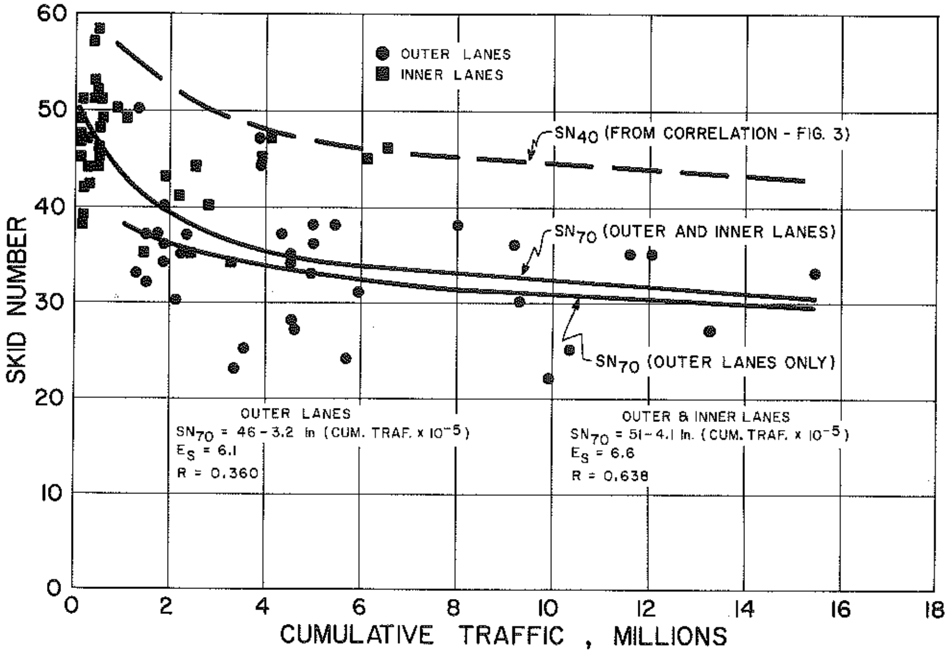


Figure 2. Effect of Traffic on Class I, Type A and Type B (Modified), Bituminous Surfaces; Interstate and Parkway Routes.

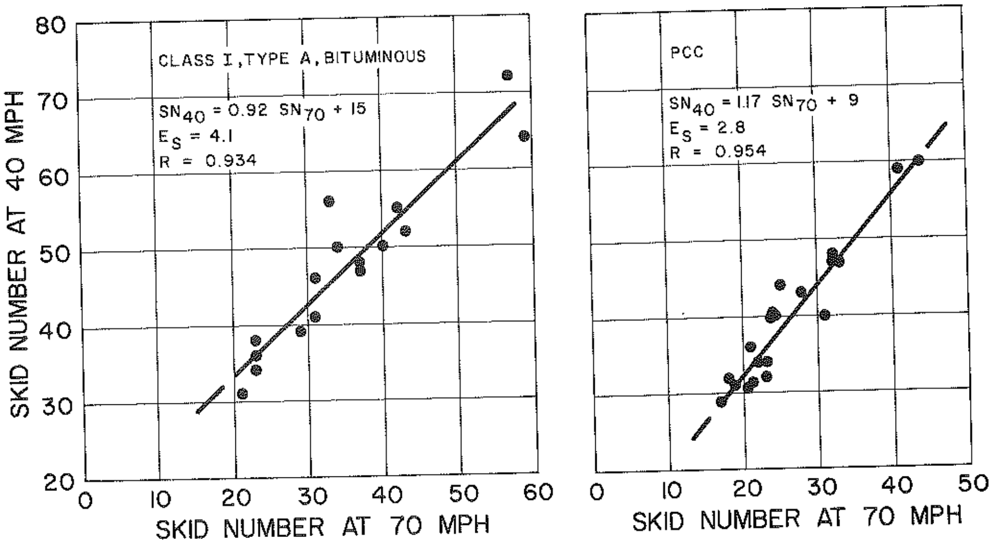


Figure 3. **Correlation of Trailer Tests Conducted at 40 mph and 70 mph on Bituminous and PCC Pavements; Interstate and Parkway Routes.**

Changes in friction with test speed are shown in Figure 4. The slopes of the lines are referred to as the speed gradient, G, expressed as change in SN per velocity increment. The smaller the G value, the less the reduction in skid resistance with increasing speed. In the increment between 40 mph and 60 mph, the average G was approximately 0.4, a loss of about 8 Skid Numbers.

Peak Slip Number has been defined previously. Figure 5 shows the measured SN and its corresponding PSN for three test speeds. Separate regression lines were required for each speed. The correlation between these values was rather good, but the data shows considerable scatter as reflected by the standard error of estimate (E_s). Figure 6 was constructed from the regression equations. Friction values were converted to PSN/SN, and equal-SN curves were drawn. This graph clearly demonstrates a proportionally higher PSN associated with the lower SN values. Moreover, for a given SN value, the PSN increased with speed. The full significance of this finding is not understood. It appears that a percentage of slip is equivalent to a percentage reduction in speed in the skid mode. For instance, 12 percent slip at 60 mph is equivalent to about 7 mph in the skid mode and 53 mph free running. These may be viewed as vector components of the velocity. Extrapolating the speed-gradient curves (Figure 4) to 7 mph yields a value of, let us say, 70 Skid Numbers. In the case chosen, the SN_{60} was 40. Now, proceeding to Figure 5, and entering the graph with an SN_{60} of 40, 70 is found to be within the limits of the PSN correlation data. Taking the highest case from Figure 4 (SN_{60} = 55), extrapolation to 7 mph yields a PSN value of 87. For the lowest in Figure 4 (SN_{60} = 25), extrapolation to 7 mph yields an SN of 51; Figure 5 also yields these values, approximately, for the PSN.

If, indeed, the above interpretations are correct, advantages of the limited-slip method of braking would be predictable from speed gradients and percent slip at which peak traction occurs. Presumably, a limited-slip braking system would shorten the stopping distance and would probably reduce side slips, also.

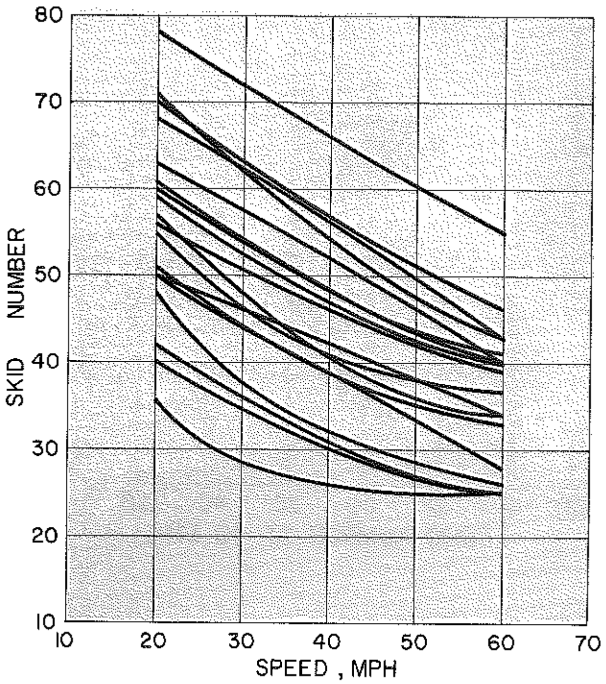


Figure 4. **Effect of Speed on Skid Resistance of Class I, Type A, Bituminous Pavements.**

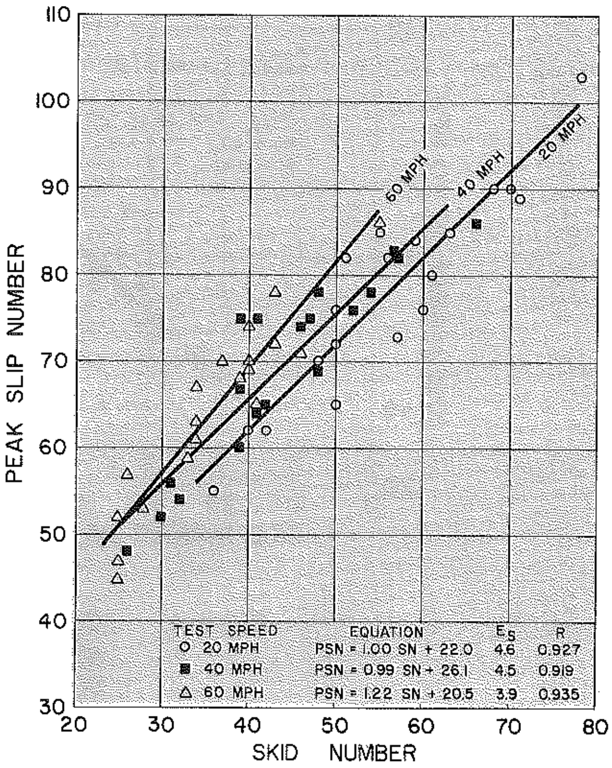


Figure 5. **Relationship between Peak Slip Number and Skid Number of Class I, Type A, Bituminous Pavements.**

KENTUCKY ROCK ASPHALT

Eleven paving projects, constructed in 1966 and 1967 under Special Provisions No. 24 and 24-A, were monitored for skid resistance. A discussion and description of Kentucky rock asphalt surfaces are given in an August 1968 report *(5)*. Performance of these surfaces is shown in Figure 7. Reduction in skid resistance with cumulative traffic is apparent. The surfaces are smooth but rather porous (about 12 percent voids). The relationship between skid resistance and speed is shown in Figure 8. The speed gradient is approximately 0.6 (40 mph to 60 mph). Figure 9 shows the SN data and corresponding PSN's. There was no increase in PSN/SN (Figure 6) as the speed increased. However, Figure 9 indicates that the loss of traction in the slip mode is almost uniquely constant, regardless of speed. This may mean that no hydraulic influences (hydroplaning) are present.

PORTLAND CEMENT CONCRETE

Limestone was used as coarse aggregate in most concrete pavements. Projects on I 75 in the northern Kentucky area and projects on I 71, however, contained crushed, calcareous, glacial gravel. Fine aggregates were natural sand, comprising 34 to 40 percent of combined solid volume of the fine and coarse aggregate. Gradations and quality requirements are given in Section 611 of the **Standard Specifications...** *(3)*.

In 1970, the latest available data, as presented in the Appendix, were used to prepare Figure 10. All but one were on interstate and parkway roads. Most were tested in 1970, but some were tested in 1969. The ADT's on some segments were quite high. In some instances both inner and outer lanes were tested. Measurements in the inner lanes did not deviate from performance trends of the outer lanes. Pavements containing gravel coarse aggregate were found to be less skid resistant at 40 mph than those containing limestone aggregate.

In 1971, the entire interstate and parkway systems were tested at 70 mph, and these results are presented in Figure 11. Several sections were also tested at 40 mph to obtain a relationship between the two speeds. These data were included in Figure 3. An equivalent SN_{40}-curve is shown in Figure 11. The 70-mph performance of pavements on I 75 containing crushed gravel appeared to be comparable to other sections containing limestone. However, the northernmost projects had posted speed limits of 50 mph and 60 mph and, therefore, perhaps greater weight should be given to the 40-mph curve shown in Figure 10. The I 71

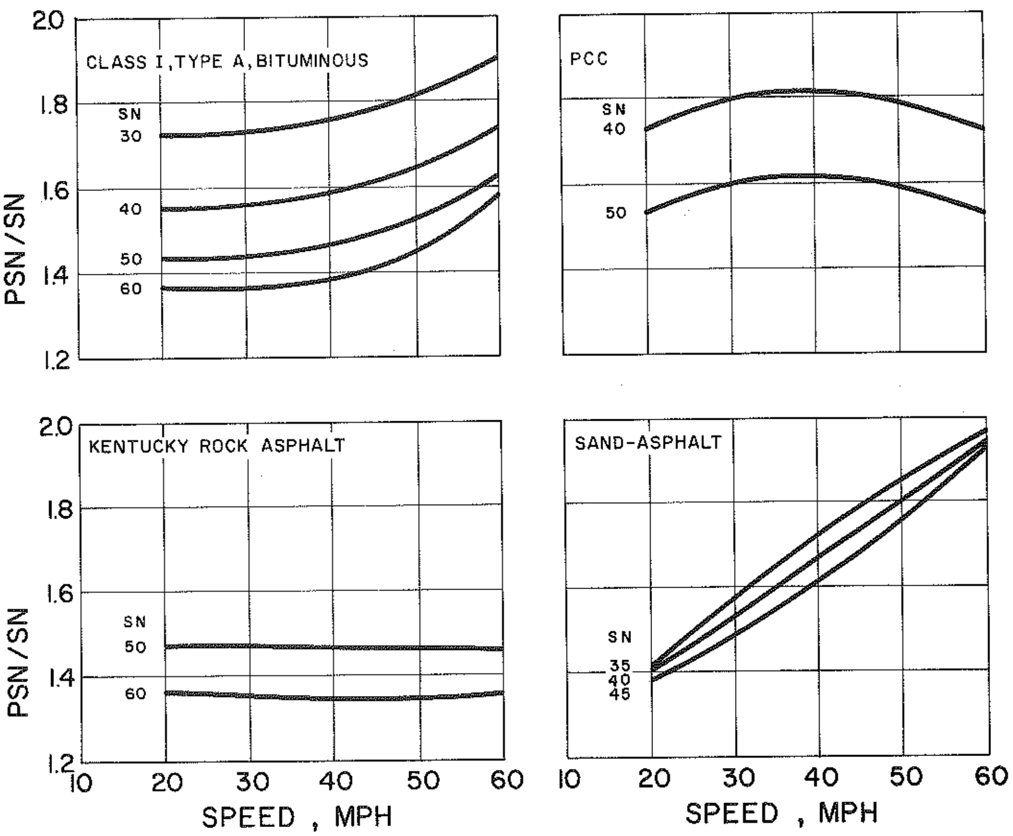


Figure 6. Relationship between PSN/SN and Speed; Several Skid Numbers.

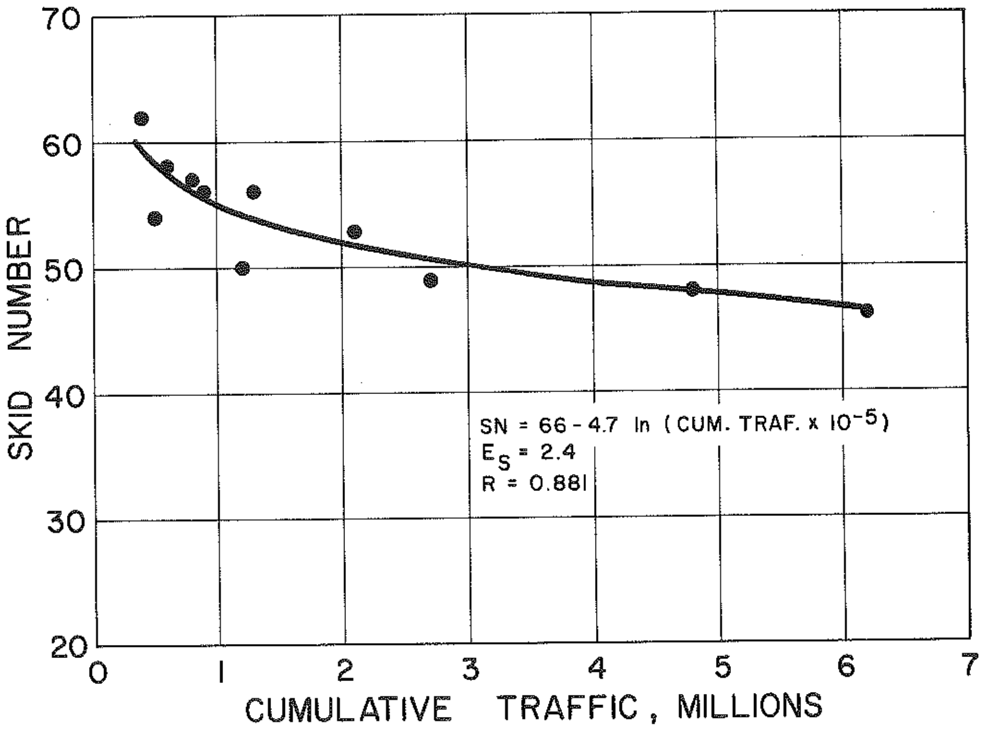


Figure 7. Effect of Traffic on Skid Resistance of Kentucky Rock Asphalt Surfaces.

concrete pavements, all constructed with calcareous glacial gravel, exhibited low skid resistance very early. Several sections of the highway should be considered slippery when wet. Visual inspection of the surfaces revealed a predominance of well-rounded and polished gravel particles exposed and protruding above the matrix.

Speed gradients for several concrete pavements are shown in Figure 12. The surfaces exhibited similar textural characteristics, and the average G was approximately 0.5. The relationships between PSN and SN are shown in Figure 13. The equal-SN curve in Figure 6 shows a peculiar hump at a test speed of 40 mph and may be due to scatter and the limited data available for analysis.

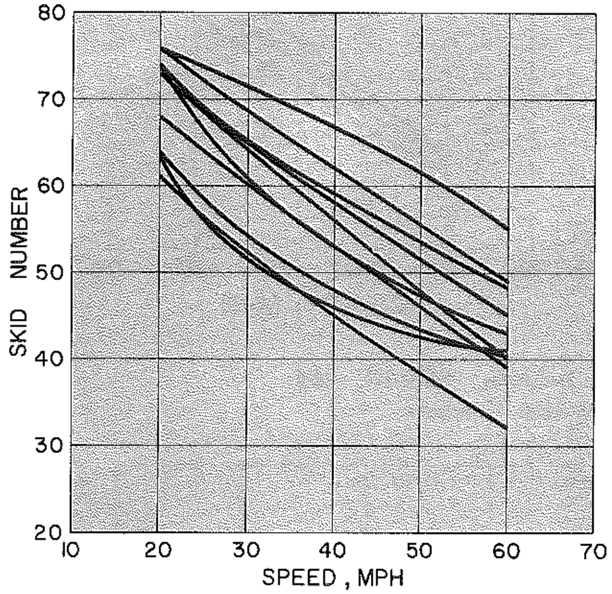
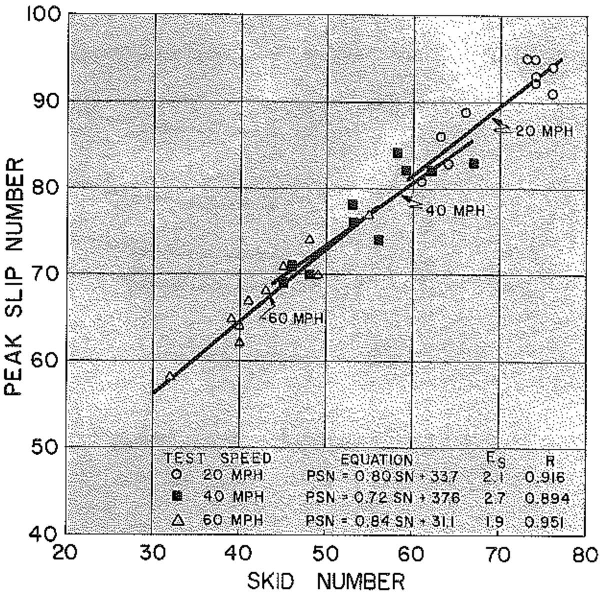


Figure 8. **Effect of Speed on Skid Resistance of Kentucky Rock Asphalt Pavements.**



TEST SPEED	EQUATION	E_S	R
○ 20 MPH	PSN = 0.80 SN + 33.7	2.1	0.916
■ 40 MPH	PSN = 0.72 SN + 37.6	2.7	0.894
△ 60 MPH	PSN = 0.84 SN + 31.1	1.9	0.951

Figure 9. **Relationship between Peak Slip Number and Skid Number of Kentucky Rock Asphalt Pavements.**

SAND ASPHALT

Between 1964 and 1970, sand asphalt surfaces were constructed under Special Provisions No. 22 and No. 22-A. A discussion and description of these surfaces were given in a February 1965 report *(6)* and a later report in October 1970 *(7)*. Only rural sections of these roads were monitored. A plot of skid resistance versus cumulative traffic is presented in Figure 14. Because of the scatter of data and the limited number of projects involved, a meaningful best-fit curve could not be obtained. Chemical composition and shape of the sands used varied considerably amongst these projects. Limestone sands, especially in the larger sand size, surely diminished skid resistance. A pavement in Boone County on KY 236 has performed well after 11 million vehicle passes. The mix contained only 13 percent limestone sand. Most surfaces did not exhibit the desired level of friction for the volume of traffic sustained. Consequently, this style of sand asphalt was discontinued.

Change in skid resistance with speed (G = 0.6) is shown in Figure 15. The relationship between the two friction measurements (Figure 16) was pronouncedly speed dependent. The PSN/SN ratio significantly increased with speed (refer to Figure 6); this might be regarded as a positive attribute of the surfaces.

EXPERIMENTAL SAND-ASPHALT PROJECTS

Because of the apparent failure to obtain desired friction level with sand asphalts composed of not less than 50 percent quartz (SiO_2), five experimental surfaces were constructed on US 27 in Pulaski County. The design, construction, and performance evaluation to October 1970 may be found in a report entitled *Experimental Silica-Sand-Asphalt Surfaces (7)*. The 1.5-mile sections were tested soon after construction. Results of these tests, conducted with an automobile, were presented in a March 1970 report *(2)*. Precise conversion of friction measurements then employed and the subsequent trailer tests was not possible. Therefore,

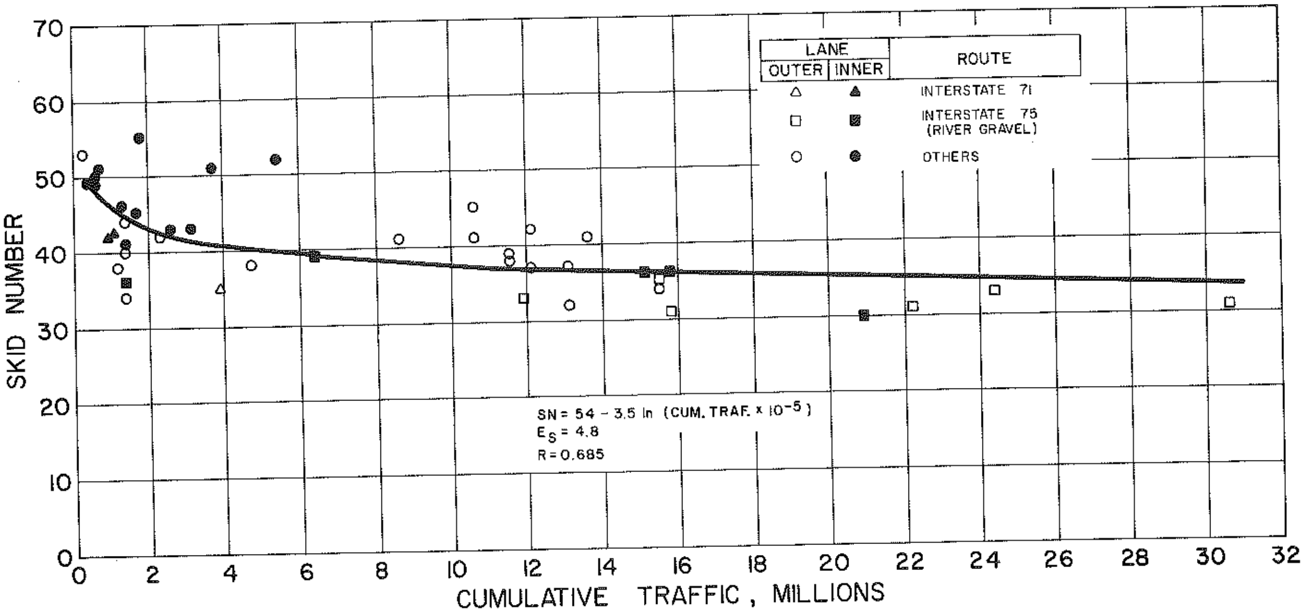


Figure 10. Effect of Traffic on Skid Resistance of PCC Pavements.

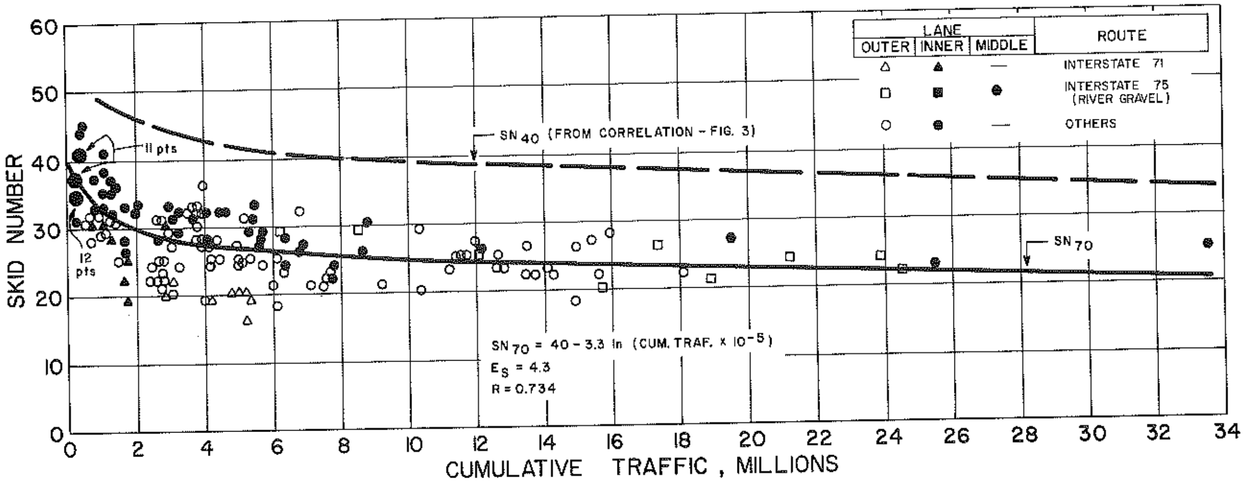


Figure 11. Effect of Traffic on Skid Resistance of PCC Surfaces; Interstate and Parkway Routes (70 mph).

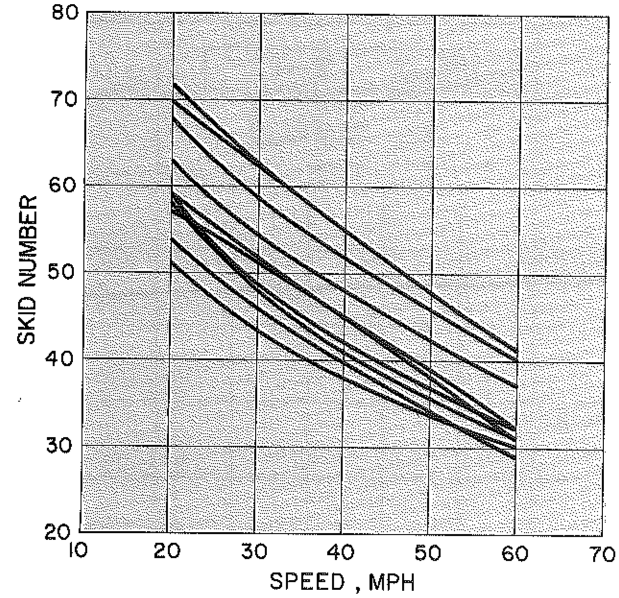


Figure 12. Effect of Speed on Skid Resistance of PCC Pavements.

performance of the surfaces since 1968, as shown in Figure 17, was based on the trailer data.

A single experimental surface, designed in accordance with a given specification and constructed with particular aggregate type available locally, introduces uncertainties as to how representative the pavement may be of a similarly designed mix placed elsewhere. Also, several other problems hindered proper evaluation of the surfaces in Pulaski County. Sections 4 and 5B were located on a rural segment of US 27 having a lower ADT than the other sections located in more congested areas near Somerset. Limestone aggregate used later to build up the shoulders adjoining the experimental sections was scattered onto the pavement and became imbedded. The percentages of the surfaces composed of extraneous aggregate were:

SECTION	PERCENT OF AREA
1 Regular Sand Asphalt	1
2B Open-Graded High Silica	16-SB, 27-NB
3 Open-Graded Medium Silica	2
4 Kentucky Rock Asphalt	3
5B Simulated Kentucky Rock Asphalt	2

Skid resistance of the sections was surely affected, particularly Section 2B. The extent of the decrease in terms of SN, however, cannot be accurately determined. Since the primary concern was in comparing the sections with each other, only the loss of friction on 2B need be considered. Simplified assumptions concerning the surface yielded an approximate difference of 3 Skid Numbers. Therefore, the skid resistance of this surface should be increased about 3 Skid Numbers.

No reduction in friction was noted on any of the sections in the three-year period of monitoring. Large variations in SN shown in Figure 17 were partly due to temperature differences encountered on the various test dates. The major variations, however, were associated with seasonal changes; SN values were lowest during the fall and highest in the late winter and spring periods.

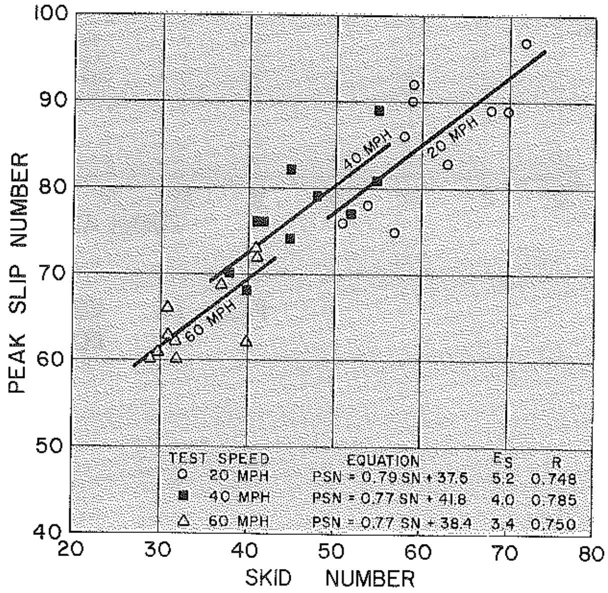


Figure 13. Relationship between Peak Slip Number and Skid Number; PCC Pavements.

The latest measurements (August 1971) (three test speeds) are presented in Figure 18. The pavements ranked in the order anticipated. Regular sand asphalt, constructed under Special Provision No. 22-A, exhibited the lowest friction and Kentucky rock asphalt (Special Provision No. 24-B) the highest. Both surfaces seemed to be rather comparable to similar pavements constructed elsewhere in accordance with the respective specifications. As expected, the open-graded, high-silica pavement yielded higher skid resistance. than the open-graded, medium-silica section. Simulated Kentucky rock asphalt did not prove to be comparable to the Kentucky rock asphalt.

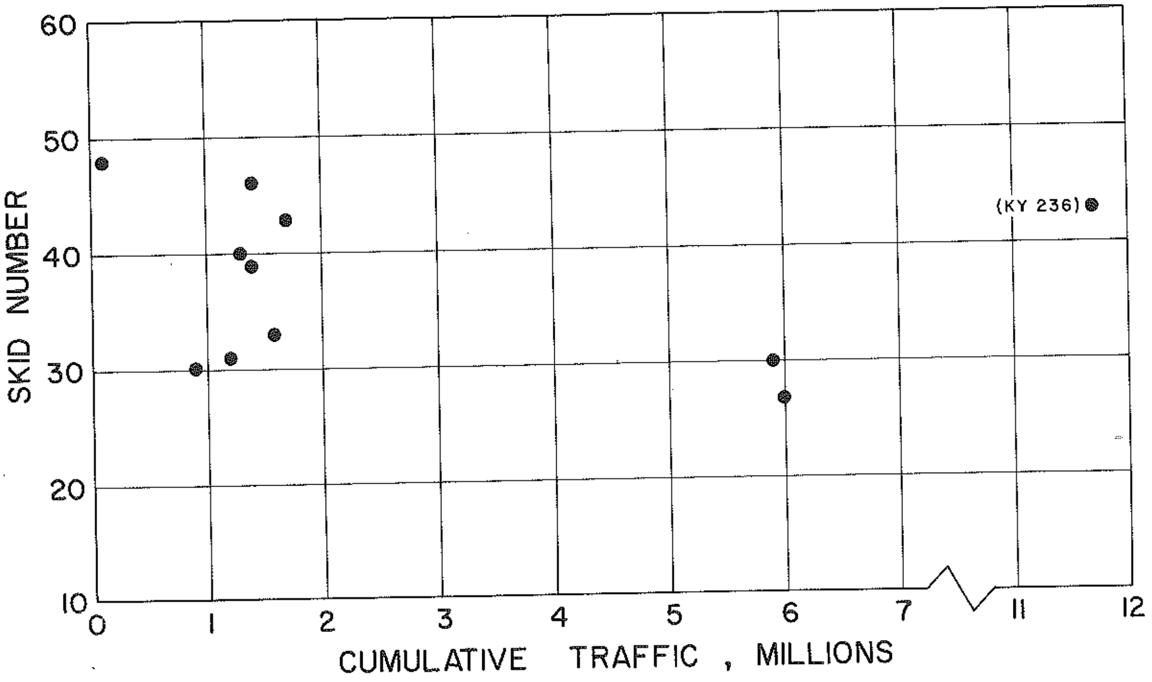


Figure 14. Effect of Traffic on Skid Resistance of Sand-Asphalt Surfaces.

Only a slight difference in friction was found between the open-graded, medium-silica and the regular sand asphalt, containing 33 percent and 36 percent limestone sand, respectively. Limestone sand obviously reduces the skid resistance of sand asphalts. The frictional level achieved on Sections 2B and 5B, however, must be viewed with some disappointment. Test values at 60 mph were very low. Surfaces of this type are not suitable for deslicking purposes on roadways carrying high-speed traffic.

Monitoring and evaluation of the experimental sections in Pulaski County will continue, but it remains doubtful whether any further insights or revelations concerning the frictional performance of these surfaces will be forthcoming. Additional experimental surfaces, containing hard, angular, silica sands and other aggregate types recognized for their high skid-resistant properties, are pending.

DISCUSSION AND RECOMMENDATIONS

The skid trailer has enabled extensive testing in the locked-wheel mode and in the incipient-skid mode. But, more importantly, tests have been made at speeds much greater than those considered to be safe with the automobile method of testing. The interstate and parkway systems, therefore, were tested at 70 mph;

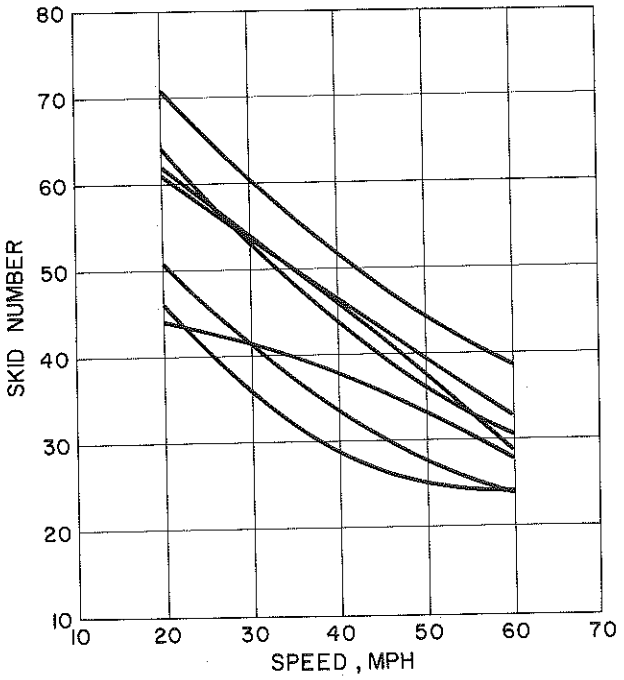


Figure 15. Effect of Speed on Skid Resistance of Sand-Asphalt Surfaces.

some selected projects were also tested at 40 mph. The regression curves in Figure 19 permit summary comparison of in-service performance of Class I bituminous and PCC surfaces on interstate and parkway routes. PCC pavements are now showing about 4 SN lower Sskid resistance than the Class I at 70 mph. These differences in performance have not been apparent previously. Wear induced by studded tires and seasonal polishing are believed to be significant influences. Obviously, corrective measures will be required to improve some sections of interstate roads before they have fulfilled their 20-year design life. Roadway curves may be remedied by overlays, grooving, etching, etc. Continuous grooving or texturing has not been found to be economically feasible.

Texturing of freshly placed concrete surfaces has been recognized to be important. The added macrotexture or macroroughness improves tire-pavement friction and reduces the potential for hydroplaning. The texture depth (amplitude), spacing (pitch) between adjoining ridges, wear rates, and direction of texturing are important considerations in choosing a method or style.

Skid resistance on most pavements has been adequate for the first few million vehicle passes.

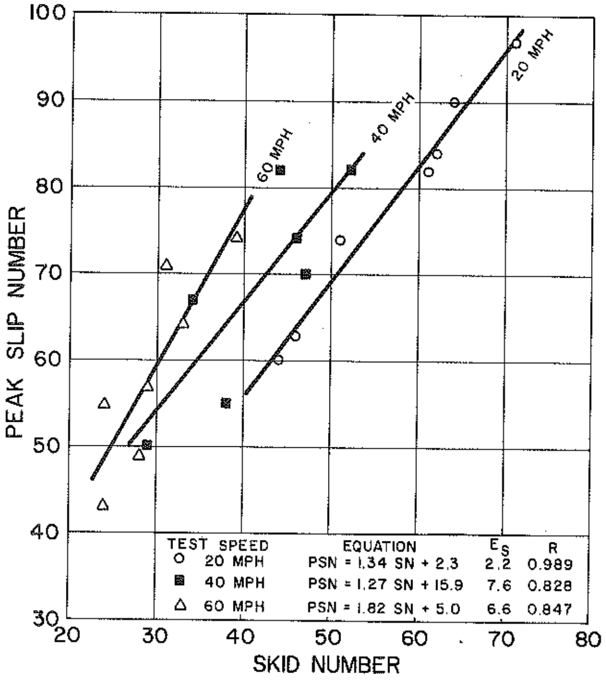


Figure 16. **Relationship between Peak Slip Number and Skid Number of Sand-Asphalt Surfaces.**

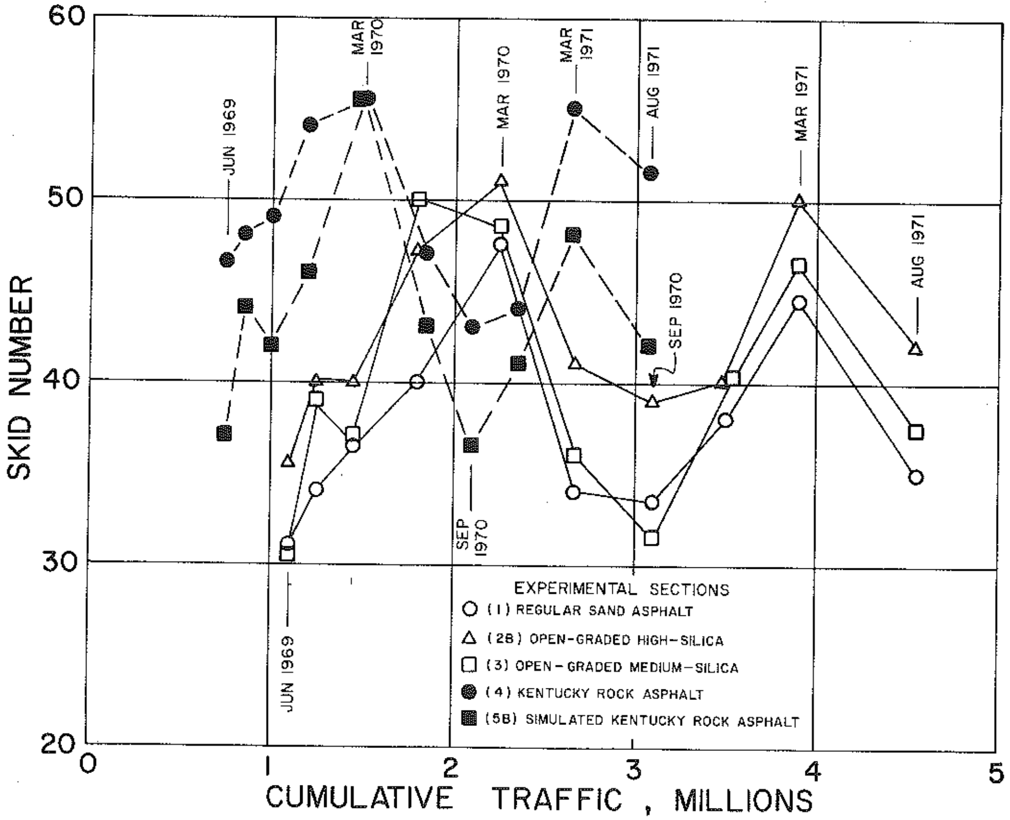


Figure 17. **Effect of Traffic on Skid Resistance of Experimental Sand-Asphalt in Pulaski County.**

Broomed finishes improve initial friction level and reduce hydroplaning; however, resulting tire noise is objectionable. A fluted roller or float method of texturing *(8)* holds promise. Such devices could be designed to construct evenly spaced grooves (3/8 inch to 1/2 inch centers) having uniform and significant (1/8 inch) amplitudes. Undoubtedly the rate of wear would be increased but the greater depth would be somewhat compensating. The net effect on long-term frictional level is believed to be positive. Regardless of the method employed, the direction of texturing should be transversely across the pavement.

Of the surface types monitored on rural US and KY highways, Kentucky rock asphalts exhibited the highest skid resistance. Sand asphalts, designed in accordance with Special Provisions No. 22 and No. 22-A, have not provided the desired level of friction primarily due to the limestone sands in the aggregate (see Figure 20).

The need for thin-layered asphaltic surface courses (approximately 1/2 inch) remains, and the demand for them will grow, particularly as concrete pavements require deslicking. Such surfaces, in contrast to the Class I bituminous surface courses, must meet the following criteria: 1) superior skid resistance, especially at the higher traffic speeds, 2) wear rates commensurate with the desired service life, and 3) competitive cost per square yard of material. However, conditions may warrant higher expenditures to achieve desired friction levels.

The demand for skid testing has exceeded the capabilities of a single tester. Testing schedules, therefore, were adjusted to high priority needs and thus limited the frequency and extent to which a given section could be tested. Multi-speed testing was kept to a minimum. Tests at 40 mph are standard according to ASTM E-274-70 and are made routinely for comparative purposes. However, selected surfaces were tested at other speeds. In summary, Figure 21 was prepared to show representative curves for each pavement type by choosing a common SN value of 40 at 40 mph. The Kentucky rock asphalts were much higher in friction and were not directly comparable.

Only limited experimental efforts were devoted to the peak friction measurements; and, therefore, much remains to be learned. Future efforts will be directed towards refinement of measurement and analysis techniques. Proportionately higher PSN were obtained on the lower SN surfaces, as shown in Figure 22. The PSN/SN ratio for several pavement types increased with speed; this indicates that the peak friction did not decrease with speed as much as the locked-wheel friction. These trends must be viewed as positive attributes towards safer driving in wet conditions. In fact, performing driving tasks and maneuvers would be further restricted and more hazardous if it were not so.

Introduction and use of studded tires in recent years, especially on vehicles from the northern states which travel the interstate roads in Kentucky, has contributed to increased rate of pavement wear. Damage to concrete pavements must be viewed with particular concern. Because the traffic stream is rather channelized, pavement wear on all surface types occurs primarily in the wheel paths and in time develops measurable rut depth. Rutting in bituminous pavements is caused partly by wear and partly by heavy loads. During rainfall, rutted wheel tracks tend to accumulate water and further increase driving hazards associated with spray and hydroplaning. Effectiveness of the studded tire as a safety innovation has not been demonstrated *(9)*. Because of limited benefits and the seldomness of icy conditions and because of the damage done otherwise, studded tires should be discouraged and perhaps outlawed as several states and Canadian provinces have already done.

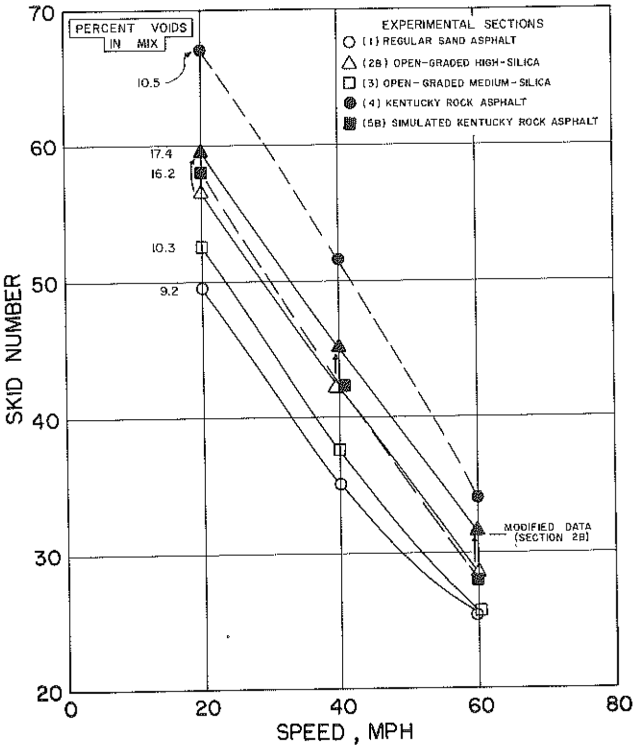


Figure 18. **Skid Resistance of Experimental Sand-Asphalt Section in Pulaski County; Three Test Speeds (August 1971).**

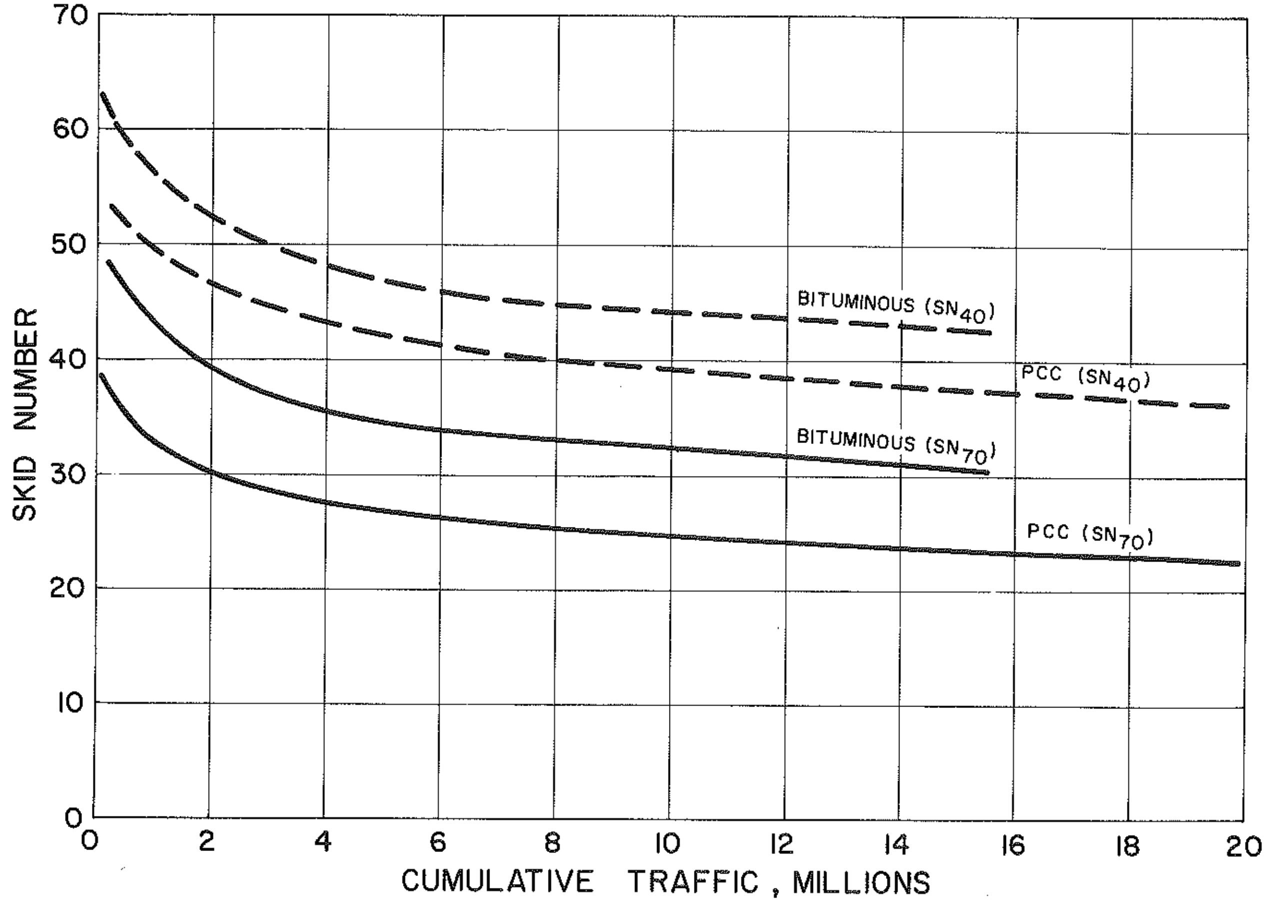


Figure 19. Comparison of Class I, Type A, Bituminous Pavements and PCC Pavements; Interstate and Parkway Routes.

Slipperiness of pavements remains a major problem. Success in the development of improved deslicking materials and surfacing courses will in time upgrade skid resistance of roadways and thereby reduce accidents attributable to pavement slipperiness.

Figure 23 shows the approximate stopping distances on dry and wet pavements. The stopping distance on wet pavements is based on the average skid resistance (trailer) of some 430 projects. The median Skid Number for these projects at 40 mph test speed was 40. Test data at other speeds were used to determine a representative SN versus speed relationships. The equivalent stopping distance was calculated largely on the basis of previous correlations between automobile stopping distances and trailer measurements. Curves shown for wet pavements (approximately 0.02 inch water depth), of course, demonstrate the distances an automobile, equipped with ASTM test tires, may skid in an emergency situation. Increased water thickness on the pavement and tires in poor condition (tread depth of 1/8 inch or less) would contribute to increasing stopping distances of automobiles, while automobiles equipped with good quality commercial tires *(10)* with significant tread depth would result in somewhat shorter distances on pavements characterized in Figure 23. Obviously, driving speeds on wet pavements would have to be reduced significantly in order to achieve the same level of safety (in terms of stopping distances) provided by dry conditions. For instance, where the speed limit is 70 mph, the dry stopping distance is 205 feet; wet-weather speed must be reduced to approximately 50 mph (for a median SN project) to be able to stop in the same distance.

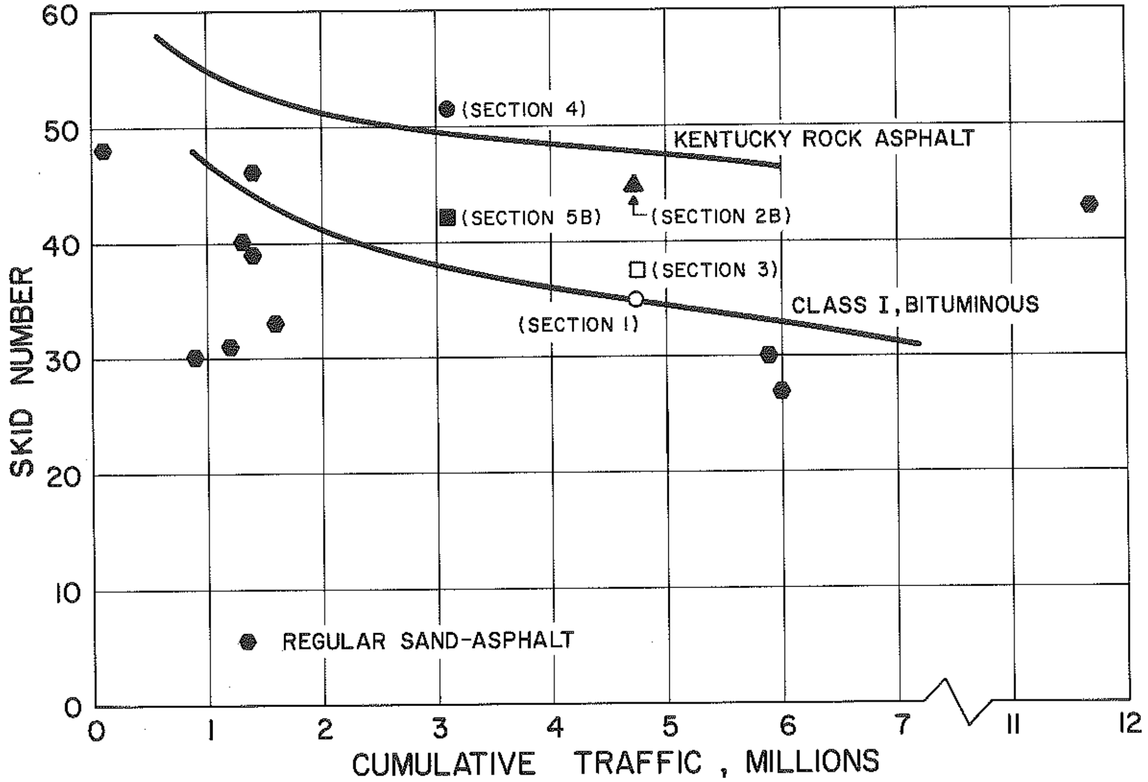


Figure 20. Comparison of Several Types of Bituminous Surfaces on US and KY Routes.

Public awareness of wet-pavement conditions has not been materially manifested in driver behavior. Most drivers choose to retain speeds near the legal limits regardless of weather and road conditions. This practice should be discouraged. Driver education through the broadcast media and by other means should, of course, be encouraged. Legal restraints on driving speeds remain a reasonable but untried alternative at this time. To safeguard the public from undue hazards associated with high-speed driving on wet pavements, the following speed limits are suggested:

Posted Speed Limit	Suggested Speed Limits When Wet
70	50
60	45
50	40

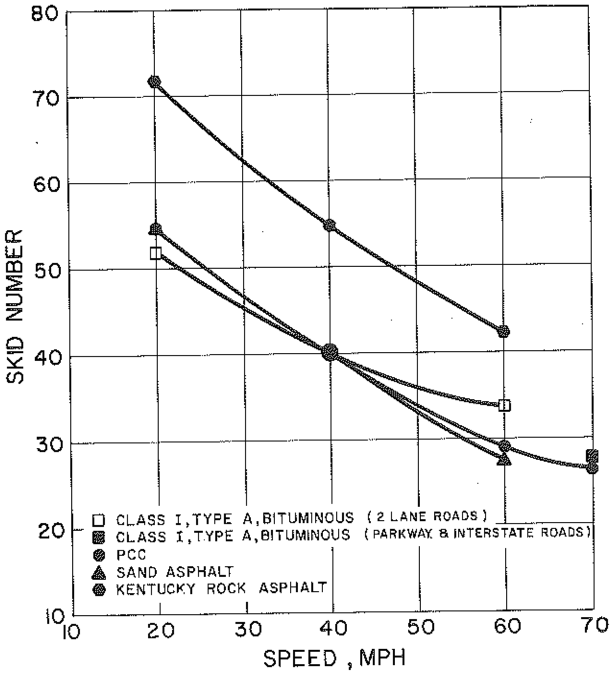


Figure 21. Effect of Speed on Skid Resistance; Several Pavement Types.

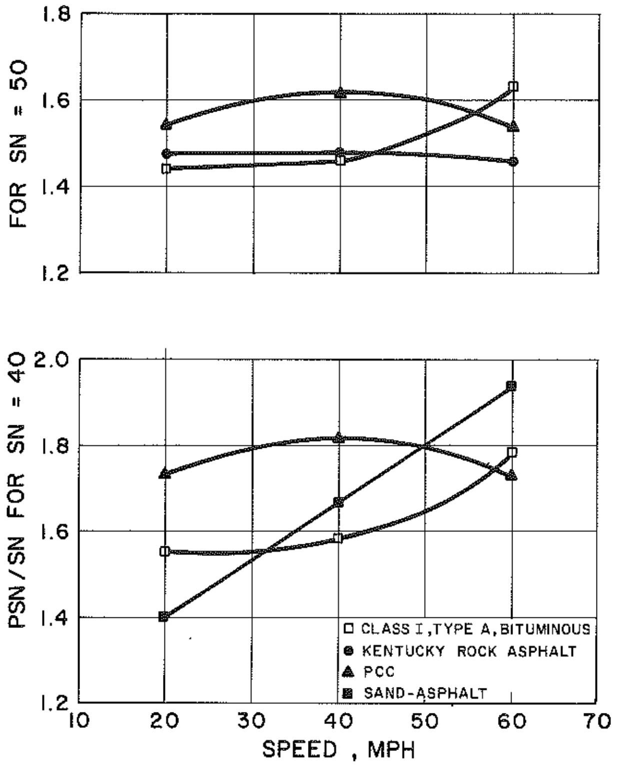


Figure 22. **Relationship between PSN/SN Ratio and Speed; Several Pavement Types.**

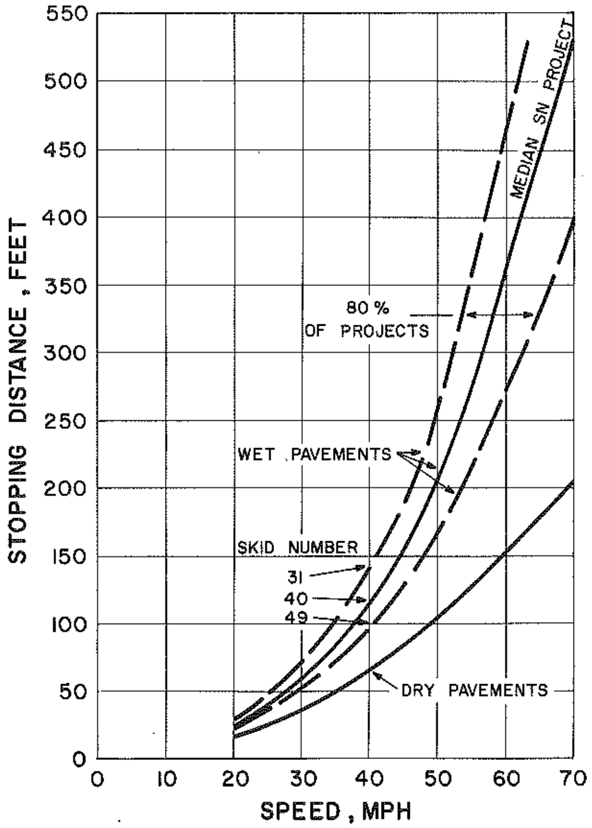


Figure 23. **Comparison of Stopping Distances on Wet Pavements, Based on Trailer Tests of 430 Projects, with Stopping Distances on Dry Pavements.**

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APPENDIX

SKID TEST DATA

SKID TEST DATA
Skid Numbers at 40 mph

CLASS I, TYPE A SURFACES

ROUTE NUMBER	COUNTY	PROJECT NUMBER	LOCATION	CONSTR YEAR	LANE	SKID NUMBER				CUMULATIVE TRAFFIC x 10^6
						1966*	1967*	1969	1970	
I 65	Hart & Larue	I 65-3(10)70	Bonnieville-Upton	1965	Outer Inner	51 64	37 49	39		5.0 1.0
I 75	Madison	I 75-3(4)87	Richmond-Lexington	1964	Outer Inner	44 64	40 61	33 53	36 49	9.5 2.4
BGP	Anderson	CK 15	Lawrenceburg-Versailles	1965	Outer Inner	59 72	51 66	53 65	54 62	3.2 0.3
US 25	Madison	MP 76-51-AH	Berea-Richmond	1965	Both		29	35	30	7.4
US 27	Campbell	MP 19-211-F	Falmouth-Alexandria	1965	Both	44	49		42	4.0
US 27	Pendleton	MP 96-237-M	Falmouth-Alexandria	1965	Both	49	49		40	2.1
US 27	Pendleton	MP 96-17-T	Falmouth-Alexandria	1965	Both	46	46		41	1.9
US 31E	Larue	MP 62-1-L	Hodgenville-Bardstown	1965	Both	56	55	49	52	1.2
US 41	Christian	MP 24-5-T	Hodgenville-Crofton	1966	Both		32	32	26	3.5
US 41	Hopkins	MP 54-20-W	Madisonville-Slaughters	1965	Both	29	35	31	28	5.9
US 41A	Hopkins	MP 54-340-J	Dixon-Madisonville	1961	Both	31	34	33	34	4.3
US 60	Breckingridge	MP 14-13-L	Hardinsburg-Irvington	1965	Both	45	44	40	43	2.4
US 60	Woodford	MP 120-95-I	Versailles-Lexington	1965	Outer Inner	38 56	37 51	33 47	36 44	6.9 3.7
US 60	Bath	MP 6-124-G	Owingsville-Morehead	1965	Both	48	42	47	46	1.6
US 60	Rowan	MP 103-2-U	Morehead-Olive Hill	1965	Both	30	23	26		2.1
US 68	Logan	MP 71-281-0	Elkton-Russellville	1965	Both	46	51	39	42	2.7
US 68	Barren	MP 5-52-M	Glasgow-Edmonton	1965	Both	48	45	31	33	2.9
US 68	Metcalfe	MP 85-84-H	Glasgow-Edmonton	1965	Both	52	49	42	37	1.6
US 68	Bourbon	MP 9-59-W	Paris-Carlisle	1964	Both	54	51	48	40	3.7
US 127	Anderson	MP 3-101-B	Harrodsburg-Lawrenceburg	1965	Outer	52	48	55	41	3.4
US 150	Boyle	MP 11-220-AC	Perryville-Danville	1964	Both	35	41	35	40	3.0
US 231	Daviess	MP 30-97-V,W,Y	Hartford-Owensboro	1965	Both	41	41	41		3.7
KY 32	Fleming	SP 35-90.	Flemingsburg-Morehead	1965	Both	47	49	40		1.5
KY 80	Floyd	SP 36-136	Hindman-Allen	1965	Both	46	32	39		2.8
KY 114	Magoffin	S 267(11)	Salyersville-Prestonburg	1965	Both	48	42	46		1.3
KY 114	Floyd	S 267(8)	Salyersville-Prestonburg	1965	Both	58	56	57		1.1
KY 1678	Bourbon	RS 9-199	Clark County Line-Paris	1965	Both	54	52	50	44	0.9

CLASS I, TYPE A (MODIFIED) SURFACES

ROUTE NUMBER	COUNTY	PROJECT NUMBER	LOCATION	CONSTR YEAR	LANE	SKID NUMBER				CUMULATIVE TRAFFIC x 10^6
						1966*	1967*	1969	1970	
US 60	Rowan	MP 103-2-U	Morehead-Olive Hill	1970	Both				38	0.2
US 460	Scott	MP 105-134-H	Georgetown-Frankfort	1969	Both				39	0.4
KY 4	Fayette	MP 34-304	Lexington Circle Road	1970	Outer Inner				33 40	1.0 0.7

*Computed from automobile data using automobile-trailer correlation equations.

ROUTE NUMBER	COUNTY	PROJECT NUMBER	LOCATION	CONSTR YEAR	LANE	SKID NUMBER					CUMULATIVE TRAFFIC x 10^6
						1966*	1967*	1968*	1969	1970	
SAND ASPHALT SURFACES (PROVISION 22)											
US 41	Hopkins	MP 54-20-Y	Madisonville-Hanson	1966	SB		25		30	27	6.0
US 60	Breckinridge	SP 14-333	Irvington-Ft. Knox	1966	Both		44		48	43	1.7
US 60	Franklin	MP 37-65-Y	Frankfort	1966	Outer	40	28	34	33	30	5.9
					Inner		39	49	43	36	1.9
US 60	Meade	SP 82-423	Irvington-Ft. Knox	1967	Both		47		39	33	1.6
US 62	Anderson	MP 3-71-P	Lawrenceburg-Versailles	1966	Both	42	45	49	51	40	1.3
US 431	Logan		Adairville	1964	Both	36	28	32	37	39	1.4
KY 236	Boone	SP 8-270-5	Cinn. Airport-US 25	1966	Both	38	33	38		43	11.7
(PROVISION 22 A)											
US 31W	Meade		Muldraugh	1970	Outer					31	1.2
					Inner					39	0.8
US 62	Hardin	SP 47-79-13	Elizabethtown	1970	Outer					48	0.1
					Inner					46	0.1
KY 61	Green	SP 44-16	Greenburg-KY 88	1969	Both				34	30	0.9
KY 121	Calloway	SP 18-123	Murray-Coldwater	1967	Both		32		46		1.4
KENTUCKY ROCK ASPHALT SURFACES											
US 31E	Barren	MP 5-12-N	Glasgow-Hodgenville	1967	Both				54	53	2.1
US 31E	Hart	MP 50-40-G	Glasgow-Hodgenville	1966	Both				57	56	0.9
US 31W & US 60	Hardin	MP 47-39-M & MP 82-3-H	Ft. Knox-Louisville	1966	Outer				46	48	4.8
					Inner					55	2.7
US 31W	Warren	MP 114-68-T	Bowling Green-Park City	1966	Outer				46	46	6.2
US 41	Henderson	MP 51-99-K	Madisonville-Henderson	1966	Both				49		2.7
US 68	Christian	MP 24-65-L	Fairview-Hopkinsville	1966	Both				60	56	1.3
US 79	Todd	MP 110-126-D	Guthie-Russellville	1967	Both				68	57	0.8
US 127	Russell	MP 104-78-J	Jamestown-Cumberland Lake	1967	Both					50	1.2
KY 70	Barren	SP 5-292-60	Cave City-Sulphur Wells	1967	Both				54		0.5
KY 80	Metcalfe	SP 85-24-5	Edmonton-Columbia	1967	Both				58		0.6
KY 101	Warren	SP 114-48-1	US 31W-Brownsville	1967	Both				62		0.4

PORTLAND CEMENT CONCRETE SURFACES

ROUTE NUMBER	COUNTY	PROJECT NUMBER	LOCATION	CONSTR YEAR	LANE	SKID NUMBER 1964*	1965*	1966*	1967*	1969	1970	CUMULATIVE TRAFFIC x 10^6
I 64	Shelby	I 64-3(10)42	Shelbyville-Frankfort	1961	Outer	53	49	47	48	45		10.6
					Inner	53	50	54	57			
I 64	Franklin	I 64-3(6)47	Shelbyville-Frankfort	1961	Outer		46	47	43	41		10.6
					Inner		49	55	54			
I 64	Fayette	I 64-4(12)77	C. L. Lexington	1964	Outer		51		47	44	38	11.5
					Inner		53		52	47	52	5.4
I 64	Fayette	I 64-5(17)79	Lexington-Winchester	1963	Inner					55		1.8
I 71	Gallatin	I 71-3(11)61	Louisville-Cincinnati	1967	Inner						42	1.0
I 71	Gallatin	I 71-3(12)66	Louisville-Cincinnati	1967	Outer						35	3.9
					Inner						42	1.0
I 75	Madison	I 75-3(12)76 I 75-3(13)81	Richmond-Berea	1966	Outer				43	38		4.7
					Inner				43			
I 75	Madison Rockcastle	I 75-3(23)69	Berea-Mt. Vernon	1967	Outer				46	42		2.3
					Inner				46			
I 75	Rockcastle	I 75-2(23)51	Mt. Vernon-Corbin	1969	Outer						34	1.4
					Inner						50	0.6
I 75	Laurel	I 75-2(28)47	Mt. Vernon-Corbin	1969	Outer						40	1.4
					Inner						49	0.6
I 75	Laurel	I 75-2(25)41	Mt. Vernon-Corbin	1969	Outer						44	1.4
					Inner						50	0.6
I 75	Laurel	I 75-2(24)35	Mt. Vernon-Corbin	1969	Outer						38	1.2
					Inner						49	0.4
I 64 I 75	Fayette	I 64-4(17)71 I 75-5(9)117	Lexington-Covington US 68 & 27-US 25	1964	Outer					41		8.6
I 75	Fayette-Scott	I 75-5(6)117 I 75-6(19)123	Lexington-Covington US 25-US 62	1963	Outer					42		12.1
					Inner					45		1.7
I 75	Scott	I 75-6(6)123 I 75-6(13)129	Lexington-Covington US 62-KY 32	1962	Outer					37		13.1
					Inner					43		2.6
I 75	Scott-Grant	I 75-6(9)134 I 75-6(14)138	Lexington-Covington KY 32-KY 330	1963	Outer					37		12.1
					Inner					41		1.4
I 75	Grant	I 75-6(16)142 I 75-7(17)151	Lexington-Covington KY 330-KY 36	1963	Outer					39		11.5
					Inner					46		1.3
I 75	Grant	I 75-7(12)153	Lexington-Covington KY 36-KY 22	1962	Outer					32		13.1
I 75	Grant	I 75-7(4)157	Lexington-Covington KY 22-KY 1548	1961	Outer					34		15.5
					Inner					43		3.1
I 75	Grant-Kenton-Boone	I 75-7(15)164	Lexington-Covington KY 1548-KY 14 & 16	1961	Outer					35		15.5
					Inner					36		1.4
I 75	Boone	I 75-7(10)169	Lexington-Covington KY 14 & 16-KY 338	1961	Outer					33		11.9
					Center					38		6.4
I 75	Boone	I 75-7(13)173	Lexington-Covington KY 338-US 42 & 127	1961	Outer					31		15.8
I 75	Boone	I 75-7(14)178	Lexington-Covington US 42 & 127-Kenton Co. Ln.	1961	Outer					32		22.1
					Center					36		15.1
I 75	Kenton	I 75-8(13)181	Lexington-Covington Kenton Co. Ln-US 25 & 42	1962	Outer					33		24.3
					Center					36		15.8
I 75	Kenton	I 75-8(7)185	Lexington-Covington US 25 & 42-Covington	1961	Outer					31		30.6
					Center					30		20.9
WKP	Grayson	WK 27-2	Leitchfield-Elizabethtown	1963	Outer	47	49	55	56			
					Inner		46	51	56	53		0.3
US 60	Woodford	SG 155(1)	Frankfort-Versailles	1959	Outer	52	46	46	40	39	41	13.6
					Inner	54	49	49	54	54	51	3.7

SKID TEST DATA - INTERSTATE & PARKWAY

Skid Number at 70 mph

BITUMINOUS SURFACES

CLASS I, TYPE A

ROUTE NUMBER	NAME OF ROAD	PROJECT NUMBER	COUNTY	LENGTH IN MILES	CONST YEAR	LANE	SKID NUMBER 1971	CUMULATIVE TRAFFIC x 10^6
I 64	Lexington-Ashland	I64-7(19)146	Rowan-Carter	8.1	1969	Outer	33	1.3
						Inner	47	0.5
I 64	Lexington-Ashland	I64-7(17)154	Carter	7.0	1969	Outer	37	1.5
						Inner	49	0.2
I 64	Lexington-Ashland	I64-7(7)161	Carter	6.7	1968	Outer	30	2.1
						Inner	42	0.2
I 64	Lexington-Ashland	I64-8(19)168	Carter	3.2	1969	Outer	32	1.5
						Inner	45	0.2
I 64	Lexington-Ashland	I64-8(10)183	Boyd	4.0	1964	Outer	28	4.6
						Inner	44	0.5
I 64	Lexington-Ashland	I64-8(11)187	Boyd	5.8	1964	Outer	27	4.6
						Inner	46	0.5
I 65	Louisville-Tenn St Line	I65-3(10)70	Larue-Hart	5.4	1965	Outer	30	9.3
						Inner	41	2.2
I 65	Louisville-Tenn St Line	I65-3(9)63	Hart	6.2	1965	Outer	25	10.4
						Inner	40	2.8
I 65	Louisville-Tenn St Line	I65-2(17)60 I65-3(21)62	Hart	3.2	1967	Outer	25	5.6
						Inner	35	2.4
I 75	Lexington-Tenn St Line	I75-3(4)87	Madison	2.6	1964	Outer	22	9.9
						Inner	34	3.2
I 75	Lexington-Tenn St Line	I75-3(28)62	Rockcastle	3.3	1968	Outer	25	3.6
						Inner	43	1.9
I 75	Lexington-Tenn St Line	I75-3(24)60	Rockcastle	2.9	1967	Outer	31	6.0
						Inner	44	2.6
I 75	Lexington-Tenn St Line	I75-2(23)51	Rockcastle	8.1	1969	Outer	23	3.4
						Inner	35	1.4
WK	Princeton-US62	WKE 11-1	Caldwell-Lyon	6.7	1968	Outer	35	2.2
						Inner	42	0.2
WK	Princeton-Elizabethtown	WK 21-1	Caldwell	5.6	1963	Outer	38	5.4
						Inner	49	0.6
WK	Princeton-Elizabethtown	WK 21-2	Caldwell	6.3	1963	Outer	35	4.5
						Inner	51	0.5
WK	Princeton-Elizabethtown	WK 21-3	Caldwell Hopkins	4.4	1963	Outer	34	4.5
						Inner	52	0.5
WK	Princeton-Elizabethtown	WK 28-1	Grayson Hardin	6.3	1963	Outer	38	5.0
						Inner	51	0.5
WK	Princeton-Elizabethtown	WK 28-2	Hardin	7.8	1963	Outer	33	4.9
						Inner	48	0.5
WK	Princeton-Elizabethtown	WK 28-3	Hardin	5.3	1963	Outer	36	5.0
						Inner	45	0.5
BG	Elizabethtown-Versailles	CK 11	Hardin Nelson	16.4	1965	Outer	44	3.9
						Inner	53	0.4
BG	Elizabethtown-Versailles	CK 12-1	Nelson	7.7	1965	Outer	47	3.9
						Inner	57	0.4
BG	Elizabethtown-Versailles	CK 15	Anderson Woodford	11.6	1965	Outer	37	4.3
						Inner	58	0.5

ROUTE NUMBER	NAME OF ROAD	PROJECT NUMBER	COUNTY	LENGTH IN MILES	CONST YEAR	LANE	SKID NUMBER 1971	CUMULATIVE TRAFFIC x 10^6
CLASS I, TYPE A (cont.)								
JPP	US62-Fulton	JPP 11-1	Fulton-Hickman	6.3	1968	Outer	37	2.4
						Inner	44	0.3
JPP	US 62-Fulton	JPP 11-2	Graves	5.0	1968	Outer	37	1.8
						Inner	39	0.2
JPP	US 62-Fulton	JPP 12	Graves	8.2	1968	Outer	36	1.8
						Inner	38	0.2
JPP	US 62-Fulton	JPP 13	Graves-Marshall	14.4	1968	Outer	34	1.8
						Inner	51	0.2
JPP	US 62-Fulton	JPP 14	Marshall	12.8	1968	Outer	40	1.8
						Inner	47	0.2
JPP	Fulton-Tenn St Line	1-3	Fulton	2.1	1968	Outer	50	1.4
						Inner	47	0.2
CLASS I, TYPE B MODIFIED								
I 64	Lexington-Ashland	I64-5(18)86	Clark	4.9	1963	Outer	35	11.6
						Inner	47	4.1
I 64	Lexington-Ashland	I64-5(9)90	Clark	3.0	1961	Outer	35	12.1
						Inner	45	3.9
I 64	Lexington-Ashland	I64-5(7)93	Clark	6.9	1961	Outer	36	9.0
						Inner	49	1.2
I 64	Lexington-Ashland	I64-5(8)100	Montgomery	8.4	1961	Outer	38	8.0
						Inner	50	0.9
I 75	Lexington-Tenn St Line	I75-4(15)98	Fayette	2.5	1963	Outer	27	13.3
						Inner	45	6.2
I 75	Lexington-Tenn St Line	I75-4(5)90	Madison	7.4	1962	Outer	33	15.4
						Inner	46	6.5
PORTLAND CEMENT CONCRETE SURFACES								
I 64	Louisville-Lexington	I64-2(40)12	Jefferson	6.5	1964	Outer	25	11.7
						Inner	28	5.7
I 64	Louisville-Lexington	I64-2(6)17	Jefferson-Shelby	6.1	1961	Outer	26	14.9
						Inner	24	6.4
I 64	Louisville-Lexington	I64-2(4)24	Shelby	6.1	1961	Outer	22	13.7
						Inner	27	5.6
I 64	Louisville-Lexington	I64-3(4)31	Shelby	6.3	1961	Outer	23	14.1
						Inner	29	5.3
I 64	Louisville-Lexington	I64-3(9)37	Shelby	5.1	1961	Outer	22	13.4
						Inner	32	4.7
I 64	Louisville-Lexington	I64-3(10)42	Shelby-Franklin	4.3	1961	Outer	23	12.6
						Inner	32	4.5
I 64	Louisville-Lexington	I64-3(6)47	Franklin	5.4	1961	Outer	23	12.8
						Inner	32	4.0
I 64	Louisville-Lexington	I64-4(9)52	Franklin	4.3	1962	Outer	23	11.2
						Inner	31	3.1
I 64-75	Louisville-Lexington	I64-4(17)71 I75-5(9)117	Fayette	4.9	1964	Outer	25	11.6
						Inner	28	4.1
I 64	Lexington-Ashland	I64-4(12)77	Fayette	2.3	1963	Outer	18	14.9
						Inner	22	7.7
I 64	Lexington-Ashland	I64-5(17)79	Fayette	7.2	1963	Outer	25	11.4
						Inner	31	3.7
I 64	Lexington-Ashland	I64-6(7)109	Montgomery-Bath	10.2	1967	Outer	25	4.4
						Inner	34	0.5

PORTLAND CEMENT CONCRETE SURFACES (cont.)

ROUTE NUMBER	NAME OF ROAD	PROJECT NUMBER	COUNTY	LENGTH IN MILES	CONST YEAR	LANE	SKID NUMBER 1971	CUMULATIVE TRAFFIC x 10^6
I 64	Lexington-Ashland	I64-6(14)123	Bath-Rowan	7.1	1968	Outer	24	2.4
						Inner	33	0.3
I 64	Lexington-Ashland	I64-6(15)130	Rowan	6.9	1968	Outer	25	1.4
						Inner	34	0.2
I 64	Lexington-Ashland	I64-7(16)138	Rowan	8.8	1969	Outer	30	1.1
						Inner	38	0.1
I 65	Louisville-Tenn St Line	I65-4(6)78	Hardin	11.5	1959	Outer	28	16.0
						Inner	33	5.5
I 65	Louisville-Tenn St Line	I65-3(4)76	Hardin-Larue	2.6	1963	Outer	24	6.4
						Inner	34	1.0
I 65	Louisville-Tenn St Line	I65-2(16)57	Hart	3.4	1967	Outer	23	7.7
						Inner	31	5.1
I 65	Louisville-Tenn St Line	I65-2(12)48	Hart-Barren	10.1	1968	Outer	19	4.0
						Inner	26	1.7
I 65	Louisville-Tenn St Line	I65-2(14)35	Barren,Edmonson Warren	12.2	1969	Outer	20	3.0
						Inner	33	1.3
I 65	Louisville-Tenn St Line	I65-(14)22	Warren	6.3	1966	Outer	21	7.5
						Inner	29	3.2
I 65	Louisville-Tenn St Line	I65-1(15)28	Warren	6.8	1966	Outer	24	5.7
						Inner	33	1.7
I 65	Louisville-Tenn St Line	I65-1(13)13	Warren-Simpson	9.1	1965	Outer	22	7.6
						Inner	33	2.1
I 65	Louisville-Tenn St Line	I65-1(16)2 I65-1(17)6	Simpson	10.9	1965	Outer	21	7.1
						Inner	32	2.0
I 71	Louisville-Covington	I71-1(28)9 I71-1(29)15	Jefferson-Oldham	12.6	1968	Outer	19	5.4
						Inner	30	2.9
I 71	Louisville-Covington	I71-1(27)22	Oldham-Henry	5.8	1969	Outer	22	3.1
						Inner	28	1.3
I 71	Louisville-Covington	I71-1(26)28	Henry	9.4	1968	Outer	19	4.0
						Inner	31	1.0
I 71	Louisville-Covington	I71-2(15)37	Henry, Trimble Carroll	7.2	1968	Outer	20	2.9
						Inner	31	0.7
I 71	Louisville-Covington	I71-2(12)48	Carroll-Gallatin	12.2	1967	Outer	20	5.0
						Inner	28	1.7
I 71	Louisville-Covington	I71-3(11)61	Gallatin	4.6	1967	Outer	20	4.8
						Inner	22	1.6
I 71	Louisville-Covington	I71-3(12)66	Gallatin	8.1	1967	Outer	20	5.2
						Inner	19	1.7
I 71	Louisville-Covington	I71-3(10)74	Boone	7.6	1967	Outer	16	5.2
						Inner	25	1.7
I 75	Covington-Lexington	I75-8(7)185	Kenton	2.8	1961	Outer	30	35.0
						Middle	31	49.1
						Inner	31	28.2
I 75	Covington-Lexington	I75-8(13)181	Kenton	4.5	1962	Outer	22	24.6
						Middle	25	33.5
						Inner	26	17.4
I 75	Covington-Lexington	I75-7(14)178	Boone	3.2	1961	Outer	24	23.8
						Middle	23	25.5
						Inner	25	12.0
I 75	Covington-Lexington	I75-7(13)173	Boone	4.6	1961	Outer	21	18.9
						Middle	27	19.5
						Inner	29	8.5

PORTLAND CEMENT CONCRETE SURFACES (cont.)

ROUTE NUMBER	NAME OF ROAD	PROJECT NUMBER	COUNTY	LENGTH IN MILES	CONST YEAR	LANE	SKID NUMBER 1971	CUMULATIVE TRAFFIC x 10^6
I 75	Covington-Lexington	I75-7(10)169	Boone	4.0	1961	Outer	20	15.6
						Middle	26	12.2
						Inner	29	6.2
I 75	Covington-Lexington	I75-7(15)164	Kenton, Boone, Grant	5.4	1961	Outer	24	21.2
						Inner	28	10.2
I 75	Covington-Lexington	I75-7(4)157	Grant	7.4	1961	Outer	22	18.1
						Inner	26	8.6
I 75	Covington-Lexington	I75-7(12)153	Grant	4.4	1962	Outer	22	15.6
						Inner	24	7.8
I 75	Covington-Lexington	I75-6(16)142	Grant	9.7	1963	Outer	27	15.4
		I75-6(17)147				Inner	30	8.8
		I75-7(17)151						
I 75	Covington-Lexington	I75-6(9)134	Grant-Scott	8.0	1963	Outer	25	12.6
		I75-6(14)138				Inner	31	5.4
I 75	Covington-Lexington	I75-6(6)123	Scott	10.5	1962	Outer	27	12.0
		I75-6(13)129				Inner	29	5.8
I 75	Covington-Lexington	I75-5(6)117	Scott-Fayette	7.0	1963	Outer	22	14.2
		I75-5(7)121				Inner	26	6.8
		I75-6(19)123						
I 75	Lexington-Tenn St Line	I75-4(19)104	Fayette	5.9	1964	Outer	29	10.3
						Inner	33	3.0
I 75	Lexington-Tenn St Line	I75-4(17)100	Fayette	3.4	1963	Outer	26	13.5
						Inner	28	6.3
I 75	Lexington-Tenn St Line	I75-3(12)76	Madison	11.7	1966	Outer	19	10.4
		I75-3(13)81				Inner	27	6.9
I 75	Lexington-Tenn St Line	I75-3(23)69	Madison-Rockcastle	7.0	1967	Outer	25	6.1
						Inner	32	3.3
I 75	Lexington-Tenn St Line	I75-3(27)65	Rockcastle	3.3	1968	Outer	27	4.9
						Inner	28	2.7
I 75	Lexington-Tenn St Line	I75-2(28)47	Laurel	3.8	1969	Outer	24	3.3
						Inner	36	1.4
I 75	Lexington-Tenn St Line	I75-2(25)41	Laurel	6.2	1969	Outer	22	2.7
						Inner	32	1.1
I 75	Lexington-Tenn St Line	I75-2(24)35	Laurel	6.3	1969	Outer	25	2.7
						Inner	38	1.1
I 75	Lexington-Tenn St Line	I75-2(26)28	Laurel	5.4	1969	Outer	22	2.5
						Inner	33	0.8
I 75	Lexington-Tenn St Line	I75-2(20)25	Laurel-Whitley	4.0	1968	Outer	25	3.4
						Inner	37	0.8
I 75	Lexington-Tenn St Line	I75-1(23)16	Whitley	9.4	1967	Outer	21	4.0
						Inner	35	1.0
I 75	Lexington-Tenn St Line	I75-1(17)11	Whitley	4.6	1966	Outer	18	6.1
						Inner	35	1.0
I 75	Lexington-Tenn St Line	I75-1(8)4	Whitley	6.4	1965	Outer	32	6.8
						Inner	41	1.1
I 75	Lexington-Tenn St Line	I75-1(40)0	Whitley	3.8	1962	Outer	22	9.2
						Inner	37	1.4

ROUTE NUMBER	NAME OF ROAD	PROJECT NUMBER	COUNTY	LENGTH IN MILES	CONST YEAR	LANE	SKID NUMBER 1971	CUMULATIVE TRAFFIC x 10^6

PORTLAND CEMENT CONCRETE SURFACES (cont.)

ROUTE NUMBER	NAME OF ROAD	PROJECT NUMBER	COUNTY	LENGTH IN MILES	CONST YEAR	LANE	SKID NUMBER 1971	CUMULATIVE TRAFFIC x 10^6
PP	Hopkinsville-Henderson	Penn 12	Christian	4.1	1968	Outer Inner	34 39	0.9 0.1
PP	Hopkinsville-Henderson	Penn 13	Christian	5.2	1968	Outer Inner	31 38	0.9 0.1
PP	Hopkinsville-Henderson	Penn 14	Christian	6.6	1968	Outer Inner	31 33	1.0 0.1
PP	Hopkinsville-Henderson	Penn 15	Christian-Hopkins	6.8	1968	Outer Inner	29 35	1.0 0.1
PP	Hopkinsville-Henderson	Penn 16	Hopkins	8.8	1968	Outer Inner	28 36	0.7 0.1
PP	Hopkinsville-Henderson	Penn 17	Hopkins-Webster	8.4	1969	Outer Inner	31 36	0.7 0.1
PP	Hopkinsville-Henderson	Penn 18	Webster-Henderson	8.2	1969	Outer Innner	31 35	0.7 0.1
PP	Hopkinsville-Henderson	Penn 19	Henderson	9.7	1968	Outer Inner	32 38	0.9 0.1
WK	Princeton-Elizabethtown	WK 22-1	Hopkins	11.4	1963	Outer Inner	31 40	2.6 0.3
WK	Princeton-Elizabethtown	WK 22-2	Hopkins-Muhlenberg	6.6	1963	Outer Inner	31 41	2.8 0.3
WK	Princeton-Elizabethtown	WK 23-1	Muhlenberg	5.8	1963	Outer Inner	29 41	2.9 0.3
WK	Princeton-Elizabethtown	WK 3-2	Muhlenberg	5.4	1963	Outer Inner	27 37	3.1 0.3
WK	Princeton-Elizabethtown	WK 23-2	Muhlenberg	3.4	1963	Outer Inner	31 39	3.5 0.4
WK	Princeton-Elizabethtown	WK 4-1	Muhlenberg	6.6	1963	Outer Inner	33 44	3.7 0.4
WK	Princeton-Elizabethtown	WK 25-1	Ohio	6.1	1963	Outer Inner	33 42	3.7 0.4
WK	Princeton-Elizabethtown	WK 25-2	Ohio	11.1	1963	Outer Inner	33 40	3.7 0.4
WK	Princeton-Elizabethtown	WK 26-1	Ohio, Butler, Grayson	7.6	1963	Outer Inner	30 42	3.8 0.4
WK	Princeton-Elizabethtown	WK 26-2	Grayson	7.6	1963	Outer Inner	32 40	3.9 0.4
WK	Princeton-Elizabethtown	WK 27-1	Grayson	8.0	1963	Outer Inner	36 45	4.0 0.5
WK	Princeton-Elizabethtown	WK 27-2	Grayson	10.7	1963	Outer Inner	27 36	4.2 0.5
BG	Elizabethtown-Versailles	CK 12-2	Nelson	8.3	1965	Outer Inner	28 35	3.9 0.4
BG	Elizabethtown-Versailles	CK 13-1	Nelson	6.7	1965	Outer Inner	28 41	3.9 0.4
BG	Elizabethtown-Versailles	CK 13-2	Washington-Anderson	6.1	1965	Outer Inner	27 36	3.9 0.4
BG	Elizabethtown-Versailles	CK 14	Anderson-Mercer	14.1	1965	Outer Inner	28 42	4.4 0.5

ROUTE NUMBER	NAME OF ROAD	PROJECT NUMBER	COUNTY	LENGTH IN MILES	CONST YEAR	LANE	SKID NUMBER 1971	CUMULATIVE TRAFFIC x 10^6

PORTLAND CEMENT CONCRETE SURFACES (cont.)

MP	Winchester-Campton	EK 1-6	Clark	4.1	1962	Outer	25	5.0
						Inner	41	0.6
MP	Winchester-Campton	EK 1-7	Clark	6.3	1962	Outer	25	5.0
						Inner	36	0.6
MP	Winchester-Campton	EK 1-8	Clark-Powell	5.3	1962	Outer	24	5.0
						Inner	34	0.6
MP	Winchester-Campton	EK 1-9	Powell	3.1	1962	Outer	24	4.2
						Inner	34	0.5
MP	Winchester-Campton	EK 1-10	Powell	5.5	1962	Outer	25	4.2
						Inner	34	0.5
MP	Winchester-Campton	EK 2-5	Powell	3.5	1962	Outer	25	4.2
						Inner	34	0.5
MP	Winchester-Campton	EK 2-2	Powell	4.6	1962	Outer	21	2.8
						Inner	31	0.3
MP	Winchester-Campton	EK 2-3	Powell-Wolfe	4.4	1962	Outer	23	2.8
						Inner	37	0.3
MP	Winchester-Campton	EK 2-4	Wolfe	5.8	1962	Outer	22	2.8
						Inner	35	0.3
Audubon	Henderson-Owensboro	RVP 1-0	Henderson	8.6	1970	Outer	39	0.1
						Inner	36	0.1
Audubon	Henderson-Owensboro	RVP-12	Henderson	7.6	1970	Outer	37	0.1
						Inner	36	0.1
Audubon	Henderson-Owensboro	RVP-14	Daviess	7.2	1970	Outer	35	0.1
						Inner	36	0.1