GROOVING OF CONCRETE PAVEMENTS

FINAL REPORT

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ABSTRACT

This project was initiated by the Louisiana Department of Highways in cooperation with the Federal Highway Administration to determine whether transverse diamond cut grooves of a certain style (Christensen Style 7) placed in hardened concrete in several configurations including a solid pattern and various gapped patterns (cut 3 feet and skip 2, 3 and 4 feet) would result in skid resistance improvement and accident reduction. Three types of locations were chosen for investigation: rural, low traffic; rural, high traffic; and urban.

Generally it was found that whereas the skid resistance was improved initially, the improvement fell back within the original value range after approximately 4 million vehicle passes. At this point wear was evident and 5 1/2 years after cutting the grooves had virtually disappeared in the wheel paths. Others who use a relatively soft material will probably find that the wear will be much faster. Louisiana's concrete aggregate is exclusively chert gravel, a hard substance.

No conclusion could be drawn with regard to accident reduction because at the rural sites no accidents whatsoever have been recorded, and at the urban site the accident incidence actually went up. However, in the latter case the data is too sketchy to evaluate.

Lastly, the research concludes that, since the cost of this type of improvement runs to 2 1/2 times the cost of skid resistant overlays, and the durability of this type transverse groove is less than the durability of most overlays, the state should turn to some other type skid improvement technique both in the case of rural roadways and spot locations of high accident incidence in urban areas.

IMPLEMENTATION

This research indicates that no further work should be undertaken in this area (transverse grooving of Christenson Style 7 in hardened concrete) either in the form of continued research or in the form of field application of the technique. Both skid resistance improvement and accident reduction can be accomplished better with less expense by other methods. This statement does not encompass use of square cut, longitudinal grooves cut in hardened concrete nor is it intended to cover transverse texturing of plastic concrete. Although expensive in Louisiana, longitudinal grooving of slippery concrete surfaces has been instrumental in reducing accidents thus far. On the other hand transverse texturing in Style 7 has yet to prove itself and it is among the most expensive techniques employed.

INTRODUCTION

This research endeavor is presented in compliance with the agreement between the Louisiana Department of Highways and the U. S. Department of Transportation, Federal Highway Administration, designated as HPR 1(6) 67-1G. The field work, research of pertinent publications, evaluation of data and the assimilation of this information into the resulting report was accomplished by personnel of the Research and Development Section of the Louisiana Department of Highways.

Many states have had problems with older concrete surfaces becoming smooth and worn surfaces with traffic usage. This smooth concrete has a poor coefficient of friction or skid resistance and leads to frequent accidents, especially in wet weather. Rear end accidents at intersections are a problem at lower speeds when a vehicle can not stop in time. At higher speeds (over 50 miles per hour), low coefficient of friction and hydroplaning effects lead to steering and cornering problems where the vehicle "floats" on a film of water and almost all steering control is lost. Providing a skid resistant surface is of upmost importance in the proper performance of any roadway. All types of pavements eventually will show a reduction in their coefficient of friction values during the roadway's service life. This reduction is a result of wear and polish caused by traffic, particularly by heavy truck traffic.

PURPOSE AND SCOPE

Since diamond cutter grooving machines have been developed recently, it was the aim of this project to determine the effectiveness and life expectancy of transversely grooved concrete pavements in improving skid resistance and reducing hydroplaning caused by excessive water on the roadway surface. Safety grooving is the process of cutting small grooves in the pavement surface which serves to drain water from the road surface, thereby presenting a "drier" area to the vehicle tire. Elimination of water accumulation on the pavement surface greatly reduces the chances of a vehicle hydroplaning. Hydroplaning is probably the most dangerous type of vehicle skid, since hydroplaning is the phenomenon wherein the vehicle tire actually loses contact with pavement surface and rides on top of a thin film of water.

This transverse grooving was to be done on old concrete surfaces which had polished to a smooth surface with low coefficients of friction. There were three sections selected for this study. Two were in the Baton Rouge, Louisiana, area and the other near Slidell, Louisiana. One Baton Rouge section was an intersection which had a record of frequent rear end collisions. The other Baton Rouge section selected was concrete pavement located on a roadway where speed limits are in excess of 50 miles per hour. The Slidell section is similar to the second Baton Rouge section (speed limit over 50 miles per hour) except that the gravel aggregate was not as hard as is found in other parts of the State. This, it was hoped, would present an indication of the durability of the grooving process with different aggregate characteristics. The purpose of grooving this older polished concrete was to reduce accidents particularly during wet weather by minimizing hydroplaning, skidding and side slip through increasing breaking traction and cornering ability.

METHOD OF PROCEDURE

Equipment Description

The skid test vehicle used on this study was a standard ASTM locked wheel skid trailer which was used to record the coefficient of friction or Skid Number (SN) of the pavements. This skid trailer was constructed to the specifications as stated in ASTM E-274, "Skid Resistance of Pavements Using a Two Wheeled Trailer." The only modification to ASTM requirements was that the strain gages were mounted on the axle rather than on the brake locking pin. Axle mounts have since become standard. The readout system was a Honeywell Model 906 C visicorder. This system was used to measure the skid numbers before the grooving process as well as after for the entire life of this study.

Christensen Diamond Services, Incorporated, of Salt Lake City, Utah, was the contractor that performed the grooving for this study. The grooves were cut by a special transverse grooving device especially designed for placing them while occupying only one traffic lane. The machine is mounted on a truck body, is completely self-contained, carries its own water supply and has a 36 inch cutting arbor which utilizes surface set cutters only. Christensen Style Number 7 grooving pattern was selected for application on all the sections under study. Christensen Style 7 consists of grooves cut .115 inch deep and .100 inch wide with the ridge between grooves .115 inch wide. The top corners of the ridges are also cut at a 60 degree angle (See Figure 1 and Figure 2).

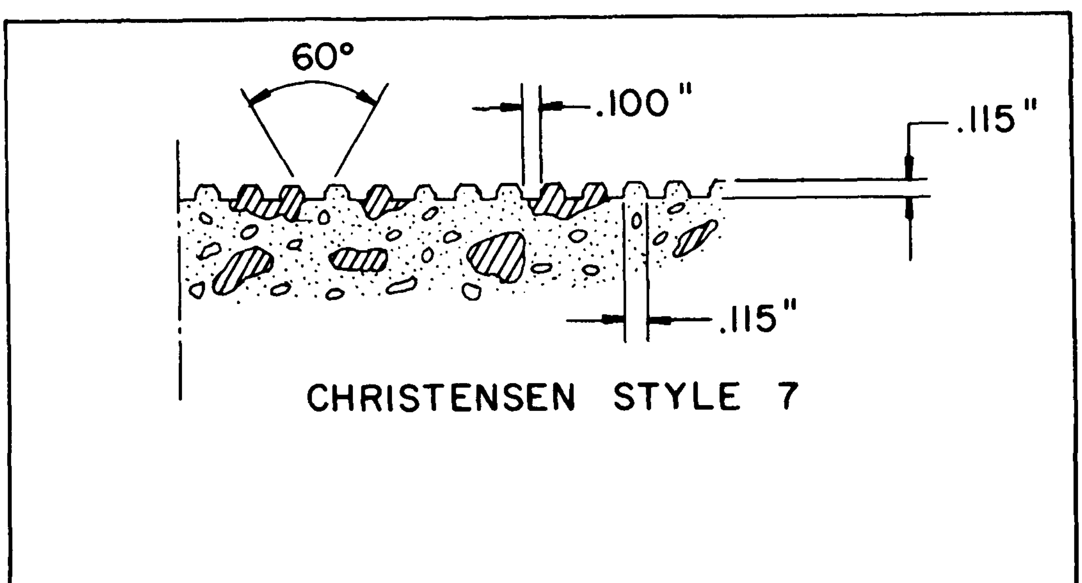

Figure 1: Cross Section Profile of Grooves

Figure 2: Grooved Pavement Before Traffic

The intersection (Scenic Highway) patterns tested included: texture three feet - skip two feet, texture three feet - skip three feet, texture three feet - skip four feet, and solid texture. Figure 3 gives the exact placement of the different patterns at the intersection of Harding Boulevard in Baton Rouge and U.S. 61 (Scenic Highway).

Two high speed (over 50 miles per hour) roadway test configurations were grooved with the following patterns: texture three feet - skip two feet, texture three feet - skip three feet, and texture three feet - skip four feet. Figure 4 gives the exact placement of the different patterns at the U.S. 90 (Riggolets) location near Slidell and the U.S. 190 (Florida Boulevard) location in Baton Rouge.

Figures 5, 6 and 7 are different views of the grooving truck and equipment. Figure 5 is an overall view of the truck. Figure 6 shows the diamond cutters with the diamond encrusted teeth showing rather than saws. Figure 7 shows the grooving truck in operating position with the diamond cutters on the pavement surface. Note the unique transverse alignment of the cutting rails underneath the truck. The cutting heads travel along these rails under the truck.

Cost of Cutting

An agreement was reached with the cutting company to groove the entire project as defined herein for $2,500. This was a special contract price which included mobilization of the equipment as well as the work. At this price the unit cost of the cutting, not including the skipped sections, was $1.5625 per square yard. It should be pointed out, however, that the aggregate used in concrete in Louisiana is chert gravel, a very hard substance to say the least. The average abrasion loss is usually less than 25 percent and the average sulfate soundness loss for this material is only 3 or 4 percent

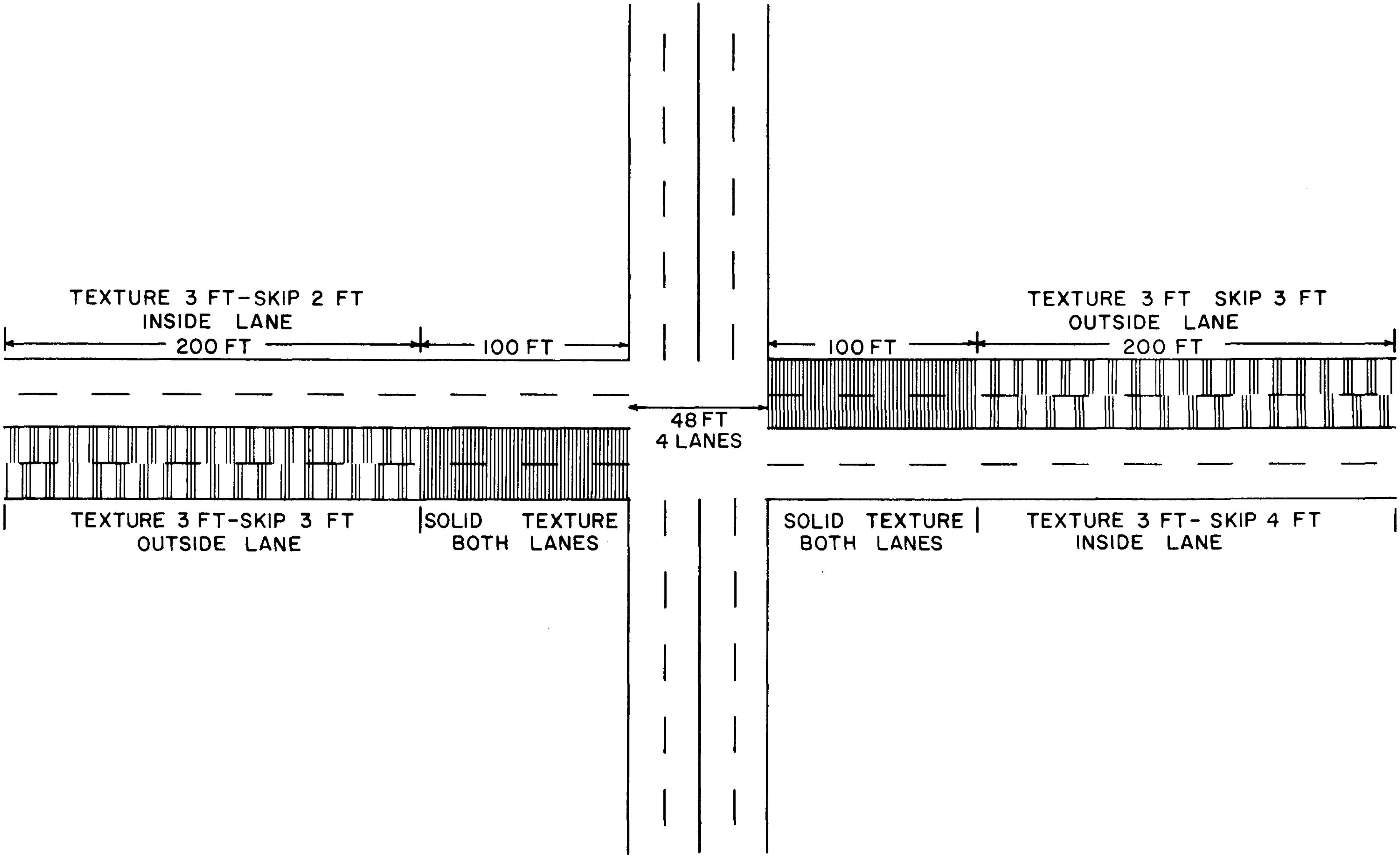

Figure 3: Grooving Configuration for U.S. 61 Site

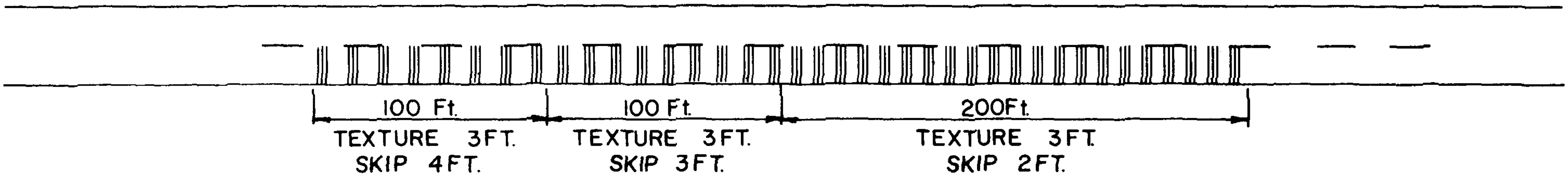

Figure 4: Grooving Configuration for High Speed Sites

Figure 5: Overall view of the grooving truck with cutter in up position

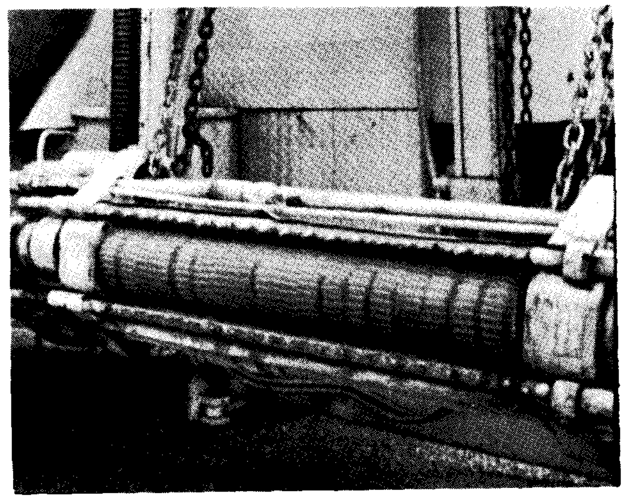

Figure 6: Close-up view of cutter showing the diamond encrusted teeth

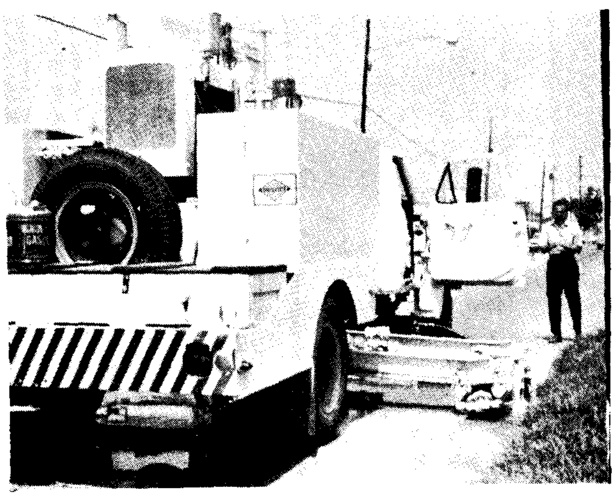

Figure 7: View of grooving truck with cutter in place for a transverse cut under the truck

By comparison, the unit price of a skid resistant thin asphaltic surfacing will run in the neighborhood of $ .62 per square yard in Louisiana depending upon the material used. Grooving, then, is about 2 1/2 time more costly based on this figure ($2,500) than resurfacing using a thin asphaltic overly with high skid resistance.

Data Acquisition

The system which was used to measure the skid numbers of the test sections was a standard ASTM locked wheel trailer. This system, in general, consists of a towed trailer, a transducer, instrumentation, a water supply and dispensing system, and controls for actuation of the brake on the test wheel. The test wheel is equipped with the Standard Test Tire (ASTM Specification E 249). After the test vehicle is brought to testing speed, water is delivered to the pavement ahead of the test tire and the brake is applied to lock the test wheel. The frictional force acting between the test tire and the surface of the pavement is recorded with the instruments on the trailer axle on a Honeywell Model 906 C Visicorder. The pavement's skid resistance is determined from the resulting force or torque on the trailer's axle and reported as Skid Number (SN). The skid number is determined from the formula:

$$SN = \frac{100F}{Wo - F(\frac{H}{L})}$$

Where:

SN = Skid Number
F = Tractive Force or horizontal force applied to the skid tire during test, lbs.
Wo = Static vertical load on the skid tire (weight), lbs.
H = Hitch height (in.)
L = Trailer length (center of the axle to center of hitch), in.

A complete description of the trailer, braking system, test tire, other parts of the measuring system, and other pertinent information can be found in reference number 5 in the bibliography.

Field Procedure

Skid tests were run immediately before the three sections were grooved and the results recorded. Tests were run immediately after grooving, then at 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33 and 36 months. There were no results for the 21st month tests on Scenic Highway since the tests were running behind schedule up to that point and got back on schedule by skipping the 21st month tests and going directly to the 24 month test.

The Scenic Highway section was run at 30 miles per hour to approximate the skid numbers a vehicle might encounter slowing down for the intersection. The higher speed sections (over 50 miles per hour) were run at 20, 40 and 60 miles per hour.

The 60 miles per hour runs were over all three patterns in the test sections since any one pattern was not long enough to accommodate the test at that speed. The testing at three different speeds was done to get an idea of the decrease in skid resistance with an increase in speed or speed gradient.

DISCUSSION OF RESULTS

The grooving process resulted in improved Skid Numbers (SN) on all three sections. This improvement was greatest immediately after grooving. With the passage of time and traffic the skid numbers began to degrade.

At the Florida Boulevard (U.S. 190) grooving site three months after grooving the skid numbers increased above the before grooving original values (an increase of 10 to 14 SN's at 20 miles per hour, 10 to 15 SN's increase at 40 miles per hour, and 10 SN's increase at 60 miles per hour). At the Riggolets (U.S. 90) site three months after grooving the skid numbers increased above the before grooving values (an increase of 10 to 11 SN's at 20 miles per hour, from 9 to 11 SN's at 40 miles per hour, and 7 SN's at 60 miles per hour). At the Scenic Highway (U.S. 61) site all tests were run at 30 miles per hour and 3 months after grooving the SN's were above the original values by 6 to 15 SN's in the outside northbound lane, 10 to 12 SN's in the inside northbound lane, 6 to 16 SN's in the outside southbound lane, and 12 to 13 SN's on the inside southbound lane. All values measured are contained in Table 1 in the Appendix.

The graphs of skid numbers versus time in months do not show any type of pattern relating to degrading of the grooved sections with the passage of time. The curves go up and down from quarter to quarter without any pattern. There is a general slight downward trend from the first tests after grooving when the points are looked at as a whole. The fitted curves of skid numbers versus the log of number of vehicle passes shows more of a pattern. This overall pattern is more of a downward trend although some of the curves (U.S. 90 at 20 miles per hour) appear to increase toward the end of the Study. Graphs of SN's versus Time and SN's versus the Log of Number of Vehicle Passes appear in the Appendix for all three sections.

It was also hoped a comparison could be made between SN's run on the Florida Boulevard U.S. 190 section and on the Riggolets U.S. 90 section. It was thought that the SN's on the Riggolets section would be lower than the SN's run on the Florida Boulevard section since a harder aggregate was used for the Florida section. Just the opposite was found, as the SN's run on the Florida section were approximately 10 points lower than the SN's on the Riggolets section. One possible explanation for this occurrence is that the Florida section carries more than 2.3 times the traffic per day than the Riggolets section. The average daily traffic figures for the three test sections follow: (1.) Florida Boulevard, U.S. 190, carries 5,595 vehicles per day per lane (2.) Riggolets, U.S. 90, carries 2,420 vehicles per day per lane (3.) Scenic Highway, U.S. 61, carries 7,452 vehicles per day per lane.

Accident Data

No wet weather skidding accidents were recorded on the Florida Boulevard or Riggolets grooved sections either before or after grooving. The only available data was at the Scenic Highway section. During the previous five year period before grooving there were seven accidents which occurred in wet weather. Four of these seven were wet weather rear end collisions. After grooving there were four wet weather skidding accidents in the first 16 months succeeding grooving operation. Of these four accidents, three were rear end collisions.

It would appear then that the grooving actually increased the incidence of accidents in one case and had absolutely no effect one way or the other in the others. But, it should be remembered that the sampling of data is very limited. Accident rates or accident studies of any type can not really be valid when they are studied over such a short distance. Both the Riggolets and the Florida Street extension sets are on tangent sections on relatively high speed rural roadways several miles long. Accident records over the entire length of these two sections have significance but obtaining a record of accidents that show up on a mere 400 foot stretch of one lane of roadway requires luck. In the urban area where the surface was grooved at an intersection controlled by a traffic light, and where the accident incidence went up, the situation is controlled by a large number of factors such as driver attitude, percentage of wet time, wear rate of the grooves, tire tread condition and so on. This large number of variations statistically require a great abundance of data not obtainable in this situation in order to draw a valid conclusion.

Speed Gradient

The speed gradient or the change (decrease) in skid number per change (increase) in speed, is computed and shown graphically in Figure 32 in the Appendix. The method of computation of this value needs some discussion. First, it will be recalled that at 60 miles per hour no one pattern was long enough to accommodate the test, so all patterns had to be tested with one shot producing only an overall average. This limits the computations. Second, since the results varied from test to test producing a saw tooth graphical representation as is shown in Figures 28 and 29 in the Appendix, another average was necessary to produce a speed gradient which would be a representative value. Thus the SN's at each speed were picked from the plots of SN versus Log of Traffic at the 1,000,000 vehicle point on the x axis. An average SN for all patterns was chosen at that ordinate for both the U.S. 190 and U.S. 90 sites. Surprisingly, as can be seen in the figures, both values are the same and agree with what can be considered a national average of 0.5. Figure 33, also in the Appendix, presents the same values as discussed above for the non-grooved (control) sections. It can be seen that the speed gradient was improved by grooving in one case and damaged in the other. The reason for this is unknown.

Groove Wear

Before drawing the conclusions reached during this study, the wearability of the grooves imprinted in the concrete should be mentioned. At present, five and one-half years after they were cut, the grooves are gone for all practical purposes. All patterns exhibit only remnants of the former grooves outside of the wheel paths. Rarely, very shallow striations show up where the vehicle tires contact the pavements; otherwise, the pavement is smooth. Of the three sites grooved, the Riggolets section, supposely containing softer aggregate, is worn the most. Figures 8 and 9, taken in June 1973 display the amount of wear at this location. Notice the worn area in the tire path in Figure 8. Both the photographs are of "skip 2 grooved 3" sections although not in the same spot.

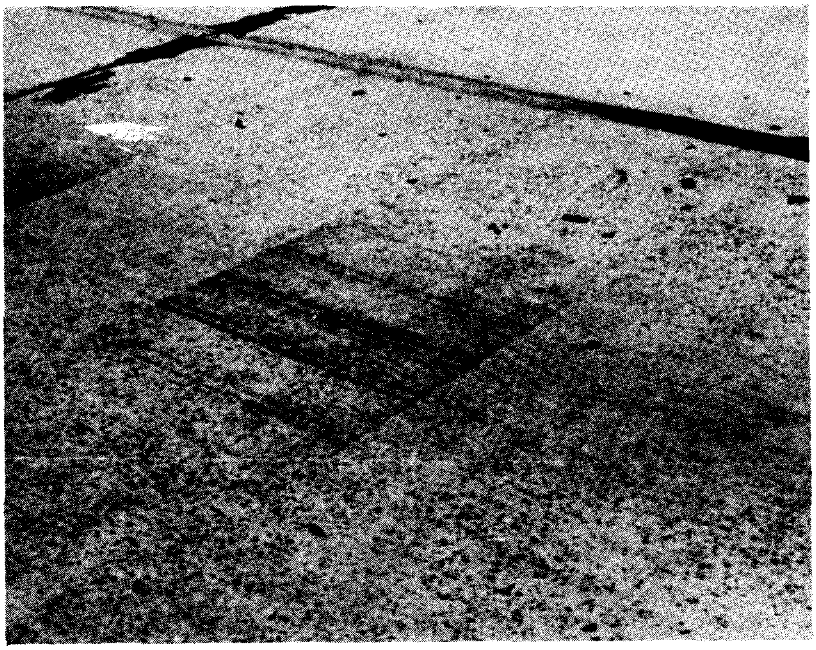

Figure 8: Groove Wear on U.S. 90

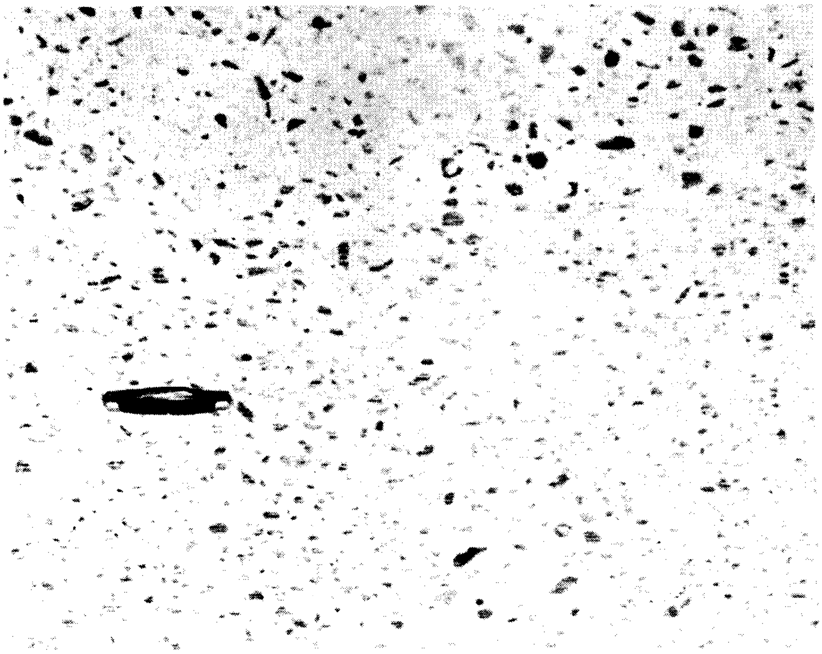

Figure 9: Worn Grooves on U.S. 90 (Close up)

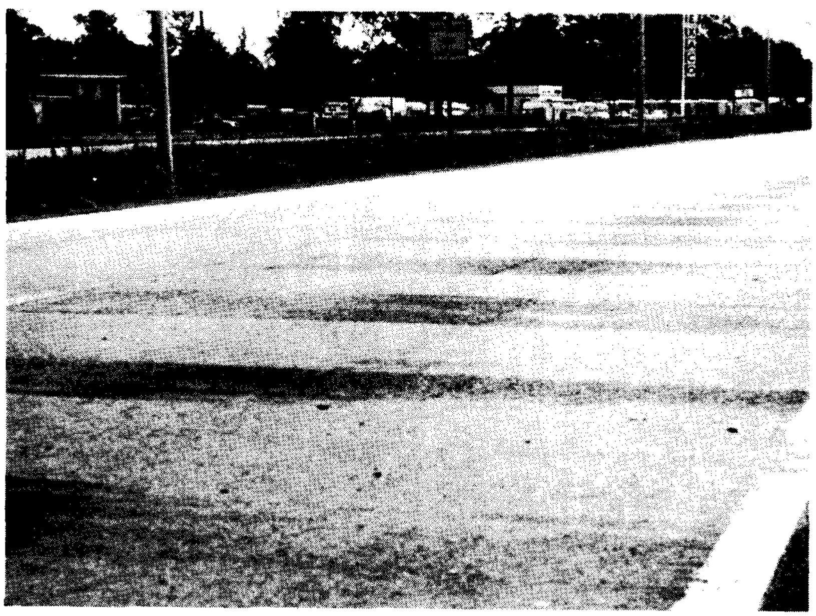

Figure 10: Groove Wear on U.S. 190

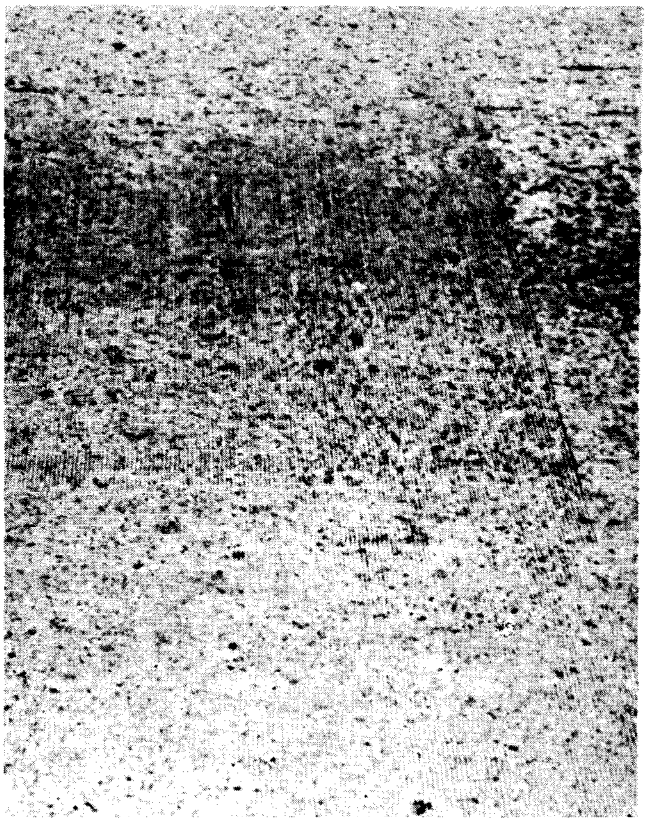

Figure 11: Worn Grooves on U.S. 190 (Close-up)

The other two sites are shown in Figures 10 and 13. The Florida Street Section is depicted by Figures 7 and 8, while the Scenic Highway site is shown in 12 and 13. All sections exhibit wear even though the pavement in Figure 10 does appear as worn as the others. The photograph in Figure 13 was taken outside the wheel path right at the intersection near the very end of the solid grooved section in the southbound lane. Except for the worn spot in the center of the photograph, probably created by vehicles turning to the right, it can be used as a basis of comparison - worn to relatively unworn grooving. However, the reader may also refer to Figure 2 for newly grooved pavement.

Mention should be made of the shape of the groove. Christensen Style 7 is, for all practical purposes, a "V" shaped groove as shown in Figure 1. This means that, as the pavement wears, the width of the groove becomes smaller. Wear of half of the depth results in a groove one-half as wide at the open end as it

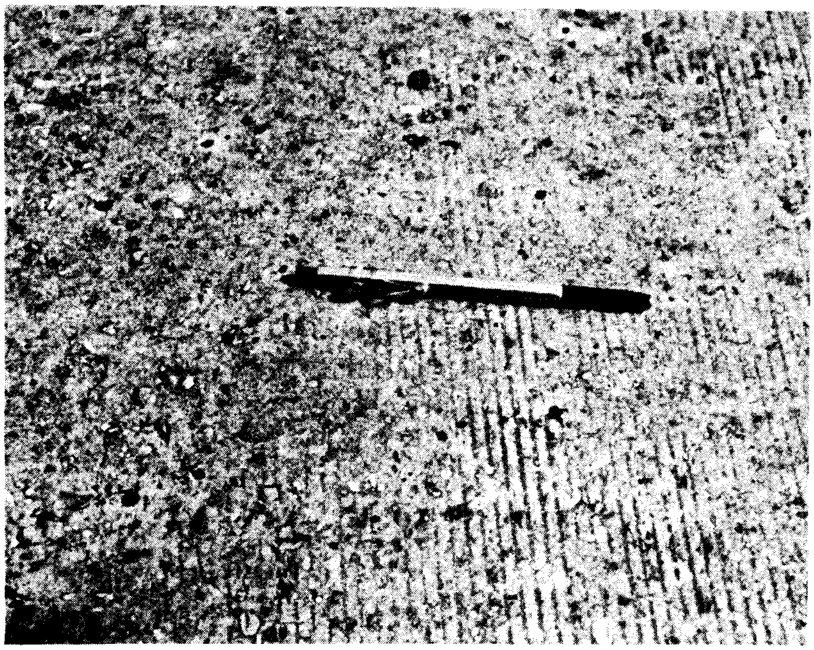

Figure 12:
Worn Grooves on
U.S. 61

was originally. But its volume is only one-fourth of the original volume so that one of the two main functions of grooved pavement, that of providing a drainage path for water in the tire-pavement interface, is seriously hampered. For this reason, square cut grooves would seem to be superior to V shaped ones in that they will tend to disappear less rapidly and act as drainage paths longer.

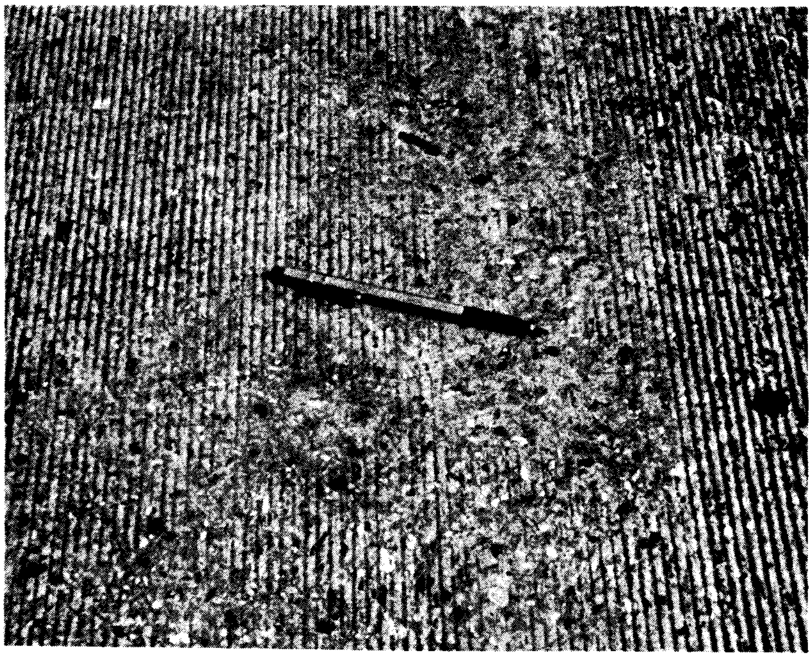

Figure 13:
Unworn Grooves
U.S. 61

CONCLUSIONS AND RECOMMENDATIONS

The conclusions reached after completing the study of effects of transverse grooving of hardened concrete by diamond cutting can be summarized as follows:

1. Grooving of concrete does increase skid resistance initially by as much as 16 numbers in some cases, but a nominal increase is about 10 to 12 months.

2. The initial increase lasts only a short time. Skid numbers fall back into range of the original values at about 4,000,000 vehicles passes. This is demonstrated visually by the virtual disappearance of the grooves from tire wear.

3. Grooving of the type employed in this study had the effect of "standardizing" the speed gradient at 0.5, i.e., it brought one pavement up from 0.42 and the other down from 0.62.

4. This study did not confirm the fact that grooving reduces wet accidents.

5. The cost per square yard of cutting the grooves in this study was approximately 2 1/2 times the price of skid resistant, thin asphaltic overlays in this state.

As a result of the above conclusions, transverse grooving of Christensen Style 7 in concrete pavements can not be recommended as a practice for the purpose of increasing skid resistance or reducing accidents.

LIST OF REFERENCES

1. Concrete Planner Reports. Salt Lake City: Christensen Diamond Services, Incorporated.

2. Concrete Planning and Material Removal. Salt Lake City, Christensen Diamond Services, Incorporated.

3. Grooved Pavement for Safety. Grandview, Missouri: Clipper Manufacturing Company.

4. Kummer, H.W. and Meyer, W.E. Tentative Skid Resistance Requirements for Main Rural Highways. National Cooperative Highway Research Program Report 37, Highway Research Board, 1967.

5. Standard Method of Test for Skid Resistance of Paved Surfaces Using a Full - Scale Tire. Annual ASTM Standards, ASTM Designation E 274, Part II, April 1973.

APPENDIX

2 CYCLES X 28 DIVISIONS

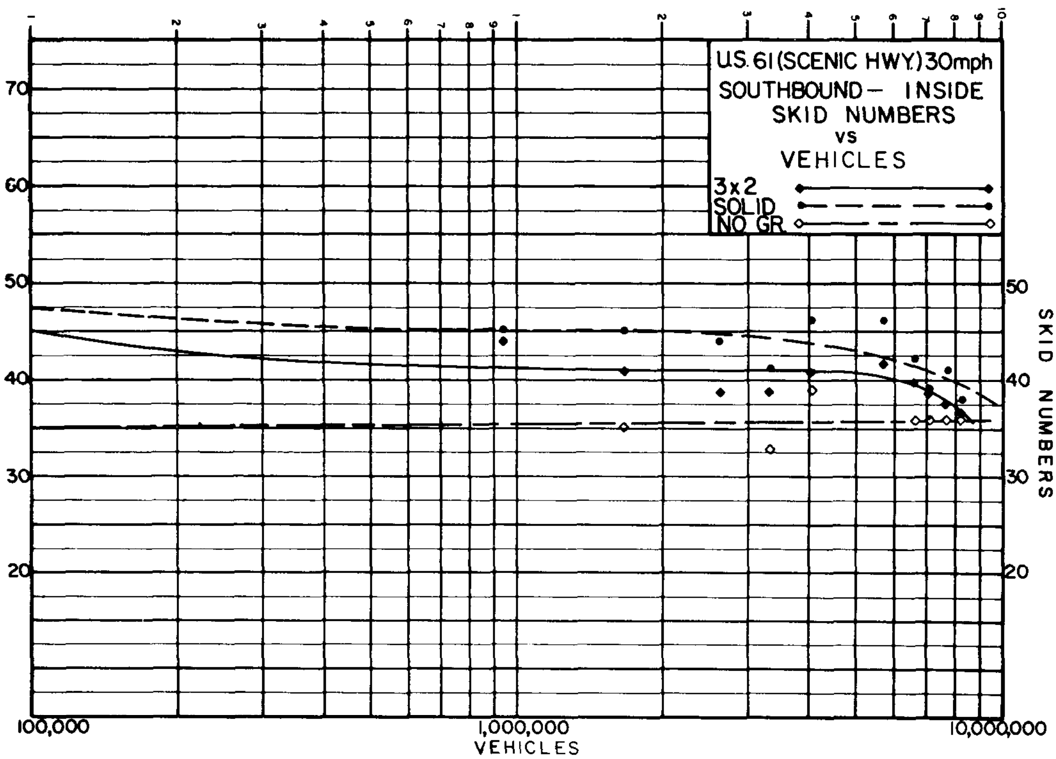

Figure 14

2 CYCLES X 28 DIVISIONS

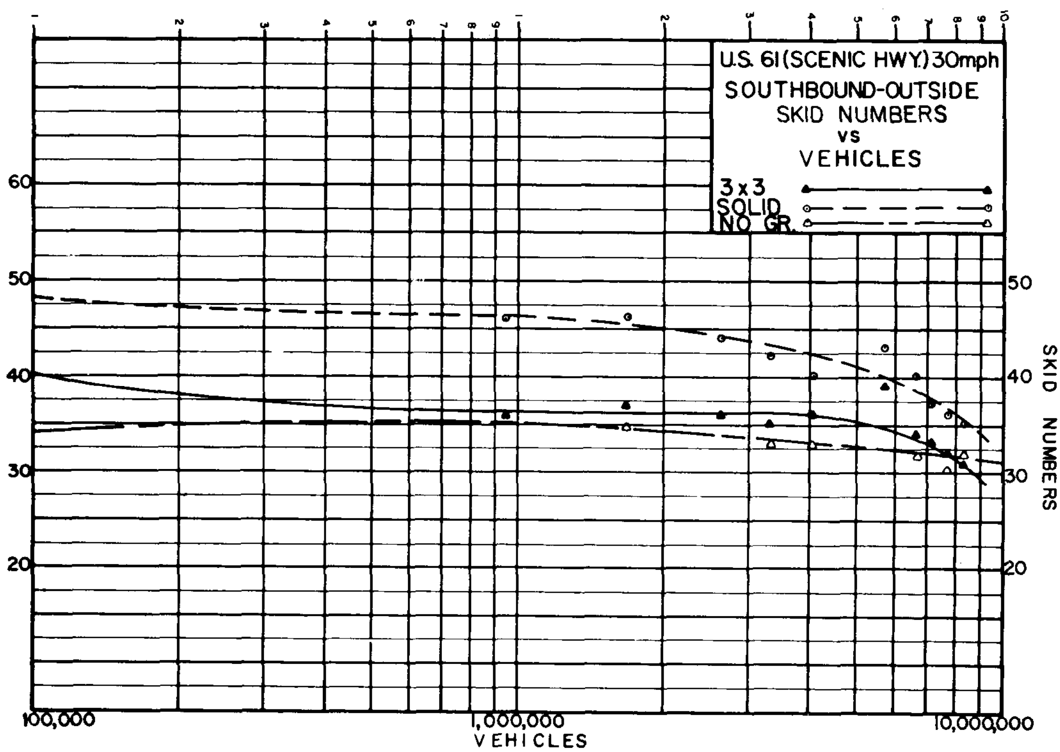

Figure 15

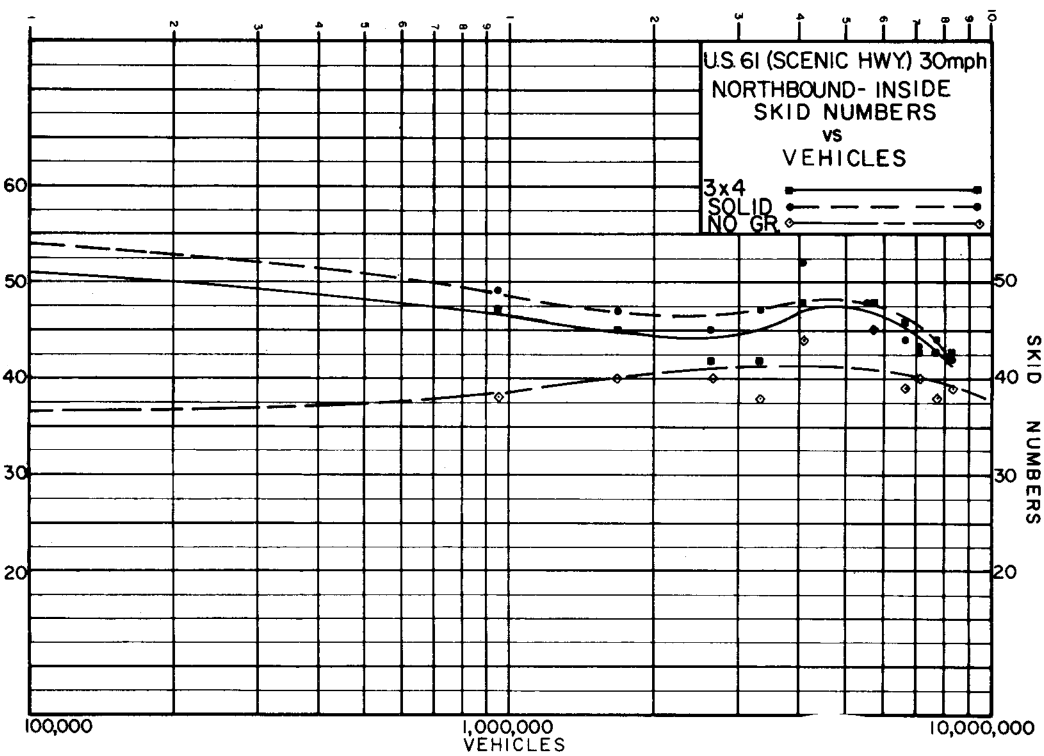

Figure 16

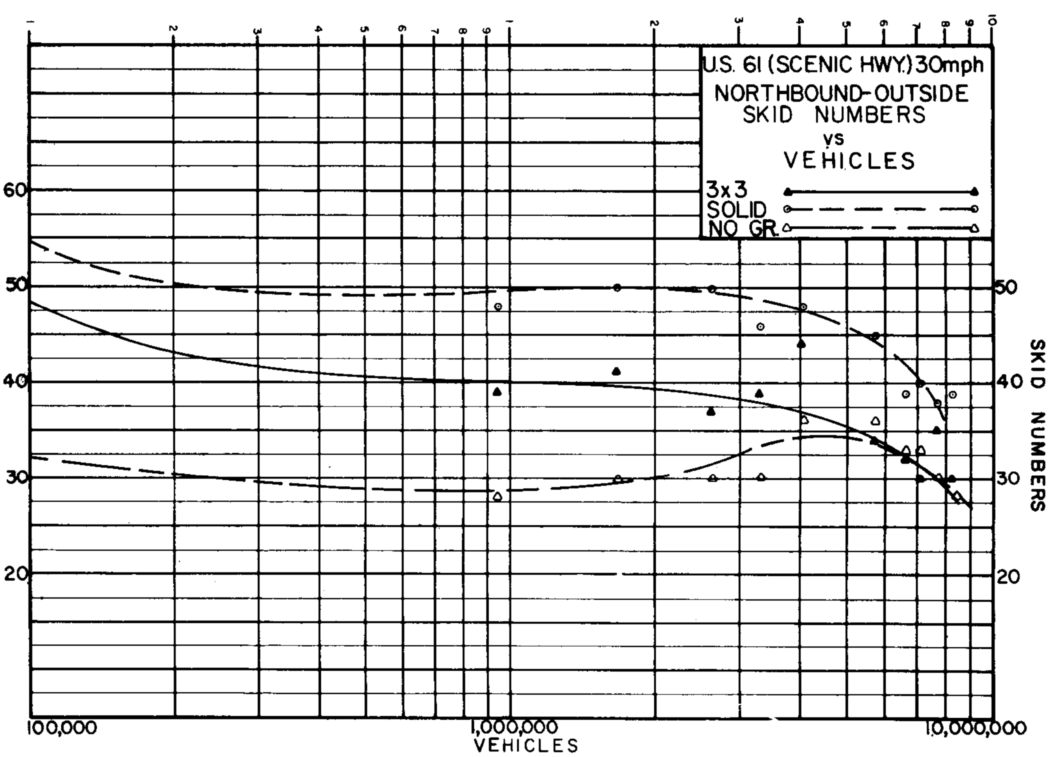

Figure 17

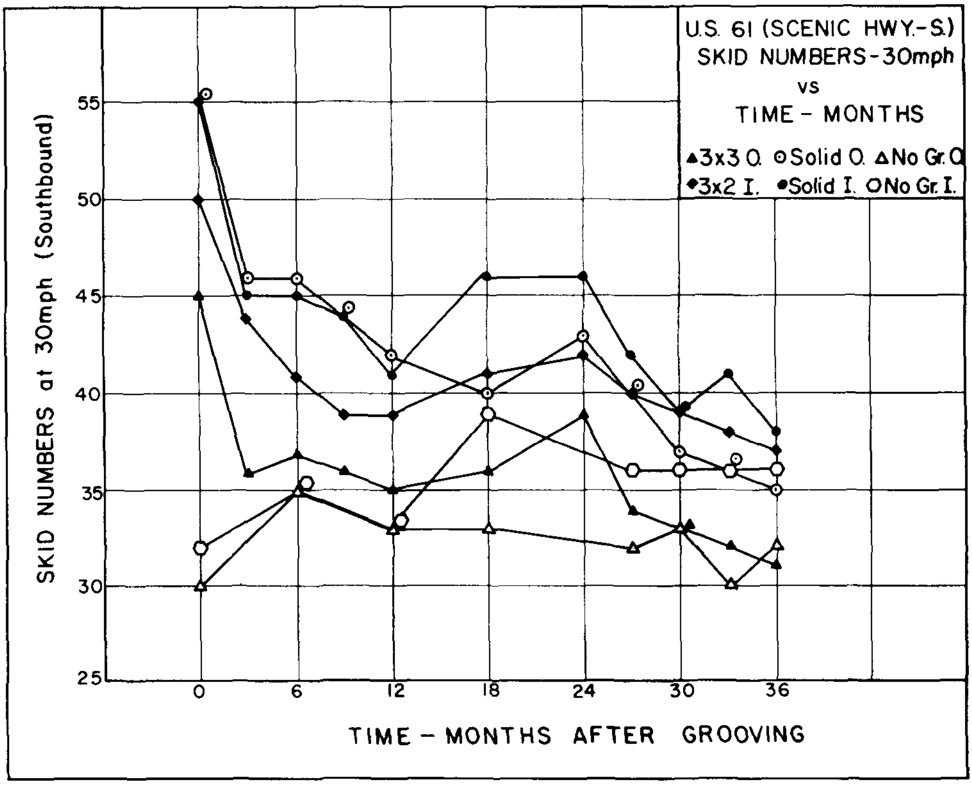

Figure 18

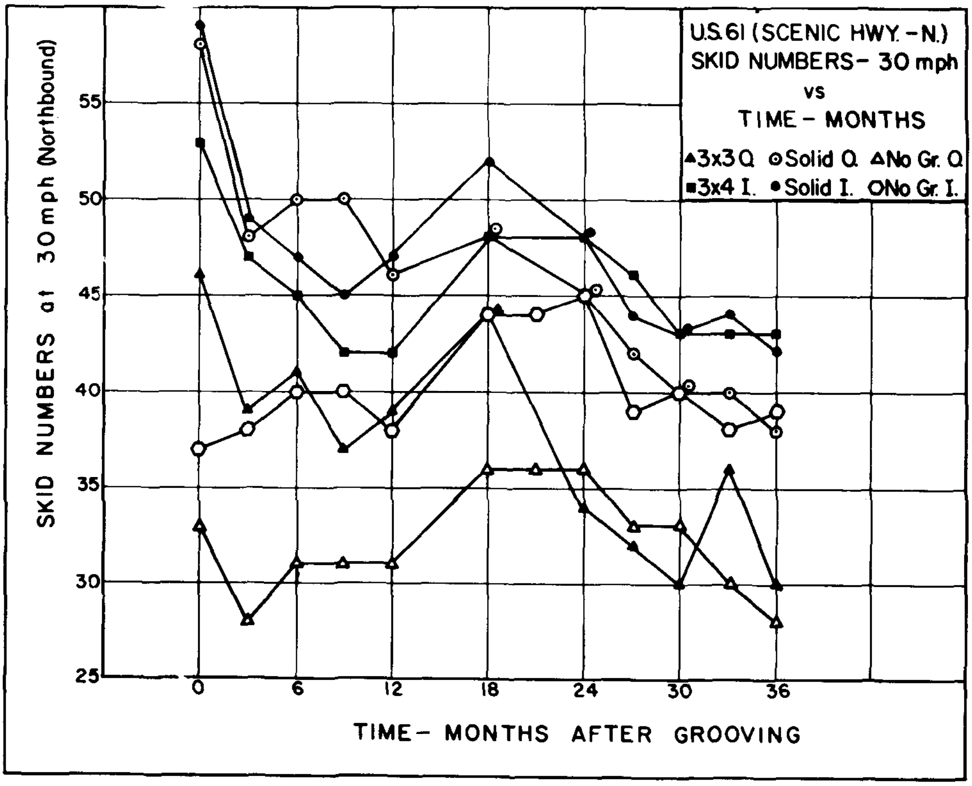

Figure 19

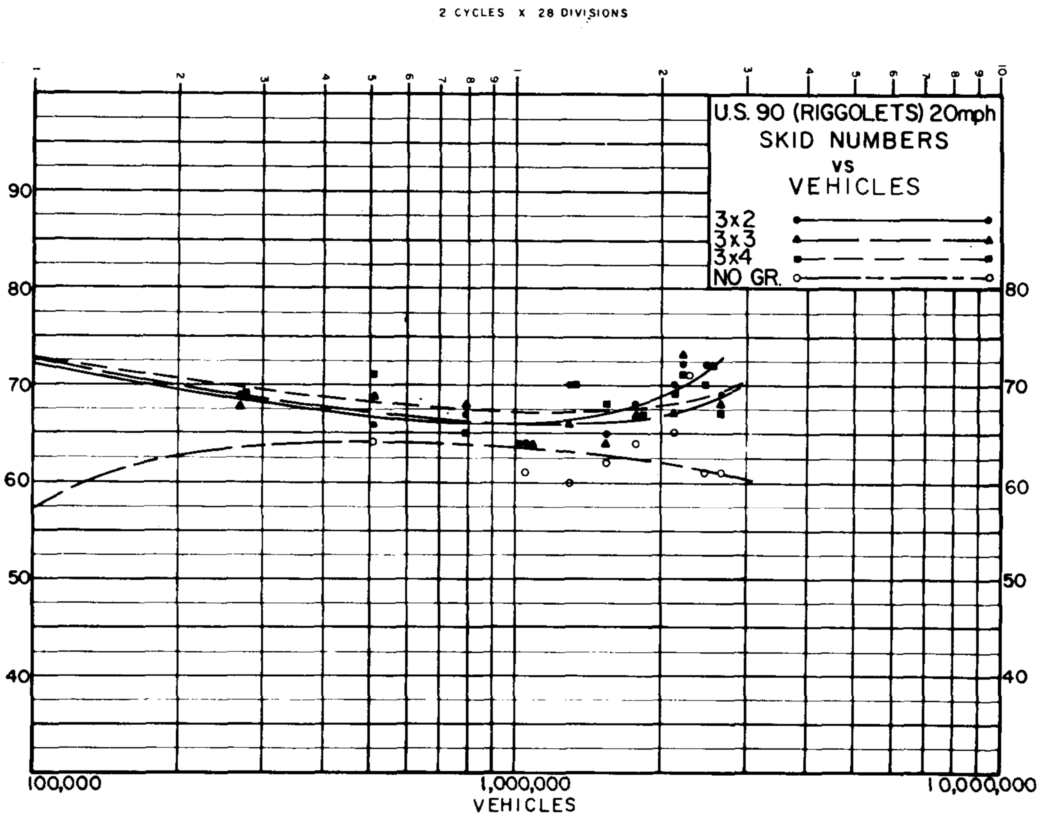

Figure 20

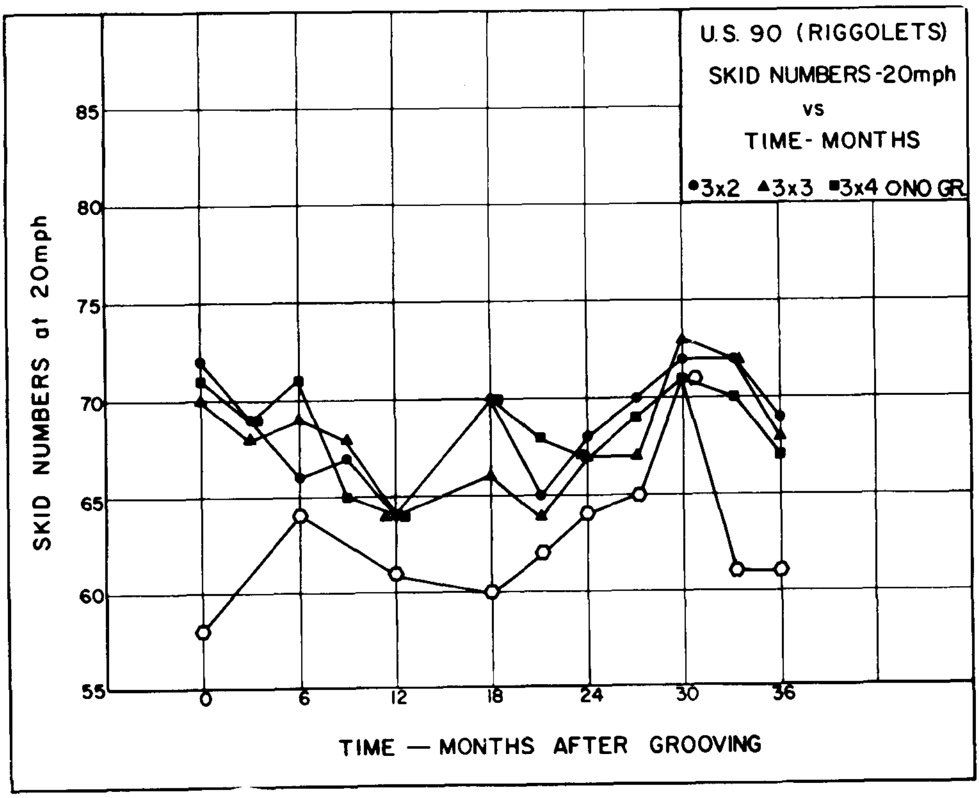

Figure 21

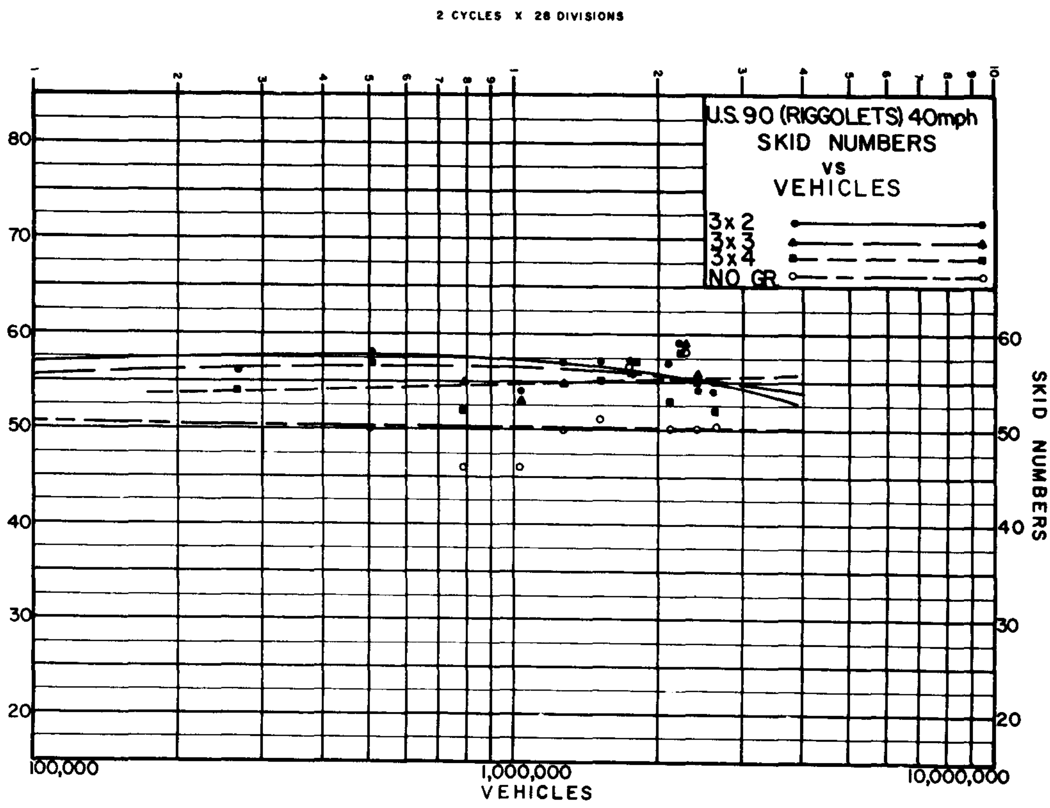

Figure 22

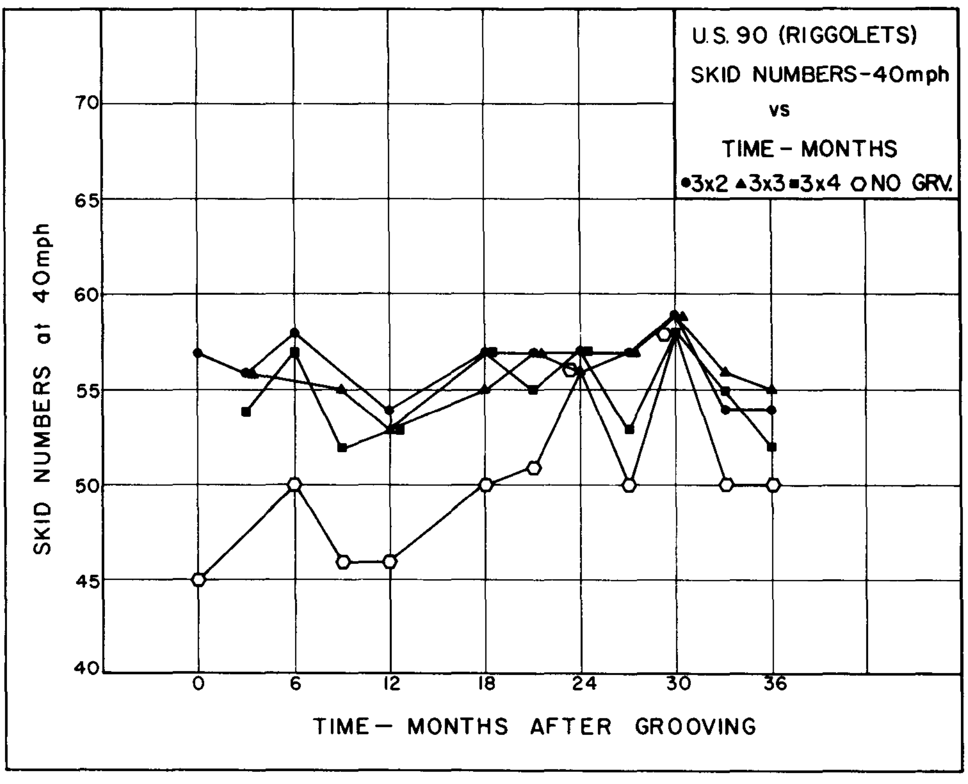

Figure 23

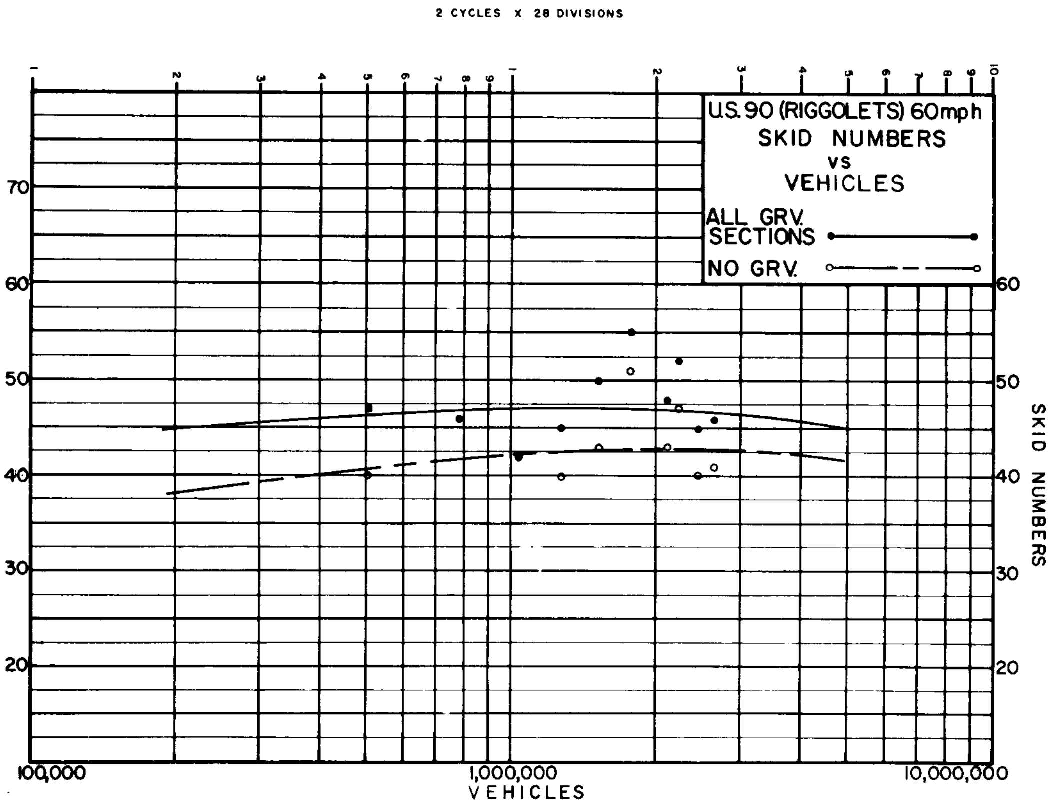

Figure 24

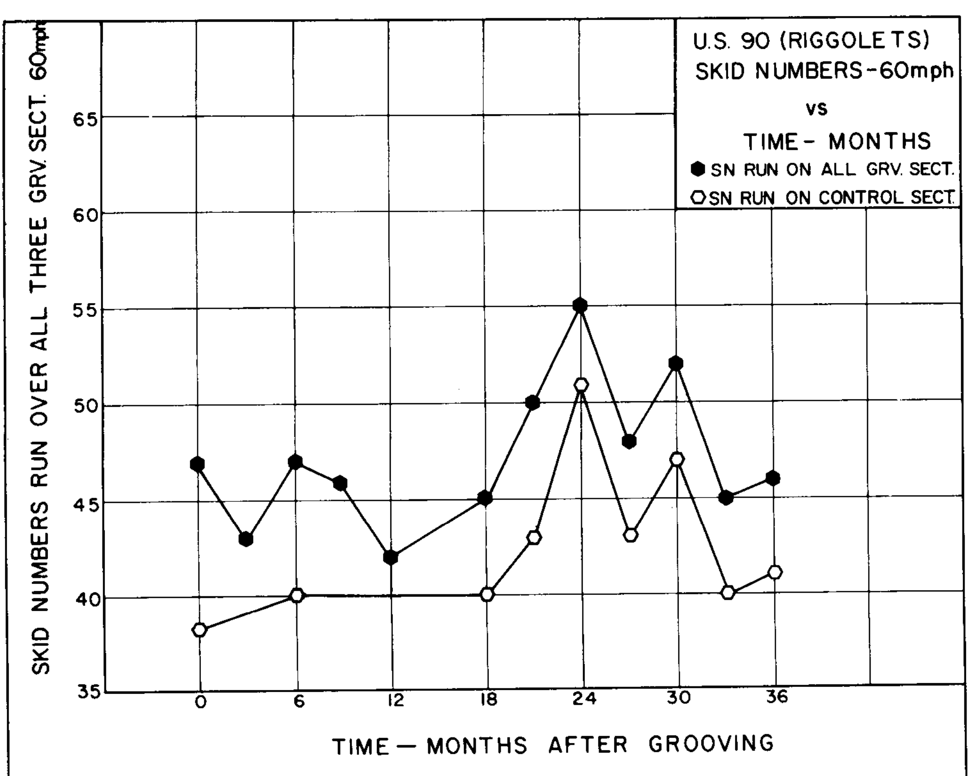

Figure 25

2 CYCLES X 28 DIVISIONS

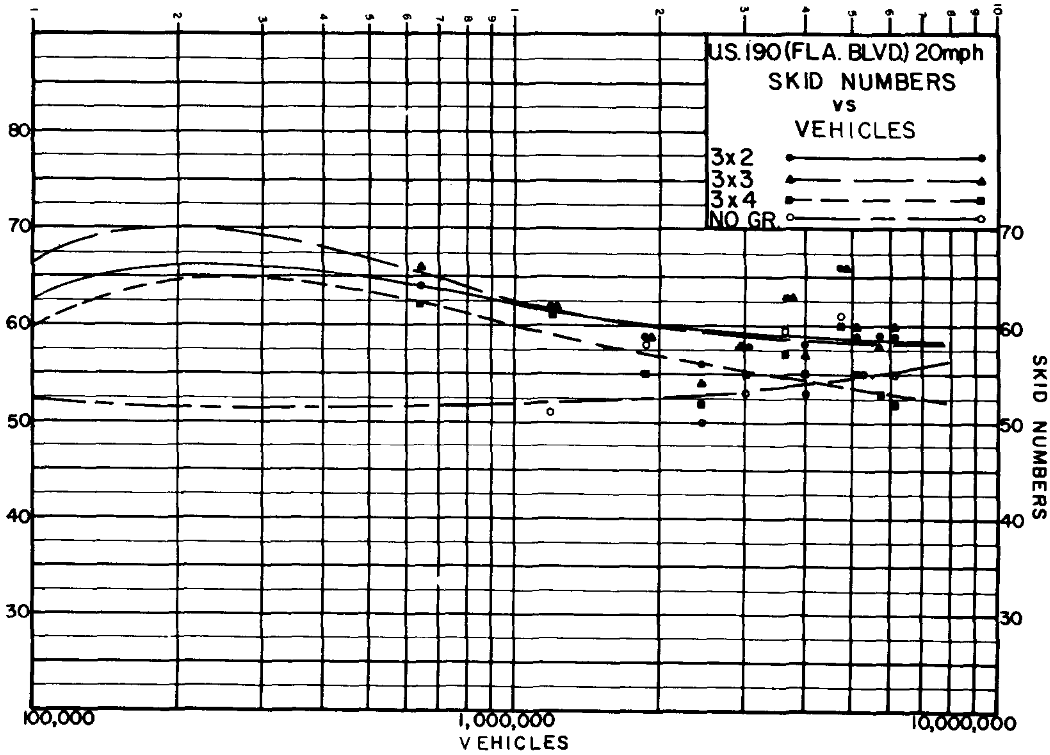

Figure 26

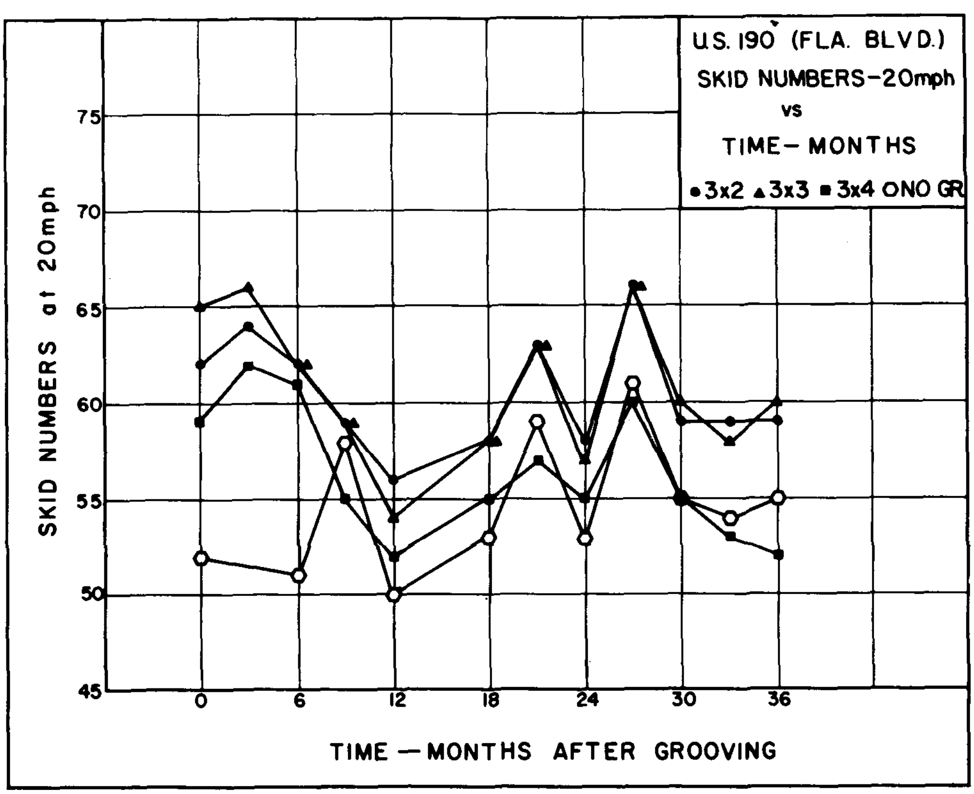

Figure 27

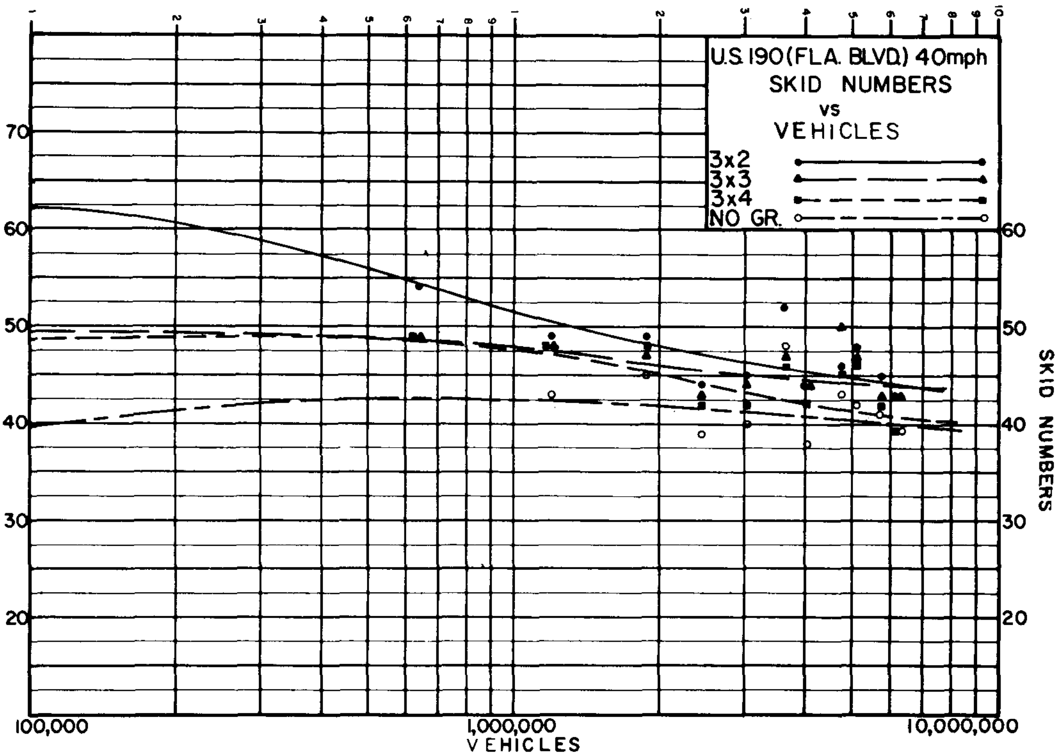

Figure 28

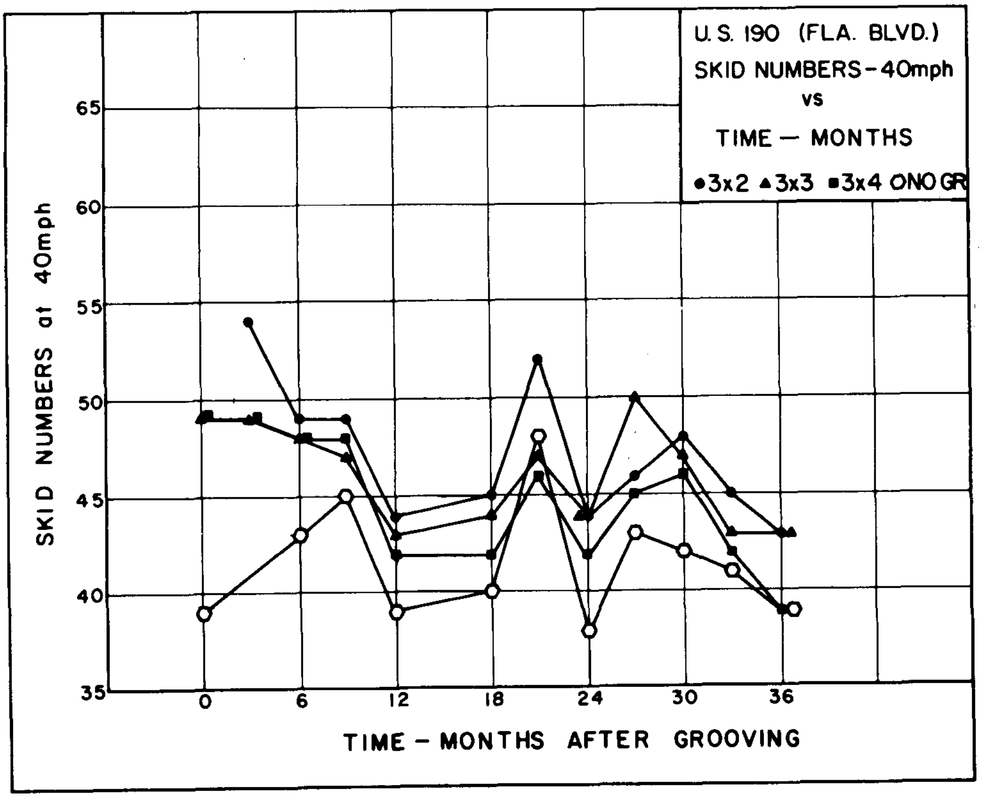

Figure 29

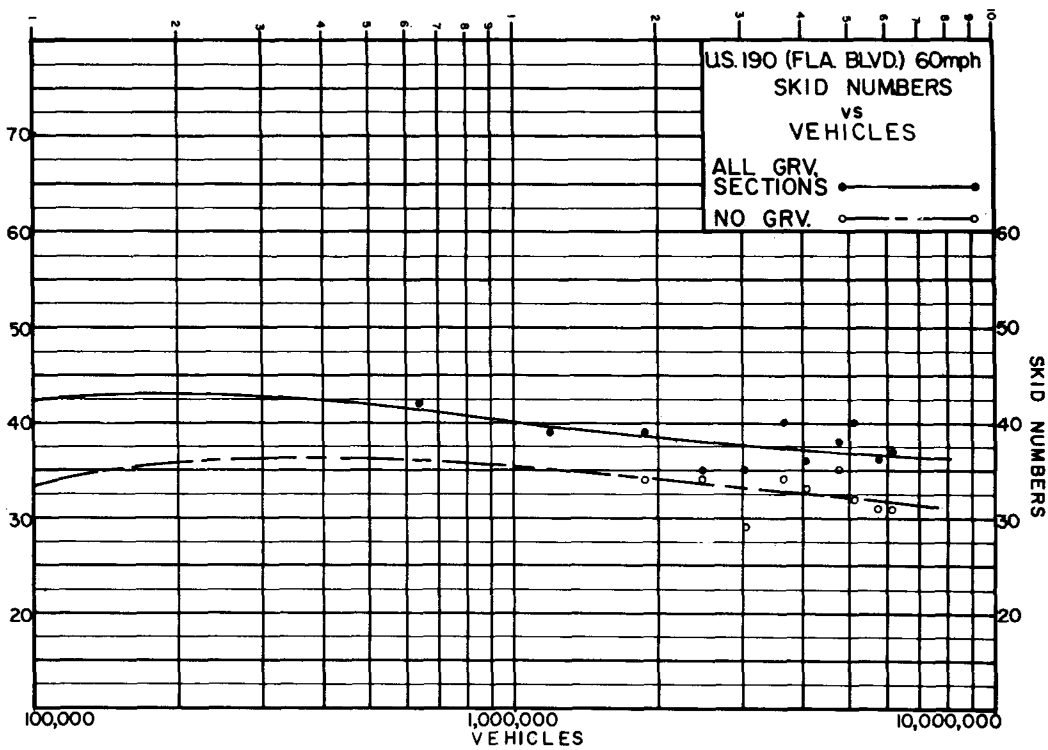

Figure 30

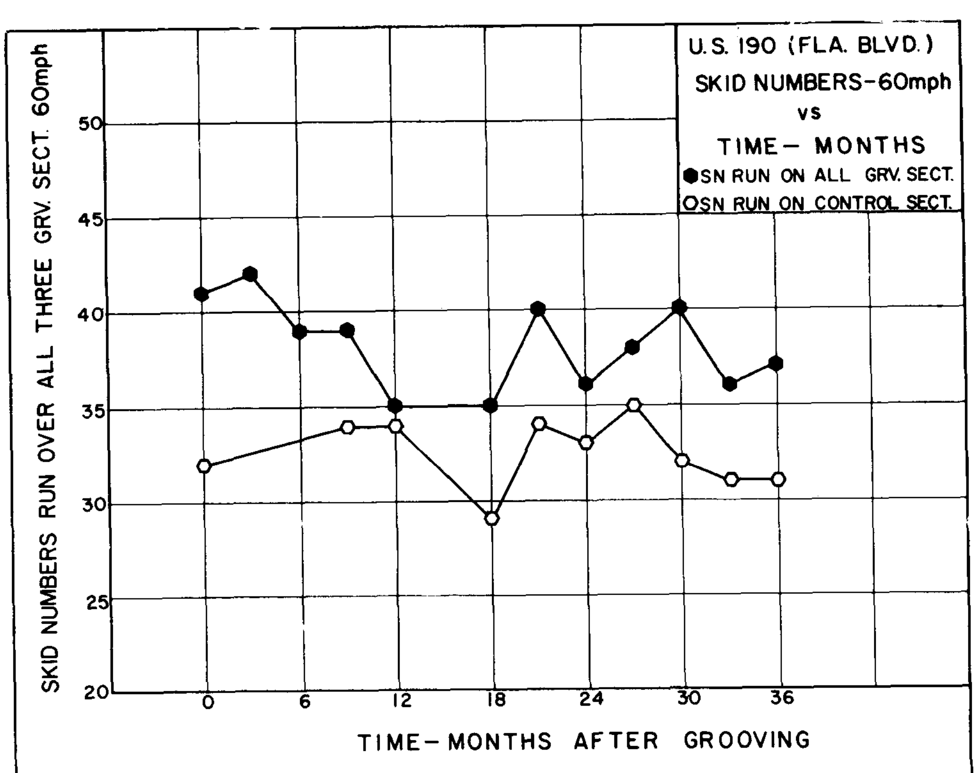

Figure 31

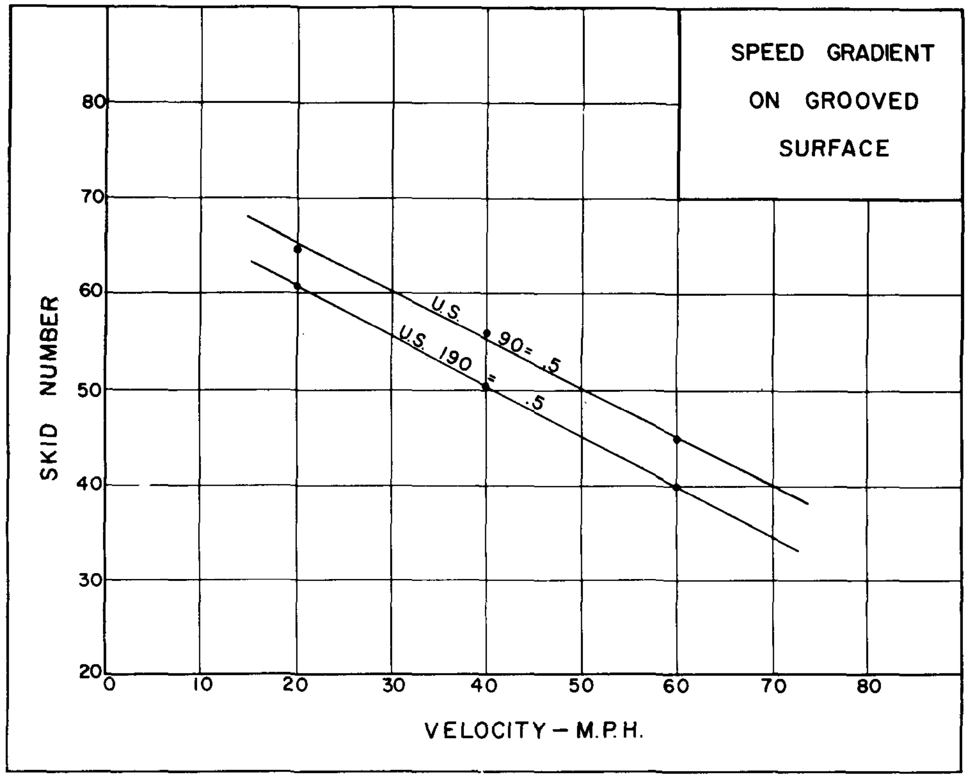

Figure 32

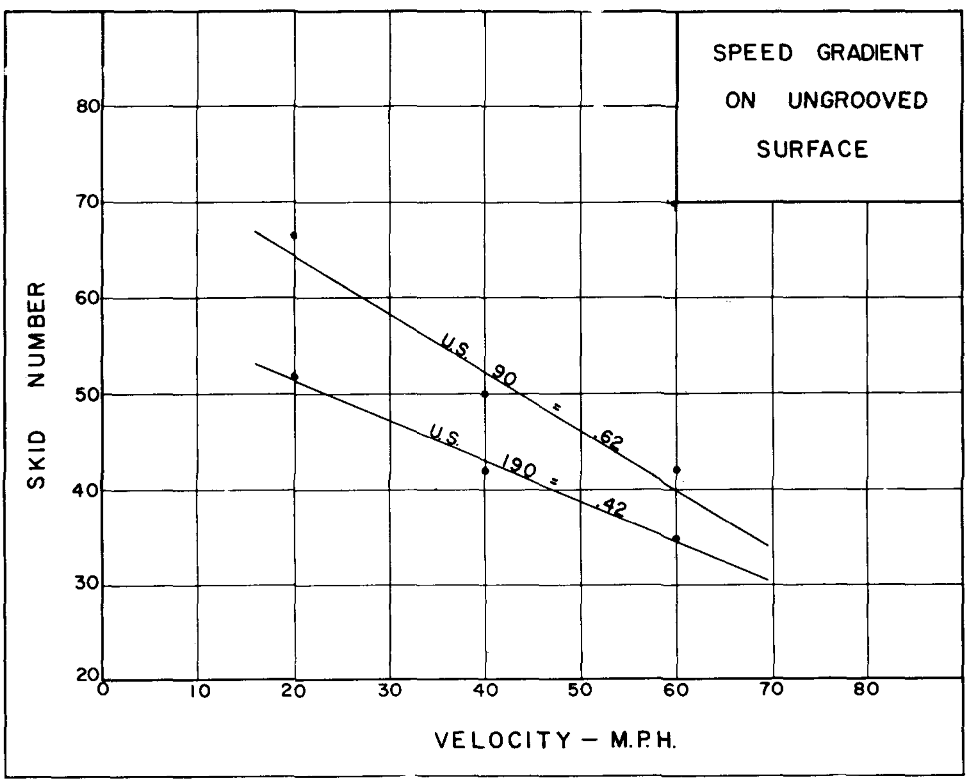

Figure 33

TABLE 1

		Before Grooving					Control Section: Area Not Grooved															
		20	30	40	60	MPH	Three Months				Six Months				Nine Months				Twelve Months			
						MPH	20	30	40	60	20	30	40	60	20	30	40	60	20	30	40	60
Scenic Highway																						
North Bound	Outside Lane		33					28				31								31		
	Inside Lane		37					38				40								38		
South Bound	Outside Lane		30									35								33		
	Inside Lane		32									35								33		
Florida Boulevard		52		39	32	SKID NUMBER					51		43		58		45	34	50		39	
U.S. 90 (Riggolets)		58		45	38						64		50				46	40	61		46	

TABLE 1 (CONTINUED)

	Before Grooving 20	30	40	60	MPH	Control Section: Area Not Grooved — Fifteen Months 20	30	40	60	Eighteen Months 20	30	40	60	Twenty-one Months 20	30	40	60	Twenty-four Months 20	30	40	60
Scenic Highway					SKID NUMBER																
North Bound Outside Lane		33					36				36								36		
North Bound Inside Lane		37					44				44								45		
South Bound Outside Lane		30					33				33								44		
South Bound Inside Lane		32					39				39								42		
Florida Boulevard	52		39	32		53		40		53		40	29	59		48	34	53		38	33
U.S. 90 (Riggolets)	58		45	38		60		49		60		50	40	62		51	43	64		56	51

TABLE 1 (CONTINUED)

	Before Grooving					Control Section Area Not Grooved															
	20	30	40	60	MPH	Twenty-seven Months				Thirty Months				Thirty-three Months				Thirty-six Months			
					MPH	20	30	40	60	20	30	40	60	20	30	40	60	20	30	40	60
Scenic Highway					SKID NUMBER																
North Bound Outside Lane		33					33				33				30				28		
North Bound Inside Lane		37					39				40				38				39		
South Bound Outside Lane		30					32				33				30				32		
South Bound Inside Lane		32					36				36				36				36		
Florida Boulevard	52		39	32		61		43	35	55		42	32	54		41	31	55		39	31
U.S. 90 (Riggolets)	58		45	38		65		50	43	71		58	47	61		50	40	61		50	41

TABLE 2

			Immediately After Grooving				Three Months After Grooving				Six Months After Grooving				Nine Months After Grooving			
		M.P.H.	20	30	40	60	20	30	40	60	20	30	40	60	20	30	40	60
Scenic Highway		Pattern	SKID NUMBER															
North Bound	Outside Lane	Solid		58				48				50				50		
		3'x3'		46				39				41				37		
	Inside Lane	Solid		59				49				47				45		
		3'x4'		53				47				45				42		
South Bound	Outside Lane	Solid		55				46				46				44		
		3'x3'		45				36				37				36		
	Inside Lane	Solid		55				45				45				44		
		3'x2'		50				44				41				39		
Florida Boulevard																		
		3'x4'	59			41	62		49	42	61		48	39	55		48	39
		3'x3'	65		49	41	66		49	42	62		48	39	59		47	39
		3'x2'	62			41	64		54	42	62		49	39	59		49	39
U.S. 90 (Riggolets)																		
		3'x4'	72		57	47	69		56	43	66		58	47	67			46
		3'x3'	70			47	68		56	43	69			47	68		55	46
		3'x2'	71			47	69		54	43	71		57	47	66		52	46

Note: 3'x4' denotes that the first figure (3') is grooved; the second figure (4') is that clear width between grooved sections.

Solid denotes that the entire section is grooved.

All grooving was the Christensen Company style seven.

TABLE 2 (CONTINUED)

			Twelve Months After Grooving				Fifteen Months After Grooving				Eighteen Months After Grooving				Twenty-one Months After Grooving			
		M.P.H. (SKID NUMBER)	20	30	40	60	20	30	40	60	20	30	40	60	20	30	40	60
Scenic Highway		Pattern																
North Bound	Outside Lane	Solid		46				48				48						
		3'x3'		39				44				44						
	Inside Lane	Solid		47				52				52						
		3'x4'		42				48				48						
South Bound	Outside Lane	Solid		42				40				40						
		3'x3'		35				36				36						
	Inside Lane	Solid		41				46				46						
		3'x2'		39				41				41						
Florida Boulevard																		
		3'x4'	52		42	35	55		42	35	55		42	35	57		46	40
		3'x3'	54		43	35	58		44	35	58		44	35	63		47	40
		3'x2'	56		44	35	58		45	35	58		45	35	63		52	40
U.S. 90 (Riggolets)																		
		3'x4'	64		54	42	70		56	45	70		57	45	65		57	50
		3'x3'	64		53	42	66		55	45	66		55	45	64		57	50
		3'x2'	65		53	42	70		57	45	70		57	45	68		55	50

Note: 3'x4' denotes that the first figure (3') is grooved; the second figure (4') is that clear width between grooved sections.

Solid denotes that the entire section is grooved.

All grooving was the Christensen Company style seven.

TABLE 2 (CONTINUED)

			Twenty-four Mos. After Grooving				Twenty-seven Mos. After Grooving				Thirty Mos. After Grooving				Thirty-three Mos. After Grooving			
		M.P.H.	20	30	40	60	20	30	40	60	20	30	40	60	20	30	40	60
Scenic Highway		Pattern																
North Bound	Outside Lane	Solid		45				42				40				40		
		3'x3'		34				33				30				37		
	Inside Lane	Solid		48				44				43				44		
		3'x4'		48				46				43				43		
South Bound	Outside Lane	Solid		43				40				37				37		
		3'x3'		39				34				33				32		
	Inside Lane	Solid		46				42				39				41		
		3'x2'		42				40				39				38		
Florida Boulevard			SKID NUMBER															
		3'x4'	55		42	36	60		45	38	55		47	40	53		42	36
		3'x3'	57		44	36	66		50	38	60		48	40	58		43	36
		3'x2'	58		44	36	66		46	38	59		49	40	59		46	36
U.S. 90 (Riggolets)																		
		3'x4'	68		57	55	70		57	48	72		59	52	72		54	45
		3'x3'	67		56	55	67		57	48	73		59	52	72		56	45
		3'x2'	67		57	55	69		53	48	71		58	52	70		55	45

Note: 3'x4' denotes that the first figure (3') is grooved; the second figure (4') is that clear width between grooved sections.

Solid denotes that the entire section is grooved.

All grooving was the Christensen Company style seven.

TABLE 2 (CONTINUED)

Thirty-six Months After Grooving

			Skid Number			
		M.P.H.	20	30	40	60
Scenic Highway		Pattern				
North Bound	Outside Lane	Solid		38		
		3'x3'		30		
	Inside Lane	Solid		42		
		3'x4'		43		
South Bound	Outside Lane	Solid		37		
		3'x3'		31		
	Inside Lane	Solid		38		
		3'x2'		35		
Florida Boulevard						
		3'x4'	52		39	37
		3'x3'	60		43	37
		3'x2'	59		43	37
U.S. 90 (Riggolets)						
		3'x4'	69		54	46
		3'x3'	68		55	46
		3'x2'	67		52	46

Note: 3'x4' denotes that the first figure (3') is grooved; the second figure (4') is that clear width between grooved sections.

Solid denotes that the entire section is grooved.

All grooving was the Christensen Company style seven.