PROGRESS REPORT No. 4 ON SKID RESISTANCE STUDY U.S. 31 TEST ROAD

APRIL - 1956
No. 19

by
F.M. Holloway

Joint Highway Research Project

PURDUE UNIVERSITY
LAFAYETTE INDIANA

PROGRESS REPORT NO. 4

ON THE

SKID RESISTANCE STUDY OF U. S. 31 TEST ROAD

TO: K. B. Woods, Director
Joint Highway Research Project

April 19, 1956

File: 8-15-1
C-36-53E

FROM: Harold L. Michael, Assistant Director

Attached is "Progress Report No. 4 on the Skid Resistance Study of U. S. 31 Test Road." This report has been prepared by Mr. F. M. Holloway, Research Engineer, of our staff.

This study is a continuation of the skid project for the U. S. 31 Test Road and is the fifth semi-annual study to be made.

This report is also being transmitted to the Test Road Committee of the Indiana State Highway Department for their distribution.

Respectfully submitted,

Harold L. Michael

Harold L. Michael, Assistant Director
Joint Highway Research Project

HLM:cjg

Attachment

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by

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Research Engineer
Joint Highway Research Project

C-36-53E

Purdue University
Lafayette, Indiana
April 19, 1956

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SKID RESISTANCE STUDY OF U. S. 31 TEST ROAD

INTRODUCTION

One of the elements of comparison of the portland cement concrete and the bituminous concrete sections of the U. S. 31 Test Road near Columbus, Indiana is that of skid resistance. Test Road Committee Memorandum No. 5 establishes the purpose of the study as: "to measure the relative skid resistance of the two types of pavement and to measure the changes in skid characteristics as the pavements are under traffic."

In conformance with discussions at the Joint Highway Research Project Advisory Board Meeting on January 27, 1954, the Joint Highway Research Project, in co-operation with the State Highway Department of Indiana, has conducted and will continue to conduct periodic skid tests on the Test Road. In this report are the results of the group of tests made in March, 1956 and a discussion of the stopping distance trends to date.

SCOPE

The 7.1417 miles of flexible or bituminous concrete test pavement (detailed on Figure 1 as sections F-1, F-2, and F-3) and the 6.9392 miles of rigid or portland cement concrete test pavement (detailed on Figure 1 as sections R-1, R-2, R-3, R-4, and R-5) are the subject of this study. All tests made on these test sections were performed so as to compare the skid resistance characteristics of the flexible and rigid test pavements. Studies of the skid characteristics have been made since shortly after the sections were opened to traffic and tests will be conducted periodically as long as the Test Road Committee requires them.

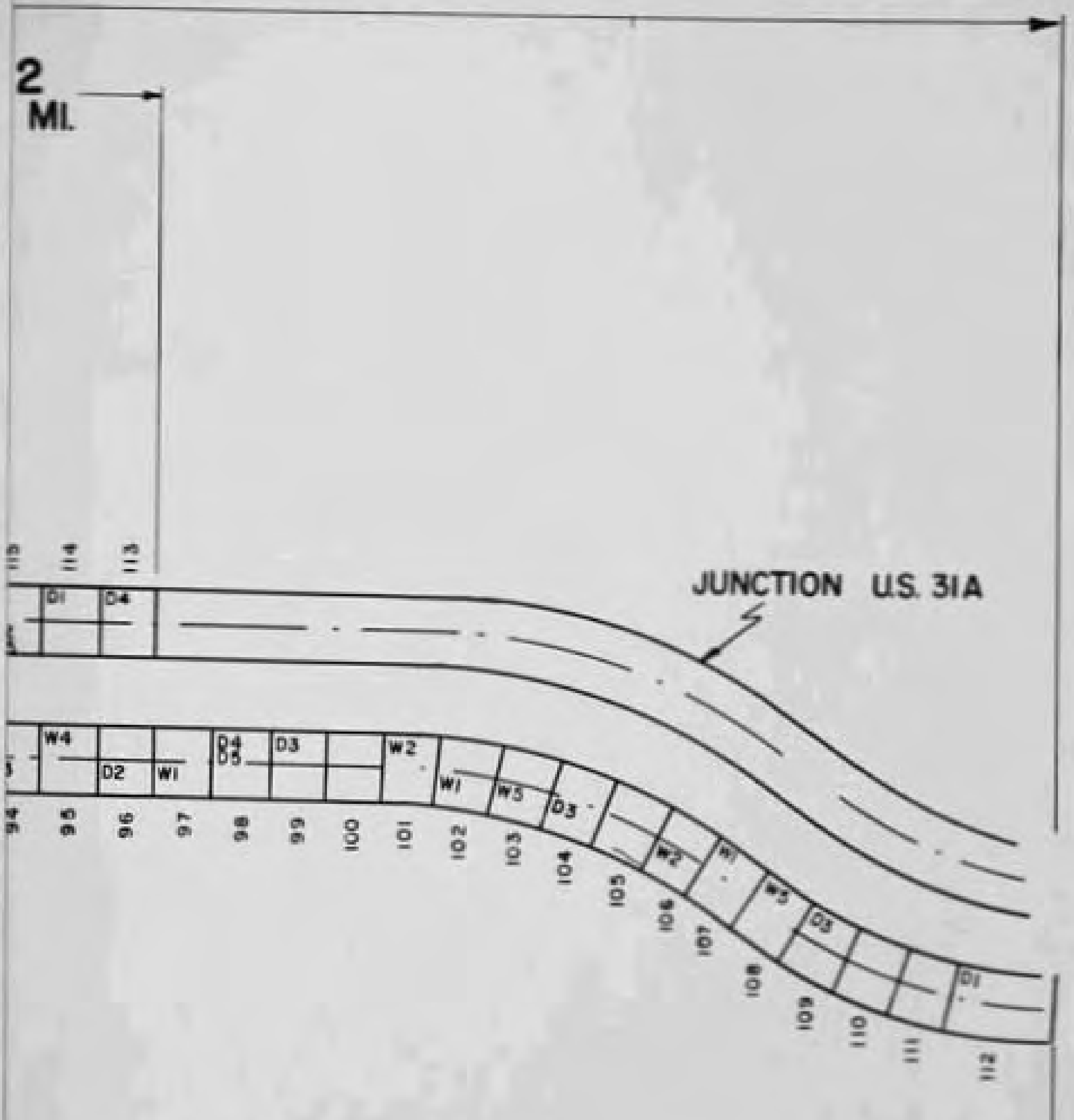


FIGURE 1

AYOUT AND TEST SITES FOR SKID RESISTANCE STUDY OF U.S.31 TEST ROAD

(REDRAWN FEB. 1956)

FIGURE 1

LAYOUT AND TEST SITES FOR SKID RESISTANCE STUDY OF U.S. 31 TEST ROAD

(REDRAWN FEB. 1956)

PROCEDURE

As planned, skid tests are being performed twice a year, once during the winter and once during the summer. The winter tests are conducted in February or March and the summer tests in July or August on days that weather will permit. Tests have now been performed in February and March, 1954; August, 1954; March, 1955; August, 1955; and March, 1956.

The skid equipment which was developed in 1954 for a comprehensive skid resistance study of pavement types has been utilized for all tests except those made in February and March, 1954. Since those tests were made with different equipment, the data were adjusted on the basis of comparative tests as reported in Progress Report No. 1, so as to be comparable with subsequent test data.

Each of the two test pavement types are divided into 70 one-tenth mile sections (see Figure 1). Each of these one-tenth mile sections has been and will continue to be considered as a possible site for test skids.

For each semi-annual study to date the following plan has been used as a guide:

1. Skid tests were made at a speed of 30 m.p.h.
2. Skid tests were made under wet and dry conditions. Wet tests were made by artificially wetting the pavement until water would stand on the surface.
3. An equal number of skid tests were made on each pavement type.
4. An equal number of skid tests were made in each traffic lane and for each direction of traffic flow.
5. Sixteen sites were selected for wet tests and sixteen different sites for dry tests. These sites were selected in a manner that gave each one-tenth mile section an equal opportunity of getting into the sample, but that maintains the policies established in items 3 and 4 above.

6. Two skids were made at each site.

7. The average stopping distance, wet and dry, for each pavement type was determined by statistical methods and 95% confidence limits were established.

8. Sources of variation in stopping distances due to different sites, lanes, and directions, as well as various combinations of these, were statistically tested for significant differences.

9. Temperatures were recorded several times during the testing.

DATA PRESENTATION AND ANALYSIS

The sites selected for the tests of March, 1956 are shown in Table 1. All sites selected for all tests to date are indicated on Figure 1. It can be observed that the sites, randomly chosen, are well-distributed over the Test Road and may be considered as samples representing the entire section. The wet tests were made on March 14, 1956 and the dry tests were made on March 20, 1956.

Mean stopping distances for each pavement, condition, lane, and direction were calculated and are shown in Table 2. Values for all previous tests are also shown for comparison.

It appears that the trend of stopping distances on both pavements under wet conditions is downward for the March, 1956 tests but that under dry conditions it shows little change. It is also evident that under wet conditions the average stopping distances on the outside or driving lane are greater than those on the inside or passing lane of both pavement types.

In order to determine the significance of the differences between mean stopping distances, and to establish 95% confidence limits on them, a statistical analysis was made.

TABLE 1

SITES FOR TESTS OF MARCH, 1956

	Site Numbers Tested[1]			
	Inner Lane		Outer Lane	
	Southbound	Northbound	Southbound	Northbound
Wet Tests[2]				
Flexible Pavement	93 108	115 125	73 103	118 132
Rigid Pavement	3 6	58 68	13 27	48 63
Dry Tests[3]				
Flexible Pavement	83 88	129 136	78 98	122 139
Rigid Pavement	17 24	33 43	10 20	38 53

Notes: [1] See Figure 1 for site locations

[2] Tests performed on March 14, 1956

[3] Tests performed on March 20, 1956

TABLE 2

SUMMARY OF STOPPING DISTANCES

Flexible Pavement
Mean Stopping Distance in Feet

Lane	Wet					Dry				
	Feb.* 1954	Aug. 1954	Mar. 1955	Aug. 1955	Mar. 1956	Mar.* 1954	Aug. 1954	Mar. 1955	Aug. 1955	Mar. 1956
Inner, southbound	71.8	79.7	78.4	85.5	81.6	58.3	59.2	59.9	57.6	59.3
Inner, northbound	68.2	71.8	73.6	84.6	75.2	62.9	59.6	61.1	56.5	58.0
Average, inner	70.0	75.7	76.0	85.1	78.4	60.6	59.4	60.5	57.1	58.6
Outer, southbound	72.4	80.4	94.7	102.0	90.5	60.7	59.5	59.6	54.9	57.5
Outer, northbound	74.1	75.9	94.2	101.3	92.6	63.0	59.5	63.2	56.4	57.1
Average, outer	73.2	78.1	94.4	101.6	91.6	61.9	59.5	61.4	55.6	57.3
Average, flexible	71.6	76.9	85.2	93.3	85.0	61.2	59.4	60.9	56.3	58.0

Rigid Pavement
Mean Stopping Distance in Feet

Lane	Wet					Dry				
	Feb.* 1954	Aug. 1954	Mar. 1955	Aug. 1955	Mar. 1956	Mar.* 1954	Aug. 1954	Mar. 1955	Aug. 1955	Mar. 1956
Inner, southbound	72.3	64.6	71.6	74.6	72.8	58.6	61.9	60.7	60.3	59.1
Inner, northbound	64.3	67.3	72.1	75.8	68.5	69.2	62.1	60.0	59.4	58.1
Average, inner	68.3	66.0	71.8	75.2	70.6	60.4	62.0	60.3	59.9	58.6
Outer, southbound	68.0	77.9	90.8	94.0	97.2	61.5	60.5	60.9	57.1	58.5
Outer, northbound	68.6	75.0	82.8	93.5	89.8	62.8	61.1	60.1	60.1	57.7
Average, outer	68.3	76.4	86.8	93.8	93.5	62.2	60.8	60.5	58.6	58.1
Average, rigid	68.3	71.2	79.3	84.5	82.1	61.3	61.4	60.4	59.3	58.4

* Values by original test method adjusted to compare with distances measured by method used in August, 1954 and thereafter.

It was found that the variation in values from skid tests on dry pavement was very small and about equally divided between skid to skid variation and site to site variation. In the wet skid test values the variation was much larger, with the site to site variation significantly greater than the skid to skid variation. This means that under wet conditions the stopping distance values varied somewhat from one skid to another at the same site, and that they varied considerably at different parts of the test section.

There was about the same amount of skid to skid variation in the wet skid test values of March as those of last August.

On the basis of the amount of variance involved and the number of test values used in the calculation of each mean stopping distance, 95% confidence limits were attached to each value for the two pavements under wet and dry conditions. These are shown in Table 3 along with those of the four previous testing dates. These means with their confidence limits and trend lines are shown graphically on Figure 2. Where any pair of confidence intervals are seen to be separated, the related means are significantly different.

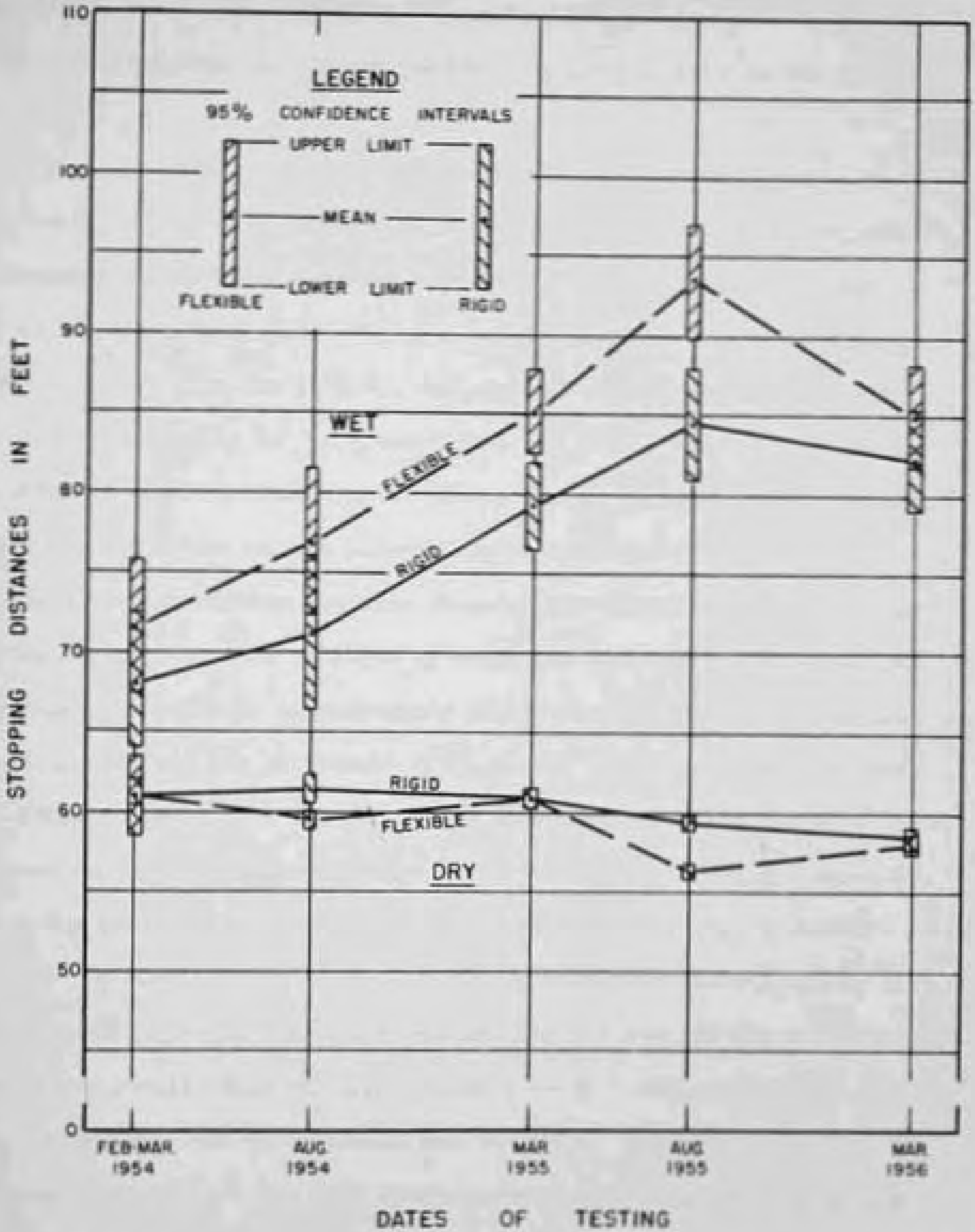
Under wet conditions the mean stopping distance on flexible pavement was 85.0 feet, while that on rigid pavement was 82.1 feet. This difference of 2.9 feet is not statistically significant. Figure 2 shows the average on wet, flexible pavement in March, 1956 to be significantly less than in August, 1955 by about 8 feet, while the corresponding values on rigid pavement differ by only 2.4 feet. The trend lines show that the mean stopping distances on wet, rigid pavement increased at a decreasing rate up to August, 1955 and then decreased in the March, 1956 tests, and that those on wet, flexible

TABLE 3

STOPPING DISTANCES AND CONFIDENCE LIMITS

Condition	Pavement Type	Study	Avg. Stopping Dist. in Feet	95% Confidence Limits in Feet
Wet	Flexible	1*	71.6	± 4.2 or 67.4 to 75.8
		2	76.9	± 4.7 or 72.2 to 81.6
		3	85.2	± 2.7 or 82.5 to 87.9
		4	93.3	± 3.5 or 89.8 to 96.8
		5	85.0	± 3.1 or 81.4 to 88.1
	Rigid	1*	68.3	± 4.2 or 64.1 to 72.5
		2	71.2	± 4.7 or 66.5 to 75.9
		3	79.3	± 2.7 or 76.6 to 82.0
		4	84.5	± 3.5 or 81.0 to 88.0
		5	82.1	± 3.1 or 79.0 to 85.2
Dry	Flexible	1*	61.2	± 2.6 or 58.6 to 63.8
		2	59.4	± 0.5 or 58.9 to 59.9
		3	60.9	± 0.4 or 60.5 to 61.3
		4	56.3	± 0.4 or 55.9 to 56.7
		5	58.0	± 0.6 or 57.4 to 58.5
	Rigid	1*	61.3	± 0.9 or 60.4 to 62.2
		2	61.4	± 0.5 or 60.9 to 61.9
		3	60.4	± 0.4 or 60.0 to 60.8
		4	59.3	± 0.4 or 58.9 to 59.7
		5	58.4	± 0.6 or 57.8 to 58.9

* Values by original test method adjusted to compare with distances measured by method used in August, 1954 and thereafter.



STOPPING DISTANCE TRENDS
BY PAVEMENT TYPE
U.S. 31 TEST ROAD

FIGURE 2

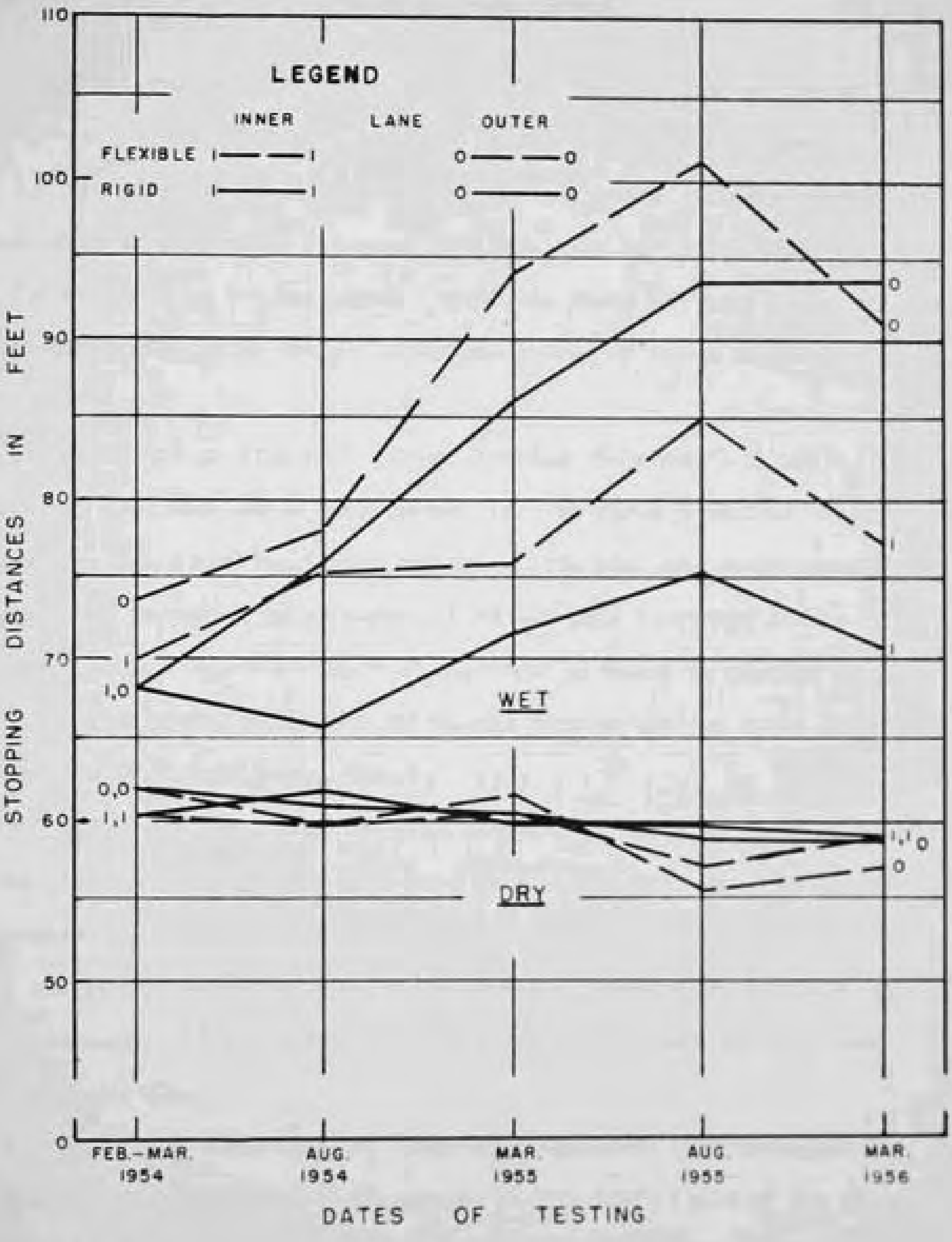
pavement are larger and increased at a steady but greater rate up to August, 1955 and then also decreased but at a greater rate in the March, 1956 tests.

The indication is that the wet skid resistance of both pavements is affected by some other factor or factors besides age. It is suggested that perhaps the pavement temperature during testing has some effect upon the skidding distances. The pavement temperature was approximately 100°F. in August compared to 40°F. during the March testing. Figure 2 also indicates that up to the present time the rigid pavement has always been the most skid resistant in the wet condition although the difference between the two types has not always been statistically significant.

Under dry conditions the mean stopping distance on flexible pavement was 58.0 feet, while that on rigid pavement was 58.4 feet. The value for the flexible pavement is significantly higher than the corresponding value of last August, and the difference of about two feet is also significant, statistically (see Figure 2). The trend lines show that the stopping distances on dry, rigid pavement are still decreasing slightly. However, a repeating pattern seems to appear in the distances on dry, flexible pavement. No significance as yet has been attached to the difference between pavement types in the winter values, but the summer values on flexible pavement are consistently and significantly lower. Because of the low variances, it is felt that these trends are reliable. The indication is that temperature may affect the skid resistance of dry, flexible pavement, a temperature rise effecting an increase in resistance. Further comparison of winter and summer values and extension of the trend line is needed to substantiate this.

The average stopping distances on outer and inner lanes were compared. As they did in March and August, 1955, the outer lane values on both pavements proved to be greater than the inner lane values under wet conditions. The difference was 13.2 feet on flexible pavement (it was 16.5 feet last August) and 22.9 feet on rigid pavement (it was 18.6 feet last August). On the outside lane the distances were 91.6 feet on flexible and 93.5 feet on rigid pavement. These differences are of high statistical significance. There are also significant differences between lanes on dry pavements, but these differences are small, did not hold true for every test, and are the reverse of the differences for wet conditions. The trend lines (see Figure 3) indicate that the skid resistance of all lanes under wet conditions increased in March (the outer rigid only 0.3 feet), that the outer or driving lane has less resistance than the inner or passing lane of both pavement types, and that the difference between outer and inner lanes has become greater on the rigid pavement.

Stopping distance averages were also compared by direction. Although the difference for dry conditions was enough to be of some significance, statistically, it was of small magnitude (the southbound being greater by less than one foot), and did not hold true for many of the tests. There was no significant difference by direction for wet conditions.



STOPPING DISTANCE TRENDS

BY LANE

U.S. 31 TEST ROAD

FIGURE 3

SUMMARY AND CONCLUSIONS

The fifth semi-annual skid tests on U. S. 31 Test Road performed during March, 1956 at 30 m.p.h. resulted in the following findings:

1. Stopping distance values under wet conditions varied somewhat from one skid to another at the same site, and they varied considerably at different parts of the Test Road. There was about the same amount of skid to skid variation in the wet skid test values of March as those of last August.

2. Under wet conditions the mean stopping distance on flexible pavement was less than three feet greater than on rigid pavement. This difference is not statistically significant. The wet skid resistance of both pavements increased up to August, 1955 and then decreased in the March, 1956 tests. The resistance of the rigid pavement is greater than that of the flexible although the difference between the two types has not always been statistically significant.

3. Under dry conditions the mean stopping distance on rigid pavement was less than one foot greater than that on flexible pavement. It appears that temperature affects the resistance of the flexible pavement more than that of the rigid pavement. A higher temperature appears to increase the skid resistance of dry, flexible pavement, but further testing is needed to substantiate this.

4. Under wet conditions the stopping distances on the outer lanes were 13.2 and 22.9 feet greater than those on the inner lanes of the flexible and rigid pavements, respectively. This infers that the wet skid resistance of the driving lanes of both pavements is considerably less than that of the passing lanes. The difference appears to be increasing more

for rigid pavement than for flexible pavement.

5. Under dry conditions the mean stopping distance on inside lanes was less than a foot greater than that on the outside lanes. This difference is believed to be of little practical importance.

6. The average southbound stopping distance was less than one foot greater than that on the northbound road under dry conditions. This is the reverse of what was reported for the August, 1955 tests. However, this difference is of such a small magnitude and was not significant for wet conditions and is of little practical importance.