Technical Report Documentation Page

1. REPORT No.

2. GOVERNMENT ACCESSION No.

3. RECIPIENT'S CATALOG No.

4. TITLE AND SUBTITLE

Results of Cooperative Test Series on Asphalts from the Zaca-Wigmore Experimental Project

5. REPORT DATE

October 1959

6. PERFORMING ORGANIZATION

7. AUTHOR(S)

J. Skog

8. PERFORMING ORGANIZATION REPORT No.

9. PERFORMING ORGANIZATION NAME AND ADDRESS

State of California
Department of Public Works
Division of Highways

10. WORK UNIT No.

11. CONTRACT OR GRANT No.

13. TYPE OF REPORT & PERIOD COVERED

12. SPONSORING AGENCY NAME AND ADDRESS

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

Presented at the Third Pacific Area National Meeting of ASTM San Francisco, California October 11-16, 1959

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The barrels were carefully heated and separated into one gallon samples. These samples were sent to nine laboratories for testing. Later four other laboratories also performed the required test schedule.

The test values for the Pensky Martens Flask, Cleveland Open Cup Flash, Penetration at 77*F and 39.2*F., Saybolt Furol Viscosity at 275*F., and Standard Loss at 325*F. were determined in duplicate by each laboratory. Also certain of the laboratories performed the Thin Film Test.

A statistical analysis of the results is presented together with a discussion on the influence of the source of the asphalt on the accuracy of the tests.

17. KEYWORDS

18. No. OF PAGES:

13

19. DRI WEBSITE LINK

http://www.dot.ca.gov/hq/research/researchreports/1959-1960/59-13.pdf

20. FILE NAME

59-13.pdf

STATE OF CALIFORNIA
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By

J. Skog

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Presented at
The Third Pacific Area National
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By J. Skog*

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The Zaca-Wigmore Experimental Asphalt Project was constructed during 1954-55 and involved sixteen individual test sections and ten different asphalts. During the construction of the pavement sixteen individual barrel samples of asphalt were obtained. Each sample represented the asphalt placed in each test section.

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Introduction

An extensive experimental asphalt test project was constructed by the California Division of Highways in 1954-55. This test road has become known as the Zaca-Wigmore project. Sixteen individual test sections involving ten different asphalts, were constructed (1).

During the construction of each individual test section a representative barrel of asphalt was obtained. After completion of the job, the barrels were sent to a producer research center where facilities were available for heating the material and breaking down into desired sample sizes.

Shortly after completion of construction, a number of representatives of producers furnishing asphalts to the project, proposed a cooperative test program for determining the precision of tests proposed for inclusion in a new asphalt specification. It appeared desirable to perform such a test series on the various asphalts used in the Zaca-Wigmore project. In order to obtain representative materials, the barrel samples were carefully heated in a steam chamber, and after thorough agitation by rolling, one gallon samples were drawn and sent to each cooperating laboratory. Sixteen asphalts, one from each test section, were sent to thirteen laboratories participating in the test series.

Test Program

The cooperating laboratories were requested to perform the following tests in duplicate, on each asphalt sample:

Pensky Martens Flash
Cleveland Open Cup Flash
Original Penetration at 77°F and 39.2°F
Standard Loss Test at 325°F
Saybolt Furol Viscosity at 275°F
Thin Film Oven Test

Unfortunately the instructions did not specifically require the reporting of the individual results from each test and only average values were returned for final analysis.

Analysis of Results

The analysis of any cooperative series initially involves the problem of the rejection of so-called "unreliable" test results. The rejection of test data in interlaboratory control studies has been the subject of discussion in a number of articles and unfortunately no definite recommendations are provided in the A.S.T.M. "Manual on Quality Control of Materials" (2). Some statistical authorities recommend that results should be rejected on the basis of the judgment of a person thoroughly familiar with the test techniques. However, if it seems advisable to reject data it would seem preferable to accept some recommended method even though such a method is not fully agreed upon by all students of the subject.

In previous cooperative studies, analyzed by this department (3) we have used the Pierce Chauvenet criterion (4) for rejection of values statistically incompatible with the data and this principle was also followed for the series reported in this paper.

The Pierce Chauvenet criterion is based on first determining the standard deviation of all results submitted. Next, the probable error, derived from the standard deviation, is multiplied by a constant whose value is based on the number of observations. If there is an observation whose value differs from the mean by an amount greater than the quantity obtained, as stated above, then the value is considered "unreliable" and is rejected. If one or more observations are beyond the limiting value then after rejection a new calculation is performed, based on the remainder of the results. This is continued until all remaining values fall within the criterion for reliable data.

The use of this criterion provides some indication of the relative performance of the various laboratories and in this series tends to indicate the possible effects of the different asphalts on the accuracy of the test. Table I shows the percentage of tests rejected from each laboratory and Table II the number rejected for each test. A study of Table I indicates that individual laboratories vary considerably in producing reliable results. Table II confirms the previous studies that our various test procedures may vary quite widely in their degree of reliability as measured by the criterion used in this paper.

A summary of the statistical analysis is shown in Table III. A comparison of the test standard deviation for the various asphalts is shown in Tables IV and V. The range in standard deviation for the tests as shown in Table IV is quite large, clearly indicating that an important variable in the precision of any asphalt test is the source of the test material. The results are further complicated by the finding, as shown in Table V, that the standard deviation varies for each test, when different asphalts are compared. In other words, an asphalt that is critical in terms of precision for the flash test may or may not be critical in the penetration test. However, the over-all rating indicates that asphalts produced by the same production source, for the two different paving periods, have about the same position in the list.

Conclusions

The average deviations for the various tests are quite high even after rejecting all unreliable results according to the Pierce Chauvenet criterion. This confirms the findings from other cooperative studies, and indicates the continued need for study of the various variables involved in the tests. This test series clearly indicates that the test material influences the precision of the final result. Consideration of this factor should be made in any future cooperative series and testing should be arranged so that a variance analysis may be performed to determine the importance of this variable.

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TABLE I

Percentage of Test Averages Rejected by Pierce-Chauvenet Criterion.

Laboratory Comparison

Laboratory	Total Number of Test Averages	Per Cent of Averages Rejected
1	160	0
2	160	2.5
3	112	7.1
4	112	8.0
5	160	0.6
6	160	2.5
7	160	1.2
8	160	5.0
9	128	5.5
10	160	5.0
11	160	1.2
12	128	0
13	160	12.5

TABLE II

Percentage of Test Averages Rejected by the Pierce-Chauvenet Criterion

Test Type Comparison

Test	PMCT Flash	COC Flash	Orig. Pen. 77°F.	Pen. 39.2°F	Pen. Ratio	Visc. 275°F	Standard Loss Test		Thin Film Test		Grand Total
							Per Cent Loss	Per Cent Orig. Pen.	Per Cent Loss	Per Cent Orig. Pen.	
Total Number of Test Averages	208	176	208	192	192	208	208	208	160	160	1920
% of Averages Rejected	8.7	6.2	2.9	5.2	5.2	1.4	0.5	3.8	0.6	1.9	3.7

TABLE III

Summary of Analysis of Results

Asphalt		PMCT Flash	COC Flash	Orig. Pen. 77°F	Pen. 39.2°F	Pen. Ratio	Visc. 275°F	Stand. Loss Per Cent		Thin Film Loss Per Cent	
								Loss	Orig. Pen.	Loss	Orig. Pen.
A	n	22	20	24	22	22	26	24	26	20	20
	Ave. $\bar{X}$	448	508	225	57	25	60	0.13	87	0.49	57
	Dev.	8.8	15.1	8.3	3.5	2.3	2.9	0.04	4.1	0.01	3.6
A-2	n	26	20	26	24	22	26	26	24	20	20
	Ave. $\bar{X}$	448	509	218	57	26	58	0.13	84	0.42	56
	Dev.	11.6	6.5	7.4	2.4	0.8	4.0	0.04	3.0	0.17	3.6
B-1	n	26	22	24	22	20	26	26	26	20	26
	Ave. $\bar{X}$	413	477	255	78	30	79	0.22	85	0.96	47
	Dev.	10.6	12.6	10.0	5.3	0.9	4.2	0.08	3.2	0.22	6.8
B-2	n	24	20	24	20	20	26	26	26	20	20
	Ave. $\bar{X}$	410	444	223	74	33	103	0.33	81	1.53	43
	Dev.	9.2	12.8	7.3	3.9	2.4	6.9	0.09	4.6	0.32	4.3
C	n	24	22	22	18	18	26	26	24	20	20
	Ave. $\bar{X}$	428	493	247	59	25	59	0.21	85	0.65	54
	Dev.	9.4	11.5	7.5	1.5	2.7	3.4	0.08	2.6	0.14	3.3
C-2	n	24	22	24	24	24	24	26	26	20	20
	Ave. $\bar{X}$	404	485	246	62	25	62	0.23	86	0.82	51
	Dev.	9.8	10.1	11.2	5.7	2.0	3.2	0.04	5.8	0.15	4.5
D	n	18	20	26	24	24	26	26	18	18	18
	Ave. $\bar{X}$	410	468	243	68	28	58	0.28	84	1.33	52
	Dev.	2.9	7.8	7.4	3.6	1.6	4.6	0.06	1.9	0.16	3.4
D-2	n	22	22	26	24	20	26	26	26	18	18
	Ave. $\bar{X}$	414	499	228	60	27	57	0.23	83	0.78	53
	Dev.	5.2	15.2	8.6	4.3	1.2	4.0	0.06	4.5	0.09	3.0
E	n	22	20	26	24	22	26	26	26	20	20
	Ave. $\bar{X}$	336	392	227	97	43	119	0.98	76	4.04	30
	Dev.	9.0	17.5	8.5	7.5	1.8	7.0	0.18	5.0	0.47	4.3
E-2	n	24	22	26	24	24	26	26	26	20	18
	Ave. $\bar{X}$	305	377	239	99	42	120	1.65	62	5.02	21
	Dev.	9.9	19.5	9.3	11.0	2.8	6.1	0.23	4.4	0.75	2.0
F	n	26	22	26	24	24	26	26	26	20	18
	Ave. $\bar{X}$	406	450	215	67	31	103	0.35	82	1.60	40
	Dev.	10.2	13.4	5.7	6.6	2.8	5.2	0.08	3.3	0.31	3.3
G	n	26	16	26	24	24	26	26	26	20	20
	Ave. $\bar{X}$	409	463	238	86	36	98	0.28	82	1.34	41
	Dev.	7.7	5.3	9.6	5.3	2.3	6.4	0.05	4.7	0.24	4.0
G-2	n	24	22	26	22	20	26	26	26	20	20
	Ave. $\bar{X}$	403	442	215	74	34	108	0.38	79	1.92	39
	Dev.	6.7	11.2	8.1	3.2	1.8	4.2	0.10	4.9	0.43	3.8
H	n	24	20	26	24	24	24	26	24	20	20
	Ave. $\bar{X}$	428	487	230	65	28	72	0.23	83	0.78	50
	Dev.	8.3	9.0	6.0	5.1	2.0	3.3	0.05	4.6	0.13	4.1
H-2	n	26	18	26	20	20	24	26	24	20	18
	Ave. $\bar{X}$	418	474	212	60	28	72	0.26	81	0.92	47
	Dev.	6.8	4.4	8.6	2.8	1.5	4.4	0.07	2.1	0.14	2.1
J	n	22	22	26	24	24	26	26	24	20	20
	Ave. $\bar{X}$	473	596	237	69	29	114	0.08	87	0.17	58
	Dev.	6.6	11.2	9.6	5.0	2.0	4.1	0.03	4.5	0.09	3.6

TABLE IV

Variation of Test Standard Deviation for the Various Asphalts

Asphalt	PMCT Flash	COC Flash	Orig. Pen. 77°F	Pen. 39.2°F	Pen. Ratio	Visc. 275°F	Stand. Loss Per Cent		Thin Film Loss Per Cent	
							Loss	Orig. Pen.	Loss	Orig. Pen.
A	8.8	15.1	8.3	3.5	2.3	2.9	0.04	4.1	0.01	3.6
A-2	11.6	6.5	7.4	2.4	0.8	4.0	0.04	3.0	0.17	3.6
B-1	10.6	12.6	10.0	5.3	0.9	4.2	0.08	3.2	0.22	6.8
B-2	9.2	12.8	7.3	3.9	2.4	6.9	0.09	4.6	0.32	4.3
C	9.4	11.5	7.5	1.5	2.7	3.4	0.08	2.6	0.14	3.3
C-2	9.8	10.1	11.2	5.7	2.0	3.2	0.04	5.8	0.15	4.5
D	2.9	7.8	7.4	3.6	1.6	4.6	0.06	1.9	0.16	3.4
D-2	5.2	15.2	8.6	4.3	1.2	4.0	0.06	4.5	0.09	3.0
E	9.0	17.5	8.5	7.5	1.8	7.0	0.18	5.0	0.47	4.3
E-2	9.9	19.5	9.3	11.0	2.8	6.1	0.23	4.4	0.75	2.0
F	10.2	13.4	5.7	6.6	2.8	5.2	0.08	3.3	0.31	3.3
G	7.7	5.3	9.6	5.3	2.3	6.4	0.05	4.7	0.24	4.0
G-2	6.7	11.2	8.1	3.2	1.8	4.2	0.10	4.9	0.43	3.8
H	8.3	9.0	6.0	5.1	2.0	3.3	0.05	4.6	0.13	4.1
H-2	6.8	4.4	8.6	2.8	1.5	4.4	0.07	2.1	0.14	2.1
J	6.6	11.2	9.6	5.0	2.0	4.1	0.03	4.5	0.09	3.6
Range Low	2.9	4.4	5.7	2.4	0.8	2.9	0.03	1.9	0.01	2.0
Range High	11.6	19.5	11.2	11.0	2.8	7.0	0.23	5.8	0.75	6.8
Ave.	8.3	11.4	8.3	4.8	1.9	4.6	0.08	3.9	0.24	3.7

TABLE V

Comparison of Test Standard Deviation Rating with Asphalt Source

Lowest Standard Deviation Rating = 1

Asphalt	PMCT Flash	COC Flash	Orig. Pen. 77°F	Pen. 39.2°F	Pen. Ratio	Visc. 275°F	Stand. Loss Per Cent		Thin Film Loss Per Cent		Rating
							Loss	Orig. Pen.	Loss	Orig. Pen.	
A	8	12	7	5	8	1	2	7	1	6	5
A-2	16	3	4	2	1	5	2	4	7	6	2
B-1	15	9	12	11	2	7	6	5	8	12	13
B-2	10	10	3	7	9	13	7	10	11	10	14
C	11	8	5	1	10	4	6	3	4	4	4
C-2	12	6	13	12	7	2	2	14	5	11	11
D	1	4	4	6	5	9	4	1	6	5	3
D-2	2	13	9	8	3	5	4	9	2	3	6
E	9	14	8	14	6	14	9	13	13	10	16
E-2	13	15	10	15	11	11	10	8	14	1	15
F	14	11	1	13	11	10	6	6	10	4	12
G	6	2	11	11	8	12	3	11	9	8	10
G-2	4	7	6	4	6	7	8	12	12	7	9
H	7	5	2	10	7	3	3	10	3	9	7
H-2	5	1	9	3	4	8	5	2	4	2	1
J	3	7	11	9	7	6	1	9	2	6	8