Technical Report Documentation Page

1. REPORT No.
643100

2. GOVERNMENT ACCESSION No.

3. RECIPIENT'S CATALOG No.

4. TITLE AND SUBTITLE
Film Stripping Study

5. REPORT DATE
February 1971

6. PERFORMING ORGANIZATION

7. AUTHOR(S)

8. PERFORMING ORGANIZATION REPORT No.
643100

9. PERFORMING ORGANIZATION NAME AND ADDRESS

10. WORK UNIT No.

11. CONTRACT OR GRANT No.

12. SPONSORING AGENCY NAME AND ADDRESS

13. TYPE OF REPORT & PERIOD COVERED
Final Report

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The surface abrasion test was developed by the Materials and Research Department as a research instrument to measure the loss of surfacing that would be caused primarily by water action. It had been difficult, in the past, to find areas in the state that exhibited distress of this nature in the field, but extensive rains and flooding in the winter of 1968-69 caused areas in District 08 and District 11 to exhibit film stripping, with resulting surface raveling. The film strip test procedure (Test Method No. Calif. 302) did not indicate problems in the use of aggregates in these areas; however, some rather high losses were noted when these aggregates were tested with the proposed surface abrasion test. Therefore, this project was initiated in order to further study the use of the surface abrasion test as an indicator of aggregates with stripping tendencies.

The surface abrasion test subjects the water-covered surface of a compacted specimen to the dynamic effect of bouncing rubber balls. With hydrophilic aggregates the result of this test is an abraded surface quite similar to a condition classified as raveling in the field. In the report "New Test Methods for Studying the Effect of Water Action on Bituminous Mixtures," published in 1963, it was recommended that the maximum allowable abrasion abrasion loss, with this test method be set at 15 grams. This study was also initiated to study the suitability of this tentative maximum permissible abrasion loss.

This study was directed toward those aggregates that have a history of raveling or rutting in the field due to water action, however, aggregates from sources with good field performances were also included in the study.

17. KEYWORDS

18. No. OF PAGES:
16

19. DRI WEBSITE LINK
http://www.dot.ca.gov/hq/research/researchreports/1971/71-28.pdf

20. FILE NAME
71-28.pdf

February 1971

643100

71-28

Final Report

Film Stripping Study

Introduction

The surface abrasion test was developed by the Materials and Research Department as a research instrument to measure the loss of surfacing that would be caused primarily by water action. It had been difficult, in the past, to find areas in the state that exhibited distress of this nature in the field, but extensive rains and flooding in the winter of 1968-69 caused areas in District 08 and District 11 to exhibit film stripping, with resulting surface raveling. The film strip test procedure (Test Method No. Calif. 302) did not indicate problems in the use of aggregates in these areas; however, some rather high losses were noted when these aggregates were tested with the proposed surface abrasion test. Therefore, this project was initiated in order to further study the use of the surface abrasion test as an indicator of aggregates with stripping tendencies.

The surface abrasion test subjects the water-covered surface of a compacted specimen to the dynamic effect of bouncing rubber balls. With hydrophilic aggregates the result of this test is an abraded surface quite similar to a condition classified as raveling in the field. In the report "New Test Methods for Studying the Effect of Water Action on Bituminous Mixtures," published in 1963, it was recommended that the maximum allowable abrasion loss, with this test method be set at 15 grams. This study was also initiated to study the suitability of this tentative maximum permissible abrasion loss.

This study was directed toward those aggregates that have a history of raveling or rutting in the field due to water action, however, aggregates from sources with good field performance were also included in the study.

Conclusions

1. Asphalt mixtures containing aggregates with hydrophilic tendencies are best evaluated in the laboratory with either the surface abrasion test or the dye strip test. The surface abrasion test, however, is best suited for routine testing due to the lesser testing time required.

2. Both the surface abrasion test and the dye strip test correlate well with field conditions.

3. The method of compaction will influence the results of the surface abrasion test on poor aggregates but is not considered significant with good aggregates.

4. The grade of paving asphalt will influence the results of both the surface abrasion test and the dye strip test with poor aggregates. The heavier the grade of asphalt the less the film stripping tendency.

Recommendations

1. Dense graded asphaltic concrete mixtures should be evaluated for film stripping by means of the Surface Abrasion Test (Test Method Calif. 361).

2. The maximum permissible abrasion loss to dense graded asphaltic mixtures, when subjected to the Surface Abrasion Test, should remain at 15 grams, until a statistical study is performed.

Discussion and Test Results

The testing program consisted of analyzing aggregates from sources considered poor as well as from sources considered good, as determined by actual field performance. The poor performing aggregates were obtained and identified as follows: District 07, Quail Lake materials site (Laboratory Test No. 70-1041), District 09, Bowman Road Materials site (Laboratory Test No. 69-1319), District 11, Daley material site (Laboratory Test No. 70-1032) and material from the State of Arizona (Laboratory Test No. 69-1819). The sources providing aggregates of good quality were: Teichert's Perkins materials site (Laboratory Test No. 69-1001), Pacific Coast aggregates of Fair Oaks (Laboratory Test No. 70-1310) and Watsonville Granite from Watsonville (Laboratory Test No. 70-1355).

In addition to the surface abrasion test, the materials where subjected to the standard film strip test. The dye strip test, which has been used for many years in California on a limited scale, was also used in the evaluation. This test has shown a history of designating film stripping better than many tests but it is tedious and time-consuming. For further evaluation the materials were subjected to the Moisture Vapor Test (Test Method No. Calif. 307) and Immersion Compression Test (AASHO Test Method T-167-60).

The aggregate from each source was sieved into individual fractions and recombined to provide a gradation that met the tolerances specified for a 3/4" max. medium grading in Section 39 of the 1969 edition of the California Standard Specifications. (An identical grading was used in each case and this was done to place emphasis on the stripping characteristics without any influence from grading variations.) It is conceded that a variation in gradation will also contribute in some manner toward stripping characteristics; however, it was beyond the scope of this study to include all possible gradings or grades of asphalt. The selection of the 3/4" medium grading was thought most desirable because 80% of the asphalt concrete being placed today in California is utilizing this grading.

Two grades of paving asphalt were used (200-300 and 85-100) to observe the influence of various asphalt film thicknesses on film strippings. (The 85-100 pen. asphalt is used most often in California.) These asphalts were obtained from the Standard Oil refineries in Richmond.

An optimum asphalt content for each source was determined in accordance with Test Method 304. All testing for film stripping was then done on specimens prepared with the optimum asphalt content and cured in a 140°F for 15 hours immediately after mixing.

The laboratory compaction of the test specimens for surface abrasion testing originally consisted of using the Kneading Compactor with 500 psi pressure. However, after some consideration it was decided to provide a compacted specimen of a density closely resembling the density actually obtained in the field.

A study of the density of pavement cores over the last several years indicated that the majority of the projects were obtaining a compaction, relative to Kneading compaction in the laboratory, of about 95%.

It was then observed that by using a variable static loading, a specimen with 95% relative compaction and a surface texture similar to that in the field, could be obtained.

A series of test specimens with 95% relative compaction was then prepared and tested for surface abrasion.Using the poor aggregates the test results indicated about twice the abrasion loss compared to specimens compacted with the conventional 500 psi. (The good aggregate sources showed no abrasion loss regardless of compaction method.)

The specimens compacted at 95% relative compaction appeared to be an excellent representation of actual field conditions.

The test results are shown in Figures 2 through 6. It can be noted in Figure 2 that the film stripping test did not properly distinguish between those aggregates with a history of field film stripping and those that had not exhibited this tendency. It is readily evident in Figure 2, and graphically illustrated in Figures 3 and 4, that the surface abrasion test definitely distinguishes between the two types of aggregates. In this series of tests, when the specimens were compacted to 95% relative compaction, those aggregates which had stripped in the field had abrasion loss of 20 grams or more. However, it is felt that tentative maximum allowable loss should remain at 15 grams. This is based on the fact that specimens with losses in the 15 to 20 gram range still have poor looking surfaces (see Figure 7) and also on results of previous tests on aggregates with stripping tendencies. Before a definite maximum loss can be accurately established, it will be necessary to test aggregates from a wide variety of sources throughout the state and to statistically analyze the test results.

The Dye Strip Test definitely distinguished between those aggregates which had stripped in the field and those that had not. This is shown in Figure 2 and graphically illustrated in Figure 5. However, as previously mentioned, this is a very tedious and time-consuming test.

The Immersion Compression Test placed the aggregates into the same groups as field experience (see Figures 2 and 5). An Arizona report[1] states that aggregates should have a retained strength of not less than 70% to be acceptable under this method. Based on this specification, two of our very good aggregates would not be acceptable (Fair Oaks gravel and Watsonville granite). Therefore, more investigational work would be required before this test method could be adopted with the recommended specifications.

It can be seen in Figure 2 that the Moisture Vapor Suspectibility test did not readily distinguish between the two types of aggregates. However, this test has been an excellent indicator of the type of distress which occurs when water vapor is generated in the pavement in desert regions of California. This type of distress is associated more with a loss of stability than raveling in the field. In any case, further study should be initiated before MVS test is disregarded.

Implementation

The result of this study can be implemented by the adoption of the Surface Abrasion Test (Test Method Calif. 361) as a standard test method. The adoption of this test method should prevent certain instances of in-service raveling of asphaltic concrete pavements.

1. "Benefication of Hydrophyllic Aggregates: An Evaluation of Proposed Treatments of Arizona Aggregates" by W. G. O'Harra.

February 1971

643100

Figure 1

ASPHALT CONCRETE DESIGN DATA

SOURCE	TEST NO.	ASPHALT GRADE	ASPHALT RECOM. OPT'M	AGGREGATE GRADATION (% PASSING) 3/4	1/2	3/8	4	8	16	30	50	100	200	S.E.
Quail Lake (Distr. 07)	70-1041	200-300	5.0	100	83	73	53	38	26	18	12	6	3	58
		85-100	5.7											
Bowman Rd. (Distr. 09)	69-1319	200-300	4.3	100	83	73	53	38	26	18	12	6	3	55
		85-100	5.0											
Daley Pit (Distr. 11)	70-1032	200-300	4.5	100	83	73	53	38	26	18	12	6	3	59
		85-100	5.2											
Arizona	69-1819	200-300	4.1	100	83	73	53	38	26	18	12	6	3	68
		85-100	4.8											
Teichert @ Perkins	70-1174	200-300	4.1	100	83	73	53	38	26	18	12	6	3	72
		85-100	4.8											
P.C.A. Fairoaks	70-1310	200-300	4.0	100	83	73	53	38	26	18	12	6	3	68
		85-100	4.7											
Watsonville Granite	70-1355	200-300	4.4	100	83	73	53	38	26	18	12	6	3	71
		85-100	5.1											

Note: A complete design set was utilized to obtain the optimum asphalt content with an 85-100 Pen. asphalt. The optimum asphalt content for grade 200-300 was then selected from a chart which corrected for viscosity: Figure V of Test Method No. Calif. 303-E.

Figure 2

February 1971
643100

TEST RESULTS

POOR AGGREGATES

SOURCE	TEST NO.	TEST FOR FILM STRIP: FILM STRIP	MOIST. VAPOR K *	MOIST. VAPOR S *	SURF. ABRAS. K *	SURF. ABRAS. S *	DYE STRIP	IMMERSION COMP.	GRADE ASPHALT
Quail Lake (Distr. 07)	70-1041	Slight	27	20	26	34	98	4	200-300
		No	30	23	10	20	72	5	85-100
Bowman Rd. (Distr. 09)	69-1319	Slight	31	26	29	52	94	6	200-300
		Slight	30	26	15	34	82	7	85-100
Daley Pit (Distr. 11)	70-1032	Slight	32	26	16	33	98	12	200-300
		Slight	31	25	15	24	92	10	85-100
Arizona	69-1819	No	25	21	24	58	92	8	200-300
		No	25	20	15	40	80	8	85-100

* K = Kneading Compactor
S = Static Compaction

GOOD AGGREGATES

SOURCE	TEST NO.	TEST FOR FILM STRIP: FILM STRIP	MOIST. VAPOR K *	MOIST. VAPOR S *	SURF. ABRAS. K *	SURF. ABRAS. S *	DYE STRIP	IMMERSION COMP.	GRADE ASPHALT
Teichert @ Perkins	70-1174	No	39	31	0	0	29	77	200-300
		No	37	31	0	0	19	90	85-100
P.C.A. Fairoaks	70-1310	No	39	32	0	0.5	35	59	200-300
		No	33	33	0.1	0.3	26	53	85-100
Watsonville Granite	70-1355	No	36	33	0	0.5	31	28	200-300
		No	33	33	0.1	0.3	26	36	85-100

Figure 3

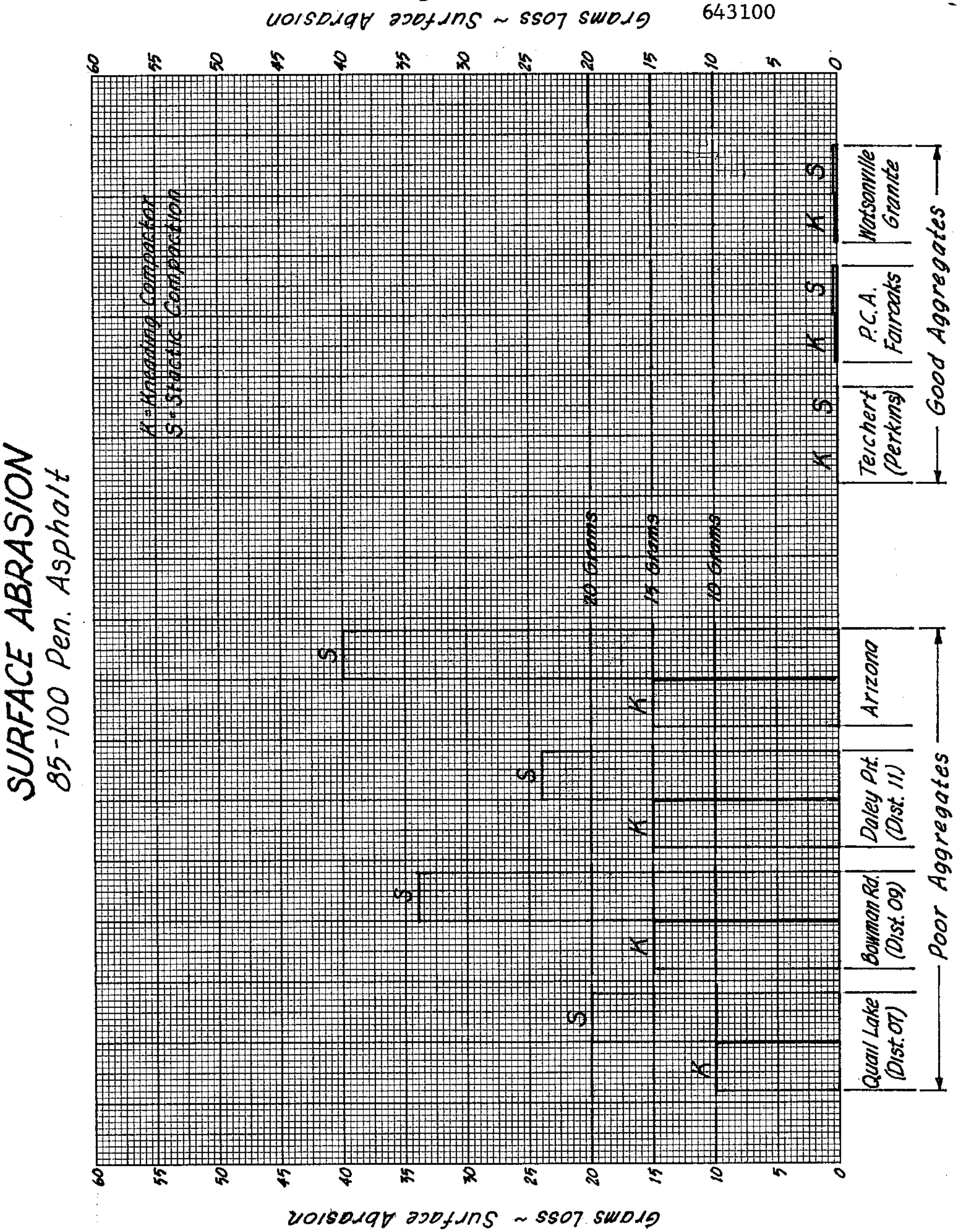
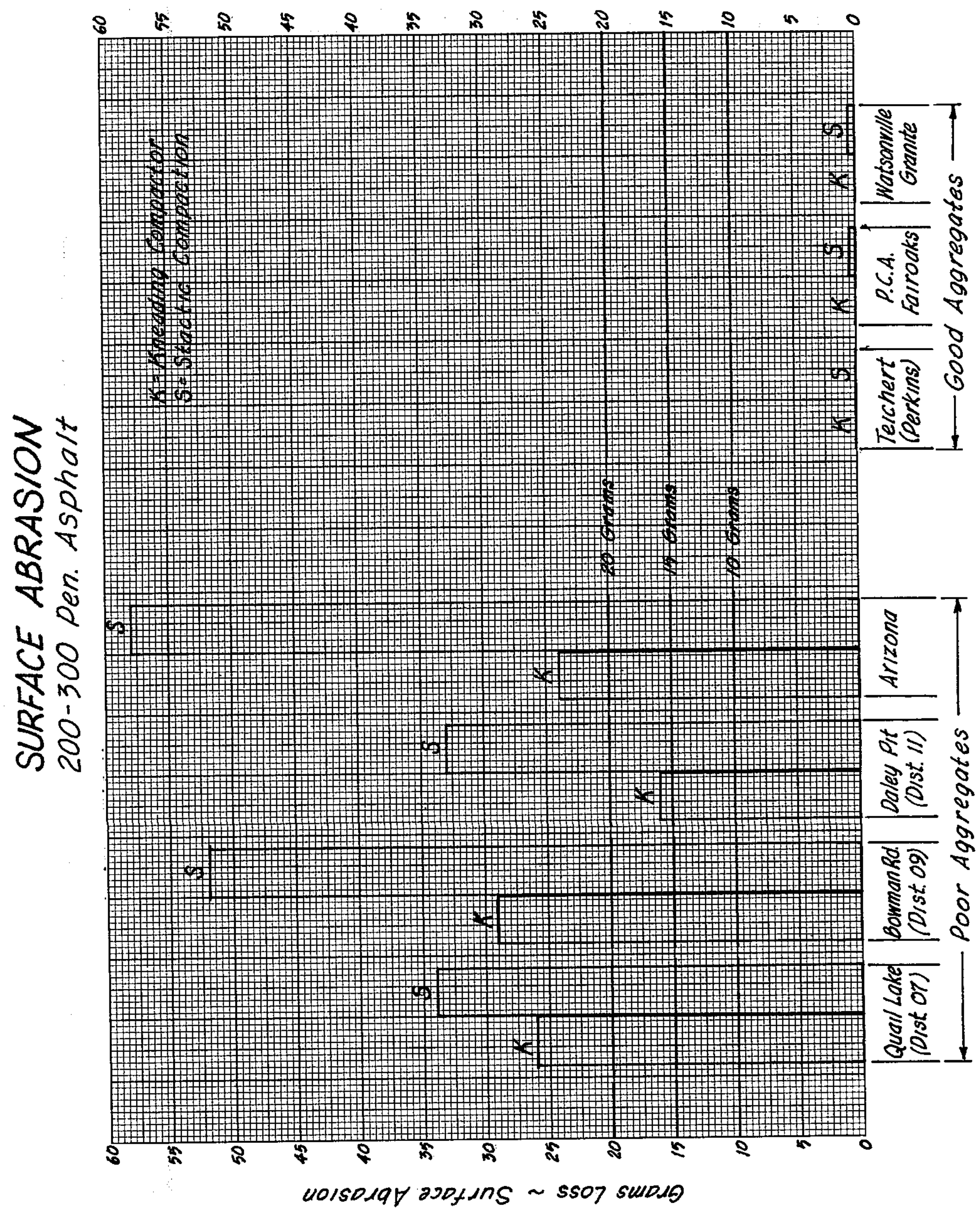

SURFACE ABRASION
85-100 Pen. Asphalt
K = Kneading Compactor
S = Static Compaction
Grams Loss ~ Surface Abrasion
0 5 10 15 20 25 30 35 40 45 50 55 60
20 Grams
15 Grams
10 Grams
K S
Quail Lake (Dist. 07)
Bowman Rd. (Dist. 09)
Daley Pt. (Dist. 11)
Arizona
Teichert (Perkins)
P.C.A. Fairoaks
Watsonville Granite
Poor Aggregates
Good Aggregates
Grams Loss ~ Surface Abrasion

Figure 4

February 1971

643100



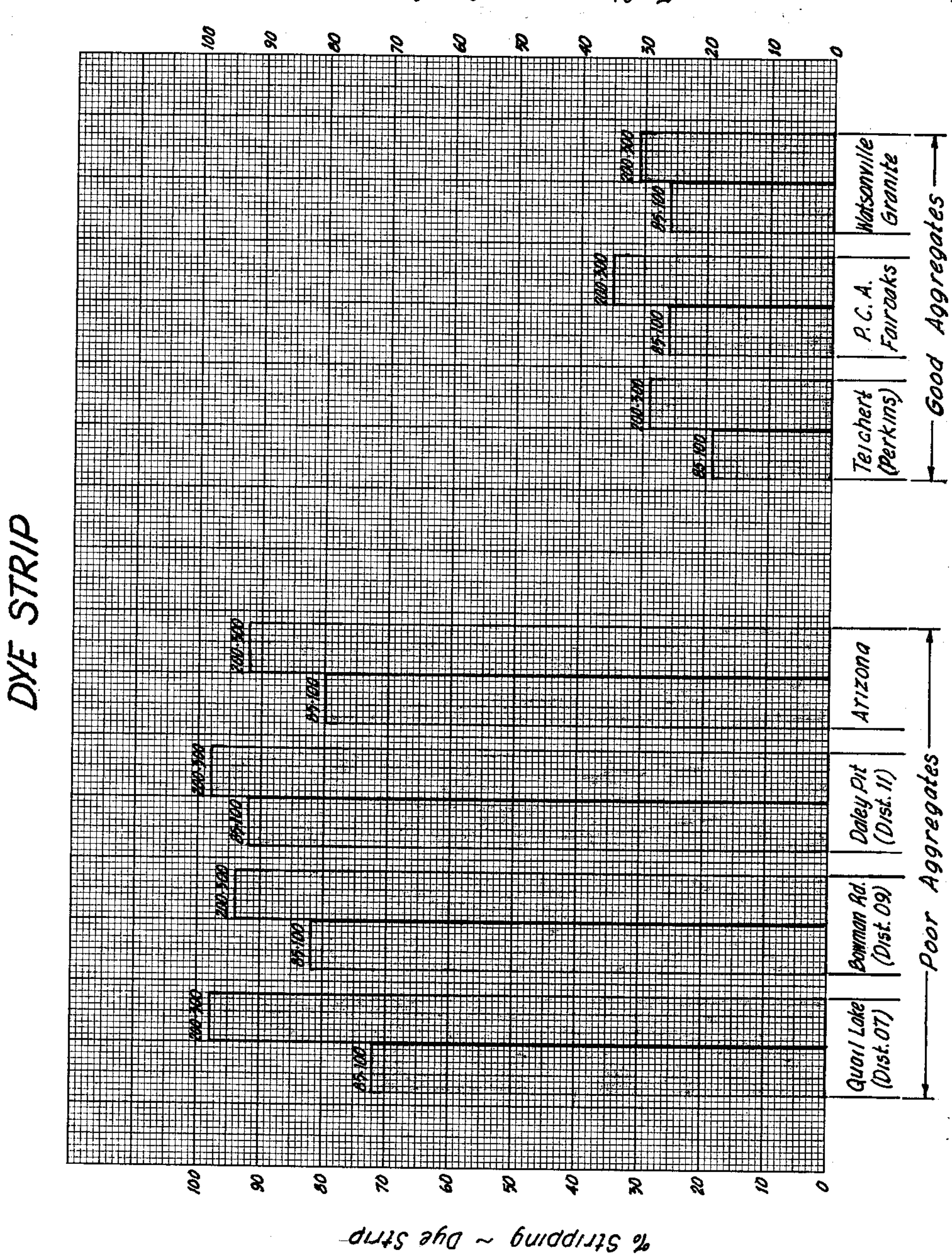
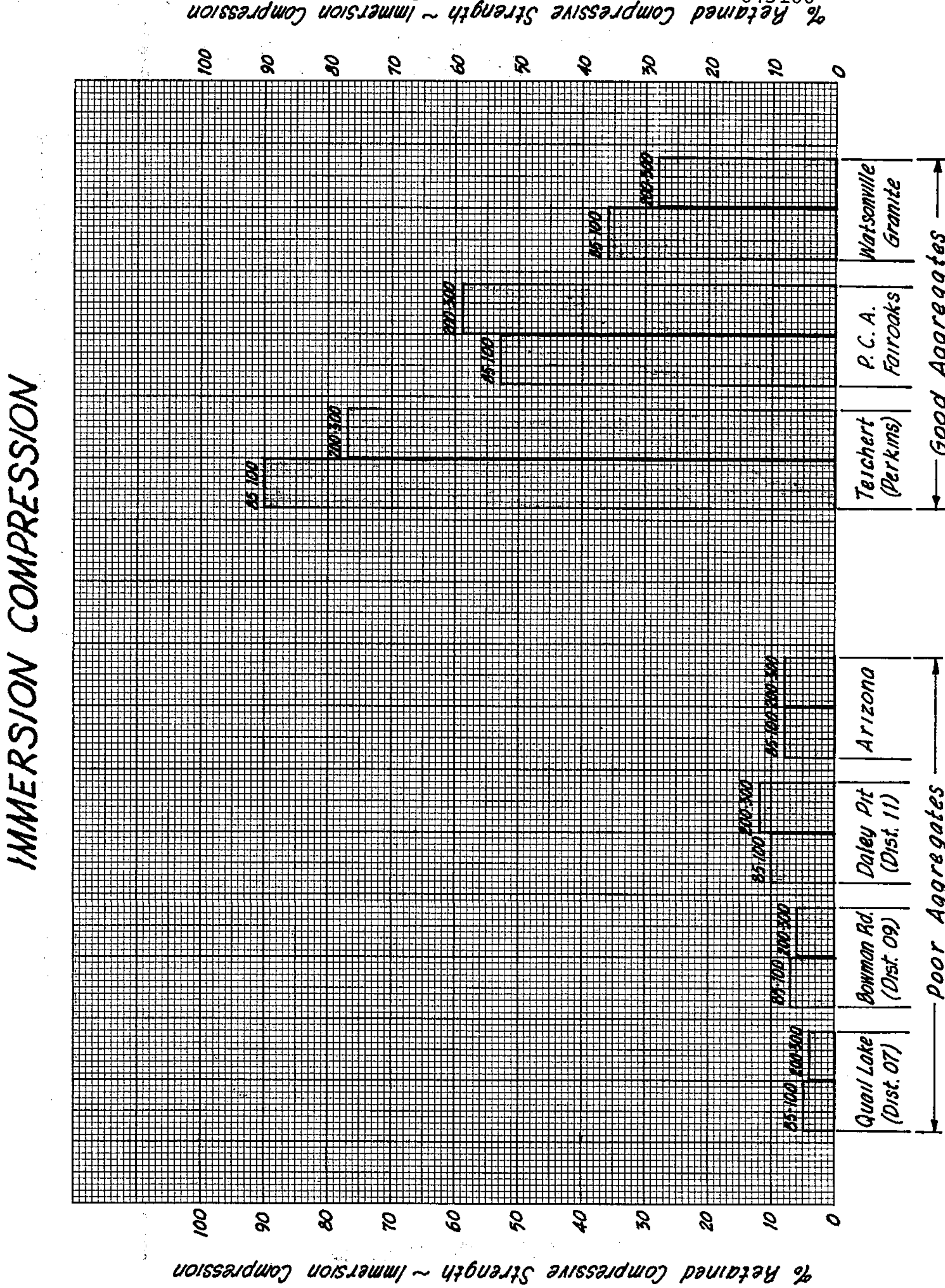
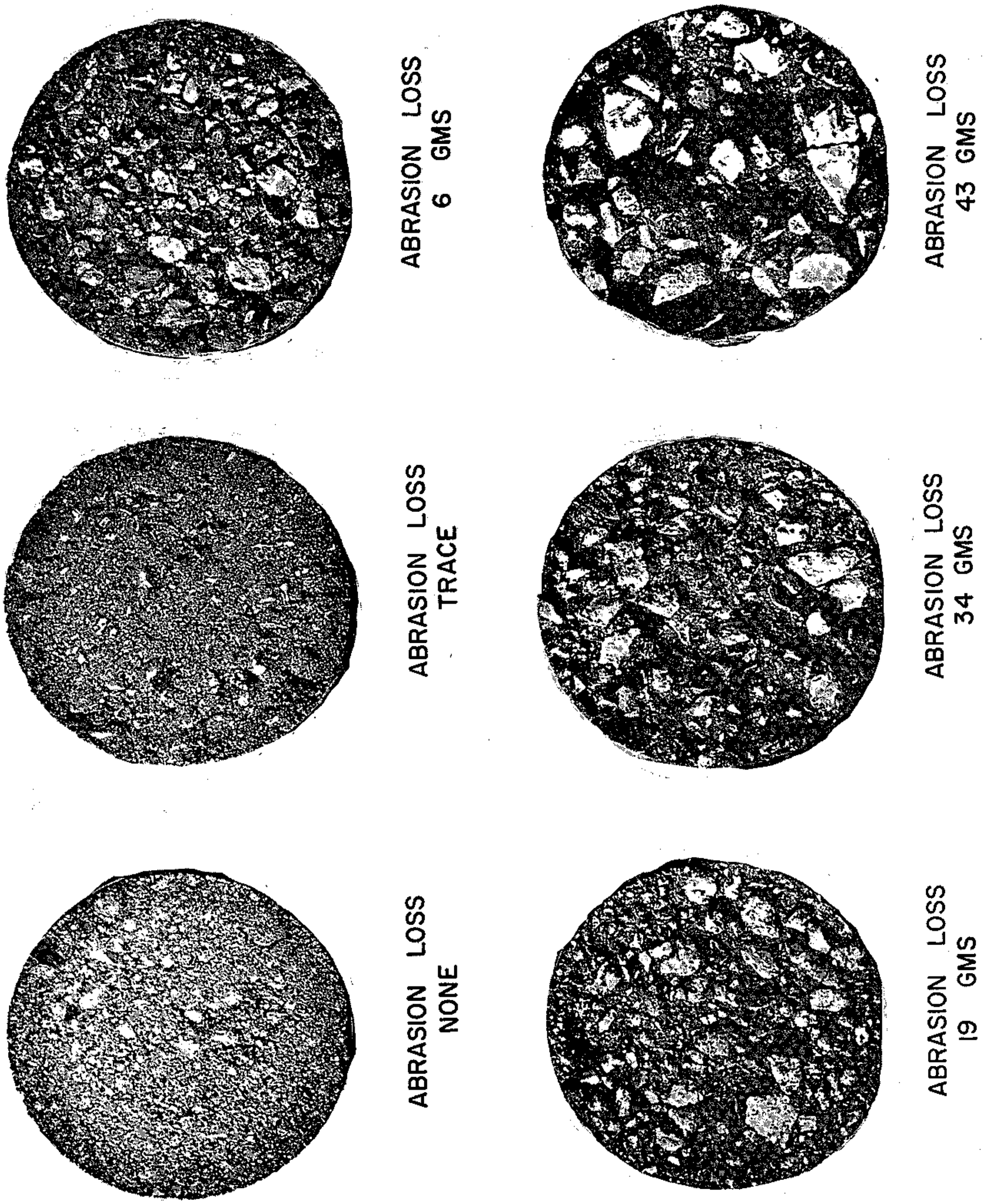

DYE STRIP
% Stripping ~ Dye Strip
0
10
20
30
40
50
60
70
80
90
100
Good Aggregates
Watsonville Granite
P.C.A. Fairoaks
Teichert (Perkins)
Poor Aggregates
Arizona
Daley Pit (Dist. 11)
Bowman Rd. (Dist. 09)
Quail Lake (Dist. 07)
85-100
200-300

Figure 6



JUN. 70

Figure 7



SURFACE ABRASION RESISTANCE OF VARIOUS AGGREGATE SOURCES

(ALL SPECIMENS CONTAIN 85-100 GRADE PAVING ASPHALT. EQUIVALENT TEST CONDITIONS)

METHODS OF TEST FOR SURFACE ABRASION OF COMPACTED BITUMINOUS MIXTURES

SCOPE

The surface abrasion test measures the ability of a compacted bituminous mixture to resist surface abrasion or raveling in the presence of water.

PROCEDURE

A. Apparatus

1. Oven capable of maintaining temperatures of 100°F to 230°F at ± 5° at any setting. (Additional ovens for each setting are permissible if they are of sufficient accuracy.)

2. *1 - Mechanical shaker for shaking mold containing sample with a 1" vertical stroke at 1200 cycles per minute.

3. 4 - Rubber balls 1-1/8" diameter 15.5 grams ± 0.7 grams each. (Manufactured by Atlantic India Rubber Co., Chicago Illinois, that are listed under mold number 1542 with a Shore Durometer hardness between 60 and 70.) The Sacramento Rubber Co. in Sacramento is presently stocking this item.

4. 1 - Steel mold - 4" diameter x 5" high (for lab fabrication).

5. 1 - 250 Ml. graduated cylinder.

6. 1 - Polyethylene wash bottle.

7. 1 - Aluminum pan 7-1/2" in diameter 2-1/2" deep.

8. 1 - Balance having a capacity of 4,500 grams and sensitive to 0.1 gram.

9. *1 - Insulating jacket for the mold (Figure V).

B. Mixing and Fabrication

The tests for abrasion shall be performed using rubber balls on asphalt concrete specimens 2 ± 0.1 inches in height, that have been mixed with the desired asphalt content, and then fabricated as follows:

1. Mix the asphalt and aggregate and cure the mix according to Test Method 304, Part I, Section E.

*Drawing No. D-469 Available at Materials and Research Department.

2. Place mold preheated to compaction temperature in mold holder and into position in the mechanical spader. (Hand Spading as described in Test Method 304, Part II, Section E, may be used in lieu of mechanical spader.) Place a 3/8" thick shim under the mold adjacent to the portion of the mold holder that extends up into the mold. Place the 4" diameter cardboard disc into the mold on top of the mold holder base.

3. Bring the mix to the proper compaction temperature:

   Asphalt concrete with liquid asphalt -- 140°F

   Asphalt concrete with paving asphalt -- 230°F

4. Weigh out sufficient material to provide a compacted briquette of a height of 2±0.1".

5. Separate the coarse and fine material by screening the mix through a 1/2" sieve onto a flat metal scoop.

6. Arrange the separated material into two parallel rows across the width of the scoop.

7. Introduce the mix onto the feeder belt of the mechanical spader, exercising care so as not to disturb the size arrangement effected on the metal scoop.

8. Start the mechanical spader and operate until all the material has been introduced into the compaction mold.

9. Place mold holder contining the mix and mold into position in the mechanical compactor.

10. Compact the mix in the kneading compactor as specified in Test Method No. Calif. 304, Section F.

11. After compaction, remove mold and specimen from compactor and place on platen of press.

12. Apply a static leveling-off load of 12,600 lb. (1,000 psi) in the press at a head speed of 0.25 in. per minute. Release load immediately.

13. Measure and record the height of the test specimen to the nearest 0.01".

14. Allow test specimen to cool to room temperature, eject from mold and determine sp. gr.

15. Compute 95% of the weight of the compacted briquette. Place this computed amount of mix in the mold by the method outlined above (1-8).

16. Place 4" cardboard disc on top of the spaded mix and remove mold and mold holder from the spader.

17. Place preheated follower on top of the spaded mix and place mix and assembly in the press for static loading.

18. Apply initial load of 4000 lb. at a loading rate of 0.25"/min. to set the mixture against the sides of the mold.

19. Release applied load and remove specimen and mold from mold holder and place on platen of press for compaction.

20. Press or compact the mix to the identical height obtained with the pilot sample that was compacted in the kneading compactor. Release applied load immediately.

21. Let the compacted specimen remain at room temperature for a minimum of 1 hour prior to start of soaking.

22. Pour 500 mls. of water on specimen in mold (both setting in pan) and allow to stand undisturbed for 20 hours $\pm$ 1 hour.

C. Test Procedure

Abrasion Tests.

1. After 20 hours of soaking, pour any water which has permeated through the sample during the soaking period back into the mold containing the specimen and place mold with sample and pan into a 100°F oven for four to six hours. (Surface of specimen must be kept covered with water during this heating period.)

2. Take specimen from oven, and remove all water from mold. Measure out 250 mls. of the removed <u>heated</u> water into a graduated cylinder and pour onto the surface of the specimen.

3. Place four clean rubber balls into the mold and place the insulating jacket over the mold.

4. Lock mold into place on mechanical shaker with wing nuts.

5. Shake sample at 1200 $\pm$ 10 CPM for 15 minutes and remove from mechanical shaker.

6. Remove rubber balls and pour contents from mold into a tared container. Wash all fines from the surface of the sample into the container with a wash bottle.

7. Let container stand for one hour and decant as much of the clear water off as possible.

8. Place container in a drying oven (230°F) and dry to a constant weight.

9. Weigh container with abraded material. Subtract container tare weight and record the difference as grams of abrasion loss.

Precautions

1. The sample should be transferred from the 100°F oven to the shaking device as quickly as possible.

2. The rubber balls shall be free of asphalt prior to testing. The asphalt shall be cleaned from the rubber balls with a cleaning solvent and allowed to dry for a minimum of 30 minutes prior to additional testing.

3. The rubber balls must be periodically checked for weight and they should be discarded when weight is not within specified tolerance.

Reporting of Results

Report the amount of abrasion loss in grams of material abraded and this amount shall be an average of three test specimens.