Technical Report Documentation Page

1. REPORT No.

2. GOVERNMENT ACCESSION No.

3. RECIPIENT'S CATALOG No.

4. TITLE AND SUBTITLE

Materials Testing and Control on Highway Projects

5. REPORT DATE

September 1963

6. PERFORMING ORGANIZATION

7. AUTHOR(S)

F.N. Hveem

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.

12. SPONSORING AGENCY NAME AND ADDRESS

13. TYPE OF REPORT & PERIOD COVERED

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

Presented at the Second Annual Paving Conference The University of New Mexico, Albuquerque December 5 and 6, 1963

16. ABSTRACT

As the years go by, more engineers are talking and writing about materials, specifications and testing than ever before. And not only engineers-- others are getting into the act. There are many reasons for this interest and concern. In the highway field, both the volume of traffic and weight of vehicles are increasing every year and at the same time, in many states, supplies of the most suitable materials are being exhausted, especially in the metropolitan areas. Materials are being processed faster and in larger quantities. Also, the effect of the tremendous interstate program and the publicity which has been given to a few unfortunate examples of poor materials control all tend to emphasize the need for accurate, significant tests conscientiously carried out. One result is that quality specification are being more rigidly enforced. This move inevitably brings up the question of tolerances and a few points near the borderline on a numerical scale, whether for thickness of pavement, sieve analysis of aggregates, plasticity index or sand equivalent, become very important. Arguments and criticism increase as most contractors and construction engineers are prone to feel that it is hairsplitting, unfair and altogether impractical to reject materials that fail to meet specified test values by only a small margin.

17. KEYWORDS

18. No. OF PAGES:

54

19. DRI WEBSITE LINK

http://www.dot.ca.gov/hq/research/researchreports/1961-1963/63-17.pdf

20. FILE NAME

63-17.pdf

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

MATERIALS TESTING AND CONTROL ON HIGHWAY PROJECTS

By
F. N. Hveem
Materials and Research Engineer
California Division of Highways

63-17

DND

Presented at the Second Annual Paving Conference
The University of New Mexico, Albuquerque
December 5 and 6, 1963

September 1963

MATERIALS TESTING AND CONTROL ON HIGHWAY PROJECTS

By

F. N. Hveem*

As the years go by, more engineers are talking and writing about materials, specifications and testing than ever before. And not only engineers -- others are getting into the act. There are many reasons for this interest and concern. In the highway field, both the volume of traffic and weight of vehicles are increasing every year and at the same time, in many states, supplies of the most suitable materials are being exhausted, especially in the metropolitan areas. Materials are being processed faster and in larger quantities. Also, the effect of the tremendous interstate program and the publicity which has been given to a few unfortunate examples of poor materials control all tend to emphasize the need for accurate, significant tests conscientiously carried out. One result is that quality specifications are being more rigidly enforced. This move inevitably brings up the question of tolerances and a few points near the borderline on a numerical scale, whether for thickness of pavement, sieve analysis of aggregates, plasticity index or sand equivalent, become very important. Arguments and criticism increase as most contractors and construction engineers are prone to feel that it is hairsplitting, unfair and altogether impractical to reject materials that fail to meet specified test values by only a small margin.

---

*Materials and Research Engineer, California Division of Highways

In order to discuss present day needs and application, it may be helpful to do some classifying and identifying of the various types of testing that are involved. The whole field of materials testing for the average highway project can be separated into two principal classes or areas.

First, is sampling and testing for the purposes of planning, design, writing specifications, et cetera. This work is properly called preliminary testing and is an essential part of the preliminary engineering required to set up any project - especially a highway grading and paving contract. With the award of a contract, however, engineering considerations suddenly become subordinate to legal interpretation. It is no longer a question of what was meant or what was intended by the engineer. The only defensible basis for settling differences or arguments between contractor and engineer is "what do the specifications say?"

A signed contract is a legal document and all the stipulations and requirements are subject to interpretation by gentlemen of the legal profession and even by the courts. Another profession also becomes involved after a contract is awarded; namely, the accountants or bookkeepers. Engineers have long been accustomed to "smooth out" or "round off" the rough corners of their plans or specifications by what they call "engineering judgment." However, neither lawyers nor auditors are given to employing the "free wheeling attitudes" characteristic of most construction engineers. A competent auditor is not disposed to disregard even small deviations or discrepancies in accounts, especially when it comes to the question of approving an expenditure of public funds which are circumscribed by law. The auditor assumes that all of the items paid for will be exactly as designated. Engineers, as a class, are no less conscientious and are equally concerned that the specifying agency will get full value for the money spent. The differences and arguments arise when the engineer applies "tolerances" and accepts what he considers to be a "reasonable" approximation even though there is no specified basis or written statement that such allowances are intended or expected. For example, if the specifications and plans call for an eight-inch concrete pavement, lawyers and accountants are very prone to believe that this means exactly what it says - eight inches. The engineer is astonished and often indignant and may point out "you can't build a pavement or a base or a subbase that is exactly eight inches in thickness everywhere - it will be either over or under by at least a small amount." Confronted with the tendency of the non-engineers to assume that specifications and plans literally mean what they say, the engineers are today belatedly amassing data to show the normal deviations which are characteristic and inevitable with all measurements and all tests. Figures 1 to 7 illustrate typical variations in thickness of pavement layers. Figures 8 to 11 show variations in quality test values.

The concern with test values is now involving more diverse interests which makes it necessary for the engineer to be even more explicit, to begin spelling out in great detail why certain tests are made, what is proper, and where do they fit in to the entire program of materials control. As indicated in the opening paragraph, we have recognized the generic difference between sampling and testing in the planning stage as compared to materials control after the award of contract. After the contractor starts to work, there are further subdivisions. Considering an Interstate highway or Federal-aid project in this year of Grace 1963, the following types of sampling and testing exist and must be recognized regardless of nomenclature or local terms:

DEFINITIONS

A. PRELIMINARY SAMPLES AND TESTS

All sampling and testing on a highway project prior to the award of a contract.

B. INITIAL SAMPLES

Samples taken after the award of contract in order to determine acceptable sources, ability to meet specifications, mix design, et cetera.

C. JOB CONTROL SAMPLES AND TESTS

Primarily means samples taken (and tests if made) by the resident engineer or his assistants to indicate the quality of materials used or work being performed by the contractor.

D. PROGRESS SAMPLES AND TESTS

Record Sampling and Testing Required by U.S.B.P.R.

Periodic check samples taken by the District Materials Engineer or his representatives as a check on the control work performed by the resident engineer.

E. FINAL SAMPLES AND TESTS

Random Samples of the completed work taken by representatives of the Control Laboratory as a final spot check on the thickness and quality of materials in place.

Central

The relationship between these five classes of samples is further illustrated by Chart, Fig. 12. This chart indicates the areas in which questions are primarily within the province of the engineer and those where legal interpretation is likely to take precedence.

The foregoing definitions cover sampling and testing activities more or less in chronological order as ordinarily required on the job. There is, of course, some overlapping as progress sampling and even final sampling of materials may be under way concurrently with the control sampling, for example. However, there are other distinctions which could be made and at times these may be important. We are facing a problem in communication. It is becoming necessary to distinguish between tests performed primarily on individual fractions or component parts and those that measure the quality of the finished product. For example, the tests made at a concrete or hot plant to determine the sieve analysis of aggregates are not in the same "frame of reference" as the testing of concrete cylinders or measuring the stability of an asphalt paving mixture. So far as I know, there is no presently established terminology that clearly defines or distinguishes between these two types of tests, but the need is becoming more apparent. For the purpose of this discussion, the following definitions are proposed:

1. Fractional Tests

   Tests made on the individual fractions or components of a mixture prior to mixing or placing.

2. End Result Tests

   Tests made on the combination of materials as they exist in the completed work.

In this changing world, engineers are being increasingly called upon to prove their case - to show that public funds are being properly expended and that the materials and structures paid for do conform to the specifications.

While most non-engineers may conclude that all specifications are of equal importance, this is not completely true. Refer again to the type of specifications that apply to the primary sizes of aggregates for portland cement concrete. These grading and cleanness controls on the aggregate fractions are essential if the concrete produced is to be uniform. However, once the cement, water and aggregates have been mixed and put into place and the concrete has been found to be of good quality with respect to strength, density, lack of permeability, et cetera, some of the tests on the individual constituents now become less important than the question of the over-all quality. Unfortunately, the use which can be made of this distinction is limited as the most practicable way to measure such things as durability is by fractional tests on the aggregates or on an asphalt, for example. Nevertheless, tests on the concrete or on the completed asphalt mixtures may often be used to confirm the quality of the product, and for final evaluation these tests may be carried out more economically and perhaps more expeditiously than the fractional tests on the ingredients.

Attached as Appendix I is a series of charts giving details of the typical sampling and testing which may be required during the life of a highway contract. This chart does not include the preliminary investigation while the project is being planned, and, of course, does not include any special investigations or studies of completed projects which have been taken over by the state. It is believed that these charts will furnish a fairly comprehensive guide to the sampling pattern appropriate to a modern highway construction contract.

Taking up the various classes of samples, the following comments and recommendations may be offered:

PRELIMINARY SAMPLING AND TESTING

The first important step in assuring workable and effective materials control is to see that the preliminary materials investigation is thorough and that the specifications are written to fit the materials that will be encountered or available for the work. There are many examples where standard specification requirements do not fit the local materials but are nevertheless a part of the contract. A thorough materials investigation and realistic specifications can save much trouble later on.

INITIAL SAMPLING AND TESTING

The term "initial" samples is meant to identify the materials work that is required to get a job under way after the contract is awarded; checking the quality of gravel pits or other sources to determine whether the materials will meet the specification requirements. Another activity at the beginning of work is the establishment of mix design proportions for both concrete and asphaltic concrete mixtures. Practices, of course, vary. Many agencies utilize the principle of a "job mix formula" in which the contractor submits a proposal for a typical grading which he would like to use. If his proposal is within the broad tolerance limits, the contractor will be authorized to proceed under the stipulation that the gradings will be controlled within a narrow range. Strictly speaking, initial sampling and testing are not for the purpose of control; these tests are generally to establish what materials and what proportions could be used. Hence, the term initial sampling and testing is meant to cover those activities that are necessary shortly after the contract is awarded, but are generally applied to materials before the contractor gets into actual production.

CONTROL TESTING

As in the past, the control testing continues to be the most important. These tests are made on materials just before or just after they are placed on a road or in a structure and the time and place of sampling becomes an important matter. In former years, most highway organizations sampled materials at the production plant, taking samples either from a stockpile, a conveyor belt, or plant bins. However, any sampling of materials at some point prior to placing on the road always leaves some degree of uncertainty. For example, it is often difficult to secure a representative sample from a stockpile because materials tend to segregate whenever they are deposited on a slope. Fairly representative samples can usually be obtained from a conveyor belt, but securing a representative sample from plant bins is not always easy. Materials loaded into a transport vehicle segregate and can lead to non-representative sampling. Reports of an investigation by the Bureau of Public Roads state that at least seven separate samples must be taken from a loaded truck and the results averaged in order to be representative of the entire load. Another variable is due to degradation or breakdown through handling, and granular materials often end up on the road with a greater amount of fines than was indicated at the plant. This final amount of dust may exceed the amounts permitted in the specifications. All experienced highway engineers are aware that a principal cause for distress and failure in base and subbase layers is the presence of too much fines, especially where such material is clay-like, having lubricating properties.

A serious problem developed in one western state where the state engineers had taken samples at the crushing plant, found that the materials met the specifications and so advised the contractor. Later sampling from the road by the U.S.B.P.R. engineer disclosed that a large number of samples were outside the specifications, both in terms of amount passing the No. 200 and in the P.I. requirements. Consideration was given to reworking or mixing with cement or sand. These proposals raised the legal question of whether, if required to rework the material, the contractor would have a legitimate claim against the state because he had been permitted to go ahead and place the material on the road. These and other developments seem to point to the necessity for basing acceptances of all materials wherever possible on samples taken after spreading on the road. This would apply to subbase, base and pavement layers, also permeable materials.

As stated before, the control testing is actually the most important and should give the most return for the cost. If this work is done properly, all subsequent sampling and testing is simply for the purpose of independent confirmation. However, several important conditions or practices must be established if the control sampling is to be completely effective. Following are some of the important administrative or organizational procedures:

A. A well organized and effective training program for all individuals who are expected to sample or test materials. It is equally important that all testing equipment used be calibrated and standardized at sufficiently close intervals to be sure that it is accurate and in good working condition.

B. The resident engineer or other supervisor should not override the materials man by ordering that materials be used regardless of test results. This is done too often on the argument that "we can't wait, we've got to get the job done," et cetera.

C. Two men should be assigned for paving plant inspection. If a modern plant is operating anywhere near capacity, one man cannot take samples, do the necessary testing and keep an eye on the plant operation at the same time. Ideally, there should be a senior plant engineer with a solid background of experience and a younger man to do the sampling and testing. This job requires someone who doesn't mind getting dirty and who is not averse to work.

The Progress Sampling Program is, of course, part of the record sampling required by the U.S.B.P.R. on all work financed in whole or in part by federal funds. Little need be said about this operation which is covered by U.S.B.P.R. directives. In essence, the Progress Sampling Program is an independent check on the work of the resident engineer.

The same comments as made for control testing apply here; namely, the need for trained men and calibrated equipment. Some construction men have regarded the record sampling operation as an insult to their integrity and an interference with their work. However, the only sound viewpoint is that, under present day circumstances, the progress sampling serves to support and defend the resident engineer if he is doing his work properly.

FINAL SAMPLING

Final sampling is also done as required by the U.S.B.P.R. In California, this is accomplished by taking one random sample from each lane mile of completed pavement. While primarily intended to furnish concrete evidence that the work financed from federal funds is in substantial compliance with specifications, the volume of work done and the test data produced have thrown some interesting light on construction operations. It appears to be the experience in most states that uniformity of construction control has improved since this program was put into effect. It has produced evidence of the inevitable variation in both thickness and quality of materials. It is evident that while this variation may be reduced it will always exist. Engineers are facing the problem of writing workable specifications which recognize the statistical patterns that are characteristic of all measurements and test values if a sufficient number are compared. While the final record sampling program has disclosed evidence of variation, it is interesting to compare comparable data from highway contracts with the variations reported from the AASHO road test. Every effort was made to develop uniformity on the AASHO test project, but the final reports show that there was substantial variation even under the elaborate control conditions employed.

The record sampling has also produced evidence of some astonishing uniformity, at least on a few California projects. These well controlled jobs prove that it "can be done." Figures 13 to 18 give examples of random samples taken from several construction jobs. Figure 13 shows the aggregate gradation on asphaltic concrete pavement on three highway projects. Note that all samples and the percentages passing specified sieves are all within the specifications. Figure 14 shows another contract where the final samples of the aggregate base were outside of the specifications on all sieves specified. Figure 15 shows excellent control of both gradation and pavement thickness on an asphalt concrete surfacing. Figure 16 shows relatively poor control, both of gradation and pavement thickness. You will notice that the thickness variations, however, tend to be on the high side rather than substandard. Figure 17 is another example showing good control of both thickness and aggregate gradation. As further evidence of the uniformity which can be achieved with the gradation of asphaltic concrete, Fig. 18 shows three groups of samples taken from the road immediately behind the paver. Again this remarkable uniformity shows that it can be done and there is no excuse for the wide variations which are all too common. While not all of the contract work is as uniform as those selected here, these results seem to demonstrate that it is possible to achieve a very high degree of uniformity on construction work without incurring abnormal construction costs.

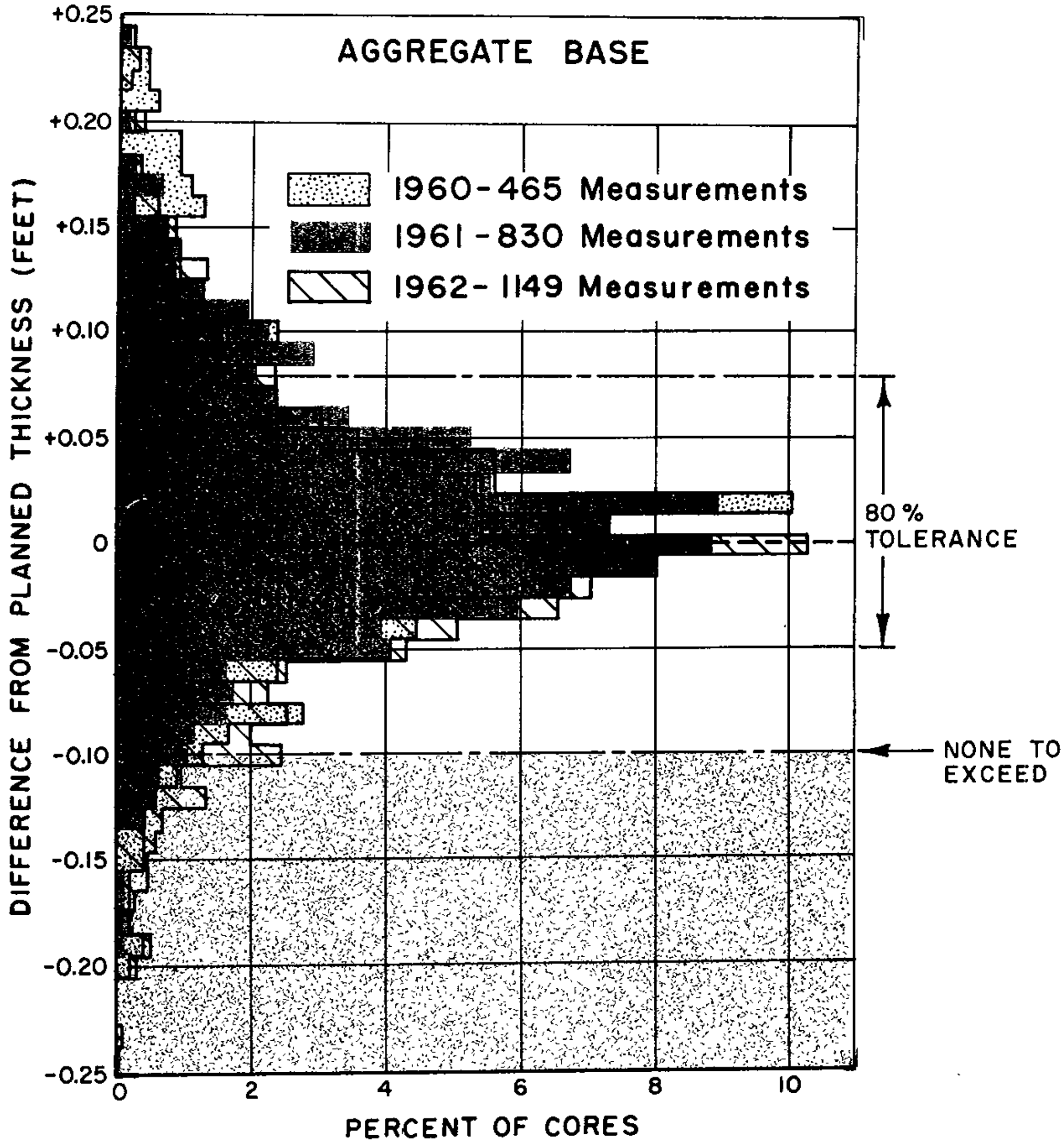
As said previously, the control sampling is the most important and should do the most good. As an example of the improvements which can be developed, the quality of cement treated base may be considered. Many miles of this type of work have been constructed in California and other states using relatively low percentages of cement. While this type of base has been very successful and there are economies to be effected using small percentages of cement -- uniform distribution of a small amount with construction equipment does pose a problem. The most effective method of insuring uniform results is to have means for testing the cement content after mixing. Figures 19 and 20 show before and after results of tests to establish the uniformity of cement distribution in a plant mix operation. Figure 21 shows similar improvement on a road mix job. In the absence of a rapid test to determine the amount of cement in different portions of the finished mix, there would be no basis for insistence on better distribution of cement and more thorough mixing.

As further evidence, Fig. 22 illustrates the average variation in cement content for road mix jobs both before and after January 1, 1960 when a field test became available. Following the use of check tests, the average job became somewhat less erratic. Figure 23 illustrates the effects of the same controls on plant mix operation. While the plant mix uniformity was better to start with, the chart indicates the very marked improvement after January, 1960. This shows quite clearly that plant mixing operations can be controlled but that road mixing, as presently conducted, is essentially and inevitably more variable and erratic. Figure 24 illustrates the characteristic and inherent differences between the two types of operation. Figure 25 shows that there can be considerable variation in the thickness of concrete pavements. On this figure, Bar Graph A shows very good control, but there were five measurements indicating less than the standard thickness. Bar Graph B illustrates a much wider range in thickness measurements even though concrete pavements represent a type of construction where it should be possible to control thickness more closely than for most pavement layers.

In conclusion, it seems appropriate to emphasize that sampling and testing is an engineering activity that must be done right if it is to be done at all. Careless sampling and sloppy test procedures are worse than no testing and can prove expensive both to the contractor and the specifying agency. This phase of engineering work is in great need of strong support and personal interest by everyone from the chief engineer on down. Over 90 percent of the money spent for highway construction is paid to contractors for obtaining, hauling, mixing and placing materials, yet the total effort and expenditure for materials control is usually only a minor fraction of the total amount spent for construction engineering.

ENGINEERING AUDIT OF CONSTRUCTION

GRAPHICAL ILLUSTRATION OF VARIATION IN THICKNESS



ENGINEERING AUDIT OF CONSTRUCTION

GRAPHICAL ILLUSTRATION OF VARIATION IN THICKNESS

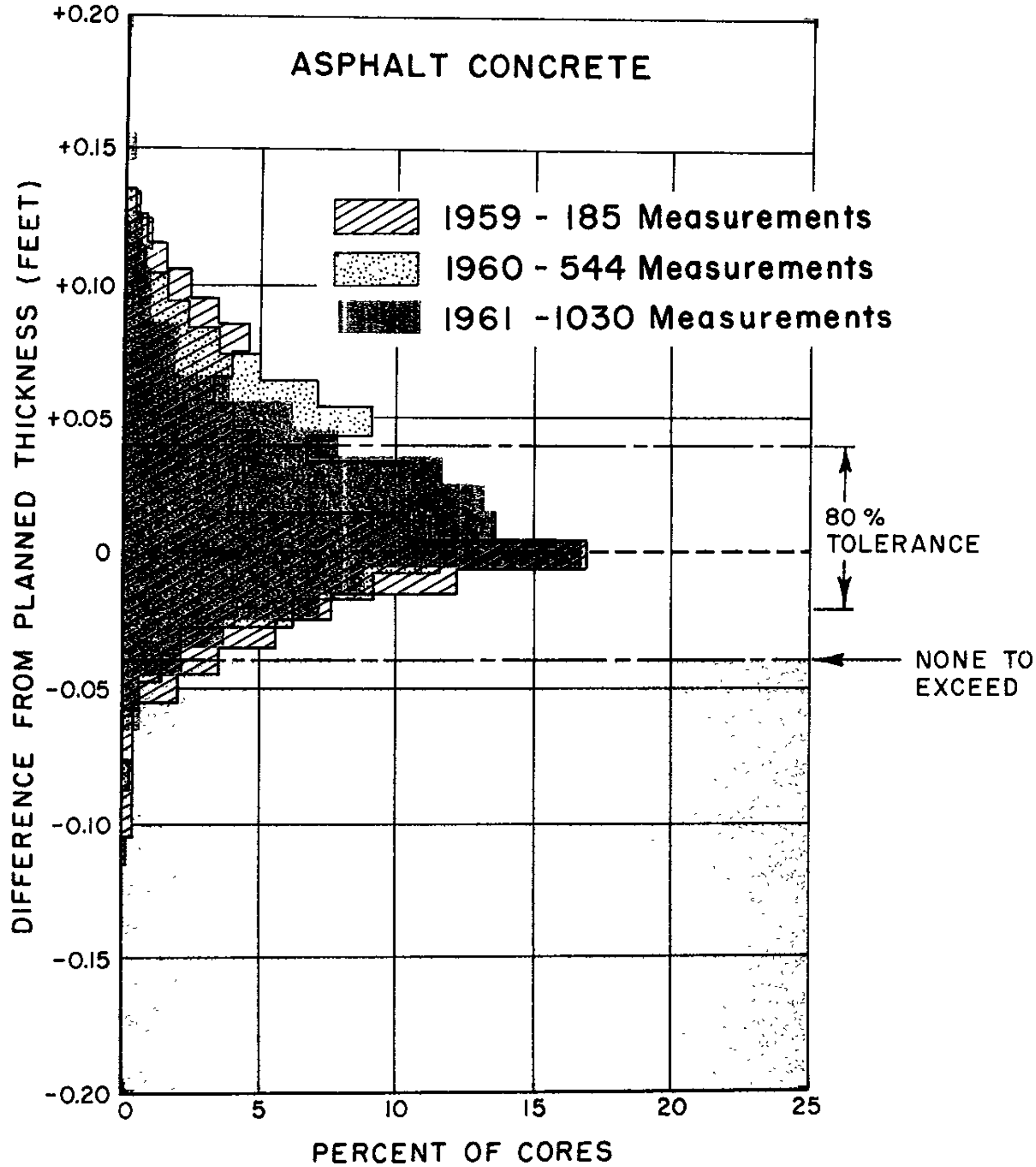
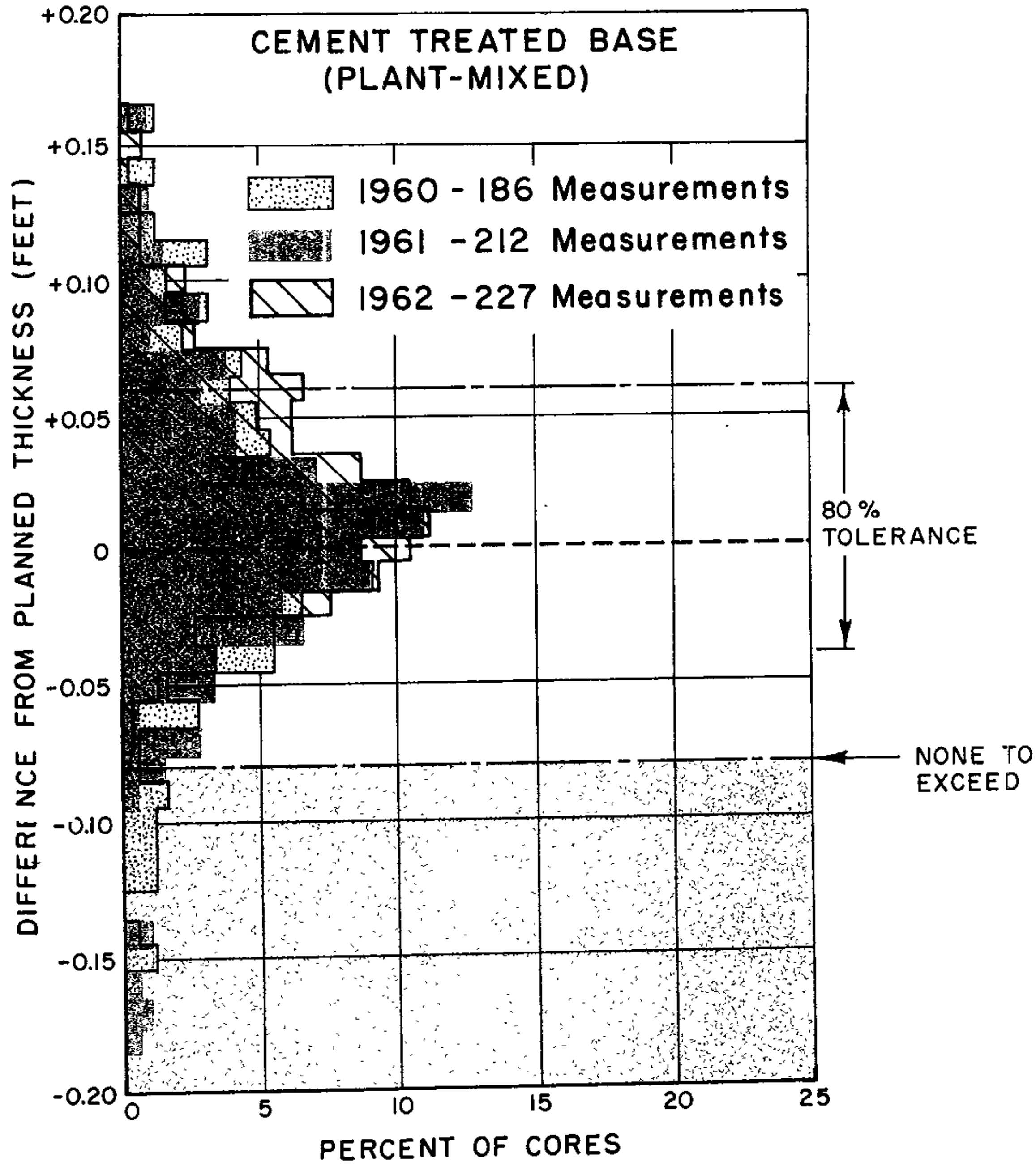


FIGURE 3

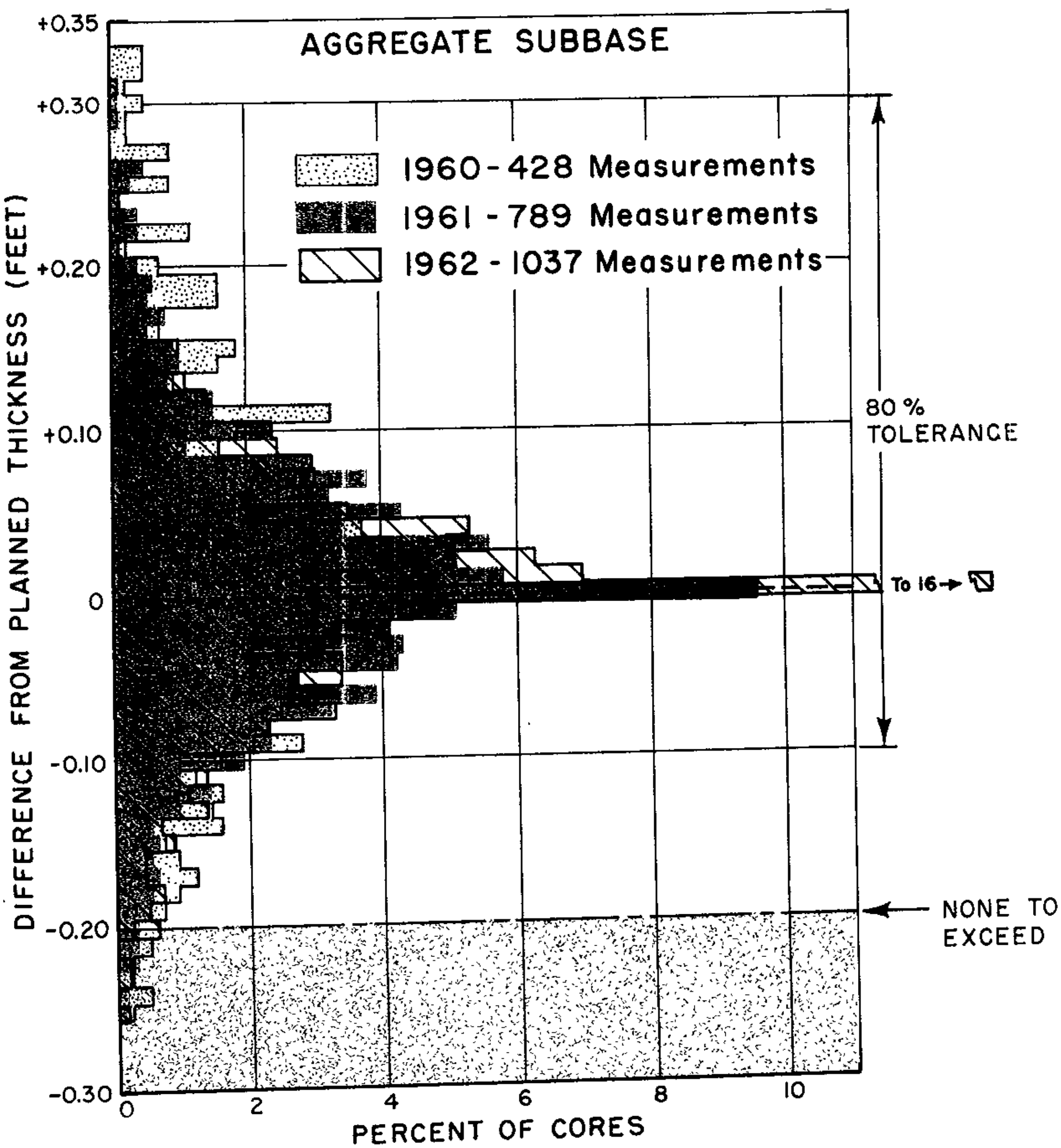
ENGINEERING AUDIT OF CONSTRUCTION

GRAPHICAL ILLUSTRATION OF VARIATION IN THICKNESS



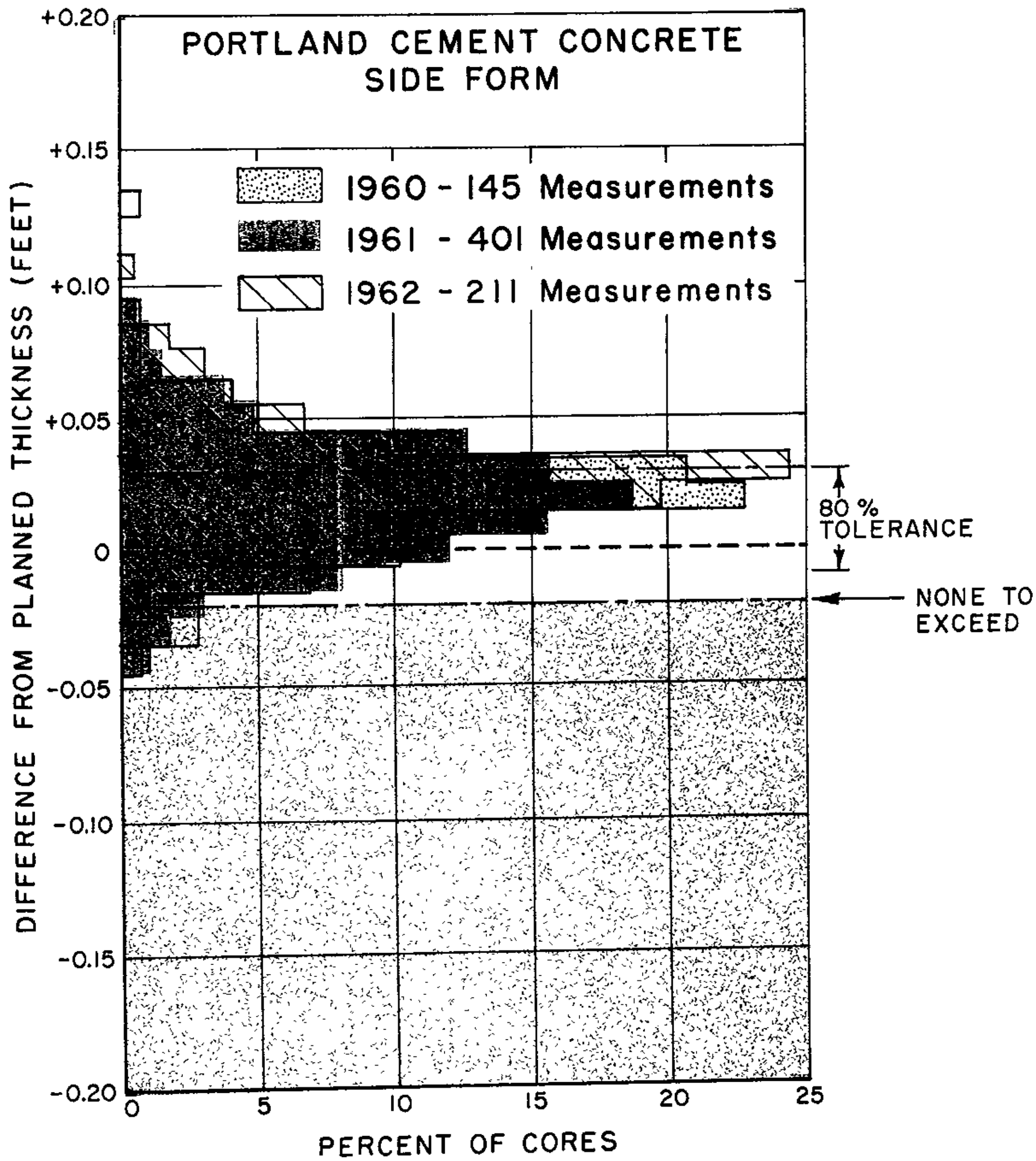
ENGINEERING AUDIT OF CONSTRUCTION

GRAPHICAL ILLUSTRATION OF VARIATION IN THICKNESS



ENGINEERING AUDIT OF CONSTRUCTION

GRAPHICAL ILLUSTRATION OF VARIATION IN THICKNESS



ENGINEERING AUDIT OF CONSTRUCTION

GRAPHICAL ILLUSTRATION OF VARIATION IN THICKNESS

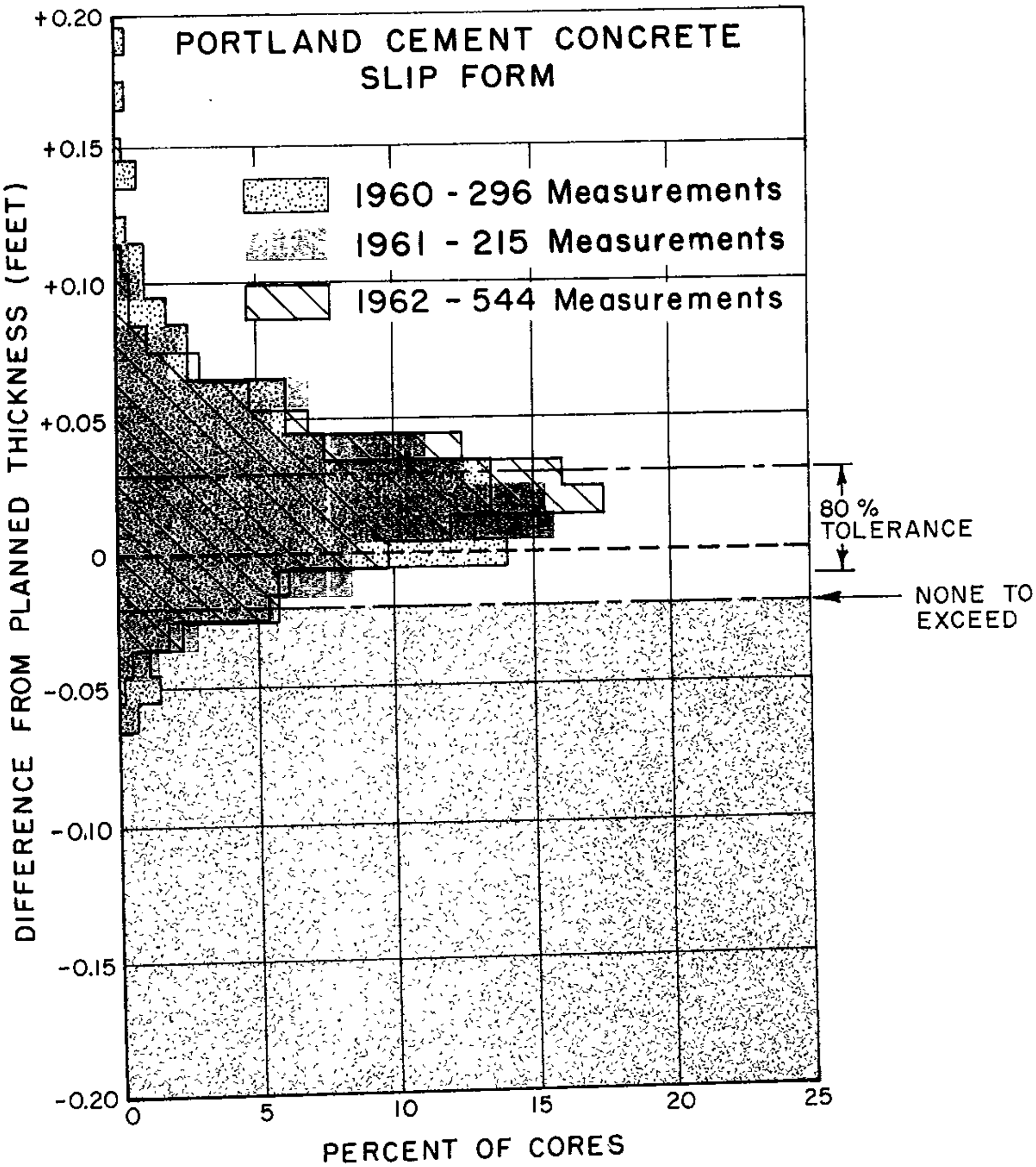
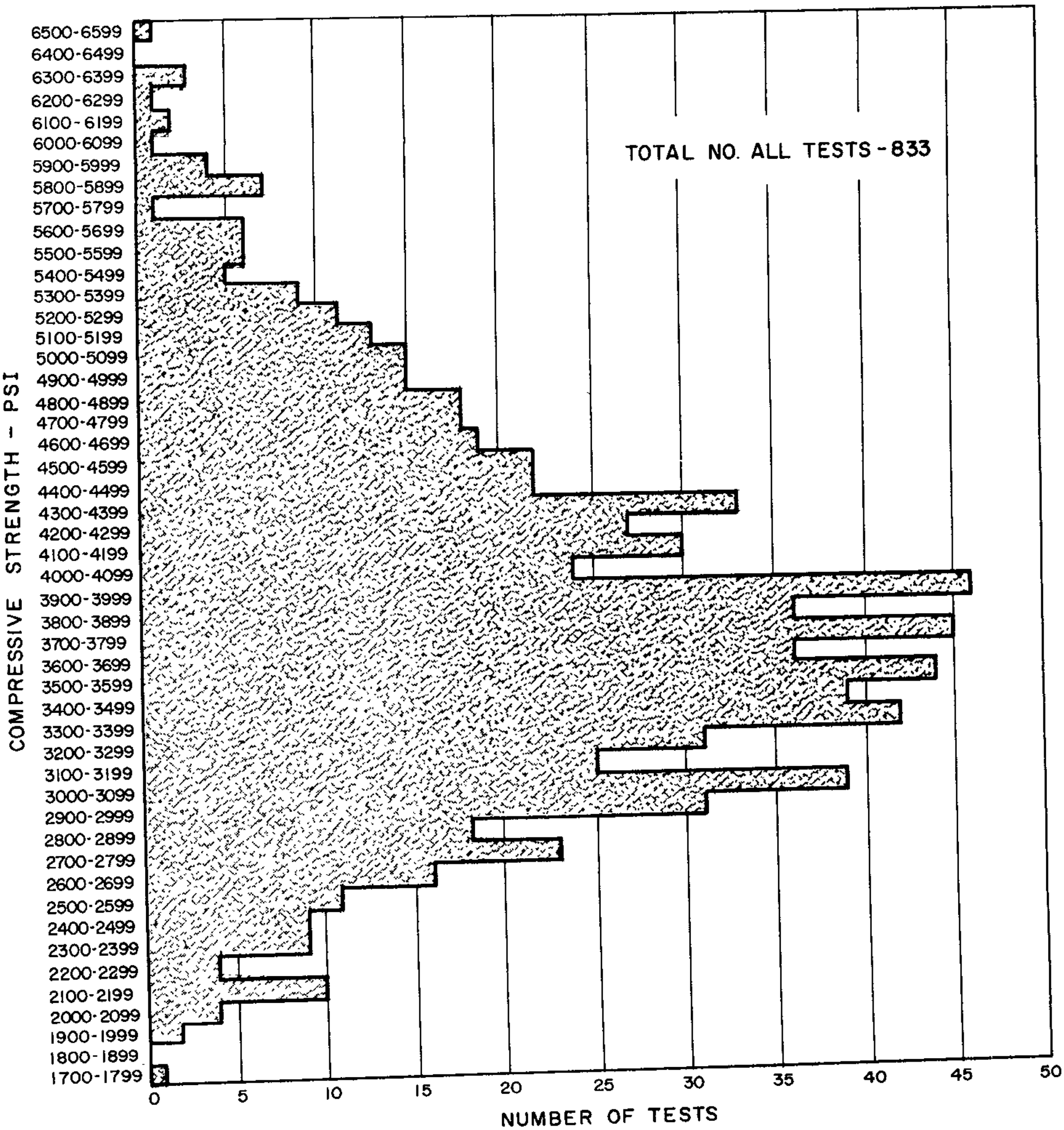


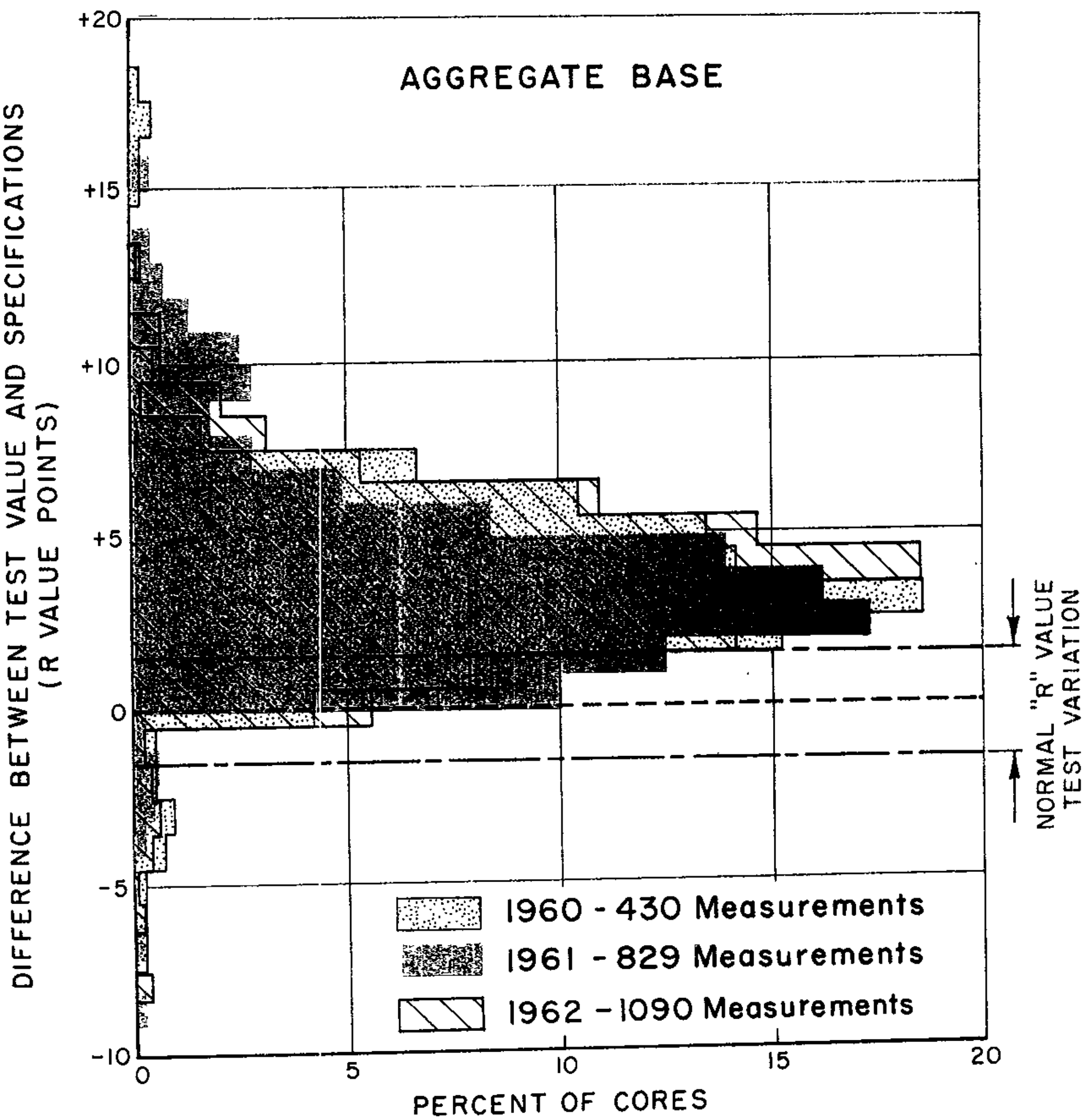
FIGURE 7

DISTRIBUTION OF COMPRESSIVE STRENGTH TESTS FOR FIVE INCH DIAMETER CORES OF PORTLAND CEMENT CONCRETE FOR JUNE 1, 1960 TO OCTOBER 1, 1961



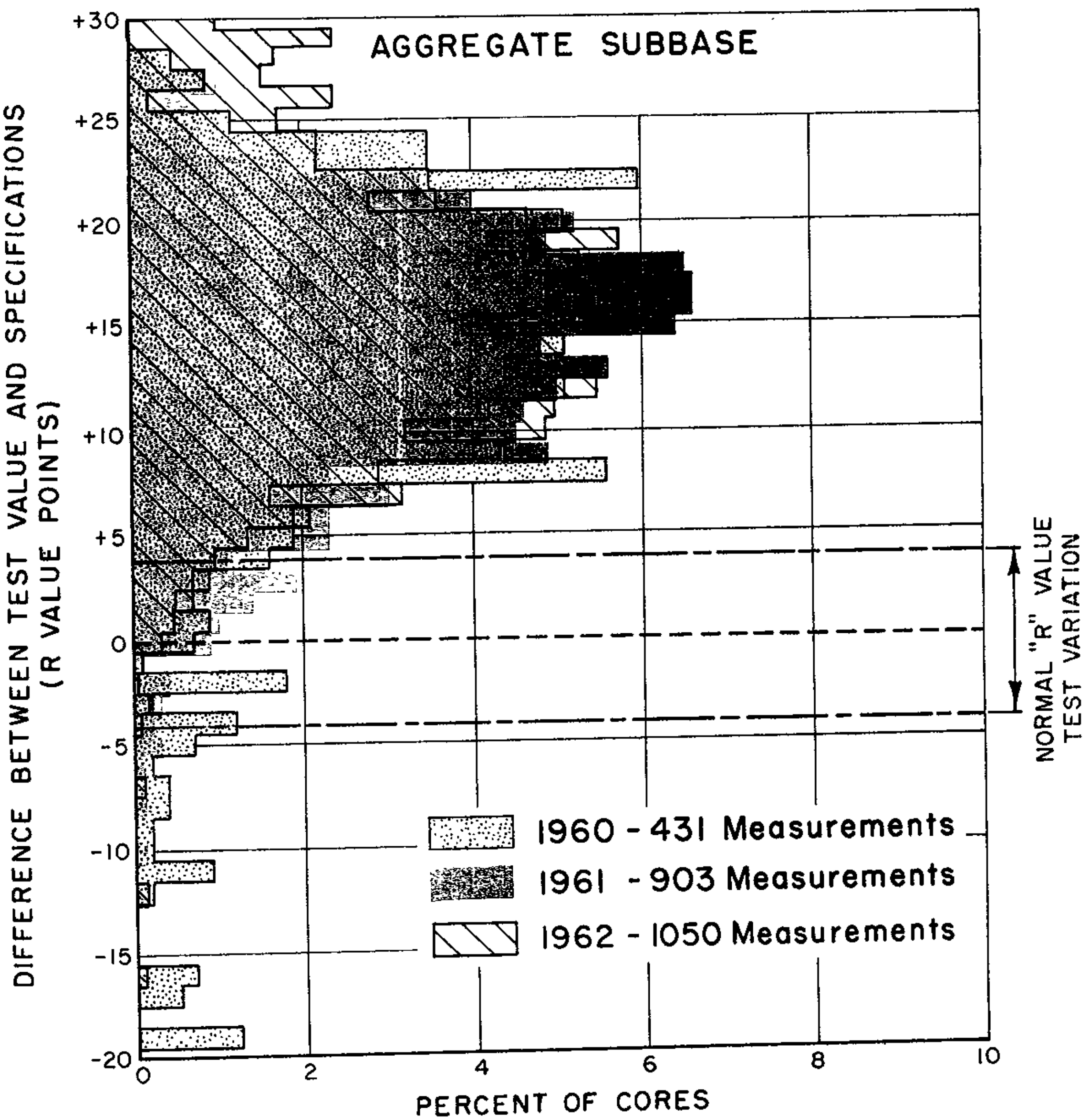
ENGINEERING AUDIT OF MATERIALS

GRAPHICAL ILLUSTRATION OF R-VALUE TEST VARIATION



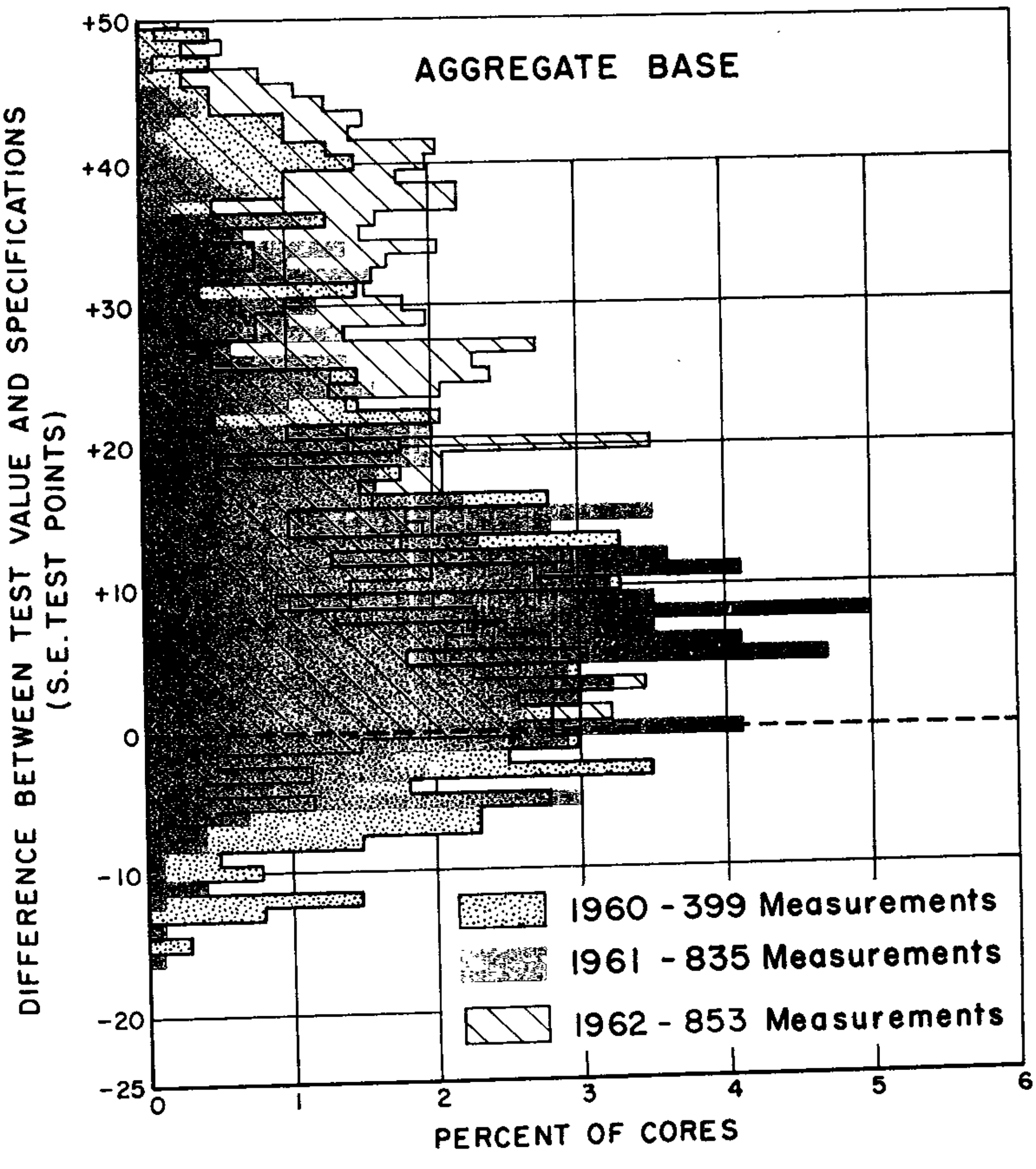
ENGINEERING AUDIT OF MATERIALS

GRAPHICAL ILLUSTRATION OF R-VALUE TEST VARIATION



ENGINEERING AUDIT OF MATERIALS

GRAPHICAL ILLUSTRATION OF S.E. TEST VALUE VARIATION



ENGINEERING AUDIT OF MATERIALS

GRAPHICAL ILLUSTRATION OF S.E. TEST VALUE VARIATION

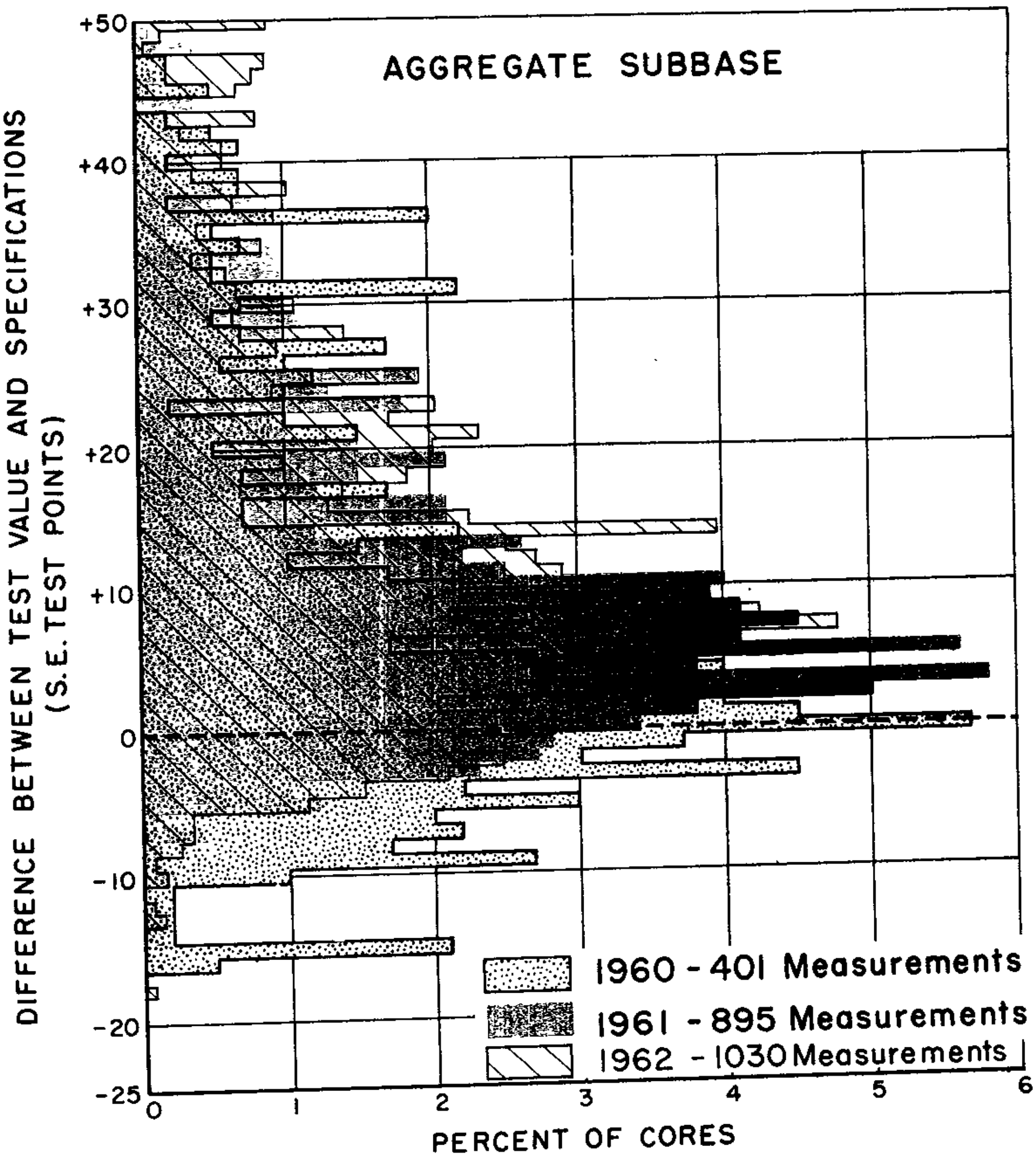


FIGURE 12

SAMPLE AND TEST CLASSIFICATION CHART

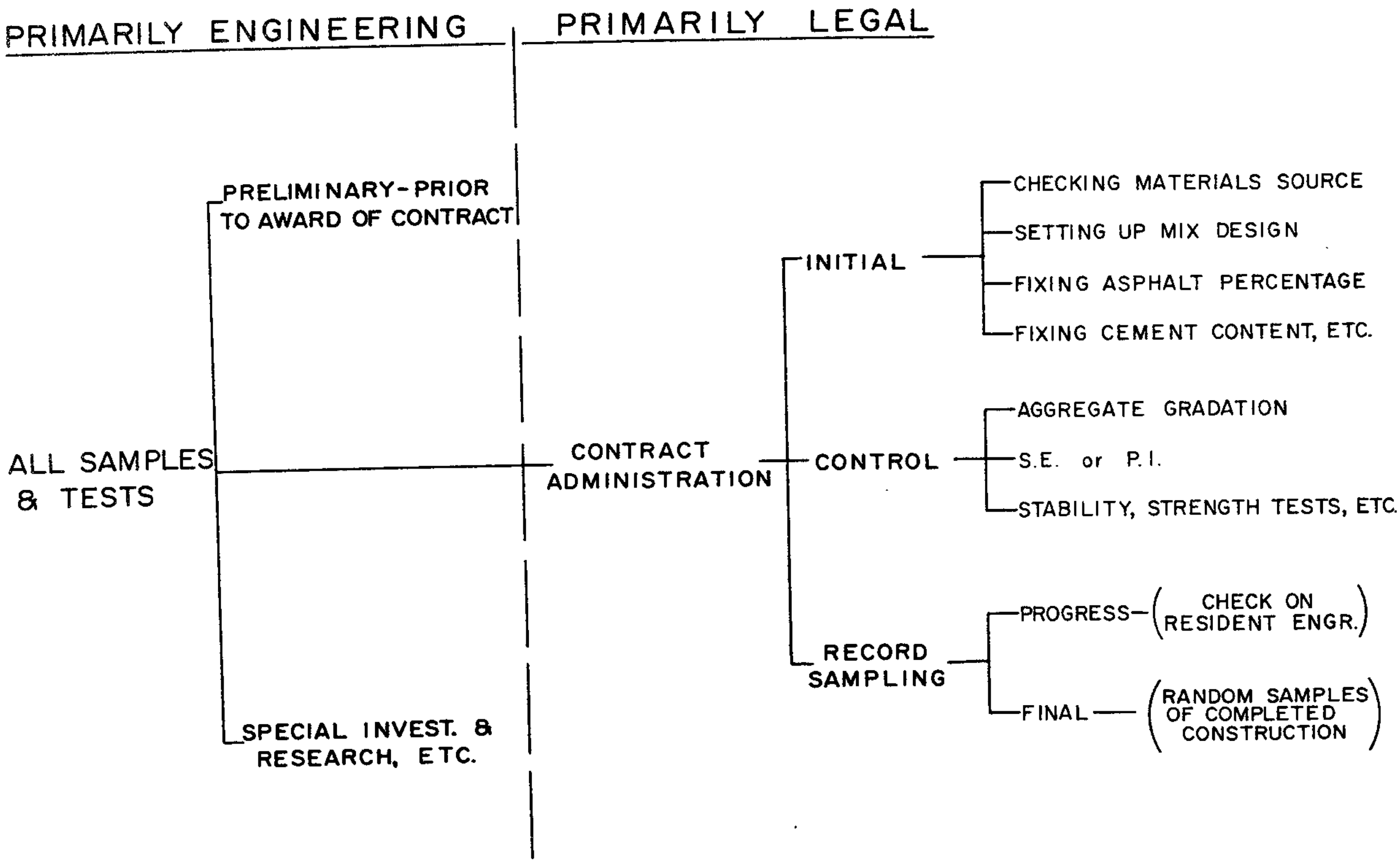


FIGURE 13

FINAL RECORD SAMPLING A.C. AGGREGATE GRADING DISTRIBUTION

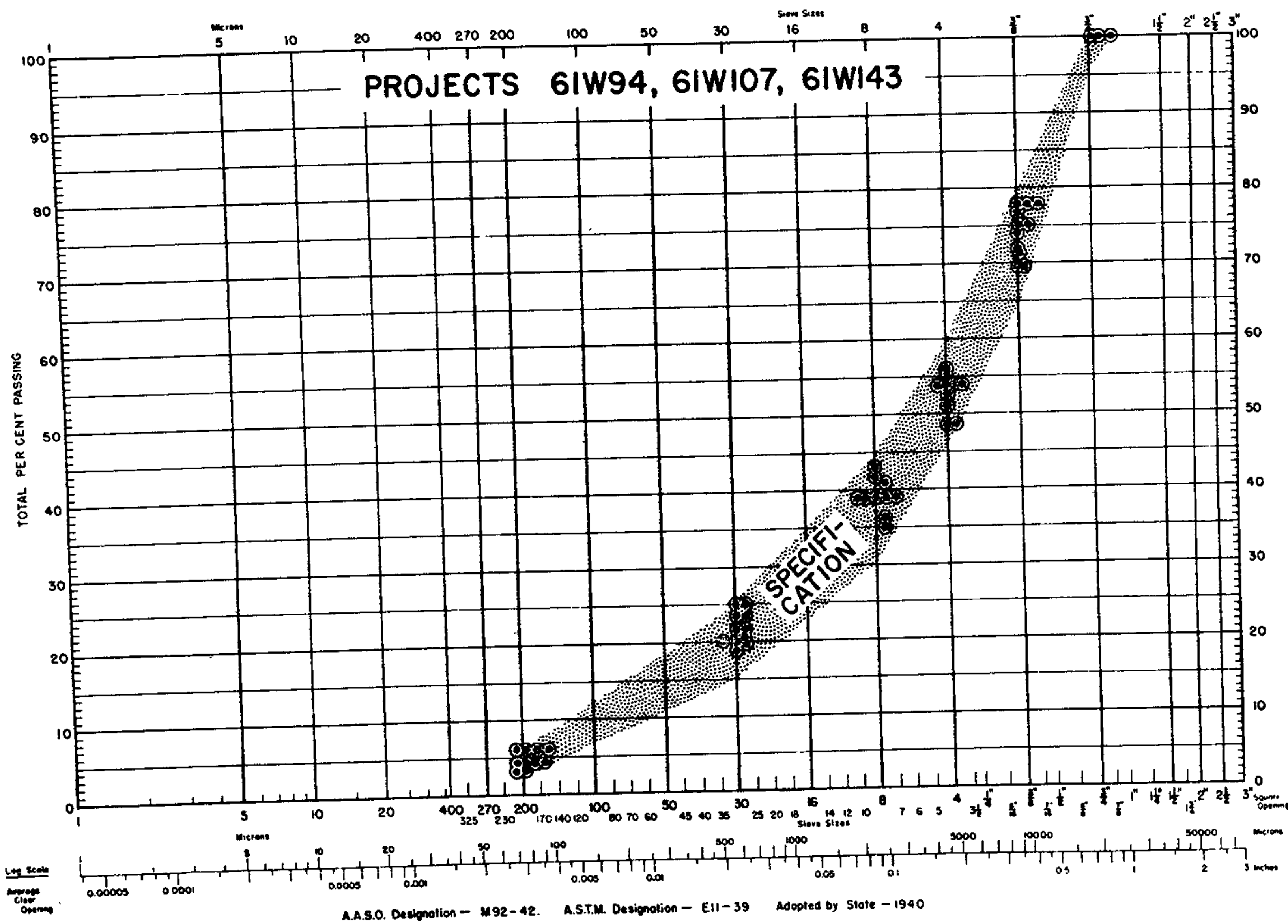
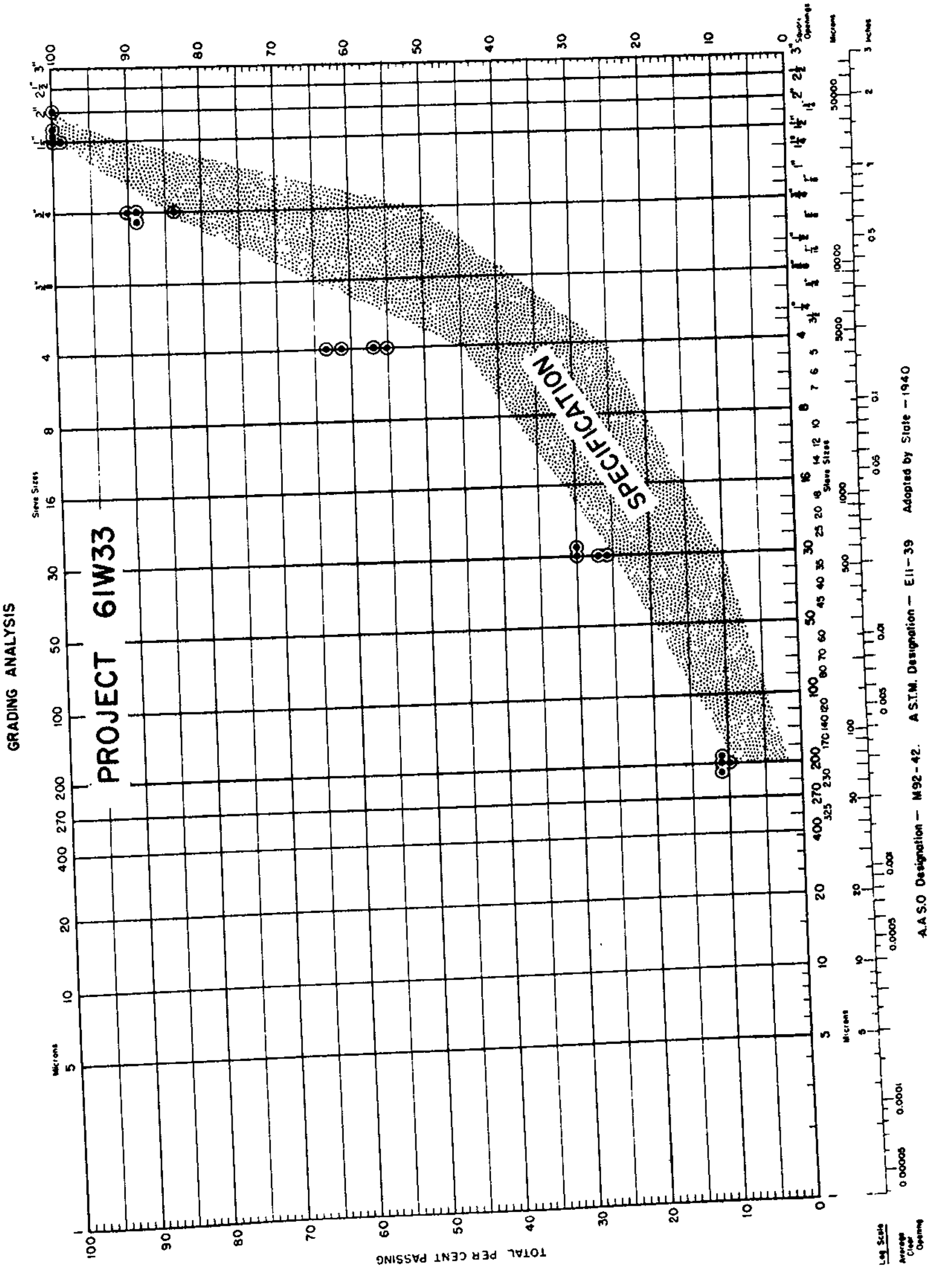


FIGURE 14

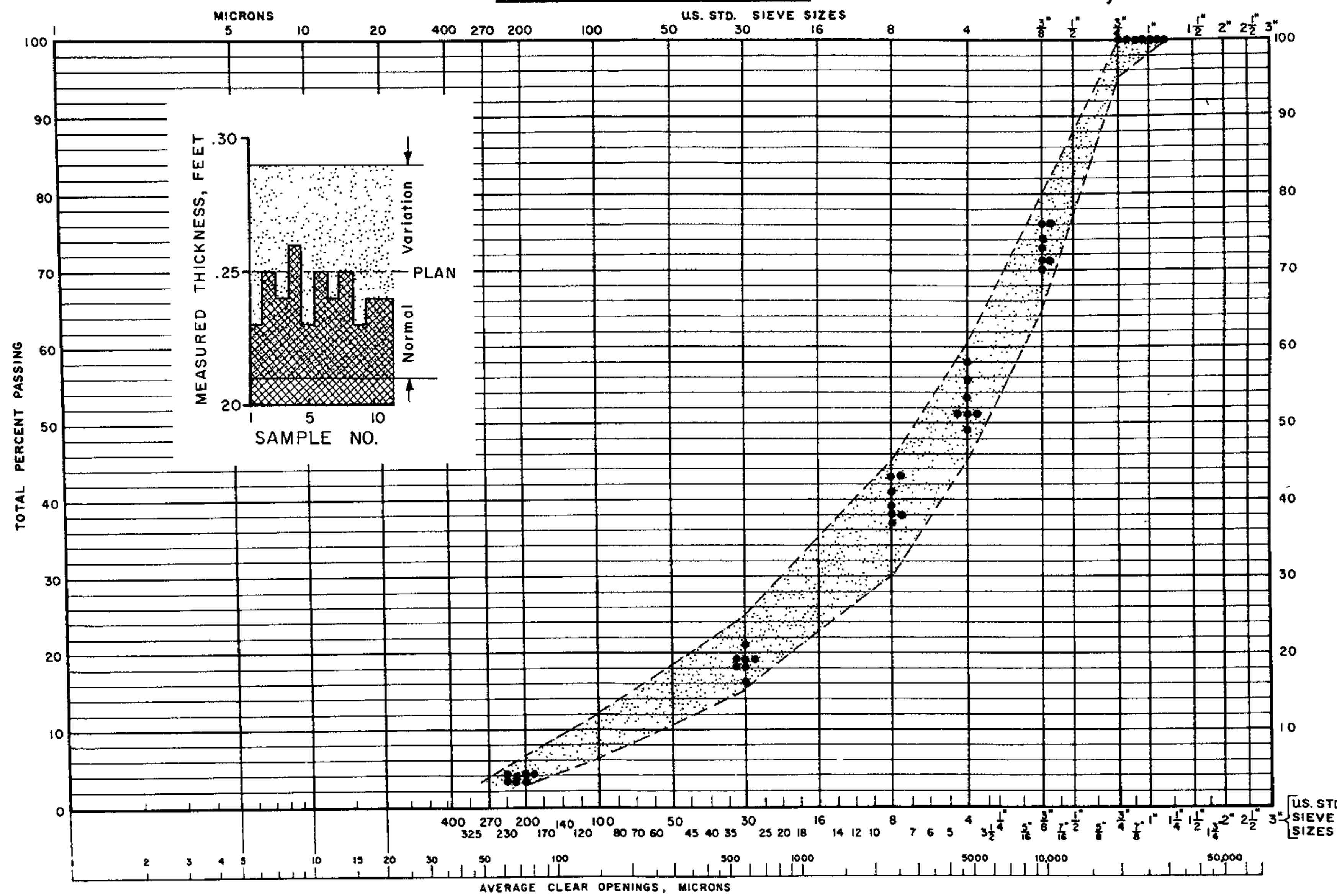
FINAL RECORD SAMPLING AGGREGATE BASE GRADING DISTRIBUTION



FINAL RECORD OF A.C. SURFACING THICKNESS & GRADING TEST RESULTS

GRADING ANALYSIS

Project 63 W 19



A.A.S.H.O. DESIGNATION – M92 A.S.T.M. DESIGNATION E 11, (SQUARE OPENINGS)

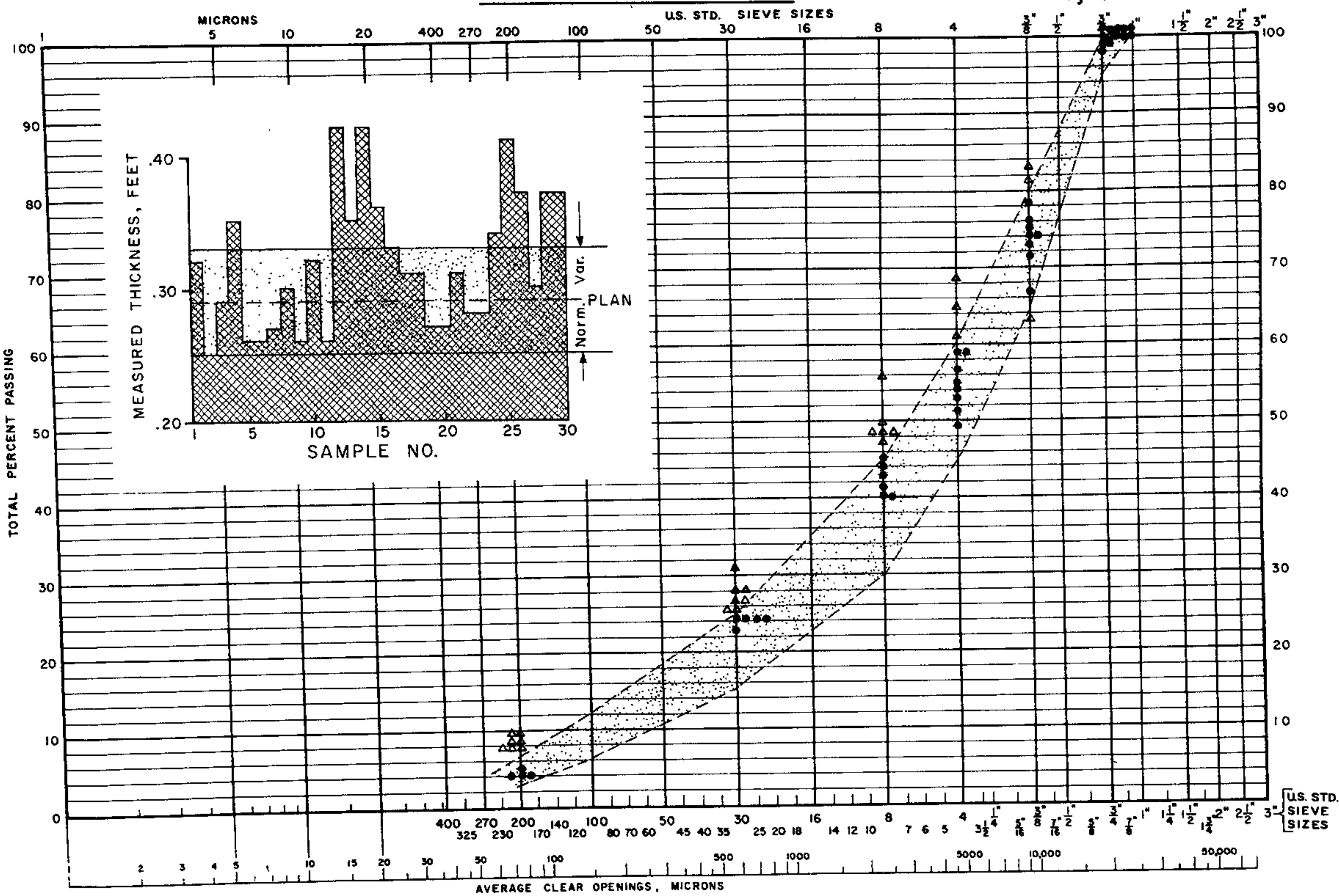
FORM T-218 (Rev. 8-63)

FIGURE 15

FINAL RECORD OF A.C. SURFACING THICKNESS & GRADING TEST RESULTS

GRADING ANALYSIS

Project 62 W 23

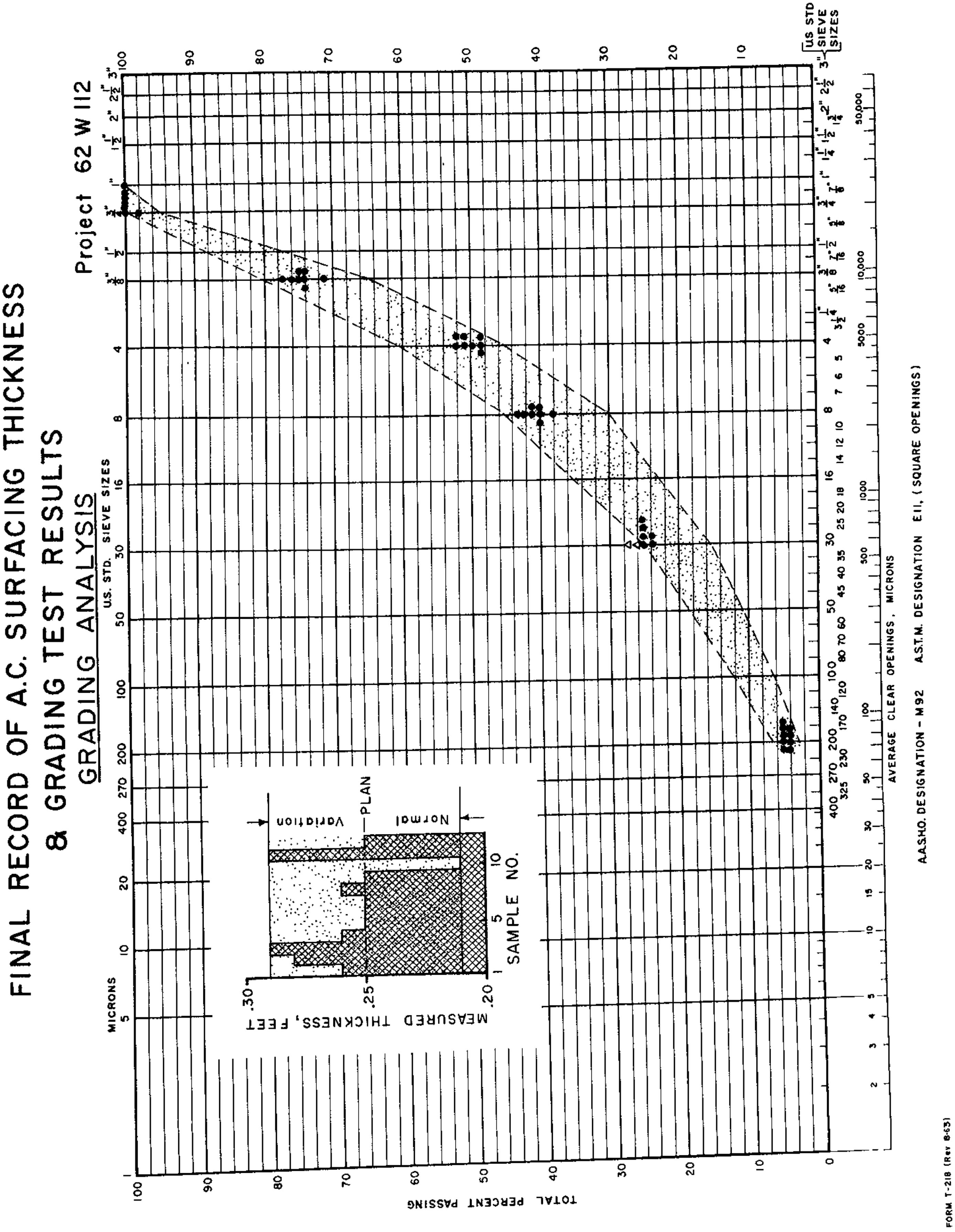


A.A.S.H.O. DESIGNATION - M92   A.S.T.M. DESIGNATION E11, (SQUARE OPENINGS)

FORM T-218 (Rev 6-63)

FIGURE 16

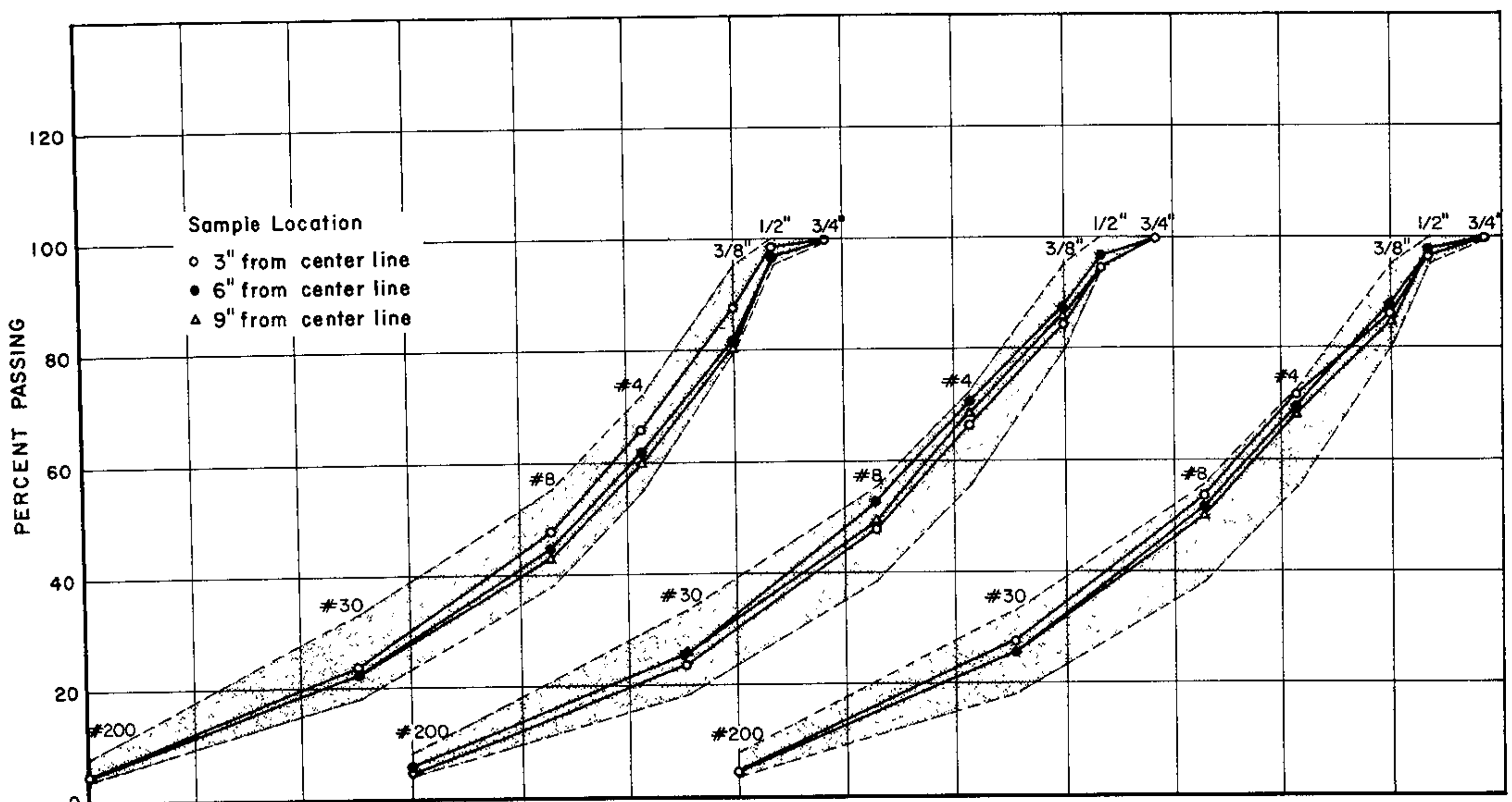
FIGURE 17



FINAL RECORD OF A.C. SURFACING THICKNESS
& GRADING TEST RESULTS
GRADING ANALYSIS
Project 62 W 112
U.S. STD. SIEVE SIZES
MICRONS
TOTAL PERCENT PASSING
US STD SIEVE SIZES
AVERAGE CLEAR OPENINGS, MICRONS
A.A.S.H.O. DESIGNATION - M92 A.S.T.M. DESIGNATION E11, (SQUARE OPENINGS)
MEASURED THICKNESS, FEET
SAMPLE NO.
PLAN
Normal
Variation
FORM T-218 (Rev 6-63)

TESTS FOR UNIFORMITY OF ASPHALT CONCRETE MIXTURE

Samples Obtained Directly Behind Paver



Sta 375	Sta 391	Sta 411
5.4 % Asphalt	4.9 % Asphalt	5.3 % Asphalt
5.0 % Asphalt	5.3 % Asphalt	5.6 % Asphalt
5.0 % Asphalt	5.2 % Asphalt	5.0 % Asphalt
$\frac{188}{188} \times 100 = 100$	$\frac{282}{284} \times 100 = 99.3$	$\frac{227}{331} \times 100 = 98.3$

PERCENT COATED AGGREGATE BY ROSS COUNT

GREATEST VARIATION AT ONE LOCATION, %

SIEVES	#200	30	8	4	3/8"	1/2"	ASPHALT
Sta. 375	0	1	4	6	7	2	0.4
Sta. 391	1	2	5	4	3	2	0.4
Sta. 411	0	2	3	3	2	1	0.6

GREATEST VARIATION BETWEEN LOCATIONS, %

SIEVES	#200	30	8	4	3/8"	1/2"	ASPHALT
	1	1	2	3	5	1	0.7

FIGURE 19

PROJECT A
BATCH PLANT CTB OPERATION

EXAMPLE OF IMPROVED DISTRIBUTION IN CTB MIXTURE BY REPLACEMENT OF INACCURATE CEMENT SCALE

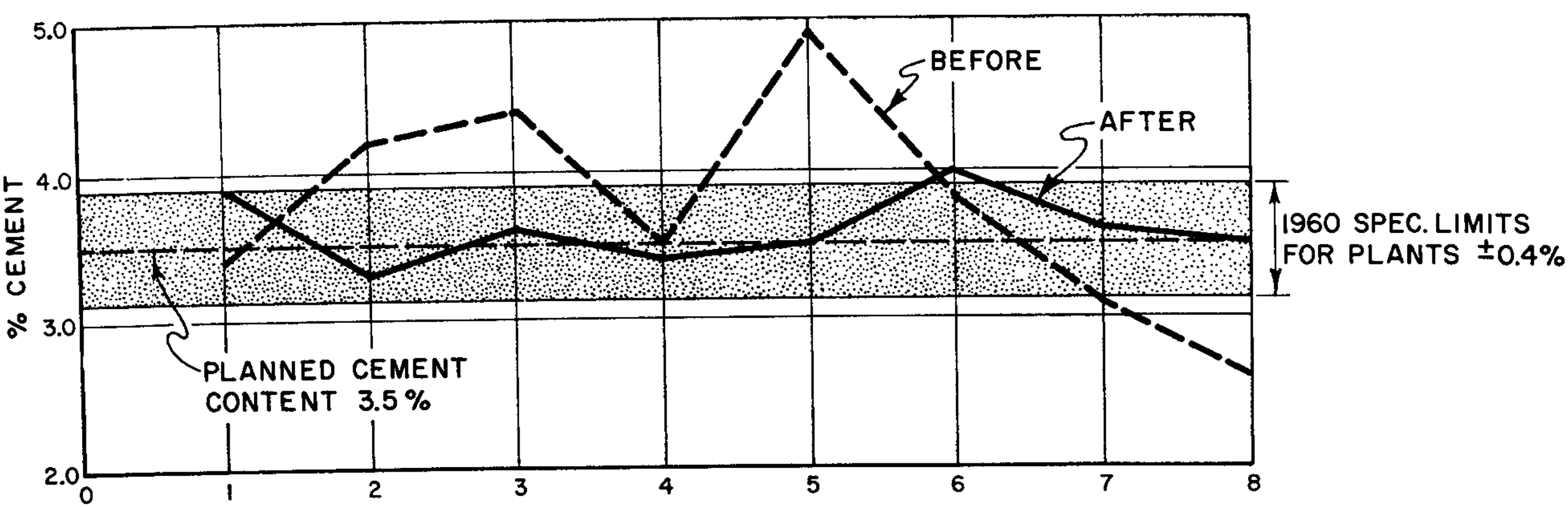
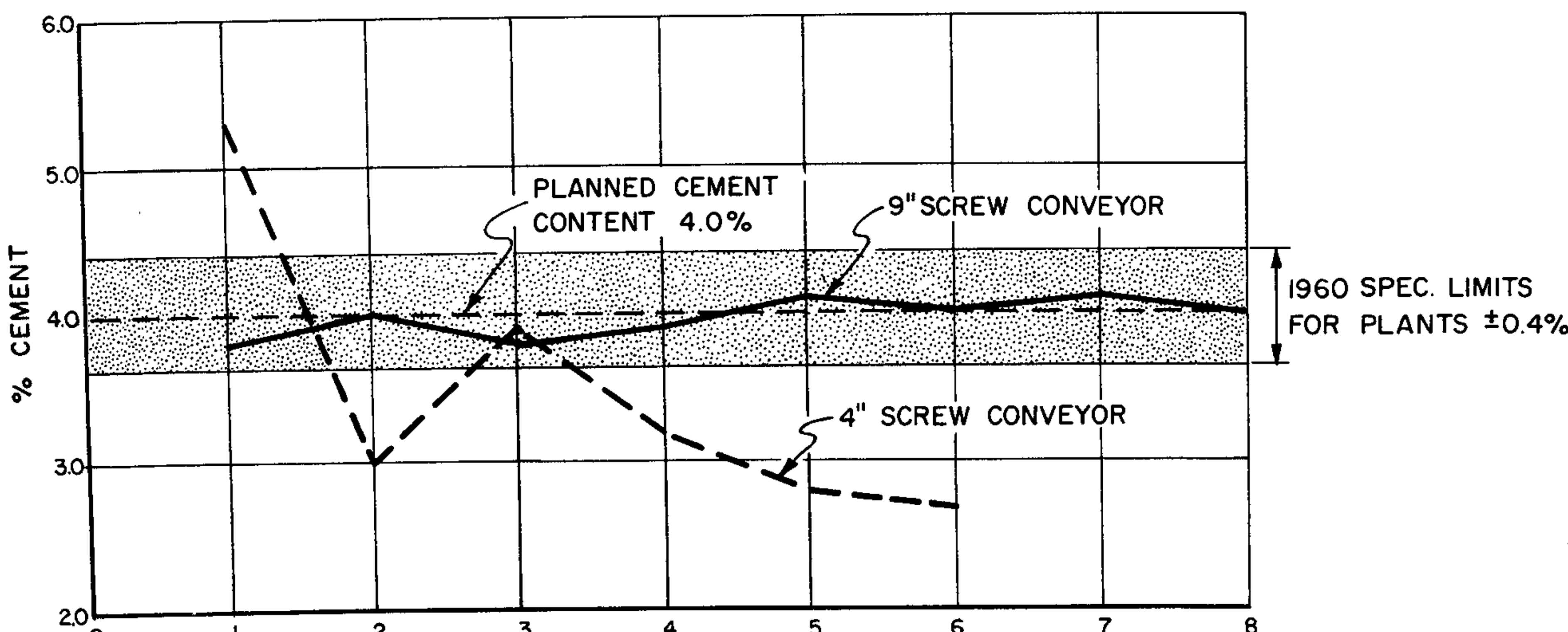


FIGURE 20

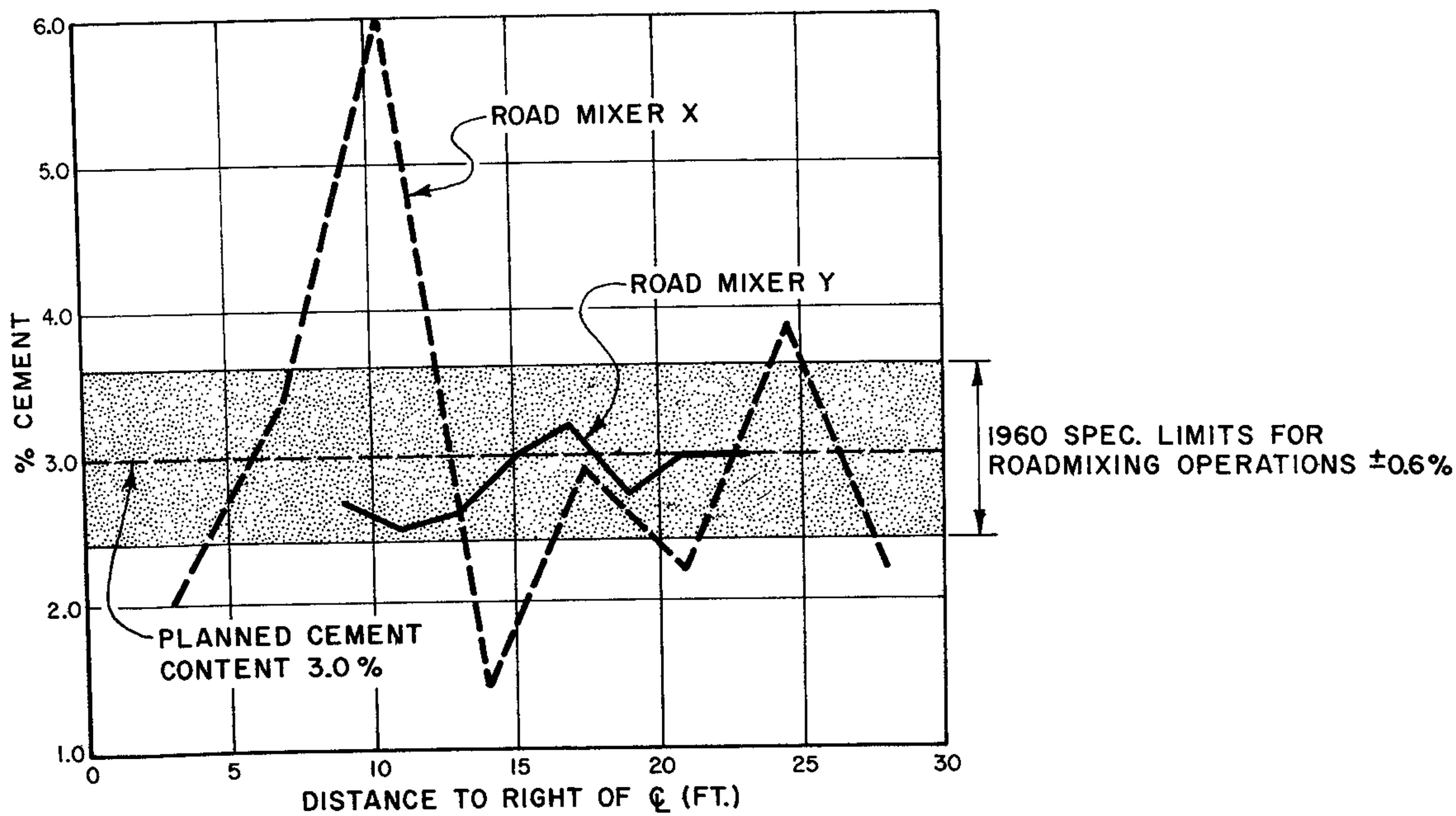
PROJECT B
CONTINUOUS MIX CTB PLANT

EXAMPLE OF IMPROVED DISTRIBUTION BY CHANGING CEMENT FEED AUGER FROM 4" DIA., 4" PITCH TO 9" DIA., 4" PITCH



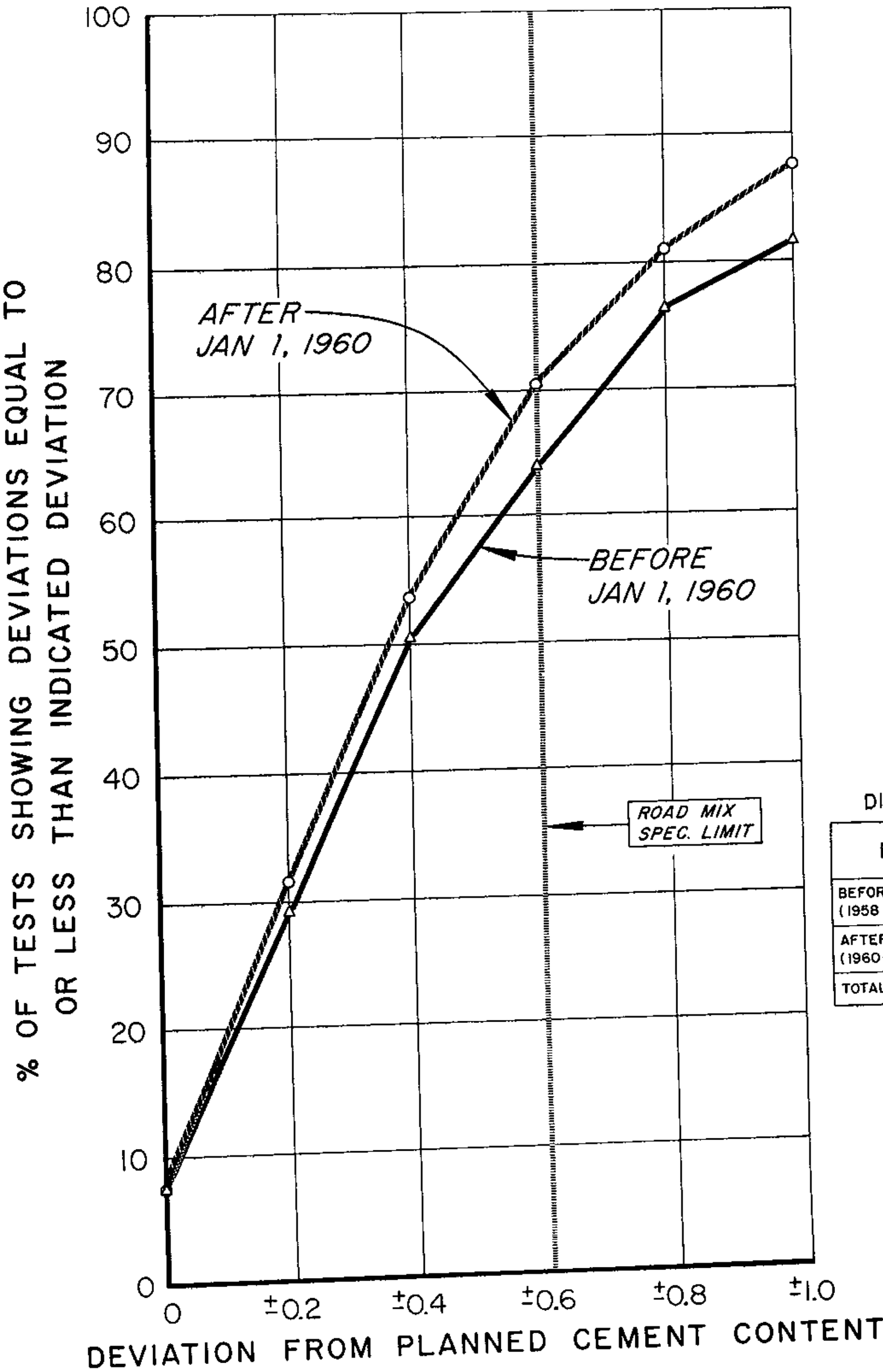
PROJECT C
ROADMIXING CTB OPERATION

EXAMPLE OF IMPROVED DISTRIBUTION BY THE REPLACEMENT OF A POORLY FUNCTIONING MACHINE WITH ONE WHICH OPERATES PROPERLY



ROAD MIX

A CHART DEMONSTRATING SOME IMPROVEMENT IN CTB CEMENT DISTRIBUTION WITH THE ADVENT OF THE JAN 1960 STD. SPECS. AND THE USE OF THE TITRATION TEST AS THE METHOD OF CONTROL



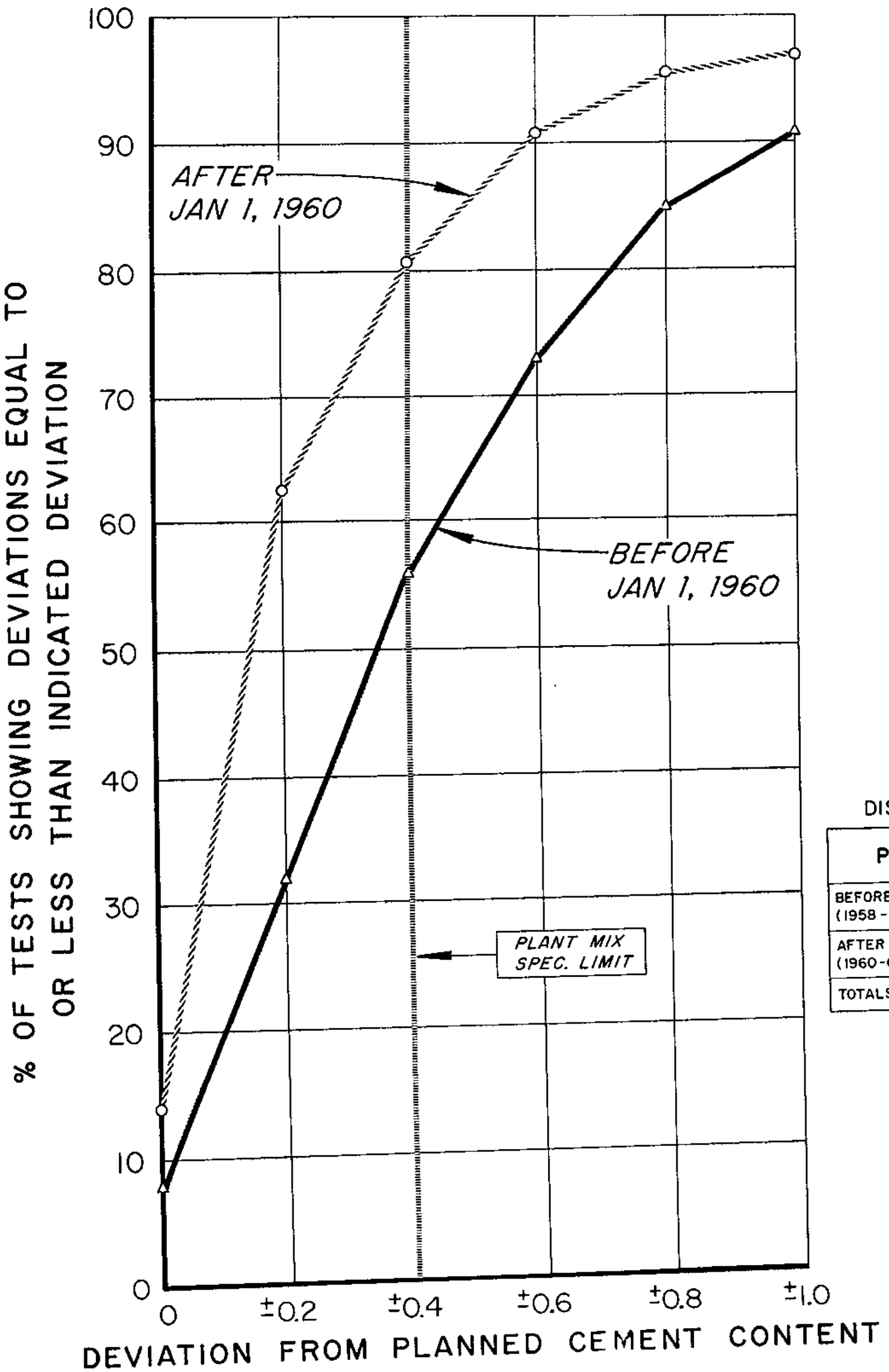
DISTRIBUTION OF TEST DATA

PERIOD	NO. OF PROJECTS	NO. OF TESTS
BEFORE JAN 1960 (1958-59)	82	3556
AFTER JAN 1960 (1960-61-62 INCL)	56	1991
TOTALS	138	5547

FIGURE 23

BATCH PLANTS

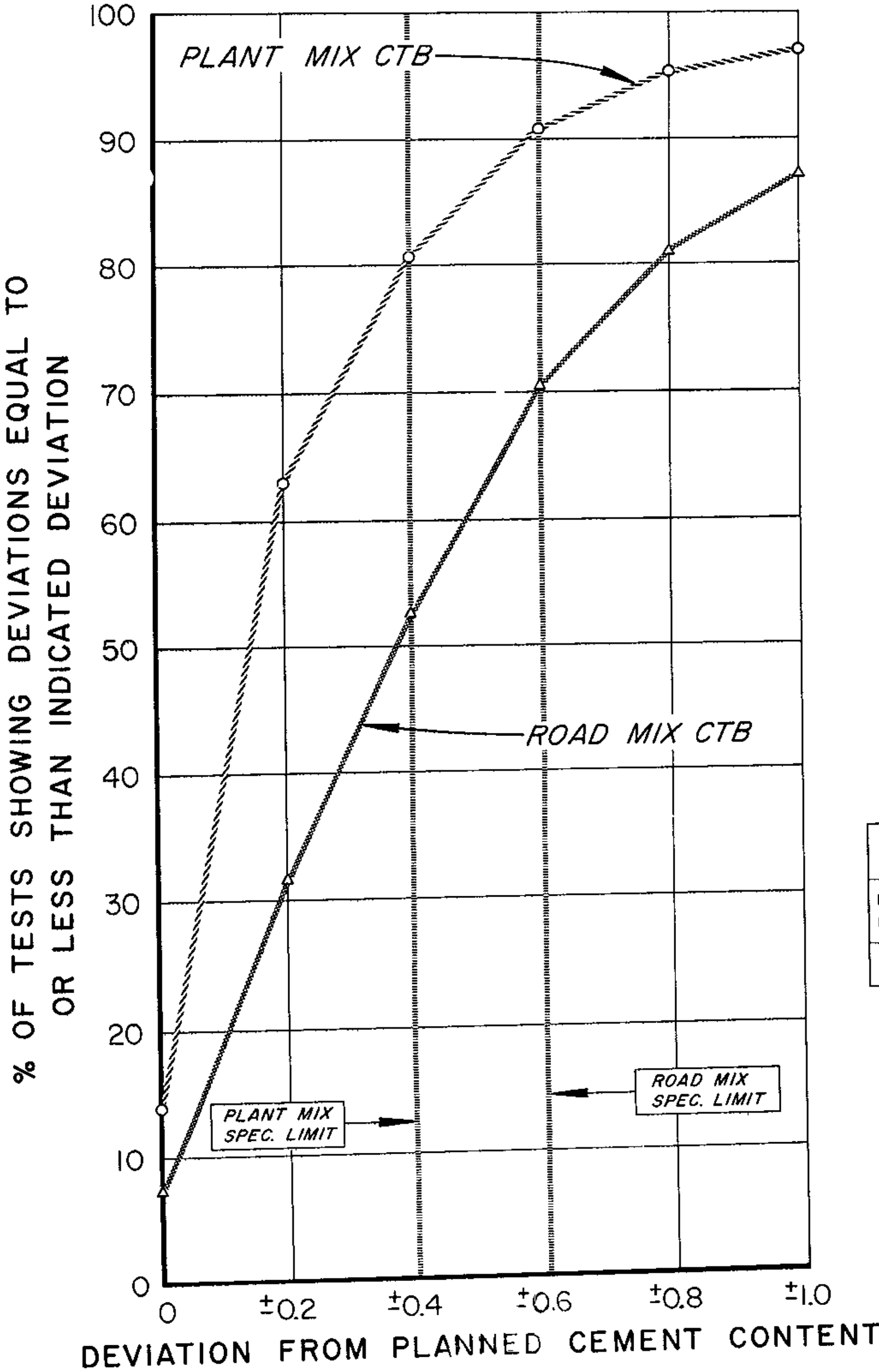
A CHART DEMONSTRATING THE IMPROVEMENT IN CTB CEMENT DISTRIBUTION WITH THE ADVENT OF THE JAN 1960 STD. SPECS. AND THE USE OF THE TITRATION TEST AS THE METHOD OF CONTROL



DISTRIBUTION OF TEST DATA

PERIOD	NO. OF PROJECTS	NO. OF TESTS
BEFORE JAN 1960 (1958-59)	15	587
AFTER JAN 1960 (1960-61-62 INCL.)	27	735
TOTALS	42	1322

COMPARISON OF BATCH TYPE PLANT MIX WITH ROAD MIX CTB OPERATIONS FROM TITRATION TESTS ON FIELD SAMPLES 1960-61-62

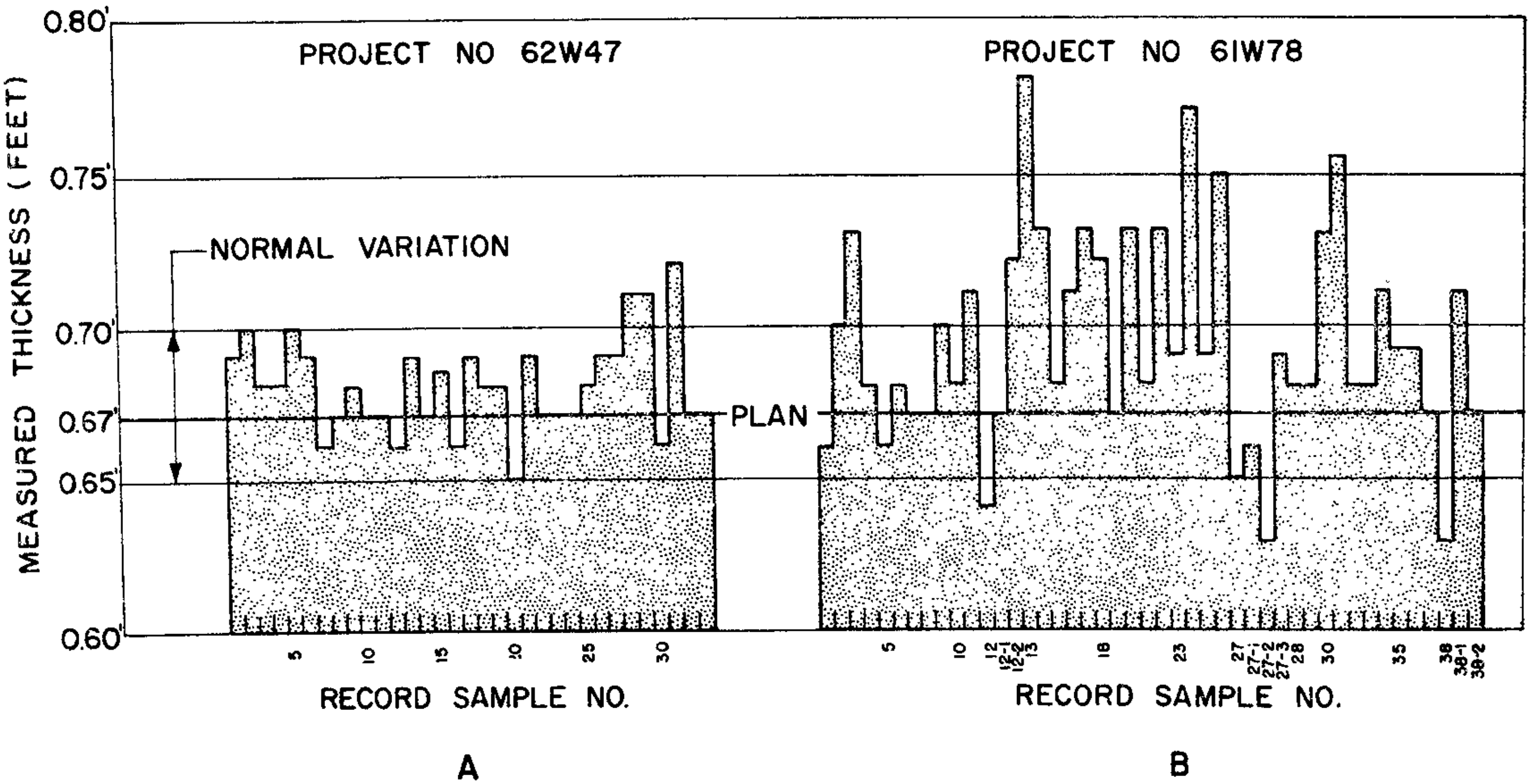


DISTRIBUTION OF TEST DATA

TYPE	NO. OF PROJECTS	NO. OF TESTS
PLANT MIX	27	735
ROAD MIX	56	1991
TOTAL	83	2626

FIGURE 25

FINAL RECORD THICKNESS MEASUREMENTS FROM TWO P.C.C. PAVEMENTS



APPENDIX I

PORTLAND CEMENT CONCRETE – BRIDGES & MAJOR STRUCTURES

R.C.B. – P.C.C Arch Culverts – Retain Walls Slope Paving

SIZE, FREQUENCY AND LOCATION OF SAMPLING AND TESTING — MINIMUM NECESSARY

MATERIAL OR PRODUCT	TEST FOR	TEST NO	SIZE OF SAMPLE	INITIAL: LOCATION OR TIME OF SAMPLING	CONTROL: FREQUENCY OF SAMPLING	PROGRESS: LOCATION OR TIME OF SAMPLING	PROGRESS: FREQUENCY OF SAMPLING	FINAL: LOCATION OR TIME OF SAMPLING	FINAL: FREQUENCY OF SAMPLING	REMARKS
MINERAL AGGREGATE – COARSE AGGREGATE	LA Rattler (500 rev.)	211	See Note (3)	See Note (2)						
MINERAL AGGREGATE – COARSE AGGREGATE	Cleanness Value	227	See Note (3)	See Note (2)	1 for approx. every 300 cu yds of concrete (1) At least 1 per job	Batch Bin-Just prior to mixing	Approx once for each 10 days of conc. production (1)			
MINERAL AGGREGATE – FINE AGGREGATE	Colorimetric Test	213	See Note (3)	See Note (2)	None unless Initial test shows critical or contamination suspected.	Batch Bin-Just prior to mixing				
MINERAL AGGREGATE – FINE AGGREGATE	Mortar Strength	515	See Note (3)	See Note (2)						
MINERAL AGGREGATE – FINE AGGREGATE	Sand Equivalent	217	See Note (3)	See Note (2)	1 for approx. every 300 cu yds of concrete (1) At least 1 per job	Batch Bin-Just prior to mixing	Approx once for each 10 days of conc production (1)			
MINERAL AGGREGATE – COARSE & FINE AGGREGATE	Freeze Thaw	528	See Note (3)	See Note (2)						
MINERAL AGGREGATE – COARSE & FINE AGGREGATE	Soundness	214	See Note (3)	See Note (2)						
MINERAL AGGREGATE – COARSE & FINE AGGREGATE	Sieve Analysis	202	See Note (3)	See Note (2)	1 for approx every 300 cu yds of concrete (1) At least 1 per job	Batch Bin-Just prior to mixing	Approx. once for each 10 days of conc production (1)			
MINERAL AGGREGATE – COARSE & FINE AGGREGATE	Specific Gravity & Absorption	206 & 207	See Note (3)	See Note (2)	When aggregate changed	See Note (2)				
MINERAL AGGREGATE – COARSE & FINE AGGREGATE	Moisture	223 or oven dry			As required for control	Batch Bin-Just prior to mixing				
CEMENT	Compliance with Std. Specs. and Special Provisions	ASTM C150	4 lb	None with Cert of Comp (SEE REMARKS)	1 for approx. every 300 cu yds of concrete (1) (See Const.Man 8-02 06a)	Cement weigh hopper or screw leading to weigh hopper.	Witness sampling method at least once during project			If no certificate of compliance, sample at least 7 days prior to use for previously tested brands-28 days for untested brands
WATER	Compliance with Sec. 90 of Std Specs. & Special Prov.	405	1/2 Gallon	At point of use (SEE REMARKS)	As required for control (SEE REMARKS)	At point of use				City water supplies for domestic use usually need not be tested unless suspected of high chloride or sulphate content On-the-job wells should be tested
ADMIXTURES – Air entraining Agents	Air entraining properties-- Chlorides Identification	415	1 Qt. can of liquid 2 lb powder	Samples must reach testing lab at least one week prior to use.	Each new lot of material brought to job.	Samples must reach testing lab at least one week prior to use				
ADMIXTURES – Water Reducers Set Retarders	Claimed properties Chlorides Identification	530 or 415	1 Qt. can of liquid 2 lb. powder	Samples must reach testing lab at least one week prior to use, untested brands require 5 weeks prior to use for tests.	Each new lot of material brought to job	Samples must reach testing lab at least one week prior to use; untested brands require 5 weeks prior to use for tests				
CONCRETE	Yield, Cement Factor	518	Approx 1 cu. ft.		1 for approx every 600 cu yds. of conc.—min of 2	At point concrete is deposited in the work	Witness test at least once per job			
CONCRETE	Slump-Kelly Ball	520			When test specimens fabricated and when consistency questionable	At point concrete is deposited in the work	Witness test procedure approx. once for every 1000 c y or fraction			
CONCRETE	Compressive Strength	521	3–6 x 12 test cylinders		IA, or IB, and IC only for approx. every 300 cu yd. concrete or as required for control Min of 1 set per job	At point concrete is deposited in the work	Witness fabrication of test specimens once per job			
CONCRETE	Entrained Air	504			Approx. once every 4 hours or as required for control	At point concrete is deposited in the work	Witness test procedure approx once for every 1000 c.y. or fraction thereof.			
CONCRETE	Coarse aggregate per C.F. of concrete.	529			As required to assure uniformity of concrete	1st & last 1/4 of batch	Witness test method at least once during project			

(1) Not required if P.C.C. from same source is being used on other works and test is being made there. No need to duplicate the test, just for the sake of the record. The actual test results may be used anywhere they are applicable.
(2) From Material Site or Stockpile. Two months prior to use (Nine months prior to use if subject to Freezing & Thawing)
(3) 150# of 2½" x 1½" – 100# of 1½" x ¾" – 75# of 1" x No. 4 – 75# of ¾" x No. 4 – 75# of pea gravel – 75# of sand. This material for tests 211, 213, 214, 217, 202, 227, 515, 206, 207, 528

SIZE, FREQUENCY AND LOCATION OF SAMPLING AND TESTING

MINIMUM NECESSARY

MATERIAL OR PRODUCT	TEST FOR	TEST NO	SIZE OF SAMPLE	INITIAL: LOCATION OR TIME OF SAMPLING	CONTROL: FREQUENCY OF SAMPLING	PROGRESS: LOCATION OR TIME OF SAMPLING	PROGRESS: FREQUENCY OF SAMPLING	FINAL: LOCATION OR TIME OF SAMPLING	FINAL: FREQUENCY OF SAMPLING	REMARKS
ASPHALT CONCRETE — MINERAL AGGREGATE PRIOR TO MIXING (1)	L A Rattler	211	Type "A" & "B" UNPROCESSED 250#	Materials Site, Stockpile or Plant Bins						Not made on Type C
	Specific Gravity (coarse & fine agg.)	206 & 208		Materials Site, Stockpile or Plant Bins						
	CKE	303	PROCESSED 50# of each bin size	Materials Site, Stockpile or Plant Bins	As necessary to maintain control	Plant Bins prior to mixing				Not made on Open Graded
	Stabilometer	304		Materials Site, Stockpile or Plant Bins						
	Swell	305	**** ****	Materials Site, Stockpile or Plant Bins						
	Moist, Vapor Suscep	307	Type "C" UNPROCESSED 100#	Materials Site, Stockpile or Plant Bins						
	Moisture	311	PROCESSED 50#		As necessary for control	Plant Bins prior to mixing				Not made on Type C
	% Crushed Particles	205		Materials Site, Stockpile or Plant Bins						
	Sieve Analysis	202	**** ****	Materials Site, Stockpile or Plant Bins	2 Times Daily	Plant Bins prior to mixing	1 progress for every 10 control-minimum of three			
	Sand Equivalent	217	Open Graded 50#	Materials Site, Stockpile or Plant Bins	2 Times Daily	Plant Bins prior to mixing	1 progress for every 10 control-minimum of three			Not made on Open Graded Asphalt Concrete
	Film Stripping	302		Materials Site, Stockpile or Plant Bins						Made on Open Graded Asphalt Concrete Only
COMMERCIAL FILLER	Grading Wash & dry ratio on #200	202	10#	Source	Not necessary if tested in initial stage, unless source is changed	Before Mixing				
	Surface Area	340		Source	Not necessary if tested in initial stage, unless source is changed	Before Mixing				
	Specific Gravity	208		Source	Not necessary if tested in initial stage, unless source is changed	Before Mixing				
Paving Asphalt Liquid Asphalt Asphaltic Em	In accordance with applicable Section of Std Specs		Asphalts 1 Qt.	Test only if no certificate of compliance Plant Line.	Once daily	Plant line				
			Emulsion ½ Gal	Test only if no certificate of compliance Plant Storage Tank	Each Shipment	Plant Storage Tank or Distributor				
COMPLETE MIXTURE	Swell	305	15# Carton		As necessary for control	At point of delivery to street				Test as necessary for mix design control
	Moist, Vapor Suscep.	307			As necessary for control	At point of delivery to street				Test as necessary for mix design control
	Extraction and Moisture	310			Daily Sample for approx each 1000 tons or fraction thereof. Not more than 2 Daily	At point of delivery to street	Witness approx 1 in every 10 control samples	Completed Pav't.	1 per Lane Mile	Test as necessary for mix design control Final samples for informational purposes.
	Sieve Analysis	202			Daily Sample for approx. each 1000 tons or fraction thereof. Not more than 2 Daily	At point of delivery to street	Witness approx 1 in every 10 control samples	Completed Pav't.	1 per Lane Mile	Test as necessary for mix design control Final samples for informational purposes
	Stabilometer	304			Daily Sample for approx. each 1000 tons or fraction thereof. Not more than 2 Daily	At point of delivery to Street	Witness approx 1 in every 10 control samples			Test as necessary for mix design control
	Dimensions				As necessary for control	Completed Pav't.		Completed Pav't.	1 per Lane Mile	

(1) On smaller projects being supplied from sources currently in use on larger projects, a copy of the control test information on A.C. aggregate is all that is required

MINIMUM NECESSARY

SIZE, FREQUENCY AND LOCATION OF SAMPLING AND TESTING

MATERIAL OR PRODUCT		TEST FOR	TEST NO	SIZE OF SAMPLE	INITIAL: LOCATION OR TIME OF SAMPLING	CONTROL: FREQUENCY OF SAMPLING	CONTROL / PROGRESS: LOCATION OR TIME OF SAMPLING	PROGRESS: FREQUENCY OF SAMPLING	FINAL: LOCATION OR TIME OF SAMPLING	FINAL: FREQUENCY OF SAMPLING	REMARKS
IMPORTED BORROW		Relative Compaction	216			As Required for Control	Immediately after material placed and compacted	Witness by spot check at least once per job			
BASEMENT SOIL		R-Value	301	50#	Excavation-If not previously checked for design purposes	As required to determine adequacy of cover	Grading Plane				
		Relative Compaction	216			As necessary for control	Immediately prior to placement of cover material				
		Grade Tolerance				As necessary for control	Grading Plane				
AGGREGATE SUBBASE		Sieve Analysis	202	50#	Mat'ls Site or Stockpile	One for every 3000 tons or 2000 cu yds. (1)	At point of delivery to grade	Approx 1 in 10 control tests, minimum of three	Completed layer	1 per Lane-Mile	Final samples for informational purposes
		R-Value	301		Mat'ls. Site or Stockpile	One for every 3000 tons or 2000 cu. yds (1)	At point of delivery to grade	Approx. 1 in 10 control tests; minimum of three	Completed layer	1 per Lane-Mile	On Class 1 & 2 only—Final Samples for informational purposes
		Sand Equivalent	217		Mat'ls. Site or Stockpile	One for every 3000 tons or 2000 cu. yds. (1)	At point of delivery to grade	Approx. 1 in 10 control tests, minimum of three	Completed layer	1 per Lane-Mile	On Class 1 & 2 only —Final Samples for informational purposes.
		Relative Compaction	216			As necessary for control	In place after compaction	Witness by spot check at least once per job			
		Grade Tolerance				As necessary for control	Upon completion of layer		Each individual stage as layer is completed and before it is covered up	1 per Lane-Mile	
ROAD - MIXED ASPHALT SURFACING	MINERAL AGGREGATE	Specific Gravity Coarse & Fine Agg.	206 & 208	100# for all tests	Mat'ls, Site or Stockpile						
		Stabilometer	304		Mat'ls. Site or Stockpile						
		C. K. E.	303		Mat'ls. Site or Stockpile	1 per Windrow mile	Windrow				
		Swell	305		Mat'ls. Site or Stockpile						
		Moist. Vap. Suscep	307		Mat'ls. Site or Stockpile	As required for control					
		Sieve Analysis	202		Mat'ls. Site or Stockpile	1 per lane mile	Windrow before mixing	1 for every 10 control minimum of three			
		Sand Equivalent	217		Mat'ls. Site or Stockpile	1 per lane mile	Windrow before mixing	1 for every 10 control minimum of three			
		Moisture	310 or 311		Mat'ls. Site or Stockpile	As required for control	Windrow before mixing				
		Disintegration Test	Std. Spec		Mat'ls. Site or Stockpile						
	COMPLETED MIXTURE	Stabilometer	304	15# Carton		Once Daily	Completed Mix				
		M. V. S.	307			Once Daily	Completed Mix				
		Swell	305			Once Daily	Completed Mix				
		Extraction	310			Once Daily	Completed Mix				
		Sieve Analysis	202			Once Daily	Completed Mix				
		Moisture	310			Once Daily	Completed Mix				
		Thickness				As necessary for control	Completed Layer		Completed Layer	1 per Lane-Mile	
	LIQUID ASPHALT	In Accordance with applicable Section of Std. Specs. and/or Special Provisions		1 Qt.	None with certificate of compliance. If no cert. of comp. then from storage tank or distributor.	Each Shipment	Storage Tank or Distributor				

(1) If material is uniform and well within specification limits the frequency may be decreased to one a day unless source is changed

SIZE, FREQUENCY AND LOCATION OF SAMPLING AND TESTING

MINIMUM NECESSARY

MATERIAL OR PRODUCT	TEST FOR	TEST NO	SIZE OF SAMPLE	INITIAL: LOCATION OR TIME OF SAMPLING	CONTROL / PROGRESS: FREQUENCY OF SAMPLING	CONTROL / PROGRESS: LOCATION OR TIME OF SAMPLING	CONTROL / PROGRESS: FREQUENCY OF SAMPLING	FINAL: LOCATION OR TIME OF SAMPLING	FINAL: FREQUENCY OF SAMPLING	REMARKS
EMBANKMENT	Relative Compaction	216	30#		As required for Control	In place after Compaction	Witness by spot check at least once per job			
PERMEABLE MATERIAL	Sieve Analysis	202	150#	Stockpile	1 daily, or as required for control	In place, at time of placing	1 to every 10 control tests, minimum of three			
	Durability Index	229		Stockpile	If initial source changes or new source developed	Material Site or Stockpile				
	Sand Equivalent	217		Stockpile	1 daily, or as required for control	In place, at time of placing	1 to every 10 control tests, minimum of three			Class 1 & 3 only
STRUCTURE BACKFILL	Sieve Analysis	202	50#	Materials Site	As required for control, minimum of three	At time of use				
	Sand Equivalent	217		Materials Site	As required for control, minimum of three	At time of use				
	Relative Compaction	216			As required for control	In place after compaction	Witness by spot check at least once per job			
SLOPE PROTECTION	SIZE			Quarry	As required for control (SEE REMARKS)	Upon delivery to job site or at time of placing				Adequate size of slope protection documented by measuring or weighing the material
	Apparent Specific Gravity	206		Quarry						
	Absorption	206		Quarry						
	Loss in Soundness	214		Quarry						
	L. A. Rattler	211		Quarry						
TWO COMPONENT POLYSULFIDE POLYMER TYPE JOINT SEALING COMPOUND	Specification Requirements		1 Gallon of each component		1 sample from each component of each batch	From cans at job site				
WATERPROOFING MATERIALS	Specification Requirements	ASTM D173	1 sq. yd. of Asphalt Saturated Cotton Fabric		1 sample from each lot	Manufacturer's stock or contractor's yard				Meshes of Fabric Shall be Substantially open
	Specification Requirements	ASTM D449	5 pounds of Asphalt		1 sample from each lot	Manufacturer's stock or contractor's yard				Contractor's stock must be kept covered
		ASTM D41	1 Quart of Asphalt Primer		1 sample from each lot	Manufacturer's stock or contractor's yard				Contractor's stock must be kept covered

MINIMUM NECESSARY

SIZE, FREQUENCY AND LOCATION OF SAMPLING AND TESTING

PORTLAND CEMENT CONCRETE --PAVEMENT--

MATERIAL OR PRODUCT	TEST FOR	TEST NO	SIZE OF SAMPLE	INITIAL: LOCATION OR TIME OF SAMPLING	CONTROL: FREQUENCY OF SAMPLING	PROGRESS: LOCATION OR TIME OF SAMPLING	PROGRESS: FREQUENCY OF SAMPLING	FINAL: LOCATION OR TIME OF SAMPLING	FINAL: FREQUENCY OF SAMPLING	REMARKS
MINERAL AGGREGATE – COARSE AGGREGATE	LA Rattler (500 rev)	211	See Note (2) for Sample size for all Tests	See Note (1)						
MINERAL AGGREGATE – COARSE AGGREGATE	Cleanness Value	227		See Note (1)	2 times daily	Batch Bin-Just prior to mixing	1 for every 5 days of paving, min. of 3 per job			Coarse aggr only
MINERAL AGGREGATE – FINE AGGREGATE	Colormetric Test	213		See Note (1)	None unless initial test shows critical or contamination suspected.	Batch Bin-Just prior to mixing	Spot check-minimum of once a job			
MINERAL AGGREGATE – FINE AGGREGATE	Mortar Strength	515		See Note (1)						
MINERAL AGGREGATE – FINE AGGREGATE	Sand Equivalent	217		See Note (1)	2 times daily	Batch Bin-Just prior to mixing	1 for every 5 days of paving, minimum of 3 per job			
MINERAL AGGREGATE – COARSE & FINE AGGREGATE	Freeze-Thaw	528		See Note (1)						
MINERAL AGGREGATE – COARSE & FINE AGGREGATE	Soundness	214		See Note (1)						
MINERAL AGGREGATE – COARSE & FINE AGGREGATE	Sieve Analysis	202		See Note (1)	2 times daily	Batch Bin-Just prior to mixing	1 for every 5 days of paving, minimum of 3 per job			
MINERAL AGGREGATE – COARSE & FINE AGGREGATE	Specific Gravity & Absorption	206 & 207		See Note (1)	When aggregate changed	Batch Bin-Just prior to mixing				
MINERAL AGGREGATE – COARSE & FINE AGGREGATE	Moisture	223		None	As required for control min once a day.	Batch Bin-Just prior to mixing				
CEMENT	Compliance with Std Specs and Special Provisions	ASTM C 150	4 lb.	None with certificate of compliance (SEE REMARKS)	One sample for each 500 Barrels delivered or fraction thereof.	From weigh hopper or screw leading to weigh hopper	Progress Sampler to observe method of sampling at least once during project			If no certificate of compliance, sample at least 7 days prior to use for previously tested brands; 28 days for untested brands
WATER	Compliance with Section 90 of Std Specs. and Specl. Prov.	405	1/2 Gallon	At point of use (SEE REMARKS)	As required for control (SEE REMARKS)	At point of use				City water supplies for domestic use usually need not be tested unless suspected of high chloride or sulphate content. On-the-job wells should be tested.
ADMIXTURES – Air entraining Agents	Air entraining Properties Chlorides Identification	415	1 Qt can of liquid 2 lb. powder	Samples must reach testing lab at least one week prior to use	As new supplies arrive on the job or each time brand is changed	Samples must reach testing lab at least one week prior to use				
ADMIXTURES – Water Reducers Set Retarders	Claimed Properties Chlorides Identification	530 or 415	1 Qt. can of liquid 2 lb powder	Samples must reach testing lab at least one week prior to use, untested brands require 5 weeks prior to use for tests	As new supplies arrive on the jobs or each time brand is changed.	Samples must reach testing lab at least one week prior to use; untested brands require 5 weeks prior to use for tests				
CONCRETE	Yield, Cement Factor, & Unit Weight	518	See Test Method		Each 200 cu yds	At point it is deposited on the grade	Witness 1 for every 5 days of paving			
CONCRETE	Slump–Kelly Ball	520			When test specimens fabricated and when consistency questionable	At point it is deposited on the grade	Witness 1 for every 5 days of paving.			
CONCRETE	Modulus of Rupture	523	3 beams 6" x 6" x 34" each		1A, 1B, and 1C for each 750 CY C sample is an extra	At point it is deposited on the grade	Witness 1 for every 5 days of paving			
CONCRETE	Entrained Air	504	Approx 1/2 cu. ft.		Frequent enough to maintain control – Not less than once every 4 hours	At point it is deposited on the grade	Witness 1 for every 5 days of paving			
CONCRETE	Coarse Agg. per C F of Concrete	529			As required to assure uniformity of concrete See Std. Spec. Sec. 90	1st and last 4th of batch.				
CONCRETE	Dimensions				As required for control	Stab Subgrade and finished pavement.		Completed Pavement	Each Lane Mile	5" Core for final sample
Pigmented Curing Seal	Compliance (See Std. Spec.)	AASHO M148	1 Qt. (can)		One sample from each lot	From barrels of stock on the job at least 10 days prior to use.				Sample after thorough agitation

(1) From Material Site or Stockpile: – Sample 2 months prior to use (9 months prior to use if subject to Freezing and Thawing)
(2) 150# of 2½" x 1½" – 100# of 1½" x ¾" – 75# of ¾ x #4 – 75# of 1" x #4 – 75# of pea gravel – 75# of sand. This material for test numbers 211, 213, 214, 217, 202, 227, 515, 206, 207, 528

SIZE, FREQUENCY AND LOCATION OF SAMPLING AND TESTING

MINIMUM NECESSARY

MATERIAL* OR PRODUCT	TEST FOR	TEST NO.	SIZE OF SAMPLE	INITIAL: LOCATION OR TIME OF SAMPLING	CONTROL: FREQUENCY OF SAMPLING	CONTROL: LOCATION OR TIME OF SAMPLING	PROGRESS: FREQUENCY OF SAMPLING	FINAL: LOCATION OR TIME OF SAMPLING	FINAL: FREQUENCY OF SAMPLING	REMARKS
PAINT	In Accordance with Specification Requirements		1 Qt	See Note (1) on Page VIII – 11 Initial Samples and Tests	Each lot	Cans	See Note (2) on Page VIII – 11 Progress Samples and Tests			
ASBESTOS SHEET PACKING	In Accordance with Specification Requirements		12" x 12"		1 Each lot	At Delivery				Sample & Test if Not Previously Released
ASPHALT PLANK	In Accordance with Specification Requirements		Contact H Q Lab for Instructions		Contact H Q. Lab. for Instructions	At Delivery				Sample & Test if Not Previously Released
BARBED WIRE	In Accordance with Specification Requirements		3' Length		Each 50 Rolls or Fraction	At time of Use				Sample & Test if Not Previously Released
BOLTS & HARDWARE	In Accordance with Specification Requirements		2 Samples each Diameter		Each Lot	At time of Use				Sample & Test if Not Previously Released
CHAIN LINK FENCING	In Accordance with Specification Requirements		24" x width		Each 50 Rolls or Fraction	At time of Use				Sample & Test if Not Previously Released
EXPANSION JOINT FILLER	In Accordance with Specification Requirements		6" Long Full Width of Sheet		Each 1000 Sq Ft, Not less than 2 per Shipment	At Time of Use				Sample & Test if Not Previously Released
ELECTRICAL CONDUCTOR	In Accordance with Specification Requirements		2 Each 3' Long Include Markings		Each Type Each Lot	At Time of Use				Sample & Test if Not Previously Released Cert. of compliance required for 5000 Volt. Cable.
GALVANIZED PIPE	In Accordance with Specification Requirements		1' Length from each end of Length tested of each size		Each 500 Lengths or Fraction	At Time of Use				Sample & Test if Not Previously Released
MOPPING ASPHALT	In Accordance with Specification Requirements		1 Qt		Each Lot	At Time of Use				Sample & Test if Not Previously Released.
RAISED BARS (Precast)	In Accordance with Specification Requirements		1 Unit or full size bar		Each Lot	At Time of Use				Sample & Test if Not Previously Released
REINFORCING STEEL	In Accordance with Specification Requirements		2 samples 30" Long		Each Heat or Each 10 Tons or Fraction for Each Size	At Time of Use				Sample & Test if Not Previously Released
RIGID STEEL CONDUIT	In Accordance with Specification Requirements		6" Long From Center of Length		2 Samples Each Size	At Time of Use				Sample & Test if Not Previously Released
RUBBER WATERSTOP	In Accordance with Specification Requirements		6" Long Full Width		Each Lot	At Time of Use				Sample & Test if Not Previously Released
STEEL PRODUCTS	In Accordance with Specification Requirements		Contact H Q. Lab. for Instr.		Contact H Q. Lab for Instr	At Time of Use				Sample & Test if Not Previously Released
STRUCTURAL STEEL & Misc. IRON & STEEL	In Accordance with Specification Requirements		2 Samples 2" x 30" cut parallel to direction of rolling		Each Heat or Melt or 10 Tons or Fraction	At Time of Use				Sample & Test if Not Previously Released
WIRE MESH REINFORCING	In Accordance with Specification Requirements		3' x 3'		Each 10 Tons or Fraction	At Time of Use				Sample & Test if Not Previously Released
WIRE ROPE OR CABLE	In Accordance with Specification Requirements		Per Spec Prov or as Instructed		Per Spec Prov. or as Instructed	At Time of Use				Sample & Test if Not Previously Released
BRICK	In Accordance with Specification Requirements		5 Full Size		Each 50,000 bricks or if lot over 50,000-5 for each 100,000	At Time of Use				Sample & Test if Not Previously Released
CONCRETE AND CLAY PIPE	In Accordance with Specification Requirements		Contact H Q. Lab. for Instr.		Contact H.Q. Lab. for Instr	At Time of Use				Sample & Test if Not Previously Released
PLASTIC CONDUIT	In Accordance with Specification Requirements		2' Long from Center of Length		2 Samples Each Size	At Time of Use				Sample & Test if Not Previously Released

MINIMUM NECESSARY

SIZE, FREQUENCY AND LOCATION OF SAMPLING AND TESTING

MATERIAL OR PRODUCT		TEST FOR	TEST NO	SIZE OF SAMPLE	INITIAL	CONTROL	PROGRESS		FINAL		REMARKS
					LOCATION OR TIME OF SAMPLING	FREQUENCY OF SAMPLING	LOCATION OR TIME OF SAMPLING	FREQUENCY OF SAMPLING	LOCATION OR TIME OF SAMPLING	FREQUENCY OF SAMPLING	
PENETRATION TREATMENT	LIQUID ASPHALT	In accordance with Applicable Section of Std. Specs.		1 Qt.	None with certificate of compliance	Each Shipment	Plant storage tank or Distributor				
	SAND	Sieve Analysis	202			As required for control	As delivered to project				
BITUMINOUS SEALS	PAVING ASPHALT LIQUID ASPHALT ASPHALTIC EMUL.	In accordance with Applicable Section of Std. Specs.		Asphalts 1 Qt. Emulsion ½ Gal	None with certificate of compliance	Each Shipment	Storage Tank or Distributor				
		Binder Distribution	339			As necessary for control	At time of application				
	SCREENINGS	L.A. Rattler	211	50#	Stockpile	As necessary for control	As delivered to spread. equip.				
		% Crushed Particles	205		Stockpile	As necessary for control	As delivered to spread. equip.	Minimum of 3 per job			
		Sieve Analysis	202		Stockpile	Twice Daily	As delivered to spread. equip	Minimum of 3 per job			
		Film Stripping	302		Stockpile	As necessary for control	As delivered to spread equip.				
		Cleanness Value	227		Stockpile	Once daily	As delivered to spread. equip.	Minimum of 3 per job			
	SLURRY SEAL AGGREGATE	Sand Equivalent	217	25#	Stockpile	As necessary for control	Prior to mixing				
		Sieve Analysis	202		Stockpile	As necessary for control	Prior to mixing				
		Film Stripping	302		Stockpile						
Solid or Semi-Solid Air Refined Asphalt		In Accordance with Std. Spec.		3#	Barrels or Sacks	Each 29 Barrels or Sacks	Barrels or Sacks				

MINIMUM NECESSARY

SIZE, FREQUENCY AND LOCATION OF SAMPLING AND TESTING

MATERIAL OR PRODUCT	TEST FOR	TEST NO	SIZE OF SAMPLE	INITIAL	CONTROL	PROGRESS		FINAL		REMARKS
				LOCATION OR TIME OF SAMPLING	FREQUENCY OF SAMPLING	LOCATION OR TIME OF SAMPLING	FREQUENCY OF SAMPLING	LOCATION OR TIME OF SAMPLING	FREQUENCY OF SAMPLING	
AGGREGATE BASE	% Crushed Particles	205	100 lbs	Mat'l. Site or Stockpile (2)	Every 3000 tons or 2000 C.Y. (1)	At the time it is deposited on the roadbed	Approx 1 in 10 control tests; minimum of three	Completed layer	1 per lane mile	Final Sample 40–60# Sack for informational purpose.
	Sieve Analysis	202		Mat'l. Site or Stockpile (2)	Every 3000 tons or 2000 C.Y. (1)	At the time it is deposited on the roadbed				
	Durability Index	229		Mat'l. Site or Stockpile (2)	If initial source changes or new source developed.	Material site or stockpile.				
	R–Value	301		Mat'l. Site or Stockpile (2)	Every 3000 tons or 2000 C Y. (1) (See Std Specs)	At the time it is deposited on the roadbed	Approx. 1 in 10 control tests; minimum of three	Completed layer	1 per lane mile	Final Sample 40–60# Sack for informational purpose
	Sand Equivilant	217		Mat'l Site or Stockpile (2)	Every 3000 tons or 2000 C Y. (1)	At the time it is deposited on the roadbed	Approx 1 in 10 control tests, minimum of three	Completed layer	1 per lane mile	Final Sample 40–60# Sack for informational purpose.
	Moisture	216			2 Times Daily	At time of weighing				
	Relative Compaction	216	30 lbs		As necessary for control	In place after compaction	Witness at least once for each job			
	Grade Tolerance				As necessary for control	Upon completion of layer		As layer is completed and before it is covered up	1 per lane mile	
CEMENT TREATED BASE Road Mix or Plant Mix — MINERAL AGGREGATE	R-Value (with & without cement)	301	100 lbs	Mat'l Site or Stockpile						Class C
	Compressive Strength	312		Mat'l. Site or Stockpile						Class A & B
	Sieve Analysis	202		Mat'l Site or Stockpile	1 sample for each 3000 tons (1)	Prior to mixing				Class A, B, & C
	Lump Disintegration	201		Mat'l Site or Stockpile						Class A, B, & C
	Sand Equivalent	217		Mat'l. Site or Stockpile	1 sample for each 3000 tons (1)	Prior to mixing				Class A & B
CEMENT TREATED BASE — COMPLETED MIX	Compressive Strength	312		Mat'l. Site or Stockpile	1 sample for each 3000 tons (1)	Mixed but uncompacted material	Witness fabrication at least once for each job			Class C
	R-Value	301			1 sample for each 3000 tons (1)	At point of delivery to grade				Class A & B
	Density	312			As necessary for control	In place after compaction	Witness at least once for each job			
	Cement Titration	338			As necessary for control	At point of delivery to grade or after mixing				Class C & D
	Relative Compaction	216			1 sample for each 3000 tons (1)	In place after compaction	Witness at least once for each job			
	Thickness				As necessary for control	In place after compaction		As layer is completed and before it is covered up	1 per lane mile	
CEMENT	Compliance with Section 90 of Std. Specs. and Special Provisions		4 lb	None with certificate of compliance (SEE REMARKS)	Each 400 Bbls. delivered or fraction thereof	Weigh hopper or screw leading to weigh hopper or from distributor if road-mixed				If no certificate of compliance; sample at least 7 days prior to use for previously tested brands; 28 days for untested brands.
WATER	Compliance with Section 90 of Std Specs		1/2 to 1 Gallon	At point of use (SEE REMARKS)	As required for control (SEE REMARKS)	At point of use				No sample necessary if from obviously suitable source, such as municipal water supply. On-the-job wells should be tested.
LIQUID ASPHALT	In accordance with Special Prov. & Std. Specs.		1 Qt	None with Cert. of comp. If no cert. of comp then from storage tank or distributor truck	Each Shipment	Distributor Truck				

(1) If material is uniform and well within specification limits the frequency may be decreased to one a day unless source is changed.
(2) If source is being used on another concurrent project, a copy of the initial qualifying test results used for that project may be used as long as the source or material has not changed.

PORTLAND CEMENT CONCRETE – MISCELLANEOUS CONCRETE

Minor Structures, Curbs, Gutters, Sidewalks; P.C.C. Foundations or Bases
Fence Posts

SIZE FREQUENCY AND LOCATION OF SAMPLING AND TESTING

MINIMUM NECESSARY

MATERIAL OR PRODUCT		TEST FOR	TEST NO.	SIZE OF SAMPLE	INITIAL (1): LOCATION OR TIME OF SAMPLING	CONTROL: FREQUENCY OF SAMPLING	CONTROL: LOCATION OR TIME OF SAMPLING	PROGRESS: FREQUENCY OF SAMPLING	FINAL: LOCATION OR TIME OF SAMPLING	FINAL: FREQUENCY OF SAMPLING	REMARKS
MINERAL AGGREGATE	COARSE AGGREGATE	LA Rattler (500 rev.)	211	See Note (3)	See Note (4)						
		Cleanness Value	227	See Note (3)	See Note (4)	1 for each 100 cu. yds used; Min. of 1 per project (2)	Batch Bin-Just prior to Mixing				
	FINE AGGREGATE	Colorimetric Test	213	See Note (3)	See Note (4)	None unless initial test shows critical or contamination suspected	Batch Bin-Just prior to mixing				
		Mortar Strength	515	See Note (3)	See Note (4)						
		Sand Equivalent	217	See Note (3)	See Note (4)	1 for each 100 cu.yds used; Min. of 1 per project (2)	Batch Bin-Just prior to mixing				
	COARSE & FINE AGGREGATE	Freeze Thaw	528	See Note (3)	See Note (4)						
		Soundness	214	See Note (3)	See Note (4)						
		Sieve Analysis	202	See Note (3)	See Note (4)	1 for each 100 cu. yds used; Min. of 1 per project (2)	Batch Bin-Just prior to mixing				
		Specific Gravity & Absorption	206 & 207	See Note (3)	See Note (4)	When aggregate changed	See Note (4)				
		Moisture	223 or oven dry			As required for control	Batch Bin-Just prior to mixing				
CEMENT		Compliance with Std. Specs. and Special Provisions	ASTM C 150	4 lb	None with certificate of compliance (SEE REMARKS)	Each 140 Bbls delivered or fraction thereof (2) (See Const. Manual Secion 8-02.06a)	Cement weigh hopper or screw leading to weigh hopper or from sacks.				If no certificate of compliance, sample at least 7 days prior to use for previously tested brands, 28 days for untested brands.
WATER		Compliance with Sec. 90 of Std. Specs. & Special Prov.	405	1/2 Gallon	At point of use (SEE REMARKS)	As required for control (SEE REMARKS)	At point of use				City water supplies for domestic use usually need not be tested unless suspected of high chloride or sulphate content On-the-job wells should be tested
ADMIXTURES	Air entraining agent	Air entraining properties-- Chlorides Identification	415	1 Qt can of liquid 2 lb powder	Samples must reach testing lab at least one week prior to use	When new lots are to be used	Samples must reach testing lab at least one week prior to use.				
	Water reducers Set Retarders	Claimed Properties Chlorides Identification	530 or 415	1 Qt can of liquid 2 lb powder	Samples must reach testing lab at least one week prior to use, untested brands require 5 weeks prior to use for tests	When new lots are to be used	Samples must reach testing lab at least one week prior to use; untested brands require 5 weeks prior to use for tests				
COMBINED MIX		Yield, Cement Factor	518	Approx. 1 cu. ft.		1 only for each day when vol. exceeds 25 cu. yds. None if total days run less than 25 cu yds. (2)	At point concrete is deposited in the work				
		Slump-Kelly Ball	520			When test specimens fabricated and when consistency questionable	At point concrete is deposited in the work				
		Compressive Strength	521	3-6" X 12" Test Cylinders		1A, or 1B, & 1C only for each day when volume exceeds 25 c.y.(2) None if total days run less than 25 cu yds	At point concrete is deposited in the work				
		Entrained Air	504	Approx. ½ cu. ft.		As required for control	At point concrete is deposited in the work				

(1) If the material proposed for use on the project in question has recently been tested in connection with another project and is satisfactory, then refer to those recent test results to satisfy the preliminary test result requirement.
(2) Not required if P.C.C. from same source is being used on other works and test is being made there. No need to duplicate the test just for the sake of the record, the actual test results may be used anywhere they are applicable
(3) 150# of 2½" x 1½" – 100# of 1½" x ¾" – 75# of 1" x No. 4 – 75# of ¾" x No. 4 – 75# of pea gravel – 75# of sand. This material for tests 211, 213, 214, 217, 202, 227, 515, 206, 207, 528.
(4) From Material Site or Stockpile: – Sample 2 months prior to use (9 months prior to use if subject to Freezing and Thawing)