PROPOSED FIELD EXPERIMENT FOR APPLICATION OF QUALITY CONTROL TO SAMPLING FOR GRADATION ANALYSIS OF 22A AGGREGATE

MICHIGAN DEPARTMENT OF STATE HIGHWAYS

PROPOSED FIELD EXPERIMENT FOR APPLICATION OF QUALITY CONTROL TO SAMPLING FOR GRADATION ANALYSIS OF 22A AGGREGATE

Proposal No. 2

Michigan Quality Control Program

Highway Planning and Research Investigation
Conducted in Cooperation with the U. S. Department of Transportation
Bureau of Public Roads

Research Laboratory Section
Testing and Research Division
Research Project 63 G-123

State of Michigan
Department of State Highways
Lansing, April 1968

SUMMARY

The project recommended in this proposal is a part of Priority Item number four, Phase II, of the overall Quality Control Program. Item four relates to surfacing aggregates 21A, 22A, 22B, 22C, 22D, 22E, 23A and 24A. This particular proposal recommends a field experiment to determine the comparative effects of current MDSH sampling procedures on 22A aggregate gradation analysis results, and a statistically designed random sampling procedure.

A field study designed on the basis of statistical concepts is proposed to achieve three objectives:

1. To determine the performance of current inspection practices as compared with an inspection procedure based on random sampling.

2. To estimate the variance components introduced into aggregate gradation results by changes in the aggregates themselves and by changes in the sampling and testing procedures.

3. To determine practical and meaningful acceptance limits for gradation analysis of 22A aggregate.

INTRODUCTION

Michigan's quality control study began on July 1, 1963 under the auspices of the Federal Highway Planning and Research Program (HPR). Its purpose is to apply statistical control techniques to both the methods and materials of highway construction. The specific goals of the program are to delineate specific areas in the field of highway materials and construction where quality control methods appear practical and advantageous; to develop suitable quality control programs in these areas; and to modify existing methods and material specifications where appropriate.

Initial work on the project (Phase I) consisted, primarily, of determining the variabilities in current job control testing methods by analyzing past field construction records and conducting field experiments on aggregate gradation. Data compiled during this phase of the project were transmitted to the Bureau of Public Roads on March 23, 1966.

In January 1966, an Advisory Committee consisting of representatives of the Construction Division and the Testing Laboratory, Field Testing and Research Laboratory Sections was formed to review the background of the project and to develop a list of critical areas for quality control (Phase II). Thirteen highway materials were selected by the committee for investigation and a priority was established for them.

The purpose of Phase II of the project is to modify current Michigan Standard Specifications where indicated by determining and adopting tolerances based on statistical concepts, and to develop guidelines to be followed in the development of future specifications.

On May 19, 1967, a meeting was held between the Advisory Committee and representatives of the Bureau of Public Roads to discuss the present status of the project. Among other things, a review draft of an acceptance inspection plan for gradation analysis of 22A aggregate was described in detail. The Bureau expressed considerable interest in the inspection procedure and in random sampling layouts for selecting composite samples of 22A aggregate from flat-layered stockpiles.

Work on Priority Items one and three, Concrete Modulus of Rupture, and Dimensions of Neoprene Seals, is now in progress in the Research Laboratory. As a result of the Bureau's interest in the aggregate sampling procedures, and because of a lack of suitable information in the Department's files relative to concrete air and slump tests, (Priority Item two) this proposal has been prepared to study the 22A aggregate problem, for Priority Item four.

Current 22A Aggregate Inspection Practices

22A aggregate for base course construction may consist of crushed stone, crushed gravel, or blast furnace slag, which conforms to the limits of grading, crushed material content, and abrasion resistance required by MDSH specifications. Specifications require a 25-percent minimum of crushed material for gravel and, based on AASHO T4, 20- and 30-percent maximum wear for crushed and uncrushed gravel, respectively, and 30-percent maximum wear for stone. These limits are specified because of their effects on stability and abrasion resistance of the aggregate. Gradation or particle size distribution of an aggregate is determined by sieve analysis. Standard sieves (with square openings) for 22A aggregate required by current specification limits are as follows:

Sieve Size	Percent Passing
1 inch	100
3/4 inch	90-100
3/8 inch	65-86
No. 8	30-50
No. 200 (loss by washing)	3-7

Grading limits and maximum size are specified because of their effects on size of aggregate voids, degradation and permeability, frost action, segregation, and economy. Gradation specifications for 22A aggregate require that all tests from representative samples fall within the specified limits. A representative sample is one which, in the opinion of the inspector, represents an average condition of the material being sampled.

When acceptance of 22A aggregate is based upon visual and sampling inspection at the site of production or at the project, the trained aggregate inspector--under the supervision of the District Materials Supervisor--insures that the aggregate materials meet specifications and that proper methods of handling and stockpiling are used. He becomes familiar with plant processing and production problems and records the characteristics and location of the materials. If he gets a sample that does not meet specifications, he notifies the producer and tests another sample from the following production. If this sample still does not meet specifications, stockpiled material represented by the two faulty samples is rejected. If the result from either test falls within the specified limits, the material is accepted. MDSH specifications require one complete gradation analysis for each two hours of plant operation. Four or five tests per day will cover the production from an average gravel plant producing about 1500 tons per 8-hr day. The inspector takes a representative sample by gathering material from different areas of the stockpile and combining it into a composite sample of about 60 to 80 lbs. When the producer increases the production rate of 22A aggregate and the field inspector is unable to test the increased number of samples, he reports at once to his supervisor, who decides what action is to be taken.

Each composite or average sample is reduced by a Gilson sample splitter to a size (about 4,000 grams) suitable for testing for loss by washing (or passing No. 200) and sieve analysis.

PROPOSED FIELD STUDY

Based on statistical concepts, a field study of gradation analysis has been designed to achieve the following objectives:

1. To establish the relative performance between the existing inspection practices and the suggested acceptance inspection based on random sampling.

2. To estimate variance components introduced into screening results by changes in aggregate materials, sampling, and testing procedures.

3. To further develop practical and meaningful acceptance limits for sieve analysis of 22A aggregate.

The proposed research project will be divided into three stages. The first stage is to develop a sampling plan to provide data that realistically represent the desired quality of the aggregate submitted for acceptance. This will require proper recording and appraisal of the random data collected. This information, compared with that obtained by regular field inspectors, should disclose the relative difference between the two sampling procedures. The second stage is to evaluate the effects of changes in aggregate materials and in sampling and testing procedures. Well-trained inspectors assigned to this project must faithfully follow the instructions given in the proposed plan. The third stage is to compare the

random sampling results of the first two stages with those obtained by current inspection practices. This should provide a firm ground for designing a practical and economical specification for sieve analysis of 22A aggregate. It should also provide some guidance for specifying gradation tolerances of other surfacing aggregates.

The study is not intended to: (a) estimate process control of gravel plants, nor relative efficiency among gravel producers; (b) evaluate relative performance among aggregate inspectors nor relative effects of different sample size, sampling and testing equipment.

Research Procedure

All routine job control tests will be carried out in the normal manner. Additional tests recommended in this study will be carried out by special personnel without interferring with normal job control. The suggested testing plan includes the following considerations:

A. Size and Location of Experimental Projects

In selecting the test site, it is important to consider different aggregate sources, contractor's procedures--including materials control, handling and stockpiling methods--considered representative of that being practiced throughout the State. In addition, the testing program requires:

1. At least three similar projects with average gravel plants producing about 1500 tons per 8-hr day to establish the desired statistical parameters.

2. At least 100 random duplicated samples per each project to obtain reliable results.

3. Studies on projects or jobs with inexperienced contractors or with unusual materials should be avoided.

B. Controlled Variables

Those factors that must be known and recorded during the experiment include the aggregate source, type of commercial plant, production methods, and control procedures; including type of equipment for handling and stockpiling the finished product.

C. Type of Tests

Random samples from flat-layered stockpiles will be used to determine gradation and crushed material of 22A aggregate. Standard sieves (with square openings) to be used are 1 in., 3/4 in., 3/8 in., No. 8 and No. 200. Gradation tests are to be determined by the current method, AASHO T-27. Loss

by washing is to be determined by AASHO T-11, currently applied to aggregate material finer than the No. 200 sieve. Grading results are to be reported to one decimal place on standard Forms 1900 and 1901. Sieves are to be calibrated before being used by research personnel. Furthermore, the No. 8 and No. 200 sieves are to be periodically calibrated in accordance with E 11. Sieves compared with the Standard sieve, should agree within 5 percent. Sieves with deviations exceeding 10 percent should not be used in this experiment.

Percentage of crushed material is to be determined as specified for surfacing aggregate, Article 7.02.02 of the Michigan 1967 Standard Specifications.

Spot-check tests, including equipment calibration and photographic records, will also be conducted during the experiment.

D. Sampling Procedure

The significance of the proposed experiment depends on how objectively and consistently the random sampling plan is applied during continuous production of 22A aggregate. Sampling and testing are to be conducted by well-trained inspectors under the supervision of the Research Laboratory. Sampling and testing for the study will be in addition to, and not interfere with, job control carried on in the conventional manner by regular aggregate inspectors.

A random sample (or probability sample) is one in which each increment of material from a lot has an equal chance of being included in the sample. A lot is defined as "...a day's production of the same aggregate material from the same source, produced under the same operating conditions and stockpiled according to a specified construction procedure."

Regardless of the sampling procedure being used, the aggregate inspector knows that successive samples taken from the same stockpile are usually different. He also knows that aggregate materials tend to segregate and that, despite sampling variations and segregation, his problem is to make correct inferences about the quality of the aggregate source from which the sample is drawn. Thus, it is extremely important when making up a random sample, that each increment of stockpiled material have an equal likelihood of being included in the composite sample. In this connection, it is difficult to apply the probability concept whenever increments of materials cannot be taken from the interior of the stockpile. However, the probability concept may be approximated by selecting, at random, increments of materials from flat horizontal layers with thickness not exceeding 6 in. Therefore, it is recommended that for this test, aggregate be placed in layers not exceeding 6 in. in depth.

Increments of random sampling locations shall be selected from 100 different sampling layout cards designed by the Research Laboratory. Five typical

layout cards are shown in Figure 1. When a flat-layered stockpile is to be sampled (approximately 150 ft. by 24 ft.), the inspector will draw at random a three-digit number from Table 1. Suppose this number is 081, the last two digits (i.e., 81) correspond to the number of the layout to be used. Layout No. 81 will be used to determine ten locations for sampling. Each inspector will use two bags for gathering duplicate samples. At each location, one scoop (about six lbs) of gravel will be placed into each bag. Thus, each bag will contain about 60 lbs of gravel as a complete sample. Each composite sample will be reduced by a Gilson Sample Splitter to approximately 4000 grams to determine loss by washing (or passing No. 200) and for a sieve analysis (Fig. 2).

Figure 3 shows the sequence of testing operations. A minimum of two duplicate samples (a total of four samples) are taken daily, at random, from 6-in deep flat layers (Fig. 1) being stockpiled from a continuous production of 22A aggregate. Layers to be sampled will be selected at random using Table 1. It is estimated that each layer will weigh about 117 tons. Two samples are sent to the laboratory to be tested. The other two samples are immediately tested in the field, using current equipment and testing procedures (Fig. 2). The random sampling plan is continued until the aggregate production is ended, or until a minimum of 200 gradation tests (representing 100 samples) are run in the field from each aggregate source under study.

Minimum requirements for conducting the investigation are listed below. If all requirements cannot be fulfilled, the investigation will be modified as necessary. Requirements are:

1. At least three different gravel pits producing about 1500 tons per 8-hr day.

2. At least 30 days of aggregate production for each gravel pit.

3. At least three laboratory aides to perform the required field tests.

4. For each project, regular testing equipment as follows:

1 Gilson sample splitter
1 set coarse aggregate sieves
1 set fine aggregate sieves
4 washing pans
5 burners
1 100-lb gas tank/week
1 trowel, counterbrush, scoop, spoon, round file, sample pail, screen brush, slide rule, mechanical analysis book, daily aggregate reports, envelopes, stamps, pencils.
1 balance with pans, set of weights, 1 gram to 1 kilogram, extra kilogram weights
60 sample sacks

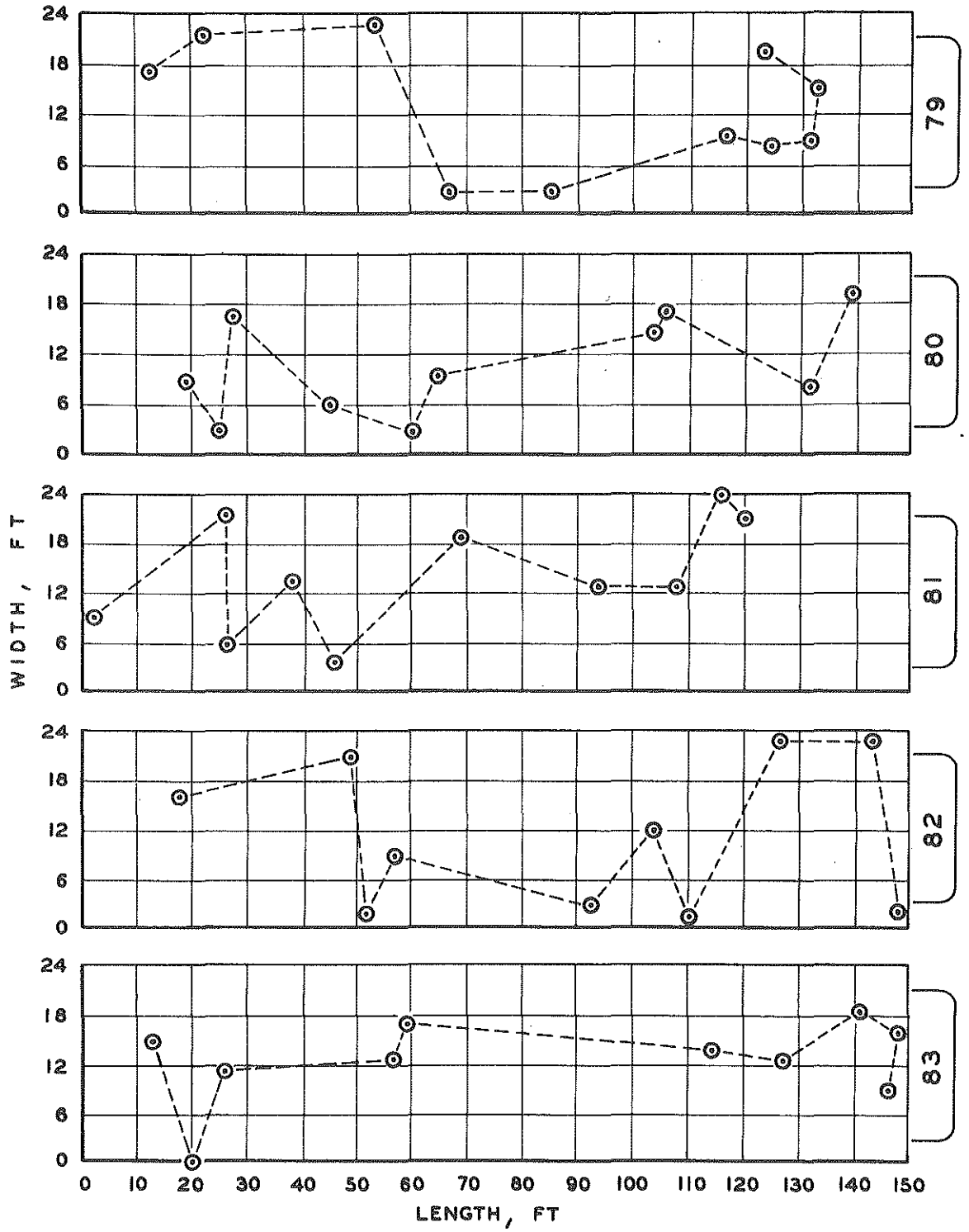

Figure 1. Plan view of random sampling layouts for flat-layered stockpiles (approximately 150 ft by 24 ft) with 10 sampling locations for selecting a composite sample of 22A aggregate.

TABLE 1
RANDOM NUMBERS

.576	.730	.430	.754	.271	.870	.732	.721	.998	.239
.892	.948	.858	.025	.935	.114	.153	.508	.749	.291
.669	.726	.501	.402	.231	.505	.009	.420	.517	.858
.609	.482	.809	.140	.396	.025	.937	.310	.253	.761
.971	.824	.902	.470	.997	.392	.892	.957	.640	.463
.053	.899	.554	.627	.427	.760	.470	.040	.904	.993
.810	.159	.225	.163	.549	.405	.285	.542	.231	.919
.081	.277	.035	.039	.860	.507	.081	.538	.986	.501
.982	.468	.334	.921	.690	.806	.879	.414	.106	.031
.095	.801	.576	.417	.251	.884	.522	.235	.398	.222
.509	.025	.794	.850	.917	.887	.751	.608	.698	.683
.371	.059	.164	.838	.289	.169	.569	.977	.796	.996
.165	.996	.356	.375	.654	.979	.815	.592	.348	.743
.477	.535	.137	.155	.767	.187	.579	.787	.358	.595
.788	.101	.434	.638	.021	.894	.324	.871	.698	.539
.566	.815	.622	.548	.947	.169	.817	.472	.864	.466
.901	.342	.873	.964	.942	.985	.123	.086	.335	.212
.470	.682	.412	.064	.150	.962	.925	.355	.909	.019
.068	.242	.667	.356	.195	.313	.396	.460	.740	.247
.874	.420	.127	.284	.448	.215	.833	.652	.601	.326
.897	.877	.209	.862	.428	.117	.100	.259	.425	.284
.875	.969	.109	.843	.759	.239	.890	.317	.428	.802
.190	.696	.757	.283	.666	.491	.523	.665	.919	.146
.341	.688	.587	.908	.865	.333	.928	.404	.892	.696
.846	.355	.831	.218	.945	.364	.673	.305	.195	.887
.882	.227	.552	.077	.454	.731	.716	.265	.058	.075
.464	.658	.629	.269	.069	.998	.917	.217	.220	.659
.123	.791	.503	.447	.659	.463	.994	.307	.631	.422
.116	.120	.721	.137	.263	.176	.798	.879	.432	.391
.836	.206	.914	.574	.870	.390	.104	.755	.082	.939
.636	.195	.614	.486	.629	.663	.619	.007	.296	.456
.630	.673	.665	.666	.399	.592	.441	.649	.270	.612
.804	.112	.331	.606	.551	.928	.830	.841	.602	.183
.360	.193	.181	.399	.564	.772	.890	.062	.919	.875
.183	.651	.157	.150	.800	.875	.205	.446	.648	.685

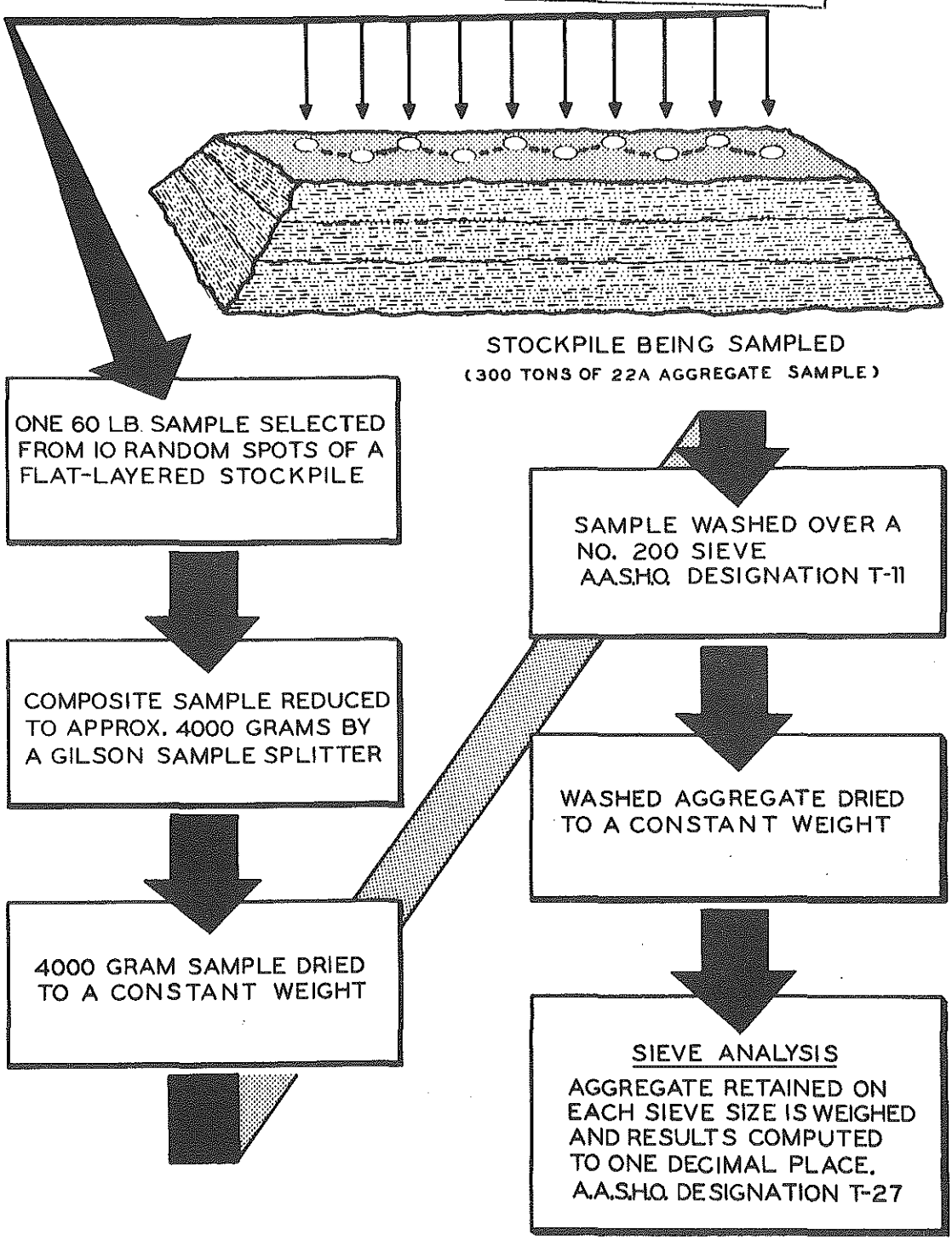

Figure 2. Flow chart for sampling and screening coarse aggregates.

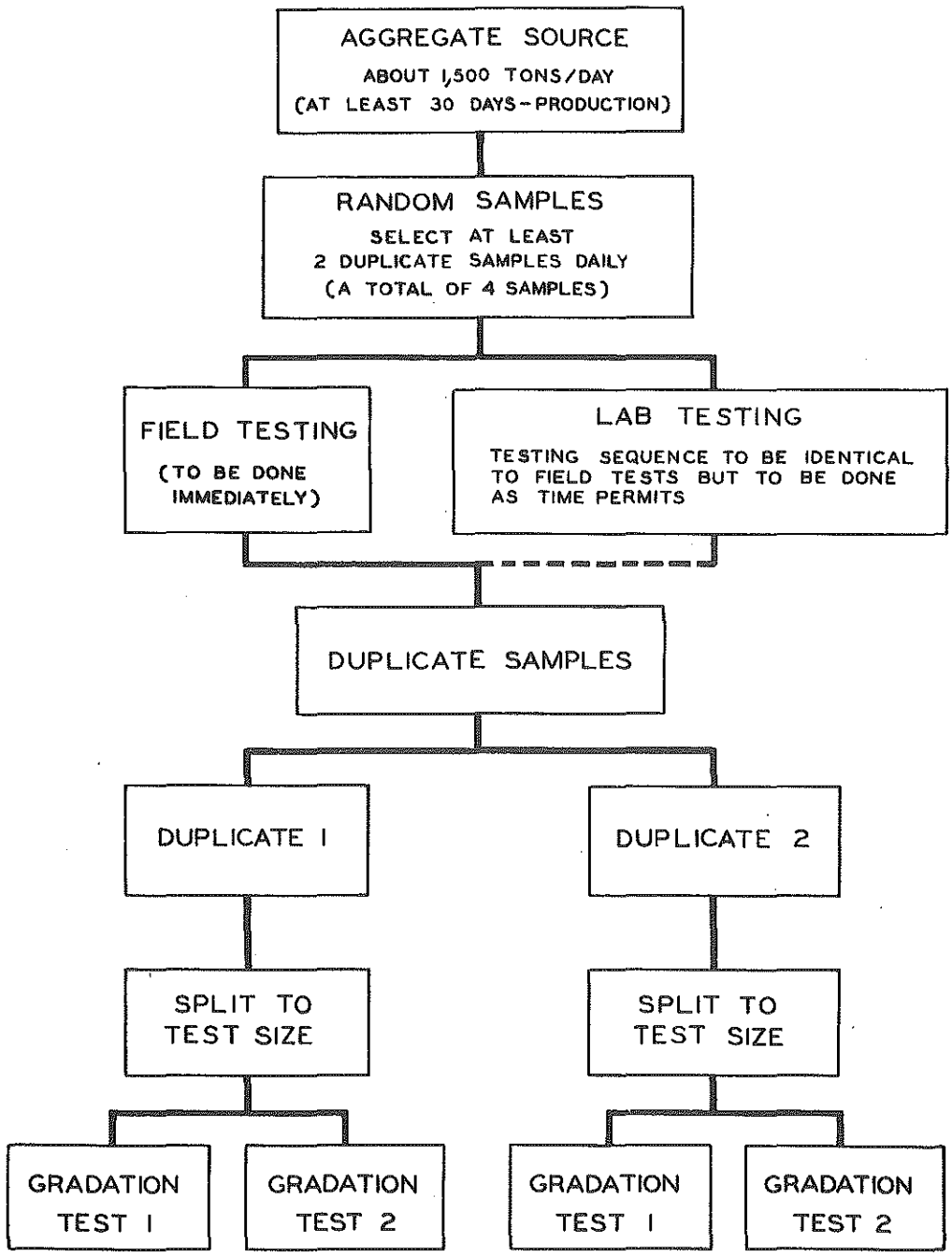

Figure 3. Controlled experiment for gradation analysis of 22A aggregate.

OFFICE MEMORANDUM

MICHIGAN
DEPARTMENT OF STATE HIGHWAYS

April 24, 1968

TO: Advisory Committee - Highway Quality Control Program
E. M. Noble
D. L. Wickham
C. M. Ellis
J. C. Brehler
C. J. Olsen
L. T. Oehler

FROM: R. L. Greenman
Testing and Research Engineer

SUBJECT: Proposed Field Experiment for Application of Quality Control to Sampling for Gradation Analysis of 22A Aggregate
Research Project 63 G-123; Quality Control Program No. 2.

Transmitted, herewith, is a copy of a proposed field experiment for your review and comments.

You will note from the subject that this is proposed as Quality Control Program No. 2, and it has been suggested that this field experiment be carried on as early as possible during the current construction season.

In order to discuss the proposed experiment at an early date, I am, by copy of this letter, requesting Mr. L. T. Oehler to schedule a meeting of this committee during the week of May 13, 1968.

TESTING AND RESEARCH DIVISION

R. L. Greenman

R. L. Greenman
Testing and Research Engineer

RLG:BI