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# The Sand Equivalent as an Acceptance and Control Test for Asphaltic Concrete in New Mexico

Delmar E. Calhoun

THE SAND EQUIVALENT AS A TEST FOR ASPHALTIC CONCRETE - CALHOUN

| NAME AND ADDRESS | DATE |
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| Jim Laporte | 10/22 - 10/30/74 |

# THE SAND EQUIVALENT AS AN ACCEPTANCE AND CONTROL TEST FOR ASPHALTIC CONCRETE IN NEW MEXICO

By

Delmar E. Calhoun

A Thesis

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MASTER OF SCIENCE

Stuart A. Northrop
Dean

June 1, 1962
Date

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Thesis committee

J. E. Martinez
Chairman

W. C. Wagner

A. H. Clough

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# CHAPTER I

# INTRODUCTION

The most abundant building material that man has at his disposal is the earth itself. Numerous engineering feats of history as well as the massive projects of today attest to the versatility and adaptability of soil as a building and foundation material. It is small wonder in this day of rising costs of construction that soil aggregate combinations are one of the chief constituents in many engineering projects, and that new and better methods for their employment are much sought after.

In the field of highway design ways and means of improving the performance of flexible soil aggregate combinations are important not only from the standpoint of economics, but also due to the increased demands which are made upon them in the way of larger wheel loads, greater traffic densities and higher speeds.

The performance of any flexible soil aggregate combination used in highway construction is primarily measured by its resistance to displacement under load, or the stability, and the ability to withstand wear imposed by traffic and climatic conditions, called the durability.

# CHAPTER I

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These factors of stability and durability are in large part controlled by the judicious selection of aggregates. As design criteria become more demanding, methods of aggregate selection must become more rigid in order to exclude those aggregates which for a number of reasons may be unsuited for a particular job.

The sand equivalent test, proposed by Mr. F. N. Hveem of the California Division of Highways,[1] was advanced in 1953 as a means of detecting and obtaining a relative measure of the presence of detrimental clay-like materials in the very fine soil fraction of aggregates used for concrete and bituminous paving.

## The Areas of Investigation

The research reported in this thesis was sponsored by the New Mexico State Highway Department and was directed at evaluating the efficacy of the sand equivalent test when used on New Mexico aggregates used for asphaltic concrete pavements.

Actually, the purpose of the project was twofold. The first phase was to evaluate the sand equivalent test itself in an effort to determine, if possible, exactly what the test measures and what factors influence the results insofar as field conditions are concerned. It was also hoped that some method of asphalt extraction could be devised which would permit duplication, or at least correlation, of sand equivalent values before and after the

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addition and extraction of bituminous material. This would permit a more realistic evaluation of the test with respect to actual pavement performance on existing highways. No attempt was made to investigate the effect of chemicals present in the soil, nor the effect of soil alkalinity or acidity on the test.

The second phase was to correlate the performance qualities of stability and durability with the sand equivalent test results. It was recognized that both of these properties are functions of many factors other than simply the quality of the mineral filler; however, it was hoped that at least some qualitative, if not quantitative evidence would exist to indicate whether or not the test would be of any value in aggregate selection and control for asphaltic concrete pavements.

# CHAPTER II

# THE SAND EQUIVALENT TEST

## Background and Development

Any soil-aggregate combination is composed of gravel, sand and mineral filler. The mineral filler should be a relatively inert material, the greatest percentage of which passes the number 200 sieve. Its purpose is primarily one of providing a more dense mass by filling the voids between the larger particles.

It has long been recognized that both the durability and the stability of soil aggregates are adversely affected by the presence of excessive amounts of clay-like material in the mineral filler. Upon exposure to water these clayey materials both expand and act as a lubricant. The detrimental effect which these materials exhibit when incorporated into an asphaltic mix is primarily a function of their volume and activity rather than their percentage by weight. Mr. Hveem made comparisons of various filler material and found, for example, that it was necessary to use 21 percent by weight of kaolinite as opposed to only 5 percent bentonite to reduce the stabilometer R value by the same amount for a mixture of sand and filler. It should also be noted that due to a relatively large range in specific gravities of mineral

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fillers, equal weights of material may differ greatly in volume.

Various methods have been used to control the amount of clay in base materials and asphaltic concrete aggregates. The most widely used is limiting the percent passing the number 200 sieve. This method is not altogether satisfactory since it is based on weight relationships, and as previously mentioned, weight proportioning methods give no indication of the volume or activity of the colloidal fraction.

Another widely used method of controlling the amount of lubricating mineral filler is the plasticity index, as determined by the Atterberg limits. The primary objection to this test is the length of time necessary for its performance, and the difficulty in getting consistent results.

It is highly probable that both the percent passing the number 200 sieve and the plasticity index will continue to play a major role in the selection and rejection of bituminous paving aggregates. The procedures are understood by practicing engineers and their usefulness is indicated by years of reasonably successful design in the field. It is recognized, however, that these tests do have their limitations and disadvantages; also that there is a definite need for a test which will more accurately predict the detrimental qualities which the mineral filler may exhibit when used in an asphaltic concrete mix, and which overcomes the objections previously mentioned.

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Various methods have been used to control the amount of clay in base materials and asphaltic concrete paving mixtures. The most widely used is limiting the percent passing the number 200 sieve. This method is not satisfactory in all cases since it is based on weight relationships, and as previously mentioned, weight proportioning methods give no indication of the volume or activity of the material in question.

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It is highly probable that both the percent passing the number 200 sieve and the plasticity index will continue to play a major role in the selection and evaluation of bituminous paving aggregates. The procedures are understood by practicing engineers and their use is based on many years of reasonably successful design in the field. It is recognized, however, that these tests do have their limitations and disadvantages also, and there is a definite need for a test which will more accurately predict the detrimental qualities which the mineral filler may add to an aggregate in an asphaltic concrete mix, and which does away with the problems previously mentioned.

The Test Procedure

In an effort to devise a means of detecting the presence of an excessive amount of expansive clay in a mineral aggregate, Mr. Hveem advanced the sand equivalent test. This test essentially compares the volume of a partially sedimented mineral filler floc to the volume of sand in a given sample of minus number 4 material. The detailed test procedure is presented in Appendix A as California Division of Highways Test Procedure 217-C.

Briefly, the test consists of dispersing a small amount of the minus number 4 material in a graduated lucite tube, using a dilute solution of calcium chloride. The mixture is allowed to flocculate under the action of the calcium chloride solution for twenty minutes, after which the height of the clay floc is recorded in inches. A weighted foot is inserted which bears on the sand that has settled out. (See Figures 1 and 2). The height of the sand is then also recorded in inches. The sand equivalent number is computed by the equation:

$$S.E. = \frac{\text{Height of Sand}}{\text{Height of Clay}} (100)$$

This is then reported to the nearest whole number.

It is apparent that a clayey material would have a low sand equivalent, while a relatively clean material would have a high sand equivalent. By way of comparison, a

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Figure 1
Preparing the Sample.

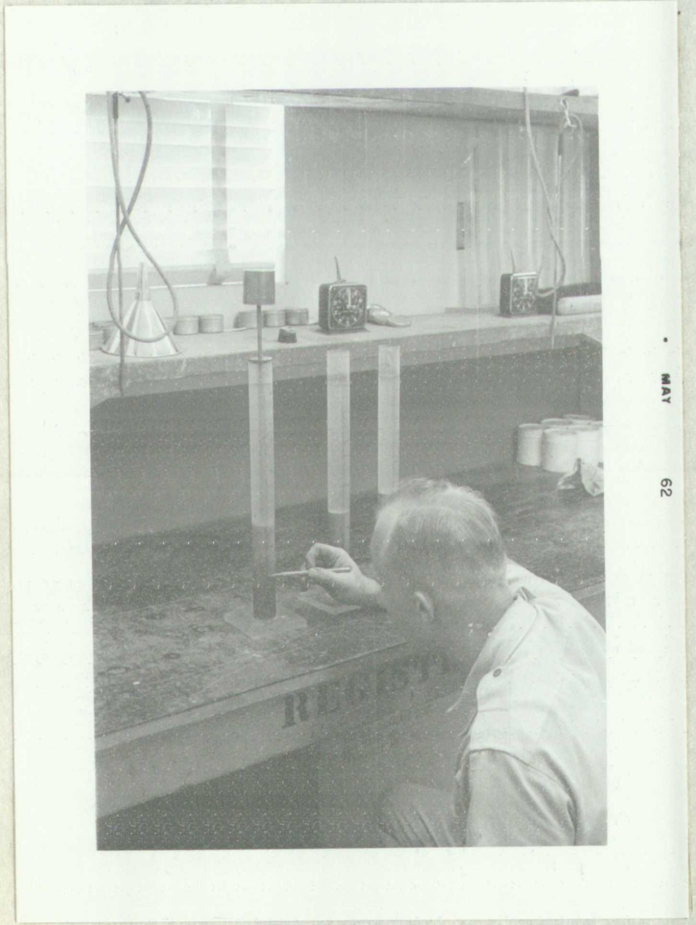
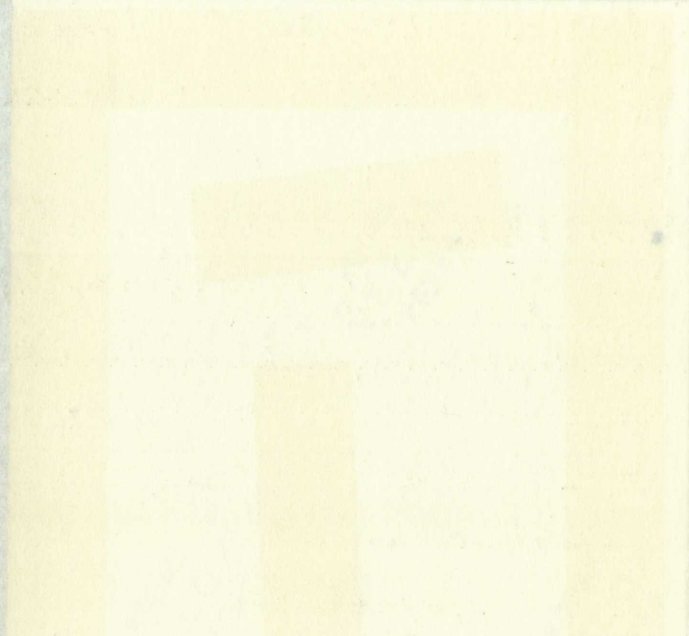



Figure 2
Sand Equivalent Test



sample of minus number 4 material, containing 7.5 percent bentonite, had a sand equivalent of 22, while a relatively clean concrete sand gave a sand equivalent value of 92.

The sand equivalent test has the inherent advantages of rather rapid performance in the field with very little equipment and by operators with a minimum of training. The very fact that the test can be performed at the pit and the results obtained in slightly over half an hour makes the test highly desirable if the results are significant and reliable. The possibility always exists, that due to the length of time necessary to perform a mechanical analysis or an Atterberg limit test, a large quantity of aggregate not meeting specifications may be processed and placed. This occurrence could be minimized by the use of a rapid, reliable field test.

Recommended Limits

In the initial presentation of his paper before the Highway Research Board in 1953,[1] Mr. Hveem gave the following recommended limits for the sand equivalent numbers of aggregates to be incorporated into various phases of highway construction.

| Aggregate Use | Minimum Sand Equivalent |
|---|---|
| Crusher run or gravel base materials...... | 30 |
| Aggregates and selected materials for road mix bituminous treatment........... | 35 |
| Aggregates for plant mix bituminous sfc... | 45 |
| Aggregates for asphaltic concrete or Class "A" plant mix..................... | 55 |
| Concrete sand............. ............. | 80 |

sample of mixes further [illegible] 2.5 [illegible]
bentonite [illegible]
clean concrete [illegible] equivalent [illegible]

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| Aggregate Use | Minimum Sand Equivalent |
|---|---|
| Crusher run or crushed base materials | [illegible] |
| Aggregates and selected materials for road mix (bituminous treated) | [illegible] |
| Aggregate for plant mix bituminous surfaces | [illegible] |
| Aggregates for portland cement concrete | [illegible] |
| Plaster sand mixes | [illegible] |
| Concrete sand | [illegible] |

Mr. W. G. O'Harra of the Arizona State Highway Department evaluated the test based on the test methods and specifications currently in use in Arizona. In 1955 he presented a paper before the Highway Research Board[2] comparing the sand equivalent number with the plasticity index and percentage passing the number 200 sieve, in minus number 4 material, based on over 2000 aggregate samples from Arizona. Mr. O'Harra concluded that although the test could not be expected to determine all of the properties which could affect the quality of aggregates, it was useful in detecting the presence of excessive amounts of clay and minus number 200 material. He proposed the following limits in predicting pavement performance from the sand equivalent number:

| Sand Equivalent Number | Quality of Materials |
|---|---|
| 0-14 | Unsatisfactory |
| 15-24 | Doubtful but usually unsatisfactory |
| 25-34 | Doubtful but usually satisfactory |
| 35-54 | Almost always satisfactory |
| 55-99 | Satisfactory |

## What the Test Measures

As previously mentioned, a large portion of the research with which this thesis was associated was devoted to the sand equivalent test itself in an effort to determine if possible, exactly what the test measures and what factors influence the results. The complete findings are beyond the scope of this paper and have been reported elsewhere by Mr. John P. Boyd.[3]

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| Sand Equivalent Number | [illegible] |
|---|---|
| 0-14 | Unsatisfactory |
| 15-24 | Doubtful, may be [illegible] satisfactory |
| 25-34 | Questionable, usually satisfactory |
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As previously mentioned, a large portion of the research with which this thesis will deal was devoted to the sand equivalent test itself in an effort to determine, if possible, exactly what the test measures and what factors influence the results. The [illegible] findings are beyond the scope of this paper and have been adequately discussed by Mr. John P. Boyd.[3]

Briefly, Mr. Boyd's investigation indicated that the sand equivalent test is extremely sensitive to small quantities of expansive clay, and that the reduction in the percentage of fines by mechanical means such as sieving or "blowing" at the hot mix plant does not appreciably improve the sand equivalent number. Thus it would seem that the expansive portion of the filler is extremely finely divided and very tightly bonded to, or held by, the larger particles. The effects that such factors as type of clay, chemicals present, and alkalinity of the soil have on the chemistry of the sand equivalent are not known and were not evaluated during the course of this project.

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# CHAPTER III

## OUTLINE OF INVESTIGATION

This thesis is specifically concerned with the second phase of the research, namely that of determining whether or not the sand equivalent test is suitable as either an acceptance or control test on New Mexico aggregates for asphaltic concrete. The test results will be examined and an attempt made to explain the pattern which they form, if any. These same trends, if they exist, will then be used to indicate what the sand equivalent number reflects and how reliably its results can be used either in design criteria or in field quality control.

In order to compare the sand equivalent number of an aggregate with the performance characteristics of the resulting asphaltic concrete, a program was established and tests chosen which would provide a means of correlating as many variables as possible with the sand equivalent number.

### The Tests Used

The immersion-compression test was chosen as the means of evaluating the stability of the asphaltic mixtures used. The procedure was a modification of ASTM method D-1075, using the Marshall Method of compacting the specimens

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The immersion-compression test was chosen as the means of evaluating the durability of the asphaltic mixtures used. The procedure was a modification of [illegible] using the Marshall [illegible]

rather than the double plunger static method. This particular test was selected because it provided a measure of both the stability and resistance to the detrimental action of water. The immersion-compression test has been used with success in the design and evaluation of paving mixtures by the Bureau of Public Roads.[4] The test has also been compared with circular track tests of paving mixtures by Mr. A. T. Goldbeck[5] of the National Crushed Stone Association.

A cold-water abrasion test was selected for an accelerated durability comparison. The test procedure used was a modification of a technique presented by Messrs. John H. Swanberg and W. L. Hinderman[6] of the Minnesota State Highway Department. This test combined the deteriorating action of water while the specimens were subjected to abrasion on a Deval abrasion machine.

To further investigate the effect of water on the aggregates in asphaltic concrete, a stripping test and a swell test were run. The stripping test was a modification of a procedure used by the Corps of Engineers, which will be described later, and the swell test was in accordance with AASHO designation T101-42, Method A.[7]

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To further investigate the effect of water on the aggregates in asphaltic concretes, a stripping test and a swell test were run. The stripping test was a modification of a procedure used by the Corps of Engineers, which will be described later, and the swell test was run in accordance with AASHO designation [illegible].

# CHAPTER IV

# THE SAMPLES

The aggregate samples used for this investigation represented three different sources. The samples numbered 1-A through 19-A were obtained from projects underway at the time of this research project. Samples 21-A through 29-A were obtained from old stockpiles and pits on projects completed by the New Mexico Highway Department. The source of these aggregates together with their respective sand equivalent numbers can be seen in Appendix B. Samples 1-B through 12-B were manufactured from one washed and sized aggregate using a constant gradation with different mineral fillers.

## Current Projects Samples

Samples of material from the coldfeed, hot bins and pugmill were obtained from projects under construction at the time of this research. The sand equivalent values referred to for these samples were obtained from the hot bin material just prior to the addition of bituminous cement. The briquettes for the immersion-compression and cold-water abrasion phases were made from the pugmill material. All computations involving the percentage of

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asphalt were based on the value obtained from a rotarex benzol extraction of the pugmill material. The gradation band into which all of these aggregates fell can also be seen in Appendix B.

Old Stockpiles

The samples taken from the old stockpiles were obtained with the intention of correlating the pavement performance with the sand equivalent number of the material. This was abandoned, however, due to the questionable location and condition of some of the old stockpiles, and also since the only old stockpiles available were from pavement sections which were apparently still in good condition.

The samples obtained from these sources were taken quite some time after the completion of the project, consequently the gradation had been affected by the leaching action of water and the infiltration of blow sand. In order to compare these aggregates with the new project and manufactured samples, the gradations were adjusted to conform, within reason, to the original specifications of the project. The gradation of these aggregates can also be seen in Appendix B. The sand equivalent numbers referred to are based on the values obtained after adjusting the gradation.

Manufactured Aggregates

Aggregates 1-B through 12-B were built up from a local Albuquerque asphaltic concrete aggregate by washing

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Manufactured Aggregates

Aggregates 1-B through 12-B were built by five local Albuquerque asphaltic concrete [illegible]

and sizing, then recombining the sized aggregate with various types and percentages of filler material to control the sand equivalent number. The gradation followed was a dense graded, flexible airfield pavement specification used by the Corps of Engineers. This grading is shown in Appendix B. The percent and type of filler used for each sample, together with the resulting sand equivalent number is also seen in Appendix B.

It should be noted at this point that all percentages are by weight unless otherwise indicated, and that all asphalt contents are expressed as a percentage of the total mixture.

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# CHAPTER V

# SAMPLE PREPARATION AND TESTING

## Immersion-Compression Specimens

Hot mix samples from the contractor's pugmill were supplied by the New Mexico State Highway Department on all of the samples 1-A through 19-A. This material was heated, weighed into 1200 gram batches and placed in pans in an electric oven where the temperature was raised to 275°F prior to molding. A standard four inch diameter Marshall mold was used, compacting the specimens with fifty blows per side using an automatic Marshall compaction hammer. The briquettes were allowed to air cure for twenty-four hours prior to being weighed in air and in water. Three of the samples were then tested according to the Marshall procedure, three placed in a water bath at room temperature, (approximately 75°F), for fourteen days, and three placed in a constant 120°F water bath for four days. At the end of the four and fourteen day immersion periods, the specimens were again weighed in air and water to determine absorption and volume change. A standard Marshall stability and flow determination was then made at 140°F.

Aggregates 21-A through 29-A from old stockpiles were proportioned into 1200 gram batches, heated to approximately 300°F and mixed with the percentage of asphalt shown in Appendix B. As previously indicated, the gradations of these samples were adjusted to generally conform to the original design specifications. These data were obtained from New Mexico State Highway Department records. These samples were thoroughly mixed with an electric mixer and placed back in an oven where the temperature was maintained at 275°F prior to molding. The same stability and flow determinations previously described were then made.

Aggregates 1-B through 12-B were proportioned into 1200 gram batches from the washed and sized aggregate. The grading specification referred to in Chapter IV was followed. The mineral filler was added and the entire sample puddled and thoroughly mixed to insure complete aggregate coverage with the filler. The wet mixing procedure was followed since it is the opinion of several investigators[8] that clay as a coating is more detrimental in an asphaltic concrete than clay as simply a filler material.

The samples were then dried, re-mixed and any lumps broken up. They were heated to 275°F, mixed with 6 percent bituminous cement, molded and tested in a manner identical to aggregates 1-A through 29-A.

Aggregates 21-A through [illegible] were proportioned into 1200 gram batches, heated to approximately 300°F and mixed with the [illegible] shown in Appendix B. [illegible] of these samples were adjusted to [illegible] the original design specifications. [illegible] from New Mexico State Highway Department [illegible]. These samples were thoroughly mixed [illegible] placed back in an oven where the [illegible] at 275°F prior to molding. [illegible] determinations previously described [illegible].

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The samples were then [illegible] broken up. They were heated to 275°F, mixed with [illegible] bituminous cement, [illegible] to aggregates 1-A through 20-A.

To compare the results of the immersion-compression test on different aggregates, it must be recognized that the stability of an asphaltic concrete is a function of the following factors:[9]

1. Percentage of bituminous cement to aggregate
2. Characteristics of the bituminous binder
3. Gradation of the aggregate
4. Maximum size of the aggregate
5. Surface texture and shape of the particles
6. The amount and type of compaction
7. Thickness of the surface
8. Influence of site, age and climate

Other factors which might be included are: hardness of the aggregate; traffic conditions; subgrade, subbase and base; and aggregate chemistry.

These factors were essentially the same only in the "B" series aggregates where the quality and quantity of filler materials were the only variables. It was felt that comparisons could be made between different "A" series aggregates if the factors compared were stated as percentages of their original values. This procedure seems justified due to the uniform specimen molding and testing techniques employed and the fact that all of the mixes had been designed by the highway department employing the same set of general specifications regarding grading,* plasticity index, grade of asphalt, etc. Comparisons between "A" and "B" series aggregates are possible for basically the same reasons, although it must be pointed out that the grading for the "B" series was somewhat more dense than for the "A" series and this single difference manifests itself in several apparent ways.

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*Except aggregate 4-A which was a base course

To compare the [illegible] test on different aggregates, it must be recognized that the stability of an asphaltic concrete is a function of the following factors:*

1. Percentage of bitumen [illegible] aggregate
2. Characteristics of the bituminous binder
3. Gradation of the aggregate
4. Maximum size of the aggregate
5. Surface texture and shape of the particles
6. The amount and type of compaction
7. Temperature of the mixture
8. Influence of [illegible], sun and [illegible]

Other factors which might be included are: [illegible] of the aggregate; traffic conditions; subgrade, mixing and laying; and aggregate chemistry.

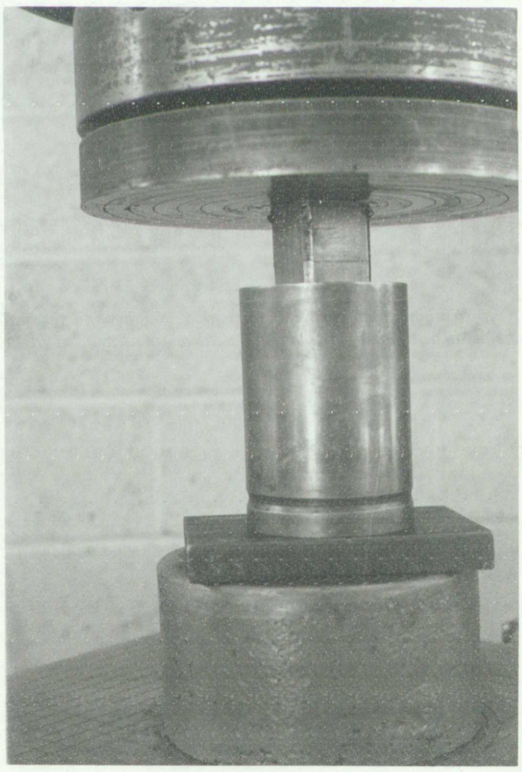
These factors were essentially the same in the "B" series aggregates where the quality and quantity of filler materials were the only variables. It was felt that comparisons could be made between different aggregates if the factors compared were stated as percentages of their original values. This procedure seems justified due to the uniform specimen molding and testing techniques employed and the fact that all of the mixes had been designed by the highway department using the same set of Texas specifications regarding grading,* plasticity index, type of asphalt, etc. Comparisons between "B" and "A" series aggregates are possible for basically the same reasons, although it must be pointed out that the grading for the "A" series was somewhat more dense than for the "B" series and this single difference manifests itself in several ways.

*Except aggregate [illegible] which was [illegible] course.

Cold-Water Abrasion

The cold-water abrasion specimens were formed from the pugmill material for samples 1-A through 19-A, and were made from material prepared as previously explained for aggregates 21-A through 29-A, and 1-B through 12-B.

The specimens were formed in a two inch diameter Hubbard-Field mold. A pre-determined quantity of material was used in order to yield a specimen two inches in height with the same density as the corresponding immersion-compression specimens. A static method of compaction was employed, with a single acting plunger. The load was applied at a constant rate to a pre-determined mark on the plunger, held for one minute and released. (See Figure 3.)



• MAY • 62

Figure 3

Cold-Water Abrasion

The cold-water abrasion specimens were prepared from the pugmill material for samples 1-A through 12-A, and were made from material prepared as previously explained for aggregates 21-A through 29-A, and 1-B through 12-B.

The specimens were formed in a four inch diameter Hubbard-Field mold. A pre-determined quantity of material was used in order to yield a specimen two inches in height with the same density as the corresponding immersion-compression specimens. A static method of compaction was employed, with a single acting plunger. The load was applied at a constant rate to a pre-determined value on the plunger, held for one minute and released. (See Figure 2.)

The specimen was then extruded, allowed to air cure for twenty-four hours, then weighed in air. Eight specimens of each mix were made and immersed in a 120°F water bath for four days, again weighed in air, then placed in a 35°F water bath prior to testing.

The cold-water abrasion test was accomplished in a Deval abrasion machine by placing eight specimens of each mix in a cylinder, filling with water at 35°F, and rotating at 33 1/3 RPM for a period of thirty minutes. Figure 4 shows the two cylinders in position on the Deval abrasion machine.

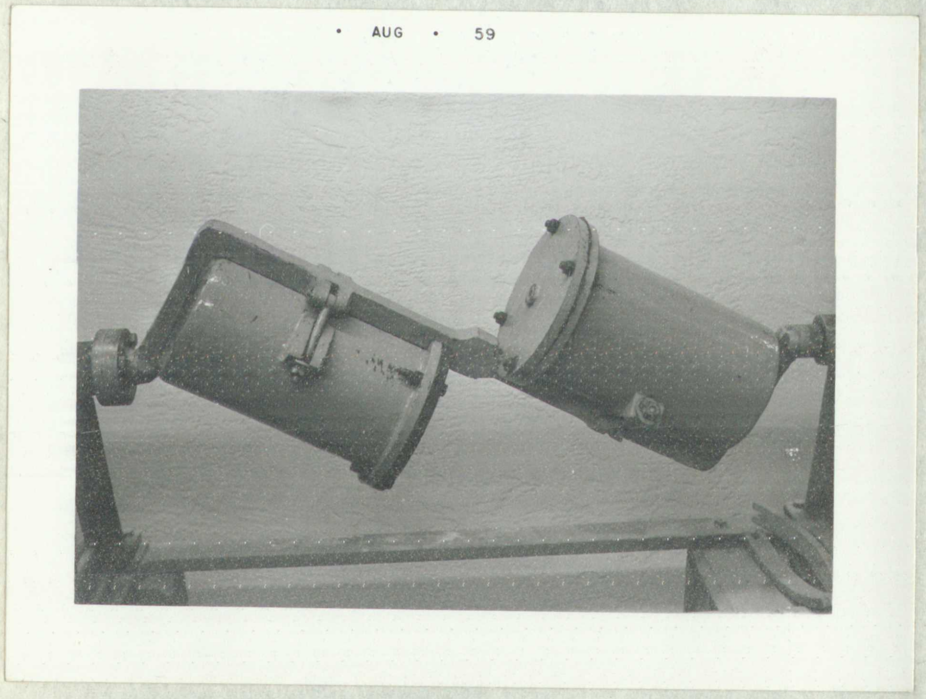



Figure 4

The contents were then emptied and the abraded briquettes weighed together in a saturated, surface dry condition. This weight was then compared with the weight prior to abrasion and the percent loss in weight computed. Figure 5 shows three sets of briquettes. The uppermost set was typical of the specimens prior to abrasion. The other two sets are from aggregates 1-A, (sand equivalent of 32) and 19-A, (sand equivalent of 56). For these tests, sample 1-A lost 23.02 percent and 19-A lost 6.55 percent of their original saturated surface dry weight.

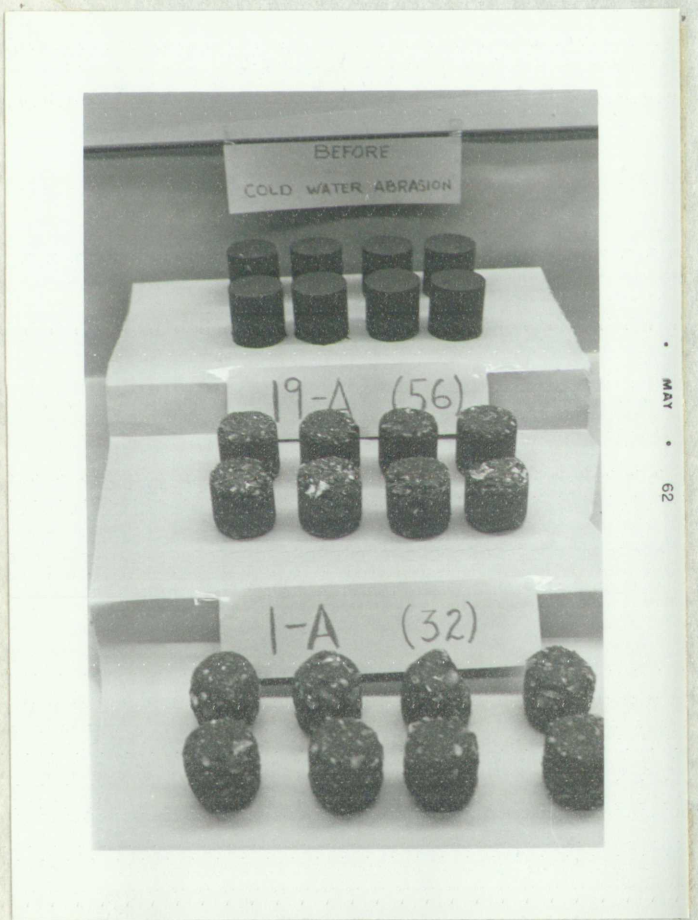



Figure 5

The condition [illegible] upon [illegible] was the [illegible] briquettes weighed [illegible] condition. This weight [illegible] prior to abrasion and the [illegible] weight [illegible]. Figure 5 shows three sets of [illegible]. The [illegible] set was typical of the specimens prior to abrasion. The other two sets are from [illegible] (of 32) and 15-4, ([illegible] of 50). [illegible] tests, sample 1-[illegible] lost 27.02 percent [illegible] percent of their original [illegible] weight.



Figure 5

Table III of Appendix C summarizes the results of the cold-water abrasion tests.

AASHO Swell Test

The specimens used in the swell test were compacted using material prepared in the same manner as for the immersion-compression and cold-water abrasion tests. The actual procedure followed in making and testing the specimens was as presented by AASHO test procedure T 101-42, Method A, "Standard Method of Determining Swell Characteristics of Aggregates Mixed with Bituminous Materials".

The results of the swell tests are presented in Table IV of Appendix C.

Stripping Test

The stripping test was a modification of a procedure used by the Corps of Engineers. It consisted of mixing the material in the same manner as for the other specimens and then spreading in a thin layer to air cure for twenty-four hours. Approximately 1000 grams of the material were then placed in a one gallon jar, just covered with water and allowed to soak at room temperature for twenty-four hours. The jar and contents were than manually shaken for a period of fifteen minutes, the water poured off and the material placed in a pan to dry. The aggregate was then inspected and the stripping action described qualitatively.

No extensive tabulation of the results of the stripping test was attempted due to the extremely crude way in which the results were measured. A general discussion of the results is included in Chapter VI, and the stripping results for aggregates 1-A through 19-A may be seen in Table V of Appendix C.

No extensive tabulation [illegible]

test was attempted [illegible] are extremely [illegible]

the results were [illegible]. A general [illegible] of the

results is included in Tables VI, and the [illegible]

for aggregates I-A through [illegible] are [illegible] in the

Appendix C.

# CHAPTER VI

## PRESENTATION AND ANALYSIS OF RESULTS

The data obtained from the various tests are presented in Tables II through V and summarized in Table I of Appendix C. The density and void ratio computations for the immersion-compression specimens are summarized in Appendix D. These computations were made and are presented primarily in the interest of quality control. Where the size and density of specimen varied appreciably within the same mix, the specimens used for immediate testing, four day and fourteen day immersion were selected so as to have a representative set of samples in each group. A check of the various samples shows a reasonably good degree of uniformity of sample preparation and molding.

Immersion-Compression

Figures 6 and 7 show the results of the 120°F water bath on specimens 1-B (red brick clay as a filler), and 2-B (bentonite as a filler). These specimens began to show signs of distress very soon after immersion, and by the end of the four day immersion period they were in such a condition that no stability determination could be made.

## CHAPTER V

## PRESENTATION AND ANALYSIS OF DATA

The data obtained from the various tests are presented in Tables II through V and summarized in Table I of Appendix [illegible]. The density and moisture [illegible] computations for the immersion-compression specimens are summarized in Appendix [illegible]. These computations were made and are presented primarily for the purpose of quality control. Where the size and density [illegible] did not vary appreciably within the same mix, the specimens used for immediate testing, four day and fourteen day immersion were selected so as to have a nearly identical [illegible] of [illegible] in each group. A check of the results in table shows a reasonably good degree of uniformity in sample preparation and molding.

<u>Immersion-Compression</u>

Figures 6 and 7 show the results of the [illegible] water bath on specimens 1-B (two and one half [illegible]) and 2-B (bentonite as a filler). All of the specimens began to show signs of distress very soon after immersion, and by the end of the fourteen day immersion, the specimens were in such a condition that no stability [illegible] would [illegible].


Figure 6

Filler is red brick clay, 6.8 percent of total mix.
Sand equivalent number of aggregate was 25.


Figure 7

Filler is bentonite, 5.1 percent of total mix.
Sand equivalent number was 23.

These specimens dramatize the extremely detrimental effect that an active filler may have on an asphaltic concrete when exposed to water.

The sand equivalent numbers of the aggregates tested were compared with the percent stability retained, percent increase in flow, percent volume increase and percent absorption for all of the immersion-compression specimens. In no instance was there a direct correlation between pavement performance and the sand equivalent number. This was to be expected in the "A" series due to the number of uncontrolled factors. In the "B" series, where only the sand equivalent number was allowed to vary, there was still a marked difference in the performance of aggregates with essentially the same sand equivalent number. This is graphically evident in figures 8 through 15.

It is also to be noted in these figures that the "B" series aggregates generally had a higher stability retained, a smaller increase in flow, with smaller volume changes and absorptions. The generally better performance of these aggregates can probably be attributed to a more densely graded mix, which resulted in higher densities and less voids.

There did not seem to be any predictable pattern as to whether the four day at 120°F or fourteen day at room temperature immersion was the more detrimental. On the average, the values of stability retained were in reasonably

These specimens themselves [illegible] extremely water-[illegible] that an active filler may have on an asphaltic concrete when exposed to water.

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There did not seem to be any predictable pattern as to whether the high cavesealer or low cavesealer (?) [illegible] temperature [illegible] [illegible] [illegible] [illegible]. On the average, the values of stability retained [illegible] [illegible]

close agreement although there were some differences of as much as twenty to thirty percent.

Even though no definite correlation could be detected between performance and sand equivalent number, certain trends do exist which would indicate that the performance of aggregates used for asphaltic concrete might be more desirable at the higher sand equivalent values than at low values.

On the basis of the limited number of comparisons made, figures 8 and 9 indicate that the aggregates with higher sand equivalent values could generally be expected to have a greater percentage of the original stability retained. Figures 10 and 11 indicate a generally lower flow for the higher values of sand equivalent. It would seem from figures 12 and 13 that the volume increase to be expected would usually be much larger at the lower values than at values above about 40. The percent absorptions shown in figures 14 and 15 seemed less influenced by the sand equivalent number than did the other quantities compared.

Cold-Water Abrasion Test

The data obtained from the cold water abrasion test are presented in Table III and summarized in Table I, both of Appendix C.

The percent loss in weight is graphically compared with the aggregate sand equivalent number in figure 16. This comparison clearly shows that the higher sand equivalent values experienced less abrasive loss than did the lower values.

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Even though no definite correlation could be detected between performance and sand equivalent number, certain trends do exist which would indicate that the aggregates used for asphaltic concrete might be more desirable at the higher sand equivalent rather than at low values.

On the basis of the limited number of comparisons made, figures 8 and 9 indicate that the aggregates with higher sand equivalent values could reasonably be expected to have a greater percentage of the original stability retained. Figures 10 and 11 indicate a tendency toward higher for the higher values of sand equivalent. It would seem from figures 12 and 13 that the volume increase to be expected would usually be much larger at the lower values than at values above about 40. The percent stability lost in figures 14 and 15 seemed less influenced by the sand-equivalent number than did the other quantities compared.

Cold-water Abrasion Test

The data obtained from the cold-water abrasion test are presented in Table III and summarized in Table V, both of Appendix C.

The percent loss in weight is graphically compared with the aggregate sand equivalent number in Figure 16. This comparison clearly shows that the higher sand equivalent values experienced less abrasive loss than did the lower values.

Once again, however, there were aggregates with low values which performed equally as well as those with high sand equivalent numbers. It would seem that a sand equivalent number of about 40 is the dividing line between aggregates which generally experienced low abrasive loss and those whose losses extended over a wide range of values.

AASHO Swell Test

The results of the AASHO swell test are presented in Table IV of Appendix C and are graphically shown in figure 17.

The specimens, molded according to the prescribed AASHO procedure, were of the same diameter as the Marshall immersion-compression specimens, but were not as dense because of the different compacting technique. The percent swell was not as great as in the case of the immersion-compression specimens due to the AASHO specimens being radially confined.

It is to be noted in figure 17, that once again the lower sand equivalent aggregates exhibited a wider range in the swell than might be expected. It would appear that the aggregates undergoing relatively large volume changes in the immersion-compression test also had the larger percentages of swell in the AASHO test. The results of the AASHO swell test seem to further substantiate the findings of the immersion-compression test with regard to the role played by the sand equivalent number in the swelling characteristics of an aggregate.

## Stripping Test

As indicated previously, the results of the stripping test were only qualitative and based entirely on the opinion of the observer. For this reason, the degree of stripping was purely a comparative quantity from excessive to slight. The results of the stripping test performed on aggregates 1-A through 19-A are seen in Table V of Appendix C.

It was the general trend for the stripping to become greater with a decrease in the sand equivalent number. However, as in all of the other tests, a low sand equivalent number did not guarantee a highly stripped aggregate.

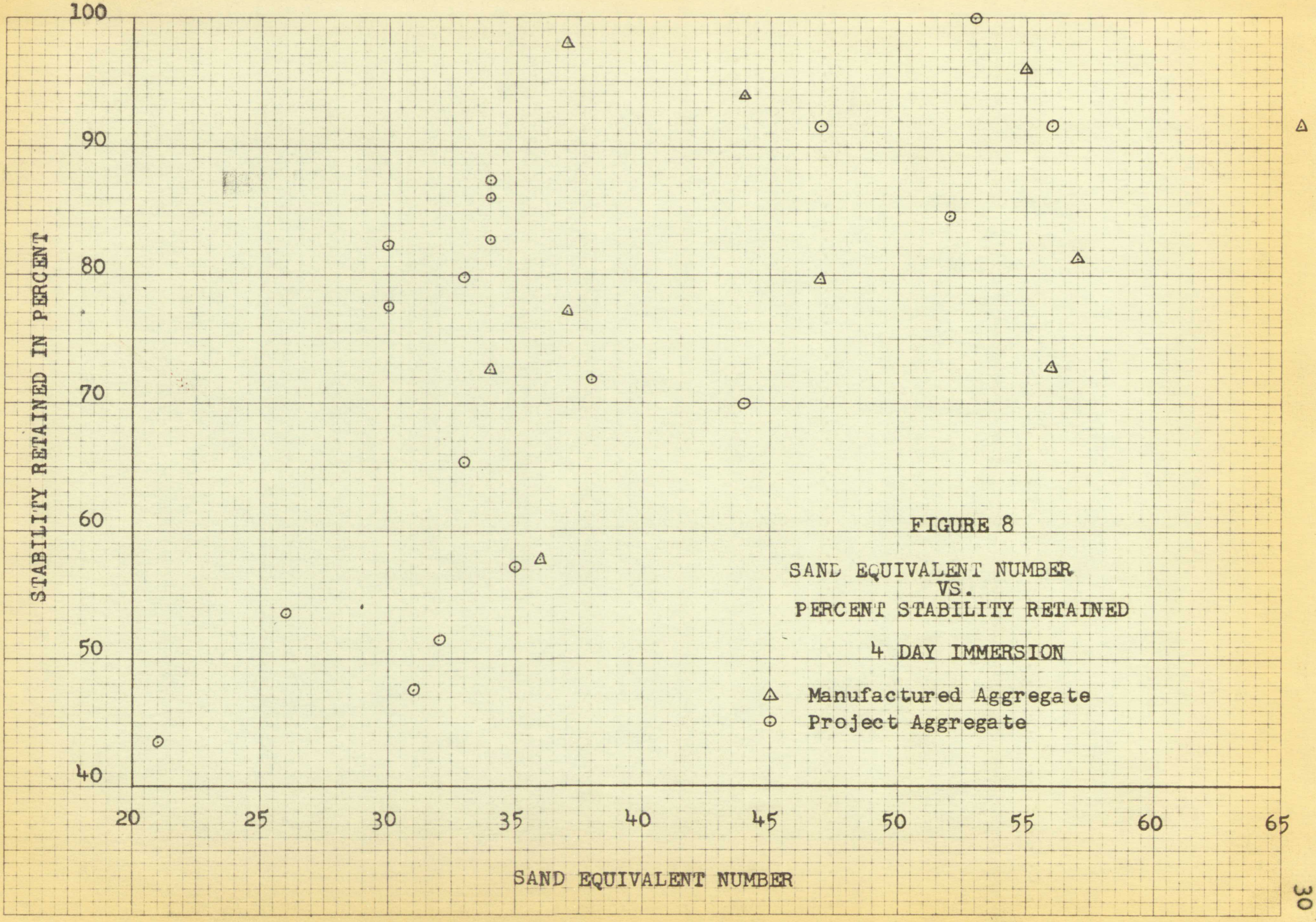



FIGURE 8

SAND EQUIVALENT NUMBER
VS.
PERCENT STABILITY RETAINED

4 DAY IMMERSION

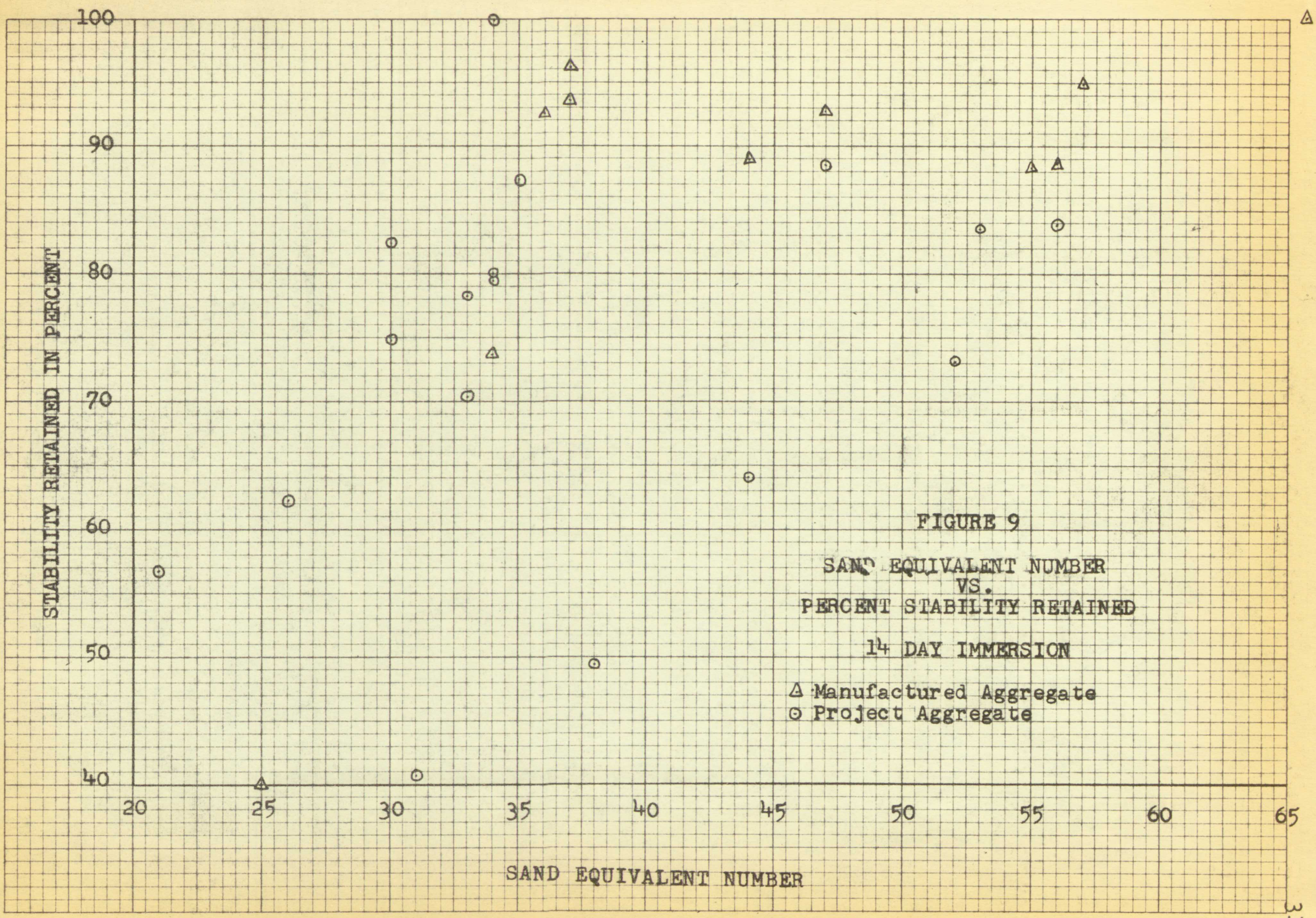



FIGURE 9

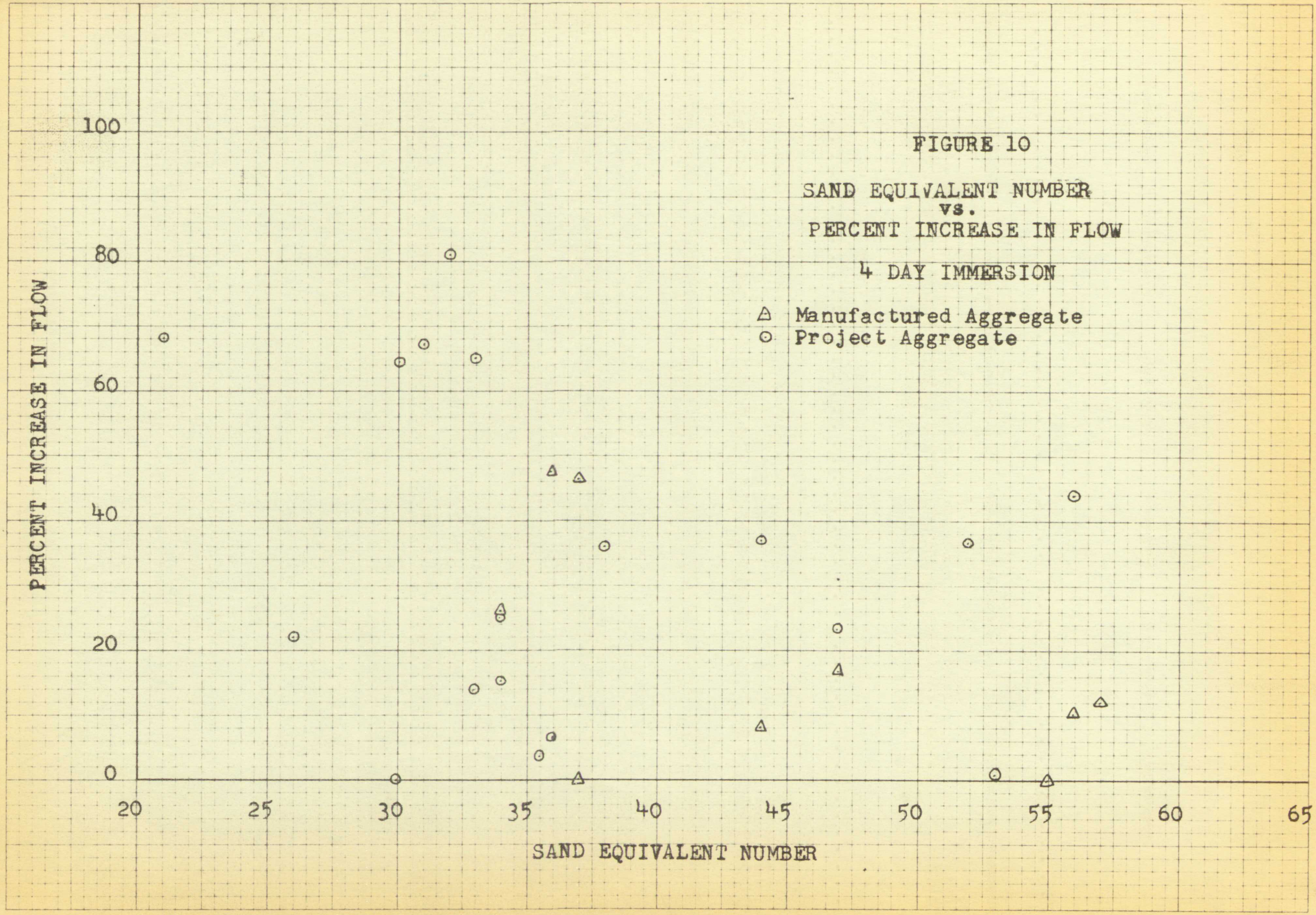
SAND EQUIVALENT NUMBER
VS.
PERCENT STABILITY RETAINED

14 DAY IMMERSION

FIGURE 10

SAND EQUIVALENT NUMBER
vs.
PERCENT INCREASE IN FLOW

4 DAY IMMERSION



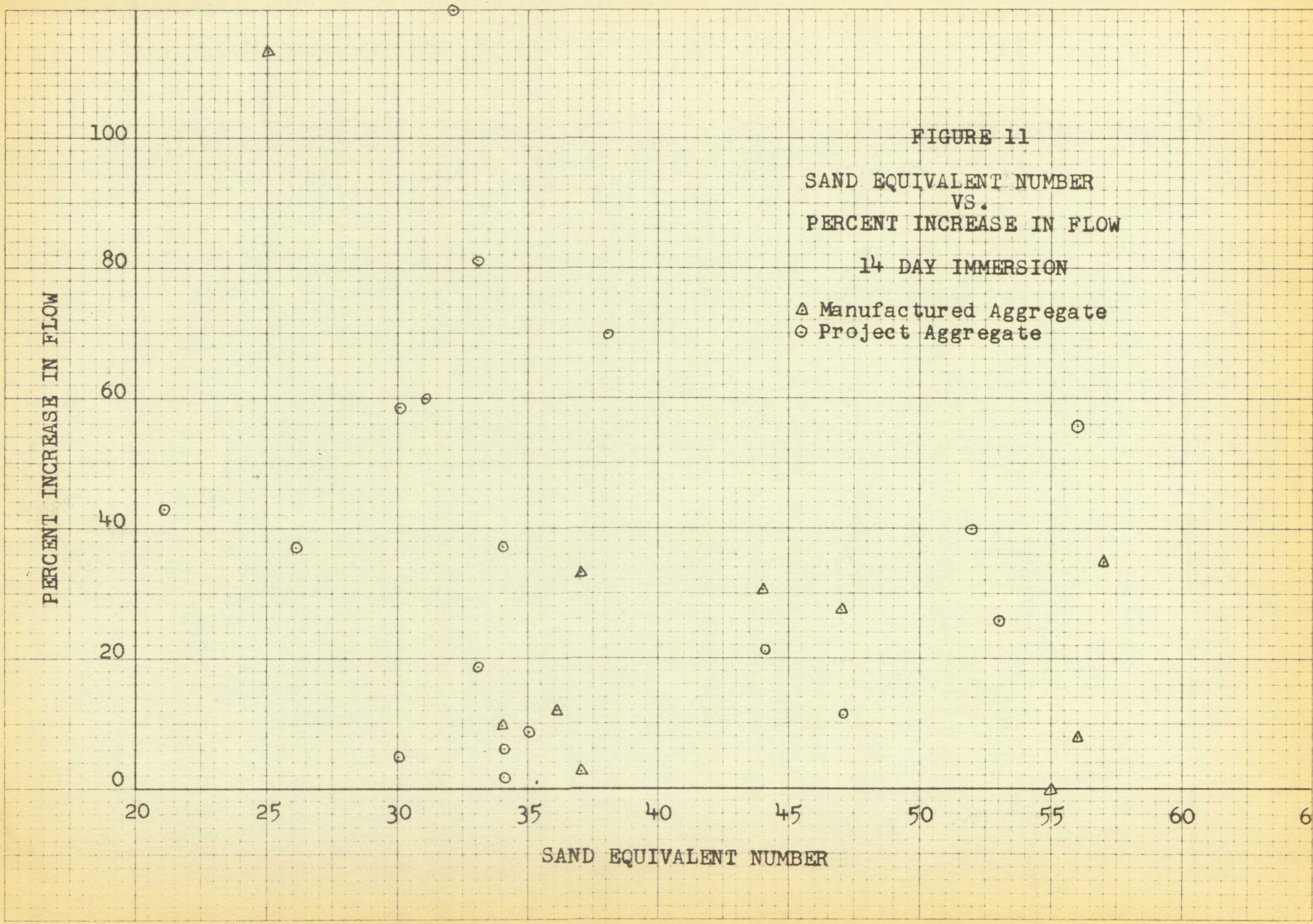


FIGURE 11
SAND EQUIVALENT NUMBER
VS.
PERCENT INCREASE IN FLOW
14 DAY IMMERSION
Manufactured Aggregate
Project Aggregate
PERCENT INCREASE IN FLOW
0
20
40
60
80
100
20
25
30
35
40
45
50
55
60
65
SAND EQUIVALENT NUMBER

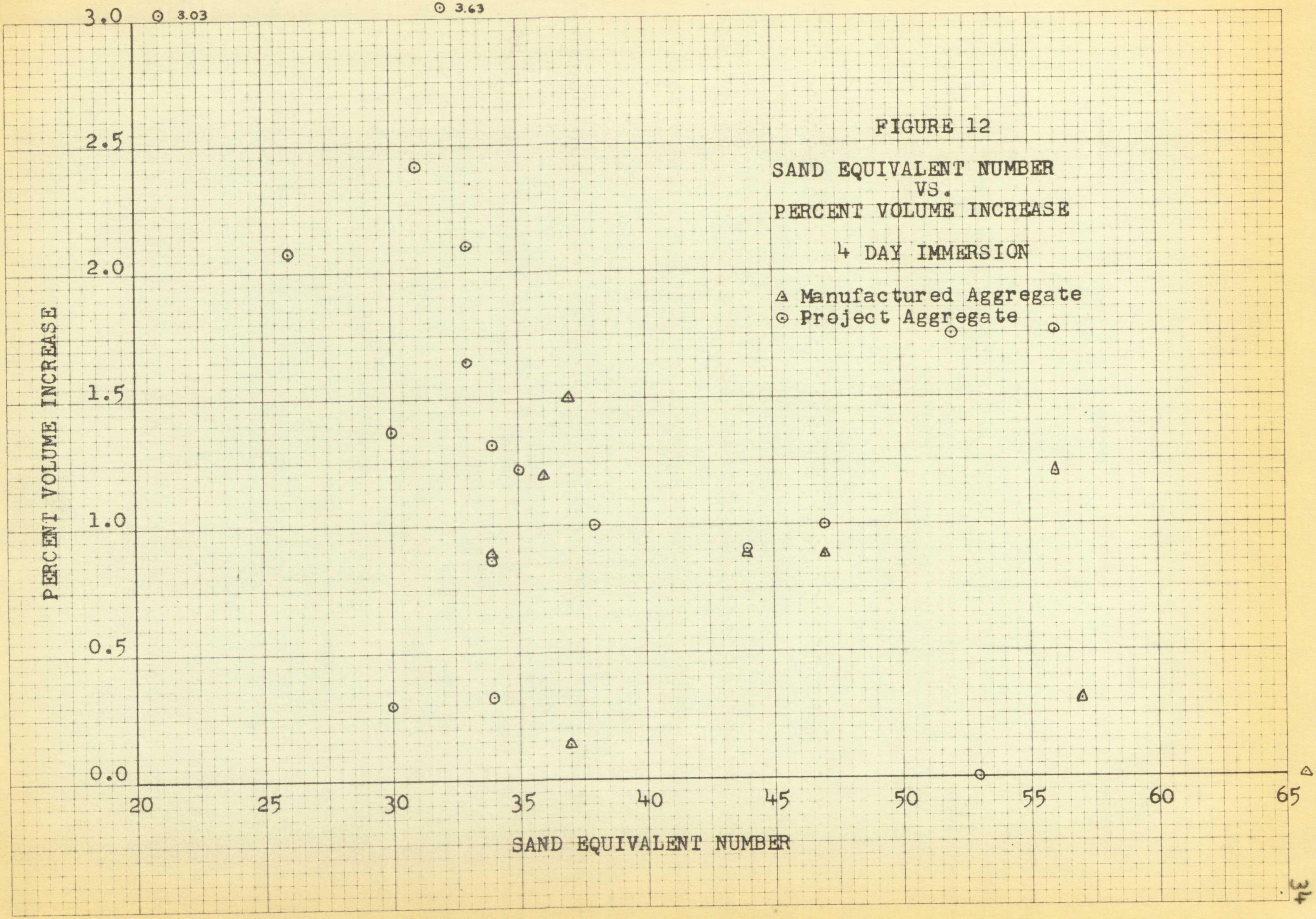


FIGURE 12
SAND EQUIVALENT NUMBER
VS.
PERCENT VOLUME INCREASE
4 DAY IMMERSION
Manufactured Aggregate
Project Aggregate
PERCENT VOLUME INCREASE
SAND EQUIVALENT NUMBER
3.0
2.5
2.0
1.5
1.0
0.5
0.0
20
25
30
35
40
45
50
55
60
65
3.03
3.63

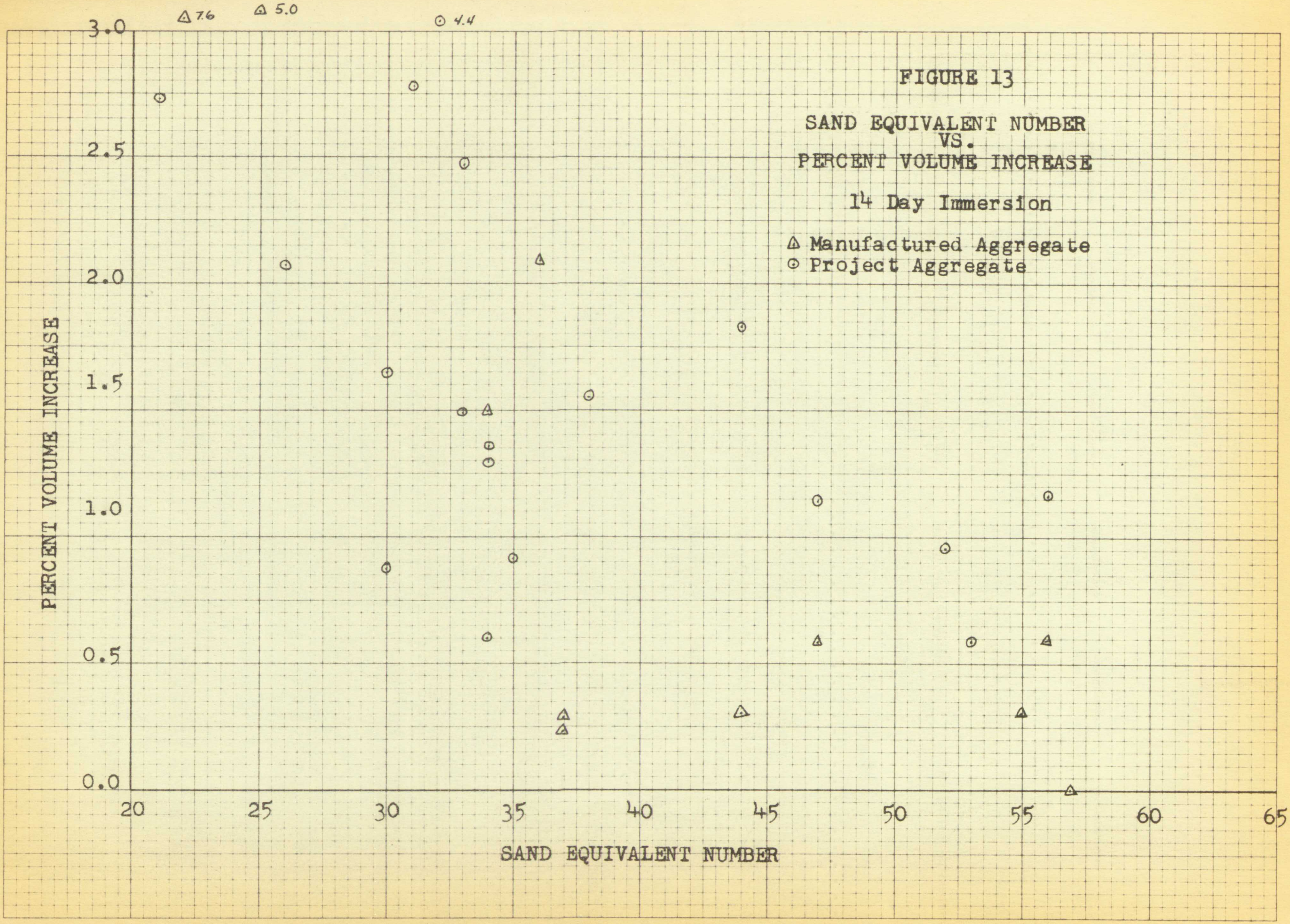


FIGURE 13
SAND EQUIVALENT NUMBER
VS.
PERCENT VOLUME INCREASE
14 Day Immersion
Δ Manufactured Aggregate
⊙ Project Aggregate
Δ 7.6
Δ 5.0
⊙ 4.4
PERCENT VOLUME INCREASE
0.0
0.5
1.0
1.5
2.0
2.5
3.0
SAND EQUIVALENT NUMBER
20
25
30
35
40
45
50
55
60
65

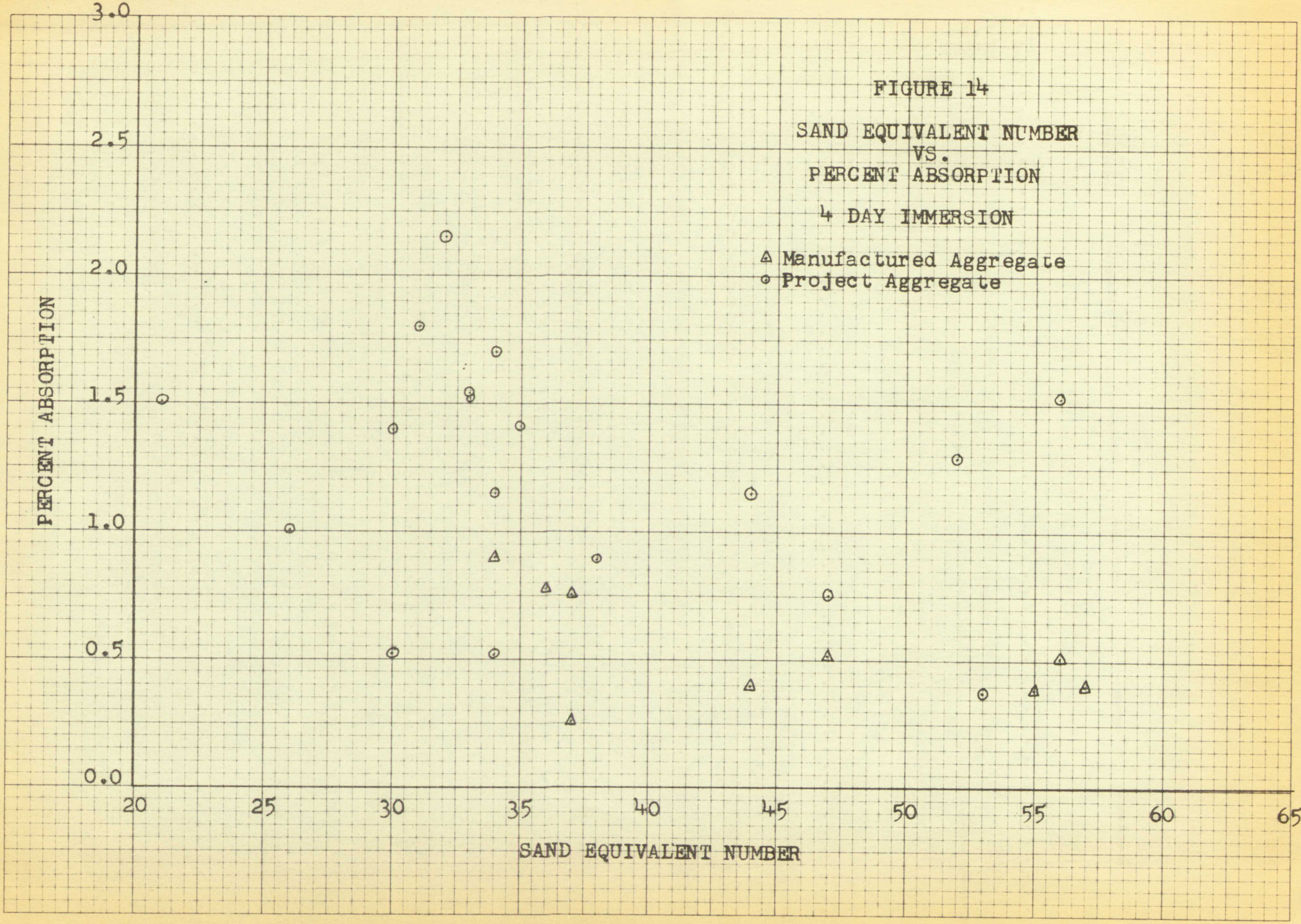


FIGURE 14
SAND EQUIVALENT NUMBER
VS.
PERCENT ABSORPTION
4 DAY IMMERSION
△ Manufactured Aggregate
⊙ Project Aggregate
PERCENT ABSORPTION
3.0
2.5
2.0
1.5
1.0
0.5
0.0
20
25
30
35
40
45
50
55
60
65
SAND EQUIVALENT NUMBER

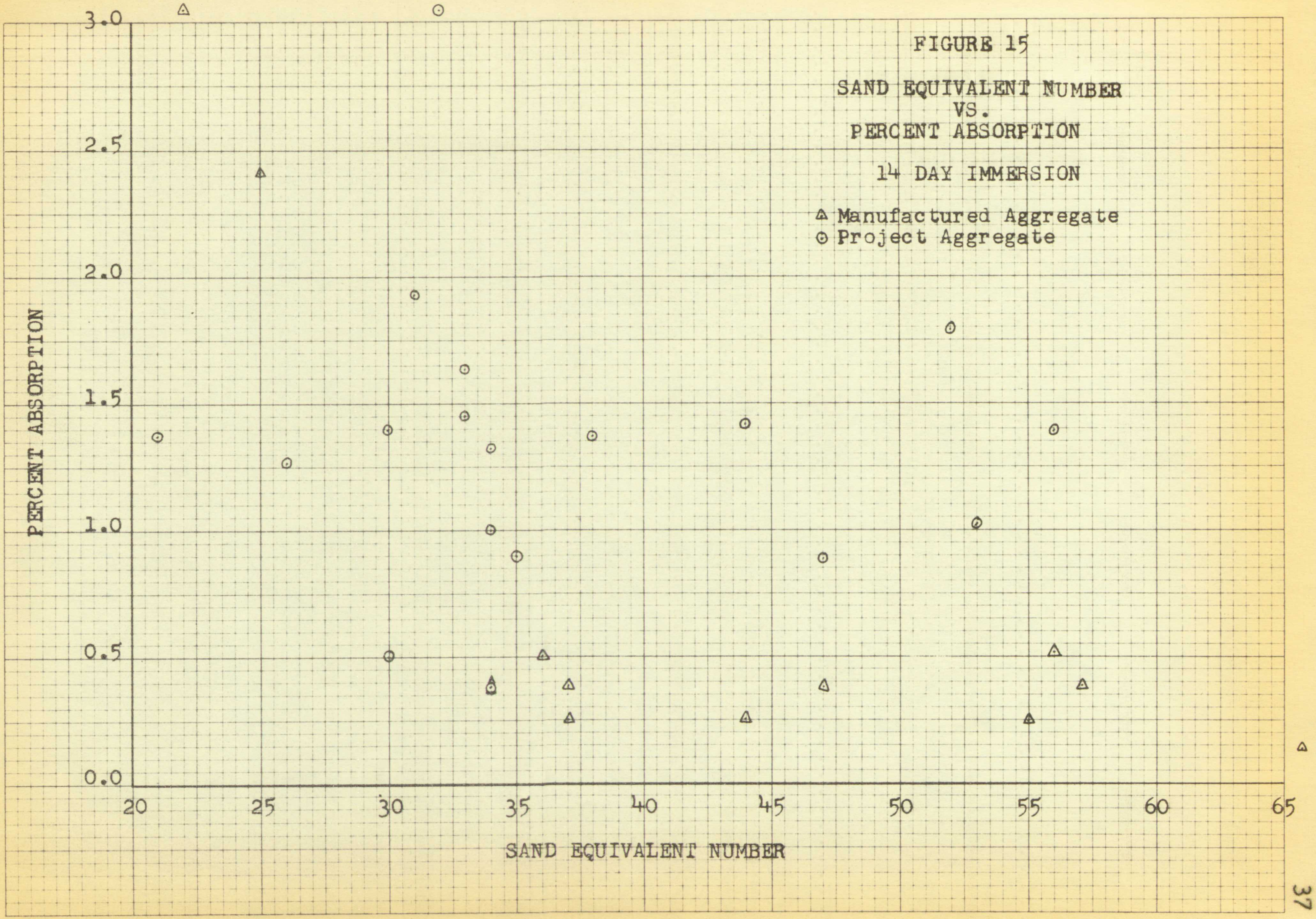


FIGURE 15
SAND EQUIVALENT NUMBER
VS.
PERCENT ABSORPTION
14 DAY IMMERSION
Manufactured Aggregate
Project Aggregate
PERCENT ABSORPTION
3.0
2.5
2.0
1.5
1.0
0.5
0.0
20
25
30
35
40
45
50
55
60
65
SAND EQUIVALENT NUMBER

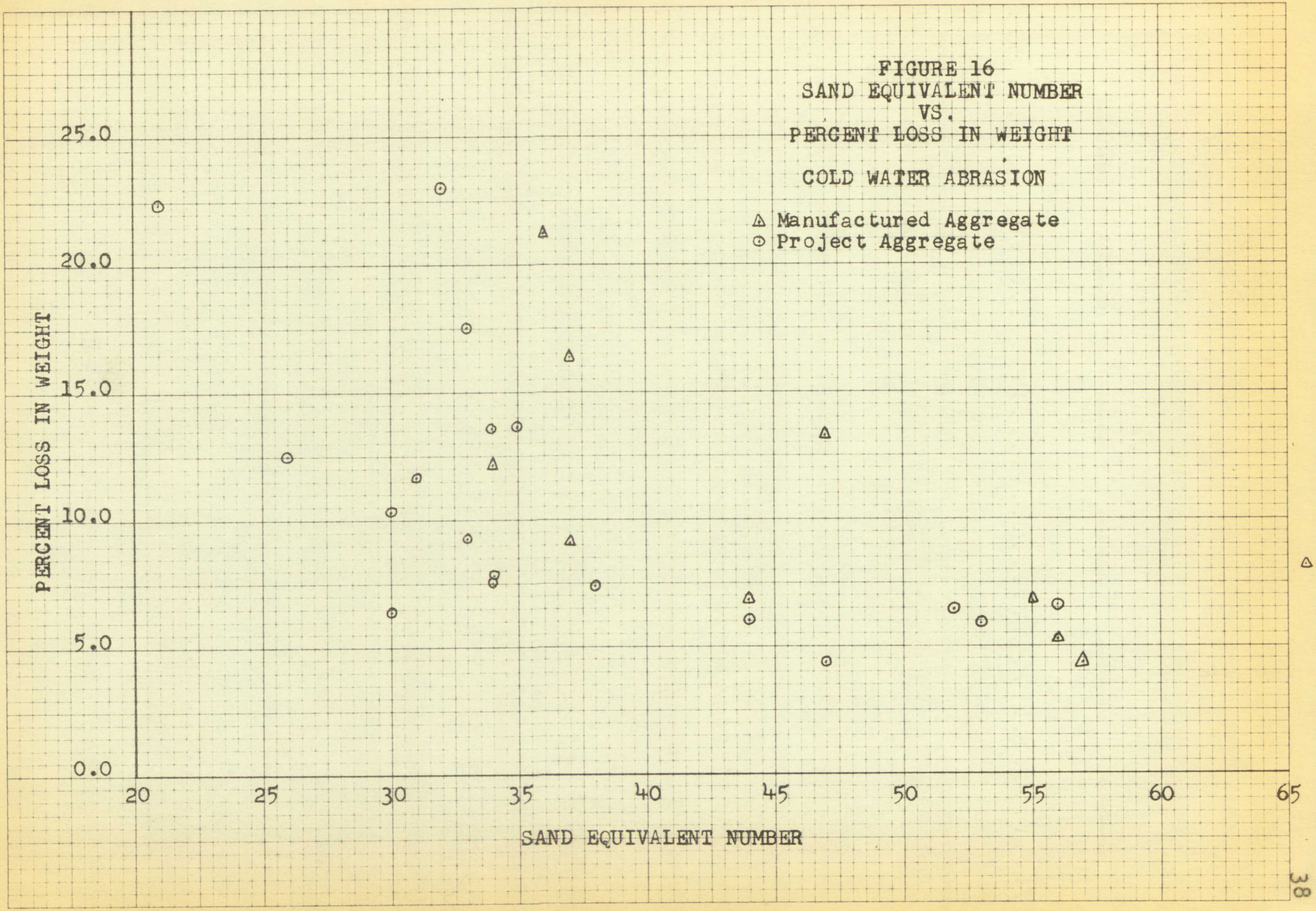


FIGURE 16
SAND EQUIVALENT NUMBER
VS.
PERCENT LOSS IN WEIGHT
COLD WATER ABRASION
Manufactured Aggregate
Project Aggregate
PERCENT LOSS IN WEIGHT
0.0
5.0
10.0
15.0
20.0
25.0
20
25
30
35
40
45
50
55
60
65
SAND EQUIVALENT NUMBER

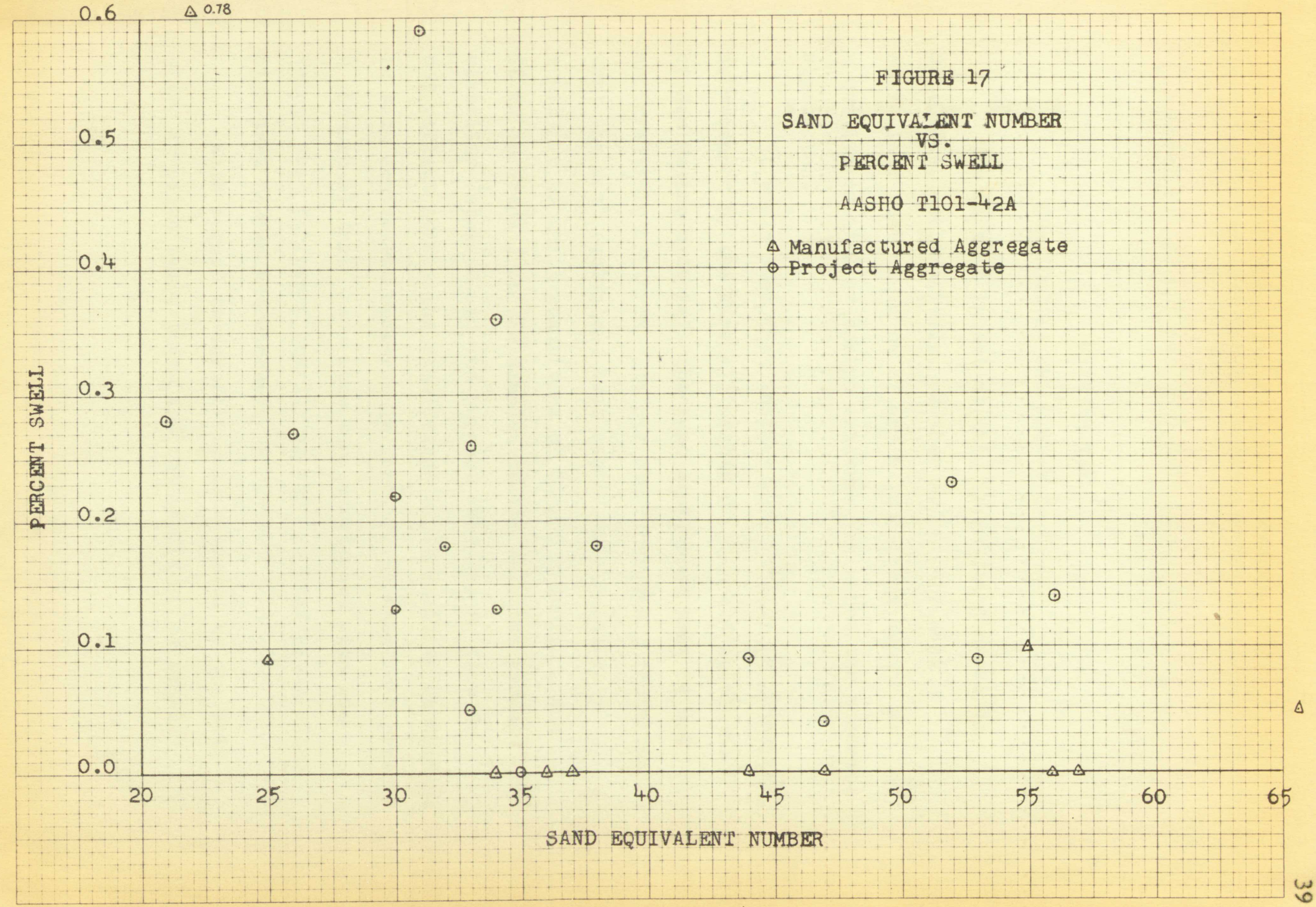


FIGURE 17
SAND EQUIVALENT NUMBER
VS.
PERCENT SWELL
AASHO T101-42A
Manufactured Aggregate
Project Aggregate
0.78
PERCENT SWELL
0.6
0.5
0.4
0.3
0.2
0.1
0.0
SAND EQUIVALENT NUMBER
20
25
30
35
40
45
50
55
60
65

# CHAPTER VII

## CONCLUSIONS AND RECOMMENDATIONS

The initial intent of this investigation was to determine, qualitatively, whether or not the sand equivalent test would be of any value in New Mexico as a quality control or design criteria for asphaltic concrete aggregates.

It would seem that insofar as stability is concerned, as measured by the Marshall method on immersed specimens of New Mexico material, the sand equivalent test is not an infallible criteria. It has been previously indicated that the sand equivalent test seems to be relatively sensitive to small quantities of clayey materials, but it is apparent from the samples tested that the percent stability retained and the percent increase in flow do not reflect nearly the same degree of sensitivity to changes in sand equivalent number. In fact, it is seen in figures 8 through 11 that there were many aggregates with low values that performed equally as well as aggregates with high sand equivalent numbers.

With regard to durability as measured by the cold-water abrasion test, there did not appear to be nearly

as much scatter in the data as on the immersion-compression specimens, but once again, it is seen that a low sand equivalent number is not a definite indication of an unsatisfactory aggregate.

The percent of volume increase on the immersion-compression specimens and the percent swell of the AASHO specimens further illustrate the wide range of values possible at sand equivalent values less than about 40.

The stripping test, which in itself is only qualitative, also did not indicate that the sand equivalent test could be depended upon to predict the stripping in the 30 to 40 range where the only variable was the sand equivalent number.

It must be emphasized that in all tests, an increase in the sand equivalent number above 40 considerably reduced the scatter in the data and resulted in much better performance of the aggregate. This in itself is indicative that the test has merit, and that the activity of the mineral filler has a definite influence on the performance of bituminous combinations.

The primary objection to using the sand equivalent test as a design criteria for New Mexico aggregates stems from the fact that many aggregates which would probably perform quite well would be rejected on the basis of their sand equivalent numbers. In areas where good aggregates are plentiful, this would not be objectionable; however, where

as much scatter in the data as [illegible] specimens, but once again it is apparent that the sand equivalent number is not a definitive indication of satisfactory aggregates.

The percent of voids increases on the immersion compression specimens and the percent swell on the [illegible] specimens further illustrate [illegible] possible at sand equivalent values less than about 40.

The stripping test, which is [illegible] qualitative, also did not indicate that the sand equivalent test could be depended upon, except at the [illegible] the 30 to 40 range where the [illegible] variable with the sand equivalent number.

It must be emphasized that in all tests, an increase in the sand equivalent number above [illegible] reduced the scatter in the data and resulted in [illegible] performance of the aggregates. This in itself indicates that the test has merit, and that the activity of the [illegible] filler has a definite influence on the performance of bituminous combinations.

The primary objection to using the sand equivalent test as a design criteria for [illegible] aggregates [illegible] the fact that many aggregates which [illegible] quite well would be rejected on the basis of their sand equivalent numbers. In areas where good aggregates are plentiful, this would not be objectionable; however, [illegible]

superior aggregates are in short supply, a minimum sand equivalent specification might needlessly increase the cost of a project.

Because of the rather limited number of aggregates used in this investigation, it is difficult to draw a definite line between sand equivalent numbers of aggregates which could be considered good, questionable or bad. It does seem, however, that Mr. Hveem's initial criteria are somewhat high for New Mexico aggregates; in fact, only one of the aggregates from New Mexico projects would meet Mr. Hveem's criteria for Class "A" plant mix in the state. If a classification for New Mexico aggregates were made, it would probably be roughly as follows:

| Sand Equivalent Number | Acceptability |
|---|---|
| Below 30 | Unacceptable |
| 30 to 45 | Probably good |
| Above 45 | Good |

This classification seems to be more in line with that proposed by Mr. O'Hara of the Arizona State Highway Department.

Finally, it is felt that the sand equivalent test is of benefit to the engineer in selecting aggregates if it is used only as an indication of the activity of the mineral filler and not necessarily as a design criteria. The test should also prove useful as a field control test because of its sensitivity to changes in colloidal content of the material and the rapidity with which the test may be run in the field.

superior aggregates [illegible] concrete [illegible]

equivalent specification [illegible]

cost of a project.

Because of the rather limited number of aggregates used in this investigation, it is difficult [illegible] definite line between [illegible] which could be considered [illegible] seem, however, that Mr. Hveem's [illegible] somewhat high for [illegible] of the aggregates from [illegible] Hveem's criteria for Class [illegible] If a classification [illegible] it would probably be [illegible]

| Sand Equivalent Number | |
|---|---|
| Below 30 | [illegible] |
| 30 to 45 | [illegible] |
| Above 45 | [illegible] |

This classification seems to be [illegible] posed by Mr. O'Hara of the [illegible]

Finally, it is felt that the sand equivalent test is of benefit to the engineer in selecting [illegible] if it is used only as an indication of the activity of the mineral filler and not used strictly as [illegible] The test should also [illegible] because of its sensitivity [illegible] of the material and the [illegible] be run in the field.

It is strongly recommended that more experience be gained with the sand equivalent test in the 30 to 45 range, and that maintenance records be kept and checked against sand equivalent number on all projects where the aggregate used fell within this range.

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# APPENDIX A

# THE SAND EQUIVALENT TEST PROCEDURE

# APPENDIX A

## THE SAND EQUIVALENT TEST PROCEDURE

Test Method No. Calif. 217-C
November 3, 1958

State of California
Department of Public Works
Division of Highways

MATERIALS AND RESEARCH DEPARTMENT

# METHOD OF TEST FOR SAND EQUIVALENT

## Scope

This test is intended to serve as a rapid field test to show the relative proportions of detrimental fine dust or claylike material in soils or fine aggregate.

## Procedure

### A. Apparatus

1. A graduated plastic cylinder, rubber stopper, irrigator tube, weighted foot assembly and siphon assembly all conforming to their respective specifications and dimensions shown in Fig. I. Fit the siphon assembly to a 1-gal. bottle of working calcium chloride solution placed on a shelf 3 ft. ± 1 in. above the work surface.
2. Flexible tubing: A length of $\frac{3}{16}$-in. flexible tubing (plastic or rubber) approximately 4 ft. long with pinch clamp for shutting off flow. Use this tubing to connect the irrigator tube to the siphon assembly.
3. Measuring tin: A 3-oz. tinned box approximately $1\frac{3}{4}$ in. in diameter with Gill style cover.
4. Funnel: A wide-mouth funnel approximately 4 in. in diameter at the mouth. (See Fig. II.)
5. Clock or watch: A watch or clock reading in minutes and seconds.
6. Graduate: A 100-ml. glass cylinder graduated in increments of 2 ml. or less.

### B. Materials

1. *Stock calcium chloride solution:* Prepare the stock calcium chloride solution with the following:

   454 g. (1 lb.) tech. anhydrous calcium chloride
   
   2,050 g. (1,640 ml.) USP glycerine
   
   47 g. (45 ml.) formaldehyde (40 percent by volume solution)

   Dissolve the calcium chloride in ½ gal. of distilled or demineralized water. Cool the solution, then filter it through Whatman No. 12 or equivalent filter paper. Add the glycerine and formaldehyde to the filtered solution, mix well, and dilute to 1 gal. with distilled or demineralized water. District laboratories should secure stock calcium chloride solution from the Service and Supply Department of the Division of Highways (Stock No. 69691).

2. *Working calcium chloride solution:* Prepare the working calcium chloride solution by diluting 88 ml. of the stock calcium chloride solution to 1 gal. with water. Use distilled or demineralized water for the normal preparation of the working solution. However, if it is determined that the local tap water is of such purity that it does not affect the test results, it is permissible to use it in lieu of distilled or demineralized water except in the event of dispute.

### C. Test Record Form

1. Record the test data on the appropriate one of work card Form Nos. T-200 and T-361.

### D. Control

1. This test may be normally performed without strict temperature control; however, in the event of dispute, retest the material with the temperature of the working solution at 72 ± 5 F.

### E. Sample Preparation

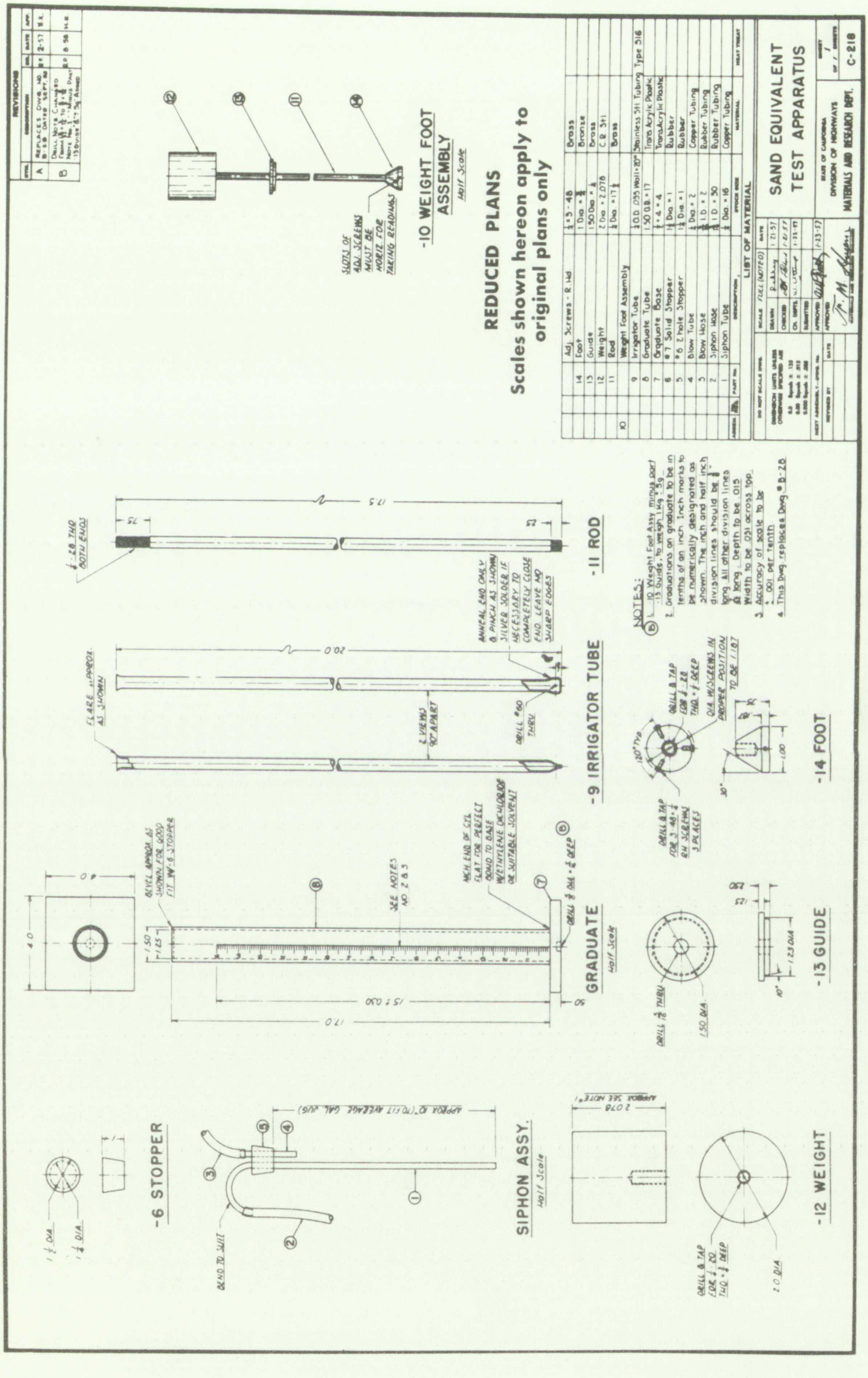
1. Prepare sand equivalent test samples from the passing No. 4 sieve portion of the material to be tested. Be sure all fines are cleaned from the retained No. 4 sieve portion and included with the passing No. 4 sieve material; use method described in Article E of Test Method No. Calif. 201.
2. Split or quarter[1] enough material from the passing No. 4 sieve portion to fill the tin measure to within $\frac{3}{16}$ in. of the brim. Use extreme care in the sand equivalent test sample preparation to obtain a truly representative sample.

   a. Splitting and Quartering Instructions and Information.

   Experiments show that as the amount of material being reduced by splitting or quartering is decreased the accuracy of providing representative portions is decreased. For this reason it is imperative that the sand equivalent test sample, which is already relatively very small, be split or quartered evenly to the correct size.

   It is realized that as a rule adjustments are required to provide the desired test sample size. However, make these adjustments

[1] If quartering method is used, follow the procedure as specified in "Hand quartering of samples weighing less than 25 lbs." under Article H of Test Method No. Calif. 201.



-6 STOPPER
SIPHON ASSY.
Half Scale
-12 WEIGHT
GRADUATE
Half Scale
-13 GUIDE
-9 IRRIGATOR TUBE
-14 FOOT
-11 ROD
-10 WEIGHT FOOT ASSEMBLY
Half Scale
REDUCED PLANS
Scales shown hereon apply to original plans only
LIST OF MATERIAL
SAND EQUIVALENT TEST APPARATUS
STATE OF CALIFORNIA
DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPT.
C-218


FIGURE I

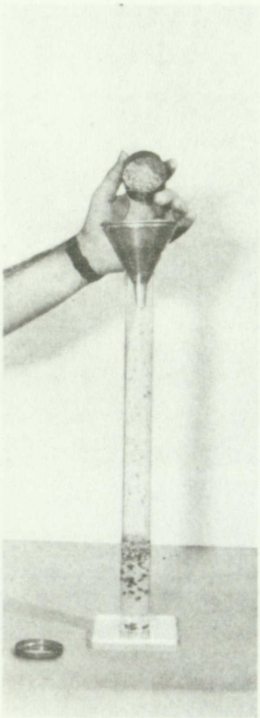


FIGURE II

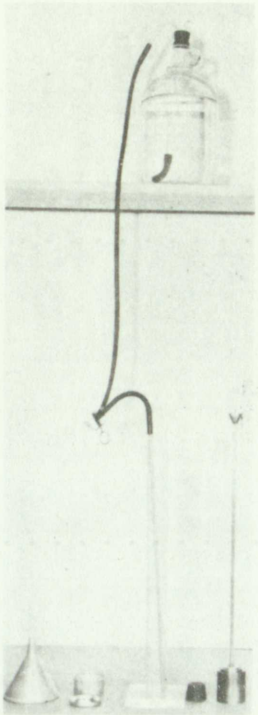


FIGURE III

before the sample is reduced below a volume equal to four tin measures, or approximately 500 grams for material of average specific gravity.

Determine the exact amount which can be split or quartered down to an even tin measure full, by dipping four full measures of the material from the sample and weighing it or by determining its volume in a dry plastic cylinder before beginning the splitting operation. Record the weight or volume determined, then return the material back to the sample and proceed to split or quarter and make adjustments necessary to obtain this predetermined weight or volume. When this weight or volume is obtained the two successive splitting or quartering operations should provide the amount of material required to fill the tin measure to within $\frac{3}{16}$ in. of the brim.

3. Dry the prepared test sample to constant weight at 200 to 250 F.
   a. As a time-saving expedient, it is permissible to test most materials without prior oven drying if the sand equivalent values are well above the specified minimum requirement, but if the test values are near or below the specified minimum limit, retest the material using an oven dry test sample.
   b. Test samples of material proposed for use in plant-mixed surfacing in a dry condition without exception.

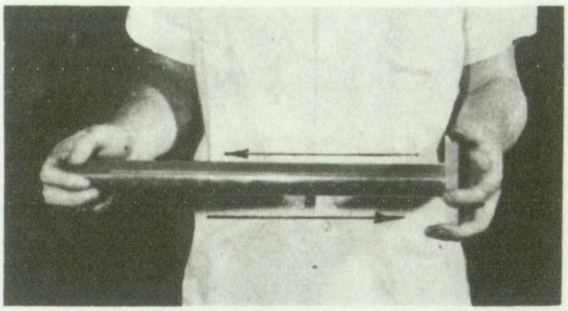


FIGURE IV

## F. Test Procedure

1. Siphon 4 ± 0.1 in. of working calcium chloride solution into the plastic cylinder.
2. Pour the prepared test sample from the measuring tin into the plastic cylinder using the funnel to avoid spillage (See Fig. III). Tap the bottom of the cylinder sharply on the heel of the hand several times to release air bubbles and promote thorough wetting of the sample.
3. Allow the wetted sample to stand undisturbed for 10 ± 1 minutes.
4. At the end of the 10-minute soaking period, stopper the cylinder, then loosen the material from the bottom by partially inverting the cylinder and shaking it simultaneously.
5. After loosening the material, hold the cylinder in a horizontal position as illustrated in Fig. IV and shake it vigorously in a horizontal linear motion from end to end.[2] Shake the cylinder 90 cycles in approximately 30 seconds using a throw of 9 ± 1 in. A cycle is defined as a complete back and forth motion. To properly shake the cylinder at this speed, it will be necessary for the operator to shake with the forearms only, relaxing the body and shoulders.
6. Following the shaking operation, set the cylinder upright on the work table and remove the stopper. Insert the irrigator tube in the cylinder and rinse material from the cylinder walls as the irrigator is lowered. Force the irrigator through the material to the bottom of the cylinder by applying a gentle stabbing and twisting action while the working solution flows from the irrigator tip. This flushes the fine material into the suspension above the coarser sand particles. (See Fig. V). Continue to apply a stabbing and twisting action while flushing the fines upward until the cylinder is filled to the 15-in. mark. Then raise the irrigator slowly without shutting off the flow so that the liquid level is maintained at about 15 in. while the irrigator is being withdrawn. Regulate the flow just before the irrigator is entirely withdrawn and adjust the final level to 15 in.

[2] See Article J "Operator Qualification."

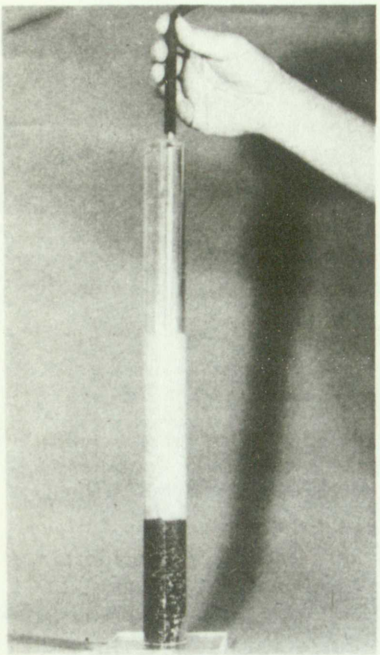


FIGURE V

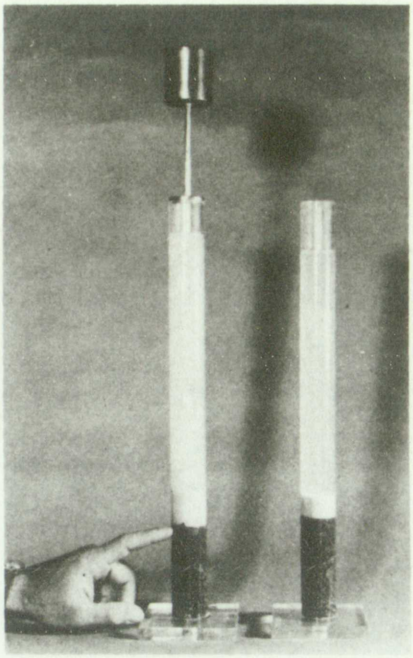


FIGURE VI

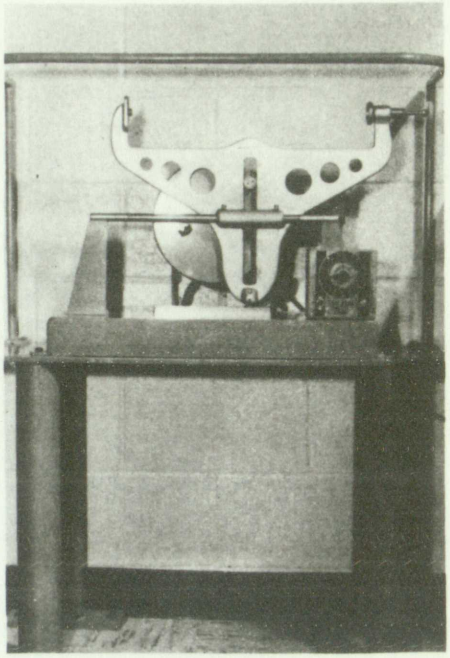


FIGURE VII

7. Allow the cylinder and contents to stand undisturbed for 20 minutes ± 15 seconds. Start the timing immediately after withdrawing the irrigator.
8. At the end of the 20-min. sedimentation period, read and record the level of the top of the clay suspension. This is referred to as "the clay reading."
9. After the clay reading has been taken, place the weighted foot assembly over the cylinder with the guide in position on the mouth of the cylinder and gently lower the weighted foot until it comes to rest on the sand. While the weighted foot is being lowered, keep one of the centering screws in contact with the cylinder wall near the graduations so that it can be seen at all times. When the weighted foot has come to rest on the sand, read and record the level of the centering screw. This reading is referred to as "the sand reading." (See Fig VI.)
10. If clay or sand readings fall between 0.1-in. graduations, record the level of the higher graduation as the reading. For example, a clay level at 7.95 would be recorded as 8.0. A sand level at 3.22 would be recorded as 3.3.

## G. Calculations and Reporting

1. Calculate the sand equivalent to the nearest 0.1 using the following formula:

$$SE = \frac{\text{Sand reading}}{\text{Clay reading}} \times 100$$

2. If the calculated sand equivalent is not a whole number, report it as the next higher whole number. For example, if the sand equivalent were calculated from the example, in paragraph 10 of Article F, the calculated sand equivalent would be:

$$\frac{3.3}{8.0} \times 100 = 41.2$$

Since this calculated sand equivalent is not a whole number, it would be reported as the next higher whole number which is 42.

3. If it is desired to average a series of sand equivalent values, average the whole number values determined as described above. If the average of these values is not a whole number, raise it to the next higher whole number as shown in the following example:
   a. Calculated $SE$ values: 41.2, 43.8, 40.9.
   b. After raising each to the next higher whole number they become: 42, 44, 41.
   c. The average of these values is then determined

   $$\frac{42 + 44 + 41}{3} = 42.3$$

   d. Since the average value is not a whole number it is raised to the next higher whole number and the reported average sand equivalent value is reported as "43."

## H. Precautions

1. Exercise extreme care to provide a representative sample for test. Use care and follow the prescribed quartering or splitting practices. When it appears necessary, dampen material to avoid loss of fines or segregation.

2. Perform the test in a location free of vibrations, because vibrations may cause the suspended material to settle at a greater rate than normal.
3. Do not expose the plastic cylinders to direct sunlight any more than is necessary.

## I. Referee Test

1. Apparatus, Materials and Controls.
   a. The apparatus, materials and controls required for the referee sand equivalent test shall include all of those described in the standard procedure plus a mechanical sand equivalent shaker. (See Fig. VII.)
   b. The mechanical sand equivalent shaker[3] shall conform to specifications and dimensions shown in the State of California, Division of Highways, Materials and Research Department Plans Designation C-256.
   c. Fasten the mechanical sand equivalent shaker securely to a firm and level mount.
2. Procedure
   a. Perform all operations of sample preparation and testing in accordance with the standard procedure except that in lieu of the manual shaking operation described in paragraph 5 of article F, substitute the following:

      "After loosening the material from the bottom of the cylinder, place the stoppered cylinder in the sand equivalent shaker and set the timer so that the machine will shake the cylinder and contents for 45 seconds. Immediately after the agitation, remove the cylinder from the machine and proceed as described in the balance of Article F beginning with paragraph 6."
3. Use the referee test whenever possible.

## J. Operator Qualifications

1. Operators performing the sand equivalent test by the manual shaking method must meet qualification test requirements. The qualification requirements are that an operator must be capable of obtaining consistent sand equivalent results on representative samples of any given material and that his results must agree with the results obtained using the referee method of test on the same material.
2. An operator's test results are considered to be consistent if three tests performed by him, on representative samples of any given material, do not vary from the average of these tests by more than ± 4 points. If the operator's test results are not consistent, he shall not be allowed to perform routine sand equivalent tests by the manual shaking method until he has perfected his technique enough to obtain consistent test results.
3. The results of an operator's tests by the manual shaking method are considered to agree with the referee test results when the respective average of three tests by each method does not differ by more than 4 points.
4. If an operator is capable of performing the sand equivalent test by the manual shaking method so that his results are consistent, but the average does not agree with the results by the referee method he shall adjust the number of manual shaking cycles sufficiently to cause the results by the manual shaking method to agree with the results by the referee method. For example, if an operator has obtained an average sand equivalent of 62 by the manual shaking method and the average results by the referee method is 70, it will be necessary for the operator to reduce the number of manual shaking cycles in performing the test so that his test results will increase to within ± 4 points of the referee value.
5. Determine the exact adjustment in the number of manual shaking cycles by the following trial and error method:
   a. Estimate the adjusted number of manual shaking cycles that might be required.
   b. Perform three tests at the adjusted number of cycles. Strive to maintain the prescribed manual shaking rate of 180 cycles per min.
   c. Compare the average of the three tests with the referee average. If the results still do not agree change the number of cycles and repeat this trial process until the average of three tests at the adjusted number of cycles gives a value within ± 4 points of the referee test average.
6. Operators should be required to perform qualification tests whenever their results tend to vary appreciably from referee check tests. Check referee tests should be made at regular intervals to insure a reasonable degree of accuracy and standardization of test results.
7. Variation in excess of ± 4 in the referee test results are usually primarily due to nonuniformity in the samples themselves. Extreme care is necessary in preparing small samples of this type to insure that they are representative. See Article E, paragraph 2 for instructions on sample preparation.

### Reporting of Results

Report test results on test report Forms T-287, T-374, or T-375.

### REFERENCES

Test Method No. Calif. 201

End of Text on Calif. 217-C

[3] This mechanical shaker is a modification of shaker designs originally developed by Henry Davis of the California Division of Highways and by the Laboratorie Central des Ponts et Chaussees, Paris, France, under the direction of Mr. R. Peltier.

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# APPENDIX B

TABLE I
Aggregate Data and Source
Current Projects

| Aggregate | S.E. No. | % A. C. | Location |
|---|---|---|---|
| 1-A | 32 | 5.82 | C. R. Davis Pit, Albuquerque, New Mexico |
| 2-A | 53 | 6.58 | Wylie Brothers Springer Pit, N.M. 422 Albuquerque, New Mexico |
| 4-A | 34 | 4.37 | Allison & Haney Pit, (Base Course Material) Albuquerque, New Mexico |
| 11-A | 44 | 6.30 | Longenbaugh & Coe, NMSHD Project I-040-2(7) 85 |
| 14-A | 33 | 5.08 | Brown Construction Co. NMSHD Project DF-051-1 (9) |
| 18-A | 52 | 7.1 | Armstrong & Armstrong, NMSHD Project F-021-2 (5) |
| 19-A | 56 | 6.12 | J. W. Jones, NMSHD Project F-018-1 (5) |

TABLE II
Aggregate Data and Source
Old Stockpiles

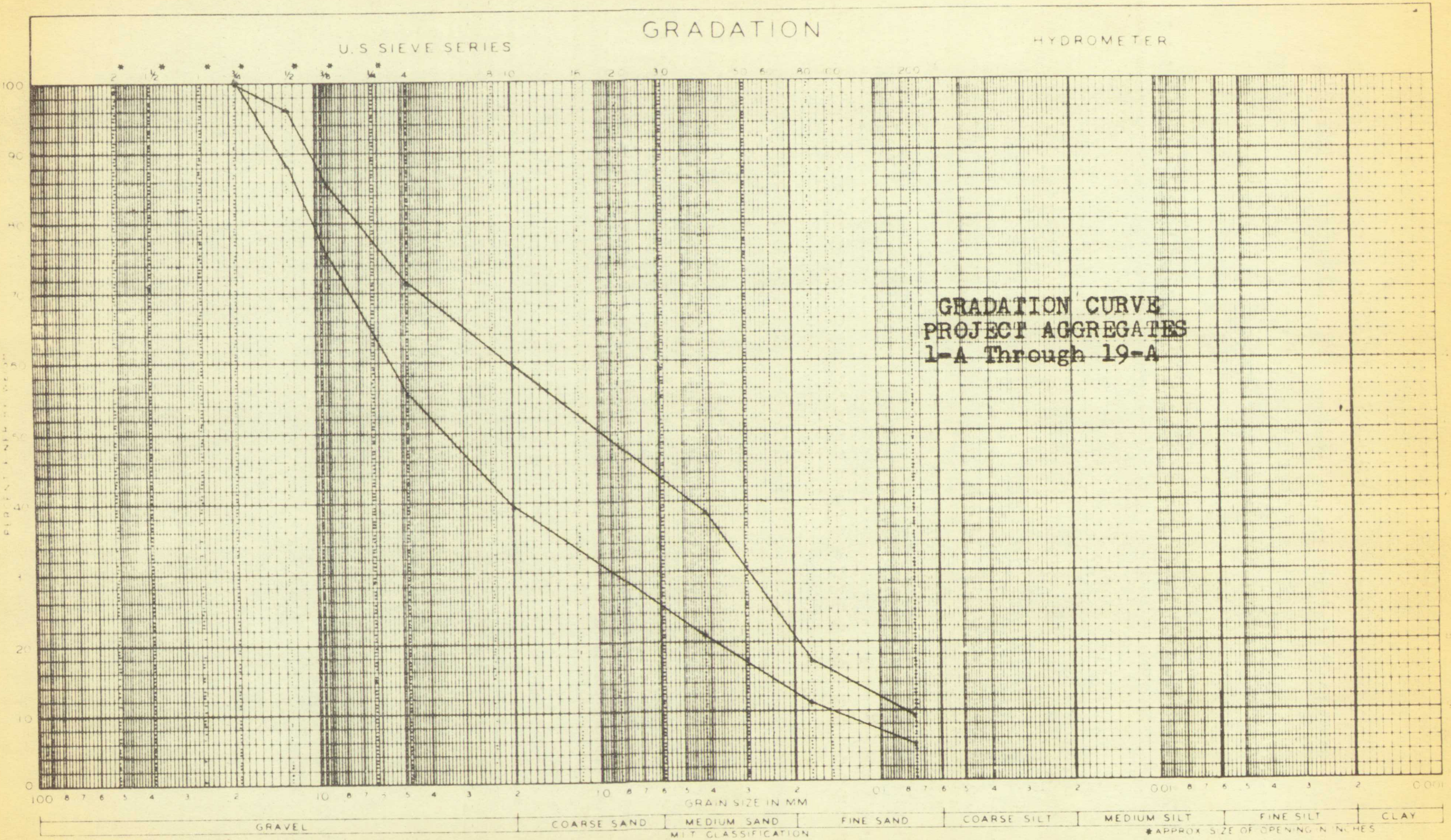
| Aggregate | S.E. No. | %A.C. | Location |
|---|---|---|---|
| 21-A | 38 | 6.25 | NMSHD Project 1-025-3(10)172 and 1-091-3(7) |
| 22-A | 34 | 5.25 | NMSHD Project F-FG-001-3(3) |
| 23-A | 26 | 5.75 | NMSHD Project I-091-3(8) |
| 24-A | 34 | 5.75 | NMSHD Project FO-17-2(2) |
| 25-A | 33 | 6.0 | NMSHD Project F-017-1(1) and F-017-2(3) |
| 26-A | 45 | 5.75 | Silver City, Lowdermilk Pit |
| 27-A | 30 | 5.75 | NMSHD Project 1-091-3(4) |
| 28-A | 30 | 6.0 | NMSHD Project 1-091-3(9) |
| 29-A | 21 | 4.5 | NMSHD Project 1-092-1(4) |

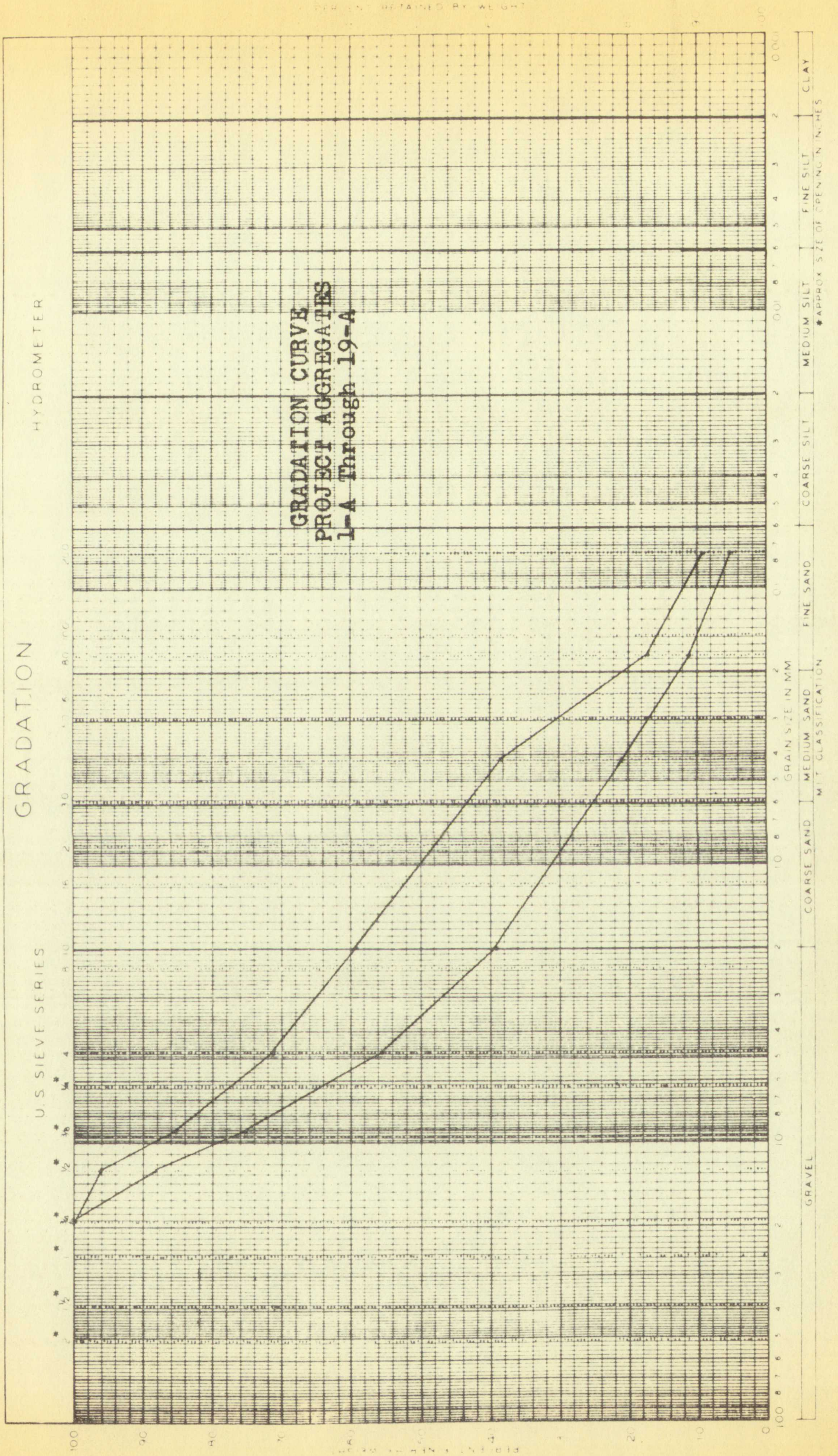
TABLE III
Manufactured Aggregate Data

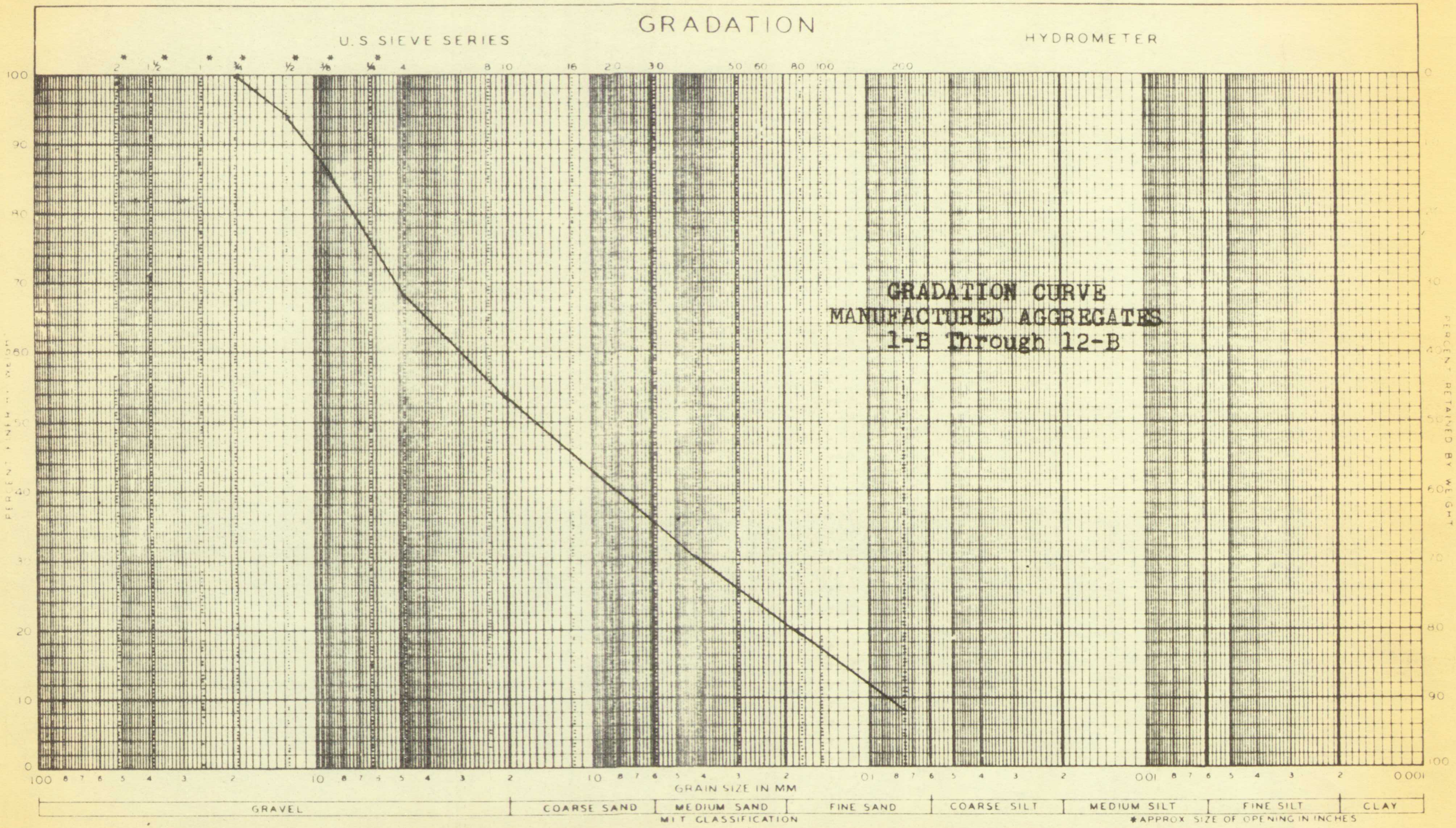
| Aggregate | S.E. No. | Percent and Type of Filler Material |
|---|---|---|
| 1-B | 25 | 10% Red Brick Clay to minus number 4, 6.8% of total mix. |
| 2-B | 22 | 7.5% Bentonite to minus no. 4, 5.1% of total mix. |
| 3-B | 57 | 11.8% Limestone Dust to minus no. 4, 8.0% of total mix. |
| 4-B | 56 | 10.1% Rock Flour and 1.7% Red Brick Clay to minus no. 4, 8.0% of total mix. |
| 5-B | 55 | 11.1% Rock Flour and 0.7% Bentonite to minus no. 4, 8.0% of total mix. |
| 6-B | 56 | 11.8% Red Silty Clay to minus no. 4, 8.0% of total mix. |
| 7-B | 34 | 11.8% Rio Puerco Silt and Clay to minus no. 4, 8.0% of total mix. |
| 8-B | 66 | 11.8% Rock Flour to minus no. 4, 8.0% of total mix. |
| 9-B | 37 | 7.1% Rock Flour and 4.7% Red Brick Clay to minus no. 4, 8.0% of total mix. |
| 10-B | 47 | 8.6% Rock Flour and 3.2% Red Brick Clay to minus no. 4, 8.0% of total mix. |
| 11-B | 37 | 10.0% Rock Flour and 1.8% Bentonite to minus no. 4, 8.0% of total mix. |
| 12-B | 44 | 10.6% Rock Flour and 1.2% Bentonite to minus no. 4, 8.0% of total mix. |

TABLE IV
Filler Material Description
Manufactured Aggregates

| Filler Material | Description |
| --- | --- |
| Bentonite | Obtained from a sack of "Aqua-Gel" drillers mud. (minus 200 material) |
| Red Brick Clay | Local Albuquerque Brick Clay. (minus 200 material) |
| Red Silty Clay | Obtained from Glorietta, New Mexico (minus 200 material) |
| Rio Puerco Silt and Clay | A river deposited silt and clay obtained at the confluence of the Rio Grande and the Rio Puerco Rivers. (minus 200 material) |
| Rock Flour | A high silica content rock flour obtained from the crusher at Albuquerque Gravel Products Co. (minus 200 material) |
| Limestone Dust | A sandy, non-plastic limestone dust obtained from crusher of Witt & Ross. (minus 200 material) |


GRADATION
U.S. SIEVE SERIES
HYDROMETER
GRADATION CURVE
PROJECT AGGREGATES
1-A Through 19-A
GRAIN SIZE IN MM
GRAVEL
COARSE SAND
MEDIUM SAND
FINE SAND
COARSE SILT
MEDIUM SILT
FINE SILT
CLAY
M.I.T. CLASSIFICATION
* APPROX. SIZE OF OPENING IN INCHES


GRADATION
U.S. SIEVE SERIES
HYDROMETER
GRADATION CURVE
PROJECT AGGREGATES
1-A Through 19-A
GRAIN SIZE IN MM
M.I.T. CLASSIFICATION
GRAVEL
COARSE SAND
MEDIUM SAND
FINE SAND
COARSE SILT
MEDIUM SILT
FINE SILT
CLAY


GRADATION
U.S SIEVE SERIES
HYDROMETER
GRADATION CURVE
MANUFACTURED AGGREGATES
1-B Through 12-B
PERCENT RETAINED BY WEIGHT
GRAIN SIZE IN MM
GRAVEL
COARSE SAND
MEDIUM SAND
FINE SAND
COARSE SILT
MEDIUM SILT
FINE SILT
CLAY
M.I.T. CLASSIFICATION
*APPROX SIZE OF OPENING IN INCHES

APPENDIX C

TABLE I DATA SUMMARY

| SAMPLE | S.E. No. | % STAB. RET. | | % INCR. FLOW | | % VOL. INCR. | | % ABSORPTION | | % VOIDS IN MIN. AGG. | % AGG. VOIDS FILLED | % THEORETICAL DENSITY | C.W. ABRASION % LOSS IN WT. | % SWELL (AASHO) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 4 DAY | 14 DAY | 4 DAY | 14 DAY | 4 DAY | 14 DAY | 4 DAY | 14 DAY | | | | | |
| 1-A | 32 | 51.4 | 31.9 | 81.1 | 130 | 3.63 | 4.38 | 2.14 | 3.73 | 21.5 | 59.4 | 91.2 | 23.02 | 0.18 |
| 2-A | 53 | 100 | 83.4 | 1.0 | 25.8 | 0.0 | 0.58 | 0.37 | 1.02 | 18.5 | 81.8 | 96.6 | 5.83 | 0.09 |
| 4-A | 34 | 87.4 | 79.6 | 25.0 | 37.5 | 1.32 | 1.35 | 1.69 | 1.32 | 15.8 | 64.4 | 94.4 | 13.50 | 0.36 |
| 11-A | 44 | 69.9 | 64.0 | 37.1 | 21.5 | 0.90 | 1.83 | 1.14 | 1.41 | 18.1 | 81.9 | 96.7 | 5.98 | 0.09 |
| 14-A | 33 | 79.8 | 70.2 | 14.2 | 19.2 | 2.10 | 1.48 | 1.52 | 1.64 | 16.7 | 71.1 | 95.1 | 9.19 | 0.05 |
| 15-A | 31 | 47.6 | 40.6 | 67.0 | 60.0 | 2.42 | 2.78 | 1.79 | 1.92 | 18.9 | 74.9 | 94.8 | 11.58 | 0.59 |
| 17-A | 35 | 57.1 | 87.4 | 3.5 | 8.8 | 1.21 | 0.91 | 1.40 | 0.89 | 16.7 | 85.7 | 97.6 | 13.64 | 0.00 |
| 18-A | 52 | 84.6 | 73.1 | 37.0 | 40.0 | 1.75 | 0.96 | 1.28 | 1.79 | 20.7 | 77.5 | 95.3 | 6.43 | 0.23 |
| 19-A | 56 | 91.7 | 83.7 | 44.4 | 55.5 | 1.76 | 1.17 | 1.51 | 1.39 | 17.6 | 80.5 | 96.5 | 6.55 | 0.14 |
| 21-A | 38 | 71.8 | 49.2 | 36.4 | 70.0 | 1.00 | 1.55 | 0.88 | 1.37 | 18.6 | 75.7 | 95.4 | 7.37 | 0.18 |
| 22-A | 34 | 82.8 | 79.7 | 15.5 | 6.4 | 0.32 | 0.60 | 0.51 | 0.38 | 14.0 | 88.1 | 98.3 | 7.49 | 0.00 |
| 23-A | 26 | 53.4 | 62.1 | 21.8 | 37.6 | 2.07 | 2.07 | 1.00 | 1.26 | 17.4 | 76.7 | 95.9 | 12.47 | 0.27 |
| 24-A | 34 | 86.0 | 103.5 | 6.8 | 2.0 | 0.86 | 1.29 | 1.13 | 0.99 | 16.3 | 79.5 | 96.7 | 7.74 | 0.13 |
| 25-A | 33 | 65.2 | 78.3 | 65.4 | 81.1 | 1.64 | 2.47 | 1.50 | 1.45 | 18.8 | 68.9 | 94.1 | 17.54 | 0.26 |
| 26-A | 47 | 91.5 | 88.6 | 23.8 | 11.9 | 1.00 | 1.14 | 0.75 | 0.88 | 17.7 | 73.2 | 95.2 | 4.28 | 0.04 |
| 27-A | 30 | 77.5 | 74.8 | 64.3 | 59.3 | 1.37 | 1.64 | 1.38 | 1.38 | 18.5 | 67.7 | 94.0 | 10.34 | 0.22 |
| 28-A | 30 | 82.1 | 82.3 | 0.0 | 4.9 | 0.29 | 0.87 | 0.51 | 0.50 | 17.0 | 80.7 | 96.8 | 6.39 | 0.13 |
| 29-A | 21 | 43.3 | 56.6 | 68.0 | 42.9 | 3.03 | 2.73 | 1.50 | 1.37 | 15.2 | 70.6 | 95.5 | 22.43 | 0.28 |
| 1-B | 25 | 0.0 | 30.9 | - | 113.6 | - | 5.0 | - | 2.40 | 17.4 | 79.3 | 96.4 | - | 0.09 |
| 2-B | 22 | - | 17.5 | - | 148.2 | - | 7.6 | - | 4.72 | 21.5 | 61.59 | 91.6 | - | 0.78 |
| 3-B | 57 | 81.2 | 94.9 | 12.4 | 35.3 | 0.32 | 0.0 | 0.38 | 0.38 | 17.1 | 81.6 | 96.8 | 4.39 | 0.00 |
| 4-B | 56 | 72.8 | 88.7 | 10.2 | 8.1 | 1.20 | 0.60 | 0.50 | 0.51 | 16.6 | 84.5 | 97.4 | 5.21 | 0.00 |
| 5-B | 55 | 96.0 | 88.2 | 0.0 | 0.0 | 0.0 | 0.3 | 0.38 | 0.25 | 16.9 | 82.5 | 87.0 | 6.75 | 0.10 |
| 6-B | 36 | 57.8 | 92.6 | 47.7 | 12.4 | 1.19 | 2.10 | 0.77 | 0.50 | 16.59 | 84.1 | 96.7 | 21.17 | 0.00 |
| 7-B | 34 | 72.6 | 73.6 | 25.9 | 10.2 | 0.89 | 1.50 | 0.89 | 0.38 | 16.9 | 82.7 | 97.1 | 12.07 | 0.00 |
| 8-B | 66 | 91.7 | 100.1 | 15.4 | 2.7 | 0.0 | 0.9 | 0.0 | 0.13 | 16.8 | 83.1 | 96.1 | 8.04 | 0.05 |
| 9-B | 37 | 77.0 | 93.5 | 46.7 | 33.6 | 1.5 | 0.28 | 0.76 | 0.38 | 17.38 | 79.8 | 96.5 | 16.34 | 0.00 |
| 10-B | 47 | 79.6 | 92.8 | 17.0 | 28.2 | 0.89 | 0.59 | 0.51 | 0.38 | 17.36 | 79.9 | 96.5 | 13.36 | 0.00 |
| 11-B | 37 | 98.0 | 96.1 | 0.0 | 3.3 | 0.14 | 0.29 | 0.25 | 0.25 | 17.81 | 77.4 | 96.0 | 9.05 | 0.00 |
| 12-B | 44 | 93.9 | 89.0 | 8.3 | 30.8 | 0.88 | 0.31 | 0.38 | 0.26 | 17.83 | 77.3 | 96.0 | 6.78 | 0.00 |

TABLE II-A
IMMERSION COMPRESSION RESULTS
4 Days at 120° F

| Sample Number | Before Immersion Wt. in Air gms. | Before Immersion Wt. in Water gms. | Before Immersion Volume cc | After Immersion Wt. in Air gms. | After Immersion Wt. in Water gms. | After Immersion Volume cc | Marshall Stability lbs. | Flow | Avg. Stability Retained % |
|---|---|---|---|---|---|---|---|---|---|
| 1-A-1 | 1192.9 | 657.7 | 535.2 | | | | 1497 | 9 | |
| 1-A-2 | 1256.5 | 689.5 | 567.0 | | | | 1529 | 10 | |
| 1-A-3 | 1183.9 | 644.1 | 539.8 | | | | 1279 | 8 | |
| 1-A-4 | 1202.0 | 662.0 | 539.8 | 1229.2 | 666.8 | 562.5 | 581 | 15 | (51.4) |
| 1-A-5 | 1202.0 | 662.2 | 539.8 | 1229.2 | 671.3 | 557.9 | 994 | 19 | |
| 1-A-6 | 1202.0 | 662.2 | 539.8 | 1224.7 | 671.3 | 557.9 | 637 | 15 | |
| 2-A-1 | 1202.0 | 680.0 | 521.6 | | | | 1586 | 9 | |
| 2-A-2 | 1192.9 | 675.9 | 517.0 | | | | 1500 | 9 | |
| 2-A-3 | 1206.6 | 689.5 | 517.0 | | | | 1829 | 10 | |
| 2-A-4 | 1215.6 | 694.0 | 521.6 | 1220.2 | 698.5 | 521.6 | 1829 | 11 | (100.0) |
| 2-A-5 | 1197.5 | 684.9 | 512.6 | 1202.0 | 689.5 | 512.6 | 1358 | 10 | |
| 2-A-6 | 1197.5 | 680.4 | 517.1 | 1202.0 | 684.9 | 517.1 | 1885 | 11 | |
| 4-A-1 | 1192.9 | 680.4 | 508.0 | | | | 1308 | 7 | |
| 4-A-2 | 1183.9 | 675.9 | 508.0 | | | | 1326 | 9 | |
| 4-A-3 | 1188.4 | 680.4 | 508.0 | | | | 1430 | 8 | |
| 4-A-4 | 1202.0 | 689.5 | 512.6 | 1220.2 | 703.1 | 517.1 | 1200 | 10 | (87.4) |
| 4-A-5 | 1206.6 | 689.5 | 517.1 | 1229.2 | 703.1 | 526.2 | 1168 | 10 | |
| 4-A-6 | Data Unreliable | | | | | | | | |
| 11-A-1 | 1183.9 | 684.9 | 499.0 | | | | 1669 | 9 | |
| 11-A-2 | 1183.9 | 684.9 | 499.0 | | | | 1552 | 9 | |
| 11-A-3 | 1202.0 | 698.5 | 503.5 | | | | 1839 | 10 | |
| 11-A-4 | 1179.3 | 680.4 | 499.0 | 1197.5 | 694.0 | 503.5 | 1032 | 12 | (69.9) |
| 11-A-5 | 1206.6 | 698.5 | 508.0 | 1202.0 | 707.6 | 512.6 | 1133 | 14 | |
| 11-A-6 | 1179.3 | 689.5 | 489.9 | 1188.4 | 694.0 | 494.4 | 1371 | 14 | |

TABLE II-A
IMMERSION COMPRESSION RESULTS
4 Days at 120° F

| Sample Number | Before Immersion Wt. in Air (gms.) | Wt. in Water (gms) | Volume (cc) | After Immersion Wt. in Air (gms) | Wt. In Water (gms) | Volume (cc) | Marshall Stability (lbs) | Flow | Avg. Stability Retained (%) |
|---|---|---|---|---|---|---|---|---|---|
| 14-A-1 | 1202.0 | 694.0 | 508.0 | | | | 2226 | 13 | |
| 14-A-2 | 1211.1 | 703.1 | 508.0 | | | | 2062 | 9 | |
| 14-A-3 | 1202.0 | 694.0 | 508.0 | | | | 2124 | 14 | |
| 14-A-4 | 1188.4 | 689.5 | 499.0 | 1211.1 | 694.0 | 517.1 | 1595 | 13 | (79.8) |
| 14-A-5 | 1192.9 | 694.0 | 499.0 | 1211.1 | 703.1 | 508.0 | 1711 | 15 | |
| 14-A-6 | 1197.5 | 694.0 | 503.5 | 1211.1 | 703.1 | 508.0 | 1812 | 13 | |
| 15-A-1 | 1183.9 | 689.5 | 494.4 | | | | 1608 | 10 | |
| 15-A-2 | 1174.8 | 684.9 | 489.9 | | | | 2012 | 10 | |
| 15-A-3 | 1174.8 | 684.9 | 489.9 | | | | 1690 | 10 | |
| 15-A-4 | 1192.9 | 694.0 | 499.0 | 1211.1 | 703.1 | 508.0 | 965 | 15 | (47.6) |
| 15-A-5 | 1192.9 | 694.0 | 499.0 | 1211.1 | 703.1 | 508.0 | 832 | 16 | |
| 15*A-6 | 1170.3 | 680.4 | 489.9 | 1197.5 | 689.5 | 508.0 | 728 | 19 | |
| 17-A-1 | 1202.0 | 703.1 | 498.9 | | | | 1944 | 12 | |
| 17-A-2 | 1192.9 | 694.0 | 498.9 | | | | 1861 | 12 | |
| 17-A-3 | 1211.1 | 707.6 | 503.5 | | | | 2062 | 10 | |
| 17-A-4 | 1188.4 | 689.5 | 499.0 | 1206.6 | 698.5 | 508.0 | 990 | 12 | (57.1) |
| 17-A-5 | 1192.9 | 698.5 | 494.4 | 1206.6 | 707.6 | 499.0 | 1274 | 11 | |
| 17-A-6 | 1197.5 | 698.5 | 499.0 | 1215.6 | 712.1 | 503.5 | 1084 | 11 | |
| 18-A-1 | 1198.0 | 661.0 | 537.0 | | | | 2062 | 9 | |
| 18-A-2 | 1195.0 | 664.0 | 531.0 | | | | 2221 | 9 | |
| 18-A-3 | 1200.0 | 670.0 | 530.0 | | | | 2400 | 12 | |
| 18-A-4 | 1192.9 | 675.9 | 517.1 | 1211.1 | 680.4 | 530.7 | 1856 | 13 | (84.6) |
| 18-A-5 | 1188.4 | 675.9 | 512.6 | 1202.0 | 680.4 | 521.6 | 1857 | 14 | |
| 18-A-6 | 1192.9 | 680.4 | 512.6 | 1206.6 | 689.5 | 517.1 | 1942 | 14 | |

TABLE II-A
IMMERSION COMPRESSION RESULTS
4 Days at 120° F

| Sample Number | Before Immersion Wt. in Air (gms) | Before Immersion Wt. in Water (gms) | Before Immersion Volume (cc) | After Immersion Wt. in Air (gms) | After Immersion Wt. in Water (gms) | After Immersion Volume (cc) | Marshall Stability (lbs) | Flow | Avg. Stability Retained (%) |
|---|---|---|---|---|---|---|---|---|---|
| 19-A-1 | 1192.9 | 684.9 | 508.0 | | | | 1918 | 8 | |
| 19-A-2 | 1202.0 | 684.9 | 517.1 | | | | 1844 | 9 | |
| 19-A-3 | 1202.0 | 689.5 | 512.6 | | | | 1812 | 10 | |
| 19-A-4 | 1206.6 | 694.0 | 512.6 | 1224.7 | 703.1 | 521.6 | 1354 | 15 | (91.7) |
| 19-A-5 | 1202.0 | 684.9 | 517.1 | 1220.2 | 694.0 | 526.2 | 1616 | 11 | |
| 19-A-6 | 1202.0 | 694.0 | 508.0 | 1220.2 | 703.1 | 517.1 | 1640 | 13 | |
| 21-A-1 | 1211.1 | 680.4 | 530.7 | | | | 1920 | 10 | |
| 21-A-2 | 1206.6 | 678.1 | 528.5 | | | | 2011 | 12 | |
| 21-A-3 | 1206.6 | 680.4 | 526.2 | | | | 2054 | 11 | |
| 21-A-4 | 1211.1 | 680.4 | 530.7 | 1220.2 | 684.9 | 535.3 | 1531 | 15 | (71.8) |
| 21-A-5 | 1206.6 | 678.1 | 528.5 | 1215.6 | 682.6 | 533.0 | 1344 | 15 | |
| 21-A-6 | 1206.6 | 678.1 | 528.5 | 1220.2 | 684.9 | 535.3 | 1421 | 15 | |
| 22-A-1 | 1202.0 | 698.5 | 503.5 | | | | 1685 | 12 | |
| 22-A-2 | 1197.5 | 694.0 | 503.5 | | | | 1737 | 10 | |
| 22-A-3 | 1206.6 | 698.5 | 508.1 | | | | 1940 | 11 | |
| 22-A-4 | 1202.0 | 698.5 | 503.5 | 1206.6 | 703.1 | 503.5 | 1508 | 12 | (82.8) |
| 22-A-5 | 1197.5 | 694.0 | 503.5 | 1206.6 | 698.5 | 508.1 | 1518 | 13 | |
| 22-A-6 | 1202.0 | 694.0 | 508.0 | 1206.6 | 698.5 | 508.1 | 1414 | 12 | |
| 23-A-1 | 1202.0 | 689.5 | 512.5 | | | | 1865 | 13 | |
| 23-A-2 | 1206.6 | 698.5 | 508.1 | | | | 2246 | 14 | |
| 23-A-3 | 1202.0 | 694.0 | 508.0 | | | | 2408 | 13 | |
| 23-A-4 | 1211.1 | 698.5 | 512.6 | 1224.7 | 698.5 | 526.2 | 984 | 16 | (53.4) |
| 23-A-5 | 1202.0 | 689.5 | 512.5 | 1211.1 | 694.0 | 517.1 | 1220 | 17 | |
| 23-A-6 | 1202.0 | 694.0 | 508.0 | 1215.6 | 694.0 | 521.6 | 1280 | 17 | |

TABLE II-A
IMMERSION COMPRESSION RESULTS
4 Days at 120°F

| Sample Number | Before Immersion Wt. in Air gms. | Before Immersion Wt. in Water gms. | Before Immersion Volume cc | After Immersion Wt. in Air gms. | After Immersion Wt. in Water gms. | After Immersion Volume cc | Marshall Stability lbs. | Flow | Avg. Stability Retained % |
|---|---|---|---|---|---|---|---|---|---|
| 24-A-1 | 1211.1 | 680.4 | 530.7 | | | | 2890 | 16 | |
| 24-A-2 | 1202.0 | 675.9 | 526.1 | | | | 3192 | 14 | |
| 24-A-3 | 1197.5 | 673.6 | 523.9 | | | | 3040 | 14 | |
| 24-A-4 | 1206.6 | 680.4 | 526.2 | 1220.2 | 689.5 | 530.7 | 2880 | 15 | (86.0) |
| 24-A-5 | 1202.0 | 675.9 | 526.1 | 1215.6 | 684.9 | 530.7 | 2539 | 16 | |
| 24-A-6 | 1206.6 | 680.4 | 526.2 | 1220.2 | 689.5 | 530.7 | 2424 | 16 | |
| 25-A-1 | 1211.1 | 657.7 | 553.4 | | | | 2225 | 13 | |
| 25-A-2 | 1206.6 | 653.2 | 553.4 | | | | 2011 | 13 | |
| 25-A-3 | 1197.5 | 653.2 | 544.3 | | | | 2530 | 12 | |
| 25-A-4 | 1206.6 | 657.7 | 548.9 | 1224.7 | 666.8 | 557.9 | 1388 | 20 | (65.2) |
| 25-A-5 | 1211.1 | 657.7 | 553.4 | 1229.2 | 666.8 | 562.4 | 1393 | 21 | |
| 25-A-6 | 1211.1 | 662.2 | 548.9 | 1229.2 | 671.3 | 557.9 | 1629 | 22 | |
| 26-A-1 | 1206.6 | 675.9 | 530.7 | | | | 2539 | 15 | |
| 26-A-2 | 1220.2 | 684.9 | 535.3 | | | | 2222 | 13 | |
| 26-A-3 | 1202.0 | 675.9 | 526.1 | | | | 2578 | 15 | |
| 26-A-4 | 1215.6 | 684.9 | 530.7 | 1224.7 | 687.2 | 537.5 | 2251 | 17 | (91.5) |
| 26-A-5 | 1211.1 | 680.4 | 530.7 | 1220.2 | 684.9 | 535.3 | 2275 | 18 | |
| 26-A-6 | 1211.1 | 680.4 | 530.7 | 1220.2 | 684.9 | 535.3 | 2189 | 17 | |
| 27-A-1 | 1211.1 | 662.2 | 548.9 | | | | 2212 | 14 | |
| 27-A-2 | 1206.6 | 657.7 | 548.9 | | | | 2247 | 14 | |
| 27-A-3 | 1206.6 | 662.2 | 544.4 | | | | 2423 | 14 | |
| 27-A-4 | 1206.6 | 662.2 | 544.4 | 1224.7 | 671.3 | 553.4 | 1589 | 25 | (77.5) |
| 27-A-5 | 1206.6 | 657.7 | 548.9 | 1220.2 | 666.8 | 553.4 | 2158 | 22 | |
| 27-A-6 | 1206.6 | 662.2 | 544.4 | 1224.7 | 671.3 | 553.4 | 1584 | 22 | |

TABLE II-A
IMMERSION COMPRESSION RESULTS
4 Days at 120° F

| Sample Number | Before Immersion Wt. in Air (gms) | Before Immersion Wt. in Water (gms) | Before Immersion Volume (cc) | After Immersion Wt. in Air (gms) | After Immersion Wt. in Water (gms) | After Immersion Volume (cc) | Marshall Stability (lbs) | Flow | Avg. Stability Retained (%) |
|---|---|---|---|---|---|---|---|---|---|
| 28-A-1 | 1197.5 | 680.4 | 517.1 | | | | 3580 | 16 | |
| 28-A-2 | 1202.0 | 684.9 | 517.1 | | | | 2925 | 14 | |
| 28-A-3 | 1206.6 | 689.5 | 517.1 | | | | 3255 | 13 | |
| 28-A-4 | 1202.0 | 684.9 | 517.1 | 1211.1 | 689.5 | 521.6 | 2500 | 13 | (82.1) |
| 28-A-5 | 1206.6 | 689.5 | 517.1 | 1211.1 | 694.0 | 517.1 | 2665 | 14 | |
| 28-A-6 | 1197.5 | 680.4 | 517.1 | 1202.0 | 684.9 | 517.1 | 2850 | 15 | |
| 29-A-1 | 1206.6 | 712.1 | 494.5 | | | | 3477 | 14 | |
| 29-A-2 | 1211.1 | 712.1 | 499.0 | | | | 3099 | 15 | |
| 29-A-3 | 1206.6 | 707.6 | 499.0 | | | | 2922 | 15 | |
| 29-A-4 | 1202.0 | 707.6 | 494.4 | 1220.2 | 707.6 | 512.6 | 1190 | 23 | (43.3) |
| 29-A-5 | 1206.6 | 707.6 | 499.0 | 1224.7 | 712.1 | 512.6 | 1550 | 23 | |
| 29-A-6 | 1211.1 | 707.6 | 503.5 | 1229.2 | 712.1 | 517.1 | 1370 | 28 | |
| 1-B-1 | 1183.9 | 680.4 | 503.5 | | | | 1394 | 12 | |
| 1-B-2 | 1197.5 | 684.9 | 512.6 | | | | 1210 | 10 | |
| 1-B-3 | 1188.4 | 675.9 | 512.5 | | | | 1540 | 9 | |
| 1-B-4 | 1188.4 | 680.4 | 508.0 | These briquettes disintigrated and could not be tested. | | | | | (0.0) |
| 1-B-5 | 1192.9 | 684.9 | 508.0 | | | | | | |
| 1-B-6 | 1188.4 | 680.4 | 508.0 | | | | | | |
| 2-B-1 | 1188.4 | 644.1 | 544.3 | | | | 916 | 11 | |
| 2-B-2 | 1188.4 | 644.1 | 544.3 | | | | 967 | 11 | |
| 2-B-3 | 1192.9 | 653.2 | 539.7 | | | | 953 | 11 | |
| 2-B-4 | 1174.8 | 644.1 | 530.8 | These briquettes disintegrated and could not be tested. | | | | | (0.0) |
| 2-B-5 | 1188.4 | 648.6 | 539.8 | | | | | | |
| 2-B-6 | 1188.4 | 644.1 | 544.3 | | | | | | |

TABLE II-A
IMMERSION COMPRESSION RESULTS
4 Days at 120°F

| Sample Number | Before Immersion Wt. in Air gms. | Before Immersion Wt. in Water gms. | Before Immersion Volume cc | After Immersion Wt. in Air gms. | After Immersion Wt. in Water gms. | After Immersion Volume cc | Marshall Stability lbs. | Flow | Avg. Stability Retained % |
|---|---|---|---|---|---|---|---|---|---|
| 3-B-1 | 1179.3 | 680.4 | 489.9 | | | | 1586 | 11 | |
| 3-B-2 | 1192.9 | 689.5 | 503.4 | | | | 1570 | 12 | |
| 3-B-3 | 1161.2 | 671.3 | 489.9 | | | | 1537 | 11 | |
| 3-B-4 | 1183.9 | 684.9 | 499.0 | 1188.4 | 684.9 | 503.5 | 1227 | 12 | (81.2) |
| 3-B-5 | 1179.3 | 680.4 | 498.9 | 1183.9 | 684.9 | 499.0 | 1326 | 13 | |
| 3-B-6 | 1179.3 | 680.4 | 498.9 | 1183.9 | 684.9 | 499.0 | 1258 | 12 | |
| 4-B-1 | 1188.4 | 684.9 | 503.5 | | | | 1586 | 13 | |
| 4-B-2 | 1188.4 | 684.9 | 503.5 | | | | 1659 | 13 | |
| 4-B-3 | 1188.4 | 684.9 | 503.5 | | | | 1550 | 12 | |
| 4-B-4 | 1183.9 | 684.9 | 499.0 | 1192.9 | 684.9 | 508.0 | 1009 | 15 | (72.8) |
| 4-B-5 | 1183.9 | 689.5 | 494.4 | 1188.4 | 689.5 | 498.9 | 1310 | 14 | |
| 4-B-6 | 1183.9 | 684.9 | 499.0 | 1188.4 | 684.9 | 503.5 | 1170 | 13 | |
| 5-B-1 | 1188.4 | 684.9 | 503.5 | | | | 1612 | 12 | |
| 5-B-2 | 1188.4 | 684.9 | 503.5 | | | | 1669 | 12 | |
| 5-B-3 | 1192.9 | 689.5 | 503.5 | | | | 1726 | 12 | |
| 5-B-4 | 1188.4 | 684.9 | 503.5 | 1192.9 | 689.5 | 503.4 | 1612 | 12 | (96.0) |
| 5-B-5 | 1192.9 | 684.9 | 508.0 | 1197.5 | 689.5 | 508.0 | 1633 | 12 | |
| 5-B-6 | 1188.4 | 684.9 | 503.5 | 1192.9 | 689.5 | 503.4 | 1560 | 12 | |
| 6-B-1 | 1188.4 | 684.9 | 503.5 | | | | 1570 | 11 | |
| 6-B-2 | 1188.4 | 684.9 | 503.5 | | | | 1638 | 11 | |
| 6-B-3 | 1197.5 | 689.5 | 508.0 | | | | 1560 | 12 | |
| 6-B-4 | 1192.9 | 689.5 | 503.5 | 1202.0 | 689.5 | 512.5 | 860 | 16 | (57.8) |
| 6-B-5 | 1183.9 | 680.4 | 503.5 | 1192.9 | 684.9 | 508.0 | 936 | 17 | |
| 6-B-6 | 1183.9 | 680.4 | 503.5 | 1192.9 | 684.9 | 508.0 | 957 | 17 | |

TABLE II-A
IMMERSION COMPRESSION RESULTS
4 Days at 120°F

| Sample Number | Wt. in Air gms. | Wt. in Water gms. | Volume cc | Wt. in Air gms. | Wt. in Water gms. | Volume cc | Marshall Stability lbs. | Flow | Avg. Stability Retained % |
|---|---|---|---|---|---|---|---|---|---|
| 7-B-1 | 1174.8 | 675.9 | 498.9 | | | | 1529 | 13 | |
| 7-B-2 | 1197.5 | 689.5 | 508.0 | | | | 1612 | 13 | |
| 7-B-3 | 1193.9 | 689.5 | 503.4 | | | | 1482 | 12 | |
| 7-B-4 | 1183.9 | 684.9 | 499.0 | 1192.9 | 689.5 | 503.4 | 1134 | 16 | (72.6) |
| 7-B-5 | 1183.9 | 684.9 | 499.0 | 1197.5 | 694.0 | 503.5 | 1144 | 15 | |
| 7-B-6 | 1202.0 | 689.5 | 512.5 | 1211.1 | 694.0 | 517.1 | 1080 | 17 | |
| 8-B-1 | 1192.9 | 689.5 | 503.4 | | | | 1482 | 12 | |
| 8-B-2 | 1192.9 | 684.9 | 508.0 | | | | 1591 | 10 | |
| 8-B-3 | 1192.9 | 689.5 | 503.4 | | | | 1602 | 11 | |
| 8-B-3 | 1202.0 | 694.0 | 508.0 | 1202.0 | 694.0 | 508.0 | 1394 | 13 | (91.7) |
| 8-B-5 | 1197.5 | 689.5 | 508.0 | 1197.5 | 689.5 | 508.0 | 1498 | 13 | |
| 8-B-6 | 1192.9 | 689.5 | 503.4 | 1192.9 | 689.5 | 503.4 | 1394 | 13 | |
| 9-B-1 | 1183.9 | 680.4 | 503.5 | | | | 1789 | 10 | |
| 9-B-2 | 1197.5 | 684.9 | 512.6 | | | | 1550 | 11 | |
| 9-B-3 | 1197.5 | 684.9 | 512.6 | | | | 1510 | 11 | |
| 9-B-4 | 1192.9 | 684.9 | 508.0 | 1202.0 | 684.9 | 517.1 | 1225 | 17 | (77.0) |
| 9-B-5 | 1188.4 | 684.9 | 503.5 | 1197.5 | 684.9 | 512.6 | 1240 | 16 | |
| 9-B-6 | 1188.4 | 680.4 | 508.0 | 1197.5 | 684.9 | 512.6 | 1270 | 14 | |
| 10-B-1 | 1197.5 | 684.9 | 512.6 | | | | 1750 | 12 | |
| 10-B-2 | 1192.9 | 684.9 | 508.0 | | | | 1810 | 10 | |
| 10-B-3 | 1192.9 | 684.9 | 508.0 | | | | 1586 | 13 | |
| 10-B-4 | 1197.5 | 684.9 | 512.6 | 1206.6 | 689.5 | 517.1 | 1370 | 14 | (79.6) |
| 10-B-5 | 1188.4 | 684.9 | 503.5 | 1192.9 | 684.9 | 508.0 | 1352 | 13 | |
| 10-B-6 | 1192.9 | 684.9 | 508.0 | 1197.5 | 684.9 | 512.6 | 1375 | 13 | |

TABLE II-A
IMMERSION COMPRESSION RESULTS
4 Days at 120°F

| Sample Number | Before Immersion Wt. in Air gms. | Wt. in Water gms. | Volume cc | After Immersion Wt. in Air gms. | Wt. in Water gms. | Volume cc | Marshall Stability lbs. | Flow | Avg. Stability Retained % |
|---|---|---|---|---|---|---|---|---|---|
| 11-B-1 | 1192.9 | 680.4 | 512.5 | | | | 1680 | 12 | |
| 11-B-2 | 1192.9 | 680.4 | 512.5 | | | | 1595 | 13 | |
| 11-B-3 | 1188.4 | 680.4 | 508.0 | | | | 1706 | 13 | |
| 11-B-4 | 1188.4 | 680.4 | 508.0 | 1192.9 | 684.9 | 508.0 | 1560 | 13 | (98.0) |
| 11-B-5 | 1183.9 | 678.1 | 505.8 | 1183.9 | 680.4 | 503.5 | 1659 | 12 | |
| 11-B-6 | 1197.5 | 684.9 | 512.6 | 1202.0 | 684.9 | 517.1 | 1660 | 11 | |
| 12-B-1 | 1192.9 | 684.9 | 508.0 | | | | 1830 | 13 | |
| 12-B-2 | 1192.9 | 680.4 | 512.5 | | | | 1580 | 12 | |
| 12-B-3 | 1197.5 | 684.9 | 512.6 | | | | 1615 | 11 | |
| 12-B-4 | 1197.5 | 684.9 | 512.6 | 1202.0 | 684.9 | 517.1 | 1725 | 14 | (93.9) |
| 12-B-5 | 1183.9 | 675.9 | 508.0 | 1188.4 | 675.9 | 512.5 | 1470 | 12 | |
| 12-B-6 | 1202.0 | 684.9 | 517.1 | 1206.6 | 684.9 | 521.7 | 1525 | 13 | |

TABLE II-B
IMMERSION COMPRESSION RESULTS
14 Days at Room Temp.

| Sample Number | Before Immersion Wt. in Air gms. | Before Immersion Wt. in Water gms. | Before Immersion Volume cc | After Immersion Wt. in Air gms. | After Immersion Wt. in Water gms. | After Immersion Volume cc | Marshall Stability lbs. | Flow | Avg. Stability Retained % |
|---|---|---|---|---|---|---|---|---|---|
| 1-A-1 | 1192.9 | 657.7 | 535.2 | | | | 1497 | 9 | |
| 1-A-2 | 1256.5 | 689.5 | 567.0 | | | | 1529 | 10 | |
| 1-A-3 | 1183.9 | 644.1 | 539.8 | | | | 1279 | 8 | |
| 1-A-7 | 1192.9 | 653.2 | 539.7 | 1238.3 | 671.3 | 567.0 | 406 | 20 | (31.9) |
| 1-A-8 | 1188.4 | 653.2 | 535.2 | 1229.2 | 675.9 | 553.0 | 459 | 20 | |
| 1-A-9 | 1265.5 | 689.5 | 576.0 | 1315.4 | 712.1 | 603.3 | 509 | 22 | |
| 2-A-1 | 1202.0 | 680.4 | 521.6 | | | | 1586 | 9 | |
| 2-A-2 | 1192.9 | 675.9 | 517.0 | | | | 1500 | 9 | |
| 2-A-3 | 1206.6 | 689.5 | 517.1 | | | | 1829 | 10 | |
| 2-A-7 | 1202.0 | 684.9 | 517.1 | 1215.6 | 694.0 | 521.6 | 1291 | 12 | (83.4) |
| 2-A-8 | 1192.9 | 680.4 | 512.5 | 1202.0 | 689.5 | 512.5 | 1325 | 12 | |
| 2-A-9 | 1192.9 | 675.9 | 517.0 | 1206.6 | 684.9 | 521.7 | 1483 | 11 | |
| 4-A-1 | 1192.9 | 680.4 | 508.0 | | | | 1308 | 7 | |
| 4-A-2 | 1183.9 | 675.9 | 508.0 | | | | 1326 | 9 | |
| 4-A-3 | 1188.4 | 680.4 | 508.0 | | | | 1430 | 8 | |
| 4-A-7 | 1206.6 | 698.5 | 508.0 | 1220.2 | 707.6 | 512.6 | 1150 | 10 | (79.6) |
| 4-A-8 | 1174.8 | 671.3 | 503.5 | 1190.4 | 680.4 | 510.3 | 1025 | 10 | |
| 4-A-9 | 1197.5 | 689.5 | 508.0 | 1215.6 | 698.5 | 517.1 | 1058 | 13 | |
| 11-A-1 | 1183.9 | 684.9 | 499.0 | | | | 1669 | 9 | |
| 11-A-2 | 1183.9 | 684.9 | 499.0 | | | | 1552 | 9 | |
| 11-A-3 | 1202.0 | 698.5 | 503.5 | | | | 1839 | 10 | |
| 11-A-7 | 1170.3 | 680.4 | 489.9 | 1188.4 | 689.5 | 498.9 | 1100 | 13 | (64.0) |
| 11-A-8 | 1188.4 | 684.9 | 503.5 | 1206.6 | 698.5 | 508.1 | 1008 | 10 | |
| 11-A-9 | 1188.4 | 689.5 | 498.9 | 1202.0 | 689.5 | 512.5 | 1133 | 11 | |

TABLE II-B
IMMERSION COMPRESSION RESULTS
14 Days at Room Temp.

| Sample Number | Before Immersion Wt. in Air gms. | Before Immersion Wt. in Water gms. | Before Immersion Volume cc | After Immersion Wt. in Air gms. | After Immersion Wt. in Water gms. | After Immersion Volume cc | Marshall Stability lbs. | Flow | Avg. Stability Retained % |
|---|---|---|---|---|---|---|---|---|---|
| 14-A-1 | 1202.0 | 694.0 | 508.0 | | | | 2226 | 13 | |
| 14-A-2 | 1211.1 | 703.1 | 508.0 | | | | 2062 | 9 | |
| 14-A-3 | 1202.0 | 694.0 | 508.0 | | | | 2124 | 14 | |
| 14-A-7 | 1206.6 | 694.0 | 512.6 | 1224.7 | 703.1 | 521.6 | 1675 | 14 | (70.2) |
| 14-A-8 | 1197.5 | 689.5 | 508.0 | 1220.2 | 703.1 | 517.1 | 1508 | 15 | |
| 14-A-9 | 1202.0 | 689.5 | 512.5 | 1220.2 | 703.1 | 517.1 | 1317 | 14 | |
| 15-A-1 | 1183.9 | 689.5 | 494.4 | | | | 1608 | 10 | |
| 15-A-2 | 1174.8 | 684.9 | 489.9 | | | | 2112 | 10 | |
| 15-A-3 | 1174.8 | 684.9 | 489.9 | | | | 1690 | 10 | |
| 15-A-7 | 1174.8 | 689.5 | 485.3 | 1197.5 | 698.5 | 499.0 | 678 | 16 | (40.6) |
| 15-A-8 | 1179.3 | 689.5 | 489.8 | 1202.0 | 698.5 | 503.5 | 670 | 17 | |
| 15-A-9 | 1192.9 | 694.0 | 498.9 | 1215.6 | 703.1 | 512.5 | 810 | 15 | |
| 17-A-1 | 1202.0 | 703.1 | 498.9 | | | | 1944 | 12 | |
| 17-A-2 | 1192.9 | 694.0 | 498.9 | | | | 1861 | 12 | |
| 17-A-3 | 1211.1 | 707.6 | 503.5 | | | | 2062 | 10 | |
| 17-A-7 | 1211.1 | 707.6 | 503.5 | 1220.2 | 712.1 | 508.0 | 1861 | 12 | (87.4) |
| 17-A-8 | 1197.5 | 703.1 | 494.4 | 1206.6 | 703.1 | 503.5 | 1725 | 12 | |
| 17-A-9 | 1224.7 | 712.1 | 512.6 | 1238.8 | 721.2 | 512.6 | 1542 | 13 | |
| 18-A-1 | 1198.0 | 661.0 | 537.0 | | | | 2062 | 9 | |
| 18-A-2 | 1195.0 | 664.0 | 531.0 | | | | 2221 | 9 | |
| 18-A-3 | 1200.0 | 670.0 | 530.0 | | | | 2400 | 12 | |
| 18-A-7 | 1192.0 | 667.0 | 525.0 | 1215.6 | 684.9 | 530.7 | 1505 | 15 | (73.1) |
| 18-A-8 | 1200.0 | 669.0 | 531.0 | 1220.2 | 684.9 | 535.2 | 1600 | 13 | |
| 18-A-9 | 1195.0 | 674.0 | 521.0 | 1215.6 | 689.5 | 526.2 | 1780 | 14 | |

TABLE II-B
IMMERSION COMPRESSION RESULTS
14 Days at Room Temp.

| Sample Number | Before Immersion Wt. in Air gms. | Before Immersion Wt. in Water gms. | Before Immersion Volume cc | After Immersion Wt. in Air gms. | After Immersion Wt. in Water gms. | After Immersion Volume cc | Marshall Stability lbs. | Flow | Avg. Stability Retained % |
|---|---|---|---|---|---|---|---|---|---|
| 19-A-1 | 1192.9 | 684.9 | 508.0 | | | | 1918 | 8 | |
| 19-A-2 | 1202.0 | 684.9 | 517.1 | | | | 1844 | 9 | |
| 19-A-3 | 1202.0 | 689.5 | 512.6 | | | | 1812 | 10 | |
| 19-A-7 | 1197.5 | 684.9 | 512.6 | 1211.1 | 694.0 | 517.1 | 1475 | 14 | (83.7) |
| 19-A-8 | 1202.0 | 689.5 | 512.6 | 1220.2 | 698.5 | 521.6 | 1500 | 14 | |
| 19-A-9 | 1202.0 | 689.5 | 512.6 | 1220.2 | 703.1 | 517.1 | 1692 | 14 | |
| 21-A-1 | 1211.1 | 680.4 | 530.7 | | | | 1920 | 12 | |
| 21-A-2 | 1206.6 | 678.1 | 528.5 | | | | 2011 | 10 | |
| 21-A-3 | 1206.6 | 680.4 | 526.2 | | | | 2054 | 11 | |
| 21-A-7 | 1211.1 | 680.4 | 530.7 | 1224.7 | 689.5 | 535.2 | 1085 | 18 | (49.2) |
| 21-A-8 | 1206.6 | 678.1 | 528.5 | 1224.7 | 684.9 | 539.8 | 1014 | 19 | |
| 21-A-9 | 1211.1 | 680.4 | 530.7 | 1229.2 | 689.5 | 539.7 | 846 | 18 | |
| 22-A-1 | 1202.0 | 698.5 | 503.5 | | | | 1685 | 12 | |
| 22-A-2 | 1197.5 | 694.0 | 503.5 | | | | 1737 | 10 | |
| 22-A-3 | 1206.6 | 698.5 | 508.1 | | | | 1940 | 11 | |
| 22-A-7 | 1197.5 | 694.0 | 503.5 | 1202.0 | 694.0 | 508.0 | 1290 | 11 | (79.7) |
| 22-A-8 | 1202.0 | 698.5 | 503.5 | 1206.6 | 698.5 | 508.1 | 1591 | 12 | |
| 22-A-9 | 1192.9 | 689.5 | 503.4 | 1197.5 | 694.0 | 503.5 | 1394 | 12 | |
| 23-A-1 | 1202.0 | 689.5 | 512.5 | | | | 1865 | 13 | |
| 23-A-2 | 1206.6 | 698.5 | 508.1 | | | | 2246 | 14 | |
| 23-A-3 | 1202.0 | 694.0 | 508.0 | | | | 2408 | 13 | |
| 23-A-7 | 1197.5 | 689.5 | 508.0 | 1215.6 | 694.0 | 521.6 | 1220 | 18 | (62.1) |
| 23-A-8 | 1202.0 | 689.5 | 512.5 | 1215.6 | 694.0 | 521.6 | 1490 | 17 | |
| 23-A-9 | 1202.0 | 689.5 | 512.5 | 1215.6 | 694.0 | 521.6 | 1340 | 20 | |

TABLE II-B
IMMERSION COMPRESSION RESULTS
14 Days at Room Temp.

| Sample Number | Before Immersion Wt. in Air gms. | Before Immersion Wt. in Water gms. | Before Immersion Volume cc | After Immersion Wt. in Air gms. | After Immersion Wt. in Water gms. | After Immersion Volume cc | Marshall Stability lbs. | Flow | Avg. Stability Retained % |
|---|---|---|---|---|---|---|---|---|---|
| 24-A-1 | 1211.1 | 680.4 | 530.7 | | | | 2890 | 16 | |
| 24-A-2 | 1202.0 | 675.9 | 526.1 | | | | 3192 | 14 | |
| 24-A-3 | 1197.5 | 673.6 | 523.9 | | | | 3040 | 14 | |
| 24-A-7 | 1206.6 | 680.4 | 526.2 | 1215.6 | 684.9 | 530.7 | 3125 | 16 | (103.5) |
| 24-A-8 | 1202.0 | 680.4 | 521.6 | 1215.6 | 684.9 | 530.7 | 3235 | 15 | |
| 24-A-9 | 1202.0 | 678.1 | 523.9 | 1215.6 | 684.9 | 530.7 | 3082 | 14 | |
| 25-A-1 | 1211.1 | 657.7 | 553.4 | | | | 2225 | 13 | |
| 25-A-2 | 1206.6 | 653.2 | 553.4 | | | | 2011 | 13 | |
| 25-A-3 | 1197.5 | 653.2 | 544.3 | | | | 2530 | 12 | |
| 25-A-7 | 1202.0 | 653.2 | 548.8 | 1224.7 | 662.2 | 562.5 | 1866 | 24 | (78.3) |
| 25-A-8 | 1202.0 | 653.2 | 548.8 | 1229.2 | 666.8 | 562.5 | 1729 | 33 | |
| 25-A-9 | 1206.6 | 657.7 | 548.9 | 1229.2 | 666.8 | 562.4 | 1703 | 22 | |
| 26-A-1 | 1206.6 | 675.9 | 530.7 | | | | 2539 | 15 | |
| 26-A-2 | 1220.2 | 684.9 | 535.3 | | | | 2222 | 13 | |
| 26-A-3 | 1202.0 | 675.9 | 526.1 | | | | 2578 | 15 | |
| 26-A-7 | 1211.1 | 680.4 | 530.7 | 1220.2 | 684.9 | 535.3 | 1968 | 16 | (88.6) |
| 26-A-8 | 1206.6 | 675.9 | 530.7 | 1220.2 | 680.4 | 539.8 | 2268 | 16 | |
| 26-A-9 | 1206.6 | 675.9 | 530.7 | 1215.6 | 680.4 | 535.2 | 2266 | 17 | |
| 27-A-1 | 1211.1 | 662.2 | 548.9 | | | | 2212 | 14 | |
| 27-A-2 | 1206.6 | 657.7 | 548.9 | | | | 2247 | 14 | |
| 27-A-3 | 1206.6 | 662.2 | 544.4 | | | | 2423 | 14 | |
| 27-A-7 | 1206.6 | 662.2 | 544.4 | 1224.7 | 671.3 | 553.4 | 2020 | 21 | (74.8) |
| 27-A-8 | 1206.6 | 657.7 | 548.9 | 1224.7 | 666.8 | 557.9 | 1642 | 23 | |
| 27-A-9 | 1206.6 | 653.2 | 553.4 | 1220.2 | 657.7 | 562.5 | 1484 | 21 | |

TABLE II-B
IMMERSION COMPRESSION RESULTS
14 Days at Room Temp.

| Sample Number | Before Immersion Wt. in Air gms. | Before Immersion Wt. in Water gms. | Before Immersion Volume cc | After Immersion Wt. in Air Gms. | After Immersion Wt. in Water gms. | After Immersion Volume cc | Marshall Stability lbs. | Flow | Avg. Stability Retained % |
|---|---|---|---|---|---|---|---|---|---|
| 28-A-1 | 1197.5 | 680.4 | 517.1 | | | | 3580 | 16 | |
| 28-A-2 | 1202.0 | 684.9 | 517.1 | | | | 2925 | 14 | |
| 28-A-3 | 1206.6 | 689.5 | 517.7 | | | | 3255 | 13 | |
| 28-A-7 | 1197.5 | 680.4 | 517.1 | 1202.0 | 680.4 | 521.6 | 2885 | 17 | (82.3) |
| 28-A-8 | 1197.5 | 680.4 | 517.1 | 1206.6 | 684.9 | 521.7 | 2360 | 14 | |
| 28-A-9 | 1202.0 | 684.9 | 517.1 | 1211.1 | 689.5 | 521.6 | 2790 | 14 | |
| 29-A-1 | 1206.6 | 712.1 | 494.5 | | | | 3477 | 14 | |
| 29-A-2 | 1211.1 | 712.1 | 499.0 | | | | 3099 | 15 | |
| 29-A-3 | 1206.6 | 707.6 | 499.0 | | | | 2922 | 15 | |
| 29-A-7 | 1211.1 | 712.1 | 499.0 | 1224.7 | 712.1 | 512.6 | 1680 | 20 | (56.6) |
| 29-A-8 | 1206.6 | 707.6 | 499.0 | 1224.7 | 712.1 | 512.6 | 1785 | 22 | |
| 29-A-9 | 1202.0 | 707.6 | 499.0 | 1220.2 | 712.1 | 508.1 | 1908 | 21 | |
| 1-B-1 | 1183.9 | 680.4 | 503.5 | | | | 1394 | 12 | |
| 1-B-2 | 1197.5 | 684.9 | 512.6 | | | | 1210 | 10 | |
| 1-B-3 | 1188.4 | 675.9 | 512.6 | | | | 1540 | 9 | |
| 1-B-7 | 1183.9 | 675.9 | 508.0 | 1215.6 | 680.4 | 535.2 | 288 | 22 | (30.9) |
| 1-B-8 | 1197.5 | 680.4 | 517.1 | 1229.2 | 684.9 | 544.3 | 344 | 23 | |
| 1-B-9 | 1188.4 | 680.4 | 508.0 | 1211.1 | 680.4 | 530.7 | 648 | 21 | |
| 2-B-1 | 1188.4 | 644.1 | 544.3 | | | | 916 | 11 | |
| 2-B-2 | 1188.4 | 644.1 | 544.3 | | | | 967 | 11 | |
| 2-B-3 | 1192.9 | 653.2 | 539.7 | | | | 953 | 11 | |
| 2-B-7 | 1183.9 | 644.1 | 539.8 | 1242.8 | 662.2 | 580.6 | 145 | 26 | (17.5) |
| 2-B-8 | 1188.4 | 644.1 | 544.3 | 1238.3 | 657.7 | 580.6 | 212 | 26 | |
| 2-B-9 | 1174.8 | 639.6 | 535.2 | 1233.8 | 653,2 | 580.6 | 137 | 27 | |

TABLE II-B
IMMERSION COMPRESSION RESULTS
14 Days at Room Temp.

| Sample Number | Before Immersion Wt. in Air gms. | Before Immersion Wt. in Water gms. | Before Immersion Volume cc | After Immersion Wt. in Air gms. | After Immersion Wt. in Water gms. | After Immersion Volume cc | Marshall Stability lbs. | Flow | Avg. Stability Retained % |
|---|---|---|---|---|---|---|---|---|---|
| 3-B-1 | 1179.3 | 680.4 | 498.9 | | | | 1586 | 11 | |
| 3-B-2 | 1192.9 | 689.5 | 503.4 | | | | 1570 | 12 | |
| 3-B-3 | 1161.2 | 671.3 | 489.9 | | | | 1537 | 11 | |
| 3-B-7 | 1183.9 | 680.4 | 503.5 | 1188.4 | 689.5 | 498.9 | 1383 | 16 | (94.9) |
| 3-B-8 | 1188.4 | 684.9 | 503.5 | 1192.9 | 689.5 | 503.4 | 1633 | 15 | |
| 3-B-9 | 1192.9 | 689.5 | 503.4 | 1197.5 | 694.0 | 503.5 | 1435 | 15 | |
| 4-B-1 | 1188.4 | 684.9 | 503.5 | | | | 1586 | 13 | |
| 4-B-2 | 1188.4 | 684.9 | 503.5 | | | | 1659 | 13 | |
| 4-B-3 | 1188.4 | 684.9 | 503.5 | | | | 1550 | 12 | |
| 4-B-7 | 1192.9 | 689.5 | 503.4 | 1197.5 | 694.0 | 503.5 | 1378 | 14 | (88.7) |
| 4-B-8 | 1192.9 | 689.5 | 503.4 | 1197.5 | 689.5 | 508.0 | 1482 | 12 | |
| 4-B-9 | 1183.9 | 694.9 | 499.0 | 1192.9 | 689.5 | 503.4 | 1394 | 14 | |
| 5-B-1 | 1188.4 | 684.9 | 503.5 | | | | 1612 | 12 | |
| 5-B-2 | 1188.4 | 684.9 | 503.5 | | | | 1669 | 12 | |
| 5-B-3 | 1192.9 | 689.5 | 503.4 | | | | 1726 | 12 | |
| 5-B-7 | 1183.9 | 684.9 | 499.0 | 1188.4 | 684.9 | 503.5 | 1477 | 12 | (88.2) |
| 5-B-8 | 1183.9 | 680.4 | 503.5 | 1183.9 | 684.9 | 499.0 | 1456 | 12 | |
| 5-B-9 | 1183.9 | 684.9 | 499.0 | 1188.4 | 684.9 | 503.5 | 1482 | 12 | |
| 6-B-1 | 1188.4 | 684.9 | 503.5 | | | | 1570 | 11 | |
| 6-B-2 | 1188.4 | 684.9 | 503.5 | | | | 1638 | 11 | |
| 6-B-3 | 1197.5 | 689.5 | 508.0 | | | | 1560 | 12 | |
| 6-B-7 | 1188.4 | 684.9 | 503.5 | 1192.9 | 680.4 | 512.5 | 1475 | 12 | (92.6) |
| 6-B-8 | 1192.9 | 689.5 | 503.4 | 1202.0 | 684.9 | 517.1 | 1400 | 13 | |
| 6-B-9 | 1188.4 | 684.9 | 503.5 | 1192.9 | 680.4 | 512.5 | 1540 | 13 | |

TABLE II-B
IMMERSION COMPRESSION RESULTS
14 Days at Room Temp.

| Sample Number | Before Immersion Wt. in Air gms. | Wt. in Water gms. | Volume cc | After Immersion Wt. in Air gms. | Wt. in Water gms. | Volume cc | Marshall Stability lbs. | Flow | Avg. Stability Retained % |
|---|---|---|---|---|---|---|---|---|---|
| 7-B-1 | 1174.8 | 675.9 | 498.9 | | | | 1529 | 13 | |
| 7-B-2 | 1197.5 | 689.5 | 508.0 | | | | 1612 | 13 | |
| 7-B-3 | 1192.9 | 689.5 | 503.4 | | | | 1482 | 12 | |
| 7-B-7 | 1192.9 | 689.5 | 503.4 | 1197.5 | 684.9 | 512.6 | 1070 | 14 | (73.6) |
| 7-B-8 | 1183.9 | 680.4 | 503.5 | 1188.4 | 680.4 | 508.0 | 1206 | 13 | |
| 7-B-9 | 1197.5 | 689.5 | 508.0 | 1202.0 | 684.9 | 517.1 | 1125 | 15 | |
| 8-B-1 | 1192.9 | 689.5 | 503.4 | | | | 1482 | 12 | |
| 8-B-2 | 1192.9 | 684.9 | 508.0 | | | | 1591 | 10 | |
| 8-B-3 | 1192.9 | 689.5 | 503.4 | | | | 1602 | 11 | |
| 8-B-7 | 1192.9 | 689.5 | 503.4 | 1197.5 | 684.9 | 512.6 | 1380 | 9 | (100.1) |
| 8-B-8 | 1197.5 | 689.5 | 508.0 | 1197.5 | 684.9 | 512.6 | 1510 | 12 | |
| 8-B-9 | 1188.4 | 684.9 | 503.5 | 1188.4 | 684.9 | 503.5 | 1789 | 11 | |
| 9-B-1 | 1183.9 | 680.5 | 503.5 | | | | 1789 | 10 | |
| 9-B-2 | 1197.5 | 684.9 | 512.6 | | | | 1550 | 11 | |
| 9-B-3 | 1197.5 | 684.9 | 512.6 | | | | 1510 | 11 | |
| 9-B-7 | 1197.5 | 684.9 | 512.6 | 1202.0 | 689.5 | 512.5 | 1340 | 15 | (93.5) |
| 9-B-8 | 1188.4 | 684.9 | 503.5 | 1192.9 | 689.5 | 503.4 | 1591 | 14 | |
| 9-B-9 | 1183.9 | 680.4 | 503.5 | 1188.4 | 680.4 | 508.0 | 1602 | 14 | |
| 10-B-1 | 1197.5 | 684.9 | 512.6 | | | | 1750 | 12 | |
| 10-B-2 | 1192.9 | 684.9 | 508.0 | | | | 1810 | 10 | |
| 10-B-3 | 1192.9 | 684.9 | 508.0 | | | | 1586 | 13 | |
| 10-B-7 | 1197.5 | 684.9 | 512.6 | 1202.0 | 689.5 | 512.5 | 1595 | 16 | (92.8) |
| 10-B-8 | 1188.4 | 684.9 | 503.5 | 1192.9 | 684.9 | 508.0 | 1638 | 15 | |
| 10-B-9 | 1183.9 | 680.4 | 503.5 | 1188.4 | 680.4 | 508.0 | 1539 | 14 | |

TABLE II-B
IMMERSION COMPRESSION RESULTS
14 Days at Room Temp.

| Sample Number | Wt. in Air gms. | Wt. in Water gms. | Volume cc | Wt. in Air gms. | Wt. in Water gms. | Volume cc | Marshal Stability lbs. | Flow | Avg. Stability Retained % |
|---|---|---|---|---|---|---|---|---|---|
| 11-B-1 | 1192.9 | 680.4 | 512.5 | | | | 1680 | 12 | |
| 11-B-2 | 1192.9 | 680.4 | 512.5 | | | | 1595 | 13 | |
| 11-B-3 | 1188.4 | 680.4 | 508.0 | | | | 1706 | 12 | |
| 11-B-7 | 1197.5 | 684.9 | 512.6 | 1202.0 | 689.5 | 512.5 | 1525 | 12 | (96.1) |
| 11-B-8 | 1192.9 | 680.4 | 512.5 | 1192.9 | 680.4 | 512.5 | 1750 | 13 | |
| 11-B-9 | 1197.5 | 684.9 | 512.6 | 1202.0 | 684.9 | 517.1 | 1510 | 13 | |
| 12-B-1 | 1192.9 | 684.9 | 508.0 | | | | 1830 | 13 | |
| 12-B-2 | 1192.9 | 680.4 | 512.5 | | | | 1580 | 12 | |
| 12-B-3 | 1197.5 | 684.9 | 512.6 | | | | 1615 | 11 | |
| 12-B-7 | 1192.9 | 680.4 | 512.5 | 1197.5 | 684.9 | 512.6 | 1480 | 16 | (69.0) |
| 12-B-8 | 1192.9 | 680.4 | 512.5 | 1192.9 | 680.4 | 512.5 | 1510 | 16 | |
| 12-B-9 | 1202.0 | 689.5 | 512.5 | 1206.6 | 689.5 | 517.1 | 1480 | 15 | |

TABLE III
Cold Water Abrasion Results

| Sample Number | Total Wt. Before Immersion (gms.) | Total Wt. After Immersion (gms.) | Total Wt. After Abrasion (gms.) | Loss in Wt. (gms.) | Percent Loss in Wt. |
|---|---|---|---|---|---|
| 1-A | 1941.4 | 2009.4 | 1546.8 | 462.6 | 23.02 |
| 2-A | 2009.4 | 2023.0 | 1905.1 | 117.9 | 5.83 |
| 4-A | 2009.4 | 2050.2 | 1773.5 | 276.7 | 13.50 |
| 11-A | 2072.9 | 2122.8 | 1995.8 | 127.0 | 5.98 |
| 14-A | 2068.4 | 2122.8 | 1927.8 | 195.0 | 9.19 |
| 15-A | 2091.1 | 2154.6 | 1905.1 | 249.5 | 11.58 |
| 17-A | 2077.5 | 2127.3 | 1837.0 | 290.3 | 13.64 |
| 18-A | 1982.2 | 2045.7 | 1914.2 | 131.5 | 6.43 |
| 19-A | 2041.2 | 2077.5 | 1941.4 | 136.1 | 6.55 |
| 21-A | 1986.7 | 2032.1 | 1882.4 | 149.7 | 7.37 |
| 22-A | 2041.2 | 2059.3 | 1905.1 | 154.2 | 7.49 |
| 23-A | 2045.7 | 2109.2 | 1846.1 | 263.1 | 12.47 |
| 24-A | 2000.3 | 2050.2 | 1891.5 | 158.7 | 7.74 |
| 25-A | 1905.1 | 1991.3 | 1642.0 | 349.3 | 17.54 |
| 26-A | 1991.3 | 2014.0 | 1927.8 | 86.2 | 4.28 |
| 27-A | 1923.2 | 1973.1 | 1769.0 | 204.1 | 10.34 |
| 28-A | 2018.5 | 2059.3 | 1927.8 | 131.5 | 6.39 |
| 29-A | 2100.1 | 2163.6 | 1678.3 | 485.3 | 22.43 |
| 3-B | 2045.7 | 2063.8 | 1973.1 | 90.7 | 4.39 |
| 4-B | 2059.3 | 2086.5 | 1977.7 | 108.8 | 5.21 |
| 5-B | 2054.8 | 2082.0 | 1941.4 | 140.6 | 6.75 |
| 6-B | 2045.7 | 2100.1 | 1655.6 | 444.5 | 21.17 |
| 7-B | 2050.2 | 2104.7 | 1850.7 | 254.0 | 12.07 |
| 8-B | 2041.2 | 2086.5 | 1918.7 | 167.8 | 8.04 |
| 9-B | 2050.2 | 2109.2 | 1764.5 | 344.7 | 16.34 |
| 10-B | 2059.3 | 2104.7 | 1833.4 | 281.3 | 13.36 |
| 11-B | 2072.9 | 2104.7 | 1914.2 | 190.5 | 9.05 |
| 12-B | 2050.2 | 2072.9 | 1932.3 | 140.6 | 6.78 |

Note: Cold Water Abrasion was not attempted on 1-B and 2-B due to disintegration of the Immersion Compression specimens when immersed at 120° F.

TABLE IV
AASHO SWELL TEST RESULTS

| Sample Number | Sand Equivalent Number | Percent Swell |
|---|---|---|
| 1-A | 32 | 0.18 |
| 2-A | 53 | 0.09 |
| 4-A | 34 | 0.36 |
| 11-A | 44 | 0.09 |
| 14-A | 33 | 0.05 |
| 15-A | 31 | 0.59 |
| 17-A | 35 | 0.00 |
| 18-A | 52 | 0.23 |
| 19-A | 56 | 0.14 |
| 21-A | 38 | 0.18 |
| 22-A | 34 | 0.00 |
| 23-A | 26 | 0.27 |
| 24-A | 34 | 0.13 |
| 25-A | 33 | 0.26 |
| 26-A | 45 | 0.04 |
| 27-A | 30 | 0.22 |
| 28-A | 30 | 0.13 |
| 29-A | 21 | 0.28 |
| 1-B | 25 | 0.09 |
| 2-B | 22 | 0.78 |
| 3-B | 57 | 0.00 |
| 4-B | 56 | 0.00 |
| 5-B | 55 | 0.10 |
| 6-B | 36 | 0.00 |
| 7-B | 34 | 0.00 |
| 8-B | 66 | 0.05 |
| 9-B | 37 | 0.00 |
| 10-B | 47 | 0.00 |
| 11-B | 37 | 0.00 |
| 12-B | 44 | 0.00 |

TABLE V

STRIPPING TEST RESULTS

| Degree of Stripping | Aggregate Number | Sand Equivalent Number |
|---|---|---|
| Slight | 2-A | 53 |
| | 19-A | 56 |
| | 11-A | 44 |
| | 17-A | 35 |
| Moderate | 18-A | 52 |
| | 14-A | 33 |
| | 1-A | 32 |
| | 4-A | 34 |
| Excessive | 15-A | 31 |

APPENDIX D

TABLE I Density Computation Summary for Immersion-Compression Specimens

TABLE-I
DENSITY COMPUTATION SUMMARY
Immersion-Compression Specimens

| Sample Number | Percent Voids in Aggregate | Percent Voids Filled | Theoretical Density | Percent of Theo. Density |
|---|---|---|---|---|
| 1-A-1 | 21.1 | 60.9 | 2.429 | 91.8 |
| 1-A-2 | 21.5 | 59.3 | | 91.2 |
| 1-A-3 | 22.3 | 56.6 | | 90.3 |
| 1-A-4 | 21.7 | 58.6 | | 91.0 |
| 1-A-5 | 21.4 | 59.9 | | 91.4 |
| 1-A-6 | 22.2 | 57.0 | | 90.4 |
| 1-A-7 | 21.2 | 60.7 | | 91.7 |
| 1-A-8 | 21.2 | 60.7 | | 91.7 |
| 1-A-9 | 21.2 | 60.7 | | 91.7 |
| 2-A-1 | 19.1 | 78.7 | 2.402 | 95.9 |
| 2-A-2 | 19.0 | 79.2 | | 96.0 |
| 2-A-3 | 18.0 | 84.2 | | 97.1 |
| 2-A-4 | 18.4 | 82.4 | | 96.9 |
| 2-A-5 | 18.3 | 82.4 | | 96.9 |
| 2-A-6 | 19.0 | 83.0 | | 96.0 |
| 2-A-7 | 18.2 | 79.2 | | 97.0 |
| 2-A-8 | 17.9 | 83.6 | | 97.3 |
| 2-A-9 | 18.7 | 84.8 | | 96.4 |
| 4-A-1 | 16.3 | 61.7 | 2.483 | 93.8 |
| 4-A-2 | 16.2 | 62.1 | | 93.9 |
| 4-A-3 | 15.9 | 63.7 | | 94.2 |
| 4-A-4 | 14.6 | 70.3 | | 95.7 |
| 4-A-5 | 16.1 | 62.6 | | 94.0 |
| 4-A-6 | 15.3 | 66.8 | | 94.9 |
| 4-A-7 | 15.7 | 64.7 | | 94.4 |
| 4-A-8 | 16.1 | 62.7 | | 94.0 |
| 4-A-9 | 15.7 | 64.7 | | 94.4 |
| 11-A-1 | 18.3 | 80.6 | 2.460 | 96.5 |
| 11-A-2 | 18.3 | 80.6 | | 96.5 |
| 11-A-3 | 17.8 | 83.4 | | 97.0 |
| 11-A-4 | 17.7 | 83.7 | | 97.1 |
| 11-A-5 | 18.7 | 78.4 | | 95.9 |
| 11-A-6 | 17.9 | 82.5 | | 96.8 |
| 11-A-7 | 18.6 | 79.0 | | 96.1 |
| 11-A-8 | 18.2 | 81.1 | | 96.5 |
| 11-A-9 | 17.1 | 87.6 | | 97.8 |

TABLE I
DENSITY COMPUTATION SUMMARY
Immersion-Compression Specimens

| Sample Number | Percent Voids in Aggregate | Percent Voids Filled | Theoretical Density | Percent of Theo. Density |
|---|---|---|---|---|
| 14-A-1 | 16.8 | 70.5 | 2.490 | 95.0 |
| 14-A-2 | 16.2 | 73.7 | | 95.7 |
| 14-A-3 | 16.8 | 70.5 | | 95.0 |
| 14-A-4 | 17.2 | 68.3 | | 94.5 |
| 14-A-5 | 17.1 | 68.9 | | 94.7 |
| 14-A-6 | 17.5 | 67.0 | | 94.2 |
| 14-A-7 | 16.3 | 73.4 | | 95.7 |
| 14-A-8 | 16.0 | 75.0 | | 96.0 |
| 14-A-9 | 16.4 | 72.6 | | 95.5 |
| 15-A-1 | 19.0 | 74.4 | 2.517 | 95.2 |
| 15-A-2 | 18.9 | 75.0 | | 95.3 |
| 15-A-3 | 18.9 | 75.0 | | 95.3 |
| 15-A-4 | 18.2 | 78.9 | | 96.2 |
| 15-A-5 | 18.6 | 76.6 | | 95.7 |
| 15-A-6 | 19.2 | 73.7 | | 95.0 |
| 15-A-7 | 19.2 | 73.7 | | 95.0 |
| 15-A-8 | 19.2 | 73.7 | | 95.0 |
| 15-A-9 | 19.2 | 73.5 | | 94.9 |
| 17-A-1 | 16.5 | 87.2 | 2.461 | 97.9 |
| 17-A-2 | 17.1 | 83.3 | | 97.2 |
| 17-A-3 | 16.6 | 86.4 | | 97.7 |
| 17-A-4 | 16.6 | 86.4 | | 97.7 |
| 17-A-5 | 16.0 | 90.2 | | 98.4 |
| 17-A-6 | 17.2 | 83.0 | | 97.1 |
| 17-A-7 | 17.4 | 81.6 | | 96.8 |
| 17-A-8 | 16.4 | 88.0 | | 98.0 |
| 17-A-9 | 16.8 | 85.2 | | 97.5 |
| 18-A-1 | 22.4 | 69.7 | 2.393 | 93.2 |
| 18-A-2 | 21.7 | 72.6 | | 94.0 |
| 18-A-3 | 21.2 | 74.6 | | 94.6 |
| 18-A-4 | 21.2 | 75.6 | | 94.9 |
| 18-A-5 | 21.0 | 73.9 | | 94.4 |
| 18-A-6 | 21.4 | 79.4 | | 95.9 |
| 18-A-7 | 19.7 | 81.8 | | 96.4 |
| 18-A-8 | 19.3 | 84.0 | | 96.9 |
| 18-A-9 | 19.0 | 85.6 | | 97.2 |

TABLE I
DENSITY COMPUTATION SUMMARY
Immersion-Compression Specimens

| Sample Number | Percent Voids in Aggregate | Percent Voids Filled | Theoretical Density | Percent of Theo. Density |
|---|---|---|---|---|
| 19-A-1 | 17.4 | 81.4 | 2.427 | 96.7 |
| 19-A-2 | 18.3 | 76.9 | | 95.8 |
| 19-A-3 | 17.5 | 80.9 | | 96.6 |
| 19-A-4 | 17.9 | 79.0 | | 96.3 |
| 19-A-5 | 17.5 | 80.9 | | 96.6 |
| 19-A-6 | 17.5 | 80.9 | | 96.6 |
| 19-A-7 | 17.2 | 82.6 | | 97.0 |
| 19-A-8 | 18.3 | 76.9 | | 95.8 |
| 19-A-9 | 16.8 | 85.1 | | 97.5 |
| 21-A-1 | 18.7 | 75.4 | 2.392 | 95.4 |
| 21-A-2 | 18.6 | 75.5 | | 95.4 |
| 21-A-3 | 18.3 | 77.3 | | 95.9 |
| 21-A-4 | 18.7 | 75.4 | | 95.4 |
| 21-A-5 | 18.6 | 75.5 | | 95.4 |
| 21-A-6 | 18.7 | 75.4 | | 95.4 |
| 21-A-7 | 18.7 | 75.4 | | 95.4 |
| 21-A-8 | 18.6 | 75.5 | | 95.4 |
| 21-A-9 | 18.6 | 75.5 | | 95.4 |
| 22-A-1 | 13.7 | 90.4 | 2.419 | 98.7 |
| 22-A-2 | 14.0 | 88.1 | | 98.3 |
| 22-A-3 | 14.1 | 87.0 | | 98.2 |
| 22-A-4 | 14.0 | 88.1 | | 98.3 |
| 22-A-5 | 13.7 | 90.4 | | 98.7 |
| 22-A-6 | 14.3 | 85.7 | | 98.0 |
| 22-A-7 | 13.7 | 90.4 | | 98.7 |
| 22-A-8 | 14.0 | 88.1 | | 98.3 |
| 22-A-9 | 14.4 | 84.9 | | 97.8 |
| 23-A-1 | 17.8 | 74.6 | 2.457 | 95.4 |
| 23-A-2 | 16.8 | 80.2 | | 96.7 |
| 23-A-3 | 17.1 | 78.5 | | 96.3 |
| 23-A-4 | 17.2 | 77.7 | | 96.2 |
| 23-A-5 | 17.8 | 74.6 | | 95.4 |
| 23-A-6 | 17.1 | 78.5 | | 96.3 |
| 23-A-7 | 17.4 | 76.8 | | 95.9 |
| 23-A-8 | 17.8 | 74.6 | | 95.4 |
| 23-A-9 | 17.8 | 74.6 | | 95.4 |

TABLE I
DENSITY COMPUTATION SUMMARY
Immersion-Compression Specimens

| Sample Number | Percent Voids in Aggregate | Percent Voids Filled | Theoretical Density | Percent of Theo. Density |
|---|---|---|---|---|
| 24-A-1 | 16.6 | 77.7 | 2.370 | 96.3 |
| 24-A-2 | 16.5 | 78.3 | | 96.4 |
| 24-A-3 | 16.5 | 78.5 | | 96.5 |
| 24-A-4 | 16.2 | 80.1 | | 96.8 |
| 24-A-5 | 16.5 | 78.3 | | 96.4 |
| 24-A-6 | 16.2 | 80.1 | | 96.8 |
| 24-A-7 | 16.2 | 80.1 | | 96.8 |
| 24-A-8 | 15.8 | 82.5 | | 97.2 |
| 24-A-9 | 16.2 | 80.3 | | 96.8 |
| 25-A-1 | 19.0 | 68.1 | 2.330 | 93.9 |
| 25-A-2 | 19.3 | 66.7 | | 93.6 |
| 25-A-3 | 18.6 | 69.9 | | 94.4 |
| 25-A-4 | 18.6 | 69.6 | | 94.3 |
| 25-A-5 | 19.0 | 68.1 | | 93.9 |
| 25-A-6 | 18.3 | 71.1 | | 94.7 |
| 25-A-7 | 19.0 | 68.3 | | 94.0 |
| 25-A-8 | 19.0 | 68.3 | | 94.0 |
| 25-A-9 | 18.7 | 69.6 | | 94.3 |
| 26-A-1 | 17.9 | 72.0 | 2.394 | 95.0 |
| 26-A-2 | 17.7 | 73.1 | | 95.2 |
| 26-A-3 | 17.5 | 74.0 | | 95.4 |
| 26-A-4 | 17.6 | 73.5 | | 95.3 |
| 26-A-5 | 17.9 | 72.0 | | 95.0 |
| 26-A-6 | 17.9 | 72.0 | | 95.0 |
| 26-A-7 | 17.3 | 75.1 | | 95.7 |
| 26-A-8 | 17.6 | 73.5 | | 95.3 |
| 26-A-9 | 17.6 | 73.5 | | 95.3 |
| 27-A-1 | 18.5 | 67.7 | 2.346 | 94.0 |
| 27-A-2 | 18.7 | 66.5 | | 93.7 |
| 27-A-3 | 18.1 | 69.5 | | 94.5 |
| 27-A-4 | 18.1 | 69.5 | | 94.5 |
| 27-A-5 | 18.7 | 66.5 | | 93.7 |
| 27-A-6 | 18.1 | 69.5 | | 94.5 |
| 27-A-7 | 18.1 | 69.5 | | 94.5 |
| 27-A-8 | 18.7 | 66.5 | | 93.7 |
| 27-A-9 | 19.4 | 63.7 | | 92.9 |

TABLE I
DENSITY COMPUTATION SUMMARY
Immersion-Compression Specimens

| Sample Number | Percent Voids in Aggregate | Percent Voids Filled | Theoretical Density | Percent of Theo. Density |
|---|---|---|---|---|
| 28-A-1 | 17.2 | 79.3 | 2.401 | 96.5 |
| 28-A-2 | 16.9 | 81.1 | | 96.8 |
| 28-A-3 | 16.6 | 83.1 | | 97.2 |
| 28-A-4 | 16.9 | 81.1 | | 96.8 |
| 28-A-5 | 16.6 | 81.1 | | 97.2 |
| 28-A-6 | 17.2 | 83.1 | | 96.5 |
| 28-A-7 | 17.2 | 79.3 | | 96.5 |
| 28-A-8 | 17.2 | 79.3 | | 96.5 |
| 28-A-9 | 16.9 | 81.1 | | 96.8 |
| 29-A-1 | 14.6 | 73.9 | 2.537 | 96.2 |
| 29-A-2 | 15.1 | 71.3 | | 95.7 |
| 29-A-3 | 15.4 | 69.6 | | 95.3 |
| 29-A-4 | 15.1 | 71.3 | | 95.7 |
| 29-A-5 | 15.4 | 69.6 | | 95.3 |
| 29-A-6 | 14.9 | 72.1 | | 95.8 |
| 29-A-7 | 14.9 | 72.1 | | 95.8 |
| 29-A-8 | 15.4 | 69.6 | | 95.3 |
| 29-A-9 | 15.8 | 67.3 | | 94.8 |
| 1-B-1 | 16.9 | 82.3 | 2.424 | 97.0 |
| 1-B-2 | 17.4 | 79.1 | | 96.4 |
| 1-B-3 | 18.1 | 75.9 | | 95.7 |
| 1-B-4 | 17.6 | 78.1 | | 96.2 |
| 1-B-5 | 18.2 | 75.3 | | 95.5 |
| 1-B-6 | 17.3 | 79.8 | | 96.5 |
| 1-B-7 | 17.3 | 79.8 | | 96.5 |
| 1-B-8 | 17.0 | 81.5 | | 96.9 |
| 1-B-9 | 17.3 | 79.8 | | 96.5 |
| 2-B-1 | 22.8 | 56.5 | 2.424 | 90.1 |
| 2-B-2 | 22.8 | 56.5 | | 90.1 |
| 2-B-3 | 21.9 | 59.6 | | 91.2 |
| 2-B-4 | 21.8 | 60.1 | | 91.3 |
| 2-B-5 | 22.2 | 58.6 | | 90.8 |
| 2-B-6 | 22.8 | 56.5 | | 90.1 |
| 2-B-7 | 22.5 | 57.7 | | 90.5 |
| 2-B-8 | 22.8 | 56.5 | | 90.1 |
| 2-B-9 | 22.4 | 57.9 | | 90.6 |

TABLE I
DENSITY COMPUTATION SUMMARY
Immersion-Compression Specimens

| Sample Number | Percent Voids in Aggregate | Percent Voids Filled | Theoretical Density | Percent of Theo. Density |
|---|---|---|---|---|
| 3-B-1 | 17.1 | 81.8 | 2.440 | 96.9 |
| 3-B-2 | 16.9 | 82.9 | | 97.1 |
| 3-B-3 | 16.9 | 83.2 | | 97.1 |
| 3-B-4 | 17.5 | 79.4 | | 96.4 |
| 3-B-5 | 17.2 | 81.0 | | 96.7 |
| 3-B-6 | 16.9 | 82.9 | | 97.1 |
| 3-B-7 | 16.8 | 83.6 | | 97.3 |
| 3-B-8 | 17.1 | 81.8 | | 96.9 |
| 3-B-9 | 17.1 | 81.8 | | 96.9 |
| 4-B-1 | 16.9 | 82.5 | 2.432 | 97.0 |
| 4-B-2 | 16.9 | 82.5 | | 97.0 |
| 4-B-3 | 16.9 | 82.5 | | 97.0 |
| 4-B-4 | 16.6 | 84.5 | | 97.5 |
| 4-B-5 | 16.6 | 84.5 | | 97.5 |
| 4-B-6 | 16.5 | 85.2 | | 97.6 |
| 4-B-7 | 16.5 | 85.2 | | 97.6 |
| 4-B-8 | 15.7 | 90.2 | | 98.5 |
| 4-B-9 | 16.5 | 85.2 | | 97.6 |
| 5-B-1 | 16.9 | 82.5 | 2.432 | 97.0 |
| 5-B-2 | 16.9 | 82.5 | | 97.0 |
| 5-B-3 | 16.6 | 84.5 | | 97.5 |
| 5-B-4 | 16.5 | 85.2 | | 97.6 |
| 5-B-5 | 17.2 | 80.7 | | 96.7 |
| 5-B-6 | 16.5 | 85.2 | | 97.6 |
| 5-B-7 | 16.9 | 82.5 | | 97.0 |
| 5-B-8 | 17.3 | 80.1 | | 96.5 |
| 5-B-9 | 16.9 | 82.5 | | 97.0 |
| 6-B-1 | 16.6 | 84.1 | 2.424 | 97.4 |
| 6-B-2 | 16.6 | 84.1 | | 97.4 |
| 6-B-3 | 16.7 | 83.4 | | 97.2 |
| 6-B-4 | 16.6 | 84.1 | | 97.4 |
| 6-B-5 | 16.3 | 86.1 | | 97.8 |
| 6-B-6 | 16.6 | 84.1 | | 97.4 |
| 6-B-7 | 16.3 | 86.1 | | 97.8 |
| 6-B-8 | 16.9 | 82.3 | | 97.0 |
| 6-B-9 | 16.9 | 82.3 | | 97.0 |

TABLE I
DENSITY COMPUTATION SUMMARY
Immersion-Compression Specimens

| Sample Number | Percent Voids in Aggregate | Percent Voids Filled | Theoretical Density | Percent of Theo. Density |
|---|---|---|---|---|
| 7-B-1 | 17.1 | 81.5 | 2.432 | 96.8 |
| 7-B-2 | 17.0 | 81.8 | | 96.9 |
| 7-B-3 | 16.6 | 84.5 | | 97.5 |
| 7-B-4 | 16.6 | 84.5 | | 97.5 |
| 7-B-5 | 17.2 | 80.7 | | 96.7 |
| 7-B-6 | 17.0 | 81.8 | | 96.9 |
| 7-B-7 | 16.5 | 85.2 | | 97.6 |
| 7-B-8 | 16.5 | 85.2 | | 97.6 |
| 7-B-9 | 17.4 | 79.5 | | 96.4 |
| 8-B-1 | 16.6 | 84.5 | 2.432 | 97.5 |
| 8-B-2 | 17.3 | 80.1 | | 96.5 |
| 8-B-3 | 16.6 | 84.5 | | 97.5 |
| 8-B-4 | 16.6 | 84.5 | | 97.5 |
| 8-B-5 | 17.0 | 81.8 | | 96.9 |
| 8-B-6 | 16.9 | 82.5 | | 97.0 |
| 8-B-7 | 16.7 | 83.7 | | 97.3 |
| 8-B-8 | 17.0 | 81.8 | | 96.9 |
| 8-B-9 | 16.6 | 84.5 | | 97.5 |
| 9-B-1 | 17.2 | 80.7 | 2.432 | 96.7 |
| 9-B-2 | 17.8 | 77.7 | | 96.1 |
| 9-B-3 | 17.8 | 77.7 | | 96.1 |
| 9-B-4 | 17.8 | 77.7 | | 96.1 |
| 9-B-5 | 16.9 | 82.5 | | 97.0 |
| 9-B-6 | 17.2 | 80.7 | | 96.7 |
| 9-B-7 | 17.3 | 80.1 | | 96.5 |
| 9-B-8 | 16.9 | 82.5 | | 97.0 |
| 9-B-9 | 17.6 | 78.3 | | 96.2 |
| 10-B-1 | 17.8 | 77.7 | 2.432 | 96.1 |
| 10-B-2 | 17.3 | 80.1 | | 96.5 |
| 10-B-3 | 17.3 | 80.1 | | 96.5 |
| 10-B-4 | 17.8 | 77.7 | | 96.1 |
| 10-B-5 | 16.9 | 82.5 | | 97.0 |
| 10-B-6 | 17.2 | 80.7 | | 96.7 |
| 10-B-7 | 17.8 | 77.7 | | 96.1 |
| 10-B-8 | 16.9 | 82.5 | | 97.0 |
| 10-B-9 | 17.3 | 80.1 | | 96.5 |

TABLE I
DENSITY COMPUTATION SUMMARY
Immersion-Compression Specimens

| Sample Number | Percent Voids in Aggregate | Percent Voids Filled | Theoretical Density | Percent of Theo. Density |
|---|---|---|---|---|
| 11-B-1 | 18.1 | 76.2 | 2.432 | 95.7 |
| 11-B-2 | 18.1 | 76.2 | | 95.7 |
| 11-B-3 | 17.6 | 78.3 | | 96.2 |
| 11-B-4 | 17.8 | 77.7 | | 96.1 |
| 11-B-5 | 18.1 | 76.2 | | 95.7 |
| 11-B-6 | 17.7 | 77.7 | | 96.1 |
| 11-B-7 | 17.6 | 78.3 | | 96.2 |
| 11-B-8 | 17.6 | 78.7 | | 96.3 |
| 11-B-9 | 17.8 | 77.7 | | 96.1 |
| 12-B-1 | 17.3 | 80.1 | 2.432 | 96.5 |
| 12-B-2 | 18.1 | 76.2 | | 95.7 |
| 12-B-3 | 17.8 | 77.7 | | 96.1 |
| 12-B-4 | 18.1 | 76.2 | | 95.7 |
| 12-B-5 | 18.1 | 76.2 | | 95.7 |
| 12-B-6 | 17.4 | 79.5 | | 96.4 |
| 12-B-7 | 17.8 | 77.7 | | 96.1 |
| 12-B-8 | 18.0 | 76.8 | | 95.8 |
| 12-B-9 | 18.2 | 75.6 | | 95.6 |

**IMPORTANT!**

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