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Vogtle Project

March 11, 1985

Director of Nuclear Reactor Regulation
Attention: Ms. Elinor G. Adensam, Chief
Licensing Branch #4
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

File: X7BC35
Log: GN-544

NRC DOCKET NUMBERS 50-424 AND 50-425
CONSTRUCTION PERMIT NUMBERS CPPR-108 AND CPPR-109
VOGTLE ELECTRIC GENERATING PLANT - UNITS 1 AND 2
REQUEST FOR SUPPLEMENTAL INFORMATION
DSER OPEN ITEMS 4 AND 5

Dear Mr. Denton:

Enclosed for your staff's review are two (2) sets of the most recent VEGP settlement drawings to include the information requested by your staff in the January 23, 1985 meeting with the Structural and Geotechnical Branch. Also included are two (2) copies of the January 23, 1985 meeting presentation on Category 1 backfill as requested by your staff.

If your staff requires any additional information, please do not hesitate to contact me.

Sincerely,

J. A. Bailey

J. A. Bailey
Project Licensing Manager

JAB/sw
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B001 Drawings 1/2
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0034m

Open Item 4: Verification of FSAR commitments on compaction of category 1 backfill

Introduction

In order to discuss staff comments in the draft SER on compaction of Category 1 backfill, including laboratory maximum densities and testing procedures, it is helpful to review the underlying bases for the testing procedures used at VEGP.

The purpose of compaction criteria is to achieve a fill that has engineering properties that will conform to the design requirements. In the case of the Vogtle backfill, which is cohesionless sand or silty sand, the controlling design factor was the potential for liquefaction. Because the clean sands have lower cyclic shear strengths than silty sands, clean sands were the controlling material chosen to be tested. Noting that relative density in soil mechanics is defined as:

$$D_r = \frac{e_{max} - e}{e_{max} - e_{min}}$$

Where e is the void ratio in the ground.

e_{max} is the void ratio in the loosest state.

e_{min} is the void ratio in the densest state.

ASTM D 2049 was chosen as the accepted standard test procedure for determining "maximum" and "minimum" values for the void ratio in clean sands. These are not, of course, absolute maximums and minimums; they are merely benchmarks in the range of possible densities that can be reliably and repeatedly determined by different operators and that can be used as a basis for evaluating the achieved density in the field. The same procedure (or its equivalent) for determining the range used in design should be used in construction so that the relative density in the field will agree with the values used in design. Since the engineering properties of cohesionless soils are a function of relative density, this provides assurance that satisfactory engineering properties are achieved. It was determined that a relative density of 80 percent based on ASTM D 2049 would result in a factor of safety against liquefaction of at least 1.9 in the fill.

While ASTM D 2049 was an appropriate laboratory test for determining the density of the controlling clean sands as a basis for the liquefaction analysis, it was also acknowledged to be a less appropriate field test at Vogtle. This is because tests of the ASTM D 2049 type apply reliably only to the cleanest sands and the Vogtle fill is composed of clean sands and silty sands. This can be seen in the data from the confirmatory test program shown in Figure 2 where there is consistency only in the material with less than 6 percent finer than 0.074 mm size. Where the percent passing the 0.074 mm size exceeds 6 percent there is considerable scatter, and other tests such as ASTM D 1557 provide better reproducibility and consistency in relation to determining a maximum density. It should be noted that in Table 1 the maximum dry density obtained from ASTM D 1557 always exceeds the maximum dry density obtained from ASTM D 4253 for more than 6 percent passing .074 mm. The present field data indicate that about 77 percent of the fill placed to date has more than 6 percent passing the 0.074 mm size and ASTM D 1557 is clearly appropriate to control compaction for that type of material.

ASTM D 1557 is also appropriate for soils with less than 6 percent passing the 0.074 mm screen as is seen from a comparison of ASTM D 1557 and ASTM D 2049 data obtained from the recent confirmatory testing program. In this case, the ASTM D 4253 tests were corrected to obtain equivalent ASTM D 2049 tests by subtracting 2.2 pounds from the maximum densities (see discussion of confirmatory testing program below). The comparison is shown on Table III and also on Figure 2. On Figure 2, the ASTM D 2049 points lie with one exception in the lower portion of the range of ASTM D 1557 tests. In addition to this, a comparison was made of all of the data from the various explorations at Vogtle where a comparison of ASTM D 2049 maximum density was made with ASTM D 1557. The data are given in Table V. It should be noted that some of the older tests were made on samples with more than 6 percent passing the 0.074 mm size. These additional data have been submitted to the NRC in earlier reports. The data are shown on Figure 9. This figure shows that even with the cleaner sands the maximum density in accordance with ASTM D 1557 approximately equals or exceeds the maximum density in accordance with ASTM D 2049. The test data have a similar scatter to that indicated in Figure 2.

Because ASTM D 1557 exceeds the maximum density determined by ASTM D 2049 for sands with more than 6 percent fines and because ASTM D 1557 approximately equals or exceeds the maximum density obtained by ASTM D 2049 for sands with less than 6 percent fines, it is clearly a more appropriate test for all fill material used at Vogtle. ASTM D 1557 was therefore chosen as the laboratory maximum density test to be used in the field. The relationship between ASTM D 1557 and ASTM D 2049 was developed in the PSAR and indicates that 97 percent of the maximum density determined by ASTM D 1557 is equivalent to 80 percent relative density determined by ASTM D 2049.

Confirmatory Laboratory Test Program

DSER Section 2.5.4.3, Page 2-50 states the following:

"The laboratory results of the confirmatory testing program were provided to the NRC in an August 10, 1984 submittal. The applicant has also submitted a report to the NRC dated September 27, 1984 which evaluates the testing program results. The staff has not yet evaluated this report. The confirmatory testing program is an open item."

Response

The confirmatory testing program was initiated at the request of the NRC in June 1984. Law Engineering Testing Company (LETCO) was selected to implement the confirmatory laboratory testing program. The principal objective of the confirmatory testing program was to verify the maximum laboratory dry densities that were being used by Georgia Power Company (GPC) to determine percent compaction achieved in the field. The test data obtained from the testing program were evaluated, and a discussion of the data was presented in a report transmitted to the NRC. The report referred to in the DSER was entitled "Report on Confirmatory Laboratory Testing Program for Category I Backfill" and was dated September 1984. Prior to submittal of this report, the raw laboratory data generated by Law Engineering Testing Company and Georgia Power Company were transmitted to the NRC Staff in August 1984.

On pages 2-50 and 2-51, the NRC staff state "Preliminary observations of the staff based on the results provided in the August 10, 1984 submittal indicate the following:

"(1) A comparison of the maximum dry densities determined by the field laboratory and the independent testing laboratory indicates that the independent laboratory results show higher values of maximum densities in all of the 12 tests performed using ASTM D 1557. The increase in densities ranged from 0.8 lb/ft^3 up to 3.5 lb/ft^3. The maximum difference in dry density from the loosest state to the densest state for the medium to fine sand (SP) is about 20 lb/ft^3. The differences in results between the testing laboratories for optimum moisture content determinations were more widely scattered--differences ranged from 7.6 percent moisture below optimum to 2.5 percent above for the tests on the same type of material."

"(2) The test results also indicate that the backfill soils which have a small amount of fines (less than 6 percent passing the No. 200 sieve) attained their highest densities when tested in the relative density test (ASTM D 4253) in six of the seven tests performed. The increase in maximum dry densities between modified Proctor (ASTM D 1557) by the field laboratory and the relative density (ASTM D 4253) testing ranged from 2.4 lb/ft^3 up to 4.5 lb/ft^3. Recognition of these results would encourage a modification to current control procedures that requires the running of both the relative density test and the modified Proctor test in order to establish the maximum dry densities and percent compaction for this type backfill which has the small amount of fines."

Response:

Summary of Data

The results of the confirmatory testing program are summarized in Table I. The comparison between the two laboratories for the ASTM D 1557 test is shown on Figure 1, and the data are recorded in Table II. This shows that the LETCO values are always somewhat larger than the GPC values by amounts varying from 0.8 to 3.5 pcf, with an average difference of about 1.8 pcf. What should be noted is the consistency between the two laboratories. The scatter of data about the average is about 0.7 pcf and is similar whether the amount of material passing the 0.074 mm size is more or less than 6 percent.

In addition to ASTM D 1557, testing was also performed by ASTM D 4253 and D 2049 during the confirmatory testing program. The ASTM D 4253 test was only recently instituted in 1983. This test is similar in principle to the ASTM D 2049 test with the major difference being that in ASTM D 4253 the double amplitude of vibration is varied from 0.008 to 0.025 inch while in ASTM D 2049 the maximum density is determined at 0.025 inch amplitude. For both test methods, the frequency used is 3600 vibrations per minute.

Sample S-5 was tested by both ASTM D 2049 and ASTM D 4253. Because the requirements for density at Vogtle are based on ASTM D 2049, any meaningful discussion of densities obtained by ASTM D 1557 must be related to ASTM D 2049. Therefore it is important to note that for sample S-5, which was tested by ASTM D 4253 and ASTM D 2049, the result was that the maximum density by ASTM D 2049 was approximately 2.2 pcf lower than that obtained by ASTM D 4253 (see Figure 3). For sample S-5, the maximum density of 107.7 pcf obtained by ASTM D 4253 was at a peak vibration amplitude of approximately 0.0175 inch, whereas the maximum density obtained by ASTM D 2049 at the maximum amplitude of 0.025 inch was 105.5 pcf.

Figure 2 shows LETCO's results for ASTM D 1557 and D 4253 maximum densities plotted against percent finer than the 0.074 mm size. The peak vibration amplitude of 0.0175 inch was used to determine maximum density for samples with 6 percent or less passing the 0.074 mm size. Based on the above discussion, in order to correlate with the ASTM D 2049 maximum densities, the maximum values obtained by ASTM D 4253 were reduced by 2.2 pcf.

Figure 2 also shows the relationship for ASTM D 4253 samples with less than 6 percent passing the 0.074 mm size corrected by 2.2 pcf to estimate ASTM D 2049 maximum density. The points so plotted lie within the LETCO ASTM D 1557 test data scatter. The data for the material with less than 6 percent finer than 0.074 mm are given in Table III.

The comparison of optimum moisture contents between LETCO and GPC data is summarized in Table IV, and the data are plotted on Figure 4. The optimum moisture content refers to ASTM D 1557 and is the moisture content at which the maximum density can be achieved with the energy input for that test. In the case of the Vogtle Category I backfill, the cohesionless sands are relatively insensitive to moisture content in achieving the desired compaction, as evidenced by the flatness of the compaction curves. This can be seen in the case of Sample S-2 in the confirmatory testing program for which the compaction curve is shown on Figure 6. This sample has 3.4 percent passing the 0.074 mm size and a maximum dry density of 103.3 pcf. A relative compaction of 97 percent, which is 100.2 pcf, can be achieved for this material over a range of moisture contents of approximately 3 to 22 percent with the energy of the D 1557 test. On the other hand sample S-13, which has 9.5 percent finer than 0.074 mm, has a maximum dry density of 111.2. (See Figures 7 and 8.) To achieve 97 percent compaction, which is 107.9 pcf, the moisture content range is 5 to 18.5 percent with the energy of the ASTM D 1557 test. If energies greater than the ASTM D 1557 test are applied, they will widen the acceptable moisture content band in each case. Similarly, in the fill, greater energy will widen the moisture band within which acceptable compaction can be achieved.

Conclusions on the Confirmatory Testing Program

1. The two laboratories obtained values of ASTM D 1557 maximum density that were within the accuracy accepted by ASTM for different laboratories. The GPC values were lower by about 1.8 pcf on the average. However, as Figure 1 shows, the results all fall within a narrow band. The consistent difference between the two laboratories is attributed to the fact that LETCO performed the tests manually and GPC used a mechanical compactor, which is calibrated every 90 days. Since the mechanical compactor is an approved ASTM procedure, it is concluded that the GPC laboratory is carrying out the required tests correctly within the accuracy accepted by the ASTM and by a procedure accepted by the industry. Therefore, the PSAR and FSAR commitments with regards to density have been met.

2. The original compaction criteria were developed based on testing of clean sands at 80 percent relative density determined in accordance with ASTM D 2049. Therefore, any determination of the adequacy of the fill in terms of relative density must be related to ASTM D 2049. The data shown on Figure 9 and in Table V indicate that the maximum density by ASTM D 1557 is approximately the same or larger than the maximum density determined by ASTM D 2049. Therefore, the relationship developed in the PSAR that indicates that 97 percent of the maximum density determined by ASTM D 1557 is equivalent to 80 percent relative density determined by ASTM D 2049 is reasonable.

Furthermore, as can be seen in Figure 2, the confirmatory testing program showed that, although there was slightly more scatter in ASTM D 1557 when the percent finer than 0.074 mm size was less than 6 percent than with ASTM D 2049, ASTM D 1557 provides an acceptable basis for control of the entire fill and should continue to be the control test at Vogtle.

3. The moisture content range over which 97 percent compaction can be achieved is wide because the compaction curves are flat. Therefore, the cohesionless fills at Vogtle are relatively insensitive to moisture content in achieving the desired compaction, and an amendment to the FSAR will be submitted clarifying this issue.

The next amendment to FSAR paragraph 2.5.4.5.2 will read as follows:

In accordance with the earthwork specification, Category 1 backfill is sand and silty sand with not more than 25 percent passing the U.S. No. 200 (0.074 mm) sieve size. The sand and silty sand materials actually used to date as Category 1 backfill consist of less than 15 percent passing the U.S. No. 200 (0.074 mm) sieve size. The laboratory compaction curves for these materials used in the backfill are relatively flat and indicate that 97 percent compaction can be achieved over a wide range of moisture contents. Therefore, because of the insensitivity of these sands to variations in moisture content, a broad range of moisture content is acceptable for reaching the specified density. However, a target of

3 percent below to 2 percent above optimum is specified as a construction aid to facilitate compaction with the understanding that a broader range is acceptable provided the required compaction is met.

On page 2-52 of the DSER the NRC staff stated:

"The staff anticipates that in the applicant's future report which addresses the objectives of the confirmatory test program, the higher maximum dry densities obtained, for the three types of backfill materials tested, will be used to establish the percent compaction for all Category 1 backfill compacted to date. Preliminary observations, when using the higher densities for the field records from the first six months of 1983, indicate that FSAR requirements have essentially been met but at lower percent compaction values than originally reported."

Response

In a meeting with the NRC in Bethesda on July 22, 1977 it was agreed that the compaction criteria to be used for Category I fill control would be as follows: The fill shall have an average compaction of 97 percent of the maximum density determined by ASTM D 1557 with no tests below 93 percent and with not more than 10 percent of tests between 93 and 95 percent.

The quality control record at Vogtle meets the above requirement comfortably. It has been demonstrated above that ASTM D 1557 is an appropriate test and has been correctly performed. In response to the above

NRC staff statement the record has been re-evaluated in the most conservative manner possible. Using LETCO and GPC data the analysis of the record was made in the following manner:

When the percent passing the No. 200 sieve size exceeded 6 the maximum density was increased by 3.5 pcf.

When the percent passing the No. 200 was less than 6 the maximum density was increased by 4.5 pcf.

When the percent passing the No. 200 sieve was not known the maximum density was increased by 4.5 pcf.

The test record reviewed was for the period May 1980 to December 1984.

This was done because it represented the period when the mechanical compactor was in use by GPC. It also represents the bulk of Category I backfilling to-date. Based on the 10,262 tests considered it was determined that the average compaction was 100 percent. This exceeds the PSAR commitment of 97 percent average compaction. It was also found that 86.3 percent exceeded 97 percent compaction, 9.4 percent were between 95 and 97 percent, 3.8 percent were between 95 and 93 percent and 0.5 percent were less than 93 percent. The latter consisted of 52 tests which were randomly located throughout the fill.

In reality the fill consists of about 77 percent of silty sand with between 6 and 13 percent passing the 0.074 mm size so that assigning an additional 4.5 pcf to the maximum densities is undoubtedly conservative where the percent passing the No. 200 sieve is not known. Also the 4.5 pcf applies to ASTM D 4253, which yields higher maximum densities for sands with less than 6 percent finer than 0.074 mm., but the design is based on ASTM D 2049 where the maximums are lower. Table VI shows some shallow standard penetration test results in the backfill made in 1980 and reported to the NRC in Reference 16 of the FSAR. These tests show a very homogeneous competent fill.

Conclusion of Fill Evaluation

The compaction criteria for the Category I backfill are that the average compaction shall be 97 percent, no tests shall be below 93 percent and not more than 10 percent of tests between 95 and 93. Based on increasing the maximum densities by the greatest differences determined in the confirmatory test program the average compaction of the fill is 100 percent, 3.8 percent of tests are between 93 and 95, 0.5 percent of tests are below 93 percent and randomly located within the fill.

It is therefore concluded that even by this very conservative evaluation the fill meets the requirements of the Safety Analysis Report. This is further verified by the extremely high standard penetration test blowcounts recorded in six shallow borings in the fill.

TABLE I

RESULTS OF ASTM D 1557 AND D 4253 TESTING

Sample No.	Percent Passing 0.074 mm	ASTM D 1557 Max. Dry Density		ASTM D 4253 Max. Dry Density	
		LETCO	GPC	Wet	Dry
S-1	3.2	105.5	103.9	105.9	107.5
S-2	3.4	103.3	101.9	104.2	105.8
S-3	3.3	104.2	103.4	105.8	105.9
S-4	3.3	108.2	104.7	104.0	107.1
S-5	3.0	105.8	103.4	103.8	107.7
S-6	3.4	107.0	104.7	104.0	107.3
S-7	7.5	110.5	108.6	110.2	108.4
S-9	10.0	110.3	109.0	107.0	101.7
S-10	5.9	107.8	106.8	111.3	106.8
S-11	11.0	115.3	114.2	106.9	106.9
S-12	10.7	113.3	110.1	99.5	100.7
S-13	9.5	111.2	109.5	107.3	102.6

TABLE II

COMPARISON OF GPC AND LETCO TEST DATA
ASTM D 1557 MAXIMUM DENSITY

Sample No.	LETCO pcf.	GPC pcf.	Difference pcf.
S-1	105.5	103.9	1.6
S-2	103.3	101.9	1.4
S-3	104.2	103.4	0.8
S-4	108.2	104.7	3.5
S-5	105.8	103.4	2.4
S-6	107.0	104.7	2.3
S-7	110.5	108.6	1.9
S-9	110.3	109.0	1.3
S-10	107.8	106.8	1.0
S-11	115.3	114.2	1.1
S-12	113.3	110.1	3.2
S-13	111.2	109.5	1.7
		Average	1.8

TABLE III

COMPARISON OF D 1557, D 4253 AND D 2049
USING DATA BY LETCO

Sample No.	Percent Passing No. 200	Maximum Density Equivalent D 4253	D 2049*	D 1557
S-1	3.2	107.5	105.3	105.5
S-2	3.4	105.8	103.6	103.3
S-3	3.3	105.9	103.7	104.2
S-4	3.3	107.1	104.9	108.2
S-5	3.0	107.7	105.5	105.8
S-6	3.4	107.3	105.1	107.0
S-10	5.9	111.3	109.1	107.8

* Except for test S-5 these values have been estimated based on the difference between ASTM D 4253 and D 2049 determined by LETCO for test S-5.

TABLE IV

COMPARISON OF OPTIMUM MOISTURE CONTENTS

Sample No.	Percent Finer Than 0.074 mm	Optimum Moisture Content (Percent)	
		LETCO	GPC
S-1	3.2	15.5	12.0
S-2	3.4	16.7	11.3
S-3	3.3	19.3	11.7
S-4	3.3	18.1	13.5
S-5	3.0	18.5	13.2
S-6	3.4	16.0	15.0
S-7	7.5	11.3	13.8
S-9	10.0	14.8	14.0
S-10	5.9	14.7	10.4
S-11	11.0	13.2	14.3
S-12	10.7	11.2	13.5
S-13	9.5	13.5	13.5

TABLE V

COMPARISON OF ASTM D 2049
AND D 1557 MAXIMUM DENSITIES

ASTM D 1557 Max. Dry Density	ASTM D 2049 Max. Dry Density	Remarks
118.9	112.1	Tests performed by Geo-Testing Inc. 1972
102.3	104.3	
103.0	105.9	
101.6	103.6	
110.8	96.6	Tests by Law Engineering Testing Company 1977
102.9	99.4	
118.7	102.4	
117.4	102.3	
107.0	100.0	
120.2	103.0	
103	102.2	Tests made by Geotechnical Engineers 1977
115.4	109.7	
102.6	101.3	
105.4	102.1	Tests made by Geotechnical Engineers 1978
96.9	94.6	
105.5	105.3	Tests made by LETCO in 1984. (Note D 2049 based on D 4253 maximum reduced by 2.2 pcf)
103.3	103.6	
104.2	103.7	
108.2	104.9	
105.8	105.5	
107.0	105.1	
107.8	109.1	

TABLE VI

VOGTLE ELECTRIC GENERATING PLANT
STANDARD PENETRATION TEST BLOWCOUNTS
IN CATEGORY I FILL

Depth (ft)	Test Hole Designation					
	SPT-1	SPT-2	SPT-3	SPT-4	SPT-5	SPT-6
1 to 2	24	26	25	26	27	26
3 to 3.5	59	55	55	57	57	57
4 to 5	86	97	96	94	89	87

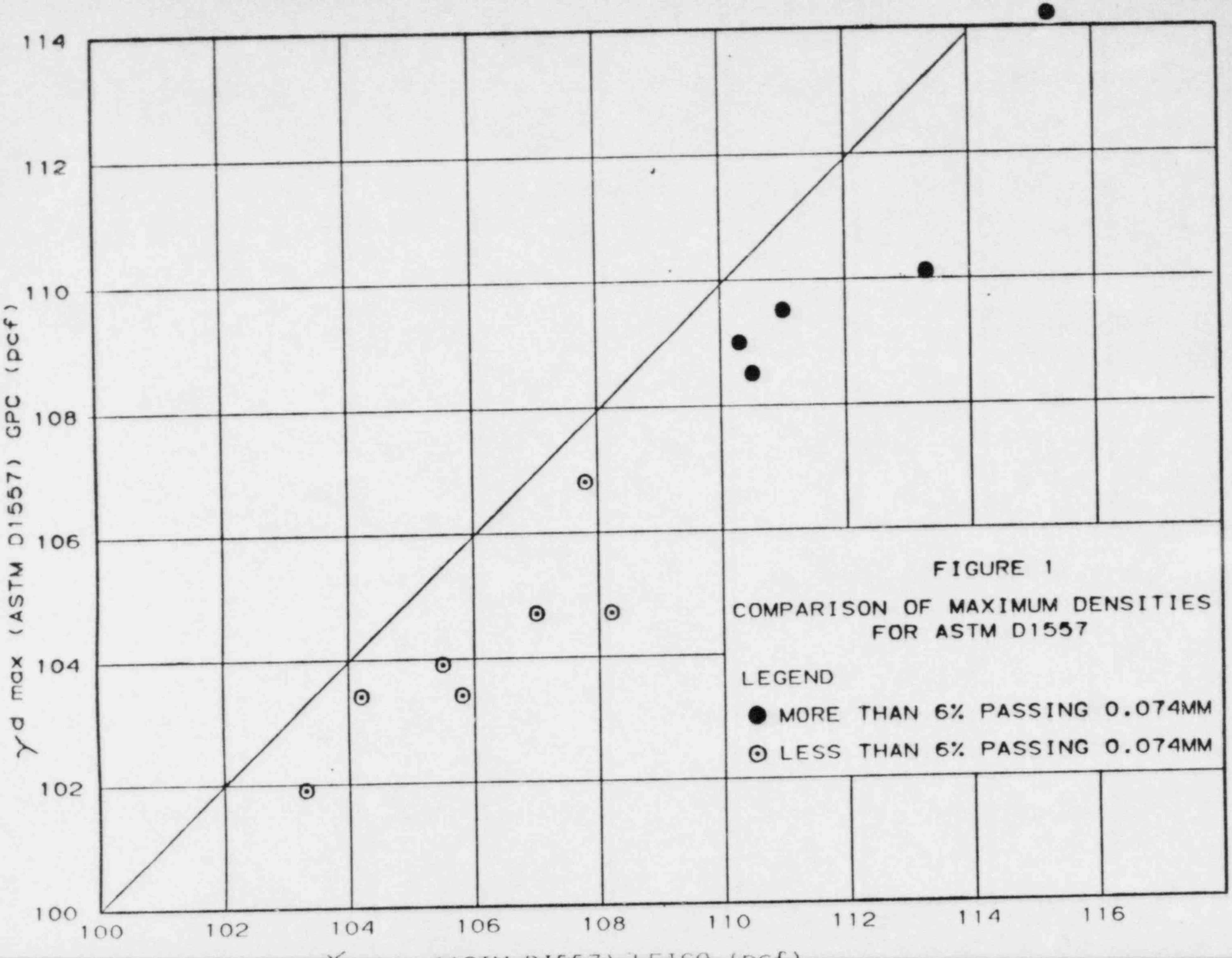


FIGURE 1
COMPARISON OF MAXIMUM DENSITIES
FOR ASTM D1557
LEGEND
MORE THAN 6% PASSING 0.074MM
LESS THAN 6% PASSING 0.074MM
γd max (ASTM D1557) GPC (pcf)
100
102
104
106
108
110
112
114
116

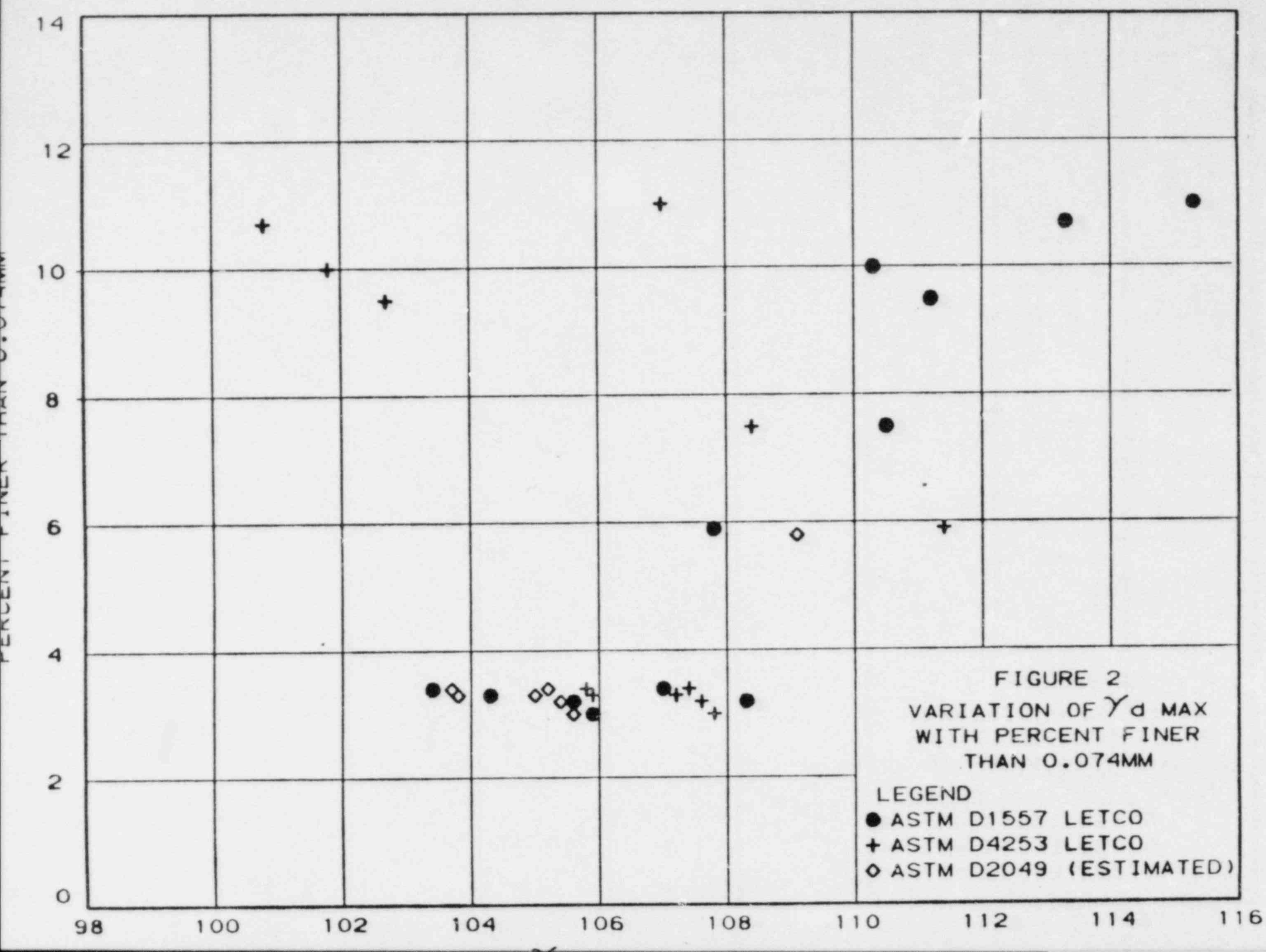
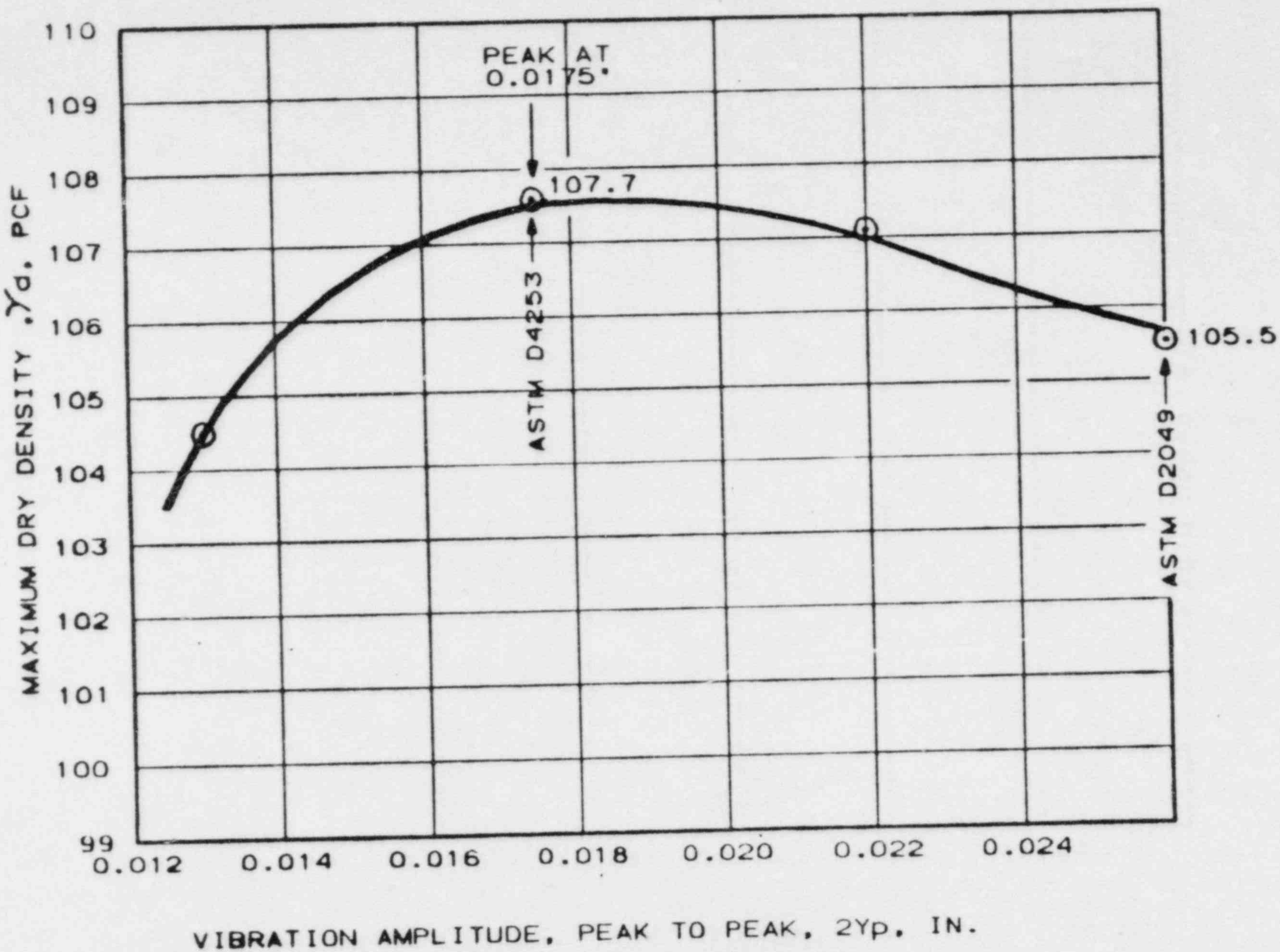


FIGURE 2
VARIATION OF γ_d MAX
WITH PERCENT FINER
THAN 0.074MM

FIGURE 3


PEAK AT
0.0175"
107.7
ASTM D4253
105.5
ASTM D2049
110
109
108
107
106
105
104
103
102
101
100
99
0.012
0.014
0.016
0.018
0.020
0.022
0.024
MAXIMUM DRY DENSITY, γd, PCF
VIBRATION AMPLITUDE, PEAK TO PEAK, 2Yp, IN.

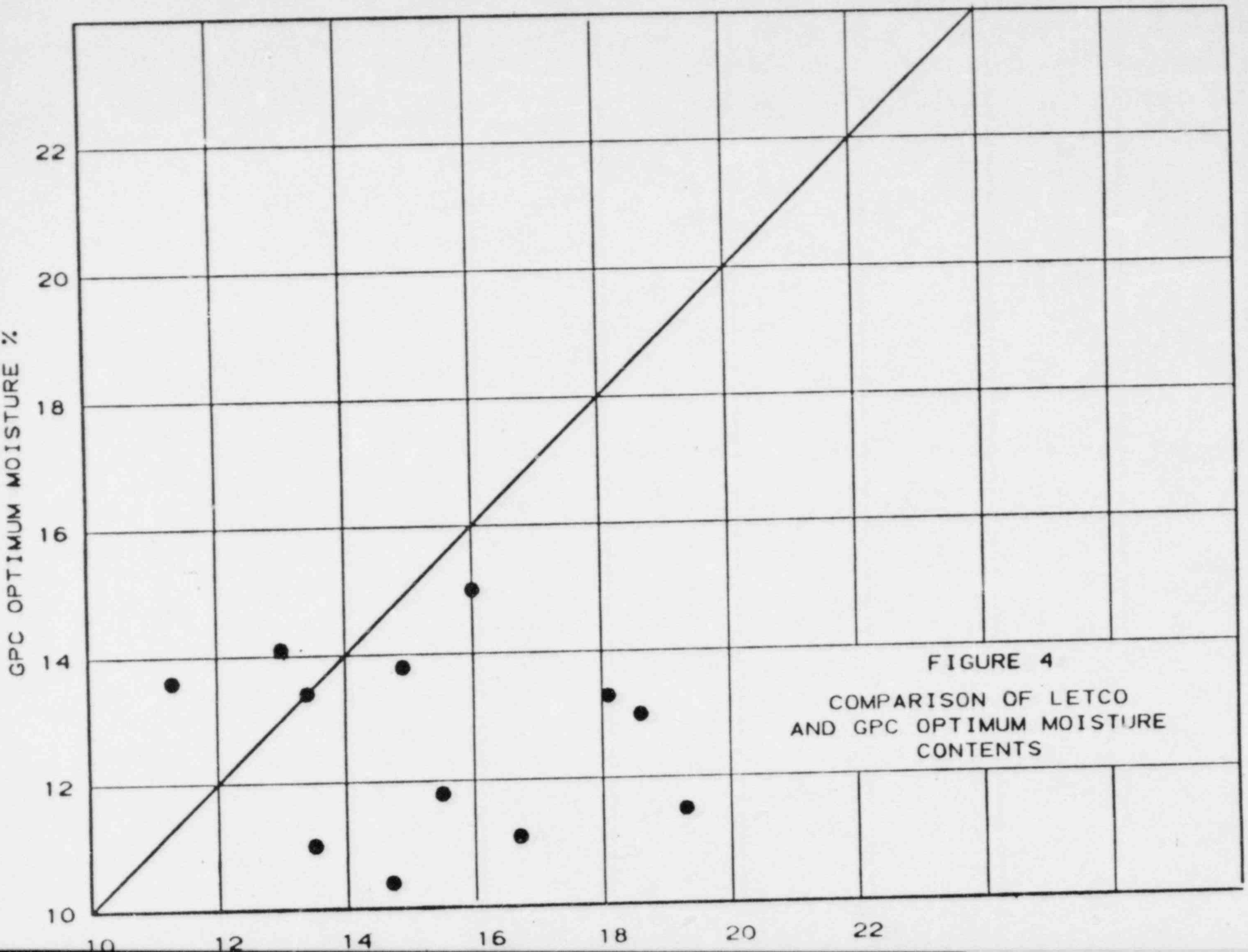
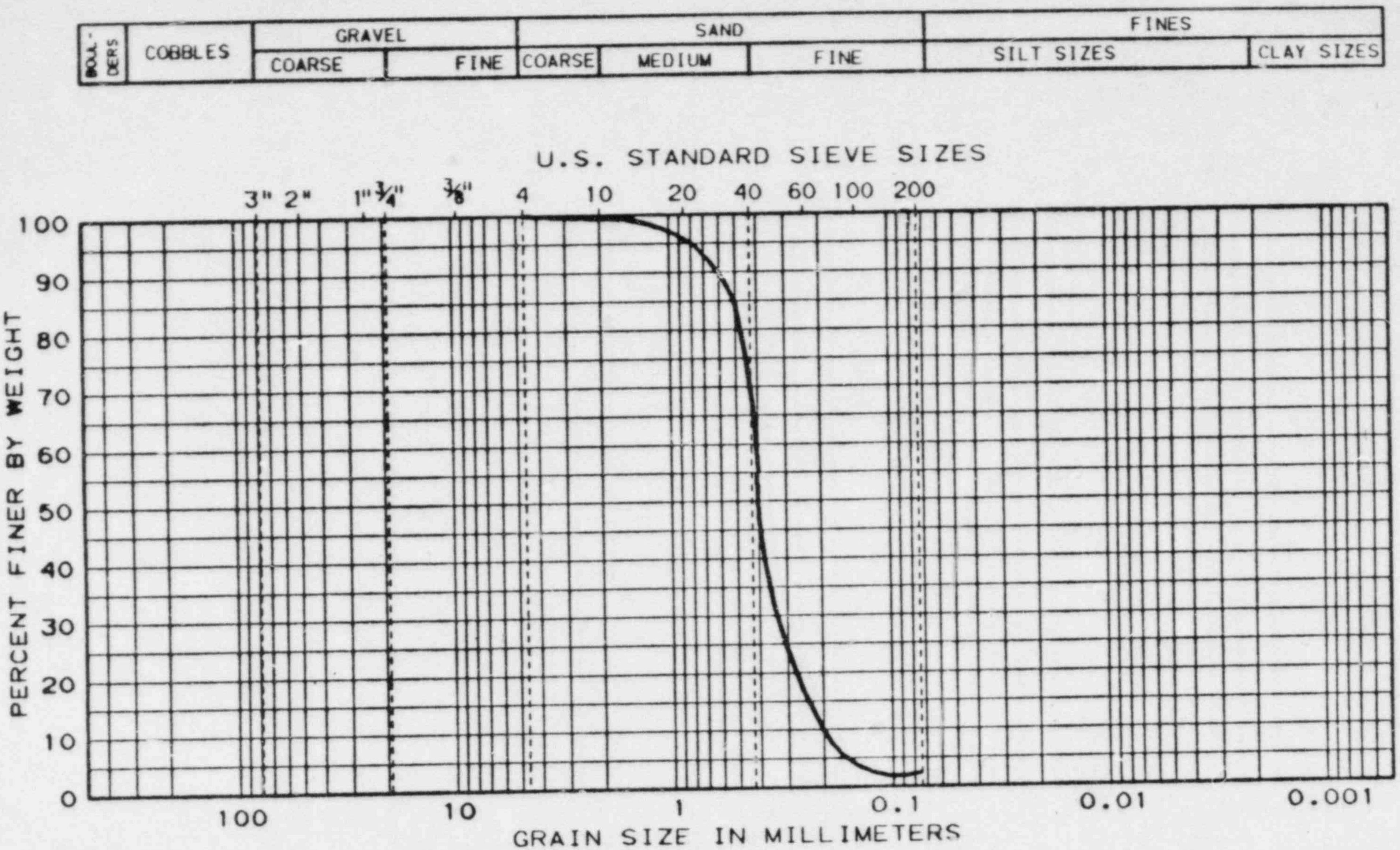


FIGURE 4

COMPARISON OF LETCO AND GPC OPTIMUM MOISTURE CONTENTS

FIGURE 5



BAG NO. 1
SAMPLE NO. 2

FIGURE 6
COMPACTION TEST
(ASTM D1557)

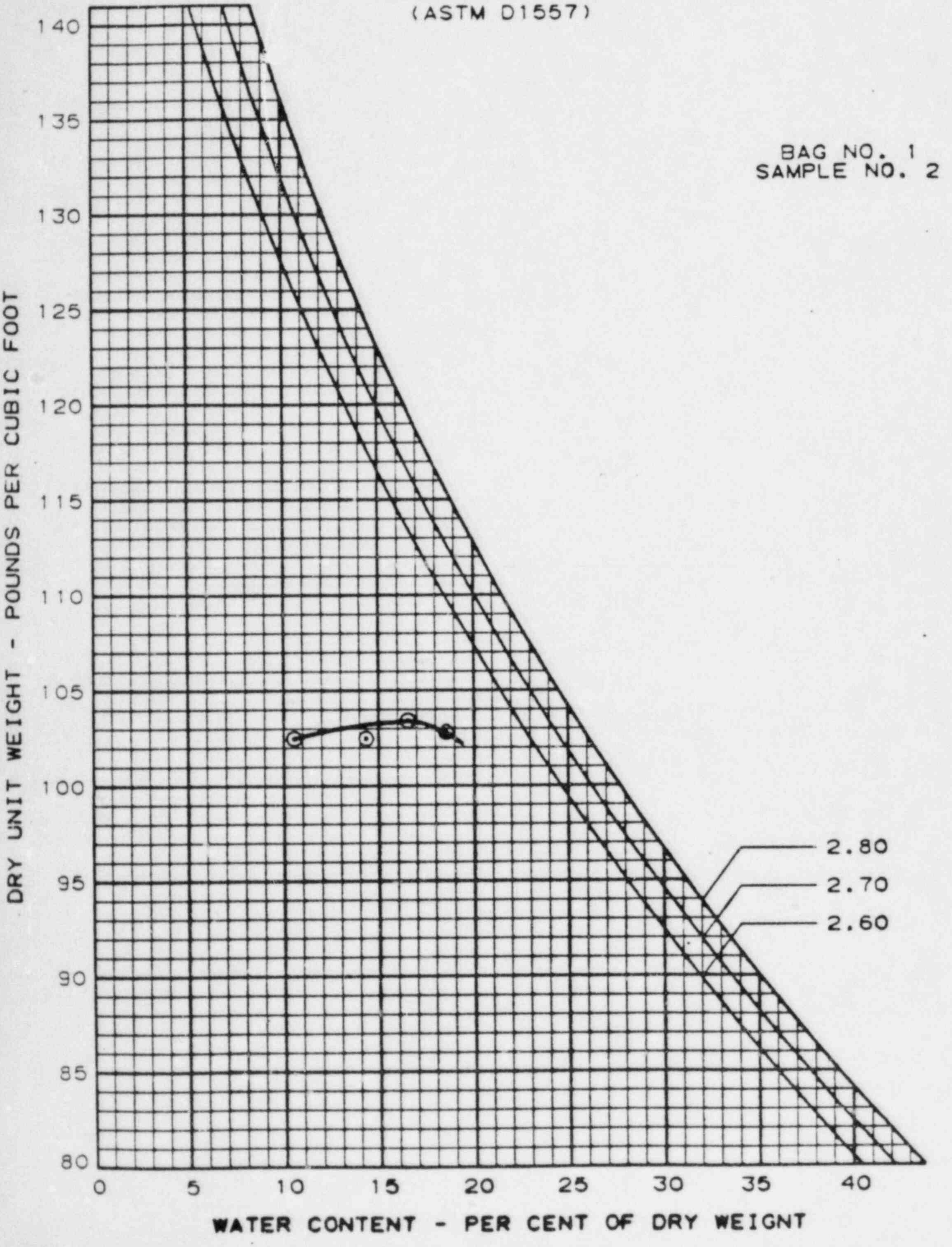
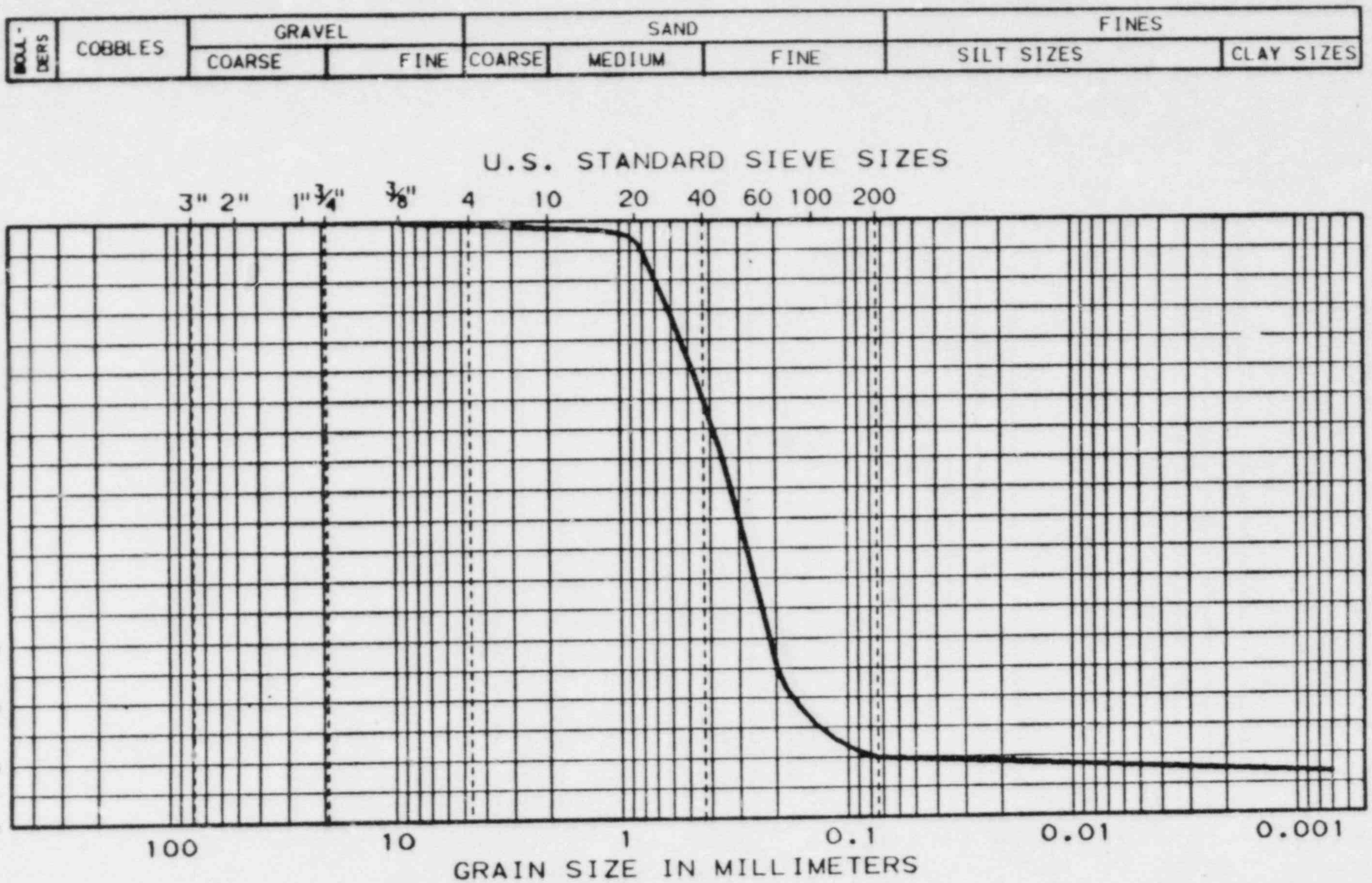
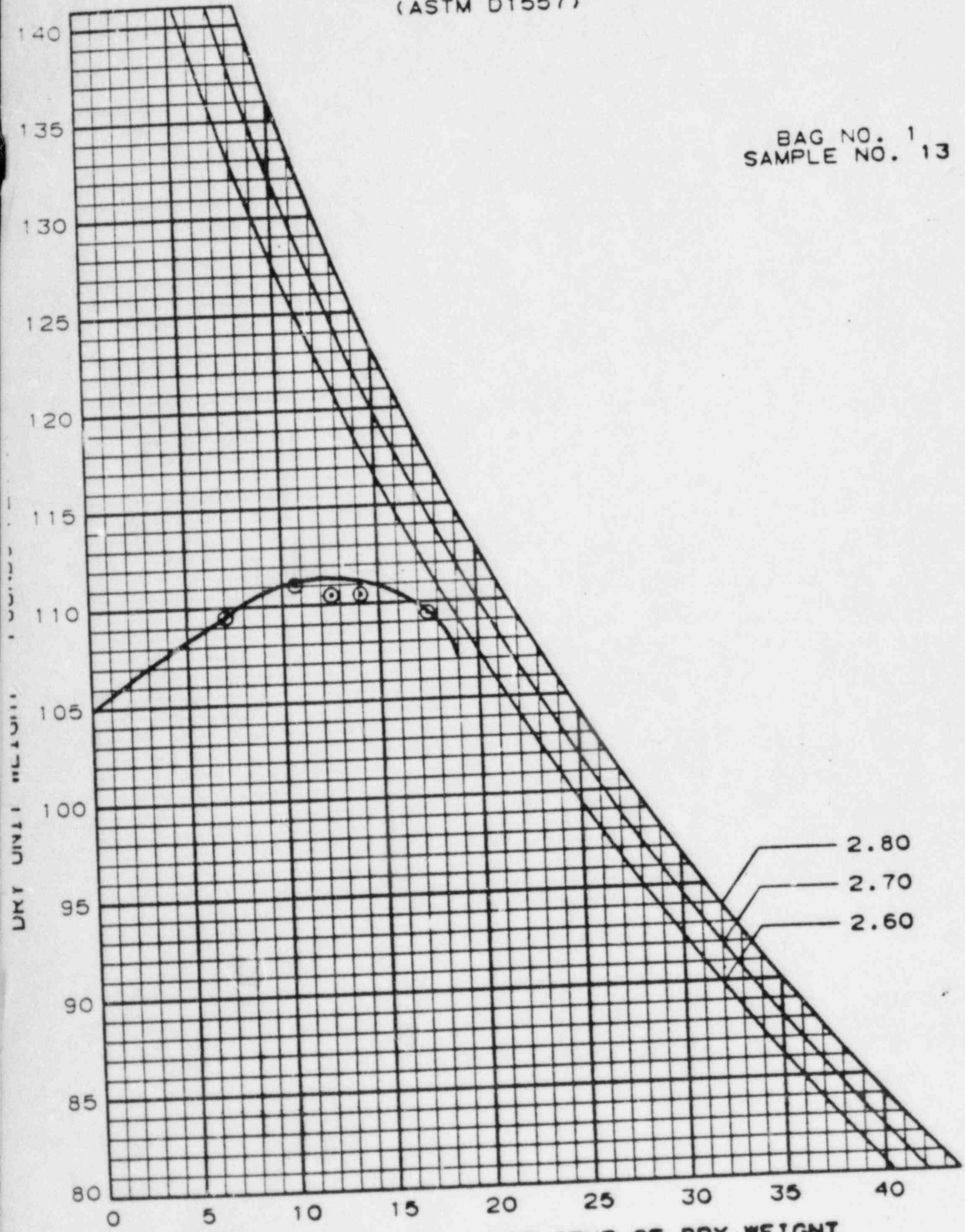


FIGURE 7



BAG NO. 1
SAMPLE NO. 13

FIGURE 8
COMPACTION TEST
(ASTM D1557)



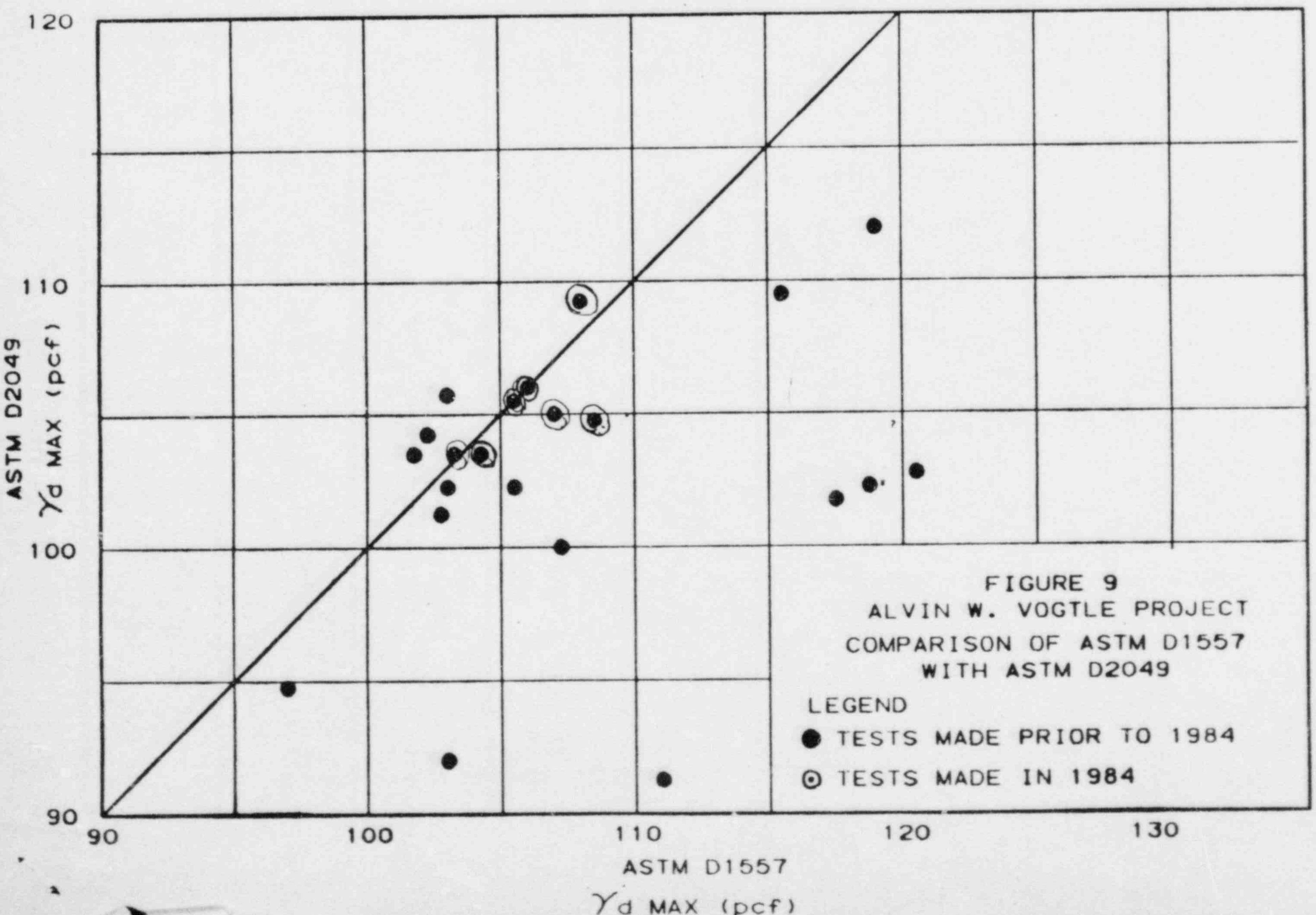


FIGURE 9
ALVIN W. VOGTLE PROJECT
COMPARISON OF ASTM D1557
WITH ASTM D2049

Open Item 5 SUBMITTAL AND EVALUATION OF SETTLEMENTS

Attached are settlement summary drawings AX2D55V050 through AX2D55V063. These drawings provide the same time scale for plotting settlement versus time and for plotting loading versus time for key settlement markers in the major power block structures.

In addition updated drawings AX2D55V001, AX2D55V006 through AX2D55V014, AX2D55V017 through AX2D55V019, AX2D55V024 through AX2D55V028 and AX2D55V050 through AX2D55V063 showing settlement versus time for all settlement markers including data for the NSCW towers and Unit 1 category 1 tunnels are attached. A load history for miscellaneous category 1 structures and radwaste structures is provided in response to question 241.17 (FSAR amendment 15).

It should be noted that the portion of the control building basemat containing marker number 222 was not placed until early 1983. For this reason its readings begin later than those of other control building settlement markers, many of which were placed in mid 1981.

A discussion of differential settlement related to structures and piping is provided in response to question 241.18 (FSAR amendment 15).

Drawings Attached

Drawing Number	Revision
AX2D55V001	10
AX2D55V006	11
AX2D55V007	11
AX2D55V008	11
AX2D55V009	10
AX2D55V010	11
AX2D55V011	11
AX2D55V012	11
AX2D55V013	7
AX2D55V014	1
AX2D55V017	3
AX2D55V018	3
AX2D55V019	3
AX2D55V024 through AX2D55V028	0
AX2D55V050 through AX2D55V063	0