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ANALYSES OF PROPERTIES OF FINER-GRAINED SAN MATEO SAND SONGS UNITS 2 AND 3 SAN ONOFRE, CALIFORNIA

FOR

Southern California Edison
P. O. Box 800
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BY

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Consulting Engineers and Geologistst

Los Angeles
31 December 1974
Project No. B576A

Southern California Edison
P. O. Box 800
Rosemead, California 91770

Attention: Mr. David H. Johns

SUBJECT : ANALYSES OF PROPERTIES OF
FINER-GRAINED SAN MATEO SAND
SONGS UNITS 2 AND 3
SAN ONOFRE, CALIFORNIA

Gentlemen:

As authorized on 22 Nov 74, we have performed Phases 1 and 2 of the project outlined in our proposal for analyses of properties of finer-grained San Mateo Sand, dated 14 Nov 74. The attached report presents our findings, supportive data, conclusions, and recommendations.

Our studies indicate that the more fine-grained sub-unit of the San Mateo Sand has substantially the same static and dynamic strength and stiffness as the more coarse-grained San Mateo Sand.

If you have any questions, or require further information, please contact us at your convenience.

Very truly yours,

WOODWARD-McNEILL & ASSOCIATES

By John A Barneich
John A. Barneich

By Andrew M Worswick
Andrew M. Worswick

JAB:AMW:ls
Attachments

ANALYSES OF PROPERTIES OF FINE-GRAINED SAN MATEO SAND SONGS UNITS 2 AND 3 SAN ONOFRE, CALIFORNIA

1.0 INTRODUCTION

During October and November 1974 design-verification field-density tests made in some areas of the site indicated dry densities somewhat lower than expected. Careful examination of these areas indicated the material was slightly finer than our previous studies of the San Mateo Sand had indicated. We therefore obtained bulk samples of the finer material and took them to our laboratory for grain-size analysis and compaction testing. The grain-size distribution tests also indicated the material was finer, and the compaction test indicated a maximum dry density of 115 pcf (versus 120 pcf for the less fine-grained material). Even though the relative density of this material appeared to be the same as for the site soils in general (~100%), it was decided to initiate field and laboratory studies to investigate its extent and strength properties. The scope of these studies is described in the following Section 2.0. A discussion of Phase 1 of the project is presented in Section 3.0, and a discussion of Phase 2 (laboratory testing program) is presented in Section 4.0. Finally, our conclusions and recommendations are presented in Section 5.0.

2.0 SCOPE OF PROJECT

The first two phases of the originally proposed project have been completed and are described in this report.

Phase 1 of the investigation was to carefully examine the site excavations to determine the location and extent of the finer material. A geologist from our staff has also examined the site, and studied geologic information provided by Mr. D. Hinkle of SCE.

Phase 2 of the investigation involved obtaining block and bulk samples of the material, performing laboratory tests, and analyzing the results. Laboratory tests performed included static and dynamic triaxial tests, compaction tests, grain-size distribution tests, and specific gravity tests.

The results of both Phases 1 and 2 are presented in the following sections.

3.0 RESULTS OF THE PHASE 1 STUDY

The zones of more fine-grained San Mateo Sand delineated during this study are shown on Fig. 1. A geologist from our staff examined the site and studied probable causes and mechanisms of deposition. A report entitled *Analysis of C and D Type Features at San Onofre Nuclear Generating Station*, dated 1 Nov 74, by Fugro, Inc., was made available to us as basic data. The studies we made indicate that some of the zones of finer material are likely associated with the geologic features discussed in the Fugro report. For example, in the Auxiliary Building area, the finer-grained zone of material appears to have been deposited below siltstone lenses. In other areas the gradational change does not appear to be associated with specific geologic features, however, the study made was not detailed enough to verify this interpretation. For either condition, all the zones of finer material appear to be associated with deposition in a more quiescent environment than for most of the San Mateo Formation. These studies did not suggest that the finer-grained material has different engineering properties than previously determined for San Mateo Sand.

4.0 RESULTS OF THE PHASE 2 STUDY

4.1 Sample Procurement

Bulk and block samples of the finer-grained material were obtained from the site for laboratory testing. The locations from which samples were obtained are shown on Fig. 1.

4.2 Laboratory Index Tests

Specific gravity tests made on 3 samples indicated the specific gravity of this material is about the same (within the accuracy of specific gravity test procedure) as the coarse-grained material. These results are summarized on Figs. 2 and 3.

Grain-size distribution analyses were made on all samples obtained from the site, and are presented on Figs. 2 through 5. These tests aided in delineating the boundaries of the zones of finer-grained material and in correlating other test data.

Laboratory compaction tests were made on selected samples in general accordance with ASTM Test No. D-1557-70. The results, presented on Fig. 6, show that the finer-grained material has different densification characteristics, as the maximum dry density obtained for any of these samples was 115 pcf (versus 120 pcf for the more coarse-grained material). This suggests that the relative density of the finer-material is near 100%, as field tests have indicated an in-situ dry density in excess of 115 pcf.

4.3 Static Triaxial Compression Tests

To evaluate the static strength characteristics of the material, consolidated, drained (CD) triaxial compression tests were made on carved-block samples obtained from the subgrade of the proposed Auxiliary and Turbine (Unit 2) Buildings. The tests were performed in the same manner, with the same loading increments, as for a testing program performed on coarse-grained material during September, 1974. The results, presented on Figs. 7 and 8, show that test specimens of finer-grained material sustained about the same loading before failure, and that the stress-strain characteristics over most of the loading range are approximately the same (i.e., same stiffness) as for the more coarse-grained material.

4.4 Dynamic Triaxial Test Results

Five dynamic triaxial tests were run on carved-block samples of the finer-grained San Mateo Sand. Cyclic loading was applied at a frequency of 1 cps on test specimens isotropically consolidated (K_c = 1.0) under an effective confining pressure of 4000 psf. Pertinent test data are presented on Table I.

Dry density measurements of these test specimens indicated an average of approximately 108 pcf, whereas in-situ dry density measurements indicated an average of approximately 116 pcf. This difference is likely due to elastic rebound (due to stress relief) of the very dense material as it was removed from the ground. Dynamic test results for the more coarse-grained San Mateo Sand presented in Appendix C of our report entitled *Liquefaction Evaluation for the Proposed Units 2 and 3, San Onofre Nuclear Generating Station, San Onofre, California,* dated 22 Jan 74, indicated that when test specimen density was increased from 109 pcf to 115 pcf, the cyclic deviator stress required to cause failure in a given number of cycles increased a minimum of 40% (i.e., dynamic strength increased at least 40%). These data were used to determine an appropriate correction factor for density. To conservatively reconcile the difference between laboratory and in-situ densities of the finer-grained test specimens, the deviator stress required to cause failure in a given number of applied stress cycles was increased by 30%. Also, the Correction Factor, C_r (defined by Seed and Idriss), was conservatively estimated to be 0.8. The in-situ dynamic strength curve for this material, based on dynamic test results and the corrections discussed above, is presented on Fig. 9. The design curve previously developed to represent the dynamic strength of all native San Mateo Sand is also shown on Fig. 9 for comparison. These data indicate that the dynamic strength curve of the more fine-grained material is as high or higher than the curve used for the more coarse-grained material. By comparison to actual test data for the more coarse-grained material, these data points fall in the same range of data scatter, and are therefore considered the same.

5.0 CONCLUSIONS AND RECOMMENDATIONS

All tests and analyses made for this study indicate the more fine-grained San Mateo Sand has static and dynamic strength of the same magnitude as previously determined for the more coarse-grained San Mateo Sand. Also, the stiffness of the material appears to be approximately the same as previously determined.

Therefore, it is recommended that no change in static and dynamic strength and stiffness parameters be made for the project.

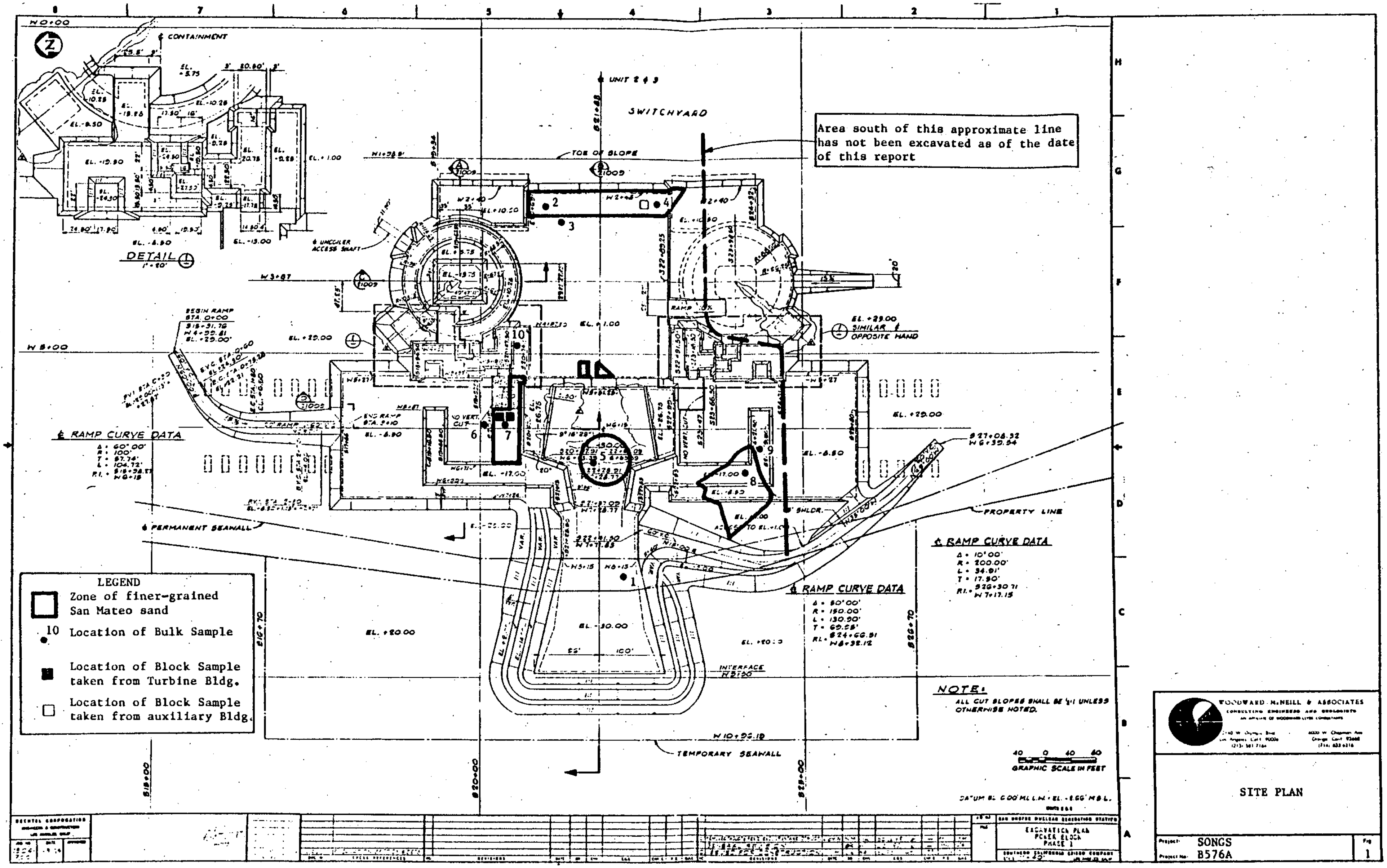
TABLE I

SUMMARY OF CYCLIC TRIAXIAL TEST RESULTS
FINE-GRAINED SAN MATEO SAND

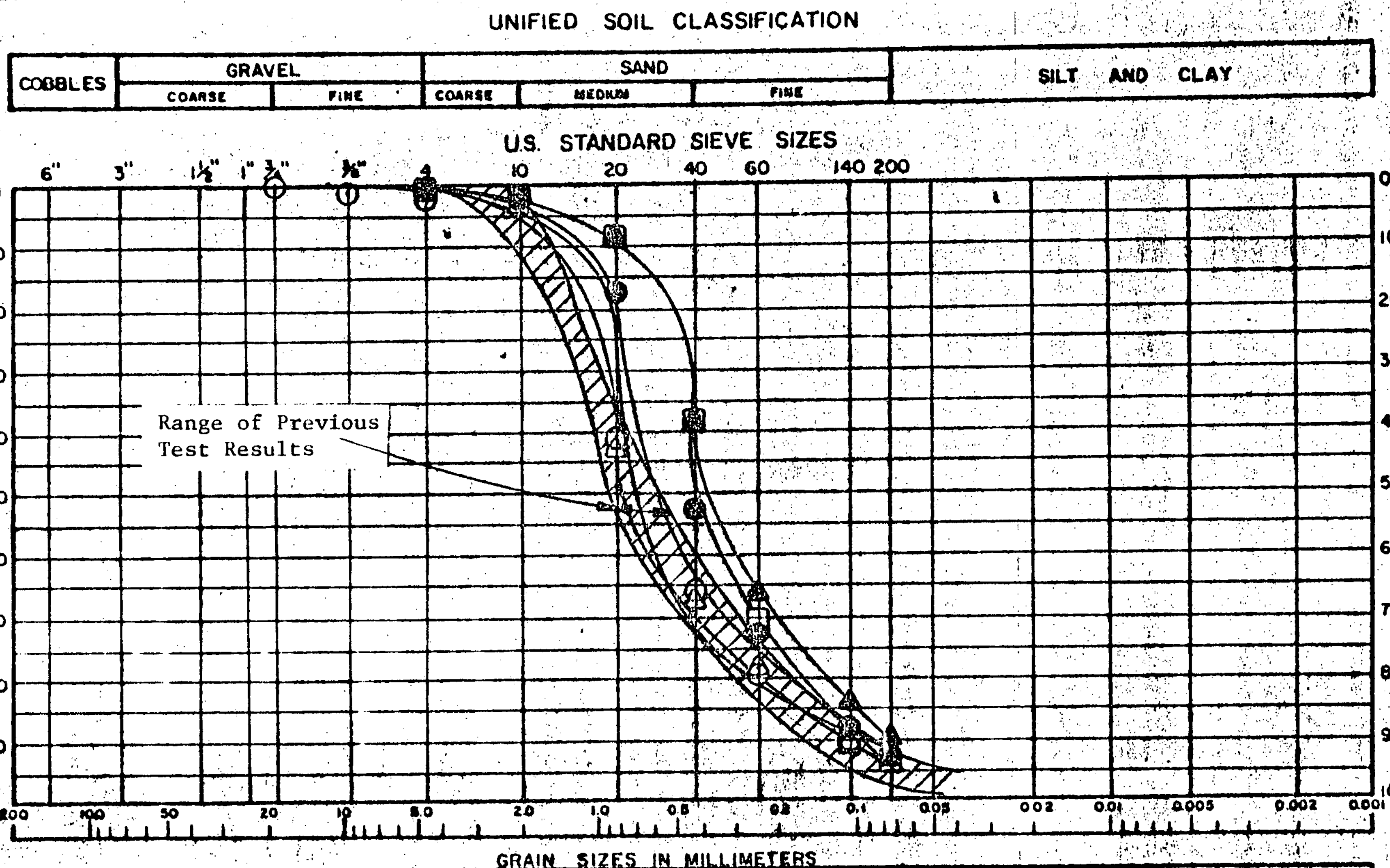
Test No.	Sample Type	Sample Location	K_c	σ_{3c} (ksf)	Dry Density (pcf)	$\pm\sigma_d$ (ksf)	N	ε (%)	$\frac{\sigma_d}{2\sigma_{3c}}$
1	Block No. 1	Turbine Bldg #2 Elev -8.5	1.0	4.0	111	3.8	19	10	.483
2	Block No. 1	Turbine Bldg #2 Elev -8.5	1.0	4.0	110	3.5	66	10	.430
3	Block No. 2	Turbine Bldg #2 Elev -8.5	1.0	4.0	106.5	4.0	9	10	.505
4	Block No. 2	Turbine Bldg #2 Elev -8.5	1.0	4.0	105	3.2	94	10	.399
5	Block No. 2	Turbine Bldg #2 Elev -8.5	1.0	4.0	107	3.7	144	10	.465

NOTES: Sample Diameter = 2.86 in.
All samples saturated
Tests at frequency of 1 cps

EXPLANATION: K_c = consolidation stress ratio $\left(\frac{\sigma_{1c}}{\sigma_{3c}}\right)$
σ_{1c} = axial consolidation stress
σ_{3c} = confing stress
σ_d = cyclic deviator stress
N = number of stress cycles
ε = axial strain @ N cycles



Area south of this approximate line has not been excavated as of the date of this report
SWITCHYARD
TOE OF SLOPE
CONTAINMENT
DETAIL
RAMP CURVE DATA
PERMANENT SEAWALL
PROPERTY LINE
TEMPORARY SEAWALL
INTERFACE
NOTE:
ALL CUT SLOPES SHALL BE ½:1 UNLESS OTHERWISE NOTED.
GRAPHIC SCALE IN FEET
LEGEND
Zone of finer-grained San Mateo sand
10 Location of Bulk Sample
Location of Block Sample taken from Turbine Bldg.
Location of Block Sample taken from auxiliary Bldg.
WOODWARD-McNEILL & ASSOCIATES
SITE PLAN
Project: SONGS
Project No: B576A
Fig 1



SAMPLE NO.	SYMBOL	SPECIFIC GRAVITY	CLASSIFICATION
#1	⊙———⊙		San Mateo SAND
#2	●———●	2.61	San Mateo SAND
#3	△———△		San Mateo SAND
#4	▲———▲		San Mateo SAND
#5	⊡———⊡	2.63	San Mateo SAND

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Job Number: B576A

GRAIN SIZE DISTRIBUTION CURVES

Fig. 2

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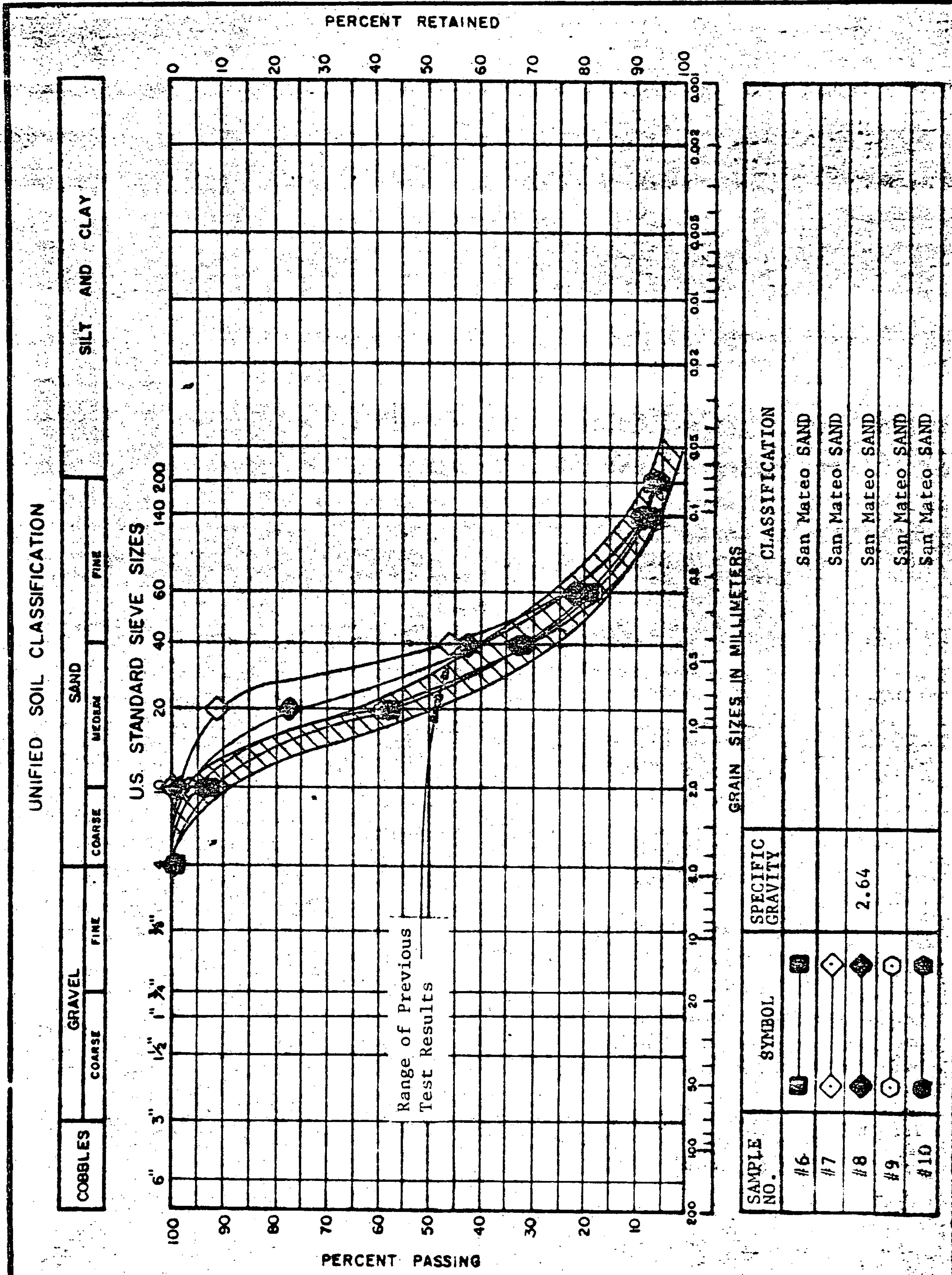
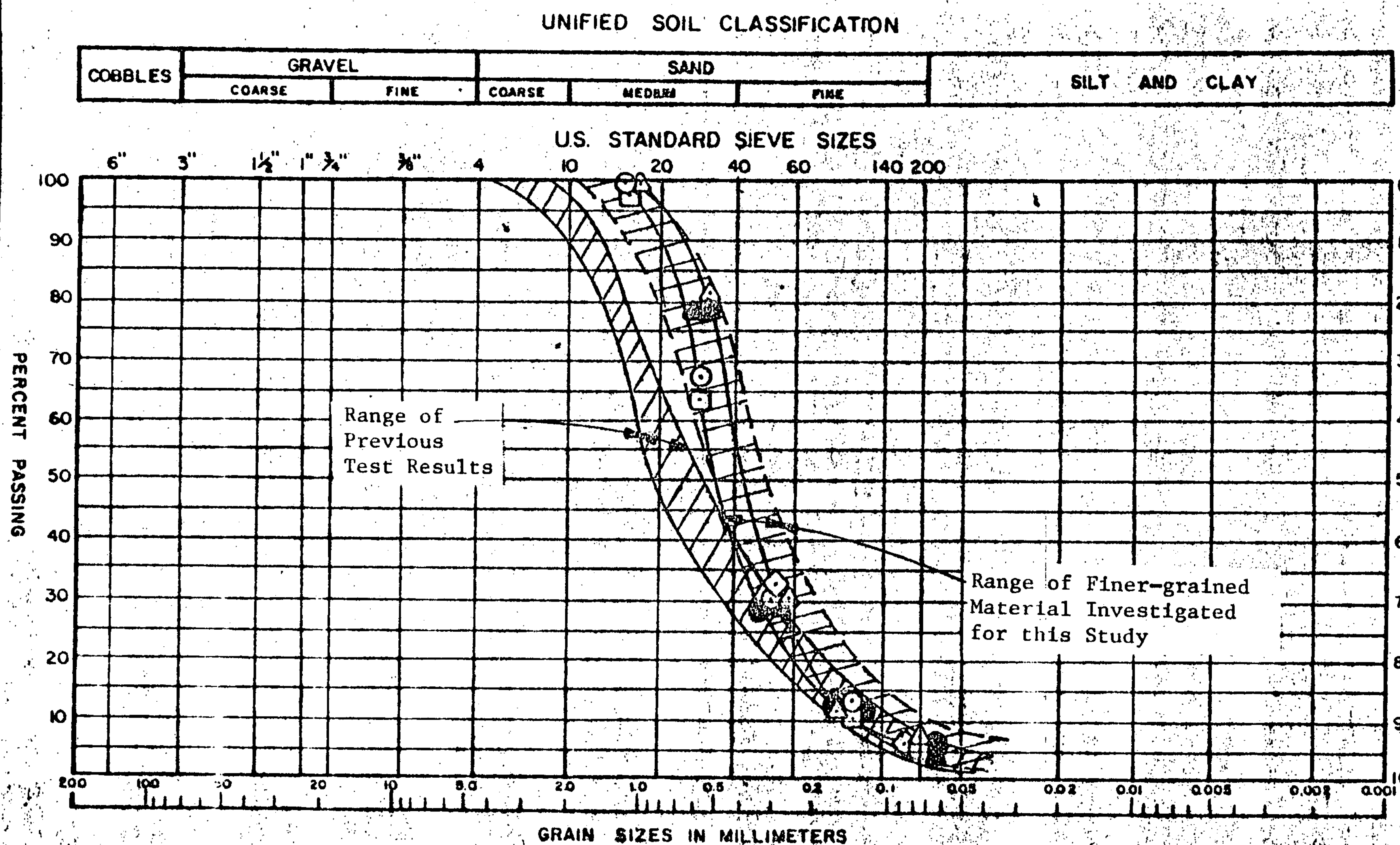


Project: SONGS	GRAIN SIZE DISTRIBUTION CURVES
Job Number: B576A	Fig 3

Project: SONGS

Job Number: B576A

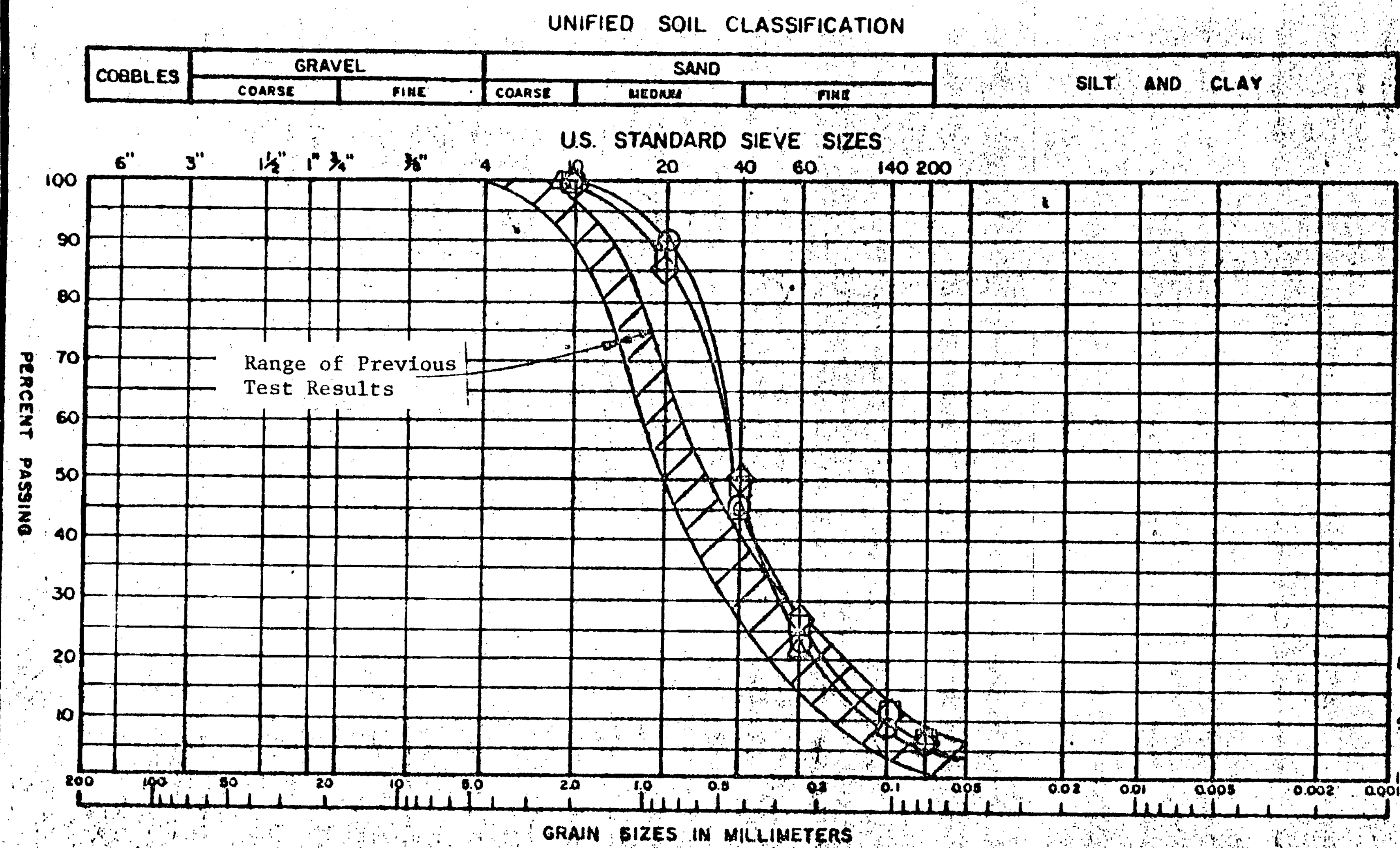


SAMPLE NO.	BLOCK	SYMBOL			CLASSIFICATION
Dyn. Test #1	1				San Mateo SAND
" " #2	1				San Mateo SAND
" " #3	2				San Mateo SAND
" " #4	2				San Mateo SAND
" " #5	2				San Mateo SAND

GRAIN SIZE DISTRIBUTION CURVES FOR DYNAMIC TRIAXIAL TEST SAMPLES

Fig. 4

Project: SONGS
Job Number: B576A

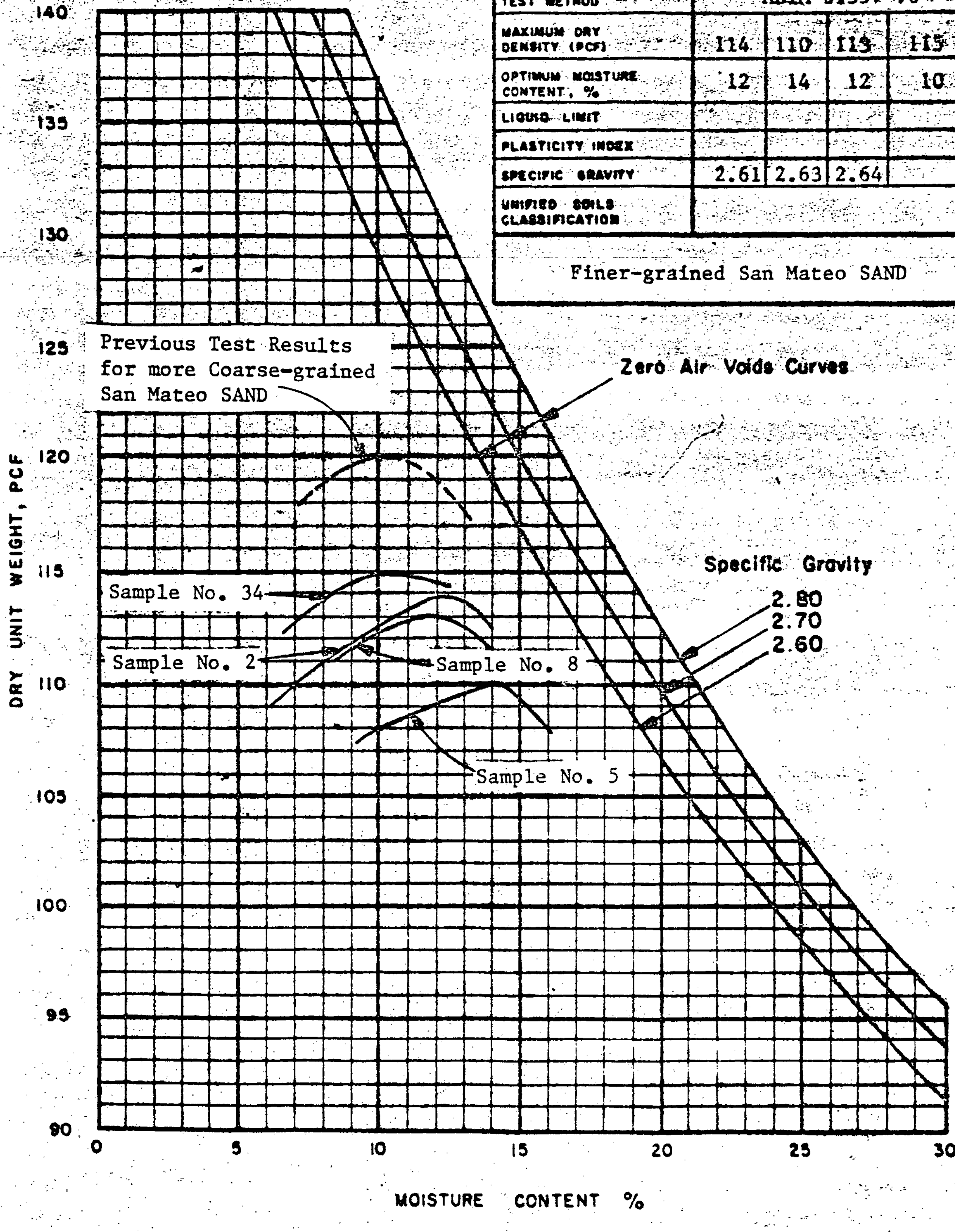


STATIC SAMPLE NO.	DEPTH	SYMBOL	LL	PI	CLASSIFICATION
#1		⊙——⊙			Finer-grained San Mateo SAND
#2		△——△			Finer-grained San Mateo SAND
#3		⊡——⊡			Finer-grained San Mateo SAND
#4		◇——◇			Finer-grained San Mateo SAND

GRAIN SIZE DISTRIBUTION CURVES
FOR STATIC TRIAXIAL TEST SAMPLES

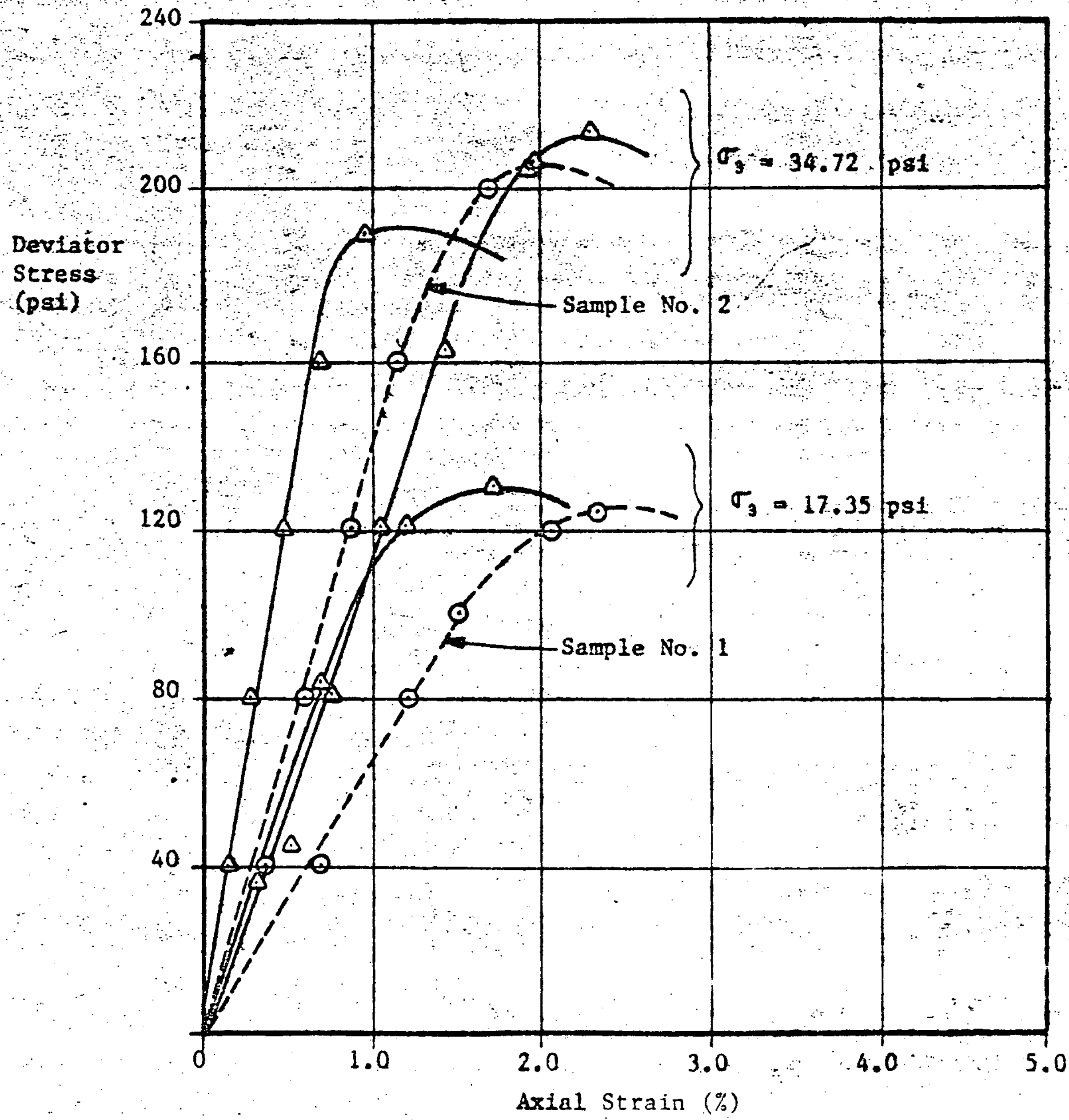
Fig 5

SUMMARY OF TEST RESULTS				
SAMPLE NO.	2	5	8	34
TEST METHOD	ASTM-D1557-70			
MAXIMUM DRY DENSITY (PCF)	114	110	113	115
OPTIMUM MOISTURE CONTENT, %	12	14	12	10
LIQUID LIMIT				
PLASTICITY INDEX				
SPECIFIC GRAVITY	2.61	2.63	2.64	
UNIFIED SOILS CLASSIFICATION				
Finer-grained San Mateo SAND				



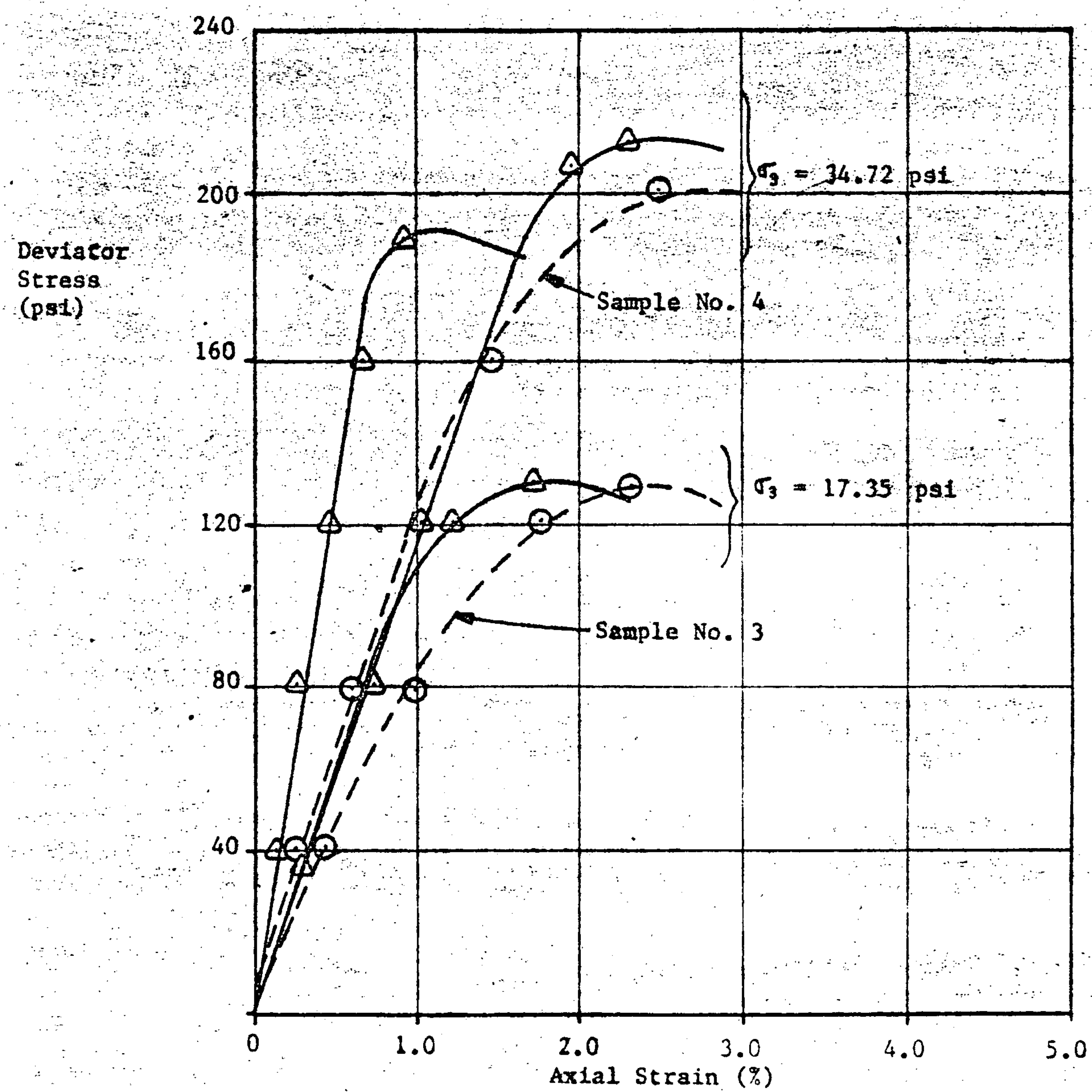
Project SONGS Job Number B576A	COMPACTION TESTS	Fig. 6

Symbol	Material
△——△	More coarse-grained San Mateo SAND (results from previous study)
⊙- - - -⊙	More fine-grained San Mateo SAND (from Unit 2 Turbine Bldg. Subgrade)

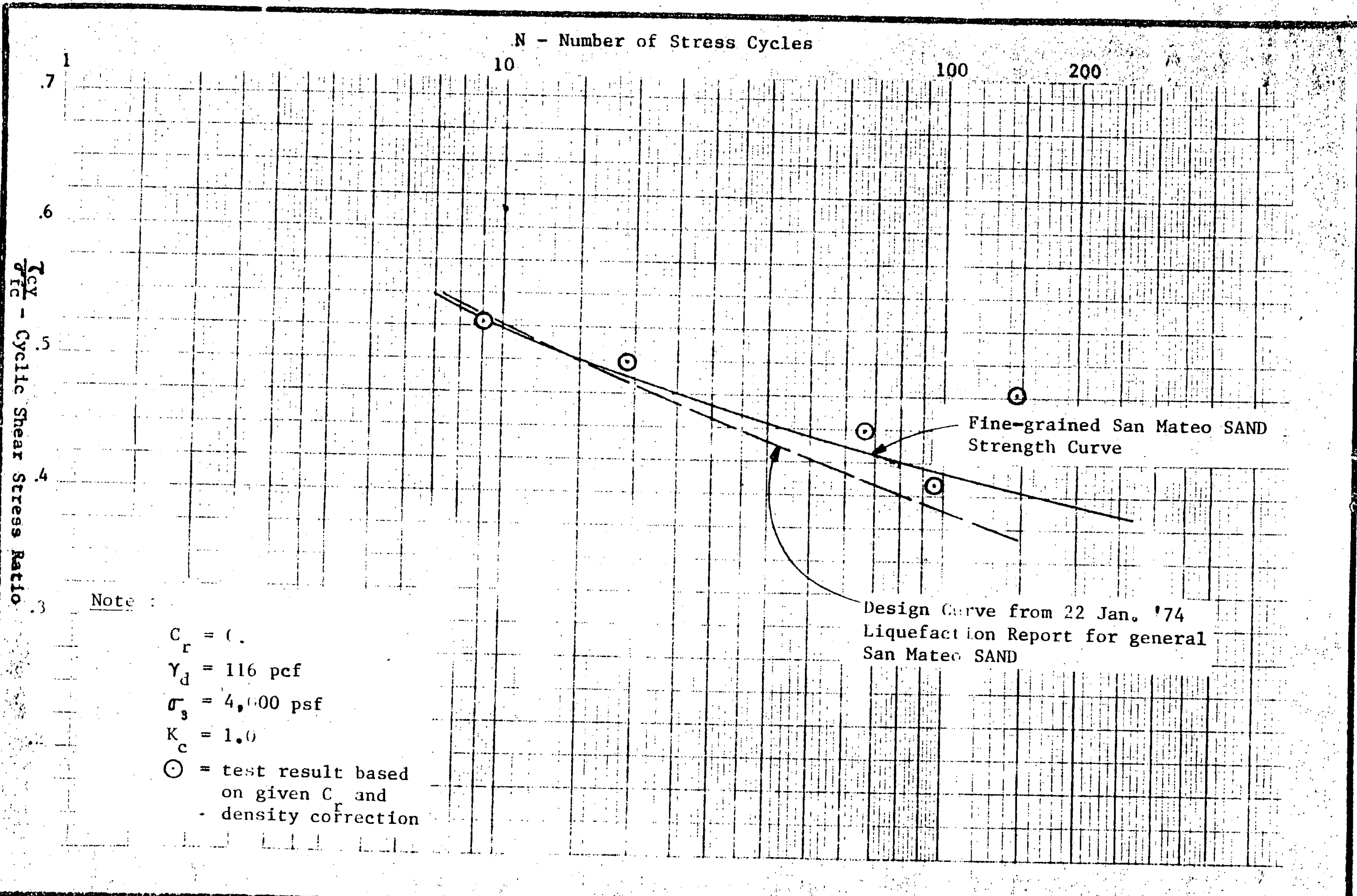


Project: SONGS Job Number: B576A	RESULTS OF STATIC TRIAXIAL TESTS UNIT 2 TURBINE BLDG. SAMPLES	Fig. 7

Symbol	Material
△———△	More coarse-grained San Mateo SAND (results from previous study)
⊙- - - -⊙	More fine-grained San Mateo SAND (from auxiliary building)



Project: SONGS Job Number: B576A	RESULTS OF STATIC TRIAXIAL TESTS AUXILIARY BLDG. SAMPLES	Fig. 8



Project: SONGS Job Number: B576A	DYNAMIC STRENGTH	Fig. 9

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