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Report On Deformation Moduli Of Embankment Soils From The Test Culvert Installation At Cedar Creek 01-Men-101

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16. ABSTRACT
Introduction: This report describes the results of a laboratory testing program to obtain strength and deformation data on soil samples taken from the embankment construction project at Cedar Creek, in Mendocino County, Road 01-Men-101, about 2.1 miles south of Leggett.

The work reported herein consists of the laboratory portion of services provided by our Department in connection with a research project conducted by the Bridge Department to study the behavior of arch culverts placed under high fills. The need for laboratory tests was mentioned in the project proposal, "Resume' of Arch Culvert Research Procedures," a copy of which was submitted to us by the Bridge Department by a memorandum dated December 13, 1967.

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State of California
Department of Public Works
Division of Highways
Materials and Research Department

January 28, 1970

01-Men-101

Lab. Auth. 32940

Mr. J. E. McMahon
Bridge Engineer
Division of Highways
Sacramento, California

Dear Sir:

Submitted for your consideration is:

REPORT

on

DEFORMATION MODULI OF EMBANKMENT SOILS

from the

TEST CULVERT INSTALLATION

at

CEDAR CREEK

01-Men-101

Study made by .... Foundation Section
Under general direction of .... Travis Smith
Work supervised by .... R. A. Forsyth and
R. H. Prysock
Report prepared by .... A. Y. Lee

Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

By [signature]
Travis Smith
Assistant Materials and
Research Engineer - Foundation

Attach.

70-35

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By Travis Smith
Travis Smith
Assistant Materials and
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Introduction

This report describes the results of a laboratory testing program to obtain strength and deformation data on soil samples taken from the embankment construction project at Cedar Creek, in Mendocino County, Road 01-Men-101, about 2.1 miles south of Leggett.

The work reported herein consists of the laboratory portion of services provided by our Department in connection with a research project conducted by the Bridge Department to study the behavior of arch culverts placed under high fills. The need for laboratory tests was mentioned in the project proposal, "Resumé of Arch Culvert Research Procedures," a copy of which was submitted to us by the Bridge Department by a memorandum dated December 13, 1967.

Project Description

The construction project involved replacement of 4-1/2 miles of existing road with a 4-lane, 60 foot wide all paved section. Two separation structures and two concrete arch culverts under high fill were also included in the section. These culverts were designed to replace two old concrete arch bridges constructed in 1933 across Big Dan Creek and Cedar Creek. The Cedar Creek embankment construction is one of the special projects being studied by the Bridge Department as part of a statewide research program to evaluate behavior or rigid arch culverts. The ultimate objective is to design a competent reinforced concrete arch culvert capable to withstand loads created by major embankments in excess of 200 feet in height.

The reinforced concrete culvert for the study is a 22 foot arch section, 763 feet long with inlet and outlet wingwalls. The culvert rests on concrete backfill and crosses the highway at Station 616+03. A cross-section of the embankment area at Station 616+00 is shown in Figure 1.

Sampling and Testing

Four soil samples, each weighing about one ton and filling eight 35-gallon steel drums, were taken during the period of August 9 to November 19, 1968. One of these samples was obtained by Bridge Department personnel and the other three were taken by Materials and Research Department personnel during various trips to the project to install soil pressure meters, settlement platforms, or to take instrumentation readings. All soil samples were taken from local sources, cuts or stream beds supplying materials for use in the embankment construction. Zones of the embankment represented by these samples are illustrated in Figure 1. The samples, originally identified by field Nos. CC-1, CC-2, CC-3 and CC-4, were labeled Laboratory Nos. 69-1217, 69-1205, 69-1180 and 69-2278, respectively,upon receipt by this department.

The laboratory testing program consisted of classification tests and strength tests. The classification tests, including grain size analysis, mechanical analysis, specific gravity, Atterberg limits, sand equivalent, and California impact, were performed to determine the index properties of soils. Details of these test results are shown in Table I with grain size analyses and the moisture-density relationships from the California impact tests presented graphically in Figures 2-A and 2-B, respectively.

All strength tests were performed using the total stress method. In this method, partially-saturated soils are subjected to a given hydrostatic confining chamber pressure and a deviator-stress increasing at a constant strain rate. The water content of the specimen does not change and no pore water pressure measurements are taken during the entire triaxial testing process.

Conventional deviator stress versus axial strain plots for all tests are shown on Figures 3 to 6, inclusive. On comparison of Figures 3, 4, and 5, a great similarity in the shape of the stress-strain curves was noted. There were no significant differences in triaxial compressive strength for any of these three samples tested. Strengths for CC-4 were somewhat less than those of the other three samples because of the relatively high percentage of fine fractions in the soil composition. Furthermore, the specimens were compacted at 90% instead of 95% relative compaction.

Mohr-Coulomb diagrams were utilized for analysis of the triaxial test data. Mohr's circles and strength envelopes for each series of triaxial tests were attained by a graphical method. Since all tests were conducted using partially-saturated specimens in a remolded state and no pore-water pressure measurements were made, the strength envelopes in Figures 7 to 10, inclusive, were plotted using the total stress circle at failure. Thus, the shear strength parameters, cohesion (c) and angle of shearing resistance (Ø) are in terms of total stress. A cohesion value of 500 psf and angle of shearing resistance of 27.5 degrees were attained for samples CC-1, CC-2 and CC-3. Lower values for both cohesion (c = 400 psf) and angle of shearing resistance (Ø = 24°) were obtained for sample CC-4.

In general, the deformation modulus of soil is approximated by a straight line portion of the stress-strain curve from triaxial test data. The slope of this straight line is the modulus of deformation. Of several available methods of determining modulus in soil mechanics, the secant modulus of deformation was chosen. The secant modulus is defined as the slope of a straight line drawn from the origin to some arbitrary point on the stress-strain curve where the stress is generally equal to a given fraction of the maximum deviator stress. Deformation moduli are found by dividing the deviator stress by the axial strain at any point along this secant.

The secant modul thus derived from one-third and one-half of the maximum deviator stress are illustrated in Figures 11 and 12, respectively. Inspection of the curves of these two figures indicates that the relationship of deformation moduls and confining pressures is very irregular. The curves for samples CC-1, CC-2 and CC-3 show a highly significant linear trend of increasing modulus as the pressure increases. This trend, however, is less pronounced in the high pressure range of 150 to 200 psi. The curve of Sample CC-4 shows a moderate increase at low pressures, but a rapid decrease at high pressures.

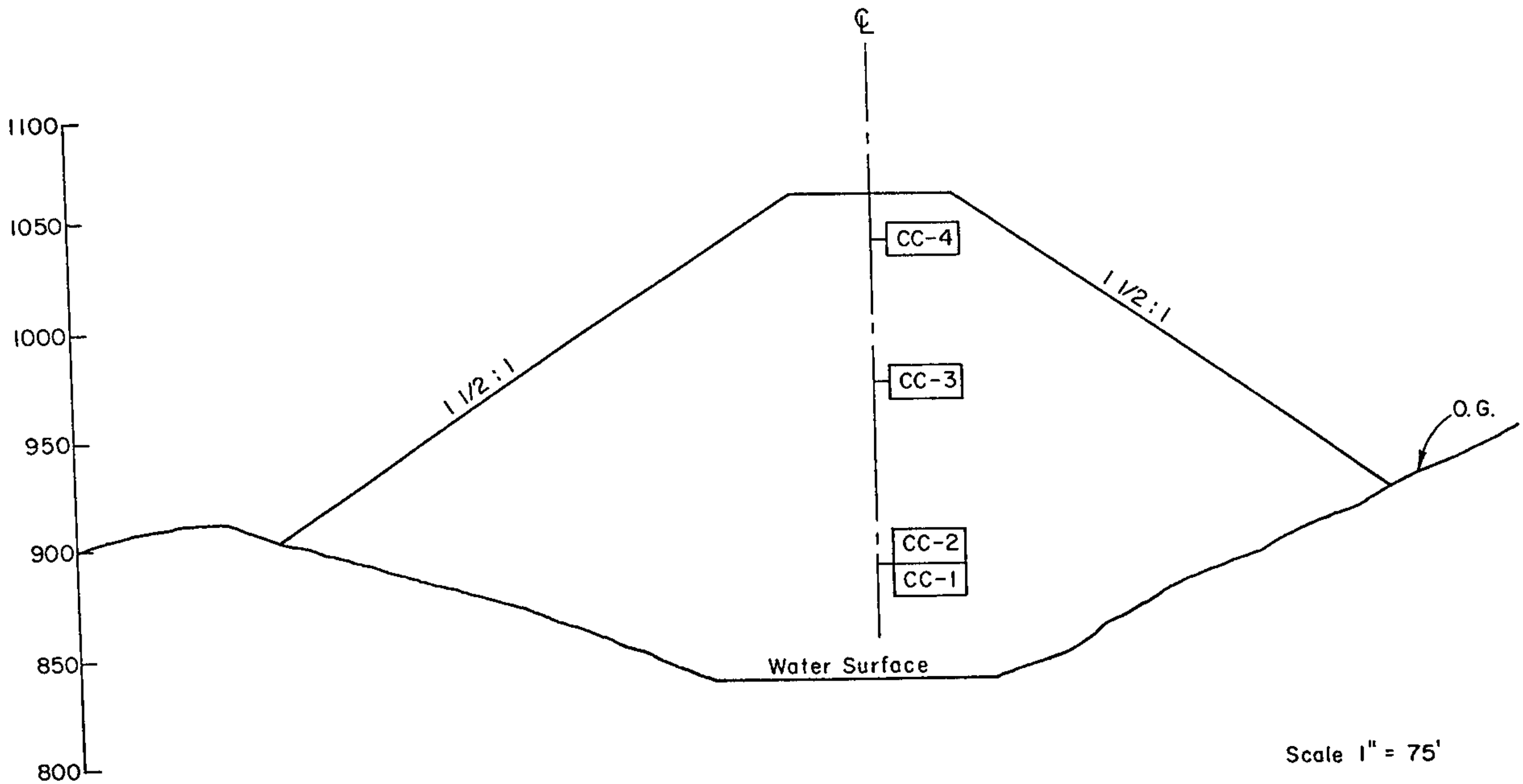
It should be noted that the deformation moduli derives from 1/3 and 1/2 of maximum deviator stress were unsatisfactory for use in selecting reliable values due to their irregular shapes. For this reason, additional moduli based on axial strain of 2-1/2, 3, 4, 5 and 6 percent were tabulated.

Table 1. Classification Test Results

Field No.	CC-1	CC-2	CC-3	CC-4
Laboratory No.	69-1217	69-1205	69-1133	69-2278
Source (Sample taken from)	Canyon Wall at Arch #17	Stream-bed	Cut at Sta. 506~	Mainline Sta. 467 - 468
Embankment Material represented (at Elev)	Elev. 880±	Elev.885±	Elev. 970±	Elev. 1035±
Max.Dry Unit Weight -pcf-	137	143	138	138
Optimum Moisture,%	7.6	7.3	7.5	7.4
Specific Gravity (+#4) B.O.D.	2.68	2.75	2.65	2.70
Specific Gravity (-#4) Appar.	2.55	2.67	2.53	2.48
Percent Absorption(+4)	2.8	1.7	2.2	3.6
Liquid Limit	24	--	21	32
Plastic Limit	22	--	18	19
Plasticity Index	2	NP	3	13
Sand Equivalent	27	35	24	19
Grain Size Analysis (% finer,by weight)				
Sieve Size 3"	91	100	99	97
2-1/2"	88	96	98	97
2"	83	86	95	96
1-1/2"	77	78	90	95
1"	65	68	81	92
3/4"	55	59	71	88
1/2"	41	50	60	82
3/8"	31	43	51	76
#4	18	28	36	65
#8	13	22	29	54
#16	9	15	22	45
#30	7	11	18	37
#50	6	7	15	32
#100	4	5	12	29
#200	3	4	10	26
5 micron	1	1	3	4
1 micron	0	1	1	7

Figure 1

CROSS SECTION AT STA 616+00
ROAD 01-Men-101, PM 83.8/90.1
CEDAR CREEK



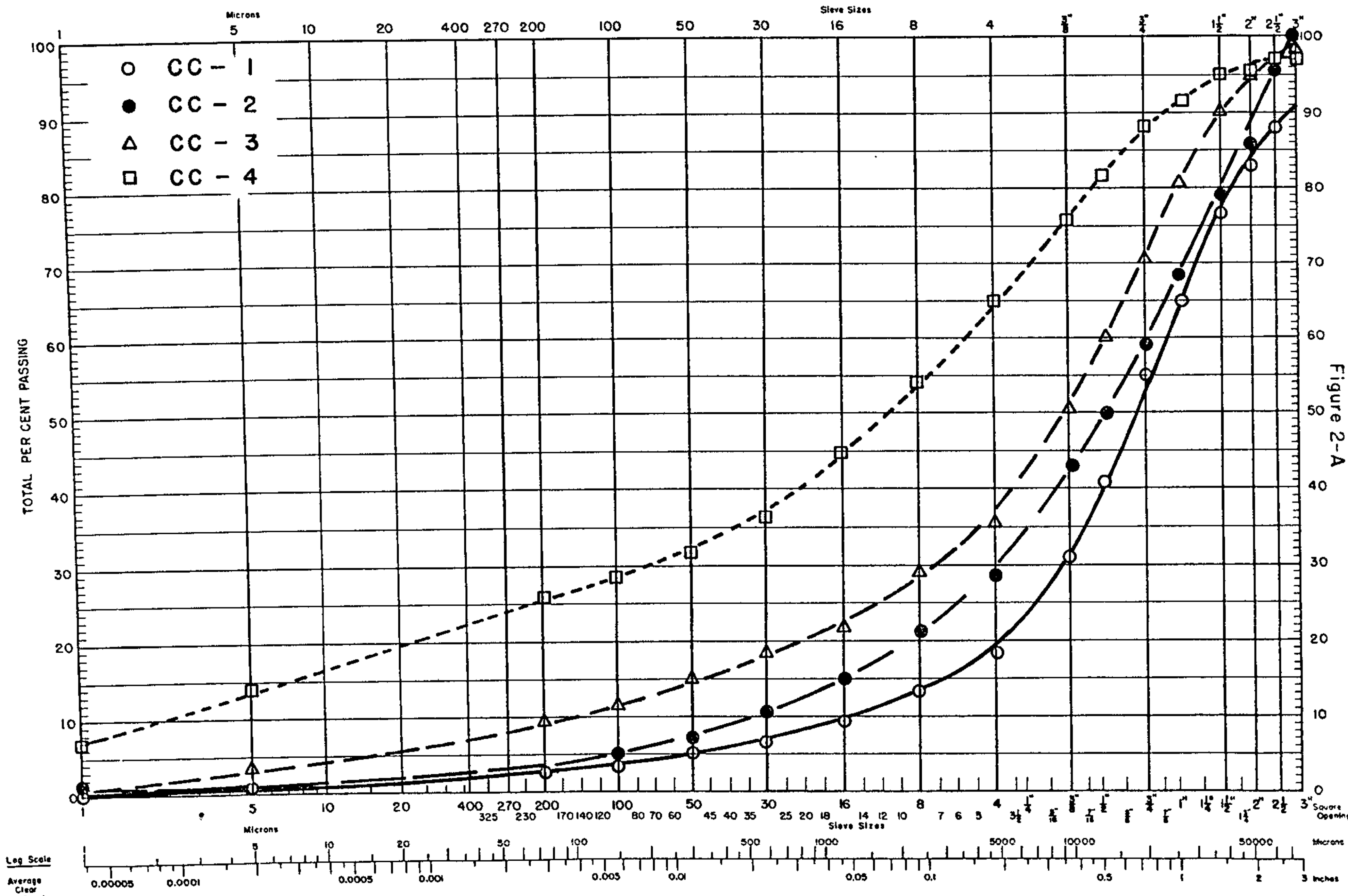
Scale 1" = 75'

STATE OF CALIFORNIA

DEPARTMENT OF PUBLIC WORKS — — — DIVISION OF HIGHWAYS

MATERIALS AND RESEARCH DEPARTMENT

GRADING ANALYSIS



A.A.S.O. Designation — M92-42. A.S.T.M. Designation — E11-39. Adopted by State — 1940

Figure 2-B

MOISTURE-DENSITY RELATIONSHIPS

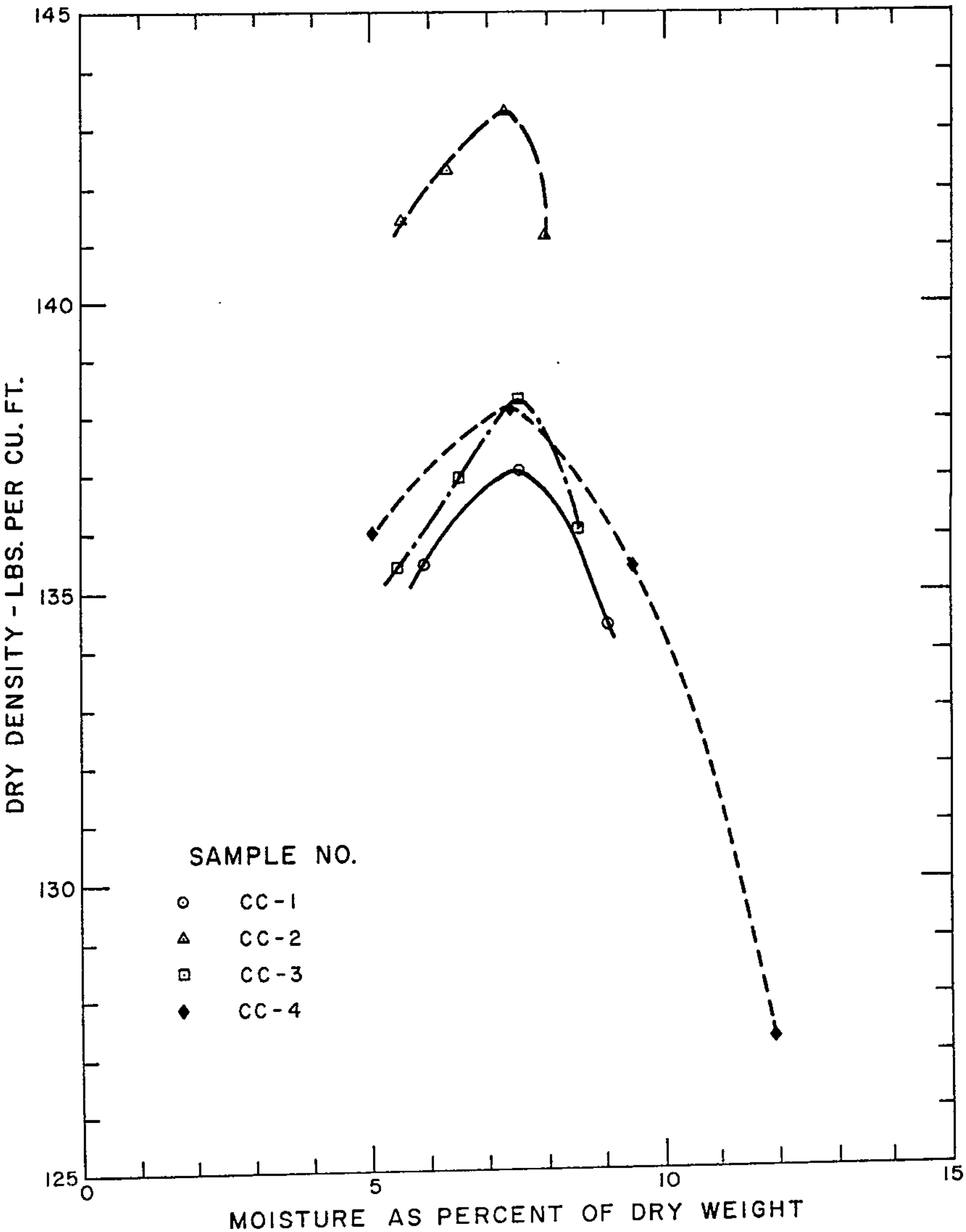


Figure 3

DEVIATOR STRESS – AXIAL STRAIN CURVES

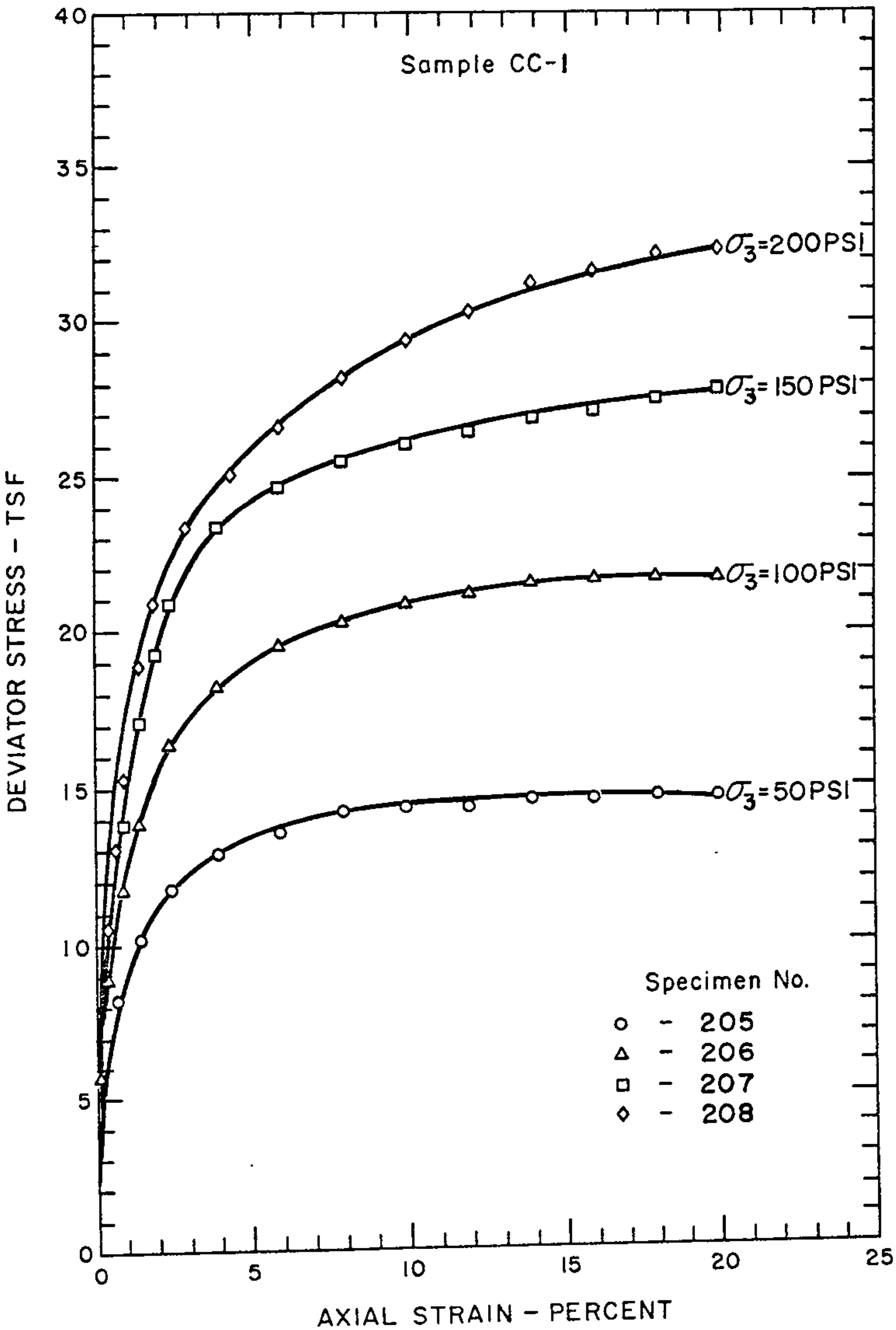


Figure 4

DEVIATOR STRESS – AXIAL STRAIN CURVES

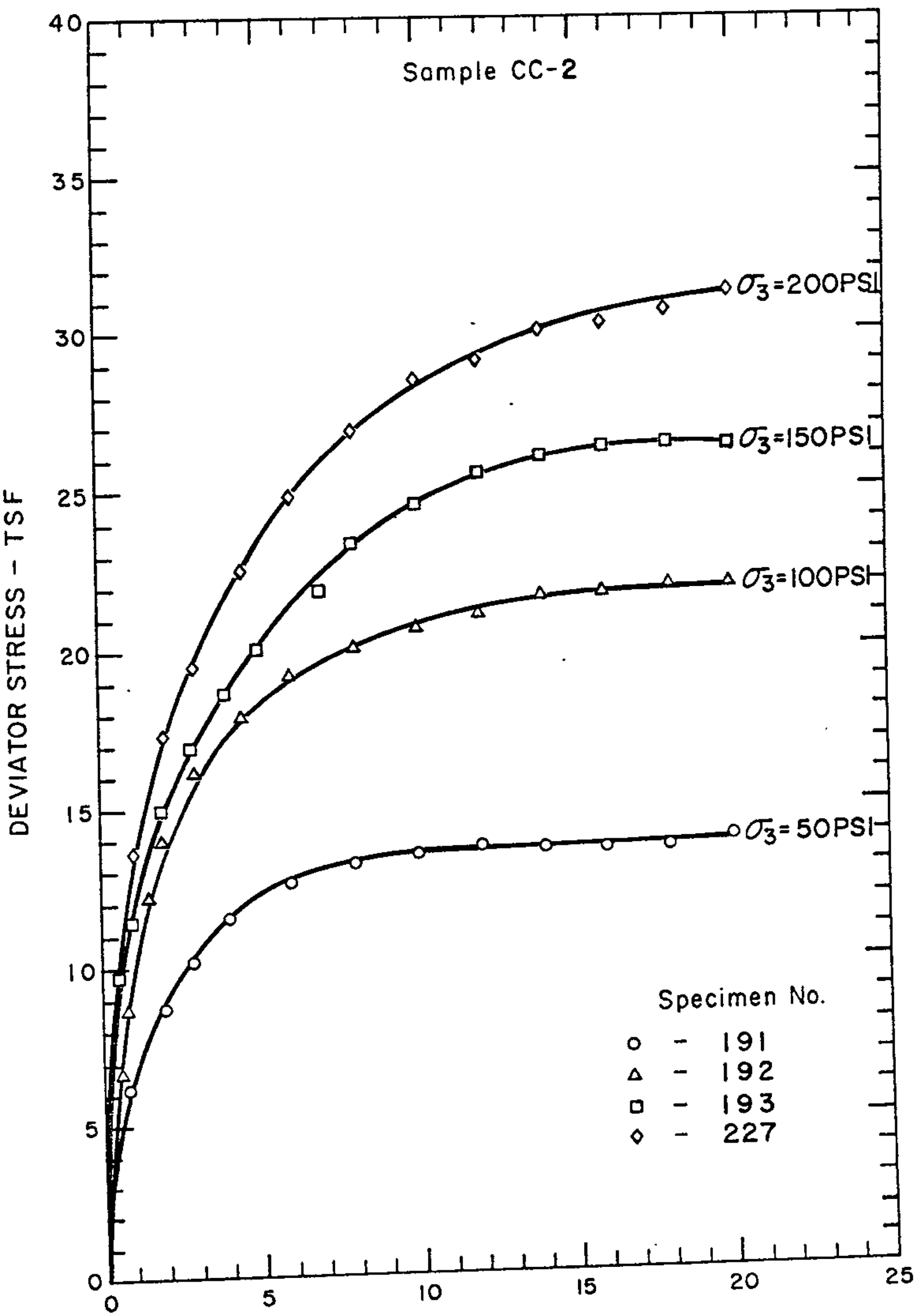


Figure 5

DEVIATOR STRESS – AXIAL STRAIN CURVES

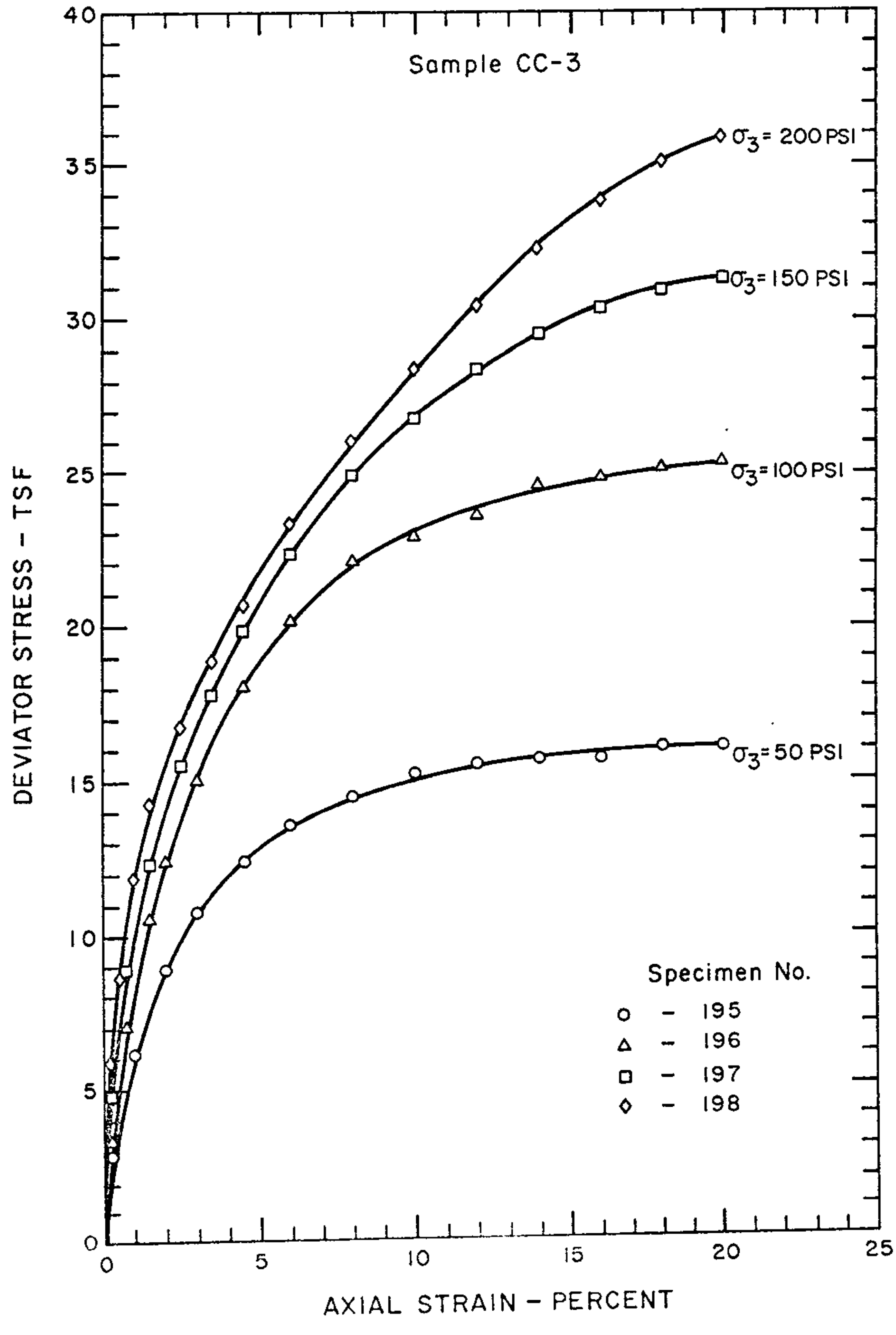
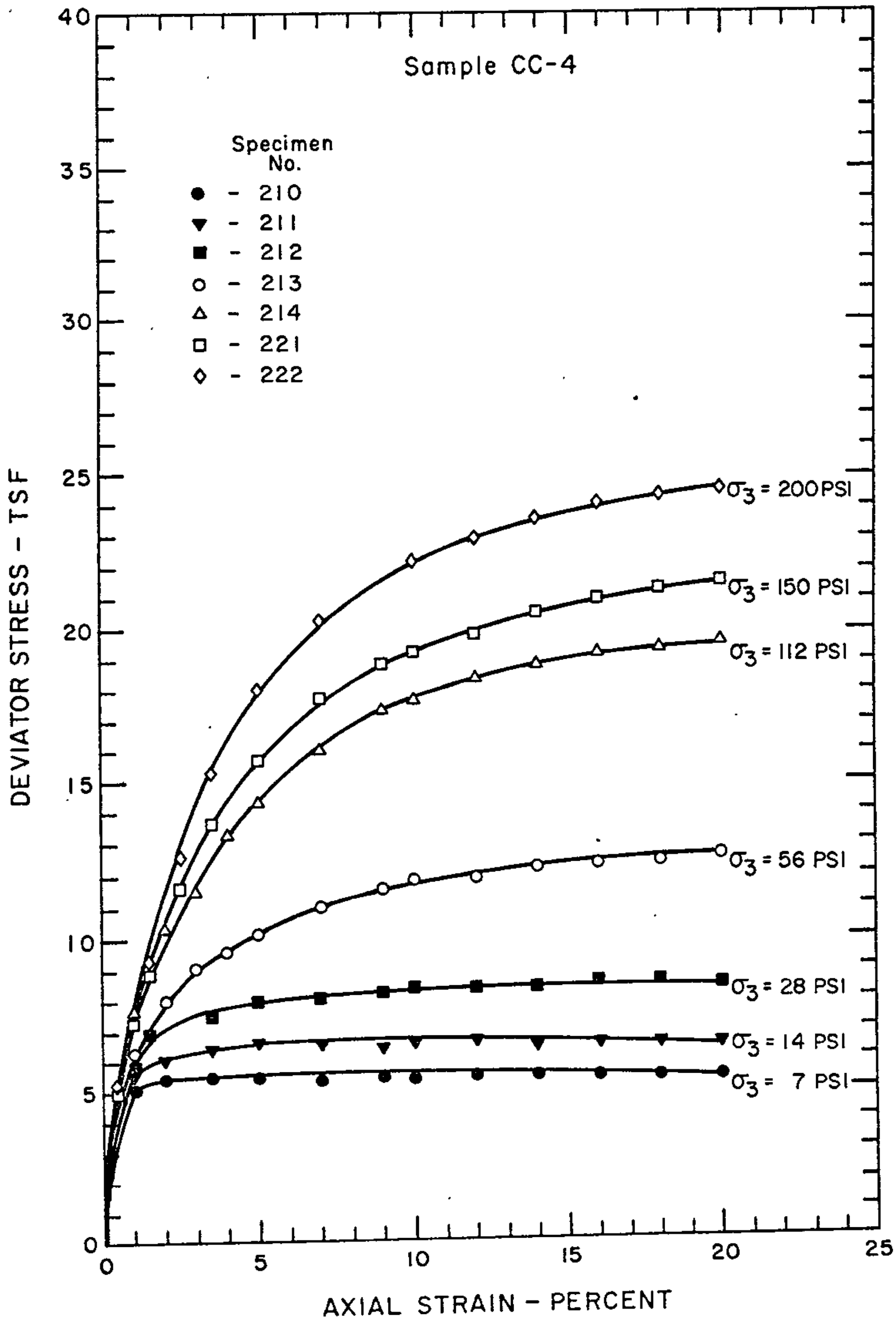


Figure 6

DEVIATOR STRESS – AXIAL STRAIN CURVES



MOHR CIRCLES AT FAILURE FOR PARTIALLY SATURATED SOIL

Figure 7

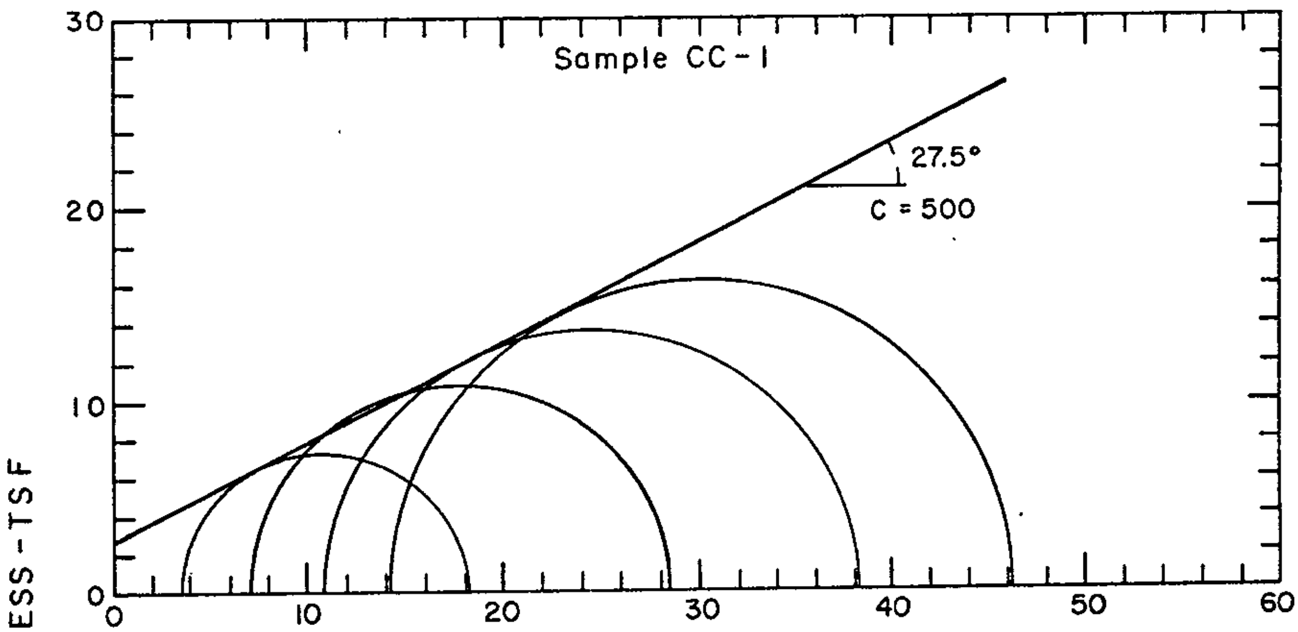
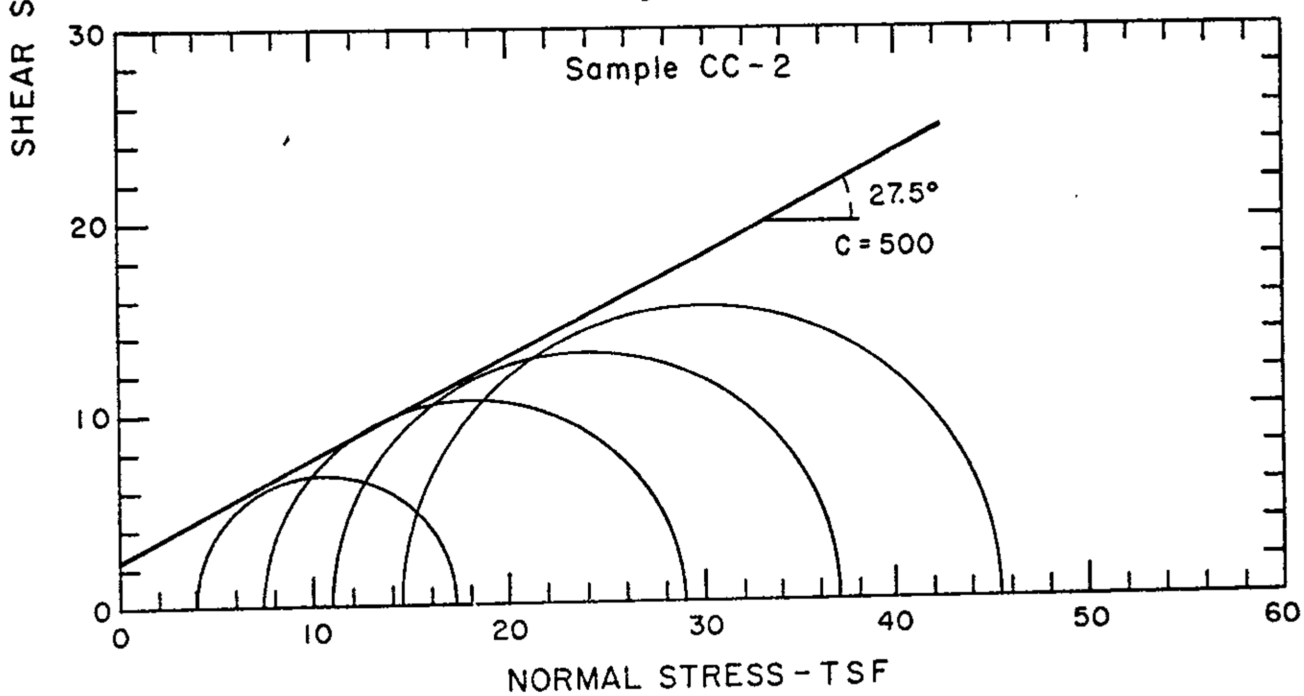


Figure 8



MOHR CIRCLES AT FAILURE FOR PARTIALLY SATURATED SOIL

Figure 9

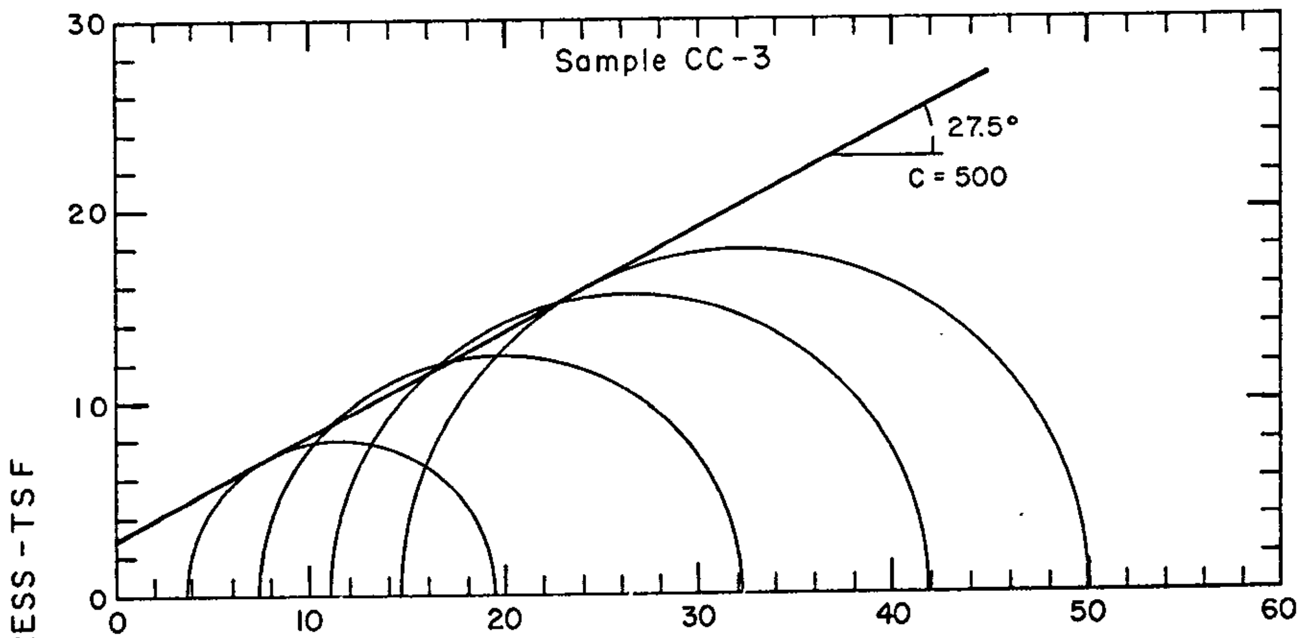


Figure 10

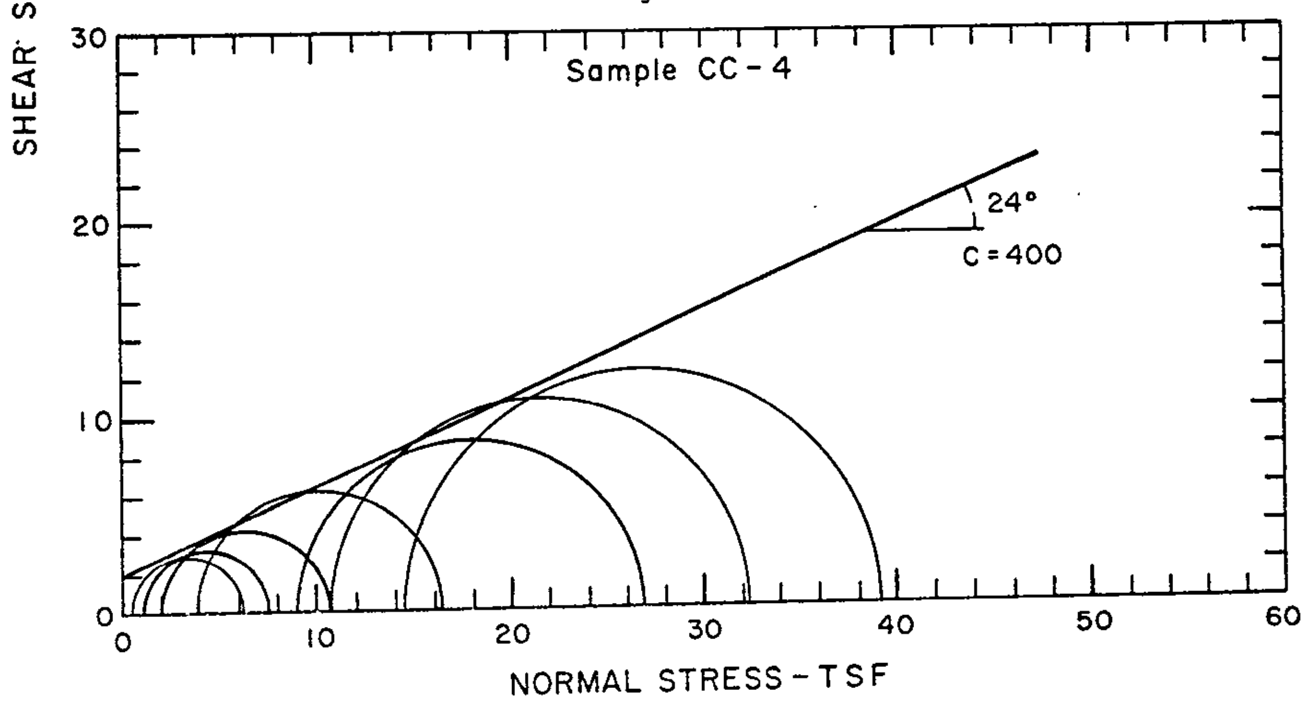


Figure 11

MODULUS OF DEFORMATION AT 1/3 MAX. DEVIATOR STRESS

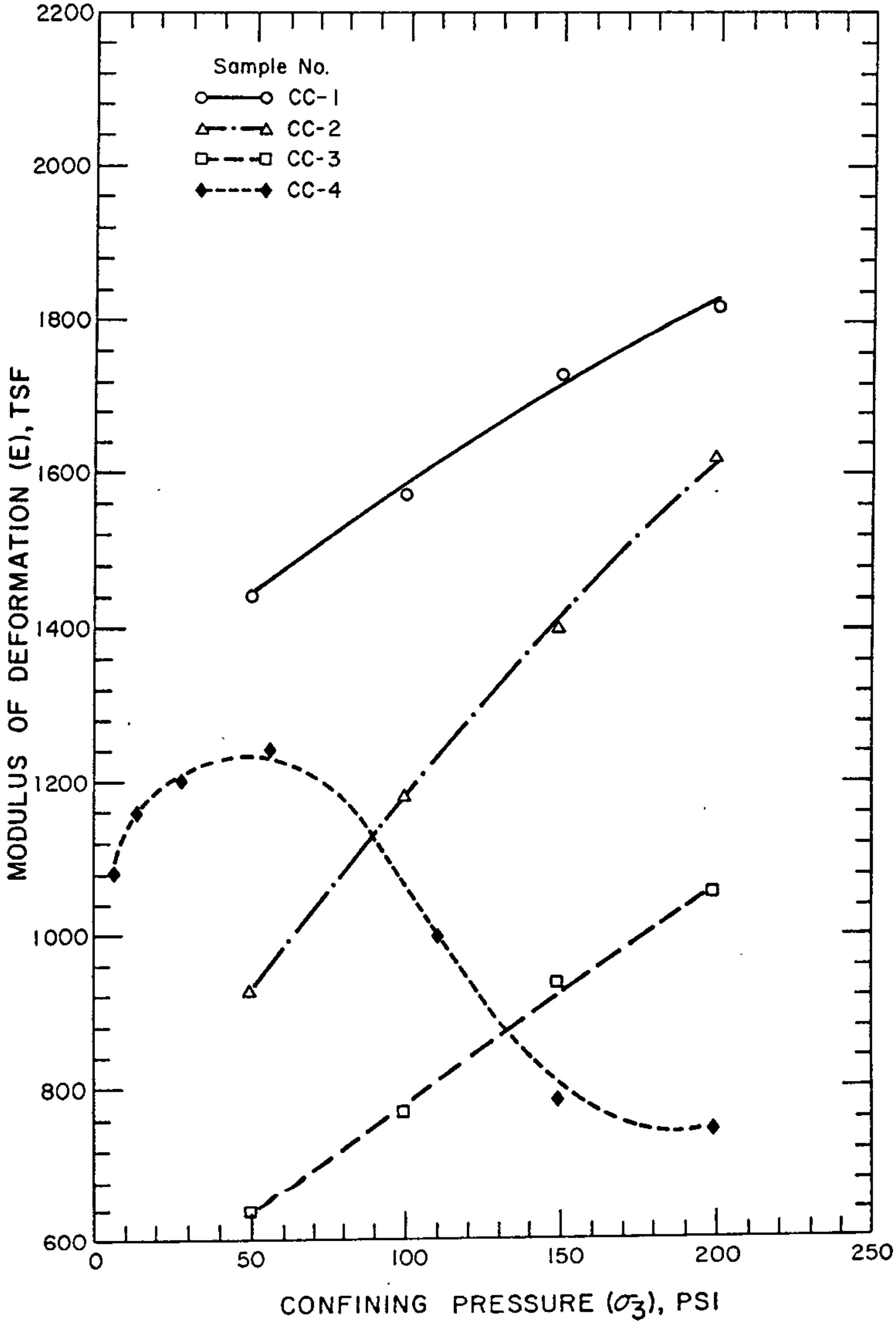


Figure 12

MODULUS OF DEFORMATION AT 1/2 MAX. DEVIATOR STRESS

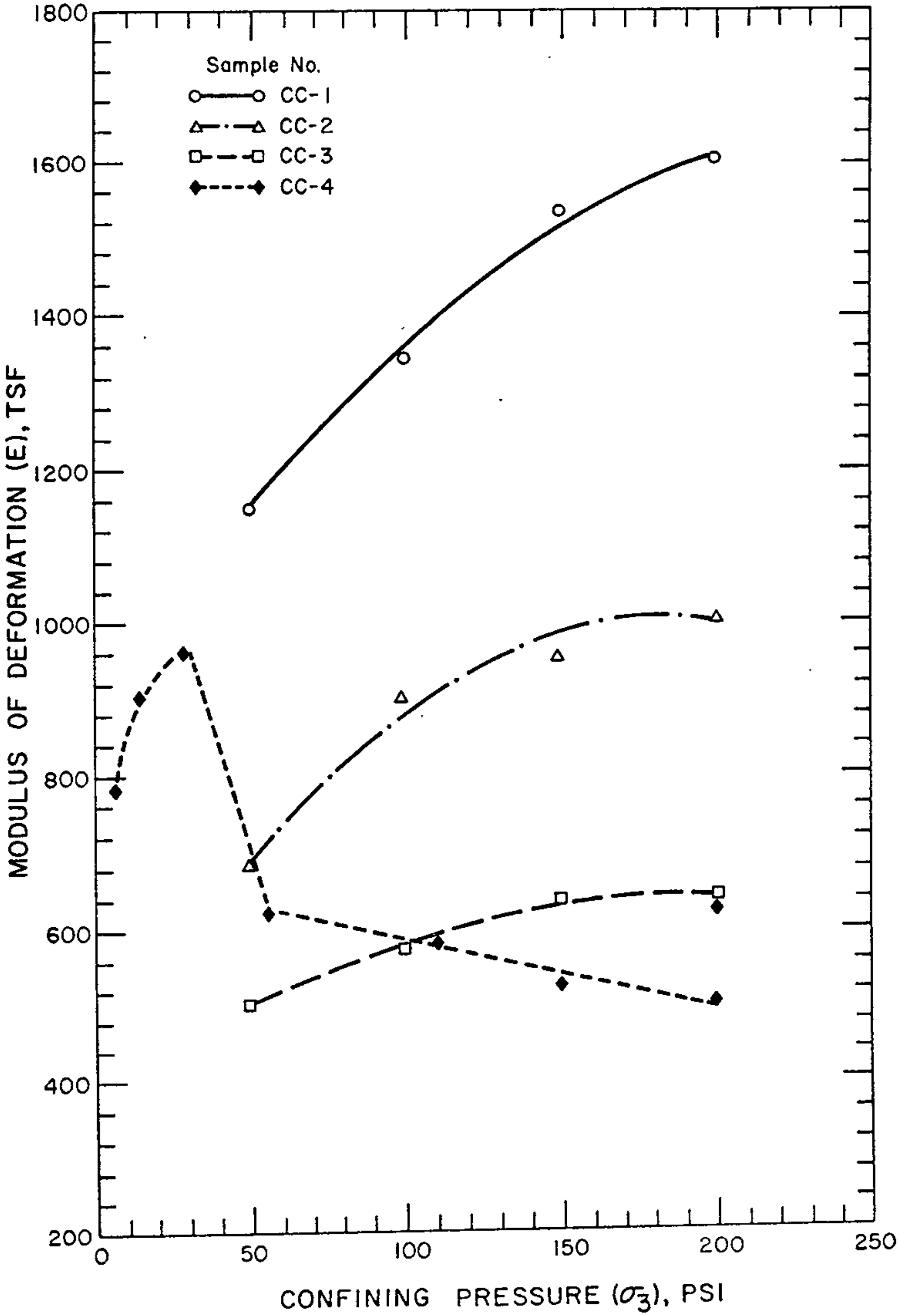


Figure 13

MODULUS OF DEFORMATION AT 2.5% AXIAL STRAIN

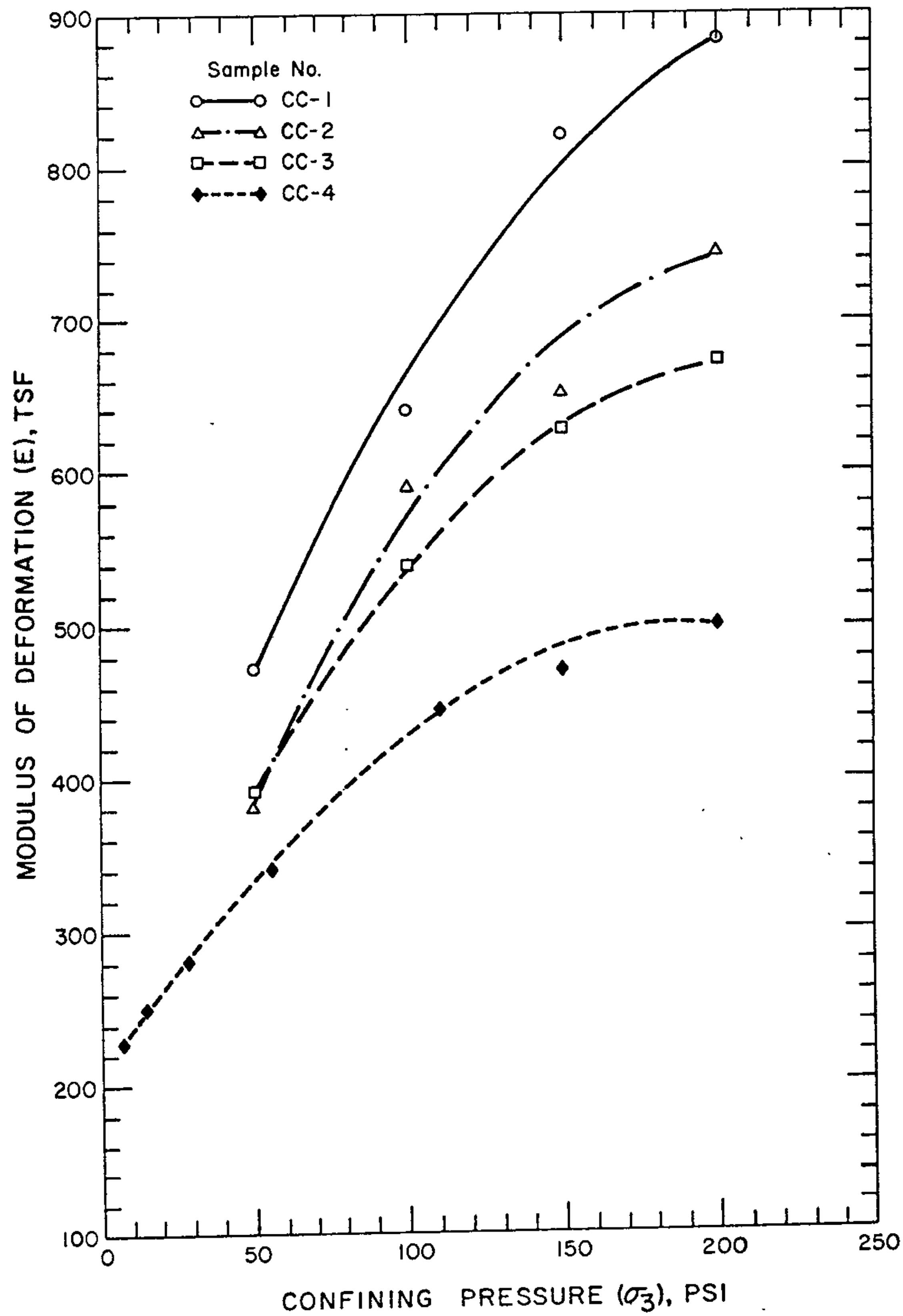


Figure 14

MODULUS OF DEFORMATION AT 3% AXIAL STRAIN

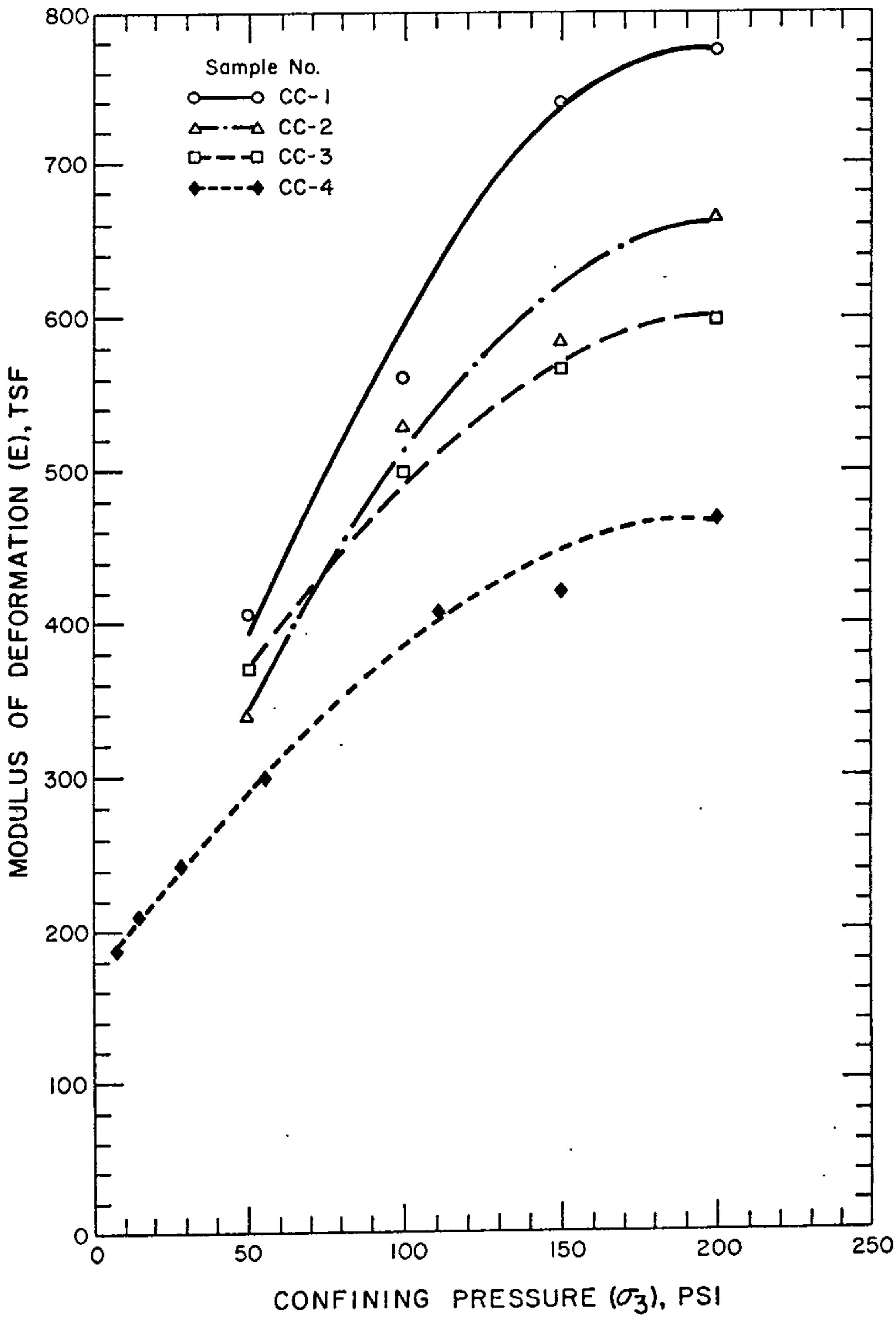


Figure 15

MODULUS OF DEFORMATION AT 4% AXIAL STRAIN

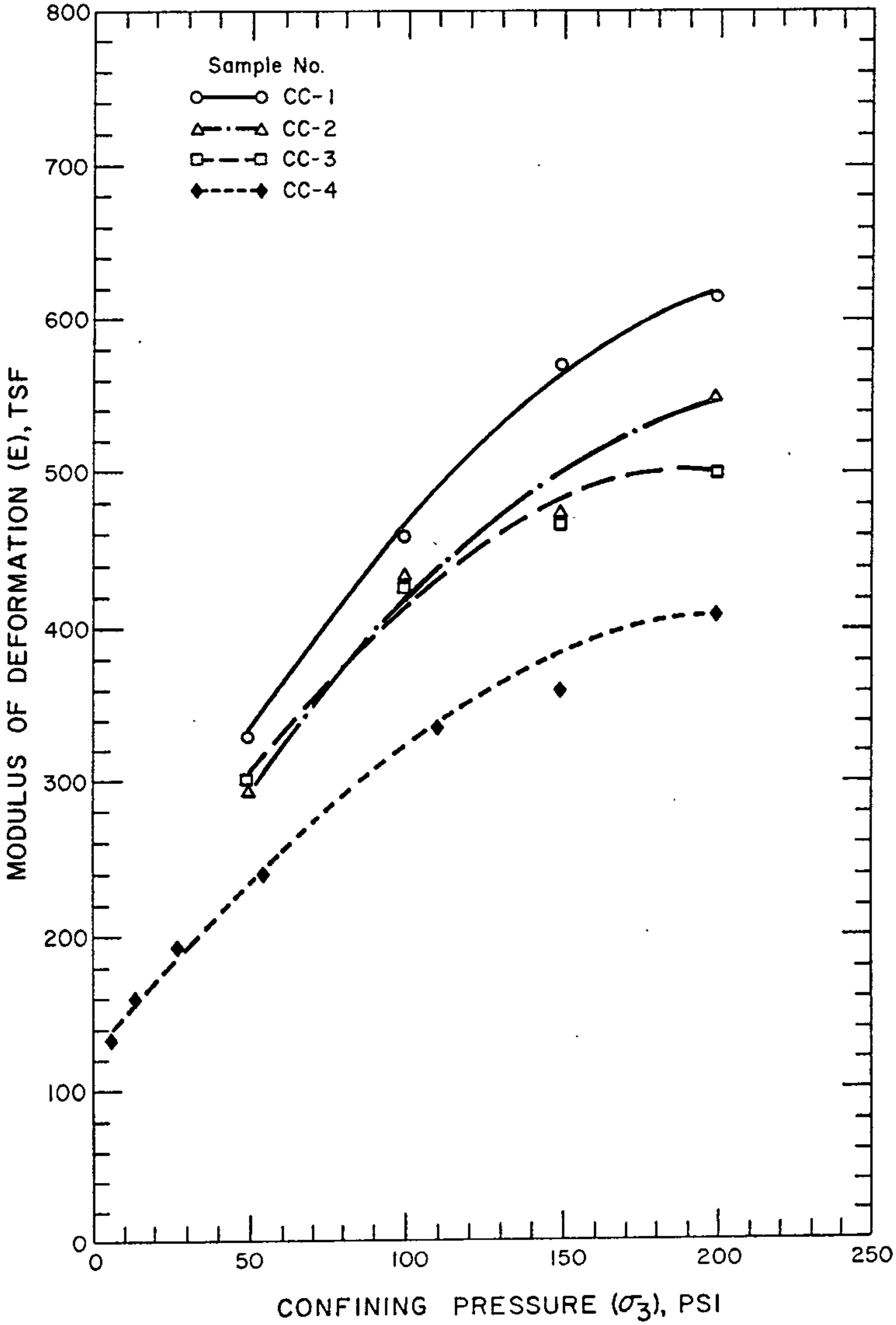


Figure 16

MODULUS OF DEFORMATION AT 5% AXIAL STRAIN

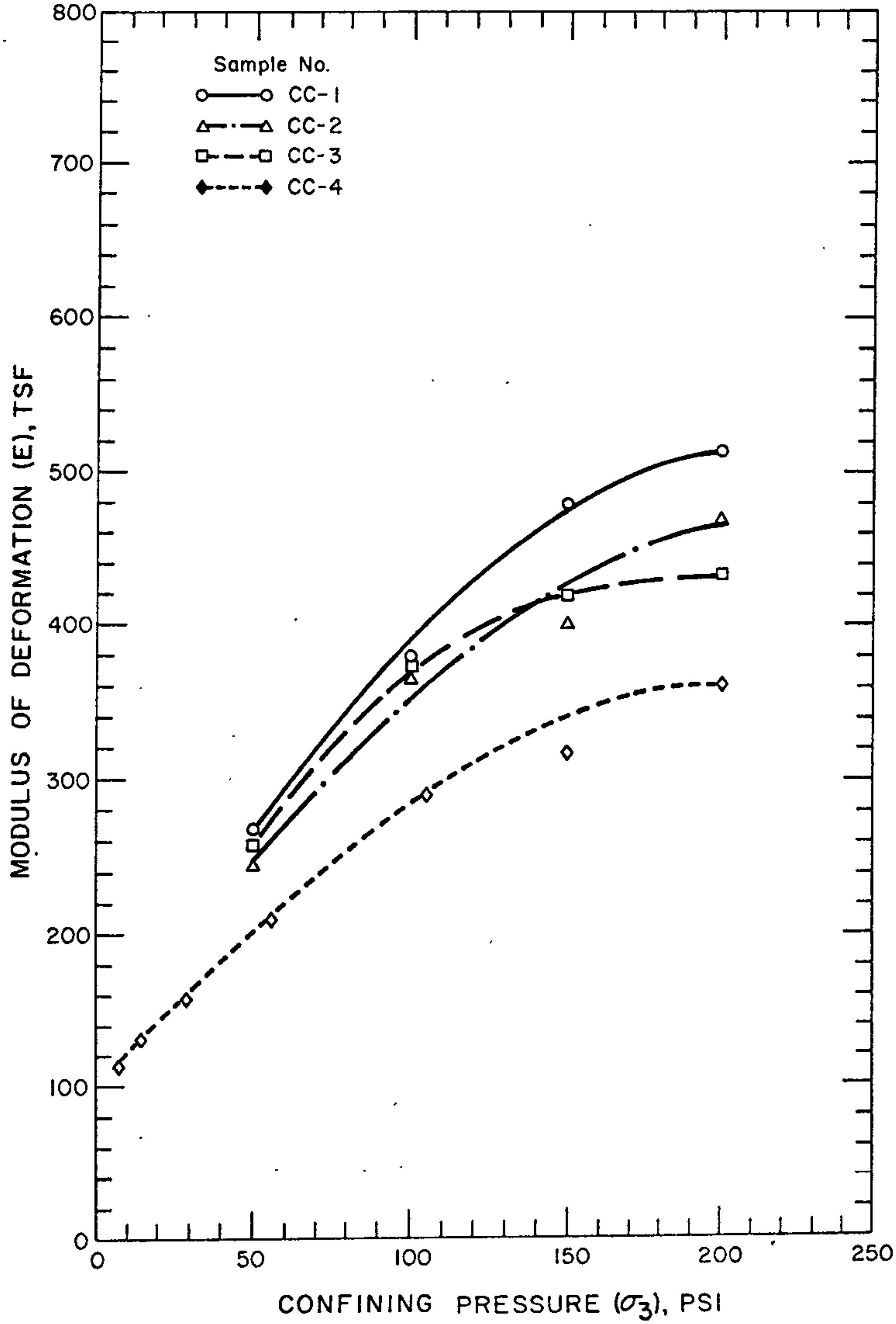


Figure 17

MODULUS OF DEFORMATION AT 6% AXIAL STRAIN