Results of Laboratory Tests Conducted for the AECOM TVA Kingston RCA Project

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3 June 2009

TABLE OF CONTENTS

List of Tables 3

List of Figures 3

1 INTRODUCTION **10**

2 TEST SAMPLES **10**

3 SCOPE OF SERVICES **11**

4 METHODS **11**
4.1 Sample Extraction 11
4.2 Water Content 11
4.3 Total and Dry Unit Weight 11
4.4 Atterberg Limits 11
4.5 Specific Gravity 12
4.6 Organic Content 12
4.7 Grain Size Distribution 12
4.8 Constant Rate of Strain (CRS) Consolidation 12
4.9 Direct Simple Shear (DSS) 13

5 RESULTS **14**
5.1 Tests Conducted, Photographs and Sample Logs 14
5.2 Index and Classification Data 14
5.3 Constant Rate of Strain Tests 14
5.4 Direct Simple Shear Tests 14
5.5 Test Specimen Photographs 15

6 REFERENCES **15**

7 NOTATION AND UNITS **16**

List of Tables

Table 1 Summary of Tests Performed.....17
Table 2 Summary of Water Content Data.....19
Table 3 Summary of Classification Test Results 21
Table 4 Summary of Constant Rate of Strain (CRS) specimen properties and test results 23
Table 5 Summary of Direct Simple Shear (DSS) specimen properties and test results.....25

List of Figures

Figure 4.8.1 Schematic of the Geonor Direct Simple Shear Apparatus 26

Figure 5.1.1 Photograph of Sample 09-100B S4 30.5 to 33.0 ft.....27
Figure 5.1.2 Photograph 1 of Sample 09-100B S5 33.0 to 35.5 ft.....28
Figure 5.1.3 Photograph 2 of Sample 09-100B S5 33.0 to 35.5 ft.....29
Figure 5.1.4 Photograph of Sample 09-100B S6 35.5 to 38.0 ft. 30
Figure 5.1.5 Photographs of Sample 09-101B S5 38.0 to 40.5 ft. 31
Figure 5.1.6 Photograph of Sample 09-103B S2 33.5 to 36.0 ft–as received 2 six inch sections.32
Figure 5.1.7 Photograph of Sample 09-103B S3 36.0 to 38.5 ft.....33
Figure 5.1.8 Photograph of Sample 09-103B S4 38.5 to 41.0 ft – as received 10inch section.....34
Figure 5.1.9 Photograph of Sample 09-103B S5 41.0 to 42.0 ft – as received section. 35
Figure 5.1.10 Photograph of Sample 09-104B S4 22.5 to 25.0 ft.....36
Figure 5.1.11 Photograph 1 of Sample 09-108B S2 23.5 to 26.0 ft.....37
Figure 5.1.12 Photograph 2 of Sample 09-108B S2 23.5 to 26.0 ft – section from 12 to 18 inches (right to left).....38
Figure 5.1.13 Photograph of Sample 09-109B S2 25.5 to 28.0 ft.....39
Figure 5.1.14 Photograph of Sample 09-200B S4 32.5 to 35.0 ft.....40
Figure 5.1.15 Photograph 1 of Sample 09-201B S2 25.5 to 28.0 ft.....41
Figure 5.1.16 Photograph 2 of Sample 09-201B S2 25.5 to 28.0 ft.....42
Figure 5.1.17 Photographs of Sample 09-202B S2 28.5 to 31.0 ft. 43
Figure 5.1.18 Photograph of Sample 09-207B S3 13.0 to 15.5 ft.....44
Figure 5.1.19 Photograph of Sample 09-210B S2 – as received 10.5 to 11.0 ft section. 45
Figure 5.1.20 Photograph of Sample 09-301B S6 87.5 to 90.0 ft.....46
Figure 5.1.21 Photograph of Sample 09-303B S9 87.5 to 90.0 ft.....47
Figure 5.1.22 Photograph of Sample 09-408B S6 33.0 to 35.5 ft.....48
Figure 5.1.23 Photograph of Sample 09-408B S7 35.5 to 38.0 ft.....49
Figure 5.1.24 Photograph of Sample 09-500B S4 26.5 to 29.0 ft.....50
Figure 5.1.25 Photograph of Sample 09-500B S5 29.0 to 31.5 ft.....51
Figure 5.1.26 Photograph of Sample 09-502B S4 22.0 to 24.5 ft.....52
Figure 5.1.27 Photograph of Sample 09-503B S2 31.0 to 33.5 ft.....53
Figure 5.1.28 Photograph of Sample 09-503B S3 33.5 to 38.0 ft.....54
Figure 5.1.29 Photograph of Sample 09-600B S2 44.0 to 46.5 ft.....55
Figure 5.1.30 Photograph 1of Sample 09-605B S7 47.0 to 49.5 ft – 12 to 29 inch section (right to left).....56

Figure 5.1.31 Photograph 2 of Sample 09-605B S7 47.0 to 49.5 ft – 1 to 12 inch section (left to right).....57
Figure 5.1.32 Photograph of Sample 09-700B S3 22.5 to 25.0 ft.....58
Figure 5.1.33 Photograph of Sample 09-800B S4 26.5 to 29.0 ft.....59
Figure 5.1.34 Photograph of Sample 09-801B S5 37.5 to 40.0 ft.....60

Figure 5.1.35 Sample log and test locations for Sample 09-100B S4 30.5 to 33.0 ft.....61
Figure 5.1.36 Sample log and test locations for Sample 09-100B S5 33.0 to 35.5 ft.....62
Figure 5.1.37 Sample log and test locations for Sample 09-100B S6 35.5 to 38.0 ft.....63
Figure 5.1.38 Sample log and test locations for Sample 09-101B S5 38.0 to 40.5 ft.....64
Figure 5.1.39 Sample log and test locations for Sample 09-103B S2 33.5 to 36.0 ft.....65
Figure 5.1.40 Sample log and test locations for Sample 09-103B S3 36.0 to 38.5 ft.....66
Figure 5.1.41 Sample log and test locations for Sample 09-103B S4 38.5-39.0 ft.....67
Figure 5.1.42 Sample log and test locations for Sample 09-103B S5 41.0-42.0 ft.....68
Figure 5.1.43 Sample log and test locations for Sample 09-104B S4 22.5-25.0 ft.....69
Figure 5.1.44 Sample log and test locations for Sample 09-108B S2 23.5-26.0 ft.....70
Figure 5.1.45 Sample log and test locations for Sample 09-109B S3 25.5-28.0 ft.....71
Figure 5.1.46 Sample log and test locations for Sample 09-200B S4 32.5-35.0 ft.....72
Figure 5.1.47 Sample log and test locations for Sample 09-201B S2 25.5-28.0 ft.....73
Figure 5.1.48 Sample log and test locations for Sample 09-202B S2 28.5-31.0 ft.....74
Figure 5.1.49 Sample log and test locations for Sample 09-206B S5 20.0-22.5 ft.....75
Figure 5.1.50 Sample log and test locations for Sample 09-207B S3 13.0-15.5 ft.....76
Figure 5.1.51 Sample log and test locations for Sample 09-210B S2 10.5-11.0 ft.....77
Figure 5.1.52 Sample log and test locations for Sample 09-301B S6 87.5-90.0 ft.....78
Figure 5.1.53 Sample log and test locations for Sample 09-303B S9 87.5-90.0 ft.....79
Figure 5.1.54 Sample log and test locations for Sample 09-408B S6 33.0-35.5 ft.....80
Figure 5.1.55 Sample log and test locations for Sample 09-408B S7 35.5-38.0 ft.....81
Figure 5.1.56 Sample log and test locations for Sample 09-500B S4 26.5-29.0 ft.....82
Figure 5.1.57 Sample log and test locations for Sample 09-500B S5 29.0-31.5 ft.....83
Figure 5.1.58 Sample log and test locations for Sample 09-502B S4 22.0-24.5 ft.....84
Figure 5.1.59 Sample log and test locations for Sample 09-503B S2 31.0-33.5 ft.....85
Figure 5.1.60 Sample log and test locations for Sample 09-503B S3 35.5-37.5 ft.....86
Figure 5.1.61 Sample log and test locations for Sample 09-600B S2 44.0-46.5 ft.....87
Figure 5.1.62 Sample log and test locations for Sample 09-601B S5 49.5-52.0 ft.....88
Figure 5.1.63 Sample log and test locations for Sample 09-602B S4 54.0-56.5 ft.....89
Figure 5.1.64 Sample log and test locations for Sample 09-605B S7 47.0-49.5 ft.....90
Figure 5.1.65 Sample log and test locations for Sample 09-605B S8 49.5-52.0 ft.....91
Figure 5.1.66 Sample log and test locations for Sample 09-700B S3 22.5-25.0 ft.....92
Figure 5.1.67 Sample log and test locations for Sample 09-800B S4 26.5-29.0 ft.....93
Figure 5.1.68 Sample log and test locations for Sample 09-801B S5 37.5-40.0 ft.....94

Figure 5.2.1 Plasticity Chart with Atterberg Limits results for selected samples (see Table 3 and sample logs for specific test specimen location) 95
Figure 5.2.2 Percent passing versus grain diameter from grain size distribution test results (see sample logs for specific test specimen location).....96

Figure 5.3.1 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS159 on sample 09-202B S2 28.5-31.0 ft. 97
Figure 5.3.2 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS159 on sample 09-202B S2 28.5-31.0 ft.....98
Figure 5.3.3 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS160 on sample 09-201B S2 25.5-28.0 ft. 99
Figure 5.3.4 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS160 on sample 09-201B S2 25.5-28.0 ft.....100
Figure 5.3.5 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS161 on sample 09-104B S4 22.5-25.0 ft. 101
Figure 5.3.6 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS161 on sample 09-104B S4 22.5-25.0 ft.....102
Figure 5.3.7 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS162 on sample 09-301B S6 87.5-90.0 ft. 103
Figure 5.3.8 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS162 on sample 09-301B S6 87.5-90.0 ft.....104
Figure 5.3.9 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS163 on sample 09-101B S5 38.0-40.5 ft. 105
Figure 5.3.10 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS163 on sample 09-101B S5 38.0-40.5 ft.....106
Figure 5.3.11 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS164 on sample 09-108B S2 23.5-26.0 ft. 107
Figure 5.3.12 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS164 on sample 09-108B S2 23.5-26.0 ft.....108
Figure 5.3.13 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS165 on sample 09-605B S7 47.0-49.5 ft. 109
Figure 5.3.14 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS165 on sample 09-605B S7 47.0-49.5 ft.....110
Figure 5.3.15 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS166 on sample 09-103B S2 33.5-36.0 ft. 111
Figure 5.3.16 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS166 on sample 09-103B S2 33.5-36.0 ft.....112
Figure 5.3.17 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS167 on sample 09-100B S5 33.0-35.5 ft. 113
Figure 5.3.18 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS167 on sample 09-100B S5 33.0-35.5 ft.....114
Figure 5.3.19 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS168 on sample 09-103B S5 41.0-43.5 ft. 115
Figure 5.3.20 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS168 on sample 09-103B S5 41.0-43.5 ft.....116
Figure 5.3.21 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS169 on sample 09-408B S7 35.5-38.0 ft. 117
Figure 5.3.22 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS169 on sample 09-408B S7 35.5-38.0 ft.....118
Figure 5.3.23 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS170 on sample 09-503B S3 35.5-38.0 ft. 119

Figure 5.3.24 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS170 on sample 09-503B S3 35.5-38.0 ft....120

Figure 5.4.1 Vertical strain versus vertical effective stress for test DSS G349 on sample 09-301B S6 87.5-90.0 ft....121
Figure 5.4.2 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G349 on sample 09-301B S6 87.5-90.0 ft....122
Figure 5.4.3 Pore pressure and normalized pore pressure versus shear strain for test DSS G349 on sample 09-301B S6 87.5-90.0 ft....123
Figure 5.4.4 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G349 on sample 09-301B S6 87.5-90.0 ft....124
Figure 5.4.5 Shear modulus and normalized shear modulus versus shear strain for test DSS G349 on sample 09-301B S6 87.5-90.0 ft....125
Figure 5.4.6 Vertical strain versus vertical effective stress for test DSS G350 on sample 09-101B S5 38.0-40.5 ft....126
Figure 5.4.7 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G350 on sample 09-101B S5 38.0-40.5 ft....127
Figure 5.4.8 Pore pressure and normalized pore pressure versus shear strain for test DSS G350 on sample 09-101B S5 38.0-40.5 ft....128
Figure 5.4.9 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G350 on sample 09-101B S5 38.0-40.5 ft....129
Figure 5.4.10 Shear modulus and normalized shear modulus versus shear strain for test DSS G350 on sample 09-101B S5 38.0-40.5 ft....130
Figure 5.4.11 Vertical strain versus vertical effective stress for test DSS G351 on sample 09-108B S2 23.5-26.0 ft....131
Figure 5.4.12 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G351 on sample 09-108B S2 23.5-26.0 ft....132
Figure 5.4.13 Pore pressure and normalized pore pressure versus shear strain for test DSS G351 on sample 09-108B S2 23.5-26.0 ft....133
Figure 5.4.14 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G351 on sample 09-108B S2 23.5-26.0 ft....134
Figure 5.4.15 Shear modulus and normalized shear modulus versus shear strain for test DSS G351 on sample 09-108B S2 23.5-26.0 ft....135
Figure 5.4.16 Vertical strain versus vertical effective stress for test DSS G352 on sample 09-109B S3 25.5-28.0 ft....136
Figure 5.4.17 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G352 on sample 09-109B S3 25.5-28.0 ft....137
Figure 5.4.18 Pore pressure and normalized pore pressure versus shear strain for test DSS G352 on sample 09-109B S3 25.5-28.0 ft....138
Figure 5.4.19 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G352 on sample 09-109B S3 25.5-28.0 ft....139
Figure 5.4.20 Shear modulus and normalized shear modulus versus shear strain

for test DSS G352 on sample 09-109B S3 25.5-28.0 ft.....140
Figure 5.4.21 Vertical strain versus vertical effective stress for test DSS G353 on sample 09-605B S7 47.5-49.5 ft 141
Figure 5.4.22 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G353 on sample 09-605B S7 47.5-49.5 ft.....142
Figure 5.4.23 Pore pressure and normalized pore pressure versus shear strain for test DSS G353 on sample 09-605B S7 47.5-49.5 ft 143
Figure 5.4.24 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G353 on sample 09-605B S7 47.5-49.5 ft 144
Figure 5.4.25 Shear modulus and normalized shear modulus versus shear strain for test DSS G353 on sample 09-605B S7 47.5-49.5 ft.....145
Figure 5.4.26 Vertical strain versus vertical effective stress for test DSS G354 on sample 09-103B S2 33.5-36.0 ft 146
Figure 5.4.27 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G354 on sample 09-103B S2 33.5-36.0 ft.....147
Figure 5.4.28 Pore pressure and normalized pore pressure versus shear strain for test DSS G354 on sample 09-103B S2 33.5-36.0 ft 148
Figure 5.4.29 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G354 on sample 09-103B S2 33.5-36.0 ft 149
Figure 5.4.30 Shear modulus and normalized shear modulus versus shear strain for test DSS G354 on sample 09-103B S2 33.5-36.0 ft.....150
Figure 5.4.31 Vertical strain versus vertical effective stress for test DSS G355 on sample 09-103B S2 33.5-36.0 ft 151
Figure 5.4.32 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G355 on sample 09-103B S2 33.5-36.0 ft.....152
Figure 5.4.33 Pore pressure and normalized pore pressure versus shear strain for test DSS G355 on sample 09-103B S2 33.5-36.0 ft 153
Figure 5.4.34 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G355 on sample 09-103B S2 33.5-36.0 ft 154
Figure 5.4.35 Shear modulus and normalized shear modulus versus shear strain for test DSS G355 on sample 09-103B S2 33.5-36.0 ft.....155
Figure 5.4.36 Vertical strain versus vertical effective stress for test DSS G356 on sample 09-100B S5 33.0-35.5 ft 156
Figure 5.4.37 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G356 on sample 09-100B S5 33.0-35.5 ft.....157
Figure 5.4.38 Pore pressure and normalized pore pressure versus shear strain for test DSS G356 on sample 09-100B S5 33.0-35.5 ft 158
Figure 5.4.39 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G356 on sample 09-100B S5 33.0-35.5 ft 159
Figure 5.4.40 Shear modulus and normalized shear modulus versus shear strain for test DSS G356 on sample 09-100B S5 33.0-35.5 ft.....160
Figure 5.4.41 Vertical strain versus vertical effective stress for test DSS G357 on

sample 09-100B S6 35.5-38.0 ft 161
Figure 5.4.42 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G357 on sample 09-100B S6 35.5-38.0 ft.....162
Figure 5.4.43 Pore pressure and normalized pore pressure versus shear strain for test DSS G357 on sample 09-100B S6 35.5-38.0 ft 163
Figure 5.4.44 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G357 on sample 09-100B S6 35.5-38.0 ft 164
Figure 5.4.45 Shear modulus and normalized shear modulus versus shear strain for test DSS G357 on sample 09-100B S6 35.5-38.0 ft.....165
Figure 5.4.46 Vertical strain versus vertical effective stress for test DSS G358 on sample 09-108B S2 23.5-26.0 ft 166
Figure 5.4.47 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G358 on sample 09-108B S2 23.5-26.0 ft.....167
Figure 5.4.48 Pore pressure and normalized pore pressure versus shear strain for test DSS G358 on sample 09-108B S2 23.5-26.0 ft 168
Figure 5.4.49 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G358 on sample 09-108B S2 23.5-26.0 ft 169
Figure 5.4.50 Shear modulus and normalized shear modulus versus shear strain for test DSS G358 on sample 09-108B S2 23.5-26.0 ft.....170
Figure 5.4.51 Vertical strain versus vertical effective stress for test DSS G359 on sample 09-408B S7 35.5-38.0 ft 171
Figure 5.4.52 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G359 on sample 09-408B S7 35.5-38.0 ft.....172
Figure 5.4.53 Pore pressure and normalized pore pressure versus shear strain for test DSS G359 on sample 09-408B S7 35.5-38.0 ft 173
Figure 5.4.54 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G359 on sample 09-408B S7 35.5-38.0 ft 174
Figure 5.4.55 Shear modulus and normalized shear modulus versus shear strain for test DSS G359 on sample 09-408B S7 35.5-38.0 ft.....175
Figure 5.4.56 Vertical strain versus vertical effective stress for test DSS G360 on sample 09-503B S3 35.5-38.0 ft 176
Figure 5.4.57 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G360 on sample 09-503B S3 35.5-38.0 ft.....177
Figure 5.4.58 Pore pressure and normalized pore pressure versus shear strain for test DSS G360 on sample 09-503B S3 35.5-38.0 ft 178
Figure 5.4.59 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G360 on sample 09-503B S3 35.5-38.0 ft 179
Figure 5.4.60 Shear modulus and normalized shear modulus versus shear strain for test DSS G360 on sample 09-503B S3 35.5-38.0 ft.....180
Figure 5.4.61 Vertical strain versus vertical effective stress for test DSS G357 and creep test G361 on sample 09-100B S6 35.5-38.0 ft 181
Figure 5.4.62 Horizontal shear stress and normalized shear stress versus shear strain

for test DSS G357 and creep test G361 on sample 09-100B S6 35.5-38.0 ft 182
Figure 5.4.63 Pore pressure and normalized pore pressure versus shear strain for test DSS G357 and creep test G361 on sample 09-100B S6 35.5-38.0 ft 183
Figure 5.4.64 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G357 and creep test G361 on sample 09-100B S6 35.5-38.0 ft 184
Figure 5.4.65 Horizontal shear strain versus time for DSS creep test G361 on sample 09-100B S6 35.5-38.0 ft 185

Figure 5.5.1 Photograph through a microscope of split open, oven dried, test specimen CRS167 on 09-100B S5. 186
Figure 5.5.2 Photograph through a microscope of split open, oven dried, test specimen DSS G357 on 09-100B S6. 187
Figure 5.5.3 Photograph through a microscope of split open, oven dried, test specimen DSS G350 on 09-101B S5. 188
Figure 5.5.4 Photograph through a microscope of split open, oven dried, test specimen DSS G355 on 09-103B S2. 189
Figure 5.5.5 Photograph through a microscope of split open, oven dried, test specimen DSS G349 on 09-301B S6. 190
Figure 5.5.6 Photograph through a microscope of split open, oven dried, test specimen DSS G360 on 09-503B S3. 191

1 INTRODUCTION

This report contains results of laboratory tests, including index and classification, constant rate of strain (CRS) consolidation and direct simple shear (DSS), conducted for AECOM, Vernon Hills, IL. Tube samples were provided by AECOM for testing. All tests described herein were conducted at the University of Massachusetts (UMass) Amherst during March to June 2009 under the supervision of Dr. Don J. DeGroot. The report includes information on the scope of services, test methods, and presentation of test results.

2 TEST SAMPLES

The test samples consisted of 3" diameter by 36" long tubes unless otherwise noted. All samples were delivered to UMass Amherst by AECOM.

Received 3/11/09
09-108B S2 23.5-26.0 ft
09-201B S2 25.5-28.0 ft
09-202B S2 28.5-28.0 ft
09-303B S9 87.5-90.0 ft

Received 3/25/09
09-101B S5 38.0-40.5 ft
09-104B S4 22.5-25.0 ft
09-109B S3 25.5-28.0 ft
09-206B S5 20.0-22.5 ft
09-207B S3 13.0-15.5 ft
09-301B S6 87.5-90.0 ft
09-600B S2 44.0-46.5 ft
09-601B S5 49.5-52.0 ft
09-602B S4 54.0-56.5 ft

Received 4/8/09
09-103B S3 36.0-38.5 ft
09-103B S4 38.5-39.0 ft (partial tube = 6")
09-103B S5 41.0-42.0 ft (partial tube = 12")
09-500B S4 26.5-29.0 ft
09-500B S5 29.0-31.5 ft
09-503B S3 35.5-37.5 ft (partial tube = 24")
09-605B S7 47.0-49.5 ft
09-605B S8 49.5-52.0 ft

Received 4/18/09
09-100B S4 30.5-33.0 ft
09-100B S5 33.0-35.5 ft
09-100B S6 35.5-38.0 ft
09-103B S2 partial tube: 34.9-35.4 (6") and 35.4-35.9 (6") ft

09-200B S4 32.5-35.0 ft
09-408B S6 33.0-35.5 ft
09-408B S7 35.5-38.0 ft
09-502B S4 22.0-24.5 ft
09-503B S2 31.0-33.5 ft
09-700B S3 22.5-25.0 ft
09-800B S4 26.5-29.0 ft
09-801B S5 37.5-40.0 ft

Received 4/29/09
09-210B S2 partial section 10.5 to 11.0 ft.

3 SCOPE OF SERVICES

The scope of services was discussed by telephone, electronic correspondence and in person between Dr. DeGroot and Dr. Bill Walton, of AECOM. The final test program consisted of the following tests on selected sample tubes: full extraction, photographs and sample log, Atterberg Limits, specific gravity, organic content, grain size distribution, CRS and DSS.

4 METHODS

4.1 Sample Extraction

Selected sample tubes were cut into several sub-sections using a pipe cutter or horizontal band saw. Each sub-section was extruded, examined and logged. Selected sections were split and photographed. Water content samples were collected from selected sub-sections.

4.2 Water Content

Water contents were determined in general accordance with American Society for Testing and Materials (ASTM) Standard D2216 *Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock.*

4.3 Total and Dry Unit Weight

The total and dry unit weights of the soil were determined by using the trimmed CRS and DSS specimens. The volume of the CRS or DSS specimen/trimming ring was first measured and after trimming the wet mass of the specimen was weighed for calculation of the total unit weight. The dry unit weight was determined using the oven dry weight of the test specimen.

4.4 Atterberg Limits

Atterberg Limits were determined in general accordance with ASTM Standard D4318 *Standard Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils.* Soil was prepared using the wet method. The as received soil was mixed with distilled water to a 15 blow count consistency using a Casagrande Cup and allowed to temper in a humid room for approximately 24 hours prior to testing. Liquid and Plastic Limit data points were determined by allowing the soil to dry at room temperature from the initial wet state to lower water contents.

4.5 Specific Gravity

Specific gravity tests were performed in general accordance with ASTM D854 *Standard Test Method for Specific Gravity of Soils*. Soil was prepared using Method A - Procedure for Moist Specimens. Approximately 50 g equivalent dry weight of test soil was dispersed in distilled water using a malt mixer and thereafter placed in a 500 mL calibrated pycnometer (in some cases less than 50 g was used because of limited sample availability). The pycnometer and soil mixture were gently boiled to remove entrapped air and then allowed to cool to room temperature. At the end of testing, the specimen's oven dry weight was measured. The specific gravity was calculated based on water at 20°C as the reference.

4.6 Organic Content

Organic content tests were conducted in general accordance with ASTM 2974 *Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils*. Specimens were prepared and tested using Test Method A with a 105°C oven to determine the moisture content and Test Method C with a muffle furnace at 440°C to determine the ash content. Data from these two methods were used to compute the organic content. In some cases less than the recommended specimen dry weight was used because of limited sample availability.

4.7 Grain Size Distribution

The grain size distribution test was conducted in general accordance with ASTM D422 *Standard Test Method for Particle-Size Analysis of Soils* using a hydrometer. The specimen was prepared for testing by allowing it to soak overnight in 125 mL of a 40 g/L sodium hexametaphosphate solution. After soaking, the specimen was dispersed using *Method A* after which the soil was transferred to a 1000 mL cylinder and mixed with distilled water. Once the test started, hydrometer readings of the soil slurry were taken for a period of approximately 24 hrs. At the conclusion of the hydrometer test, the material retained on the #200 sieve was oven dried, weighed and sieved.

4.8 Constant Rate of Strain (CRS) Consolidation

The constant rate of strain (CRS) consolidation tests were performed in general accordance with ASTM D4186 *Standard Test Method for One-Dimensional Consolidation Properties of Soils Using Controlled-Strain Loading* and Sandbeakken et al. (1986). The test was conducted using a GeoTac personal computer based test control and data acquisition system, which includes a load frame, flow pump, CRS consolidometer cell and Sigma-1 CRS consolidation software.

The general CRS test sequence consisted of the following stages:

1. Preparation of the specimen for testing first consisted of removing a test sample from a sample tube sub-section. The test specimen was hand trimmed using a soil lathe together with a sharp trimming ring and sharp trimming tools. The top and bottom surfaces of the specimen were trimmed flat with a wire saw and a long sharp edged knife with the final trimmed dimensions equaling a diameter of 2.5 in and a height of 0.75 in.
2. The specimen was placed in the CRS cell with moist top and bottom porous stones. After application of the seating load, one to three incremental loads were applied. Thereafter the cell chamber was filled with deaired water and the specimen was back pressure saturated to with a typical target back pressure equal to 4200 psf and left to sit overnight.

3. Constant rate of strain loading was typically conducted using a selected nominal strain rate between 1 to 4 %/hr (2.8×10^{-6} s^{-1} or 1.1×10^{-5} s^{-1}). An unload-reload loop was conducted during most tests and included a constant stress period prior to starting the unload phase and again prior to starting the reload phase. The target unload stress was set equal to approximately 20% of the vertical stress acting on the specimen prior to start of the unload-reload loop.
4. After the unload-reload loop was completed, CRS loading continued until a maximum stress of approximately 60,000 psf or 35% strain at which point the test was either stopped or a final unload sequence was conducted.

All measurements during testing were made using load, displacement and pressure transducers. The measured data were reduced using the methods of Wissa et al. (1971; and also described in ASTM D4186 and Sandbeakken et al. 1986). All vertical strains were computed taking into account the apparatus compliance that was determined using a steel disk. The preconsolidation stress was estimated using the Casagrande and strain energy methods (Becker et al. 1987).

4.9 Direct Simple Shear (DSS)

The Direct Simple Shear (DSS) tests were conducted using a Geonor DSS device in general accordance to the procedures described by Bjerrum and Landva (1966), DeGroot et al. (1992) and ASTM D6528 *Standard Test Method for Consolidated Undrained Direct Simple Shear Testing of Cohesive Soils.* The Geonor DSS device (Figure 4.8.1) consists of a specimen chamber, lever arm for application of consolidation weights and a gear driven thrust shaft for applying the horizontal shear stress to the specimen. Load cells and linear variable differential transformers, all connected to a dedicated data acquisition system, are used for measurement of load and displacement. Specimens are prepared for testing by trimming the soil into a 5.43 in^2 (35 cm^2) set of thin stainless steel stacked rings with an internal membrane. Carborundum porous stones with imbedded pins are placed on the top and bottom of the specimen. The membrane allows for one-dimensional consolidation during the consolidation phase of a test and direct simple shear strain mode of deformation during the shear phase of a test.

The general test sequence consisted of the following stages:

1. Preparation of the specimen for testing first consisted of removing a test sample from a sample tube sub-section followed by use of Geonor trimming equipment that allows for setting up a nominal 2.6" diameter by 0.8" height specimen inside a stacked ring membrane assembly.
2. Incremental, one-dimensional consolidation to the preshear vertical effective stress using a lever arm and dead weight system with the final preshear laboratory vertical effective stress (σ'_{vc}) set approximately equal to the estimated in situ vertical effective stress.
3. Maintaining the maximum consolidation stress acting on the specimen for a period of approximately 24 hours.
4. Undrained shearing using the constant volume procedure at a nominal shear strain rate of 5%/hour during application of the horizontal shear stress.
5. Undrained shear is continued to an approximate maximum shear strain of 20%.

All vertical consolidation strains are computed taking into account the apparatus compliance which was determined using a steel disk. The measured horizontal force during undrained shear

is corrected for the calibrated resistance of the stacked ring membrane assembly. Reduced data from the undrained shear phase of the test consists of shear strain (γ), horizontal shear stress (τ_h), equivalent change in pore water pressure (Δu), vertical effective stress (σ'_v), shear modulus ($G = \tau_h/\gamma$), and undrained shear strength (s_u) which is typically assumed to be equal to the maximum measured horizontal shear stress $(\tau_h)_{max}$ (Ladd 1991, DeGroot et al. 1992).

An undrained creep test (DSS G361) was conducted on sample 09-100B S6 (35.5 – 38.0 ft). The specimen was first consolidated to the target final vertical effective stress state. Thereafter undrained shear was performed as per the standard DSS test until the horizontal shear stress reached $0.8s_u$, with s_u = 985 psf from companion test DSS G357 on the sample, at which point the loading was switched from strain control to stress control with $\tau_h = 0.8s_u$. This shear stress was left acting on the specimen for about 3 days at which point it was increased to $0.85s_u$ and this stress was maintained until the specimen failed.

5 RESULTS

5.1 Tests Conducted, Photographs and Sample Logs

Table 1 presents a summary of the tests conducted on the sample tubes.

Figures 5.1.1 to 5.1.34 presents photographs of selected samples.

Figures 5.1.35 to 5.1.68 present the samples logs and show the location of the Atterberg Limits, grain size distribution, CRS and DSS test specimens.

5.2 Index and Classification Data

Table 2 presents water content data for the sample tubes.

Table 3 presents a summary of the Atterberg Limits results and Figure 5.2.1 plots them in a Casagrande Plasticity Chart.

Figure 5.2.2 plots results of the grain size distribution tests conducted on selected samples.

5.3 Constant Rate of Strain Tests

Table 4 presents a summary of the CRS test specimen properties and results. Figures 5.3.1 to 5.3.24 present plots of the CRS test results including the compression curve (ε_v versus σ'_v), coefficient of consolidation versus vertical effective stress, void ratio versus hydraulic conductivity and constrained modulus versus vertical effective stress.

5.4 Direct Simple Shear Tests

Table 5 presents a summary of the DSS test specimen properties and results. Figures 5.4.1 to 5.4.65 present plots of the DSS tests results including the compression curve from the consolidation phase of the test and plots from the undrained shear phase including shear stress versus shear strain, shear induced pore pressure versus shear strain, shear stress versus vertical effective stress, and shear modulus versus shear strain.

5.5 Test Specimen Photographs

Figures 5.5.1 to 5.5.6 present photographs of several DSS and CRS test specimens. The photographs are of post-test, oven dried, specimens that were split open and placed under a microscope.

6 REFERENCES

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7 NOTATION AND UNITS

Notation

c_v = vertical coefficient of consolidation (ft^2/day)
e = void ratio (-)
e_0 = initial void ratio (-)
G_s = specific gravity of solids (-)
k_v = vertical hydraulic conductivity (ft/day)
LL = liquid limit (%)
LI = liquidity index = (w – PL)/PI (-)
PI = plasticity index (%)
PL = plastic limit (%)
s_u = undrained shear strength (psf)
t = time (day, hr, min, s)
w = water content (%)

% = percentage
Δu = equivalent DSS shear induced pore pressure (psf)
ε_v = vertical strain (%)
ε_{vc} = vertical consolidation strain (%)
ε_{vf} = final vertical consolidation strain (%)
ε_{vmax} = maximum vertical strain during consolidation phase of DSS test (%)
γ = shear strain for DSS test (%)
γ_t = total unit weight (pcf)
γ_d = dry unit weight (pcf)
σ'_p = preconsolidation stress (psf)
σ'_v = vertical effective stress (psf)
σ'_{vc} = vertical consolidation effective stress (psf)
σ'_{vmax} = maximum vertical stress during consolidation phase of DSS test (psf)
σ'_{v0} = in situ vertical effective stress (psf)
τ_h = horizontal shear stress (psf)

Units

cm = centimeter
ft = feet
in = inches
min = minute
pcf = pounds per cubic foot
psf = pounds per square foot
s = seconds

Table 1 Summary of tests performed

Boring, Sample, Depth	Inspection and Sample Log	Water Content	Total and Dry Unit Weights	Atterberg Limits	Specific Gravity	Grain Size	Organic Content	Constant Rate of Strain Consolidation	Direct Simple Shear
09-100B S4 30.5-33.0 ft	complete tube	multiple							
09-100B S5 33.0-35.5 ft	complete tube	multiple	2			2 (ash)		CRS167	G356
09-100B S6 35.5-38.0 ft	complete tube	multiple	2	1	1		2		G357, G361
09-101B S5 38.0-40.5 ft	complete tube	multiple	2	1				CRS163	G350
09-103B S2 33.5-36.0 ft	partial tube (as received)	multiple	3	2 (natural and oven dry				CRS166	G354, G355
09-103B S3 36.0-38.5 ft	complete tube	multiple		1					
09-103B S4 38.5-39.0 ft	partial tube (as received)	multiple							
09-103B S5 41.0-42.0 ft	partial tube (as received)	multiple	1	1				CRS168	
09-104B S4 22.5-25.0 ft	complete tube	multiple	1	2 (natural and oven dry				CRS161	
09-108B S2 23.5-26.0 ft	complete tube	multiple	3			1 (ash)		CRS164	G351, G358
09-109B S3 25.5-28.0 ft	complete tube	multiple	1			1 (ash)			G352
09-200B S4 32.5-35.0 ft	complete tube	multiple							
09-201B S2 25.5-28.0 ft	complete tube	multiple	1	1				CRS160	
09-202B S2 28.5-31.0 ft	complete tube	multiple	1	1				CRS159	
09-206B S5 20.0-22.5 ft	tube cut in sections but not extruded	multiple							
09-207B S3 13.0-15.5 ft	complete tube	multiple							
09-210B S2 10.5-11.0 ft	partial tube (as received)	multiple		1	1				
09-301B S6 87.5-90.0 ft	complete tube	multiple	2	1		1 (ash)		CRS162	G349
09-303B S9 87.5-90.0 ft	complete tube	multiple				1 (ash)			
09-408B S6 33.0-35.5 ft	complete tube	-							
09-408B S7 35.5-38.0 ft	complete tube	multiple	2	1	1			CRS169	G359
09-500B S4 26.5-29.0 ft	complete tube	multiple		1					
09-500B S5 29.0-31.5 ft	complete tube	multiple		1	1	1 (ash)			
09-502B S4 22.0-24.5 ft	complete tube	multiple							
09-503B S2 31.0-33.5 ft	complete tube	multiple							

Boring, Sample, Depth	Inspection and Sample Log	Water Content	Total and Dry Unit Weights	Atterberg Limits	Specific Gravity	Grain Size	Organic Content	Constant Rate of Strain Consolidation	Direct Simple Shear
09-503B S3 35.5-37.5 ft	complete tube	multiple	2			1 (ash)		CRS170	G360
09-600B S2 44.0-46.5 ft	complete tube	multiple		2					
09-601B S5 49.5-52.0 ft	tube cut in sections but not extruded	multiple							
09-602B S4 54.0-56.5 ft	tube cut in sections but not extruded	multiple							
09-605B S7 47.0-49.5 ft	complete tube	multiple	2					CRS165	G353
09-605B S8 49.5-52.0 ft	tube cut in sections but not extruded	multiple							
09-700B S3 22.5-25.0 ft	complete tube	multiple							
09-800B S4 26.5-29.0 ft	complete tube	multiple							
09-801B S5 37.5-40.0 ft	complete tube	multiple							

Note: see sample logs for specific test specimen locations

Table 2 Summary of water content data

Boring, Sample, Depth	Distance from bottom of sample tube (inches)/Water Content (%)										
Distance Interval (ft)	**0-3"**	**3-6"**	**6-9"**	**9-12"**	**12-15"**	**15-18"**	**18-21"**	**21-24"**	**24-27"**	**27-30"**	
09-100B S4 30.5-33.0 ft	1"/28%		7"/31%		13"/47%		19"/42%				
09-100B S5 33.0-35.5 ft	1"/32%		7"/31%		13"/41%		19"/35%		25"/33%		
09-100B S6 35.5-38.0 ft	2"/20%		8"/18%		14"/25%		20"/21"		26"/85%	27"/96%	
09-101B S5 38.0-40.5 ft						15"/25%	21"/29%	21"/35%			
09-103B S2 33.5-36.0 ft			7"/51%		13"/29%						
09-103B S3 36.0-38.5 ft	1"/21%			10"/25%		16"/27%					
09-103B S4 38.5-39.0 ft							19"/26%			29"/19%	
09-103B S5 41.0-42.0 ft					14"/27%				26"/25%	29.5"/20%	
09-104B S4 22.5-25.0 ft	1"/23%		8"/41%	9"/118% 10"/34%	14"/78%						
09-108B S2 23.5-26.0 ft	1"/18%				12"/32%	18"/32%	19"/38% 20"/29%				
09-109B S3 25.5-28.0 ft	2"/107%		6"/32%		12"/51%		18"/34%				
09-200B S4 32.5-35.0 ft			8"/19%		14"/19%		20"/25%			28"/29%	
09-201B S2 25.5-28.0 ft						15"/20%		21"/18%			
09-202B S2 28.5-31.0 ft							20"/16%	23"/20%			
09-206B S5 20.0-22.5 ft		6"/21%				18"/21%				28.5"/23%	
09-207B S3 13.0-15.5 ft		4"/29%	8"/17%		14"/19%		20"/28%				
09-210B S2 10.5-11.0 ft	10.9'/23%	10.5'/38%									
09-301B S6 87.5-90.0 ft	1"/18%		8"/22%	10"/23%			20"/33%				
09-303B S9 87.5-90.0 ft	2"/21%			9"/23%		17"/36% 17.5"/34%		22"/30%	27"/29%		
09-408B S6 33.0-35.5 ft											
09-408B S7 35.5-38.0 ft	1"/31%		7"/31%		13"/44%		19"/36%		25"/31%		
09-500B S4 26.5-29.0 ft							19"/31%	22"/45%	24"/38%		
09-500B S5 29.0-31.5 ft					12"/34%	16.5"/48%	18"/31%				

Boring, Sample, Depth	Distance from bottom of sample tube (inches)/Water Content (%)										
Distance Interval (ft)	**0-3"**	**3-6"**	**6-9"**	**9-12"**	**12-15"**	**15-18"**	**18-21"**	**21-24"**	**24-27"**	**27-30"**	
09-502B S4 22.0-24.5 ft			6"/18%		12"/18%		18"/16%				
09-503B S2 31.0-33.5 ft	1"/31%		7"/31%		13"/31%						
09-503B S3 35.5-37.5 ft					12"/40%		18'/30%				
09-600B S2 44.0-46.5 ft			6"/22%			18"/20%		24"/23%		28"/26% 29.5"/48%	
09-601B S5 49.5-52.0 ft			8"/21%		14"/22%		20"/22%				
09-602B S4 54.0-56.5 ft		4"/24%		10"/22%				22"/22%			
09-605B S7 47.0-49.5 ft	1"/23%	6"/25%		12"/31%		17.5"/41%	18"/28%				
09-605B S8 49.5-52.0 ft	1.5"/20%		8"/21%		14"/21%		20"/21%				
09-700B S3 22.5-25.0 ft			6"/33%		12"/34%		18"/34%		24"/26%		
09-800B S4 26.5-29.0 ft			6"/22%		12"/21%		18"/21%	24"/33%			
09-801B S5 37.5-40.0 ft			6"/30%		12"/29%		18"/28%				

Notes: see also sample logs for test specimen locations

Table 3 Summary of classification test results

Boring, Sample, Depth	CRS/DSS Test	LL	PL	PI	w	LI	Void Ratio (e) DSS Specimen		Organic Matter	G_s
-	-	(%)	(%)	(%)	(%)	(-)	G_s = 2.70	G_s = 2.30	(%)	(-)
1	2	3	4	5	6	7	8	9	10	11
09-100B S4 30.5-33.0 ft										
09-100B S5 33.0-35.5 ft	G356 & CRS167				58		1.885	1.458		
09-100B S6 35.5-38.0 ft	G357	57	40	17	119	4.65	3.422	2.767	3.5 & 6.0	2.20†
09-101B S5 38.0-40.5 ft	G350 & CRS163	34	22	12	23	0.08	0.680			
09-103B S2 33.5-36.0 ft	G354 & CRS166, G355	45	35	10	105	7.00	3.122	2.511		
	oven dry sample	34	30	4						
09-103B S3 36.0-38.5 ft		27	21	6	27	1.00				
09-103B S4 38.5-39.0 ft										
09-103B S5 41.0-42.0 ft	CRS168	24	20	4	26	1.50				
09-104B S4 22.5-25.0 ft	CRS161	47	39	8	88	6.13	2.686	2.140		
	oven dry sample	43	36	6						
09-108B S2 23.5-26.0 ft	G351 & CRS164, G358				76		2.168	1.698		
09-109B S3 25.5-28.0 ft	G352				87		2.645	2.105		
09-200B S4 32.5-35.0 ft										
09-201B S2 25.5-28.0 ft	CRS160	29	20	9	20	0.00				
09-202B S2 28.5-31.0 ft	CRS159	25	17	8	19	0.25				
09-206B S5 20.0-22.5 ft										
09-207B S3 13.0-15.5 ft										
09-210B S2 10.5-11.0 ft		34	21	13	23	0.15				2.66
09-301B S6 87.5-90.0 ft	G349 & CRS162	32	19	13	22	0.23	0.638			
09-303B S9 87.5-90.0 ft										
09-408B S6 33.0-35.5 ft										
09-408B S7 35.5-38.0 ft	G359 & CRS169	30	NP		68		2.028	1.580		2.28†

Boring, Sample, Depth	CRS/DSS Test	LL	PL	PI	w	LI	Void Ratio (e) DSS Specimen		Organic Matter	G_s
-	-	(%)	(%)	(%)	(%)	(-)	G_s = 2.70	G_s = 2.30	(%)	(-)
1	2	3	4	5	6	7	8	9	10	11
09-500B S4 26.5-29.0 ft		27	NP							
09-500B S5 29.0-31.5 ft		58	31	27	34	0.11				2.58
09-502B S4 22.0-24.5 ft										
09-503B S2 31.0-33.5 ft										
09-503B S3 35.5-37.5 ft	G360 & CRS170				83		2.674	2.129		
09-600B S2 44.0-46.5 ft	at 1.5'	22	16	6	20	0.67				
	at 2.3'	24	20	4	26	1.50				
09-601B S5 49.5-52.0 ft										
09-602B S4 54.0-56.5 ft										
09-605B S7 47.0-49.5 ft	G353 & CRS165				49		1.437	1.076		
09-605B S8 49.5-52.0 ft										
09-700B S3 22.5-25.0 ft										
09-800B S4 26.5-29.0 ft										
09-801B S5 37.5-40.0 ft										

Notes:
1. See sample logs for specific test specimen locations.
2. Water content and void ratio values from adjacent DSS test specimen or CRS test specimen or water content sample if adjacent DSS or CRS test specimen not available (see Tables 4 and 5)
3.† Specific gravity test specimen contained some floating (ash) particles.

Table 4 Summary of Constant Rate of Strain (CRS) specimen properties and test results

Test #	Boring Sample	Depth	w	e_0	γ_t	γ_d	σ'_{v0}	Sample Quality (at σ'_{v0})		σ'_p		OCR		Figure Numbers
								$\Delta e/e_0$	ε_v	Casa.	S.E.	Casa.	S.E.	
-	-	ft	%	-	pcf	pcf	psf	-	%	psf	psf	-	-	-
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRS159	09-202B S2	28.5-31.0	19	0.579	128	107	1276	0.000	0.0	9525†	9815	7.33	7.55	5.3.1-5.3.2
CRS160	09-201B S2	25.5-28.0	20	0.605	127	105	1359	0.022	0.8	6935†	7100	5.10	5.22	5.3.3-5.3.4
CRS161	09-104B S4	22.5-25.0	88	2.713	86	46	1584	0.019	1.4	4760	5160	3.00	3.26	5.3.5-5.3.6
CRS162	09-301B S6	87.5-90.0	25	0.714	123	99	4236	0.092	3.8	4805†	7310	1.13	1.73	5.3.7-5.3.8
CRS163	09-101B S5	38.0-40.5	24	0.703	123	99	2136	0.022	0.9	10445†	12530	4.89	5.87	5.3.9-5.3.10
CRS164	09-108B S2	23.5-26.0	39	1.150	110	79	1577	0.032	1.7	2860	2990	1.81	1.90	5.3.11-5.3.12
CRS165	09-605B S7	47.0-49.5	31	0.942	114	87	2356	0.003	0.1	4760	4990	2.02	2.12	5.3.13-5.3.14
CRS166	09-103B S2	33.5-36.0	108	3.080	86	42	1935	0.012	0.9	3615	3780	1.87	1.95	5.3.15-5.3.16
CRS167	09-100B S5	33.0-35.5	67	2.189	88	53	1958	0.022	1.5	4929	5305	2.52	2.71	5.3.17-5.3.18
CRS168	09-103 S5	41.0-43.5	23	0.650	126	103	2221	0.034	1.3	-†	-†	-	-	5.3.19-5.3.20
CRS169	09-408B S7	35.5-38.0	46	1.434	101	70	1707	0.000	0.0	7205	6892	4.22	4.04	5.3.21-5.3.22
CRS170	09-503B S3	35.5-38.0	131	3.781	82	35	3923	0.014	1.1	7519	7519	1.92	1.92	5.3.23-5.3.24

Notes:

†no distinct break evident in compression curve

1. Notation given in Section 7
2. See sample logs for specific test specimen locations.
3. e_0 based on assumed specific gravity = 2.72
4. σ'_{v0} values from AECOM
5. For estimates of σ'_p: Casa. = Casagrande construction; S.E. = strain energy method of Becker et al. (1987)

6. Sample quality evaluation methods:

Lunne et al. (2006) quality ratings 1 = very good to excellent, 2 = fair to good, 3 = poor, 4 = very poor					Terzaghi et al. (1996) Specimen Quality Designation (SQD) A (best) to E (worst)					
OCR	$\Delta e/e_0$ at σ'_{v0}									
1 to 2	< 0.04	0.04 – 0.07	0.07 – 0.14	> 0.14	ε_v at σ'_{v0}	< 1	1 - 2	2 - 4	4 - 8	> 8
2 to 4	< 0.03	0.03 – 0.05	0.05 – 0.10	> 0.10	SQD	A	B	C	D	E
Quality	1	2	3	4						

Table 5 Summary of Direct Simple Shear (DSS) specimen properties and test results

Test No.	Boring Sample	Depth	w_n	γ_t	γ_d	σ'_{vo}	Laboratory Consolidation					Shear Data at Peak $(\tau_h)_{max} = s_u$				Figure Numbers
							σ'_{vc}	σ'_{vmax}	OCR	ε_{vmax}	ε_{vf}	γ	τ_h	τ_h/σ'_{vc}	σ'_v/σ'_{vc}	
-	-	ft	%	pcf	pcf	psf	psf	psf	-	%	%	%	psf	-	-	-
1	2	3	4	5	5	6	7	8	9	10	11	12	13	14	15	16
G349	09-301B S6	87.5-90.0	22	126	103	4236	4174	4174	-	5.0	5.0	10.8	1190	0.285	0.484	5.4.1-5.4.5
G350	09-101B S5	38.0-40.5	23	123	100	2136	2103	4220	-	3.0	2.9	13.0	1840	0.874	1.409	5.4.6-5.4.10
G351	09-108B S2	23.5-26.0	76	93	53	1577	1591	2053	-	3.2	3.1	5.6	690	0.434	0.698	5.4.11-5.4.15
G352	09-109B S3	25.5-28.0	87	86	46	1483	1505	1891	-	3.9	3.9	4.8	599	0.398	0.625	5.4.16-5.4.20
G353	09-605B S7	47.0-49.5	49	102	69	2356	2370	2904	-	3.8	3.8	5.2	805	0.340	0.624	5.4.21-5.4.25
G354	09-103B S2	33.5-36.0	105	84	41	1935	1927	2580	-	3.6	3.4	5.1	779	0.404	0.672	5.4.26-5.4.30
G355	09-103B S2	33.5-36.0	67	92	55	1935	1939	2592	-	4.2	4.1	5.7	684	0.353	0.652	5.4.31-5.4.35
G356	09-100B S5	33.0-35.5	58	92	58	1958	1971	3436	-	3.2	3.1	12.2	1060	0.538	0.872	5.4.36-5.4.40
G357	09-100B S6	35.5-38.0	119	83	38	2020	2024	3398	-	4.6	4.4	4.0	985	0.487	0.864	5.4.41-5.4.45
G358	09-108B S2	23.5-26.0	104	84	41	1577	8288	8281	1.0†	15.1	15.1	4.0	1967	0.237	0.520	5.4.46-5.4.50
G359	09-408B S7	35.5-38.0	68	93	56	1707	1692	4193	-	2.4	2.3	5.1	1106	0.654	1.065	5.4.51-5.4.55
G360	09-503B S3	35.5-38.0	83	83	46	3923	3937	4177	-	3.5	3.5	4.9	1249	0.317	0.563	5.4.56-5.4.60
G361	09-100B S6	35.5-38.0	68	95	57	2020	2022	3442	-	4.0	3.8	creep test				5.4.61-5.4.65

Notes: 1. Notation given in Section 7. 2. See sample logs for specific test specimen locations. 3. σ'_{v0} values provided by AECOM
4. Undrained shear strength $s_u(DSS) = (\tau_h)_{max}$ 5. †SHANSEP OCR = 1 test.

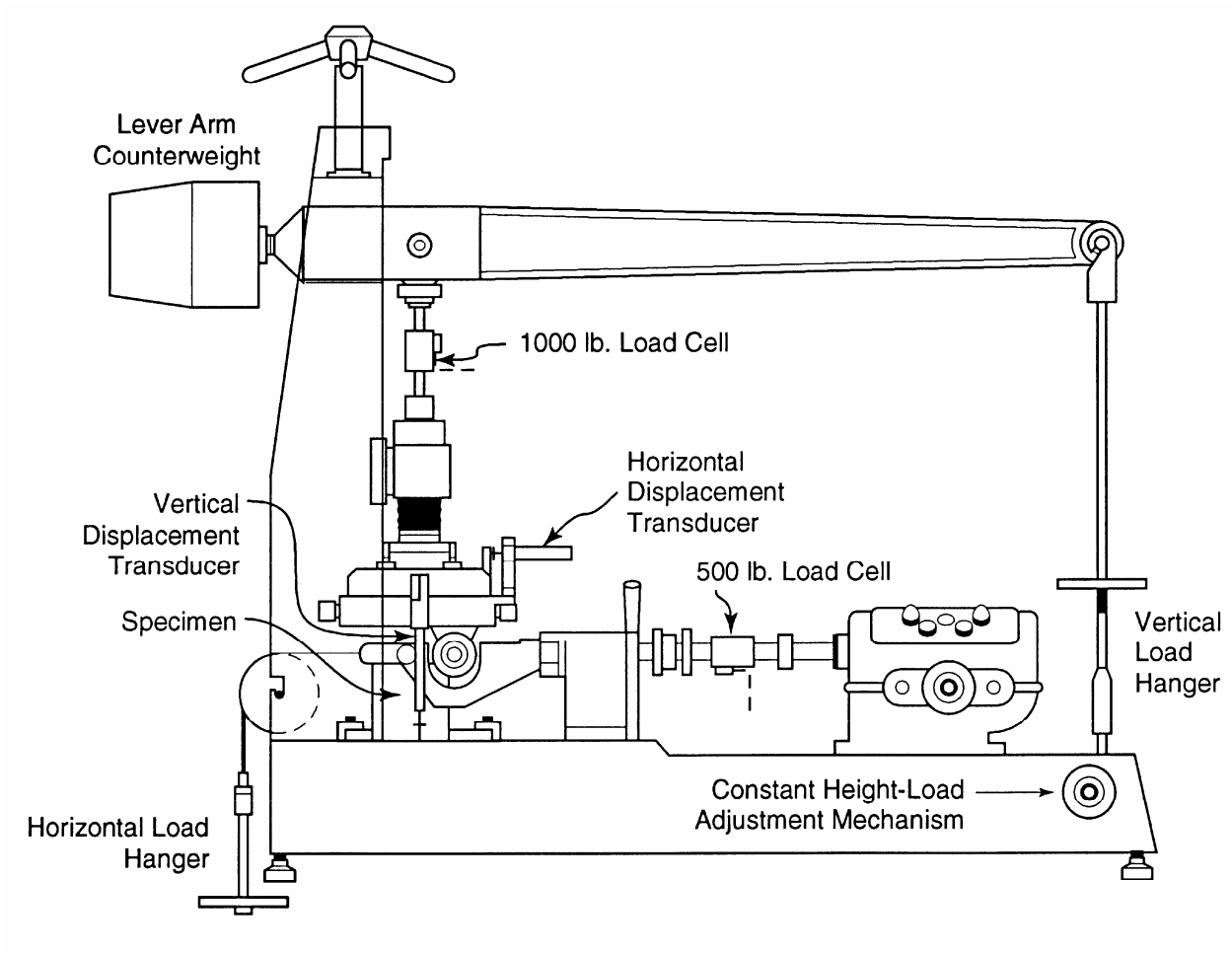

Figure 4.8.1 Schematic of the Geonor Direct Simple Shear Apparatus.

Figure 5.1.1 Photograph of Sample 09-100B S4 30.5 to 33.0 ft.

Figure 5.1.2 Photograph 1 of Sample 09-100B S5 33.0 to 35.5 ft.

Figure 5.1.3 Photograph 2 of Sample 09-100B S5 33.0 to 35.5 ft.

Figure 5.1.4 Photograph of Sample 09-100B S6 35.5 to 38.0 ft.

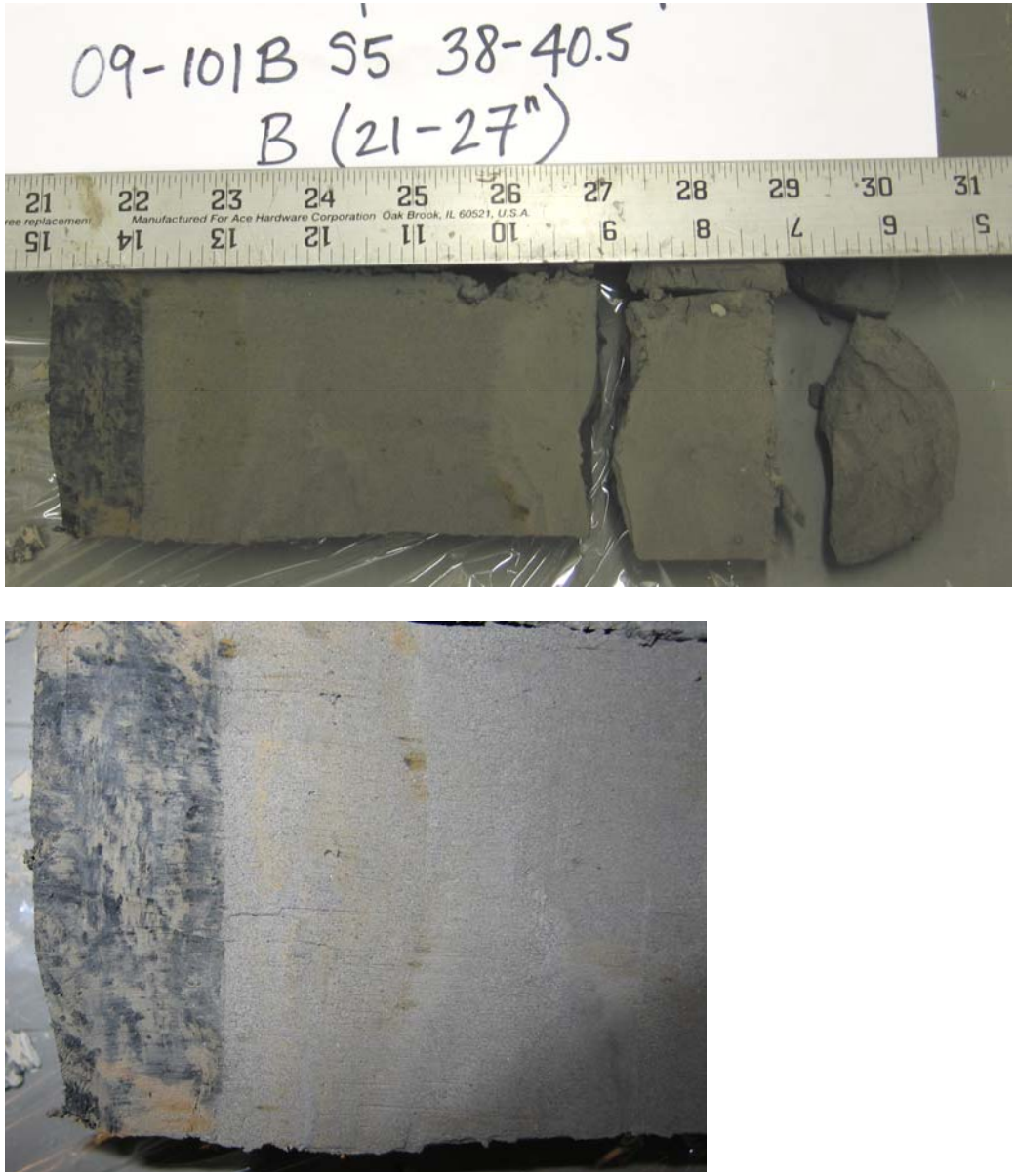

Figure 5.1.5 Photographs of Sample 09-101B S5 38.0 to 40.5 ft.

Figure 5.1.6 Photograph of Sample 09-103B S2 33.5 to 36.0 ft – as received 2 six inch sections.

Figure 5.1.7 Photograph of Sample 09-103B S3 36.0 to 38.5 ft.

Figure 5.1.8 Photograph of Sample 09-103B S4 38.5 to 41.0 ft – as received 10inch section.

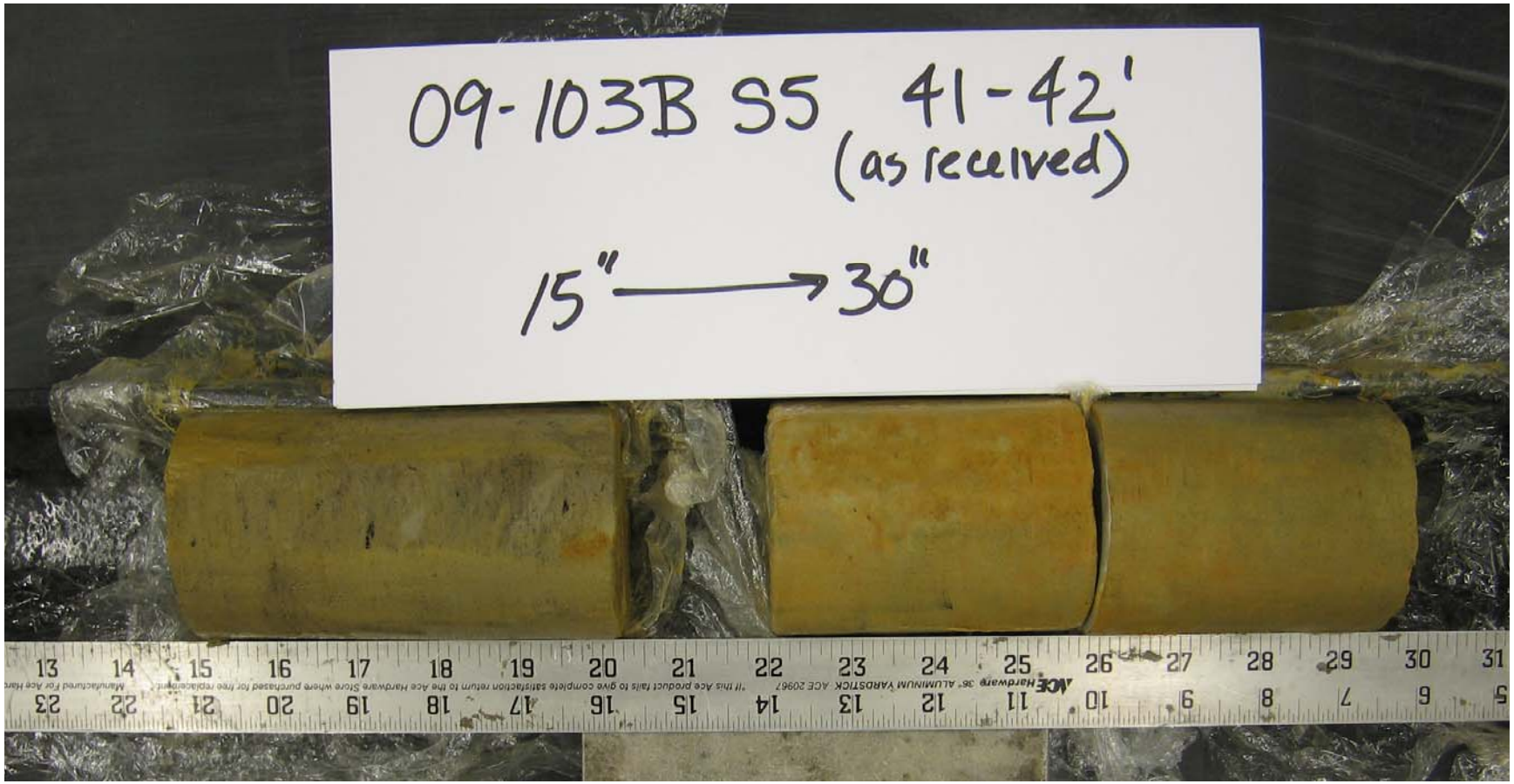

Figure 5.1.9 Photograph of Sample 09-103B S5 41.0 to 42.0 ft – as received section.

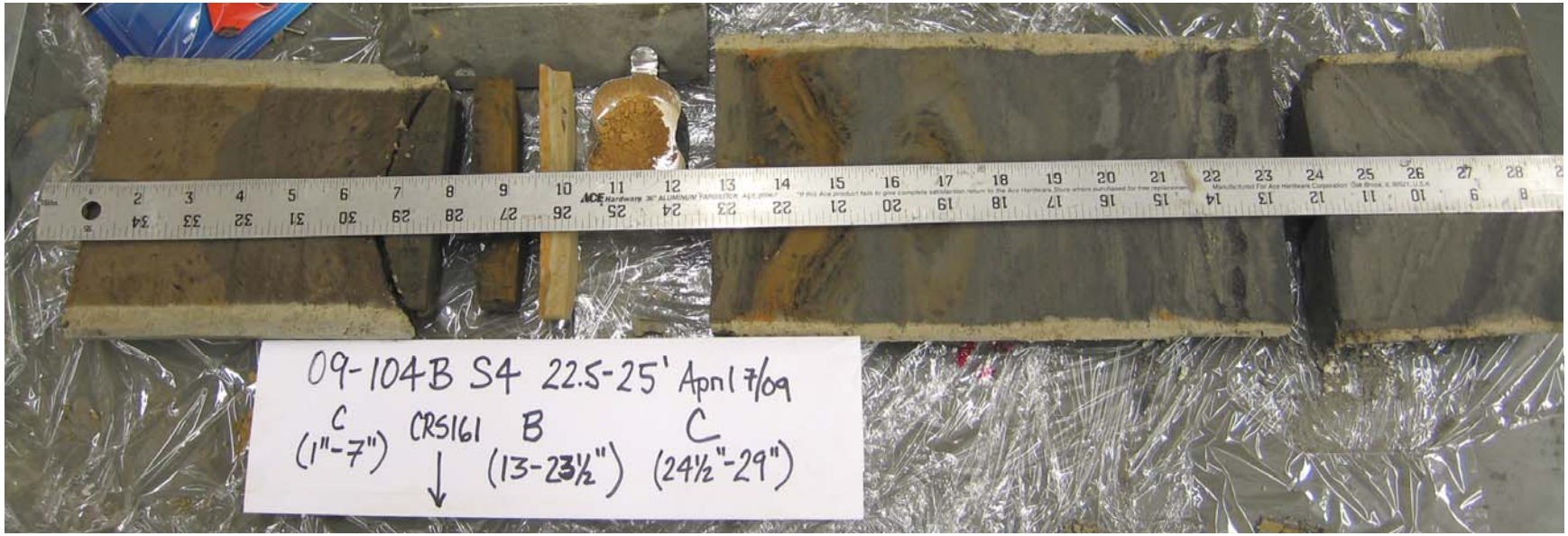

Figure 5.1.10 Photograph of Sample 09-104B S4 22.5 to 25.0 ft.

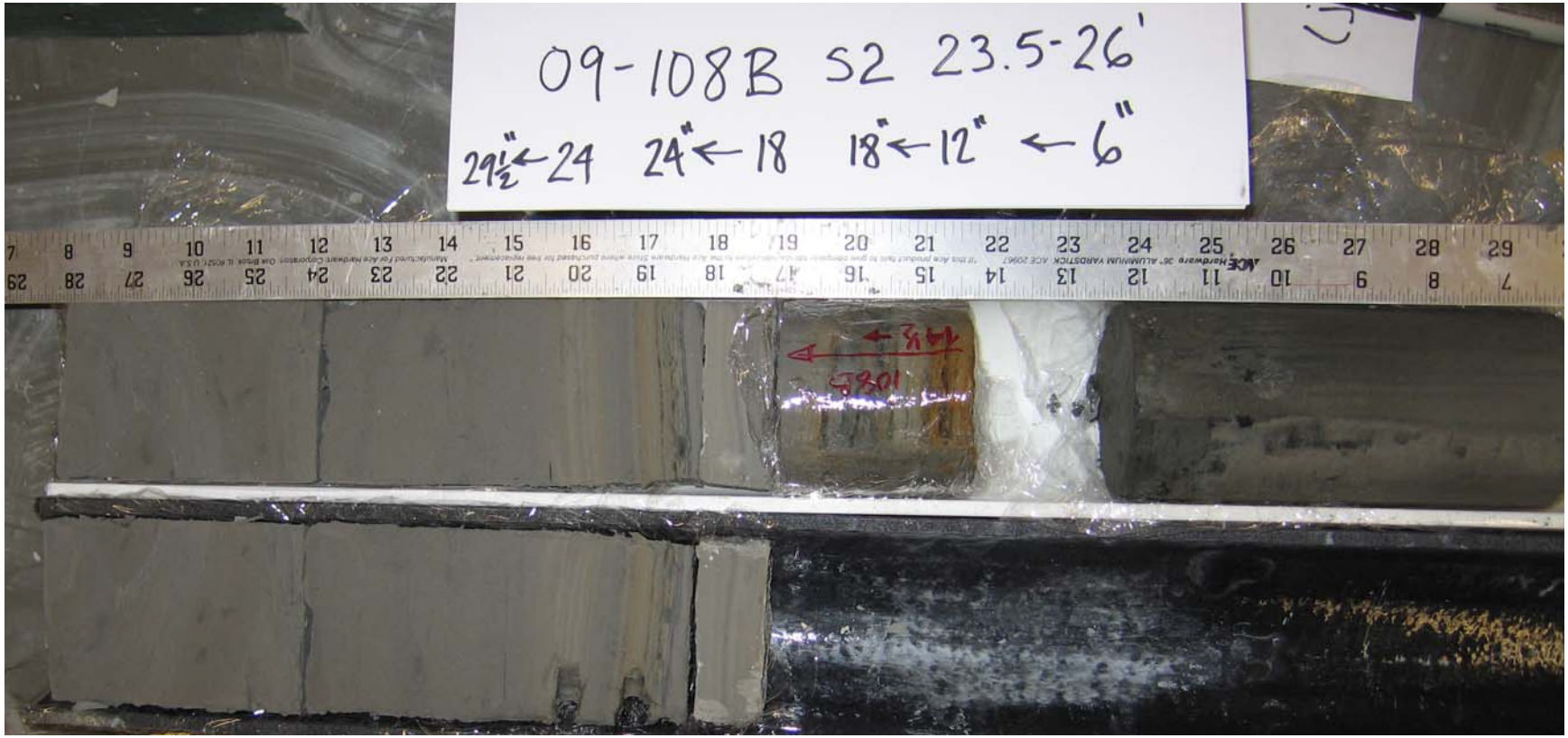

Figure 5.1.11 Photograph 1 of Sample 09-108B S2 23.5 to 26.0 ft.

Figure 5.1.12 Photograph 2 of Sample 09-108B S2 23.5 to 26.0 ft – section from 12 to 18 inches (right to left).

Figure 5.1.13 Photograph of Sample 09-109B S2 25.5 to 28.0 ft.

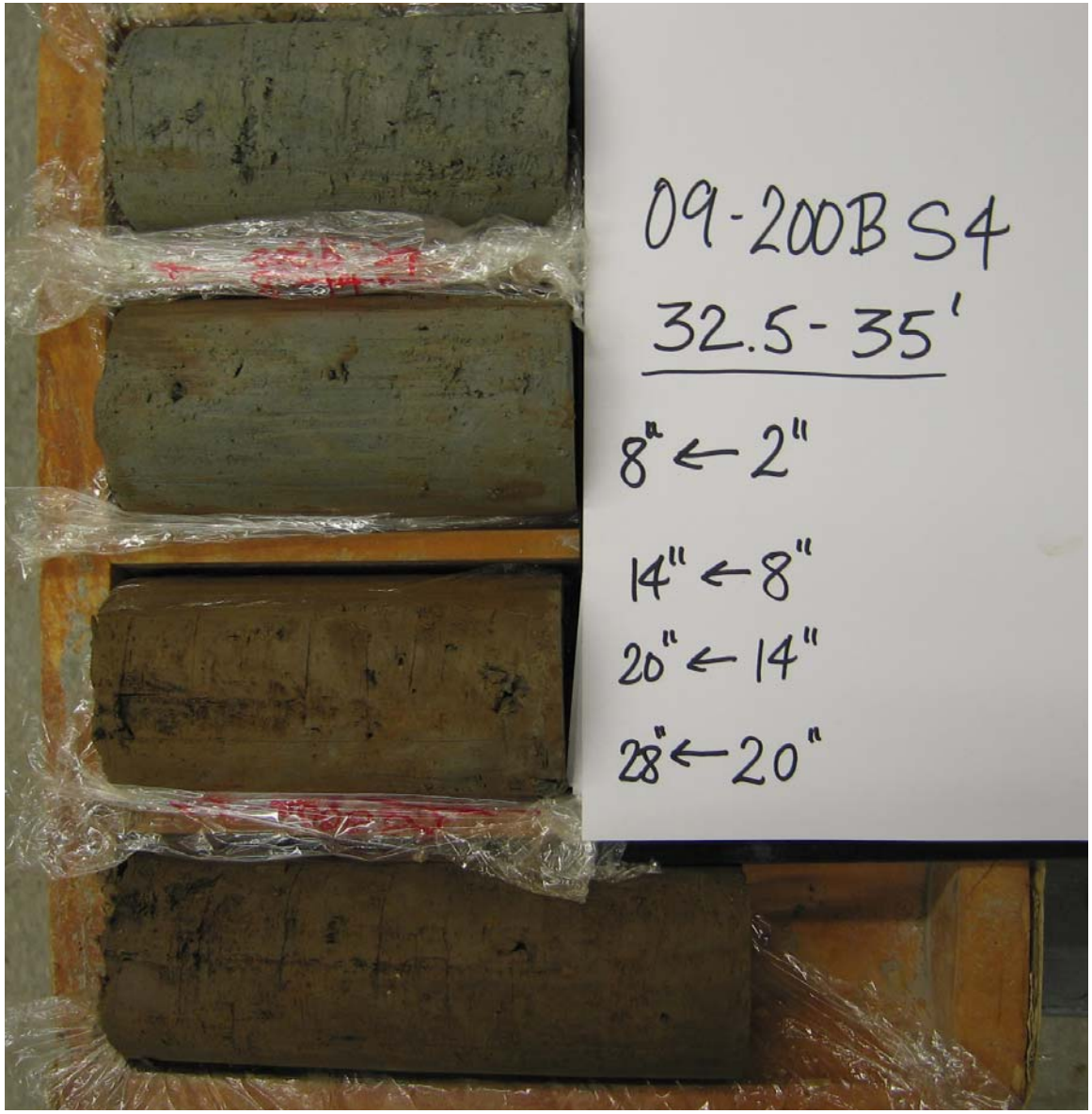

Figure 5.1.14 Photograph of Sample 09-200B S4 32.5 to 35.0 ft.

Figure 5.1.15 Photograph 1 of Sample 09-201B S2 25.5 to 28.0 ft.

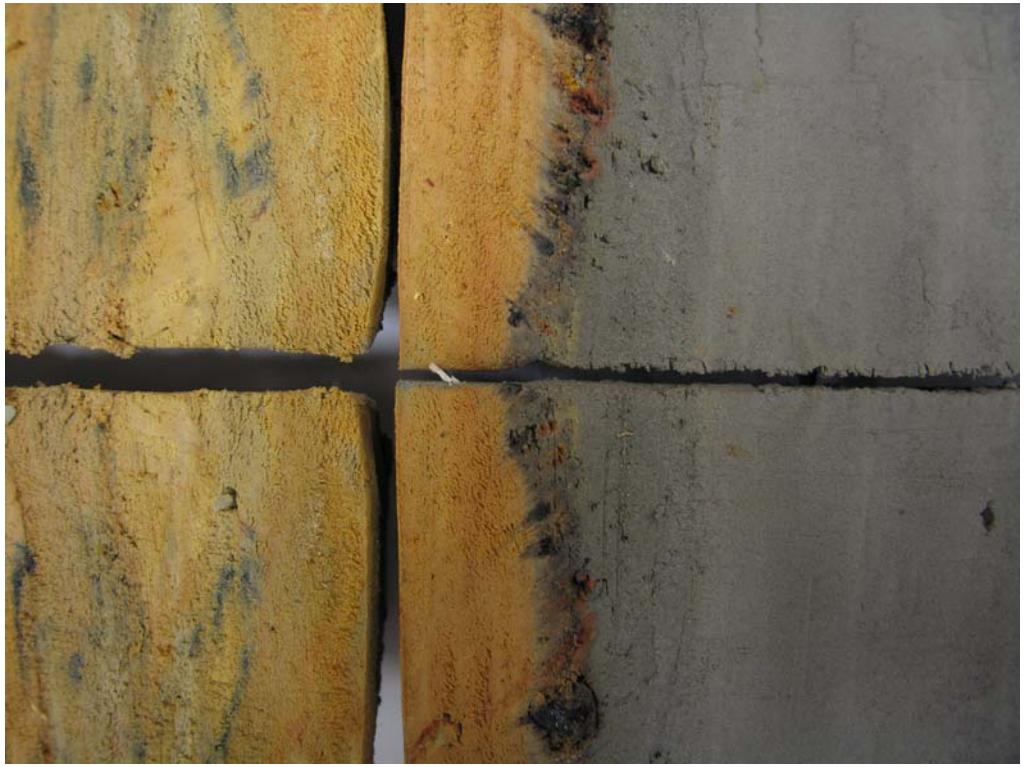

Figure 5.1.16 Photograph 2 of Sample 09-201B S2 25.5 to 28.0 ft.

Figure 5.1.17 Photographs of Sample 09-202B S2 28.5 to 31.0 ft.

Figure 5.1.18 Photograph of Sample 09-207B S3 13.0 to 15.5 ft.

Figure 5.1.19 Photograph of Sample 09-210B S2 – as received 10.5 to 11.0 ft section.

Figure 5.1.20 Photograph of Sample 09-301B S6 87.5 to 90.0 ft.

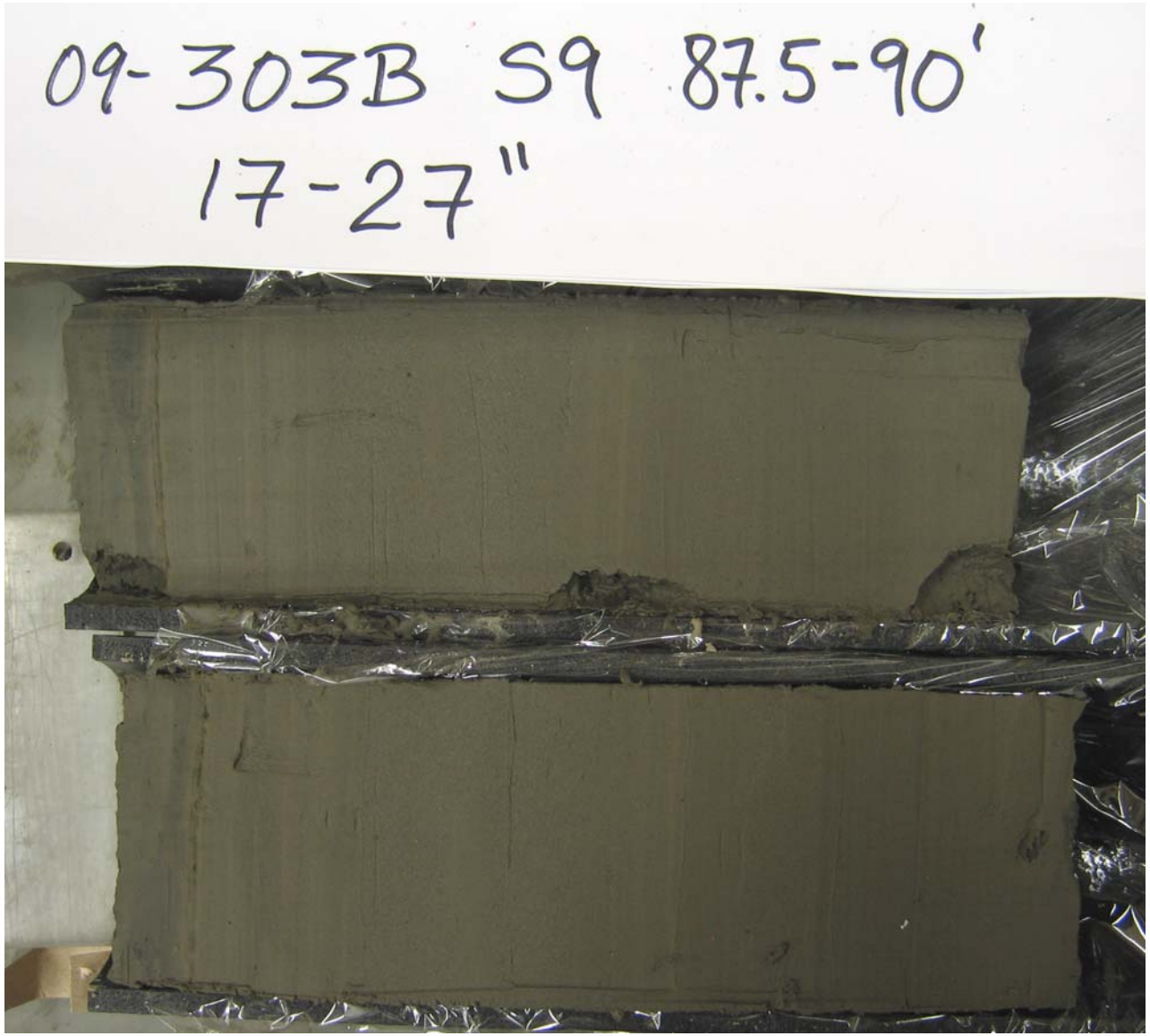

Figure 5.1.21 Photograph of Sample 09-303B S9 87.5 to 90.0 ft.

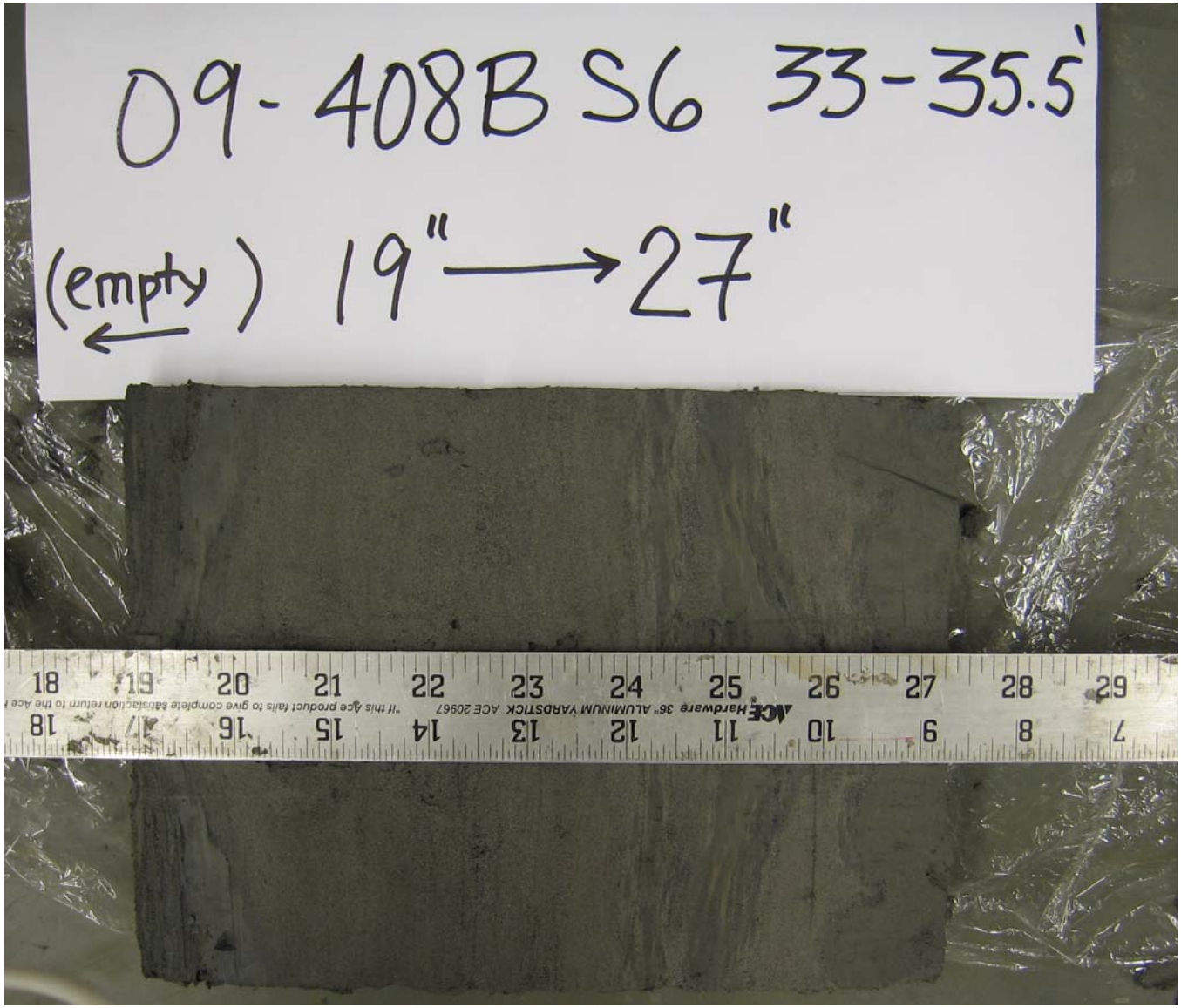

Figure 5.1.22 Photograph of Sample 09-408B S6 33.0 to 35.5 ft.

Figure 5.1.23 Photograph of Sample 09-408B S7 35.5 to 38.0 ft.

Figure 5.1.24 Photograph of Sample 09-500B S4 26.5 to 29.0 ft.

Figure 5.1.25 Photograph of Sample 09-500B S5 29.0 to 31.5 ft.

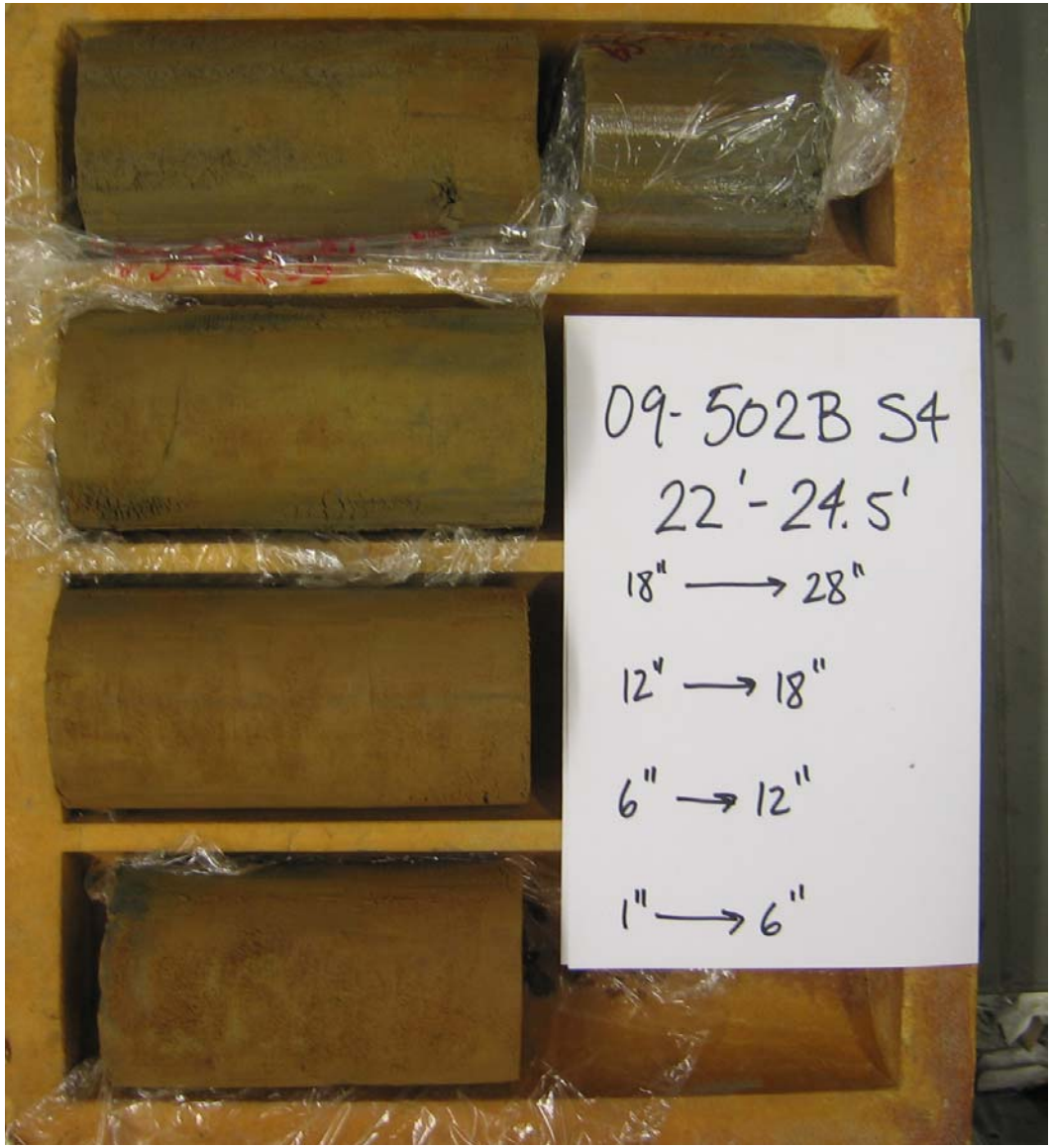

Figure 5.1.26 Photograph of Sample 09-502B S4 22.0 to 24.5 ft.

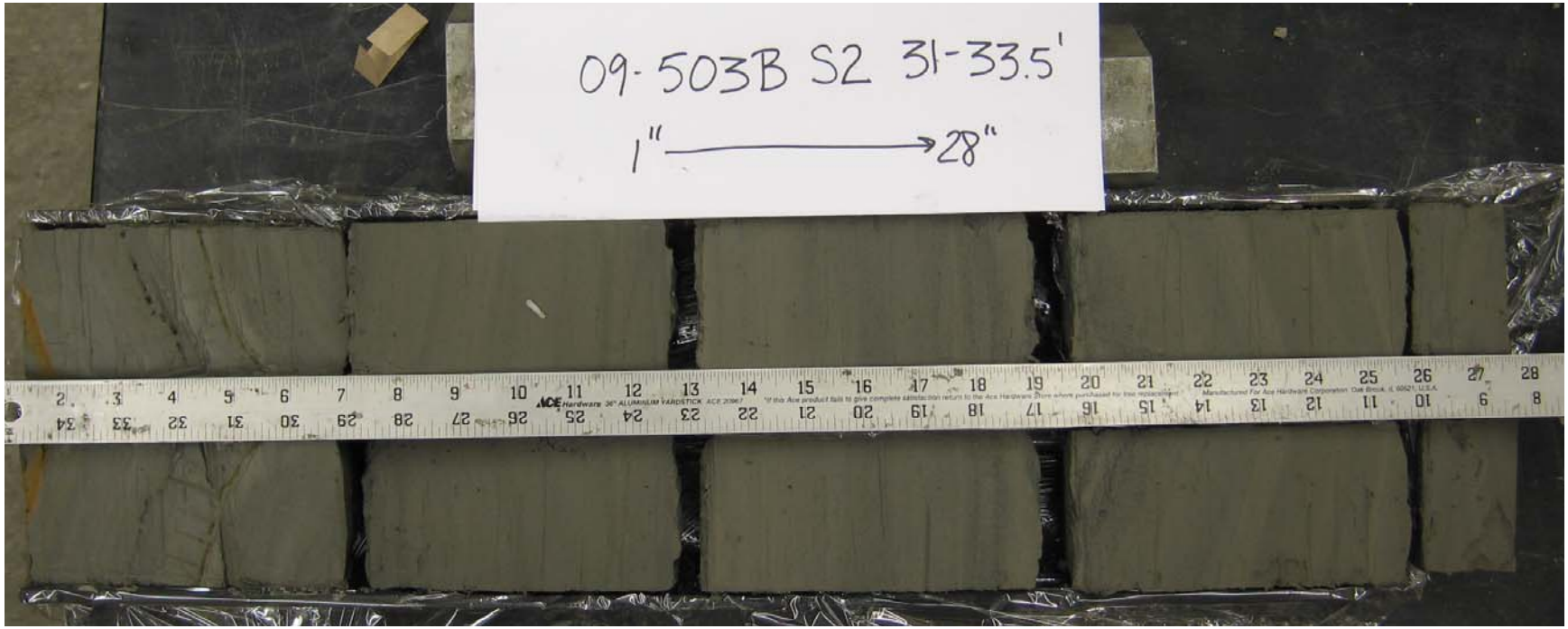

Figure 5.1.27 Photograph of Sample 09-503B S2 31.0 to 33.5 ft.

Figure 5.1.28 Photograph of Sample 09-503B S3 33.5 to 38.0ft.

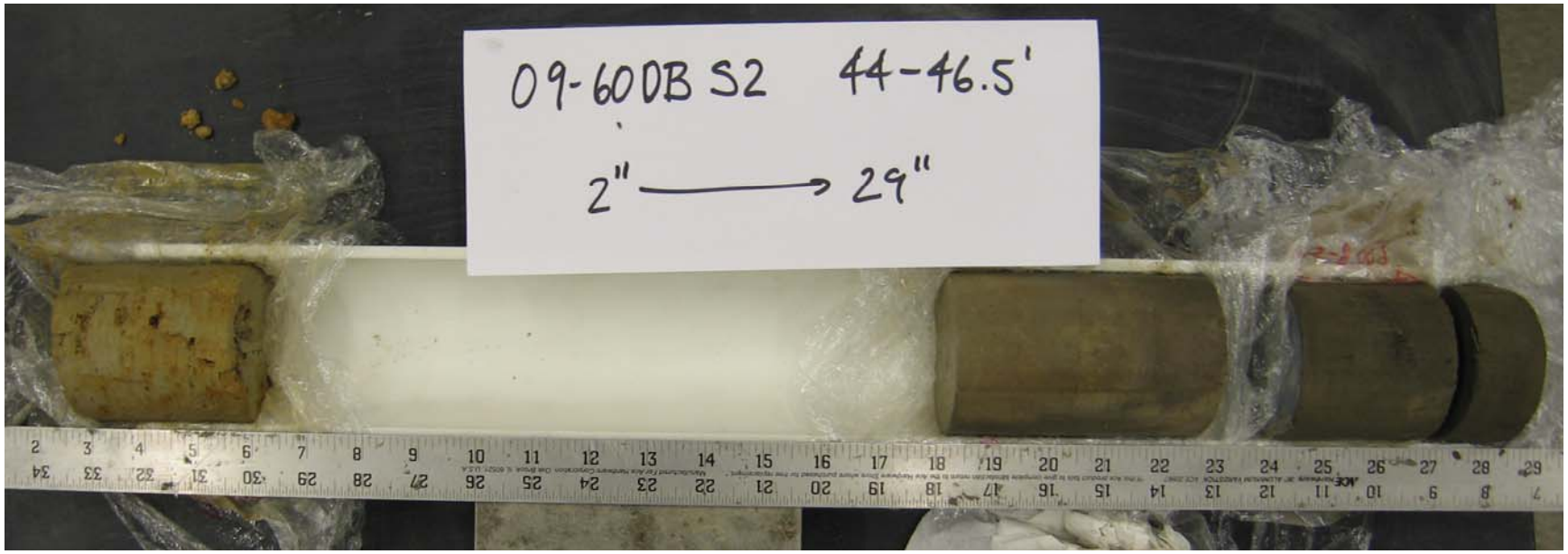

Figure 5.1.29 Photograph of Sample 09-600B S2 44.0 to 46.5 ft.

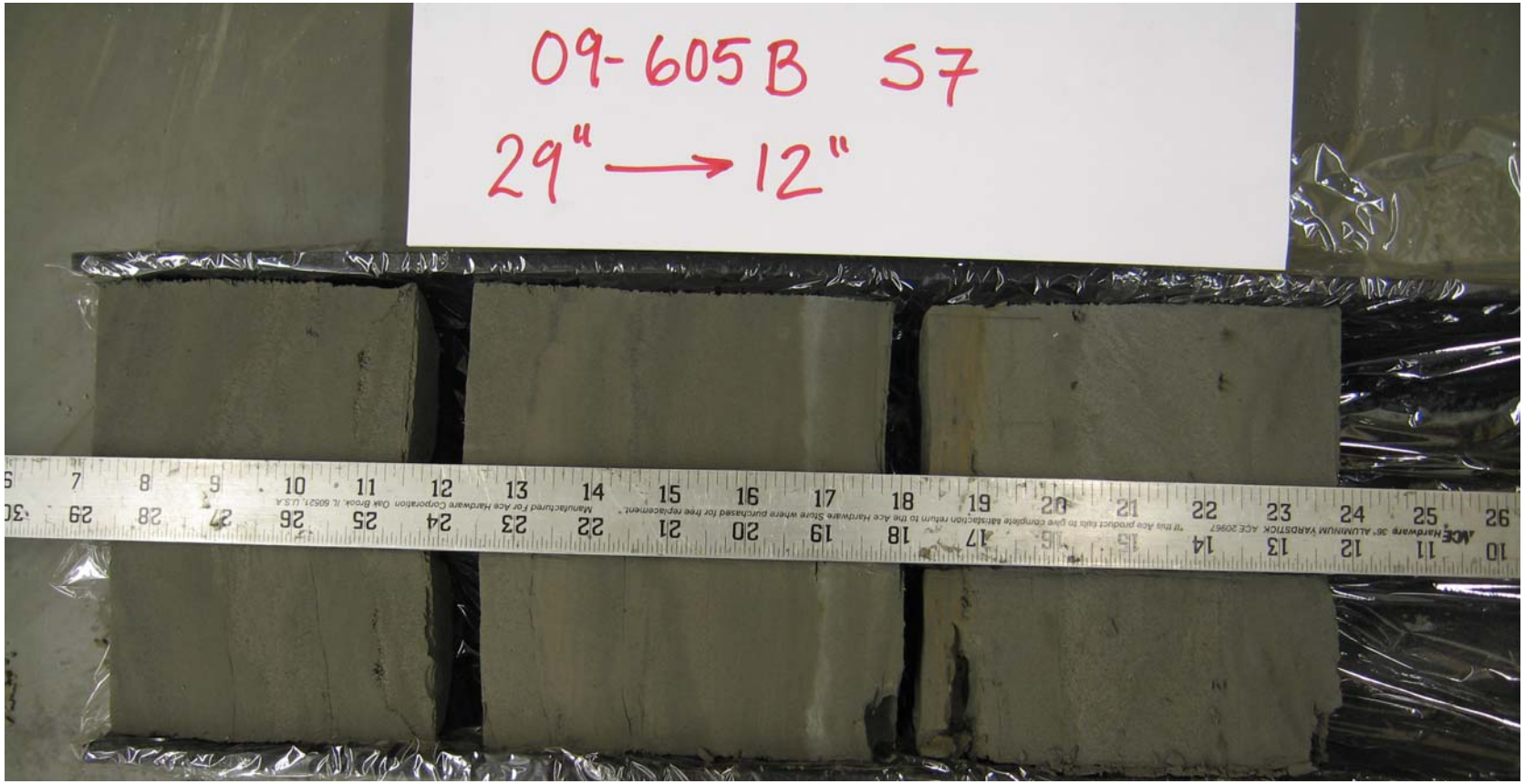

Figure 5.1.30 Photograph 1of Sample 09-605B S7 47.0 to 49.5 ft – 12 to 29 inch section (right to left).

Figure 5.1.31 Photograph 2 of Sample 09-605B S7 47.0 to 49.5 ft – 1 to 12 inch section (left to right).

Figure 5.1.32 Photograph of Sample 09-700B S3 22.5 to 25.0 ft.

Figure 5.1.33 Photograph of Sample 09-800B S4 26.5 to 29.0 ft.

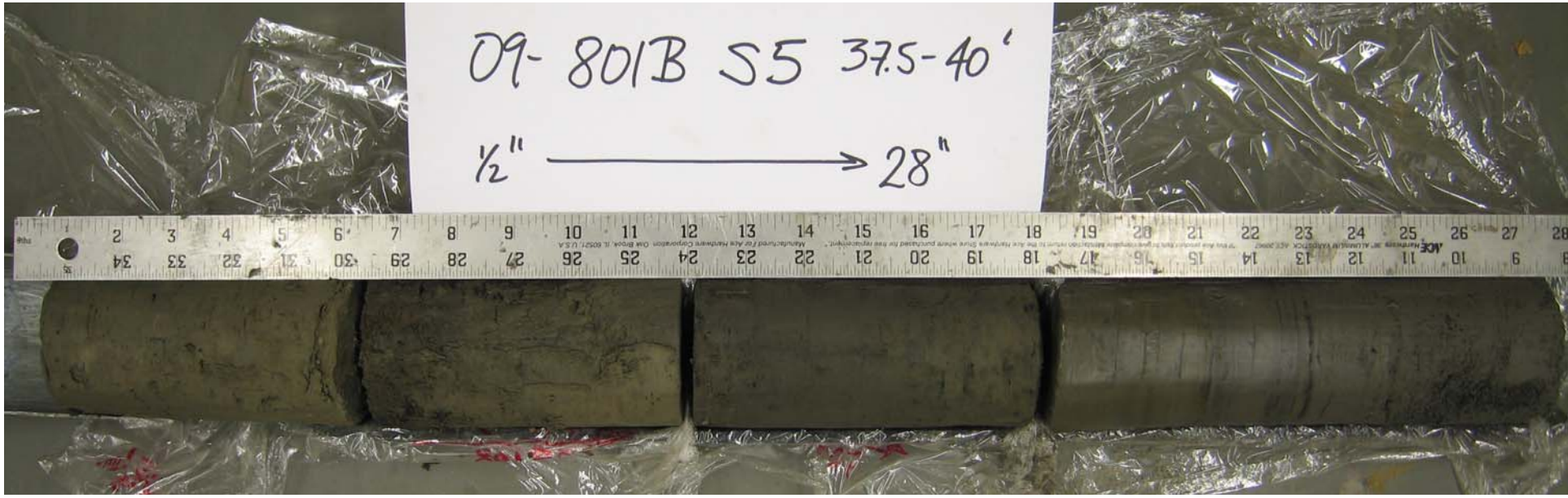

Figure 5.1.34 Photograph of Sample 09-801B S5 37.5 to 40.0 ft.

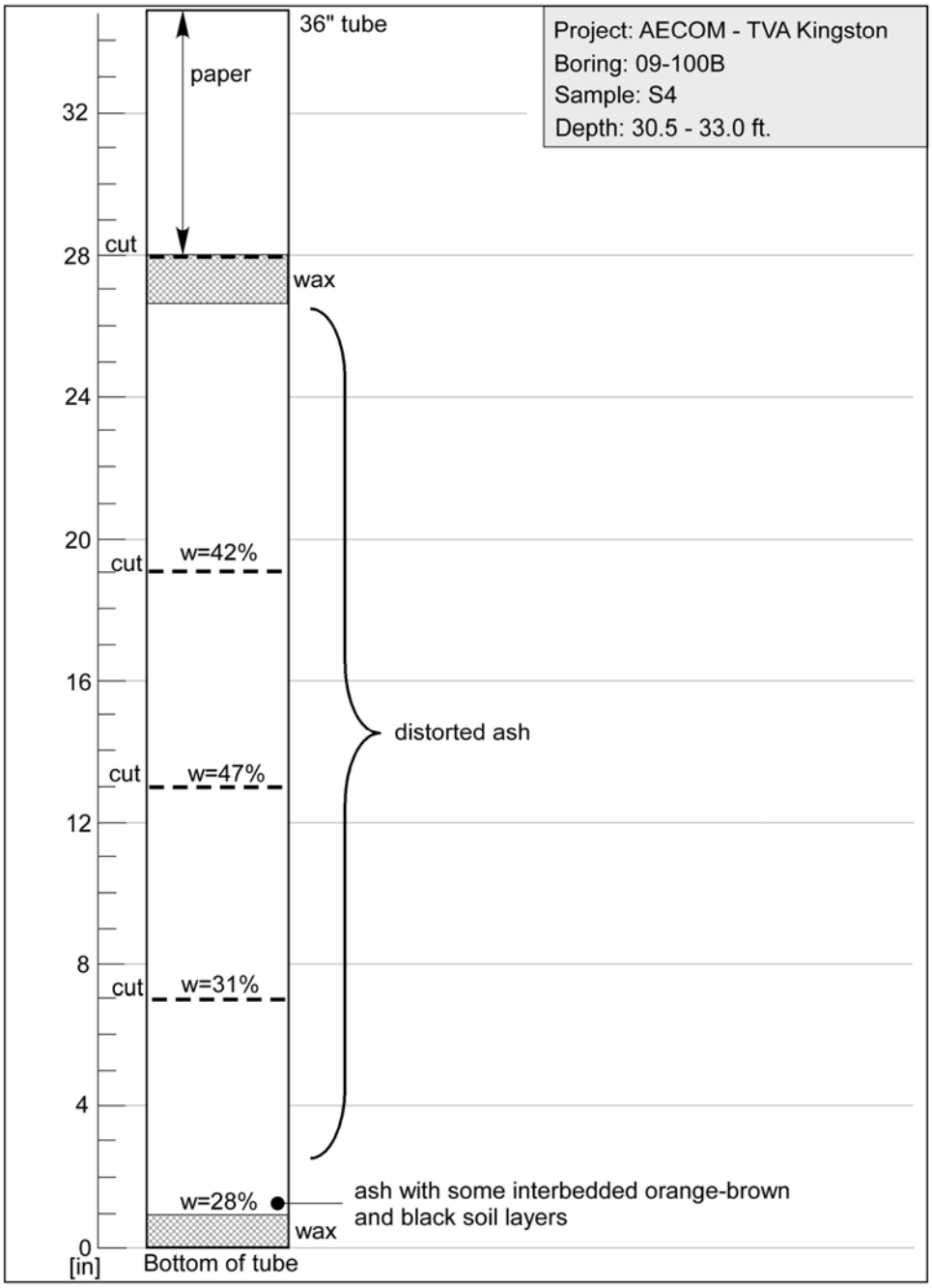

Figure 5.1.35 Sample log and test locations for Sample 09-100B S4 30.5 to 33.0 ft.

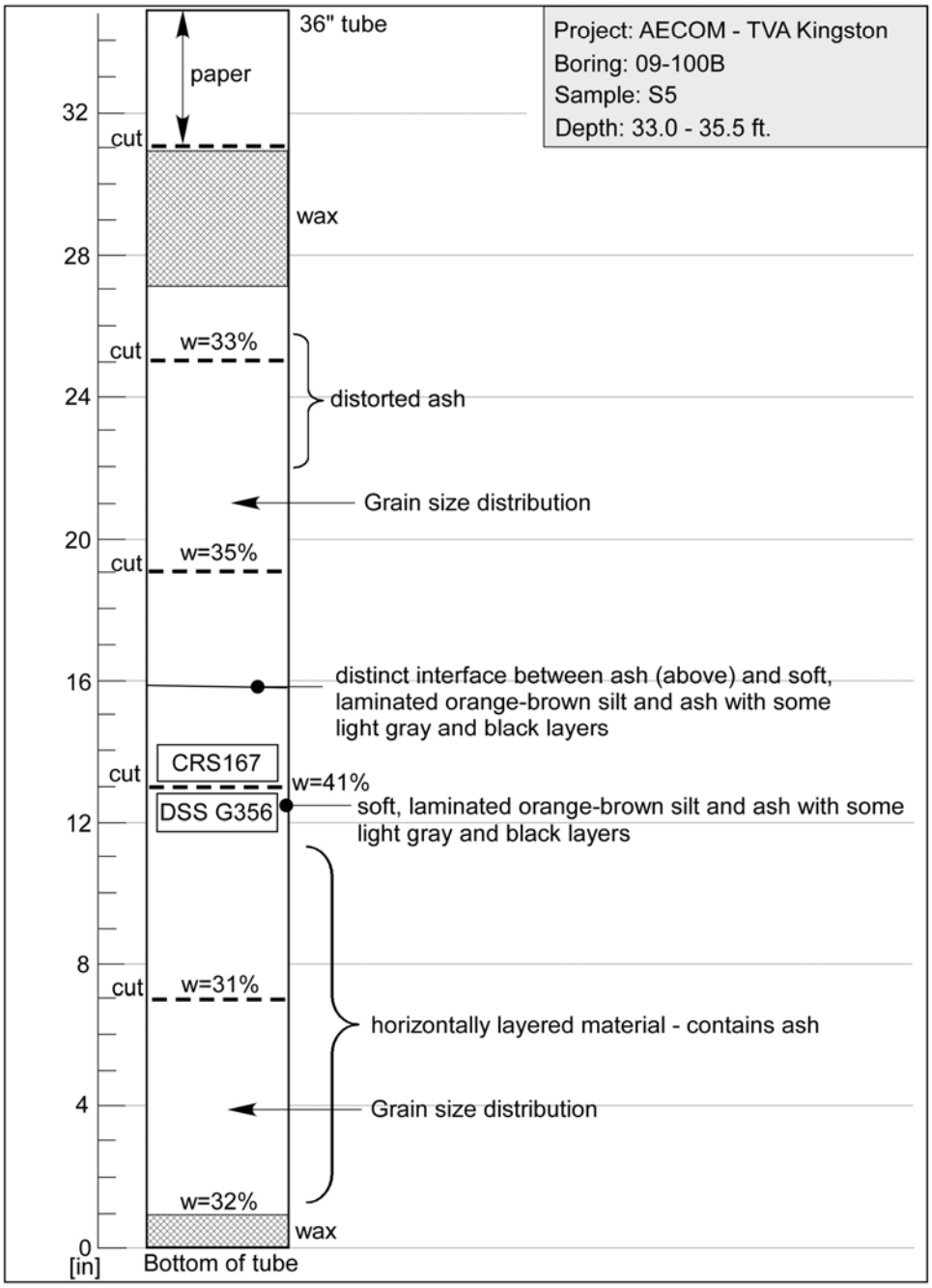

Figure 5.1.36 Sample log and test locations for Sample 09-100B S5 33.0 to 35.5 ft.

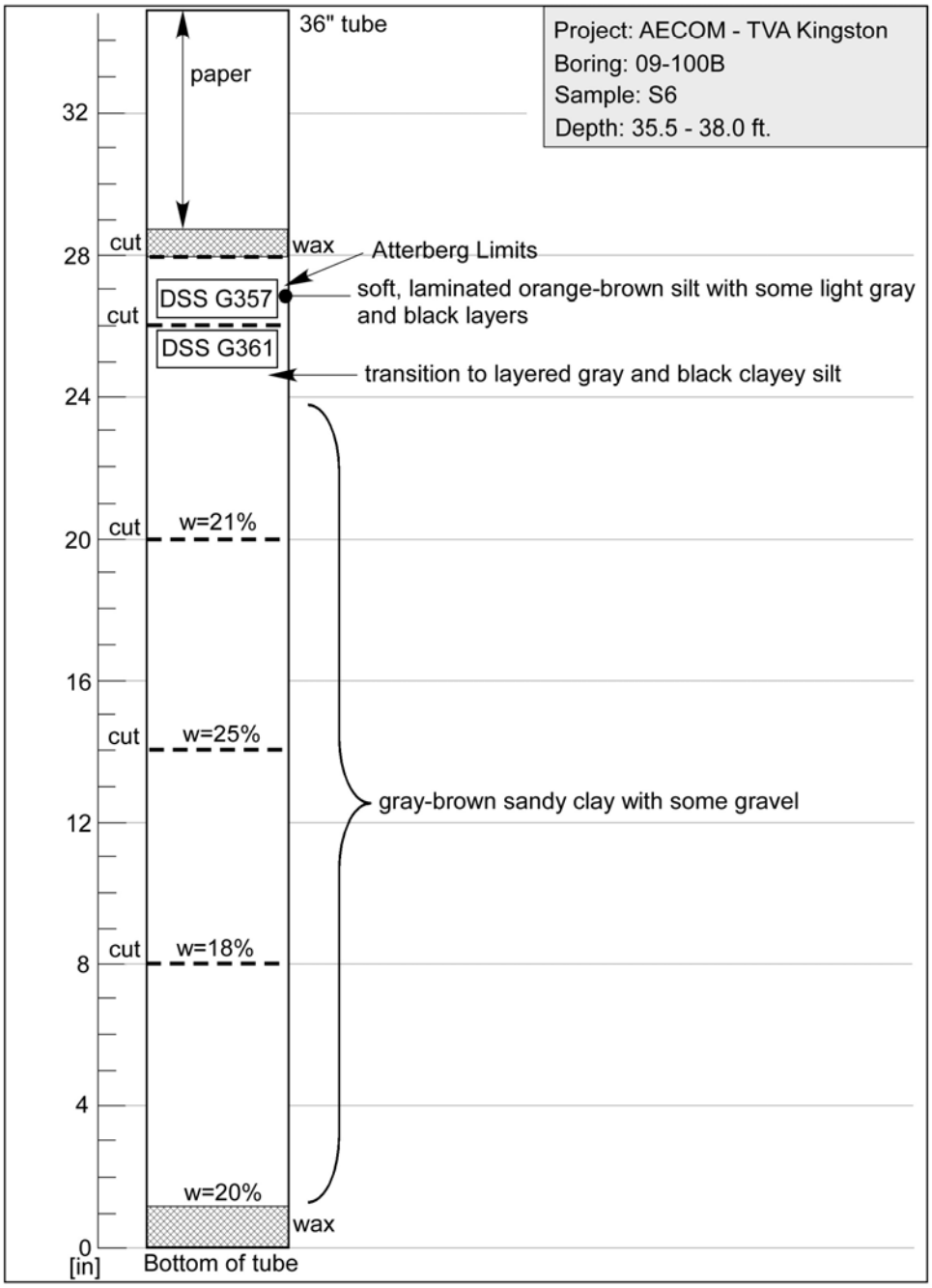

Figure 5.1.37 Sample log and test locations for Sample 09-100B S6 35.5 to 38.0 ft.

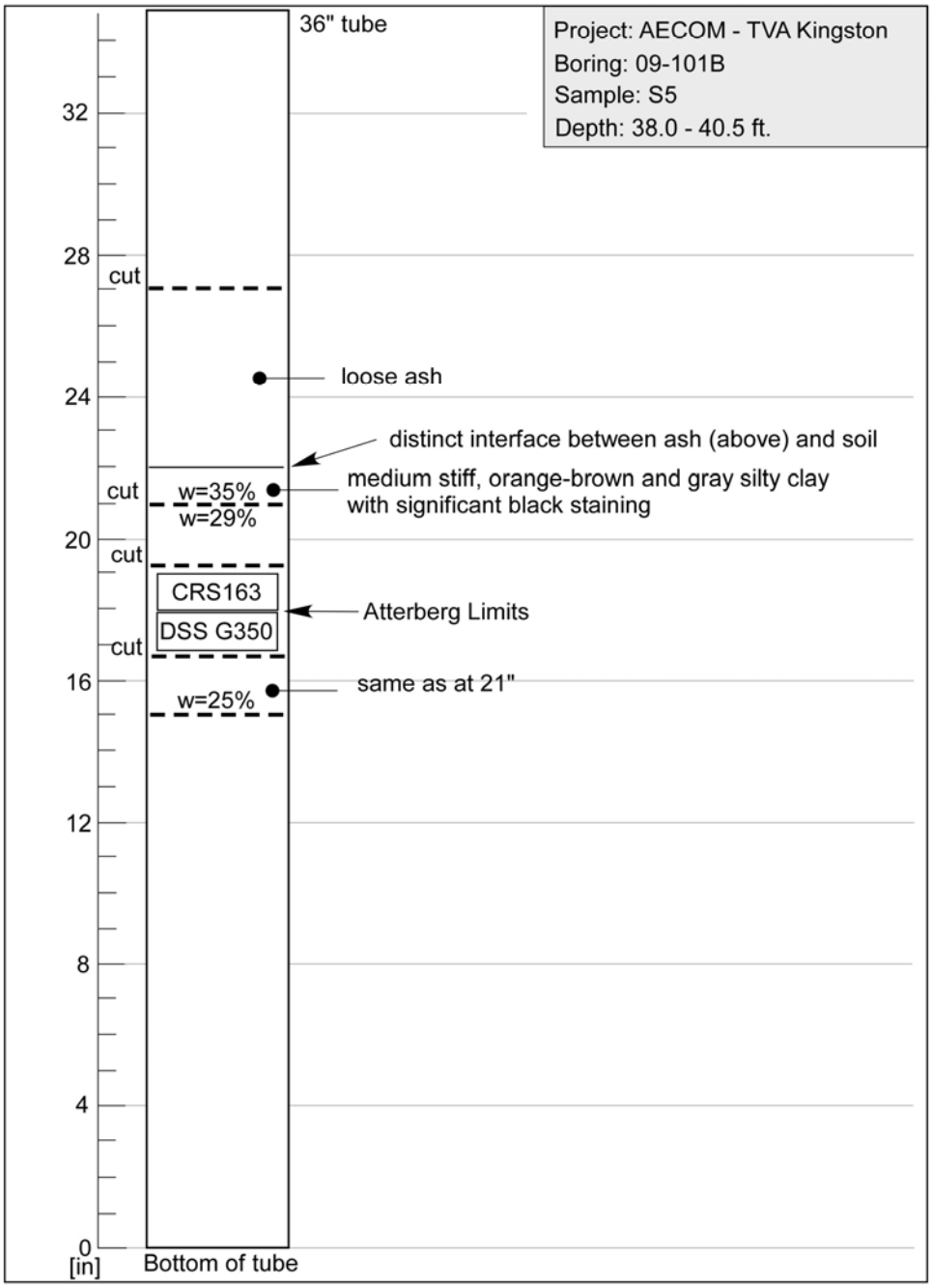

Figure 5.1.38 Sample log and test locations for Sample 09-101B S5 38.0 to 40.5 ft.

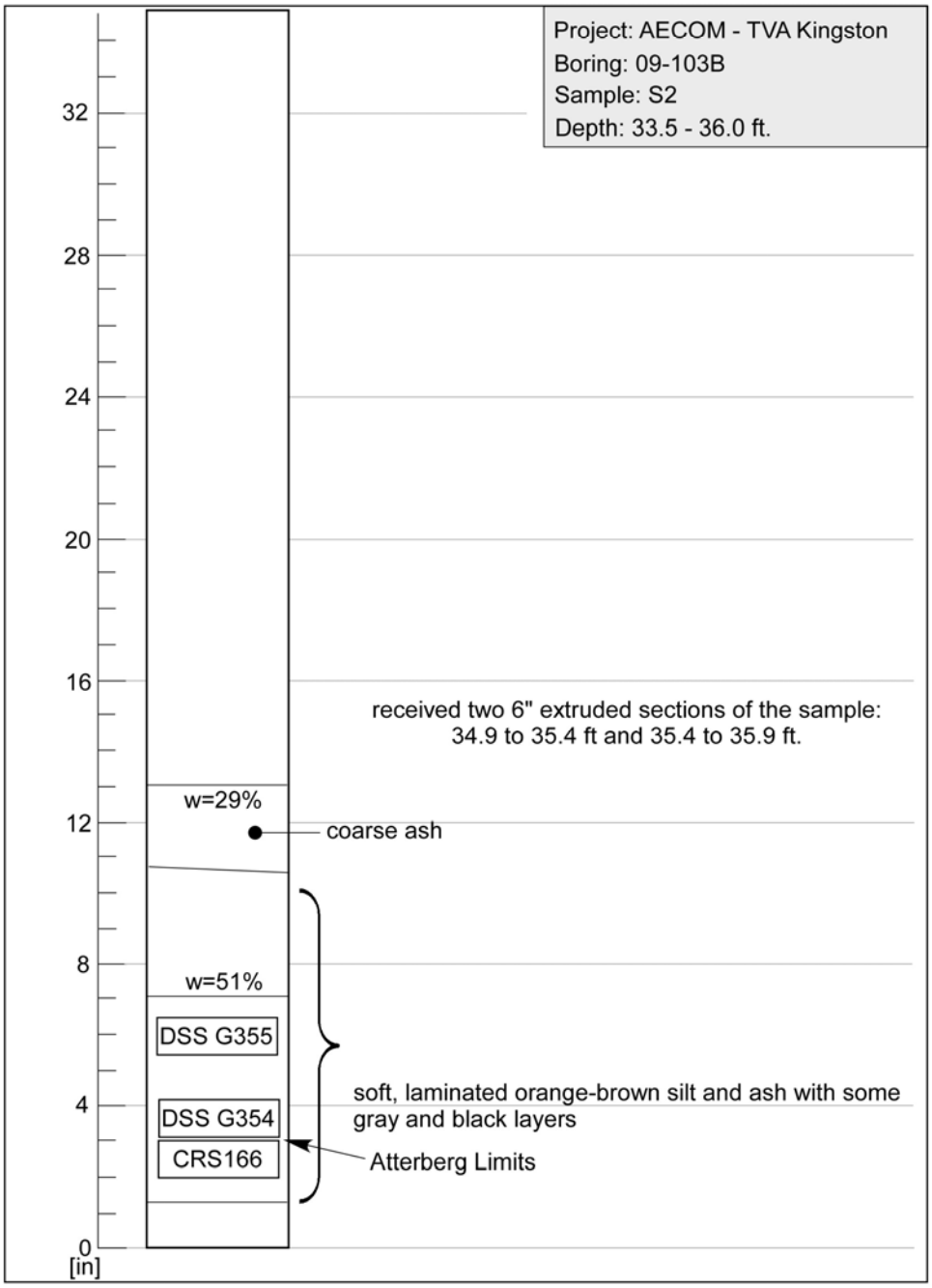

Figure 5.1.39 Sample log and test locations for Sample 09-103B S2 33.5 to 36.0 ft.

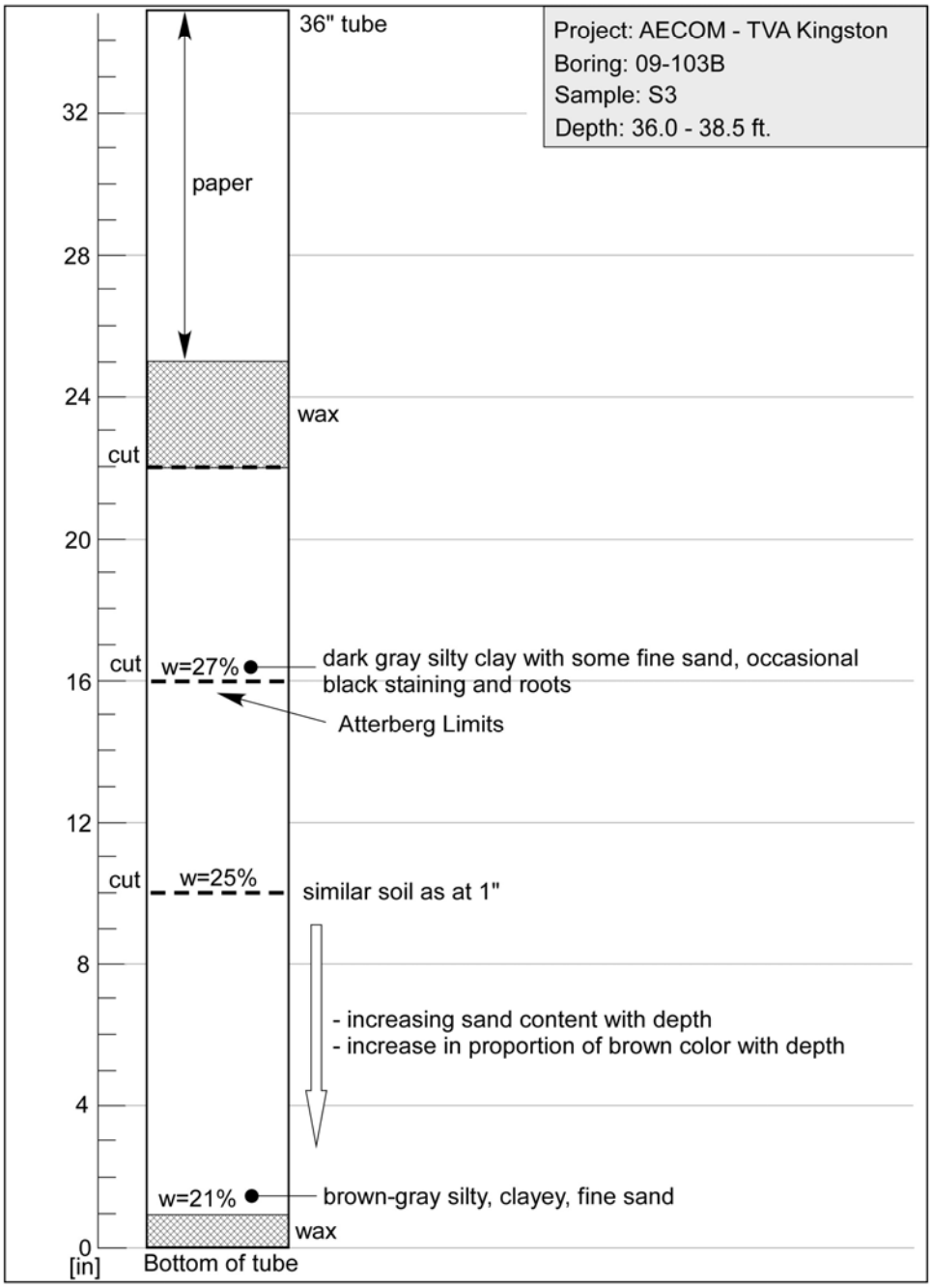

Figure 5.1.40 Sample log and test locations for Sample 09-103B S3 36.0 to 38.5 ft.

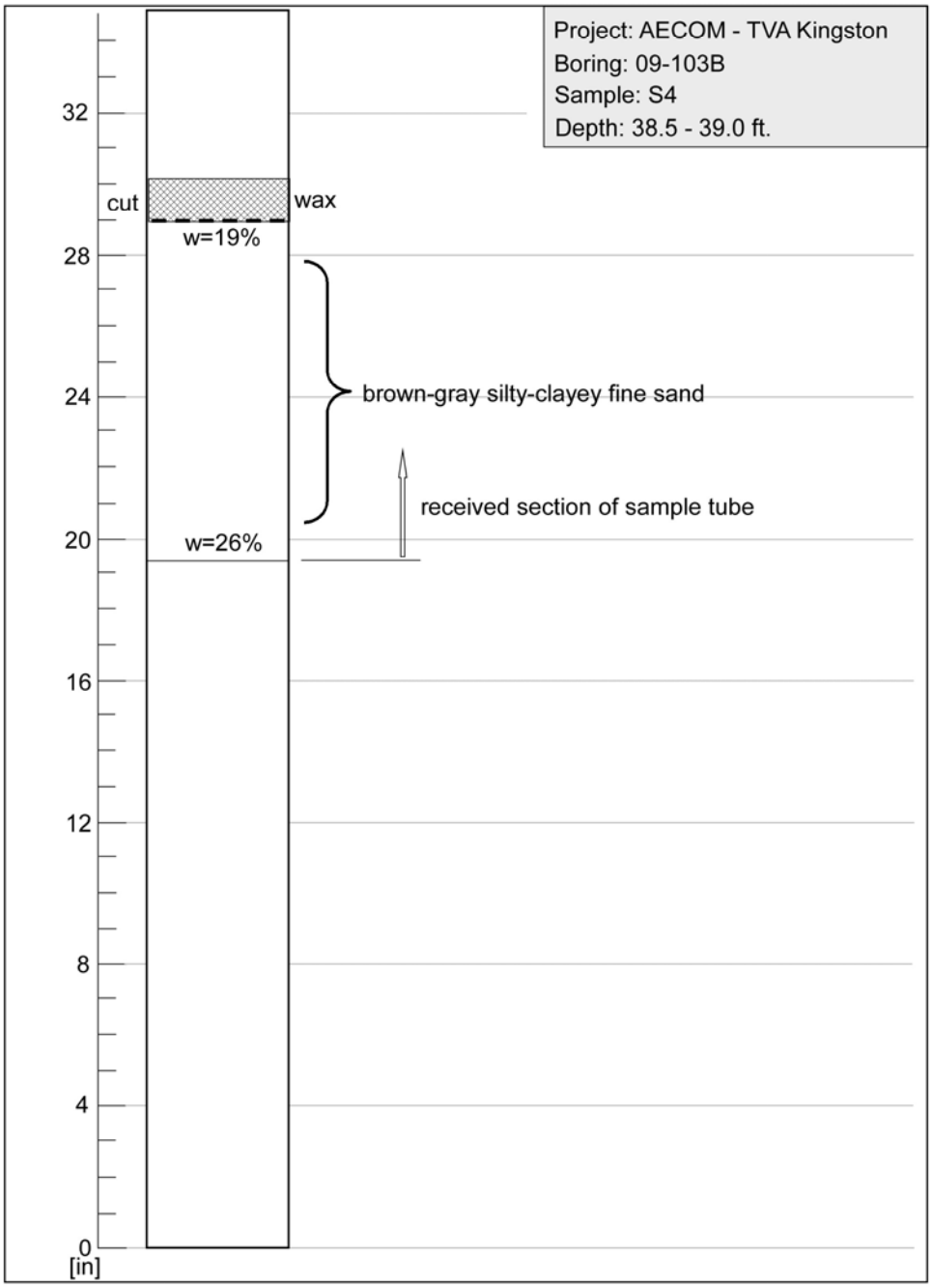

Figure 5.1.41 Sample log and test locations for Sample 09-103B S4 38.5-39.0 ft

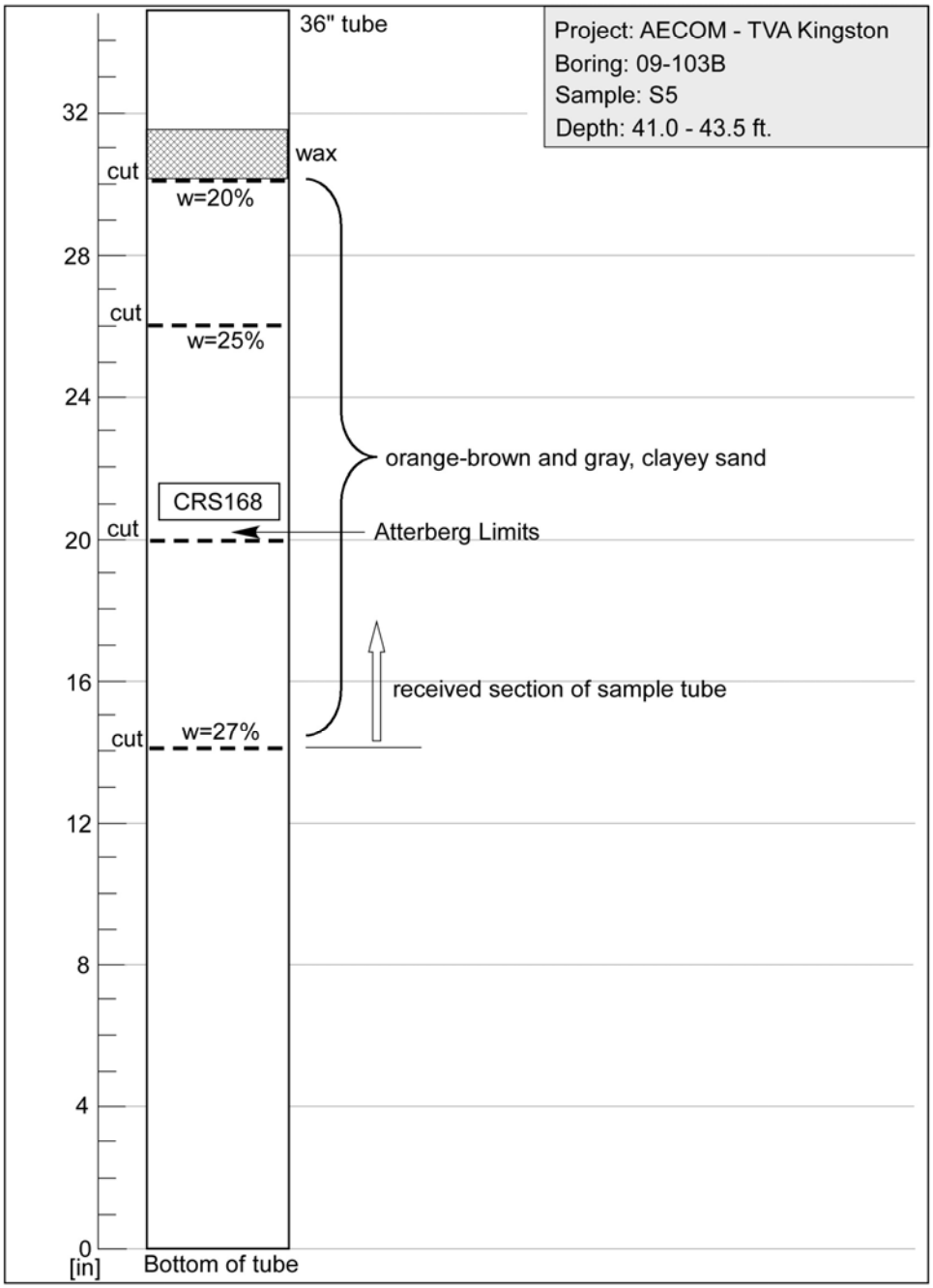

Figure 5.1.42 Sample log and test locations for Sample 09-103B S5 41.0-43.5 ft

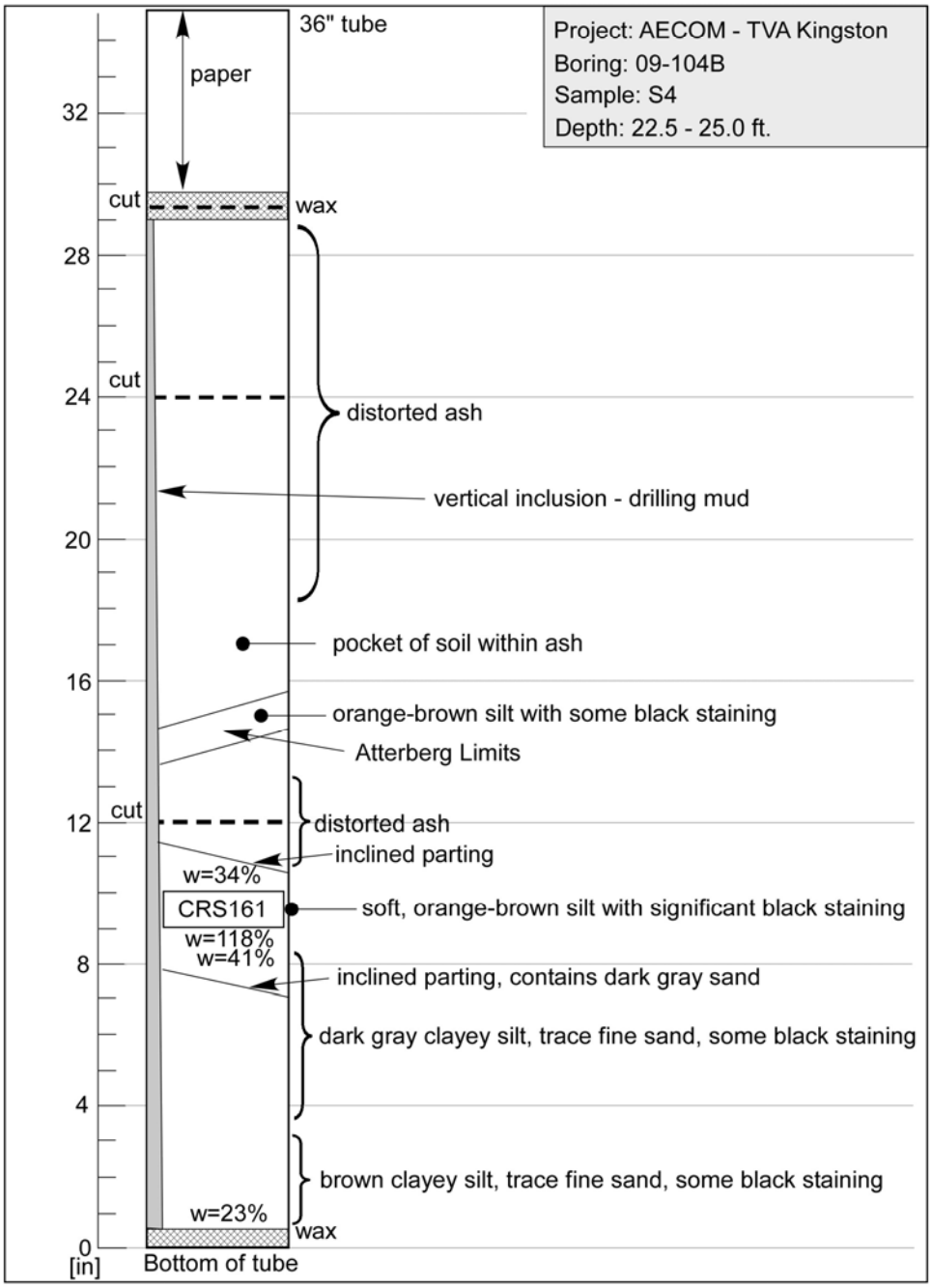

Figure 5.1.43 Sample log and test locations for Sample 09-104B S4 22.5-25.0 ft

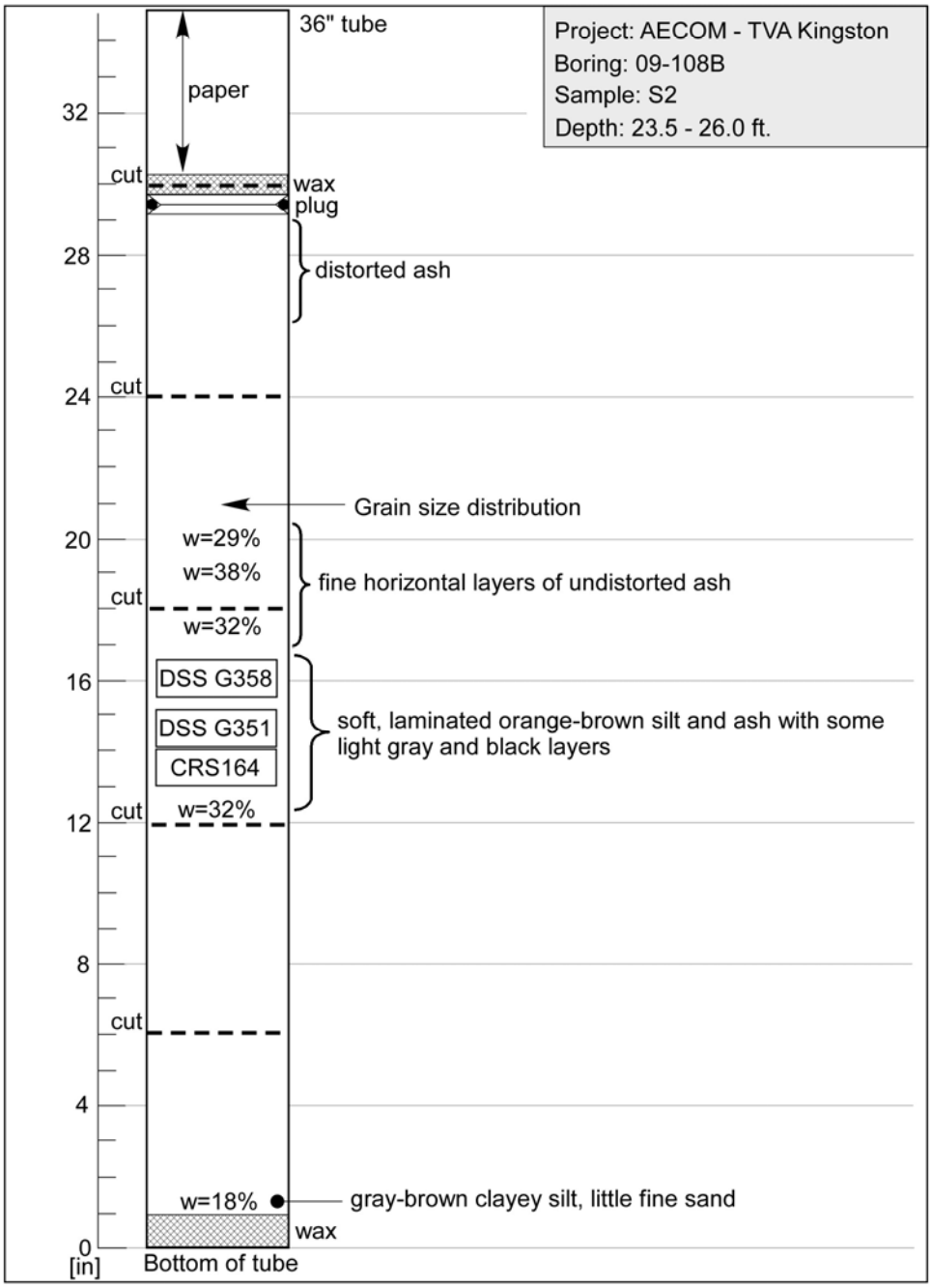

Figure 5.1.44 Sample log and test locations for Sample 09-108B S2 23.5-26.0 ft

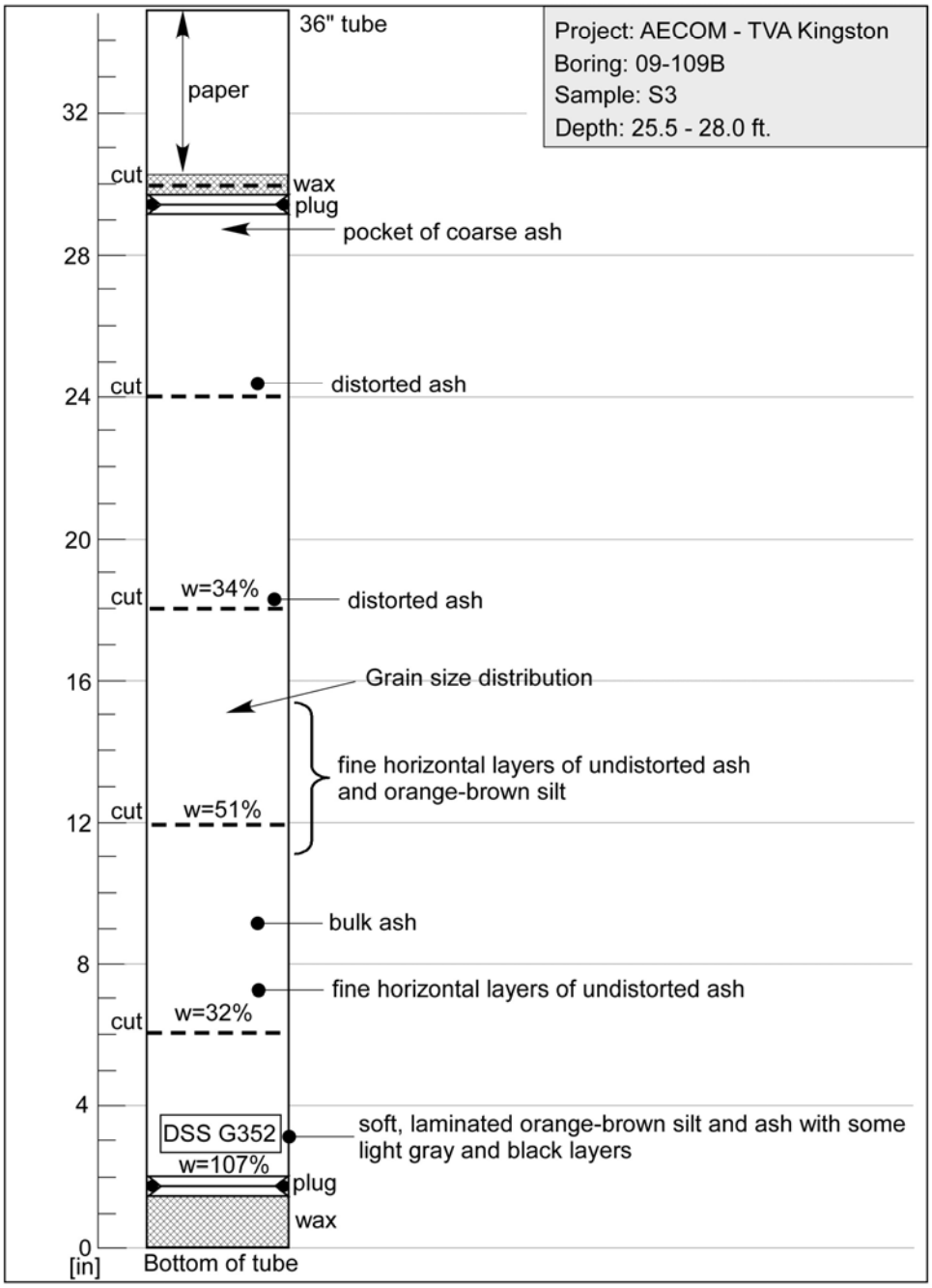

Figure 5.1.45 Sample log and test locations for Sample 09-109B S3 25.5-28.0 ft

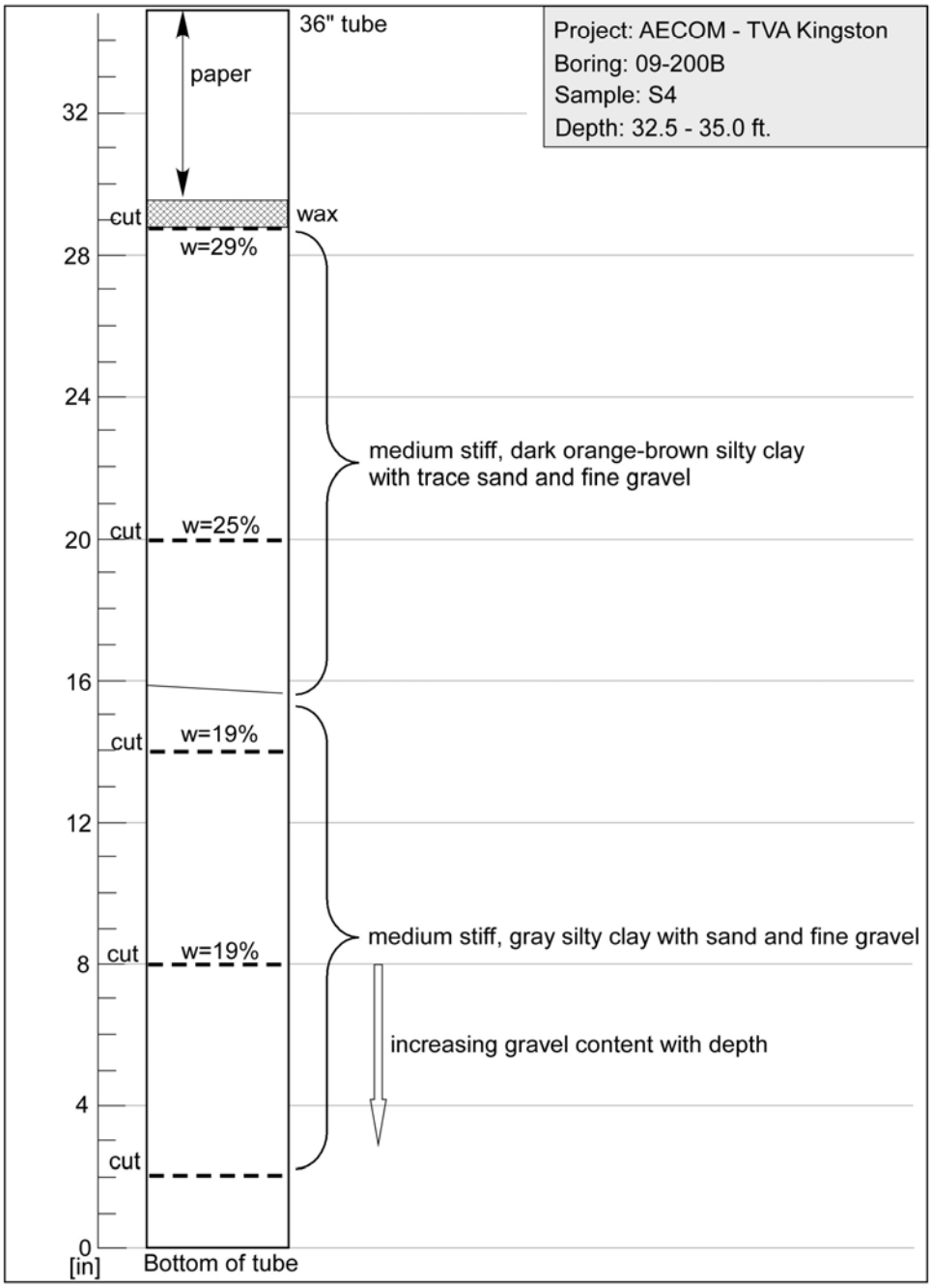

Figure 5.1.46 Sample log and test locations for Sample 09-200B S4 32.5-35.0 ft

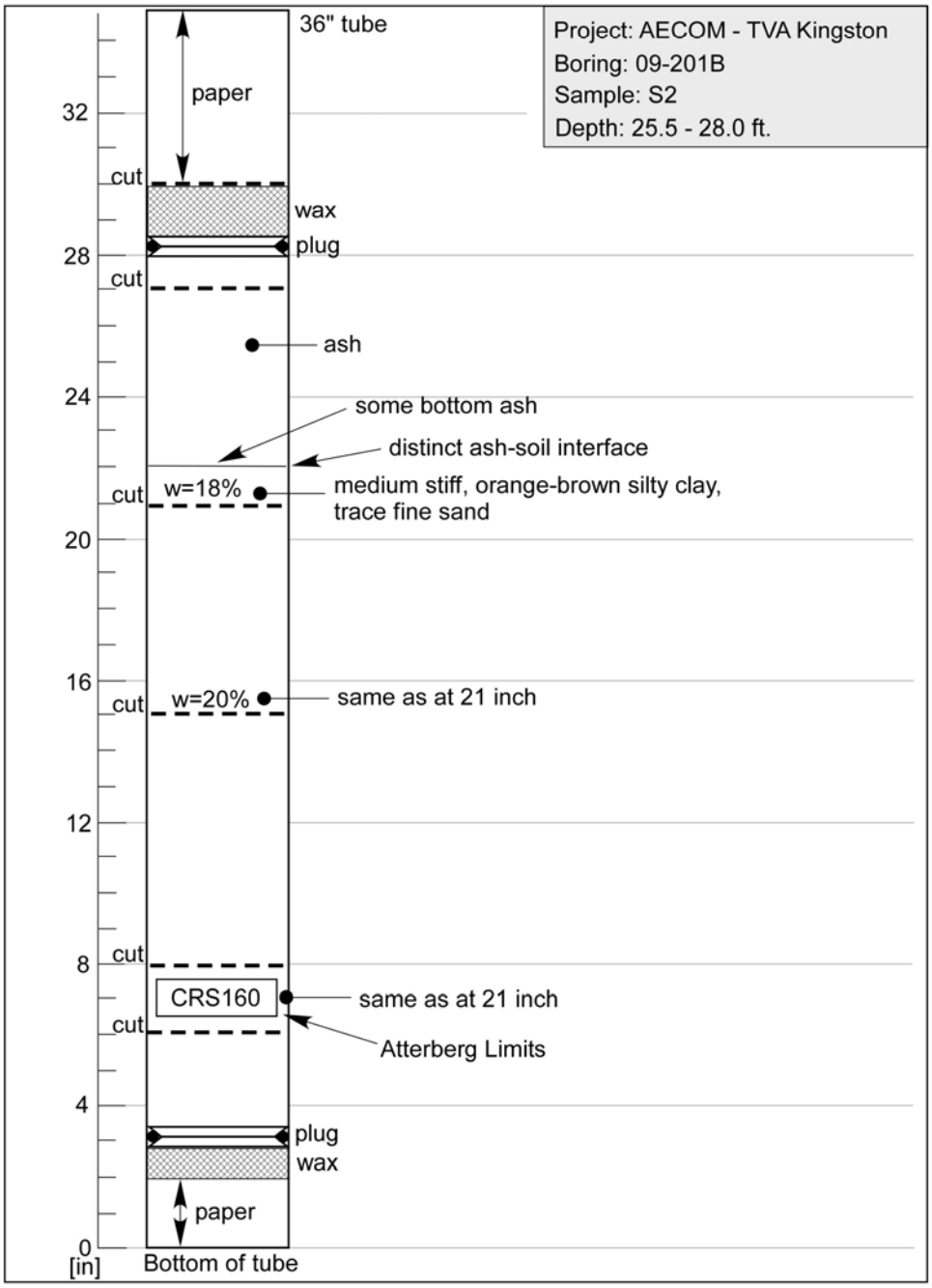

Figure 5.1.47 Sample log and test locations for Sample 09-201B S2 25.5-28.0 ft

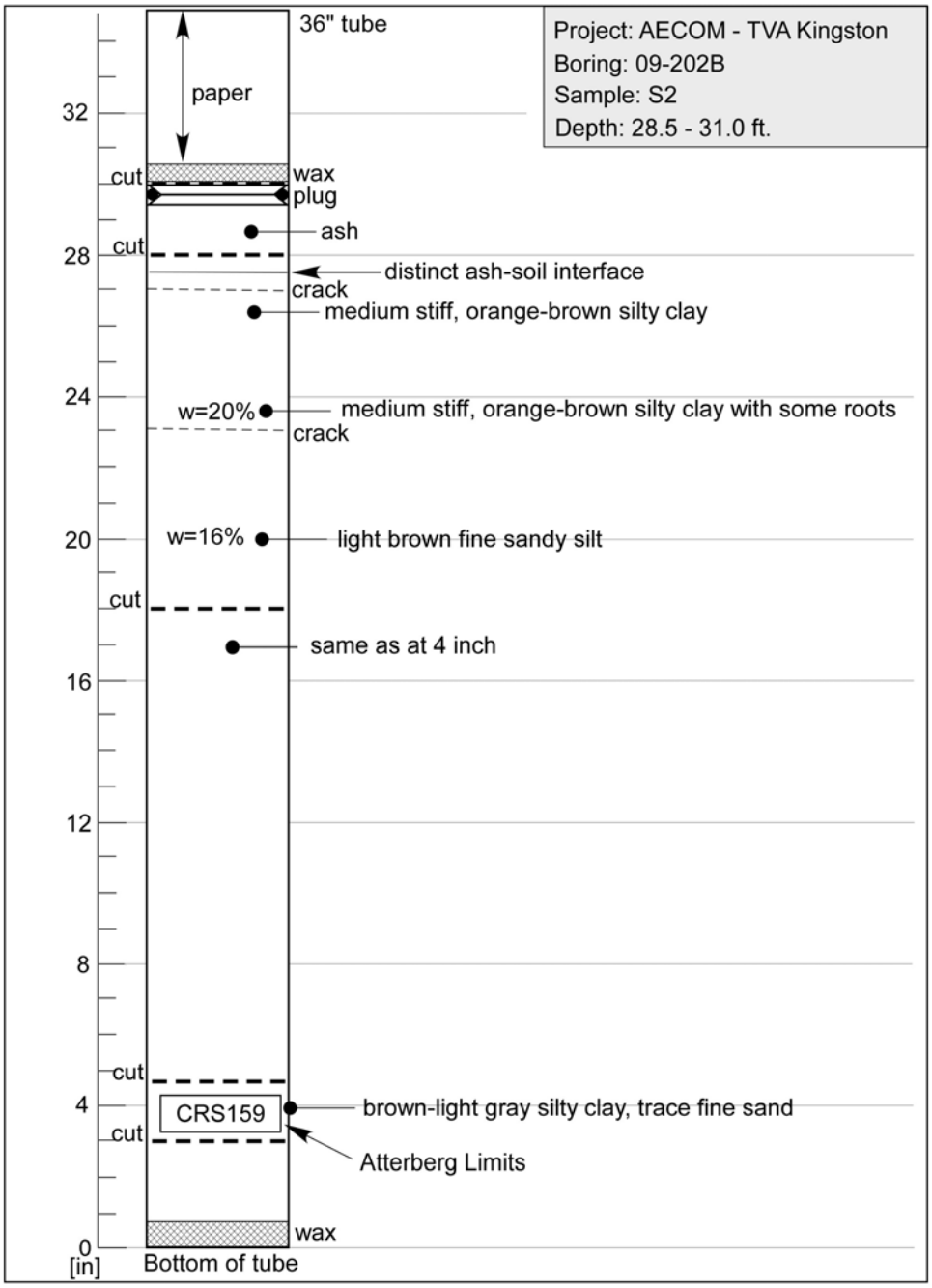

Figure 5.1.48 Sample log and test locations for Sample 09-202B S2 28.5-31.0 ft

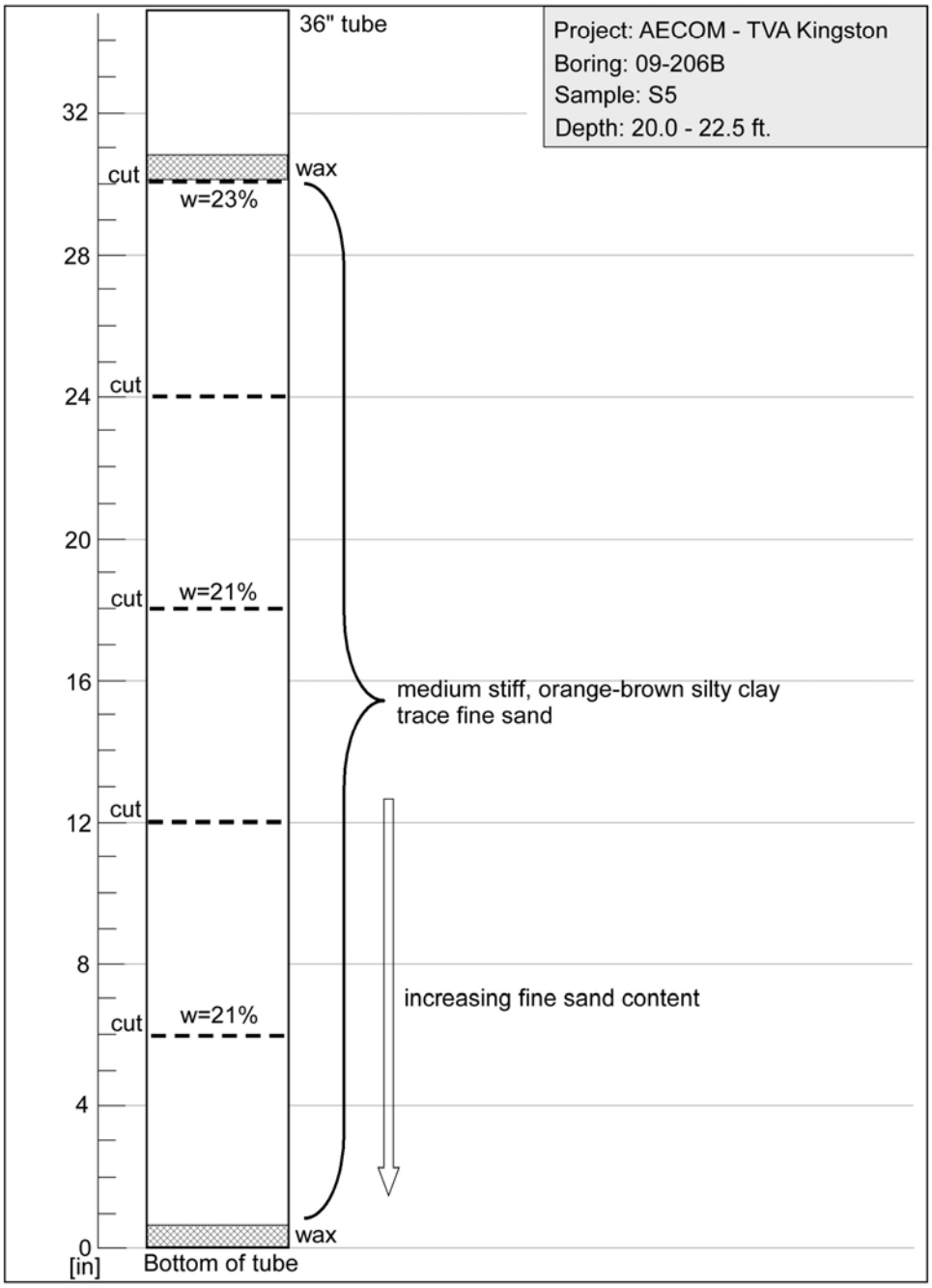

Figure 5.1.49 Sample log and test locations for Sample 09-206B S5 20.0-22.5 ft

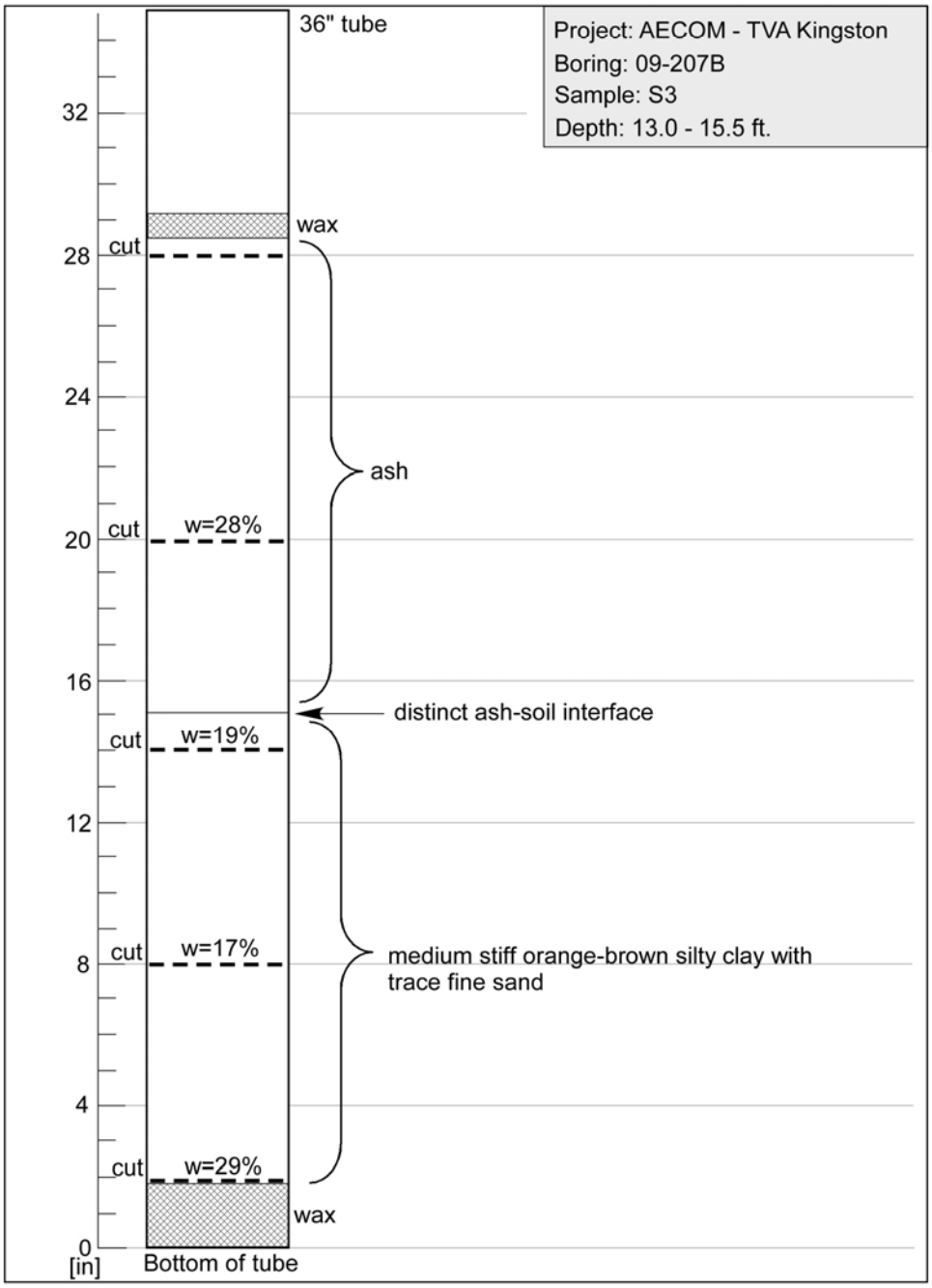

Figure 5.1.50 Sample log and test locations for Sample 09-207B S3 13.0-15.5 ft

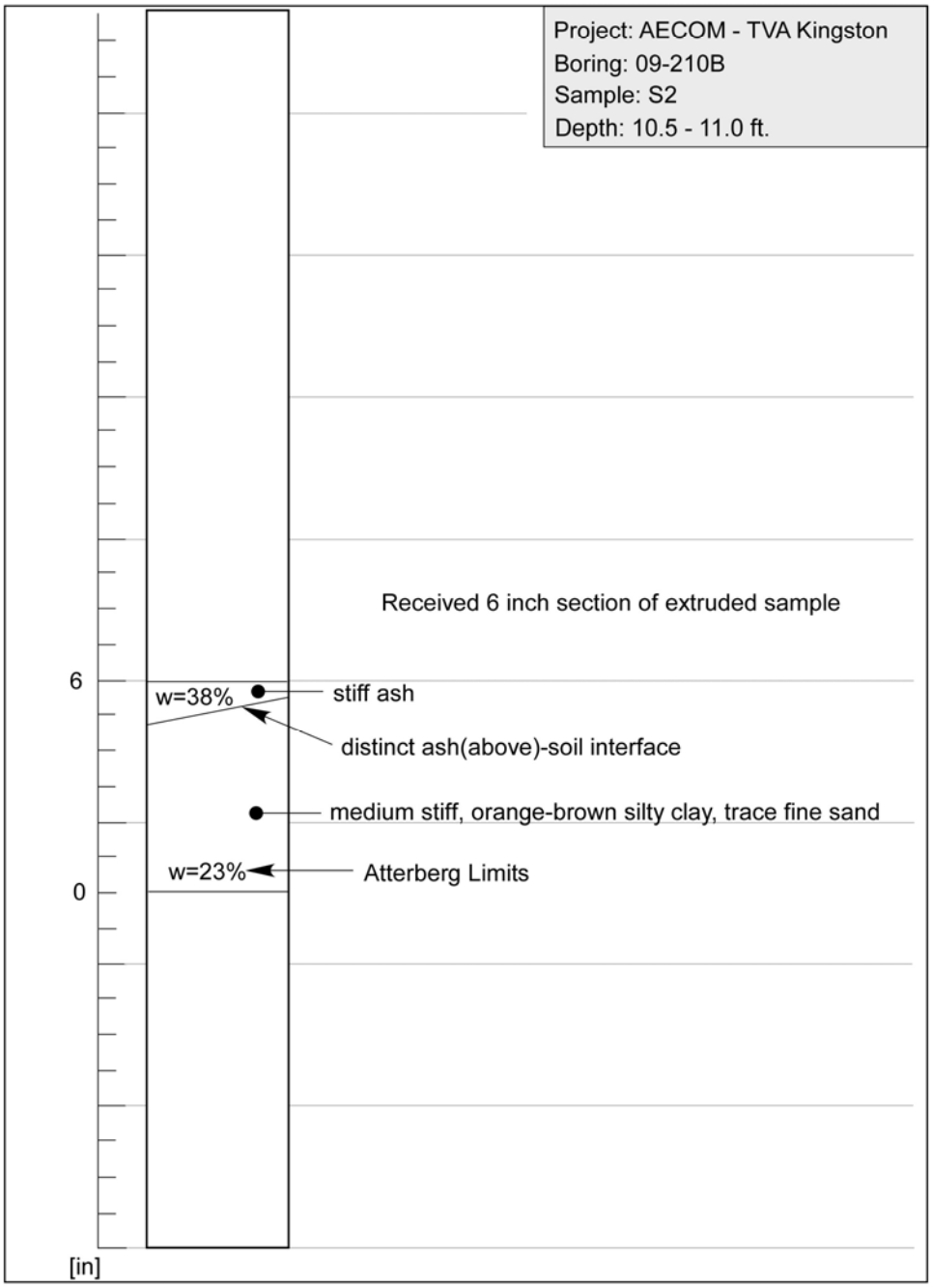

Figure 5.1.51 Sample log and test locations for Sample 09-210B S2 10.5-11.0 ft

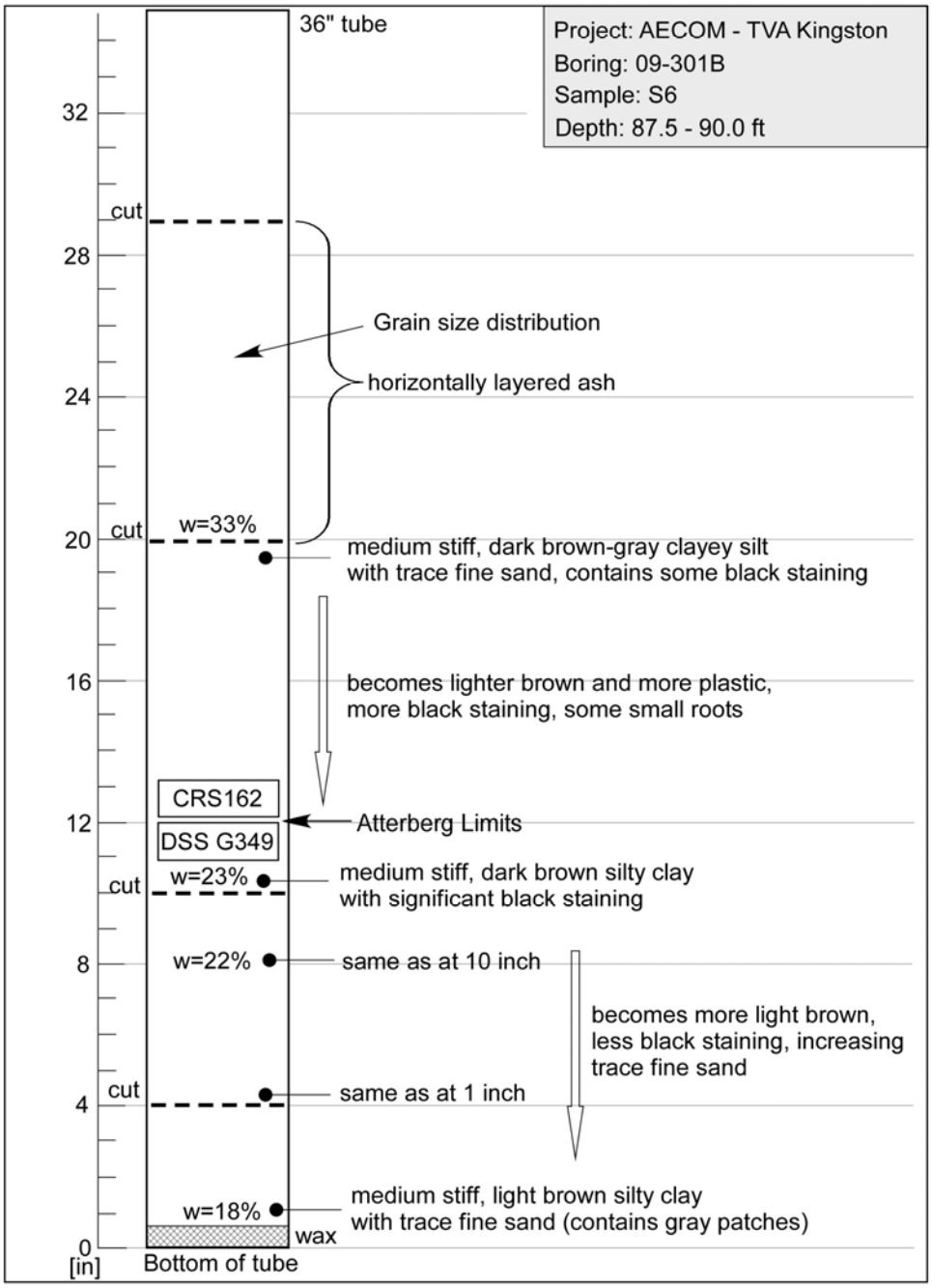

Figure 5.1.52 Sample log and test locations for Sample 09-301B S6 87.5-90.0 ft

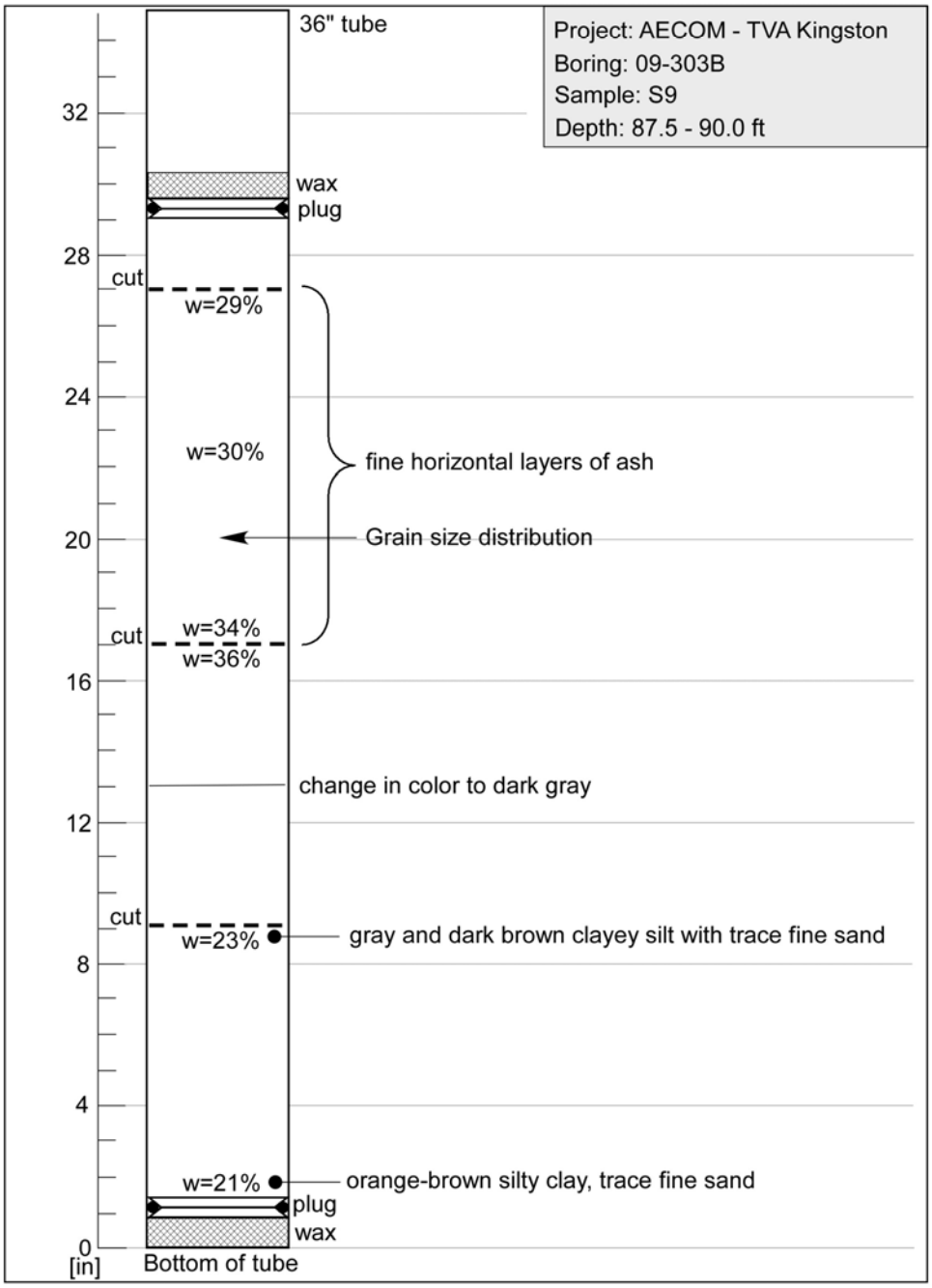

Figure 5.1.53 Sample log and test locations for Sample 09-303B S9 87.5-90.0 ft

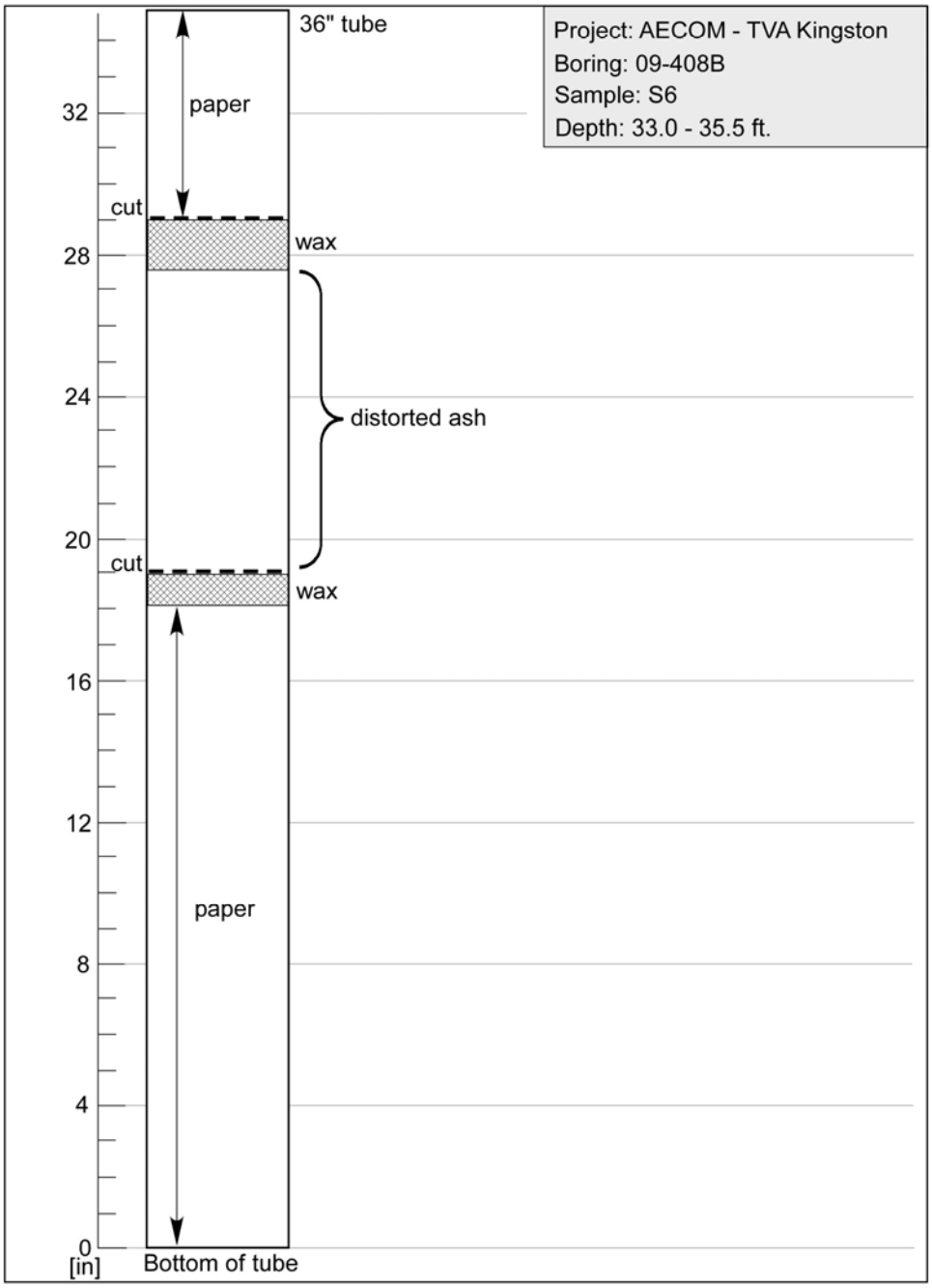

Figure 5.1.54 Sample log and test locations for Sample 09-408B S6 33.0-35.5 ft

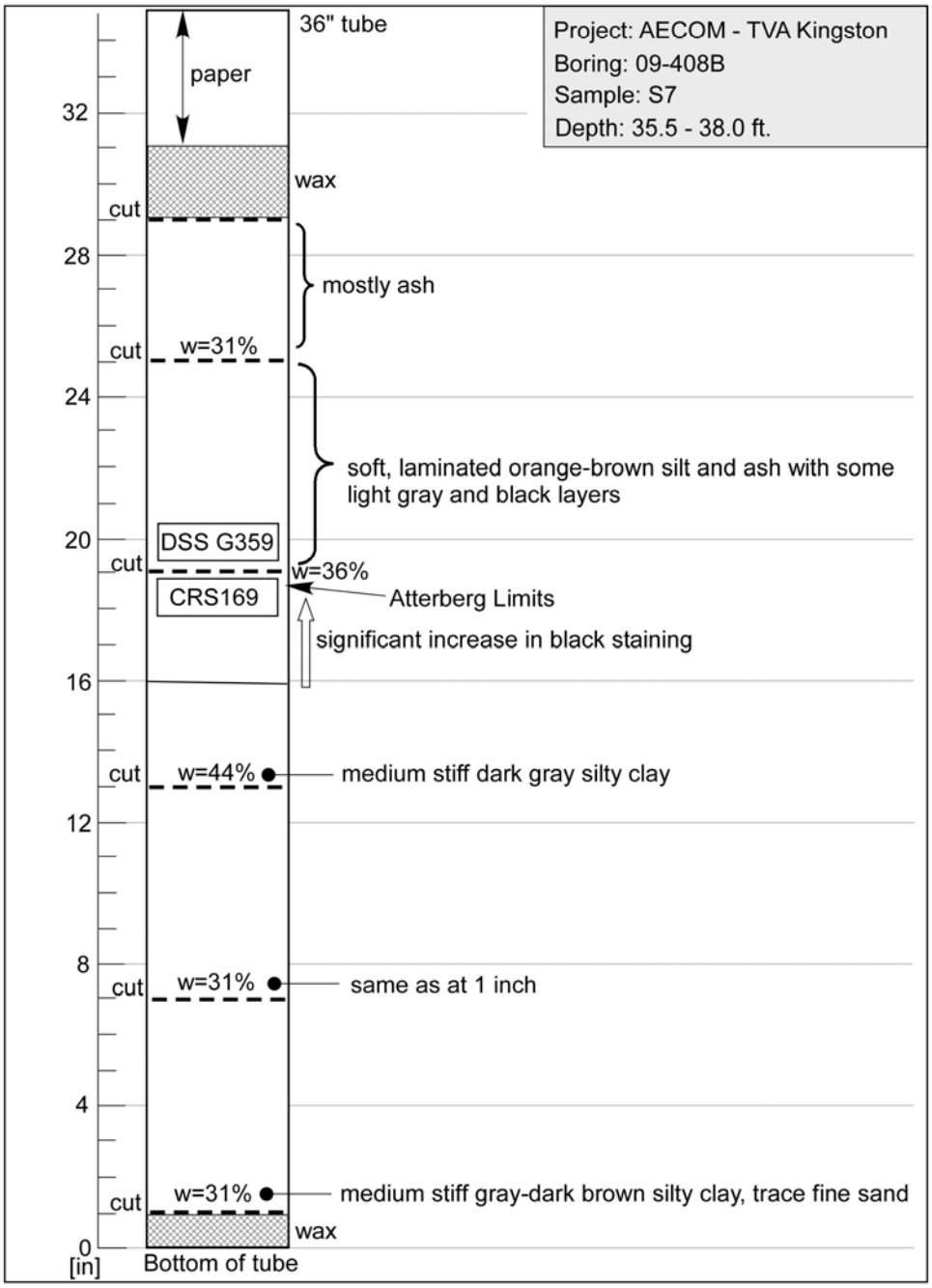

Figure 5.1.55 Sample log and test locations for Sample 09-408B S7 35.5-38.0 ft

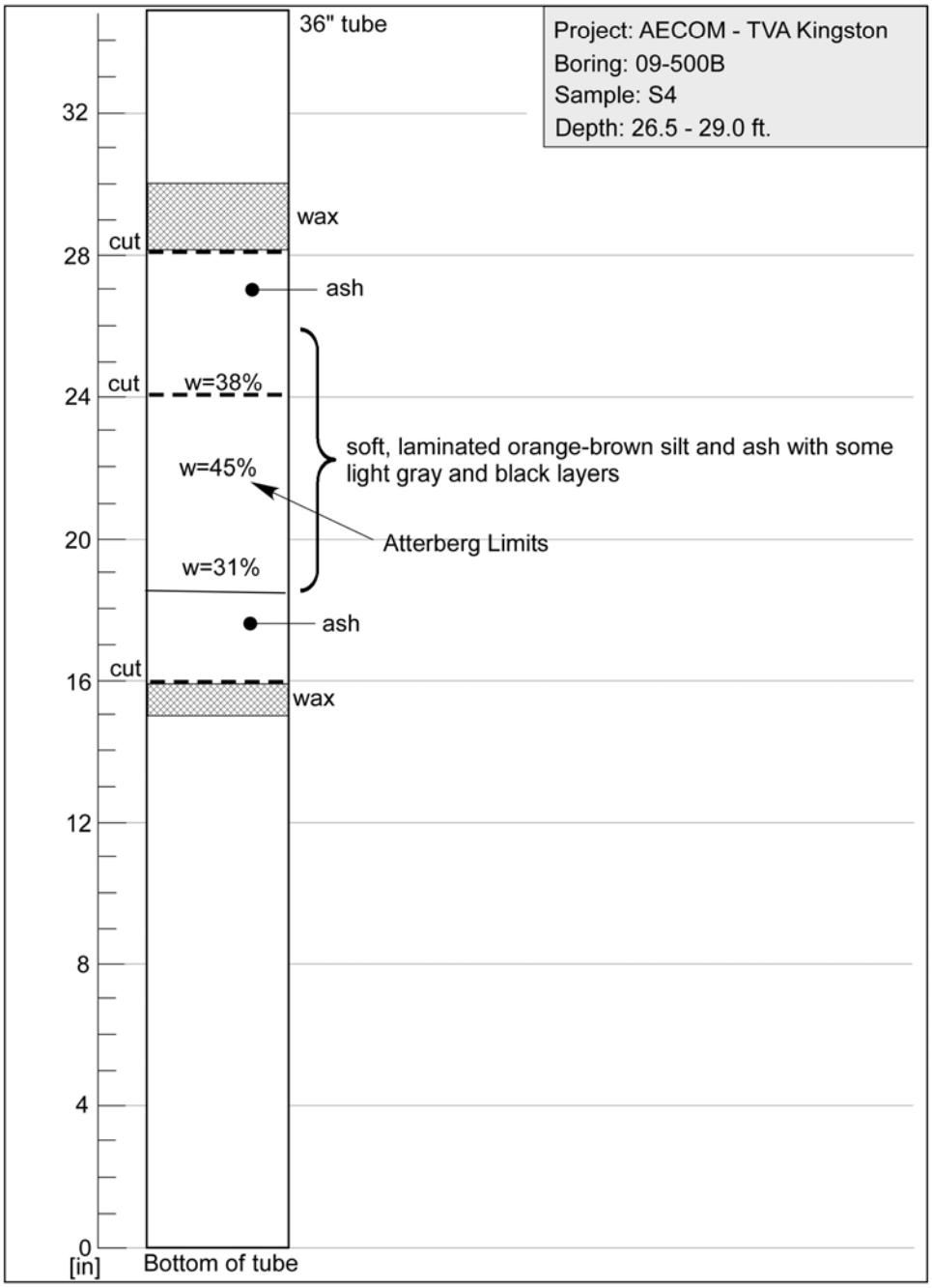

Figure 5.1.56 Sample log and test locations for Sample 09-500B S4 26.5-29.0 ft

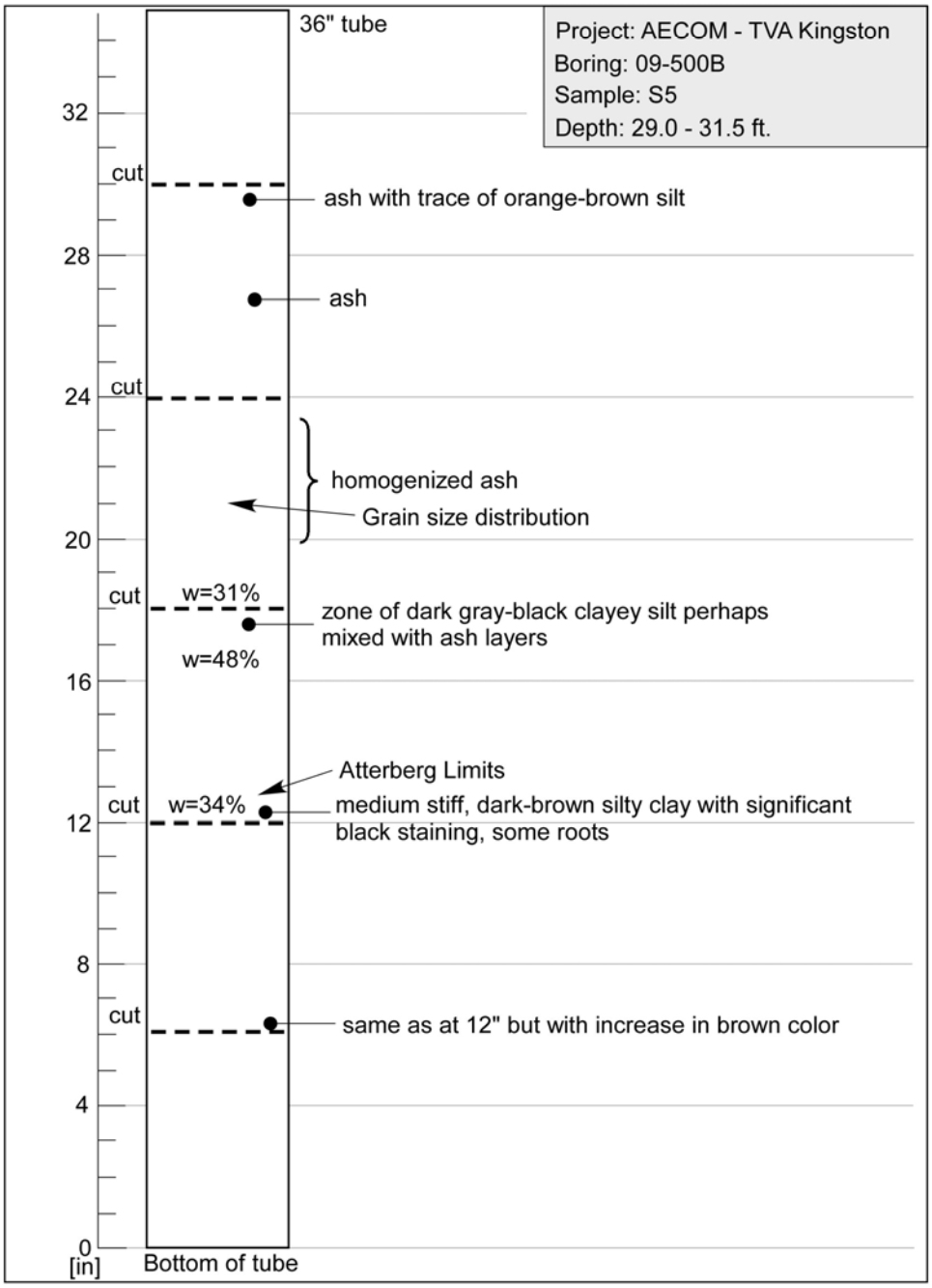

Figure 5.1.57 Sample log and test locations for Sample 09-500B S5 29.0-31.5 ft

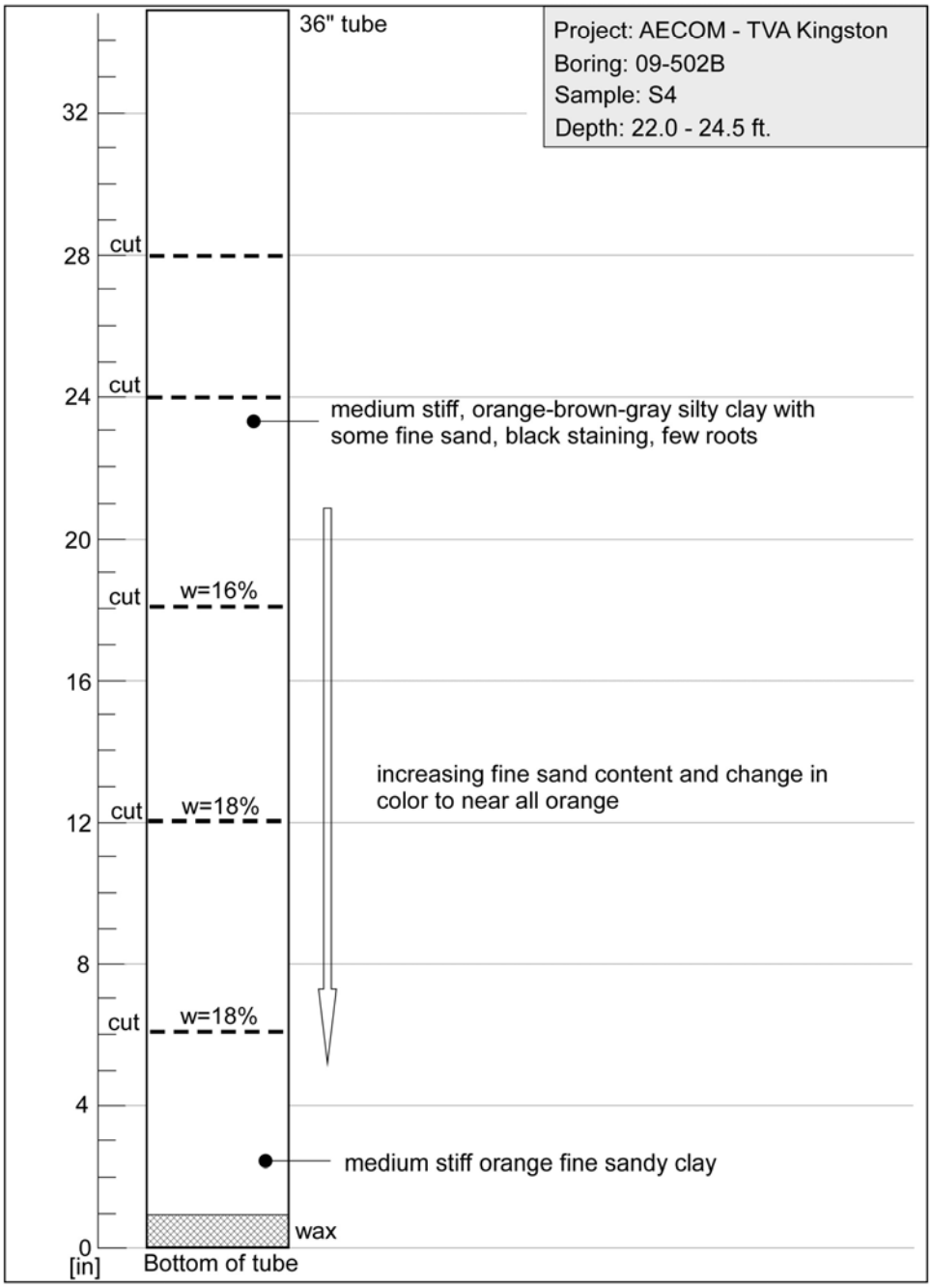

Figure 5.1.58 Sample log and test locations for Sample 09-502B S4 22.0-24.5 ft

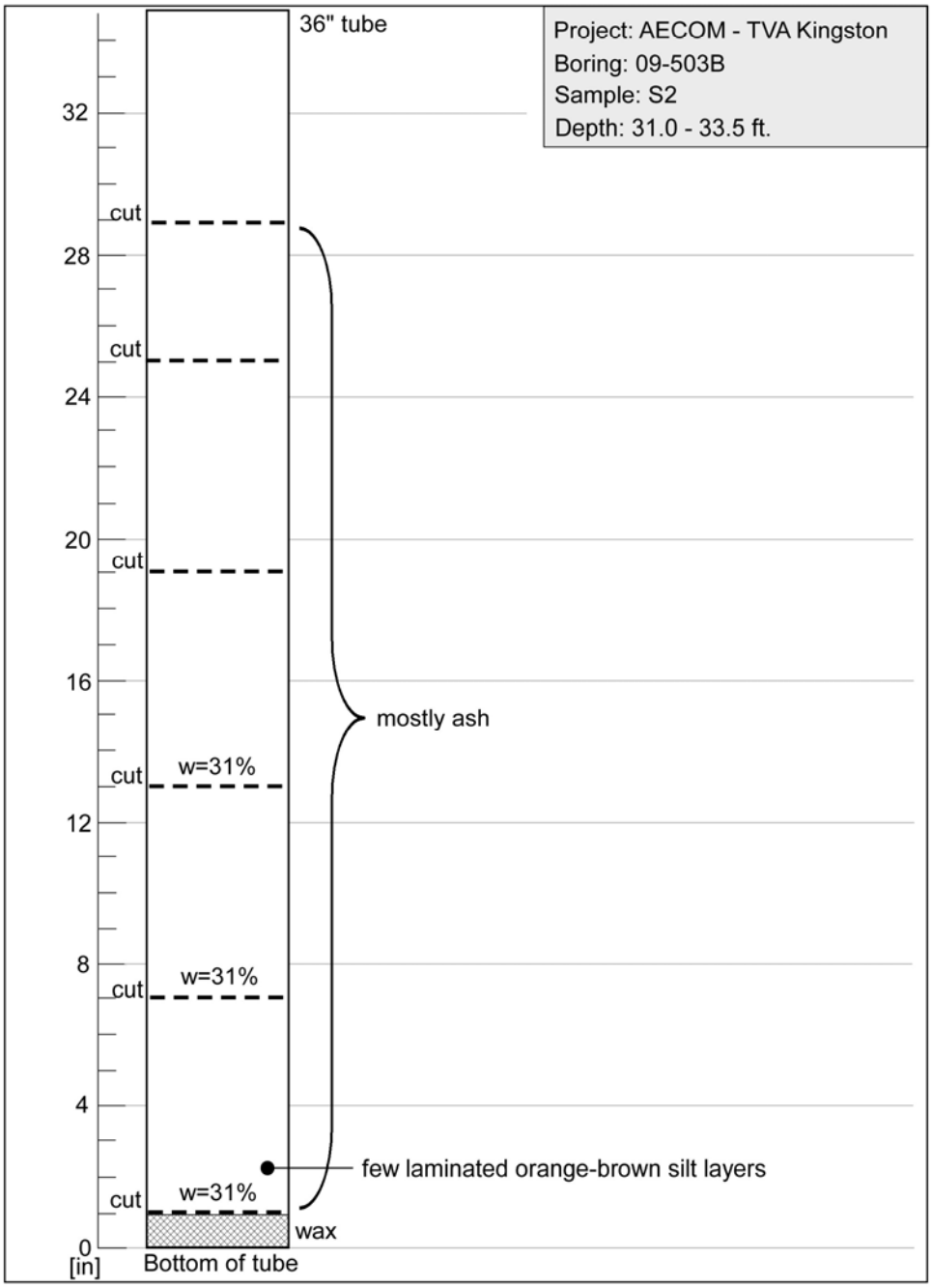

Figure 5.1.59 Sample log and test locations for Sample 09-503B S2 31.0-33.5 ft

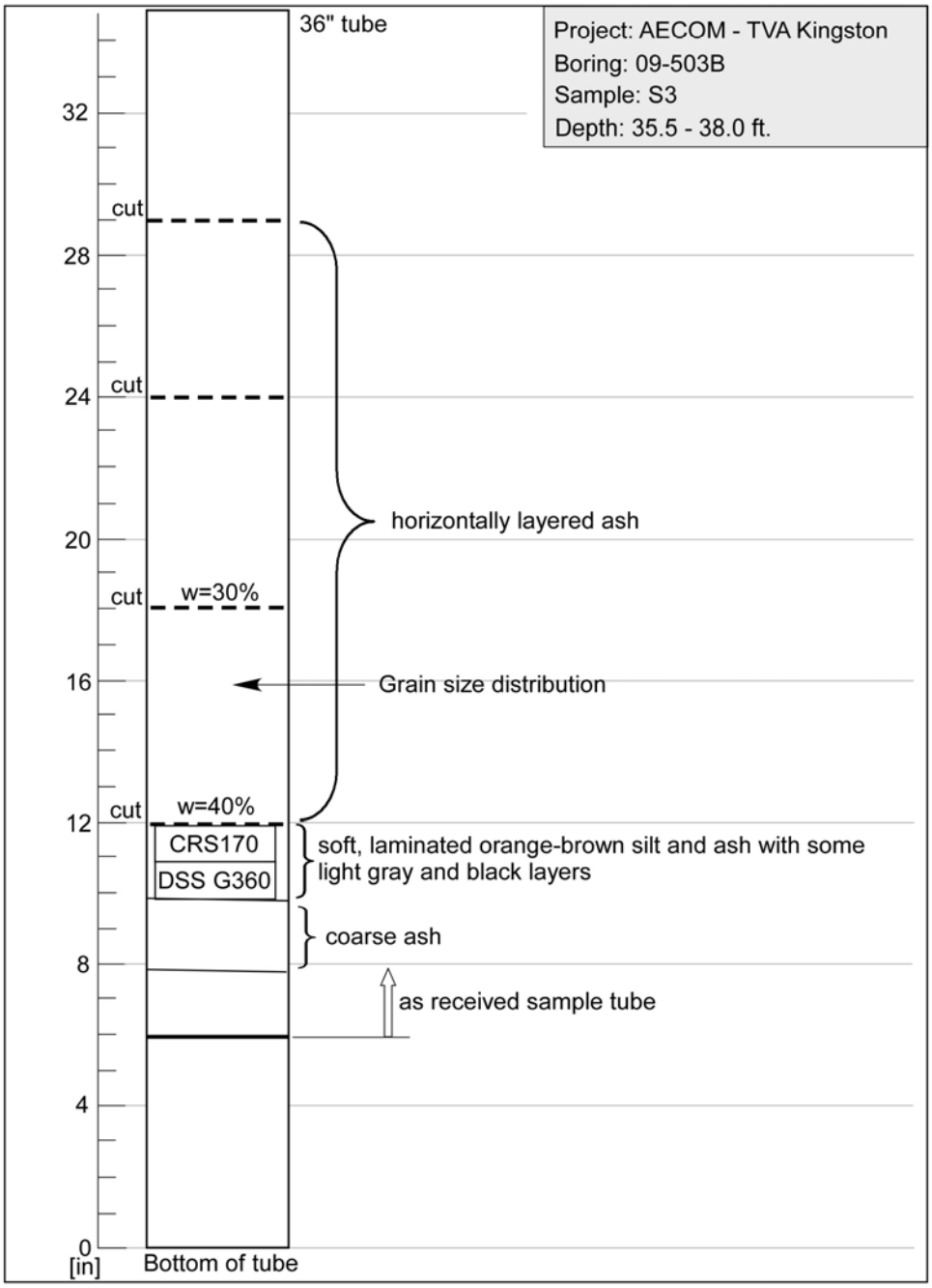

Figure 5.1.60 Sample log and test locations for Sample 09-503B S3 35.5-37.5 ft

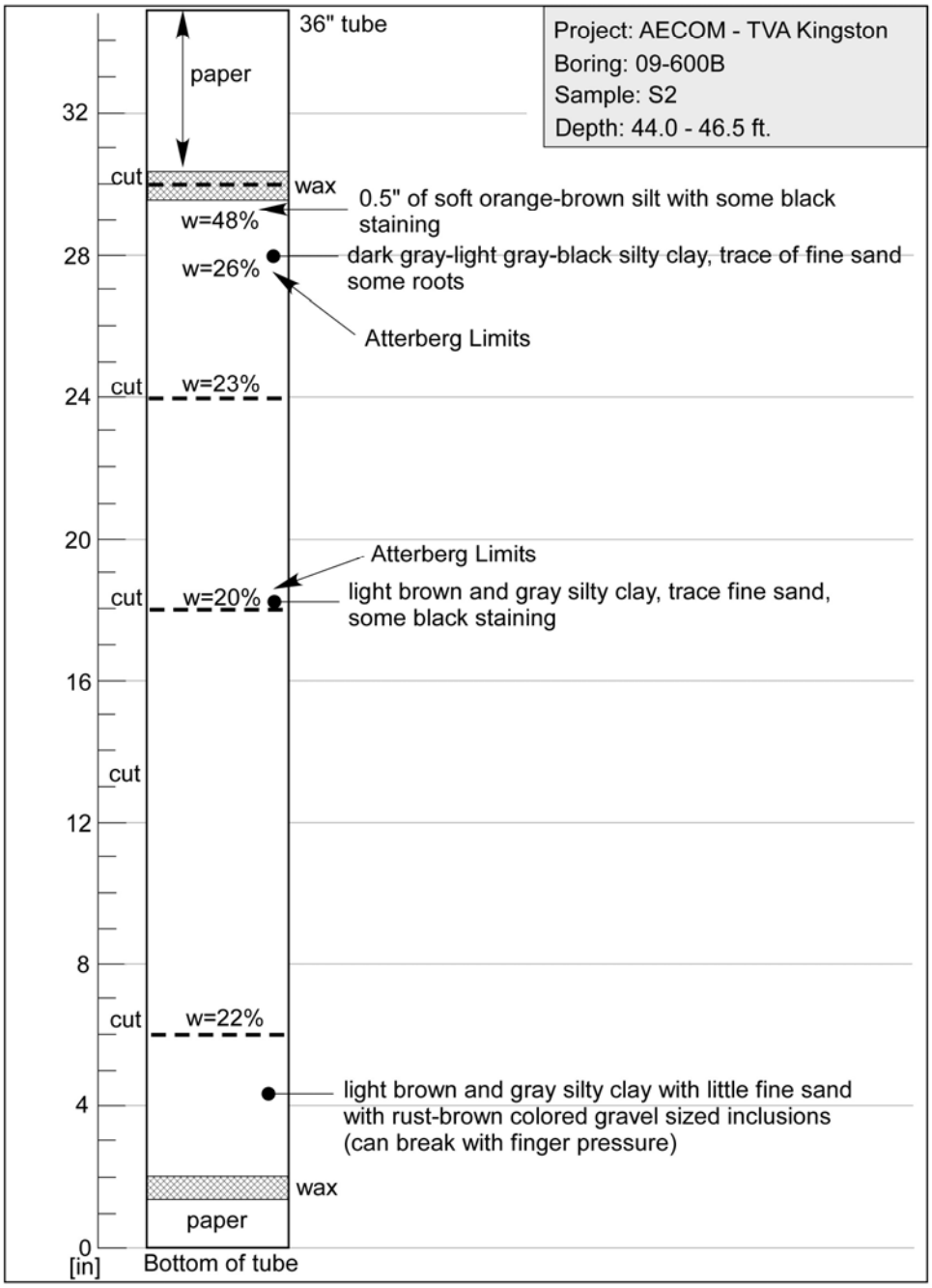

Figure 5.1.61 Sample log and test locations for Sample 09-600B S2 44.0-46.5 ft

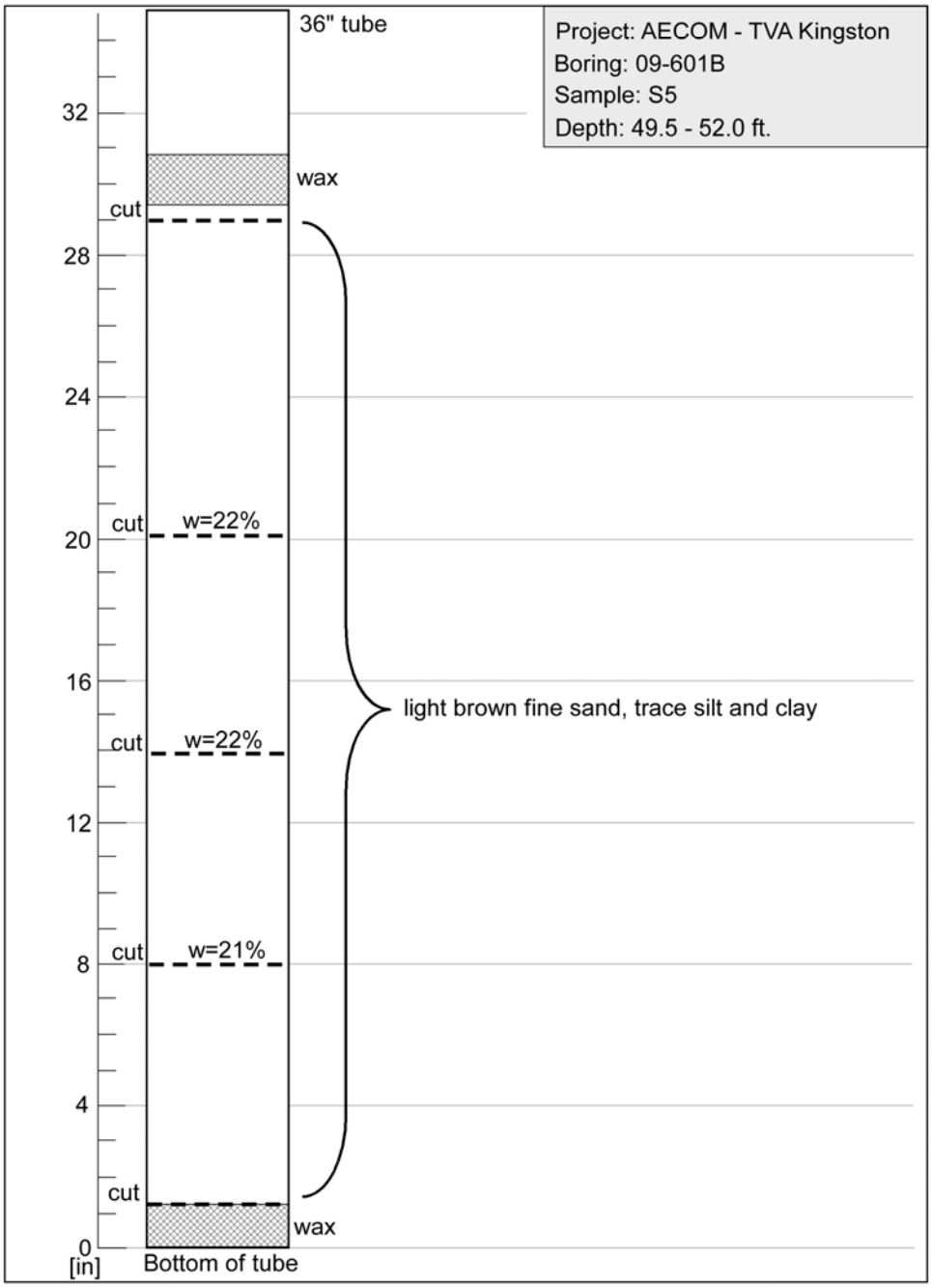

Figure 5.1.62 Sample log and test locations for Sample 09-601B S5 49.5-52.0 ft

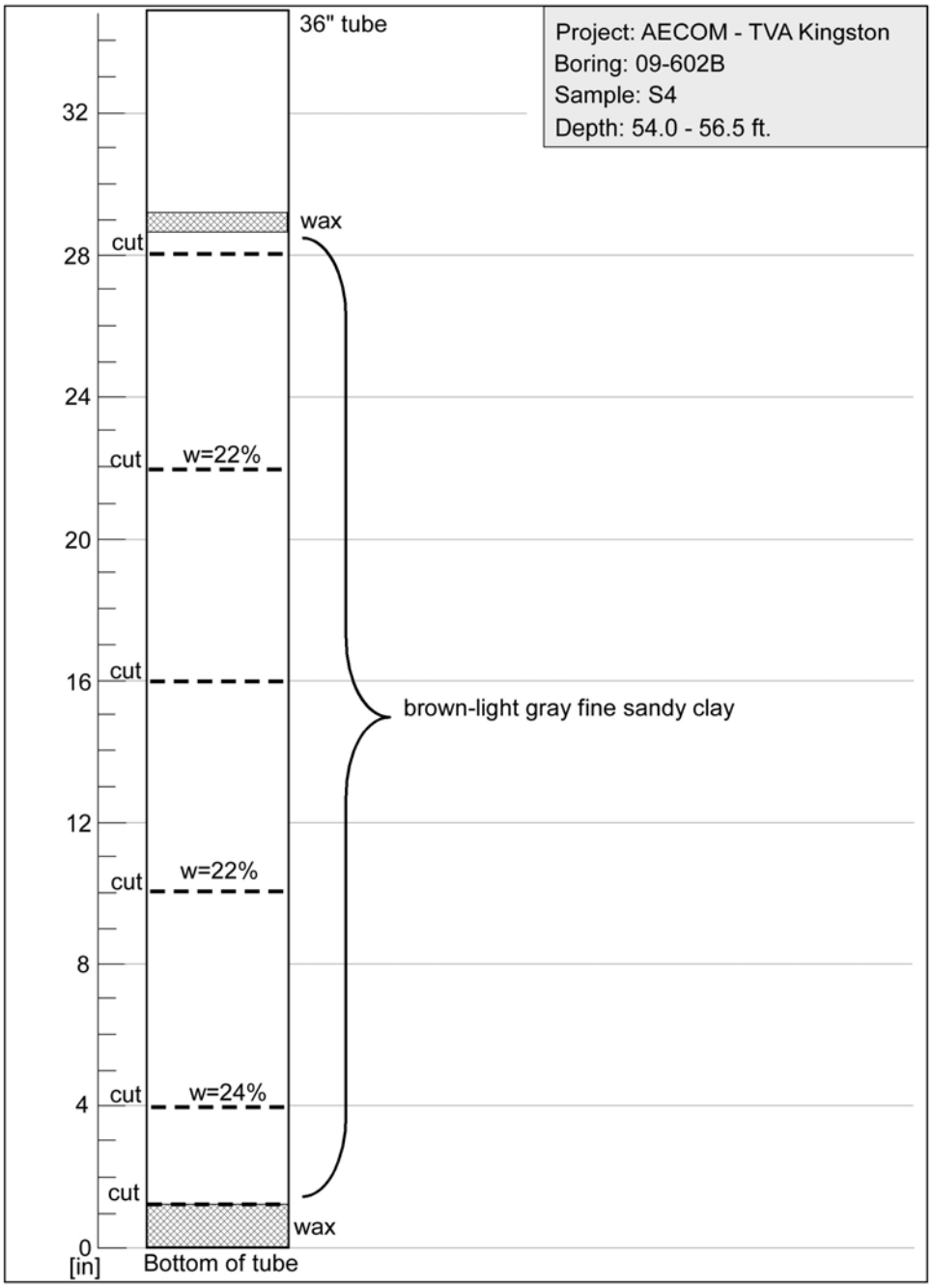

Figure 5.1.63 Sample log and test locations for Sample 09-602B S4 54.0-56.5 ft

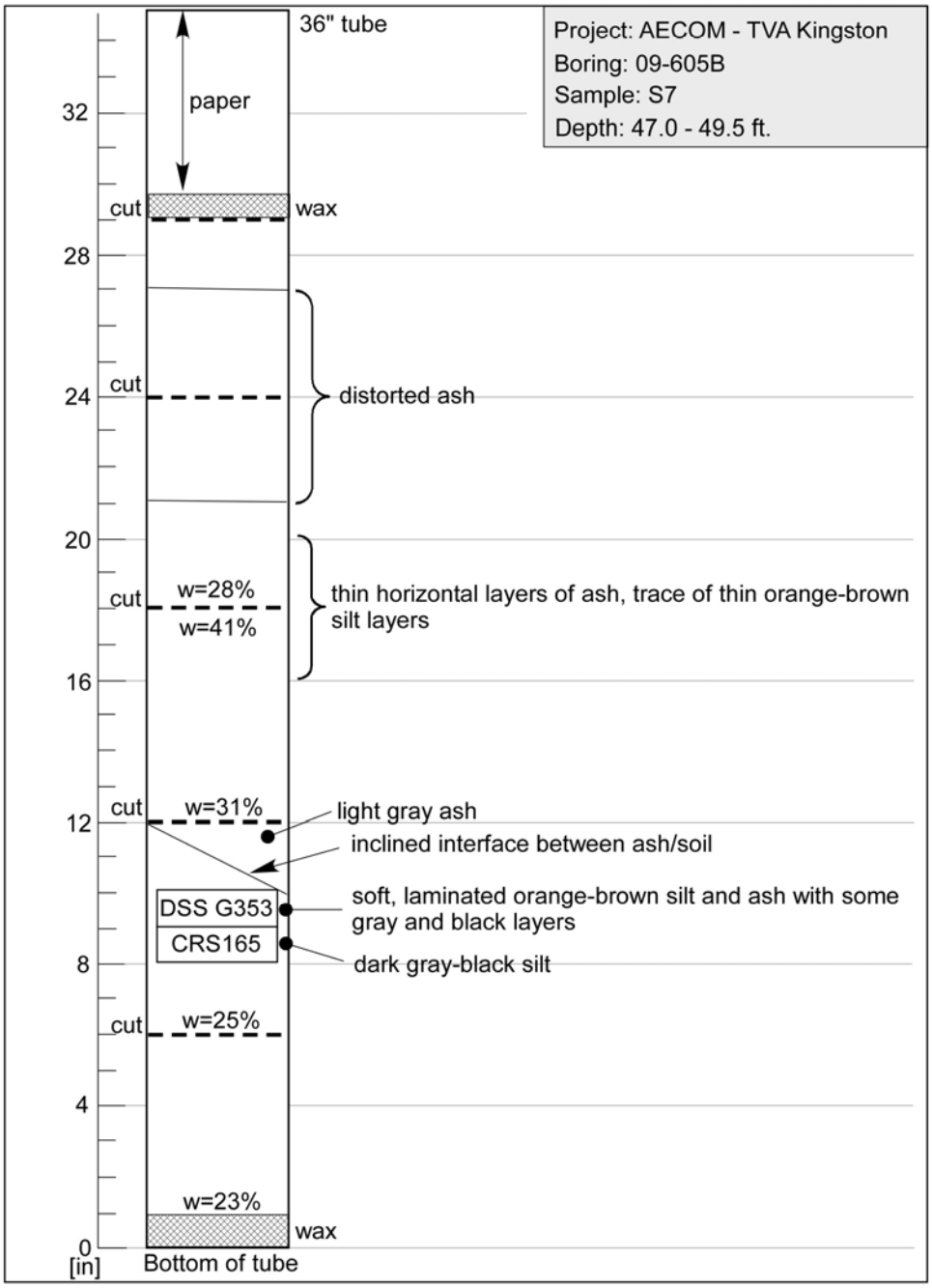

Figure 5.1.64 Sample log and test locations for Sample 09-605B S7 47.0-49.5 ft

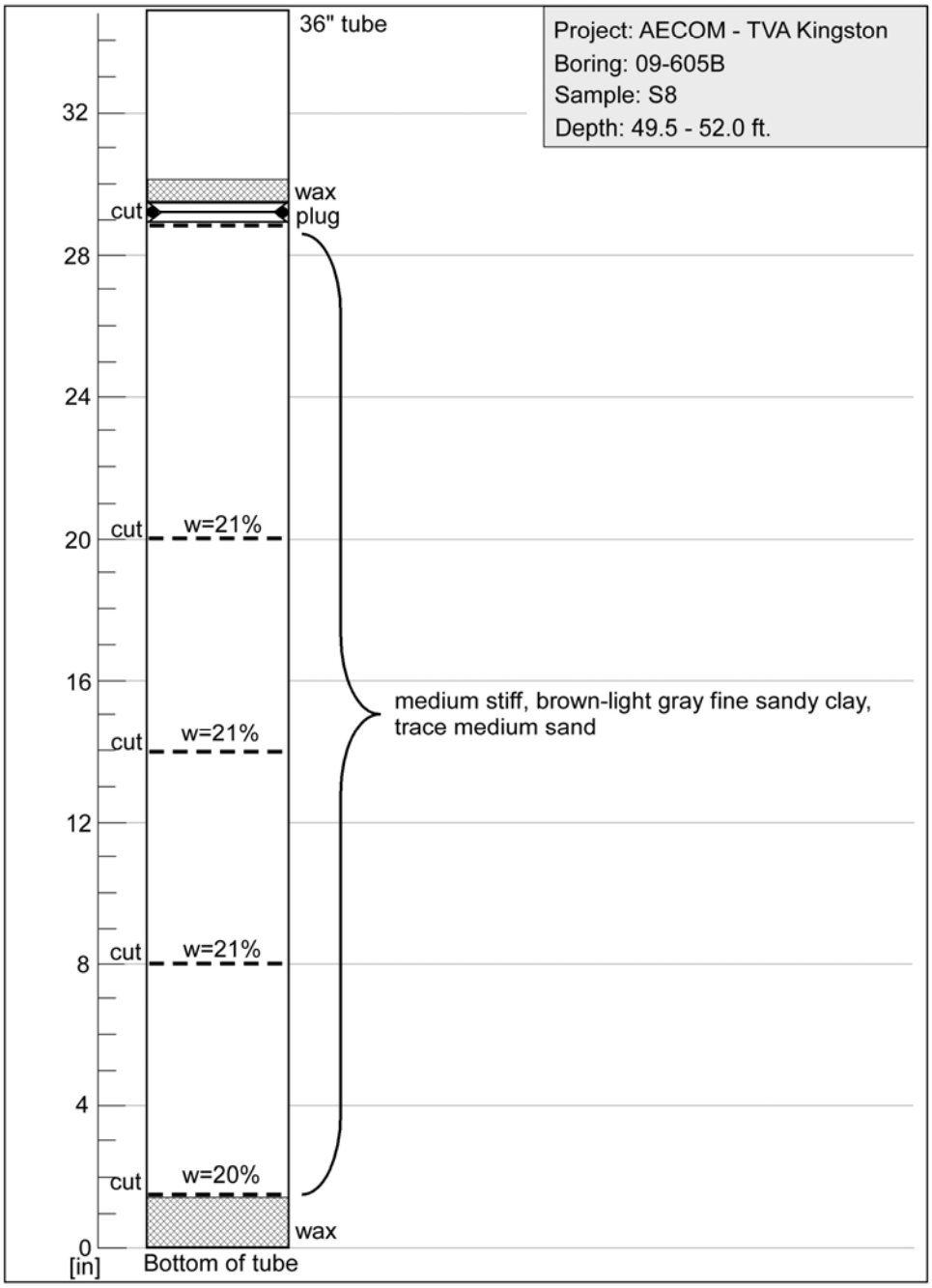

Figure 5.1.65 Sample log and test locations for Sample 09-605B S8 49.5-52.0 ft

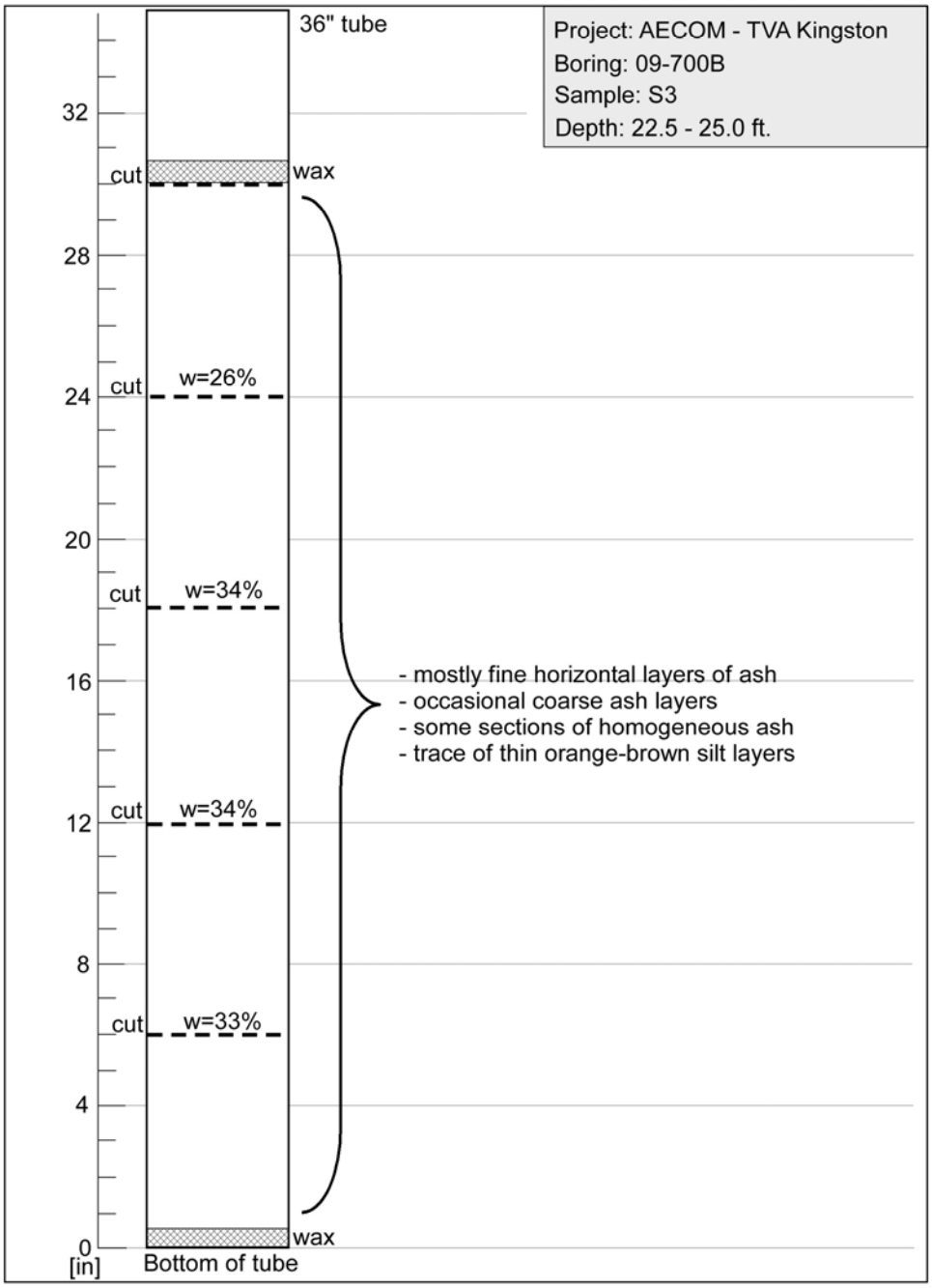

Figure 5.1.66 Sample log and test locations for Sample 09-700B S3 22.5-25.0 ft

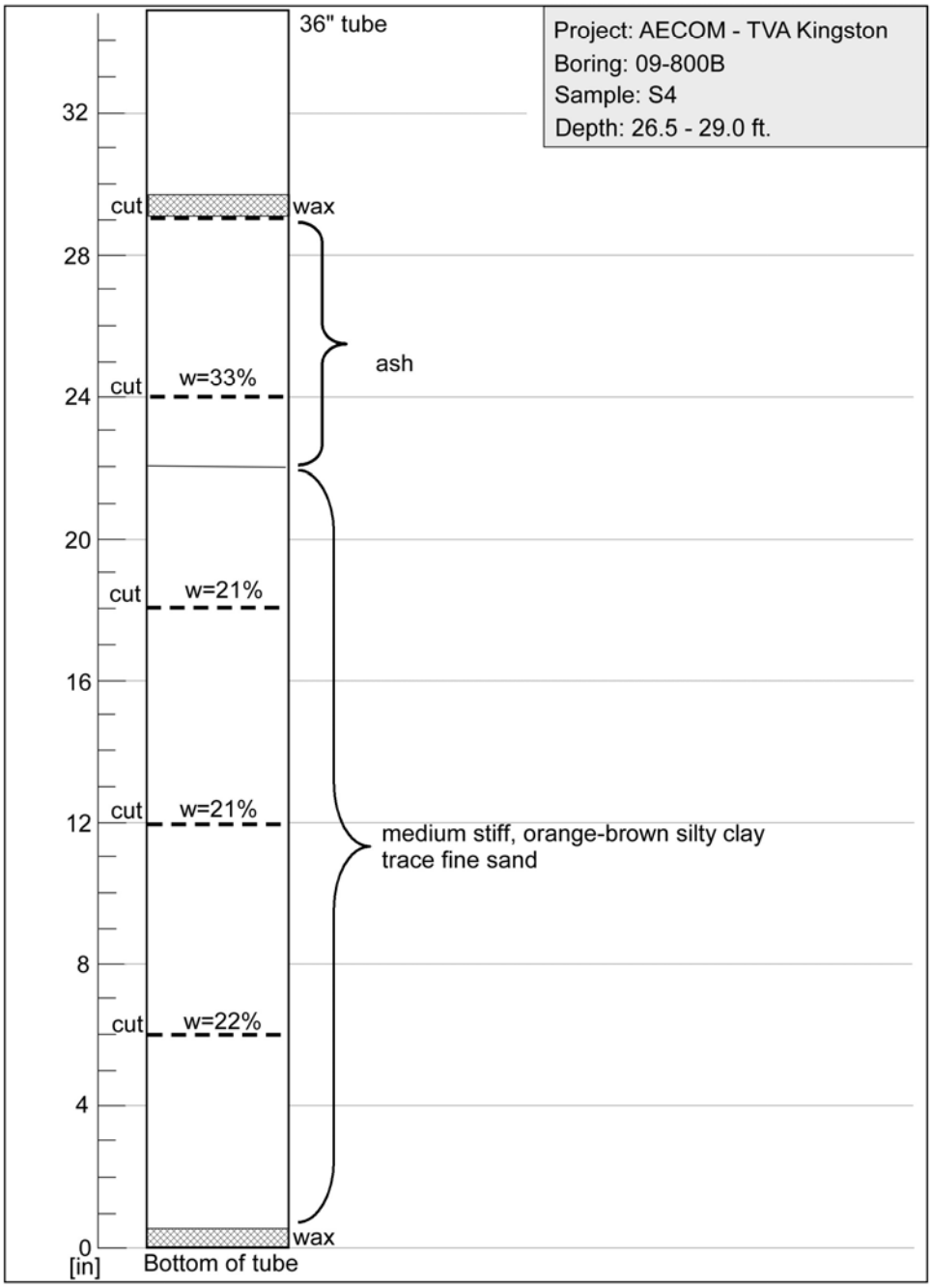

Figure 5.1.67 Sample log and test locations for Sample 09-800B S4 26.5-29.0 ft

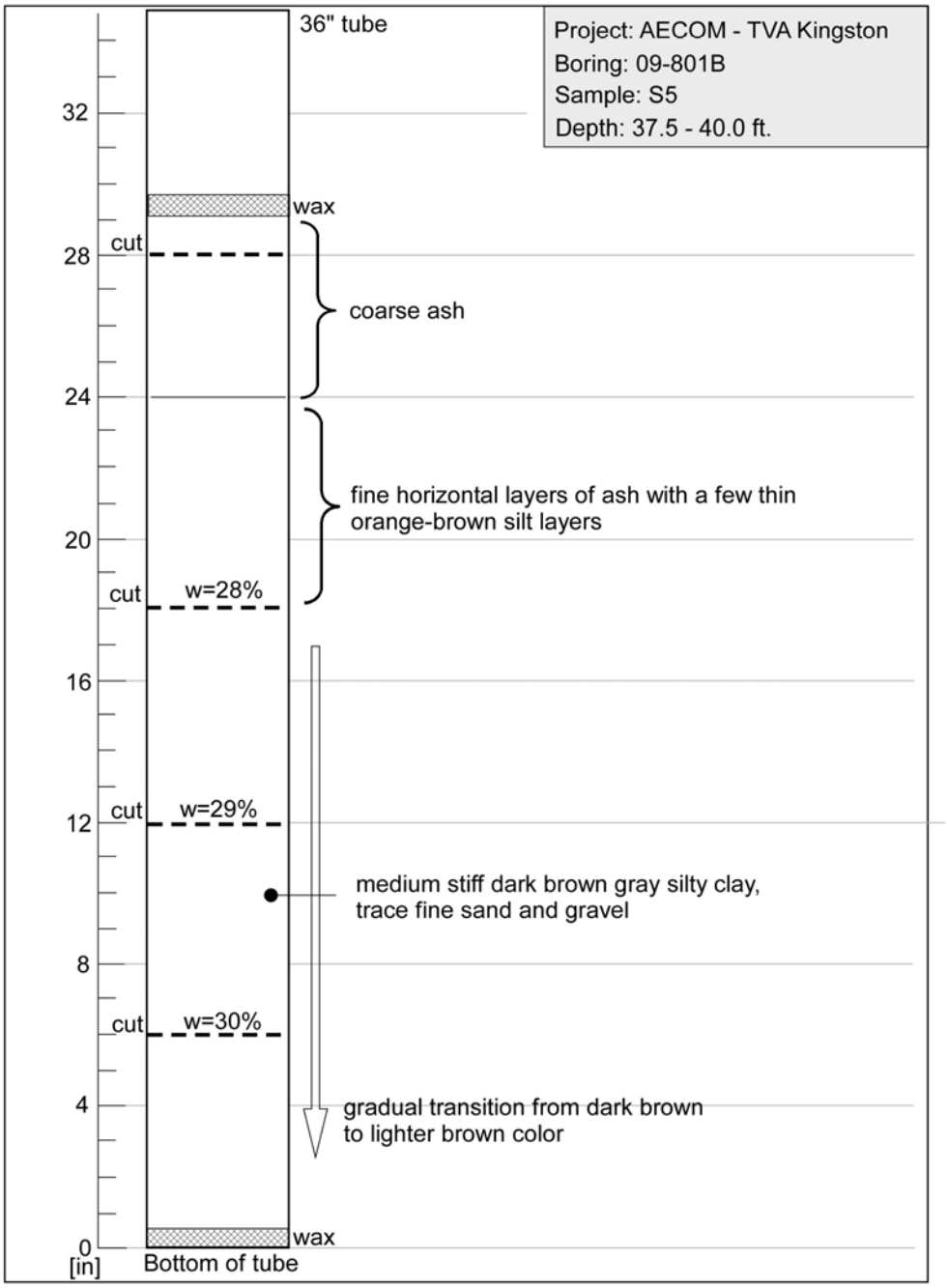

Figure 5.1.68 Sample log and test locations for Sample 09-801B S5 37.5-40.0 ft

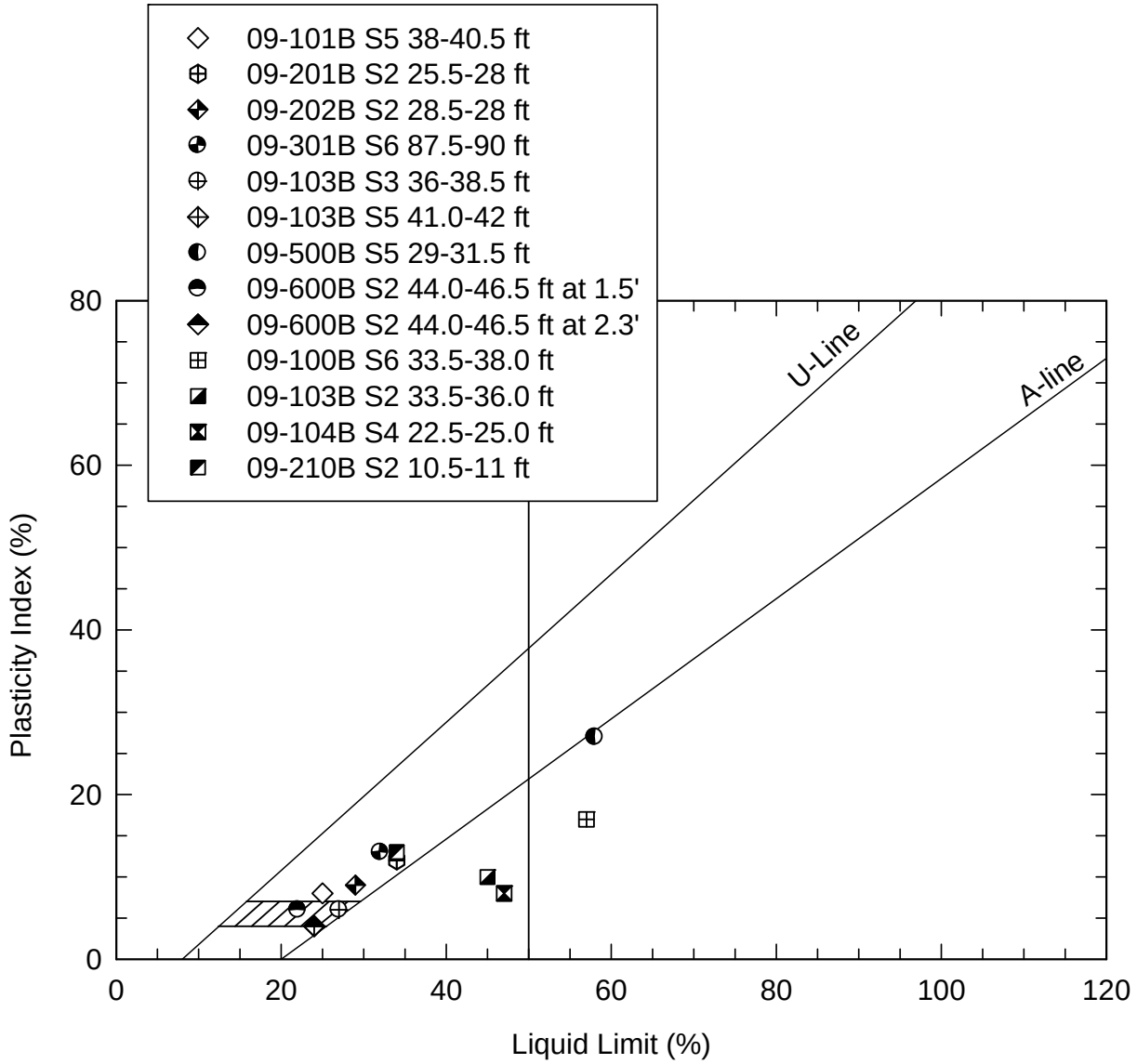

Figure 5.2.1 Plasticity Chart with Atterberg Limits results for selected samples (see Table 3 and sample logs for specific test specimen locations).

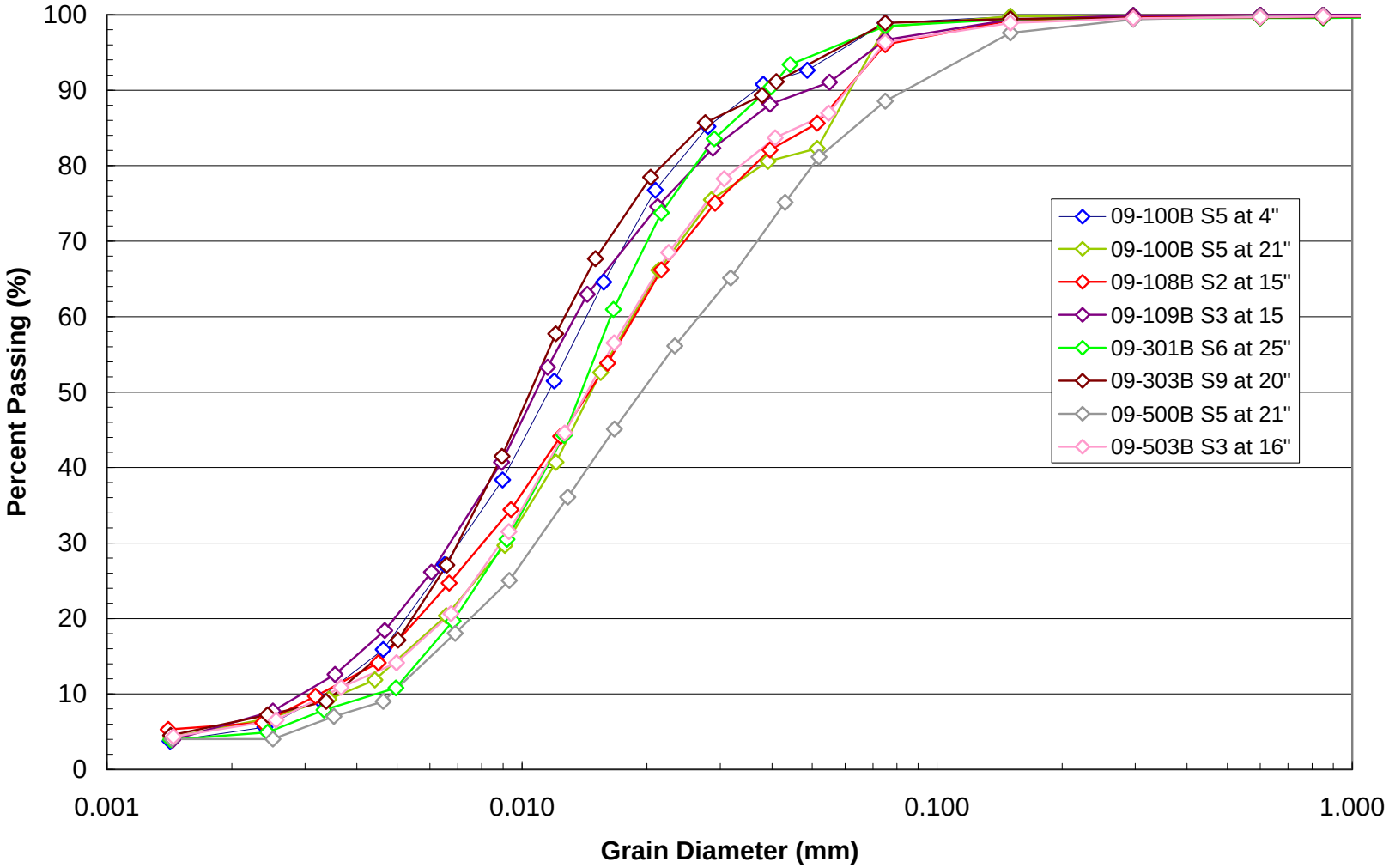

Figure 5.2.2 Percent passing versus grain diameter from grain size distribution test results (see sample logs for specific test specimen location).

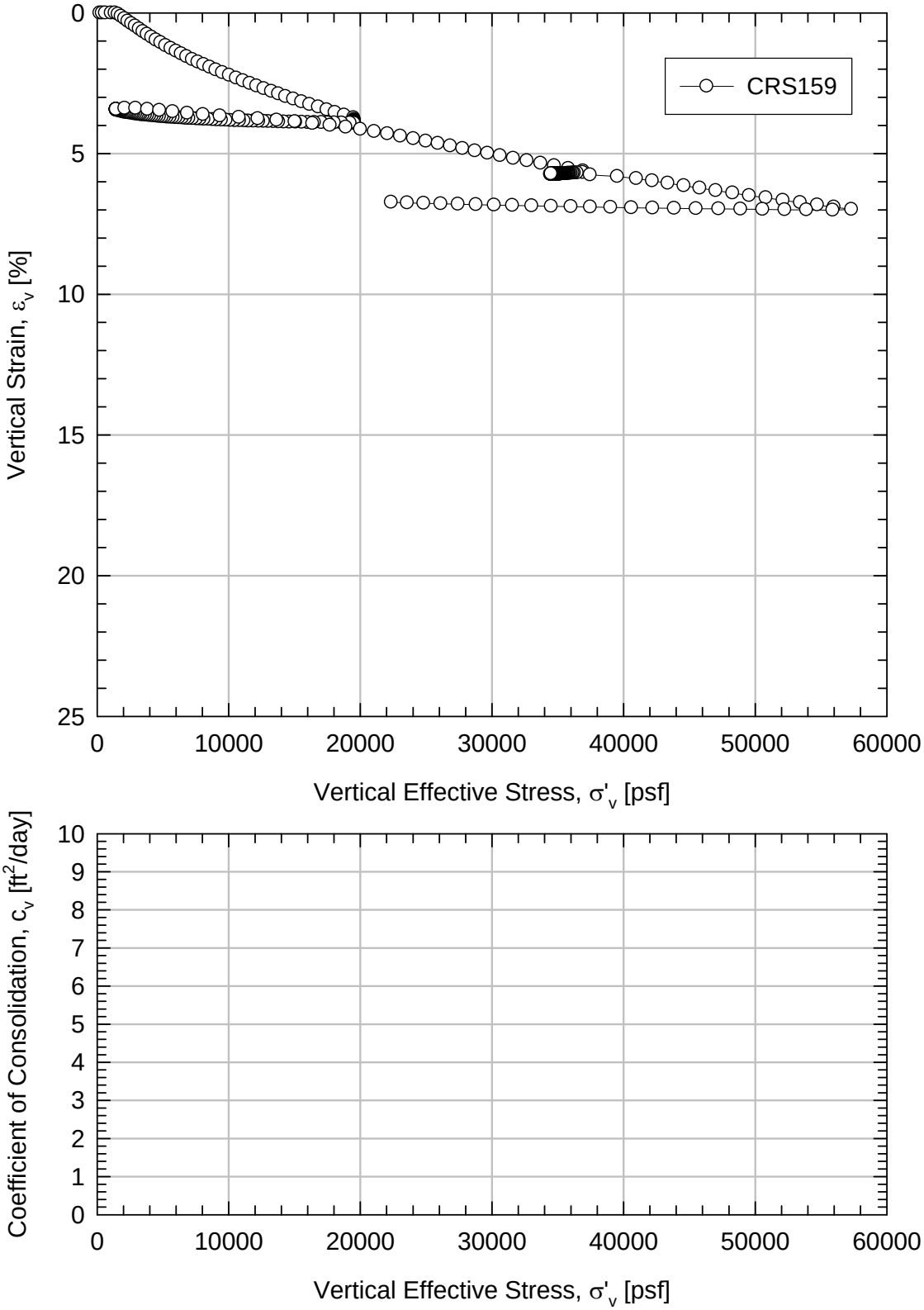

Figure 5.3.1 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS159 on sample 09-202B S2 28.5-31.0 ft.

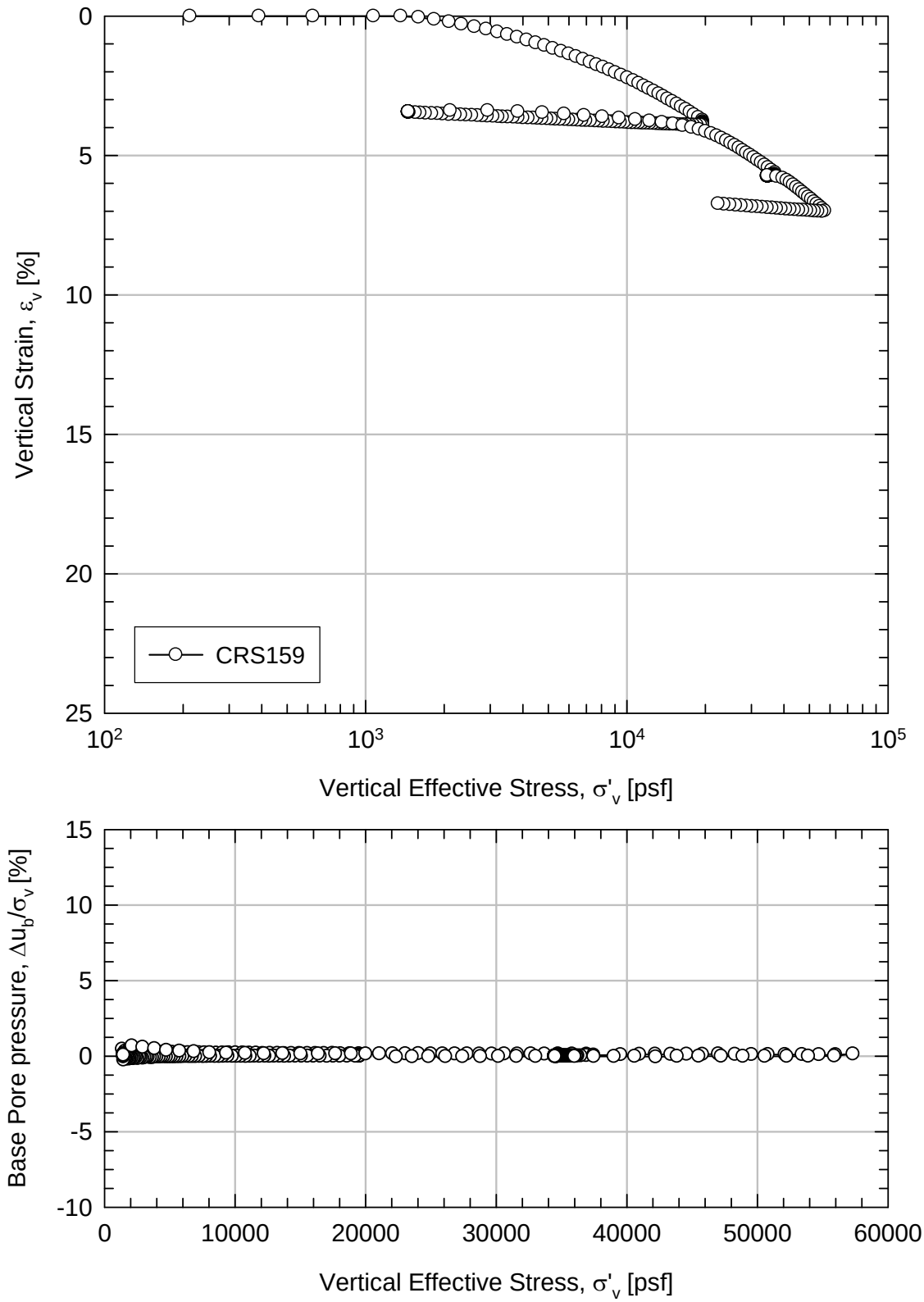

Figure 5.3.2 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS159 on sample 09-202B S2 28.5-31.0 ft.

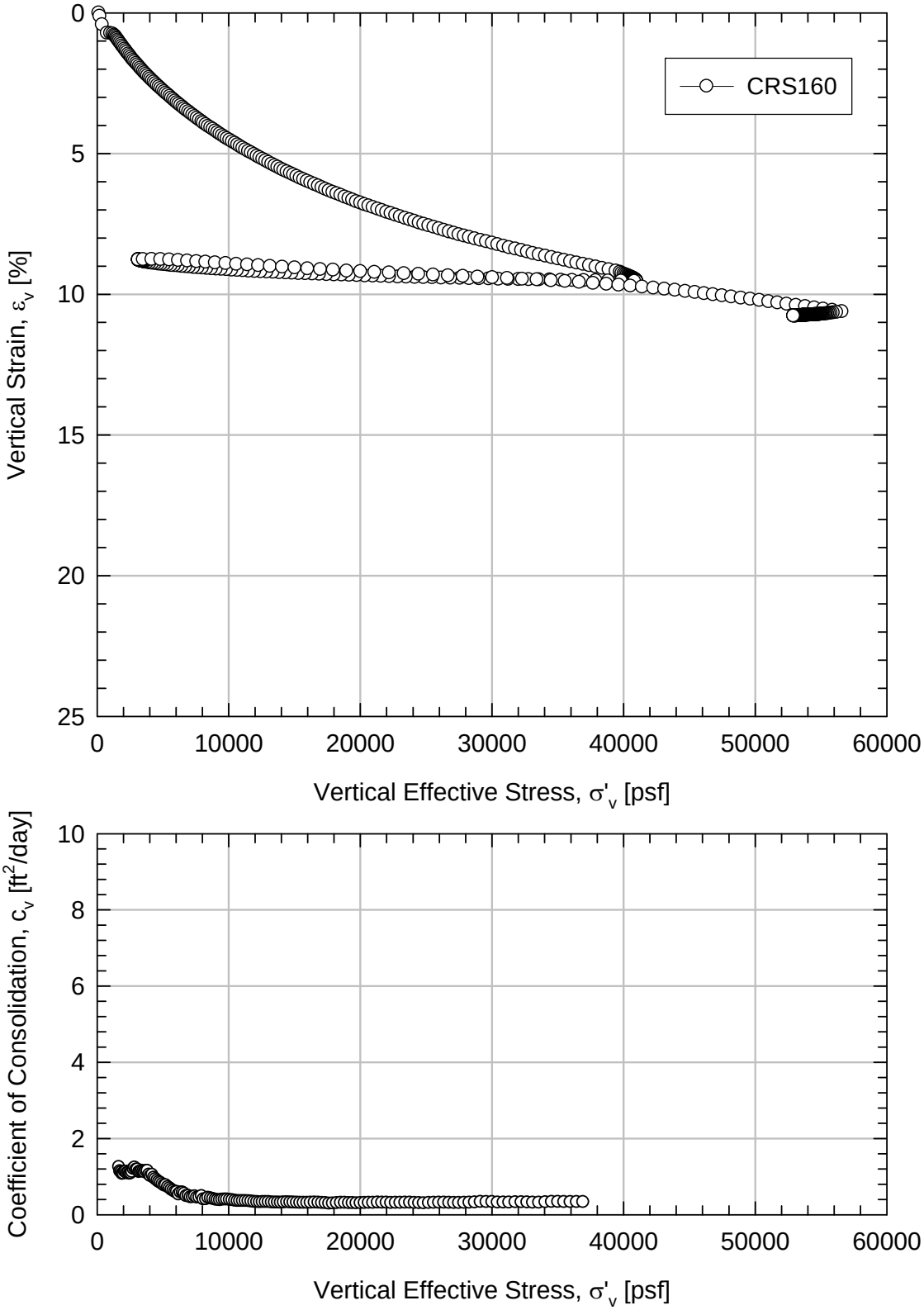

Figure 5.3.3 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS160 on sample 09-201B S2 25.5-28.0 ft.

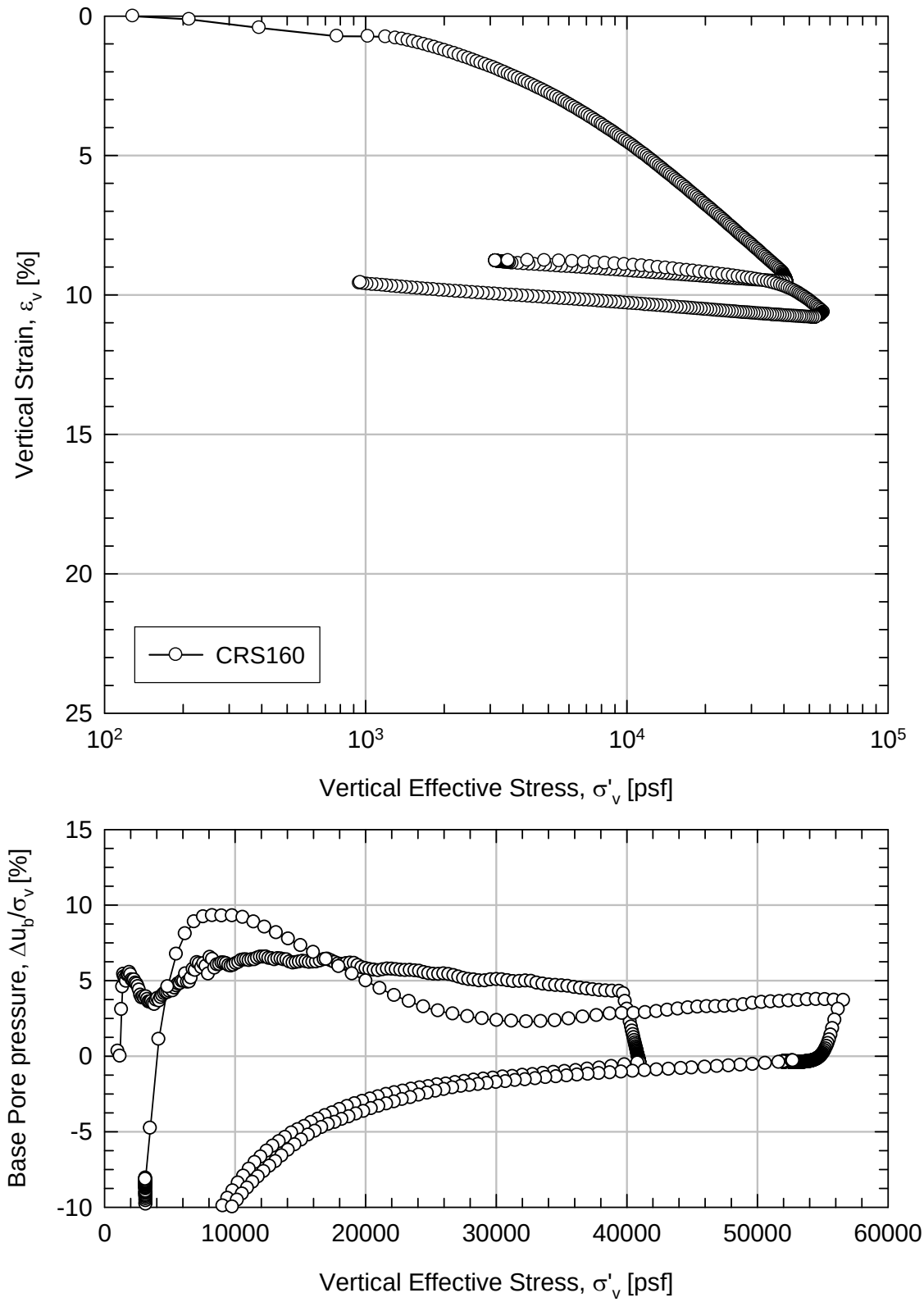

Figure 5.3.4 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS160 on sample 09-201B S2 25.5-28.0 ft.

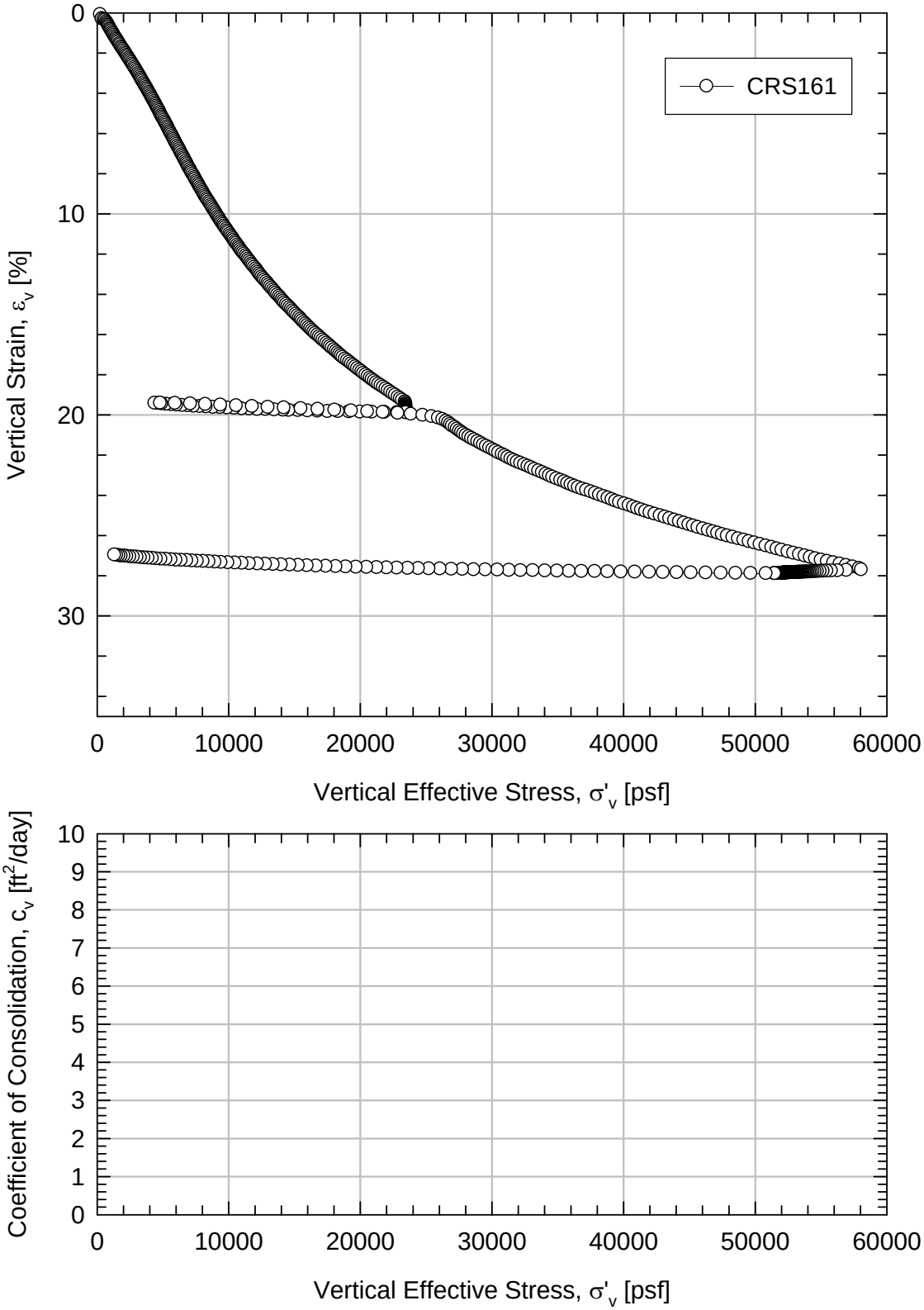

Figure 5.3.5 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS161 on sample 09-104B S4 22.5-25.0 ft.

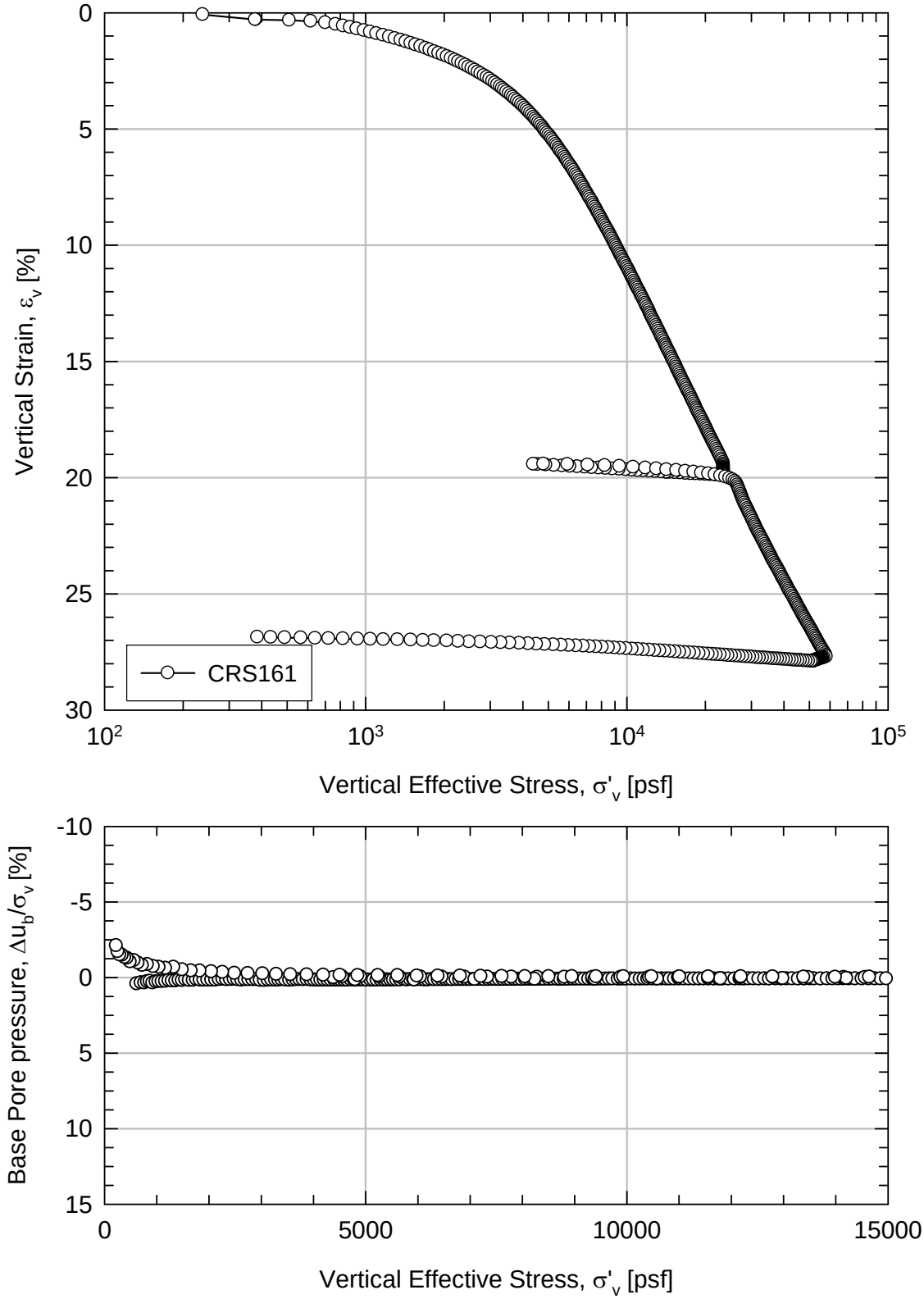

Figure 5.3.6 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS161 on sample 09-104B S4 22.5-25.0 ft.

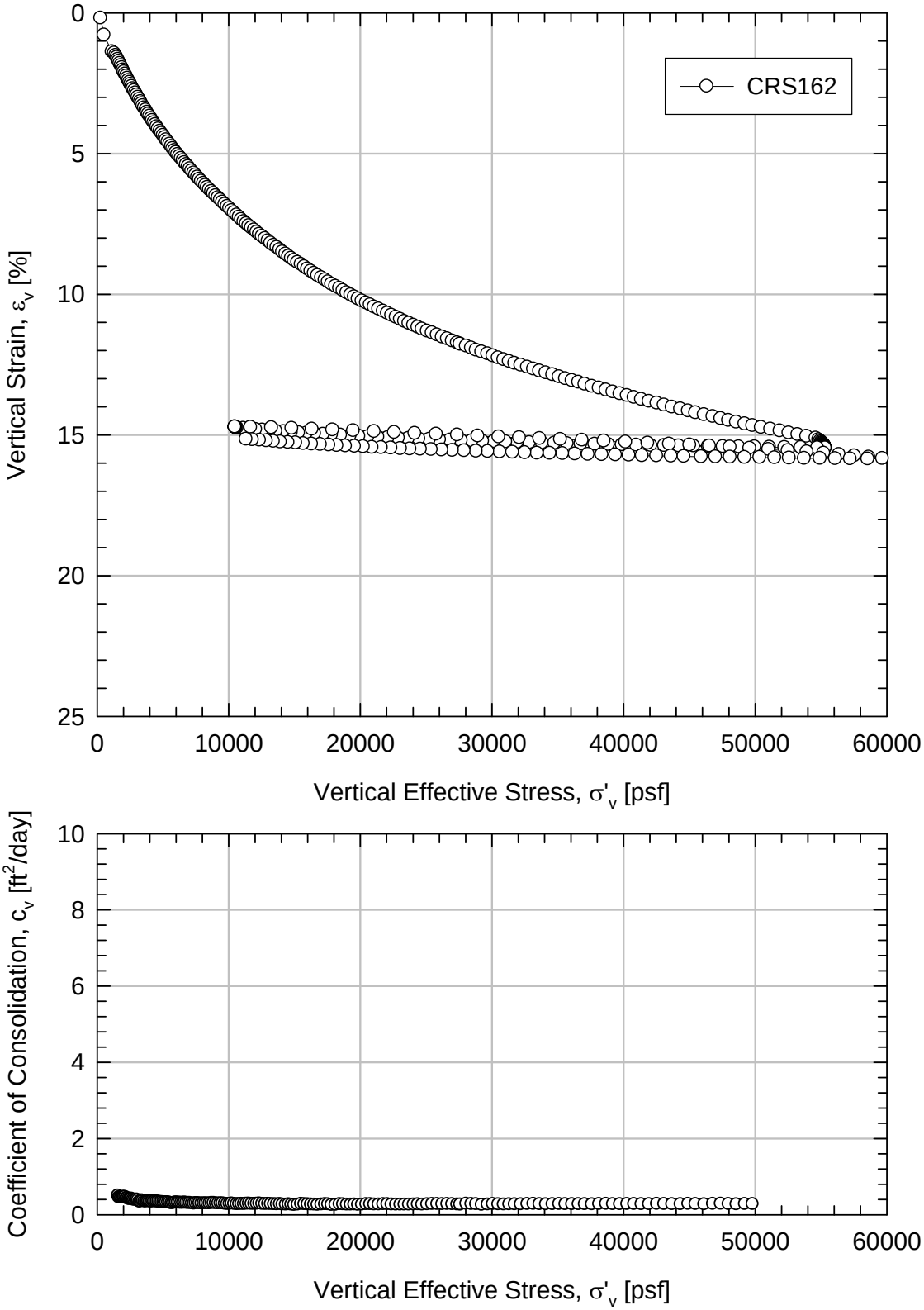

Figure 5.3.7 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS162 on sample 09-301B S6 87.5-90.0 ft.

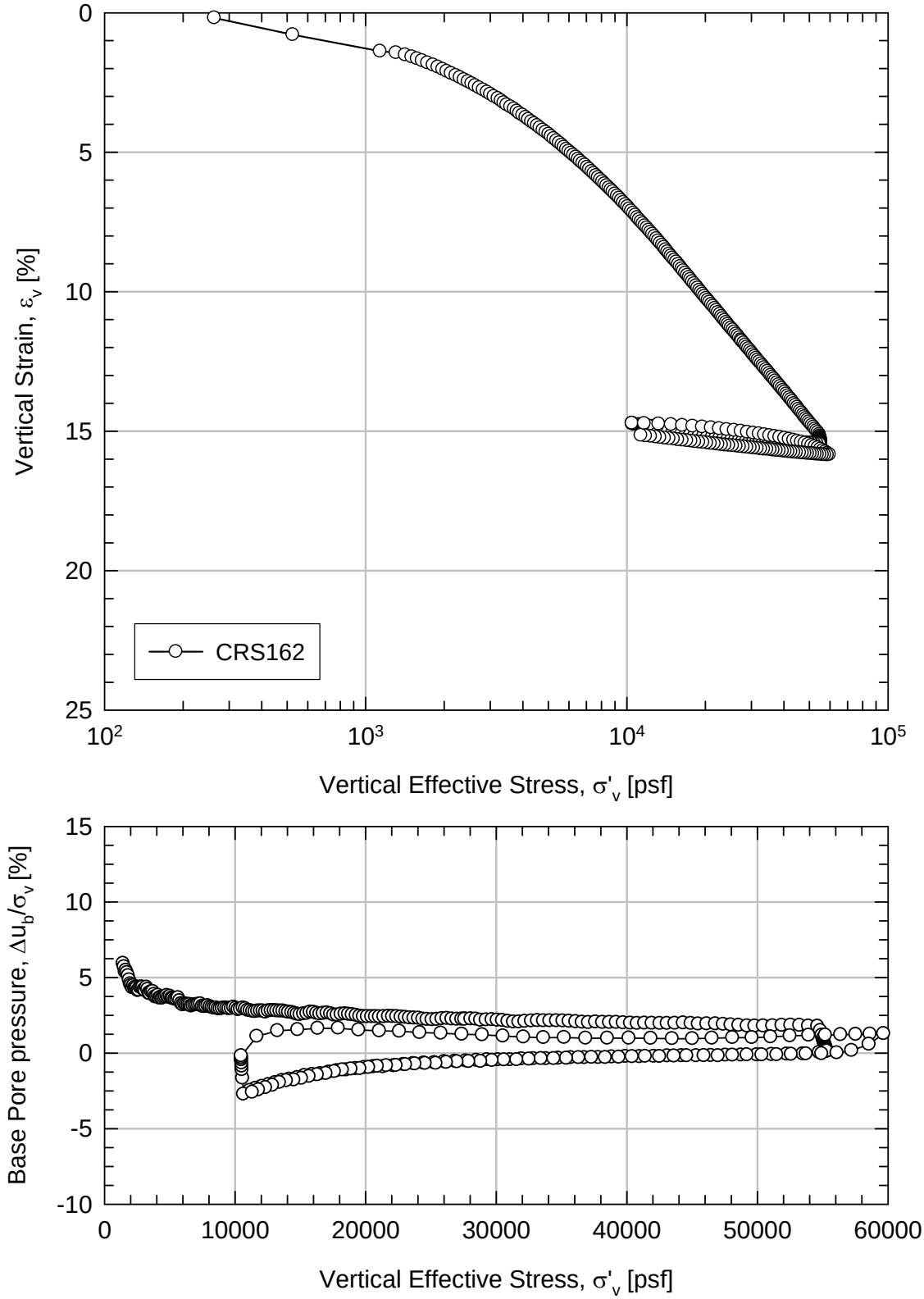

Figure 5.3.8 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS162 on sample 09-301B S6 87.5-90.0 ft.

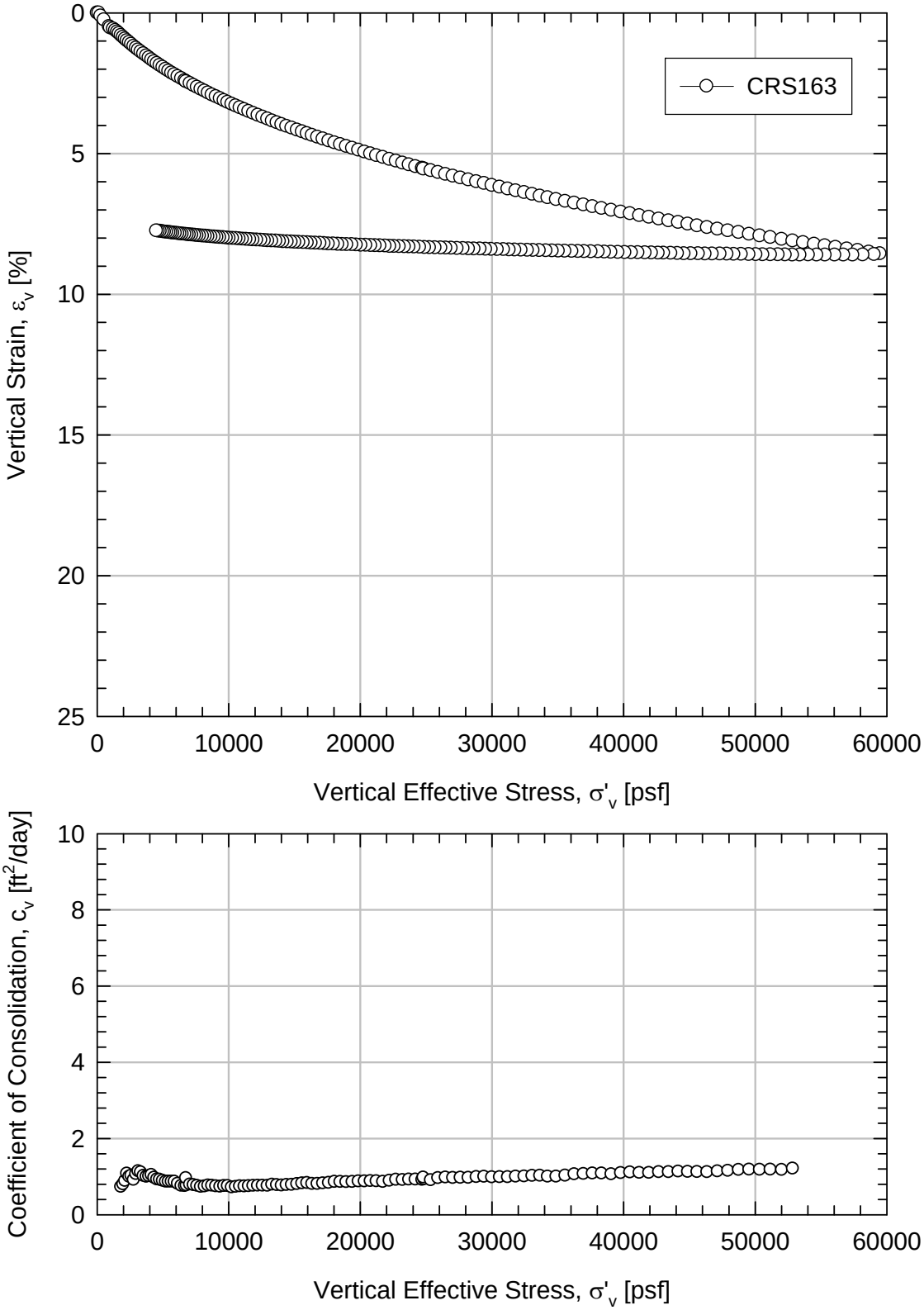

Figure 5.3.9 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS163 on sample 09-101B S5 38.0-40.5 ft.

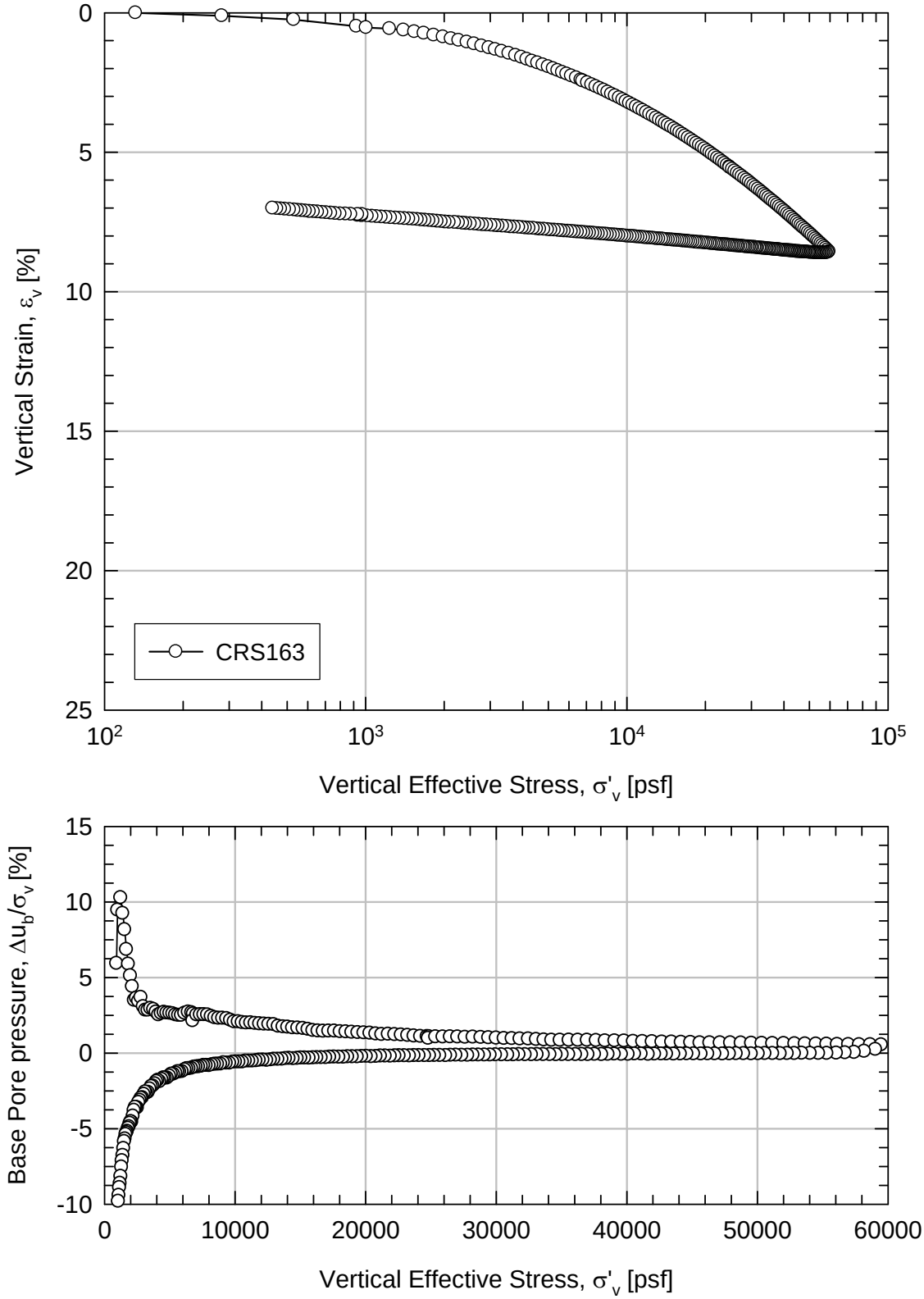

Figure 5.3.10 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS163 on sample 09-101B S5 38.0-40.5 ft.

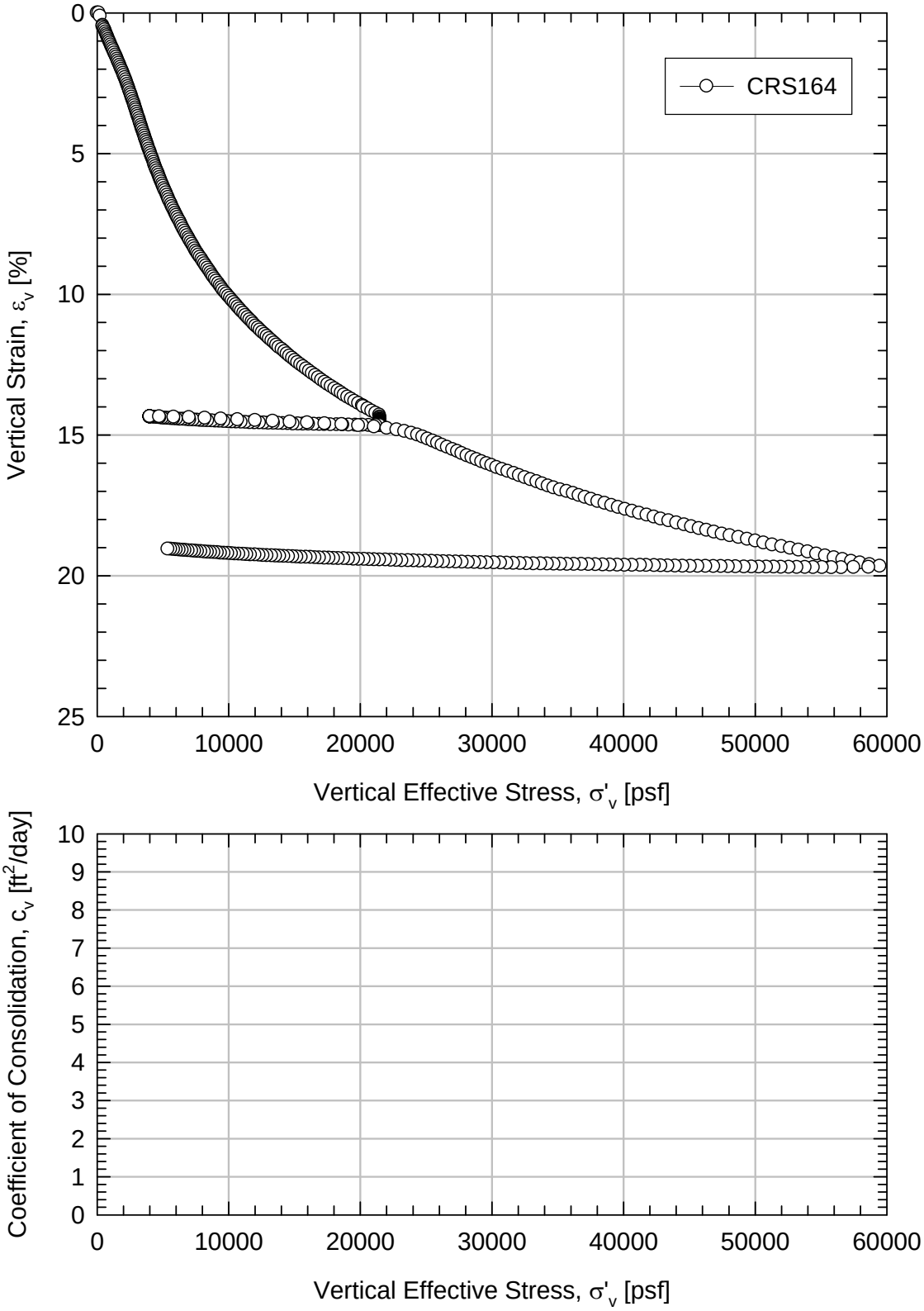

Figure 5.3.11 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS164 on sample 09-108B S2 23.5-26.0 ft.

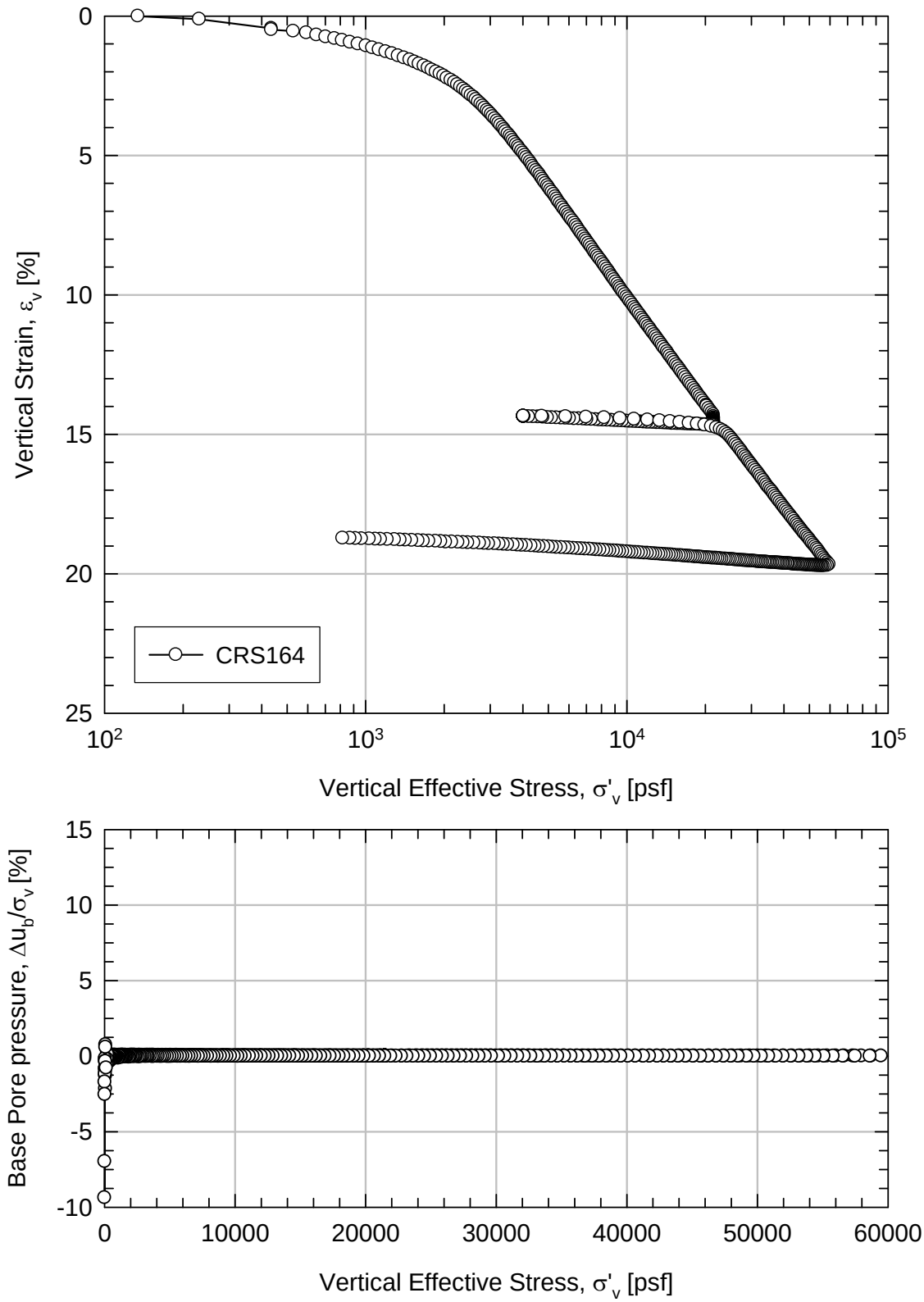

Figure 5.3.12 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS164 on sample 09-108B S2 23.5-26.0 ft.

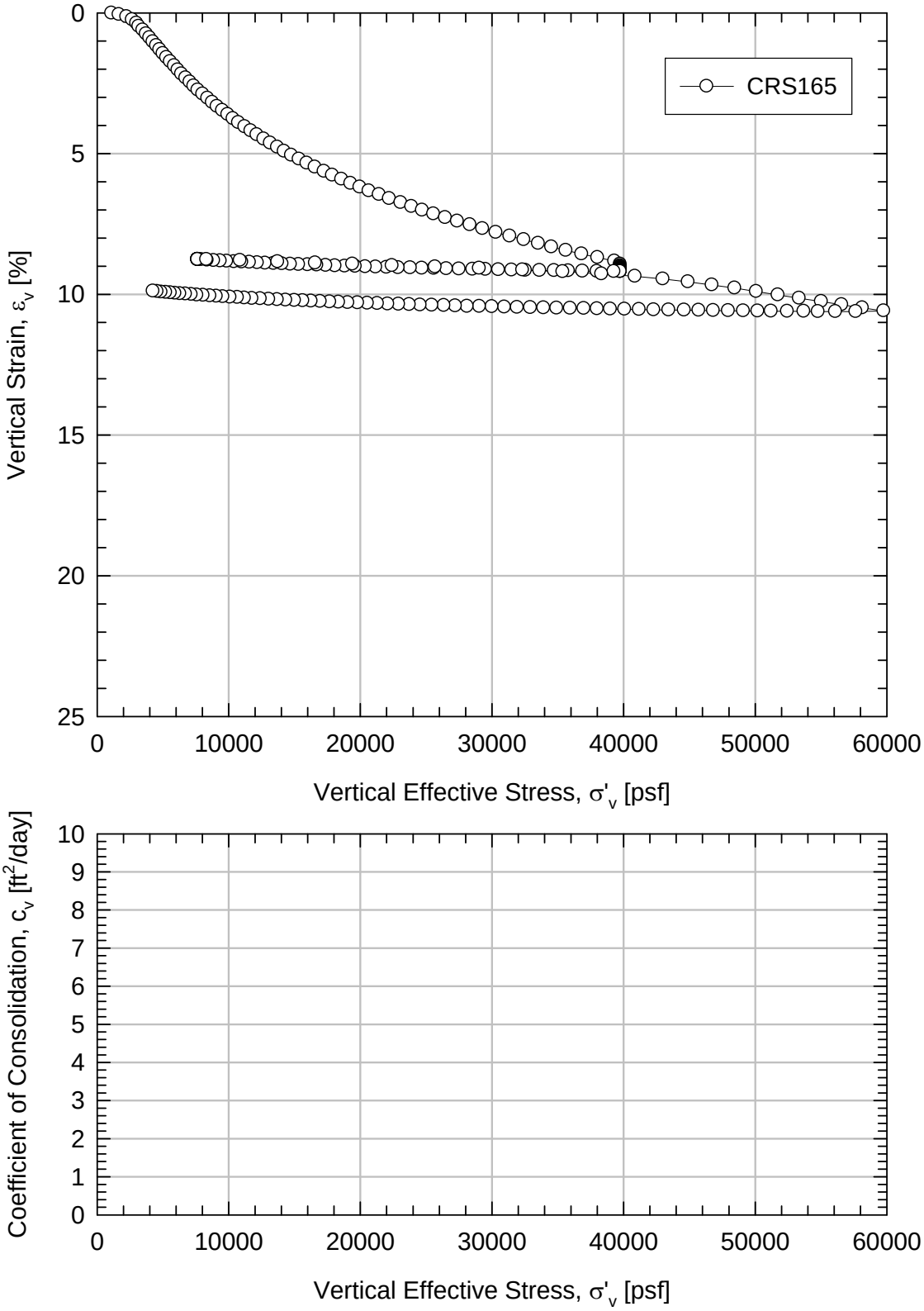

Figure 5.3.13 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS165 on sample 09-605B S7 47.0-49.5 ft.

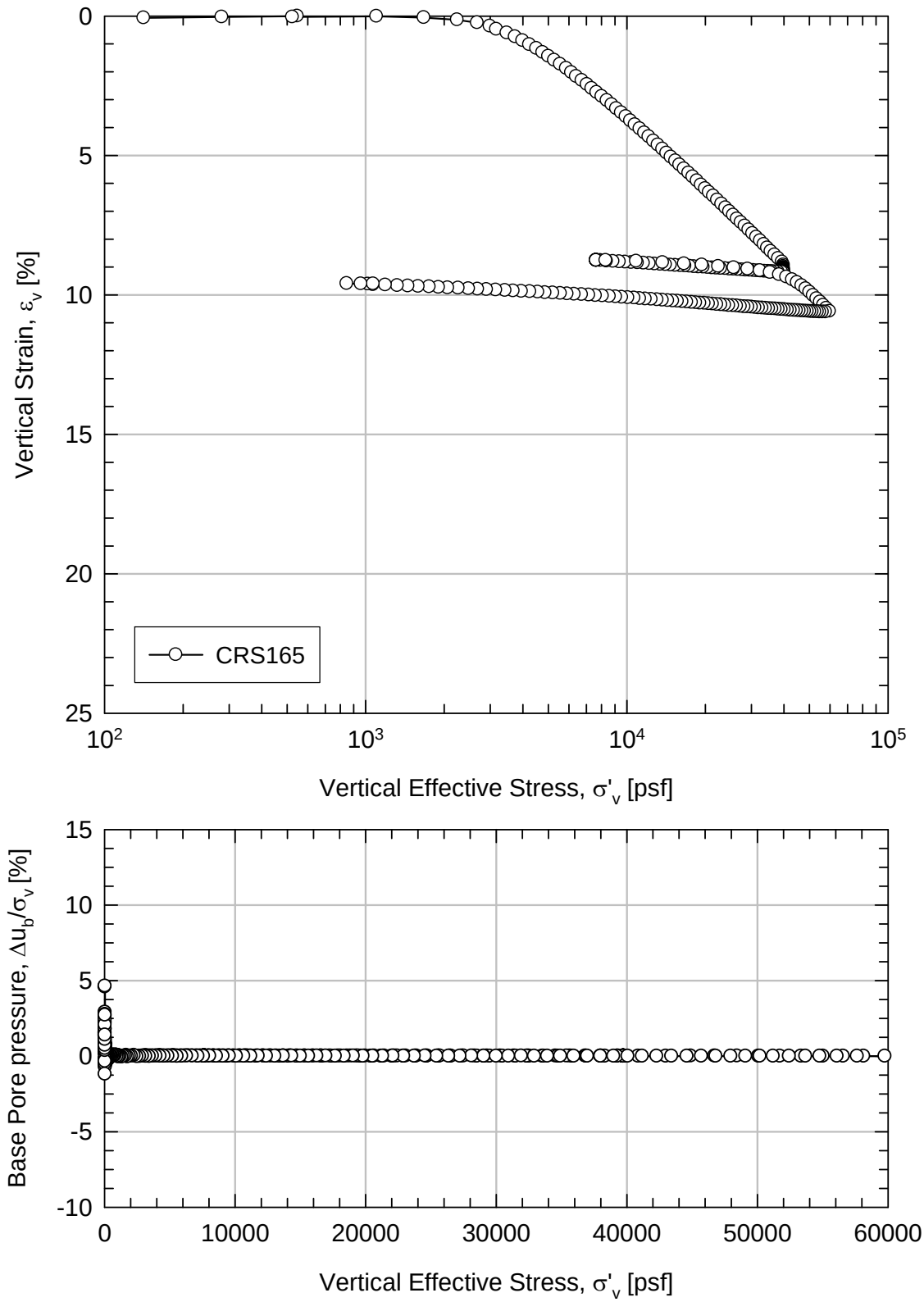

Figure 5.3.14 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS165 on sample 09-605B S7 47.0-49.5 ft.

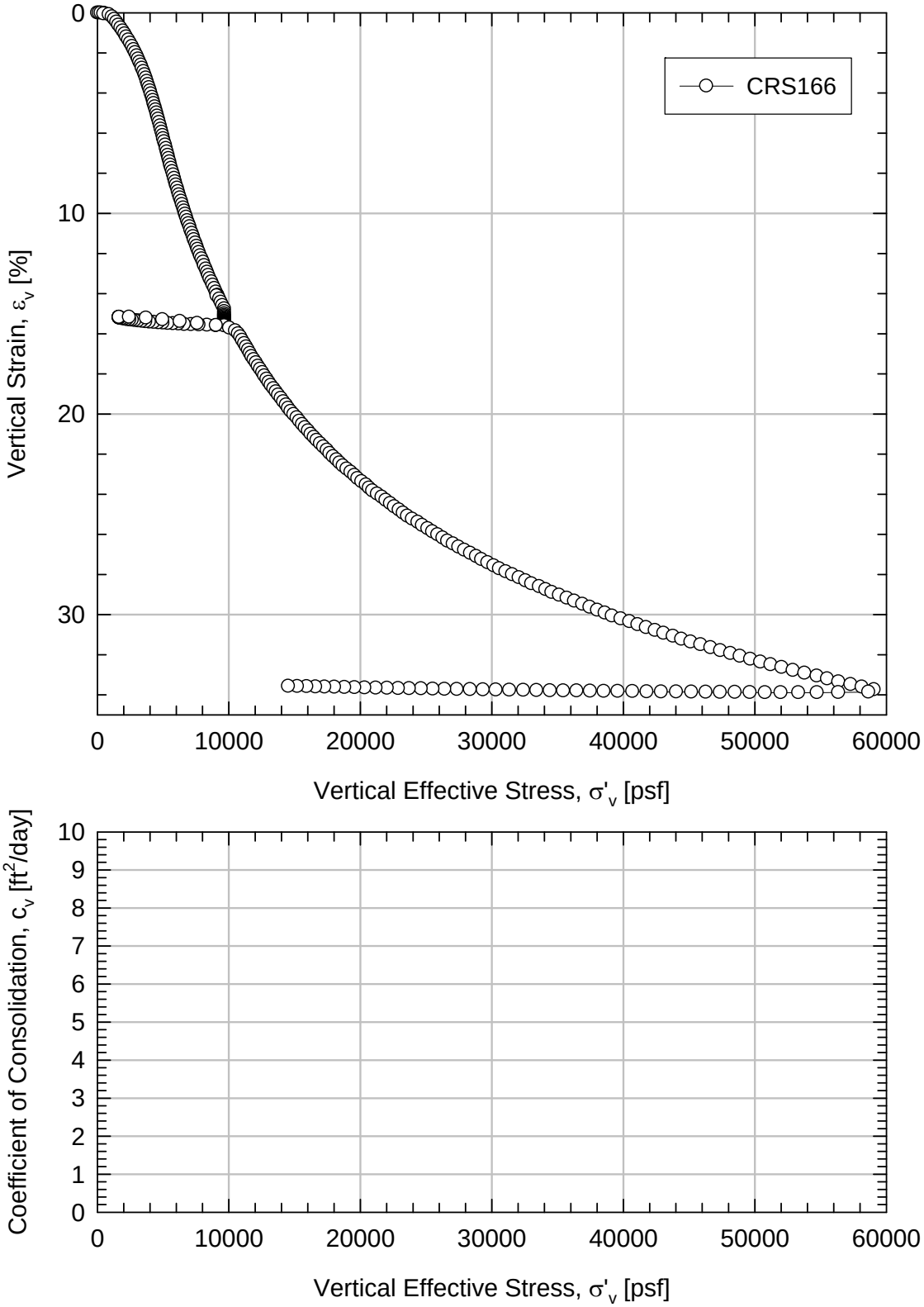

Figure 5.3.15 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS166 on sample 09-103B S2 33.5-36.0 ft.

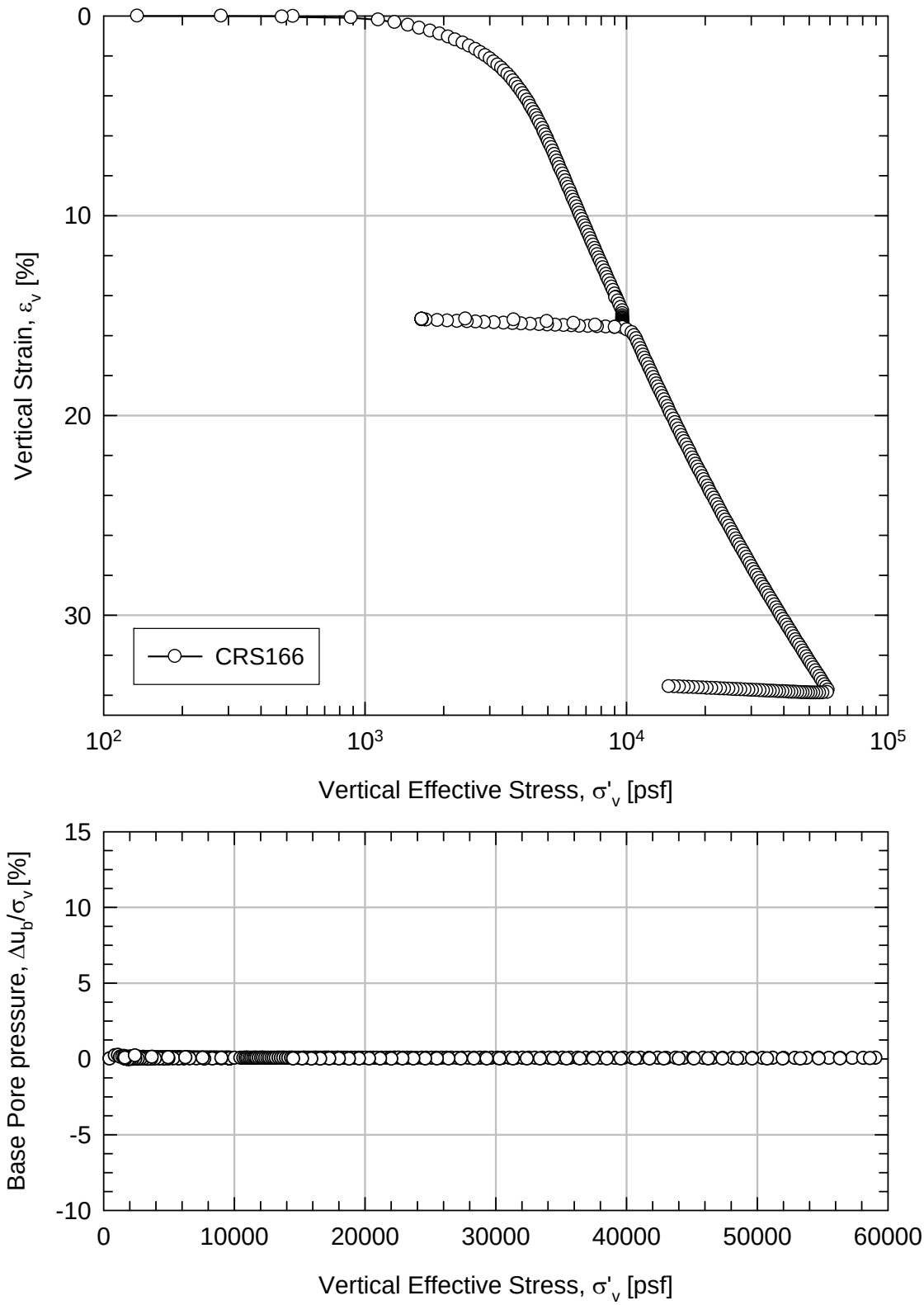

Figure 5.3.16 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS166 on sample 09-103B S2 33.5-36.0 ft.

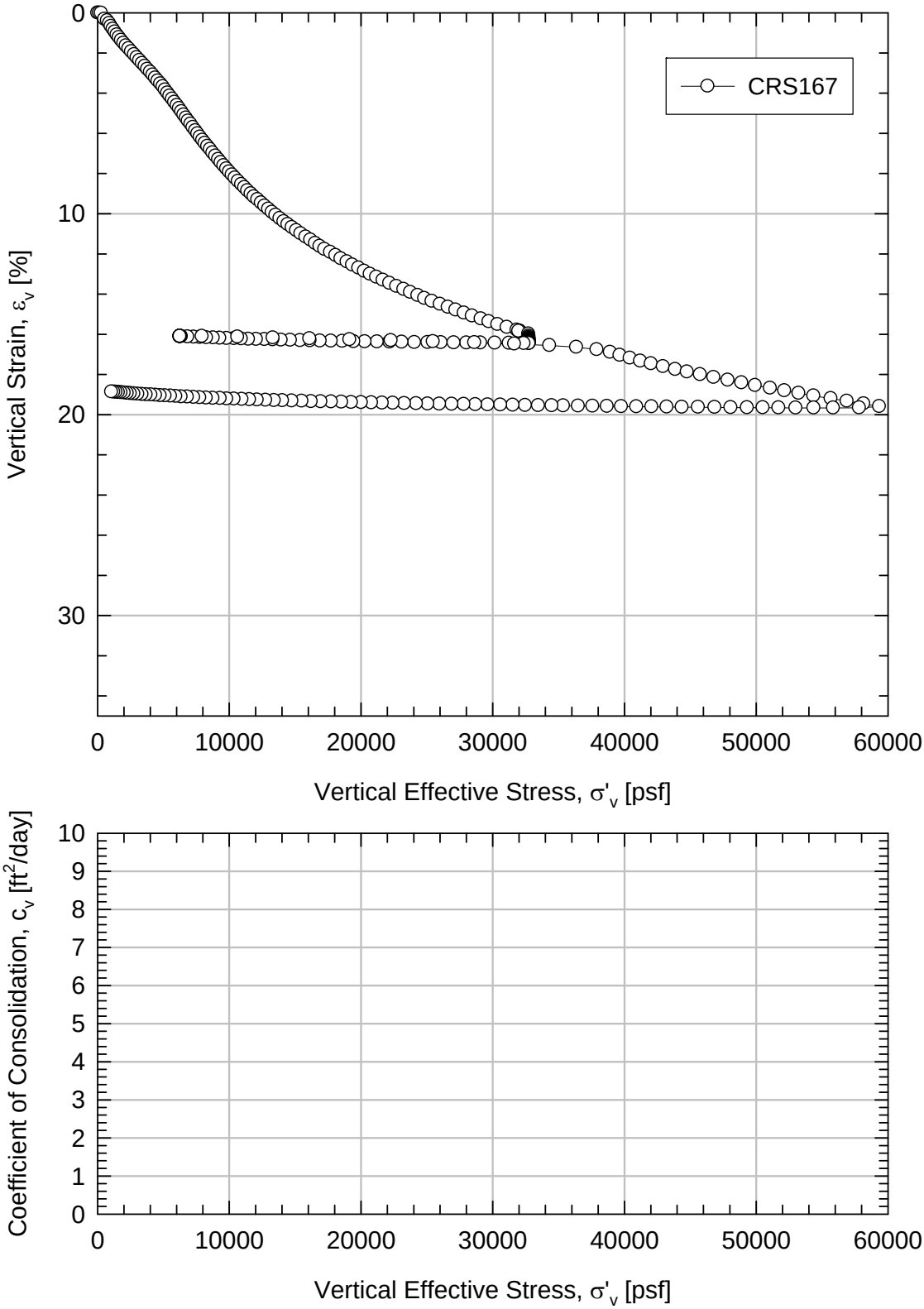

Figure 5.3.17 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS167 on sample 09-100B S5 33.0-35.5 ft.

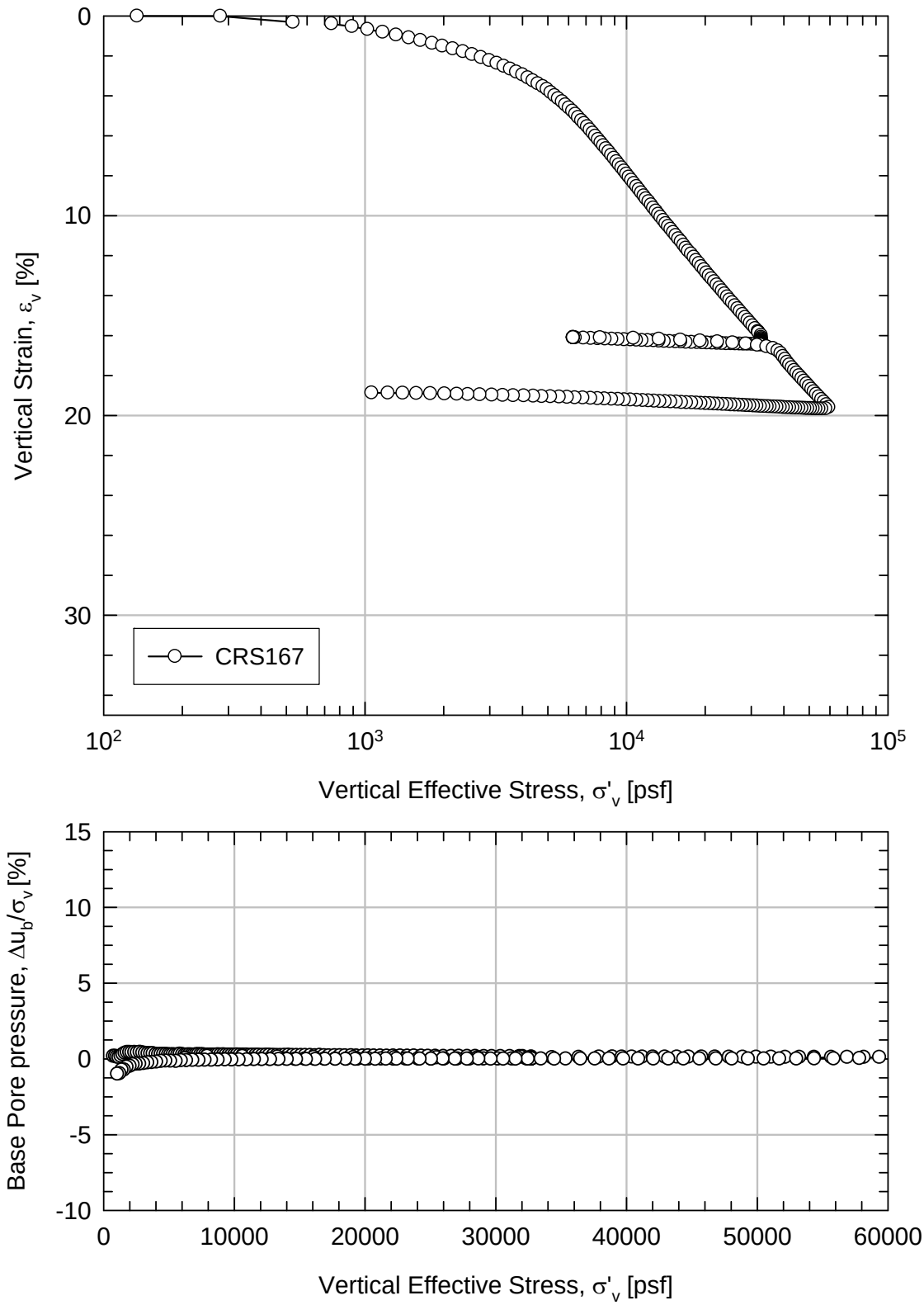

Figure 5.3.18 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS167 on sample 09-100B S5 33.0-35.5 ft.

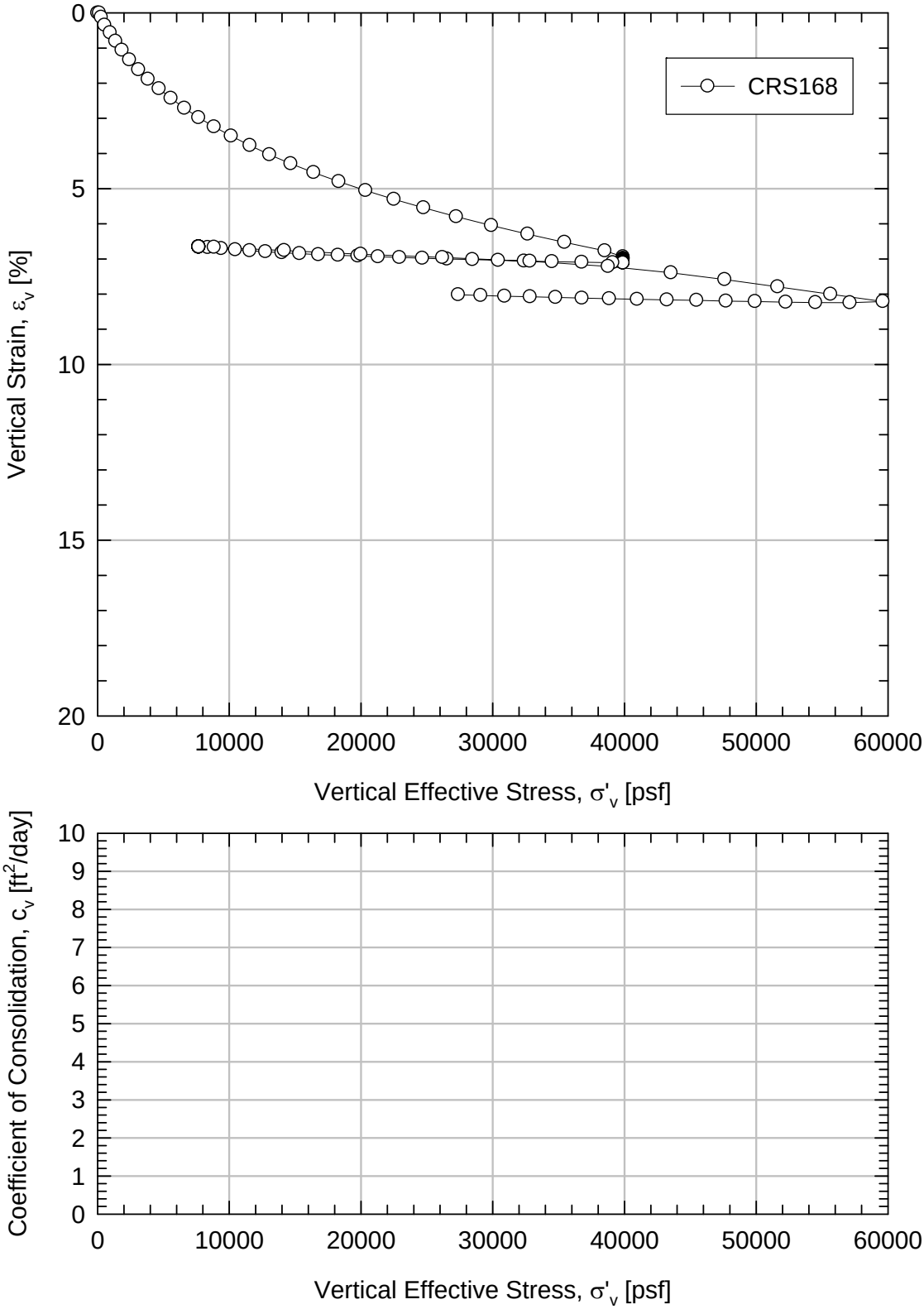

Figure 5.3.19 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS168 on sample 09-103B S5 41.0-43.5 ft.

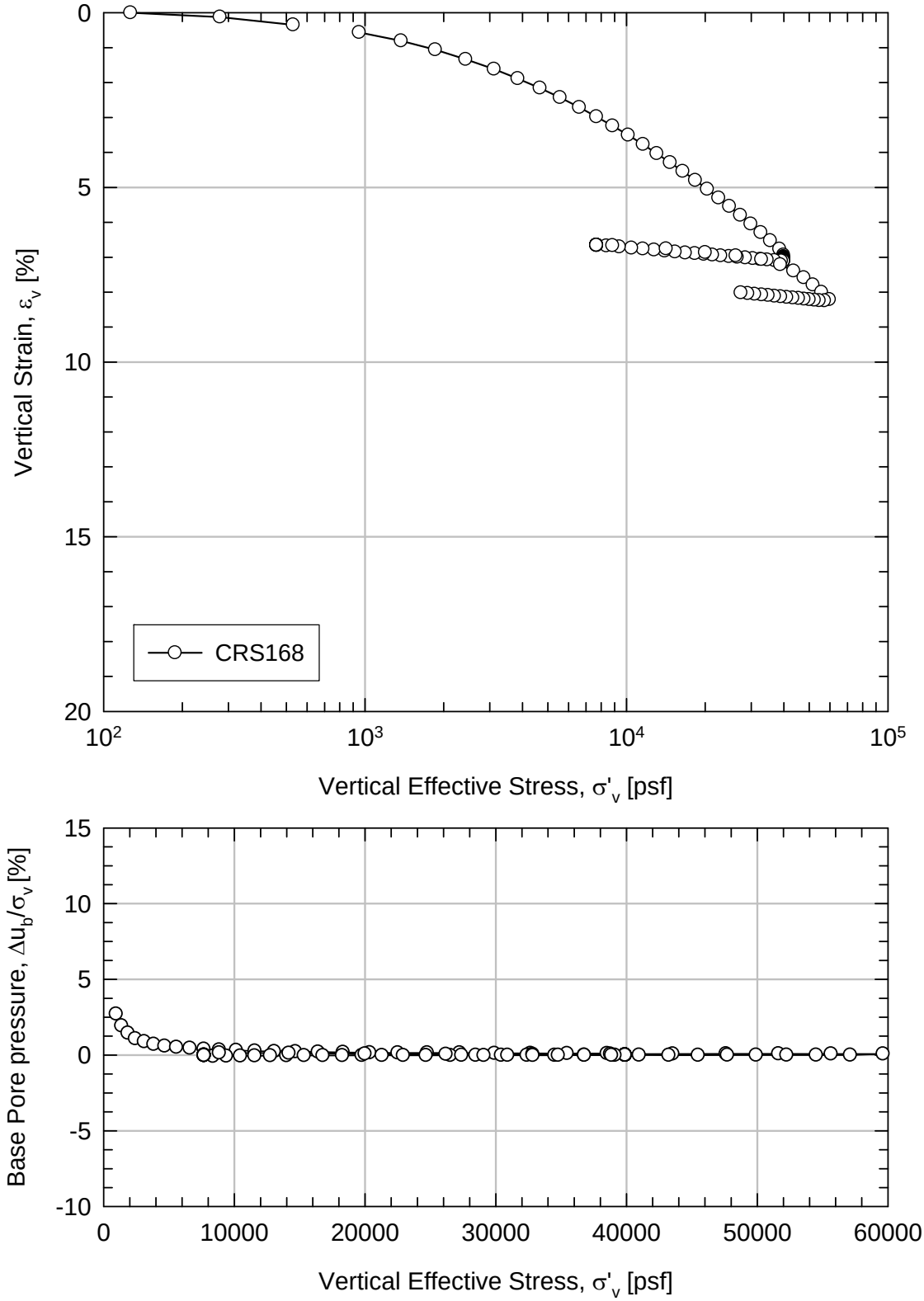

Figure 5.3.20 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS168 on sample 09-103B S5 41.0-43.5 ft.

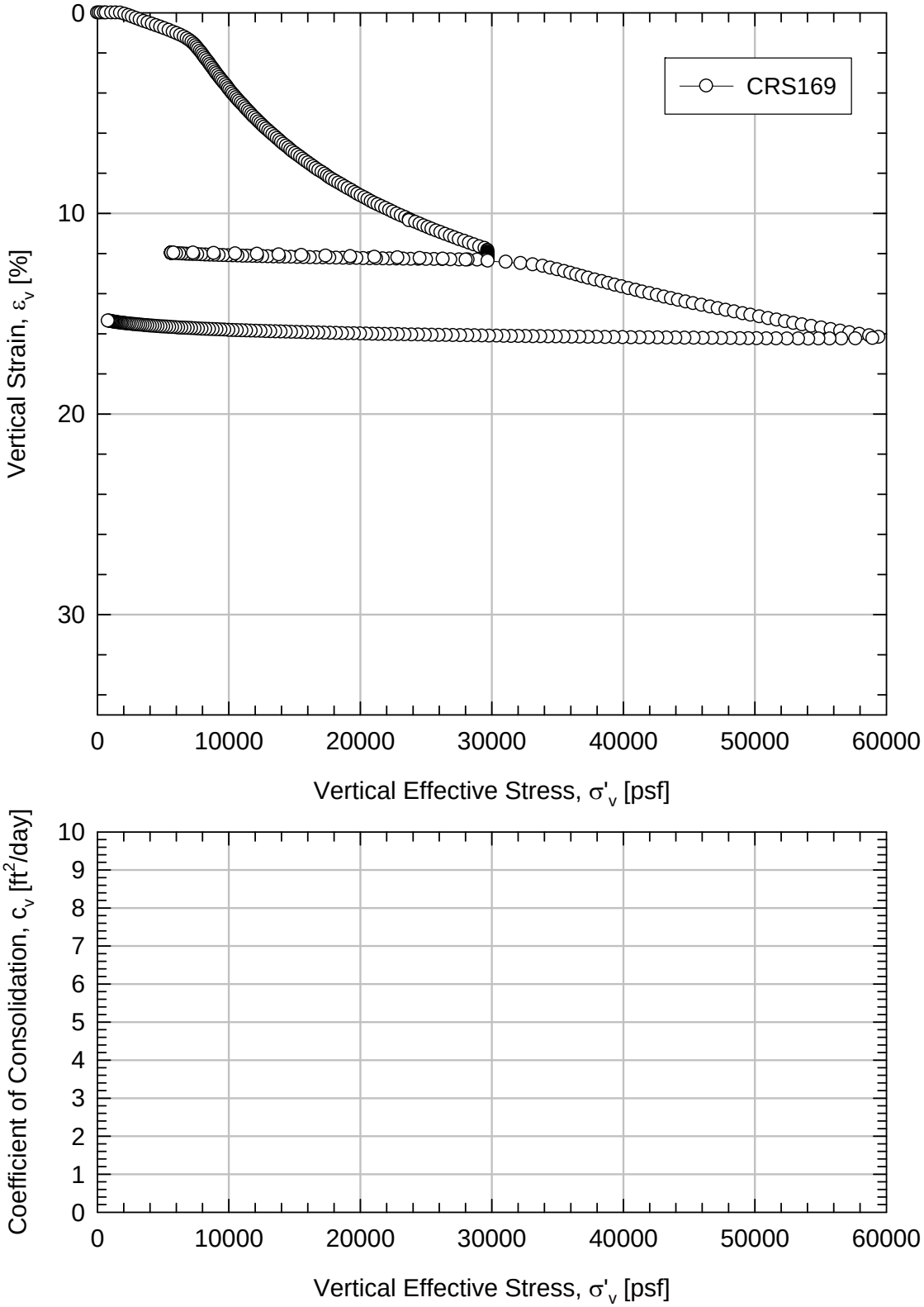

Figure 5.3.21 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS169 on sample 09-408B S7 35.5-38.0 ft.

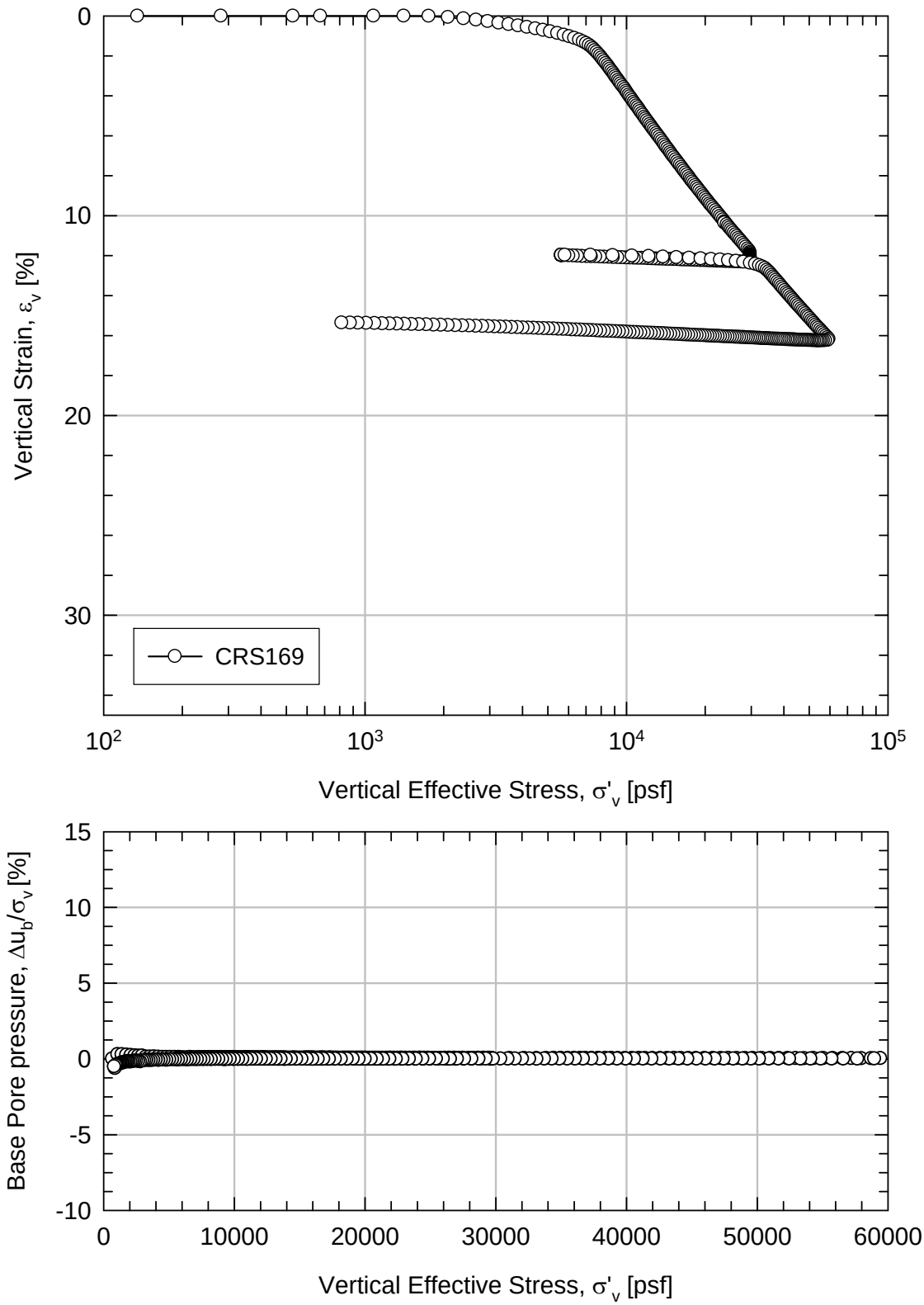

Figure 5.3.22 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS169 on sample 09-408B S7 35.5-38.0 ft.

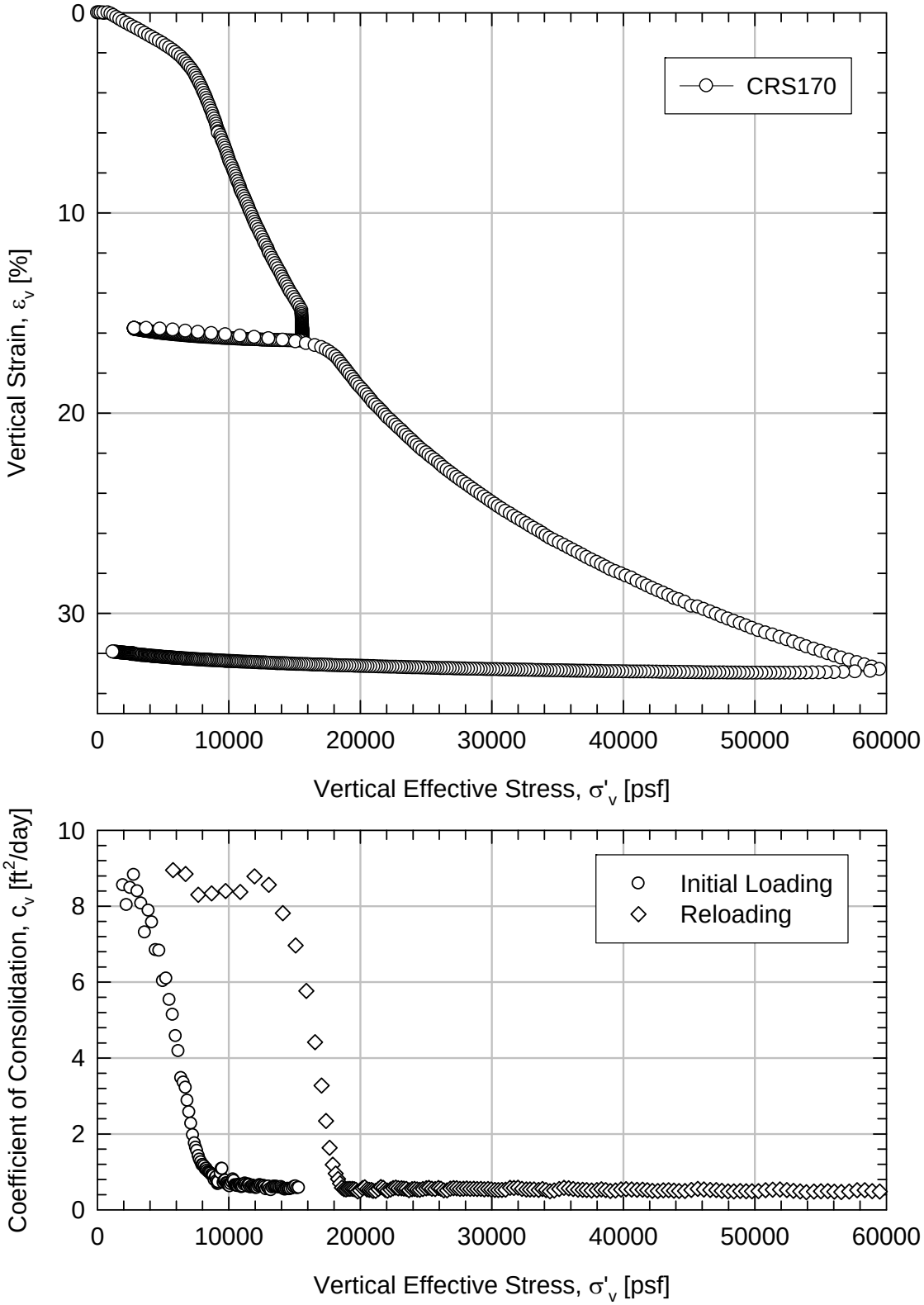

Figure 5.3.23 Vertical strain and coefficient of consolidation versus vertical effective stress for test CRS170 on sample 09-503B S3 35.5-38.0 ft.

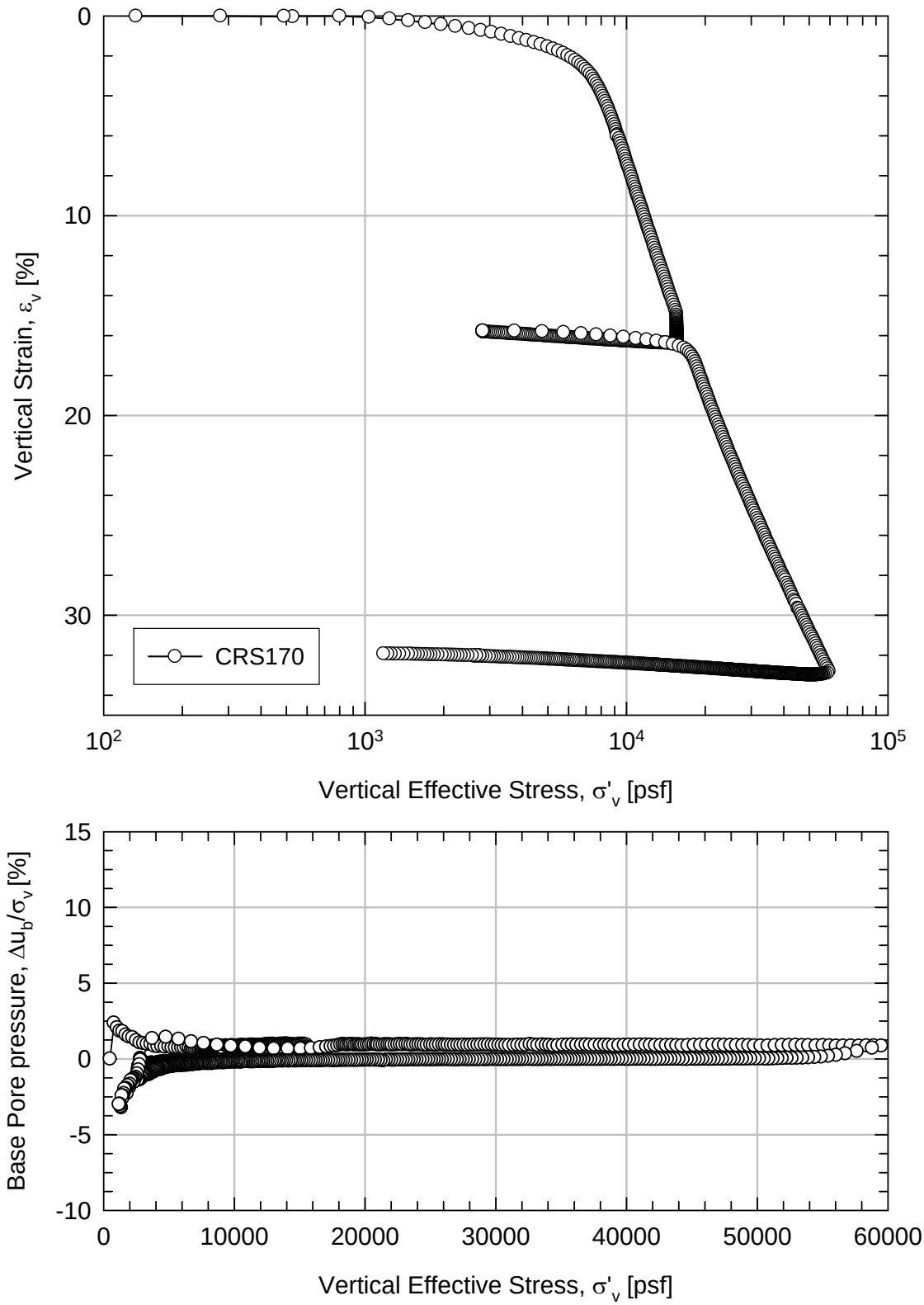

Figure 5.3.24 Vertical strain and normalized base pore pressure versus vertical effective stress for test CRS170 on sample 09-503B S3 35.5-38.0 ft.

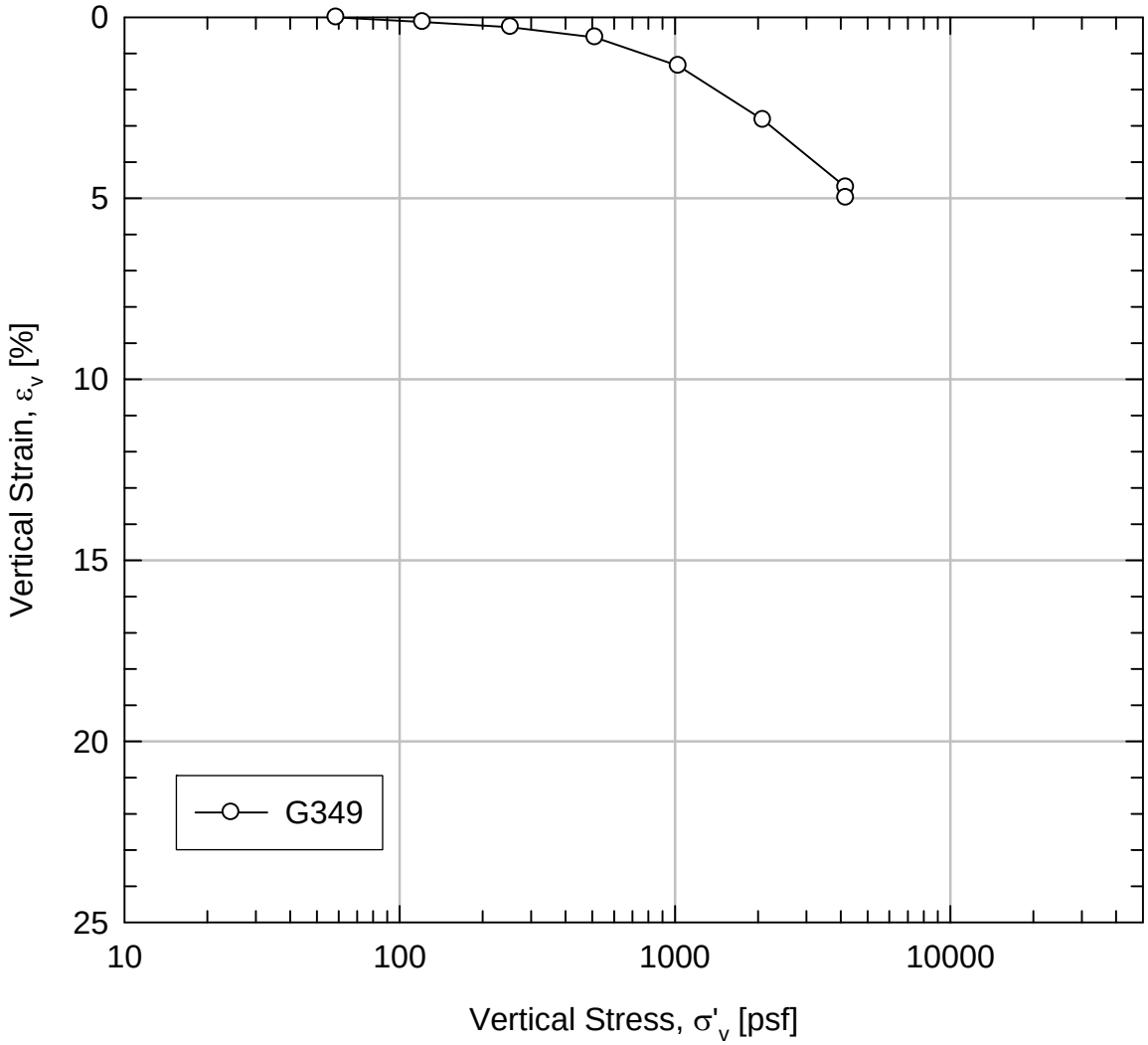

Figure 5.4.1 Vertical strain versus vertical effective stress for test DSS G349 on sample 09-301B S6 87.5-90.0 ft

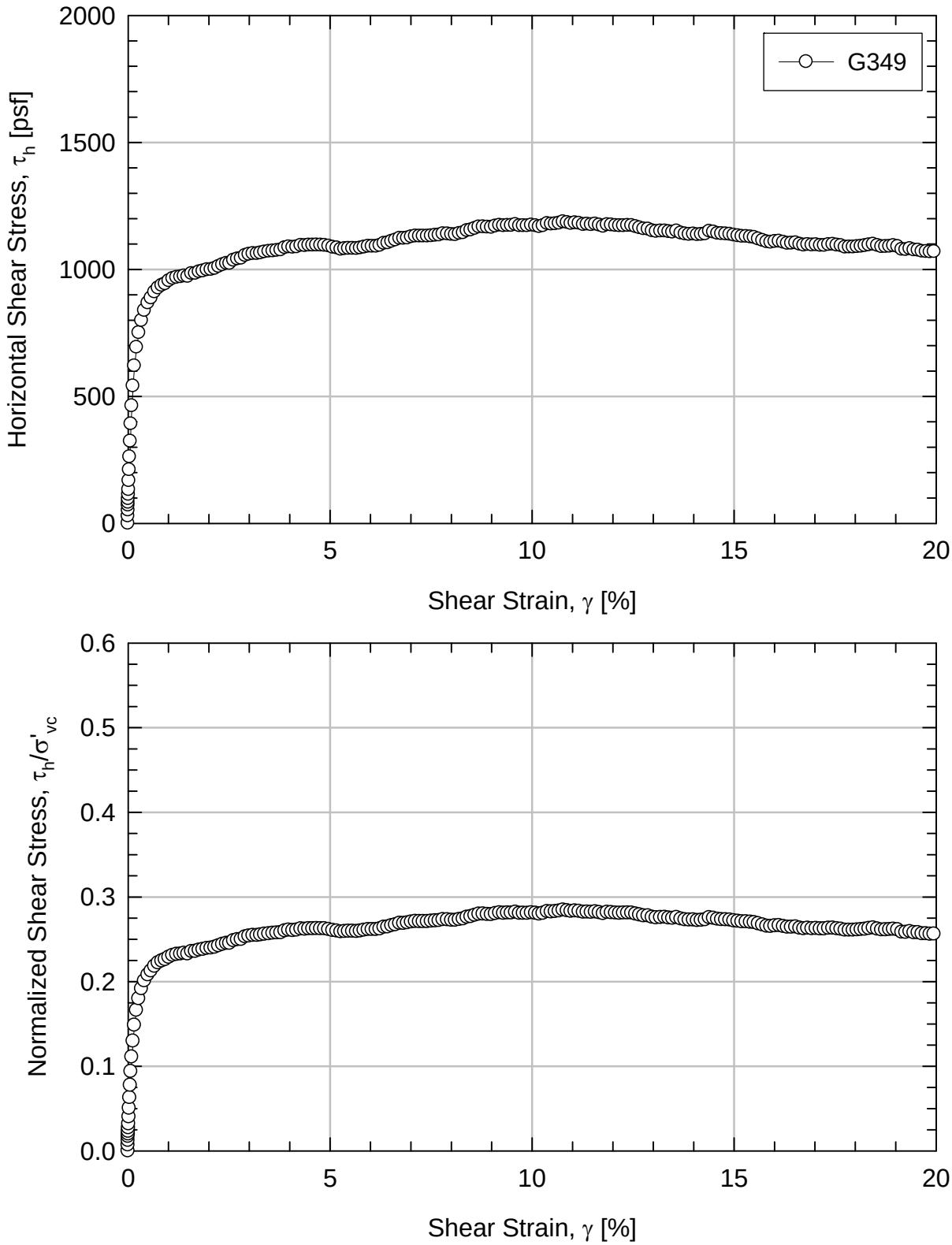

Figure 5.4.2 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G349 on sample 09-301B S6 87.5-90.0 ft

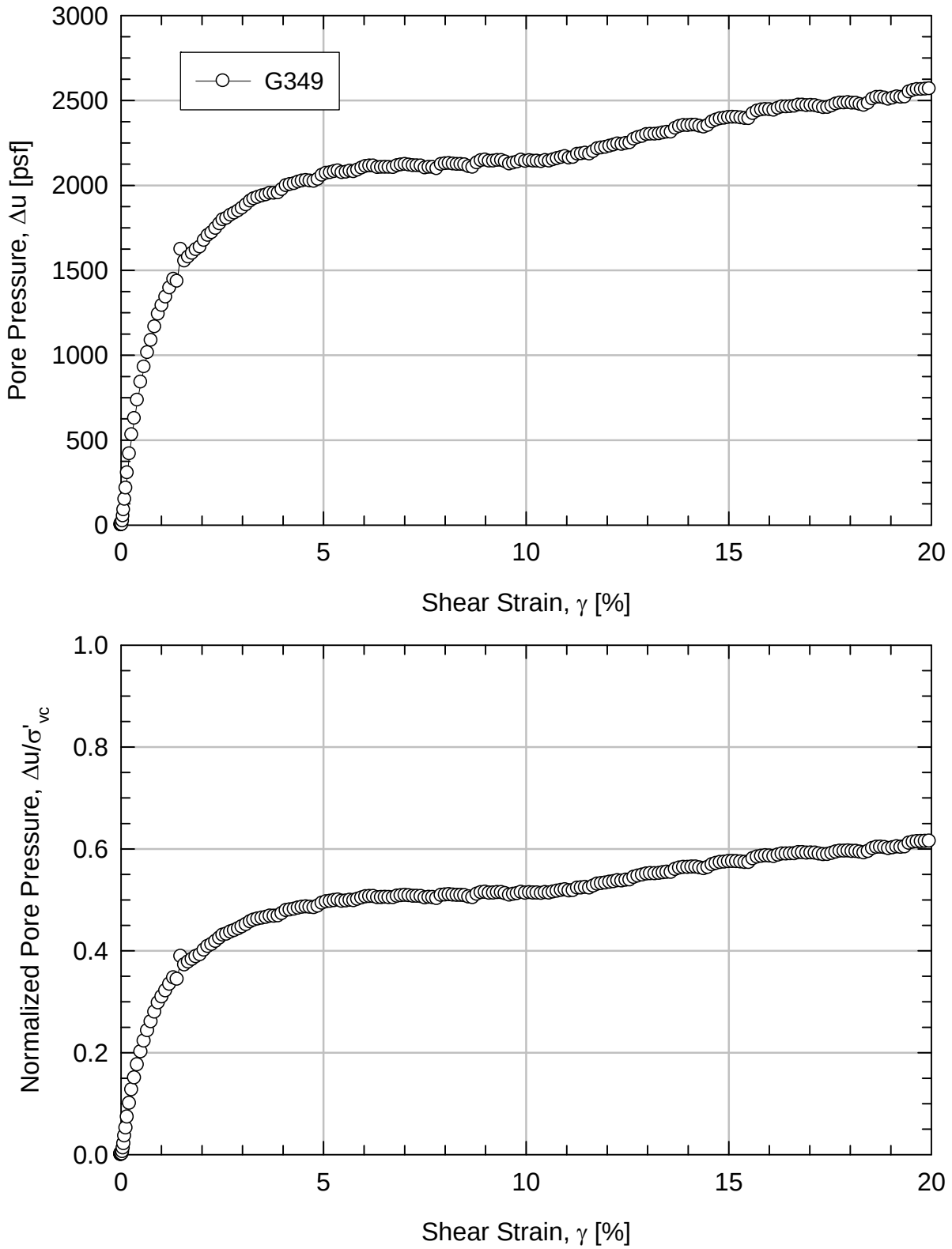

Figure 5.4.3 Pore pressure and normalized pore pressure versus shear strain for test DSS G349 on sample 09-301B S6 87.5-90.0 ft

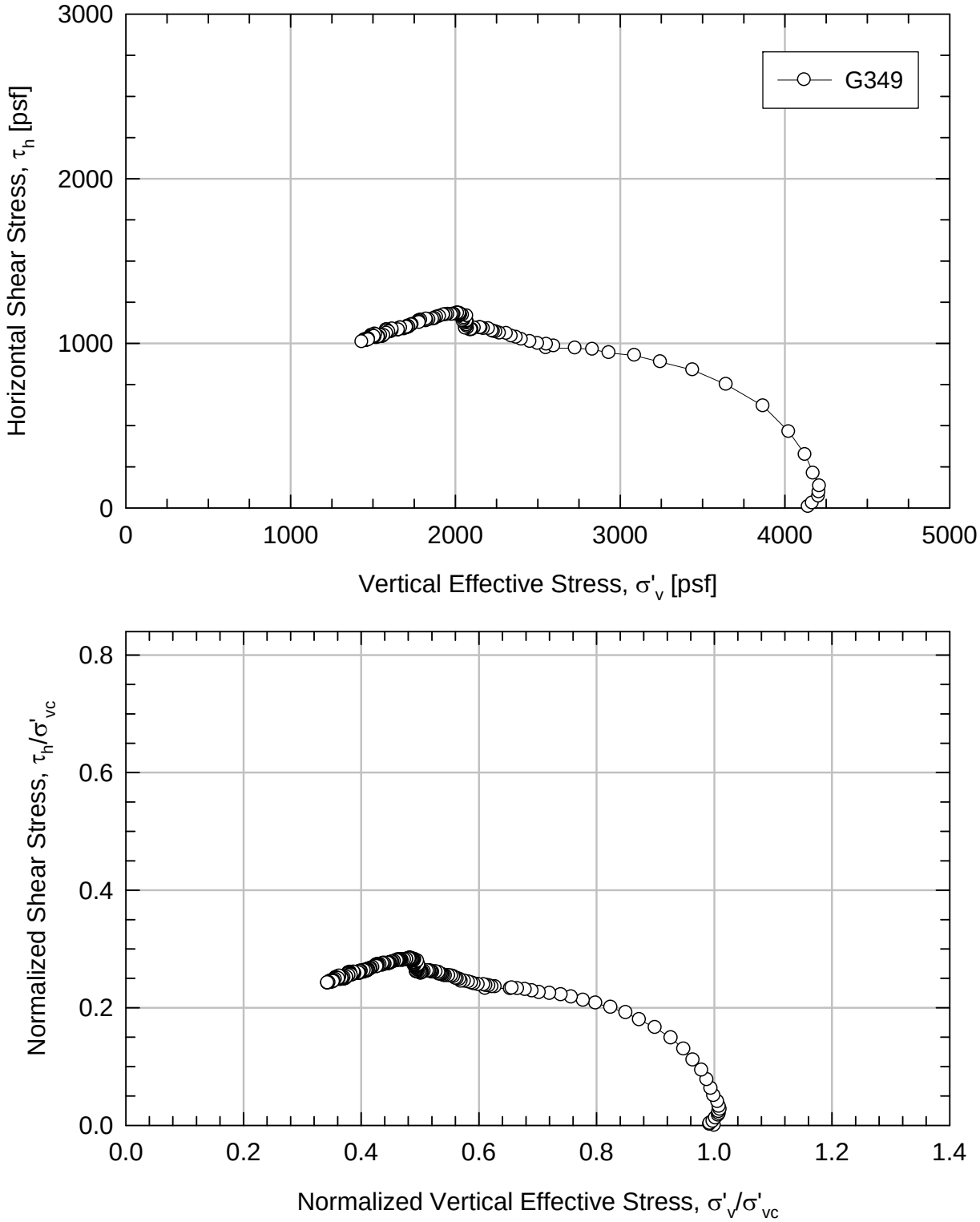

Figure 5.4.4 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G349 on sample 09-301B S6 87.5-90.0 ft.

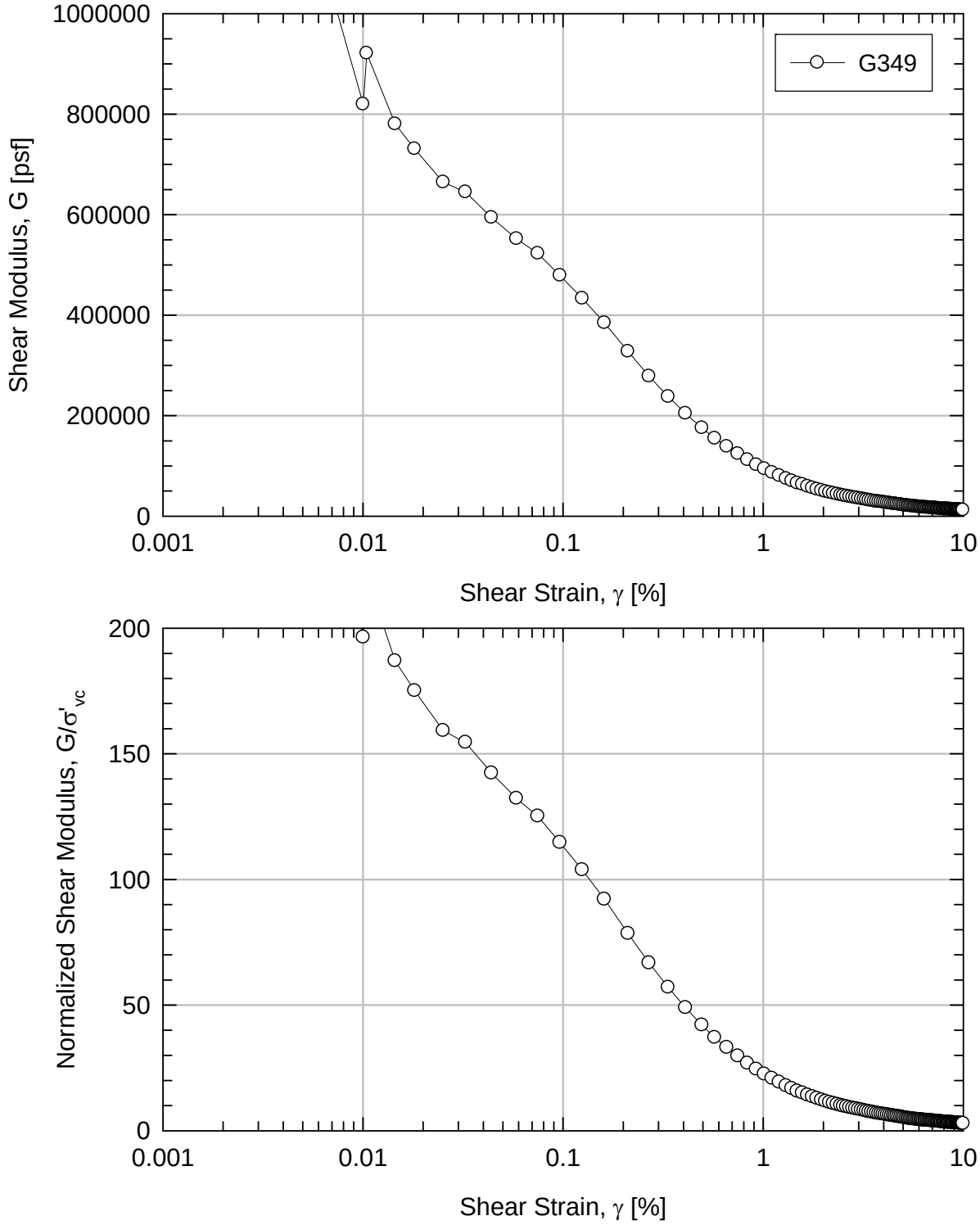

Figure 5.4.5 Shear modulus and normalized shear modulus versus shear strain for test DSS G349 on sample 09-301B S6 87.5-90.0 ft

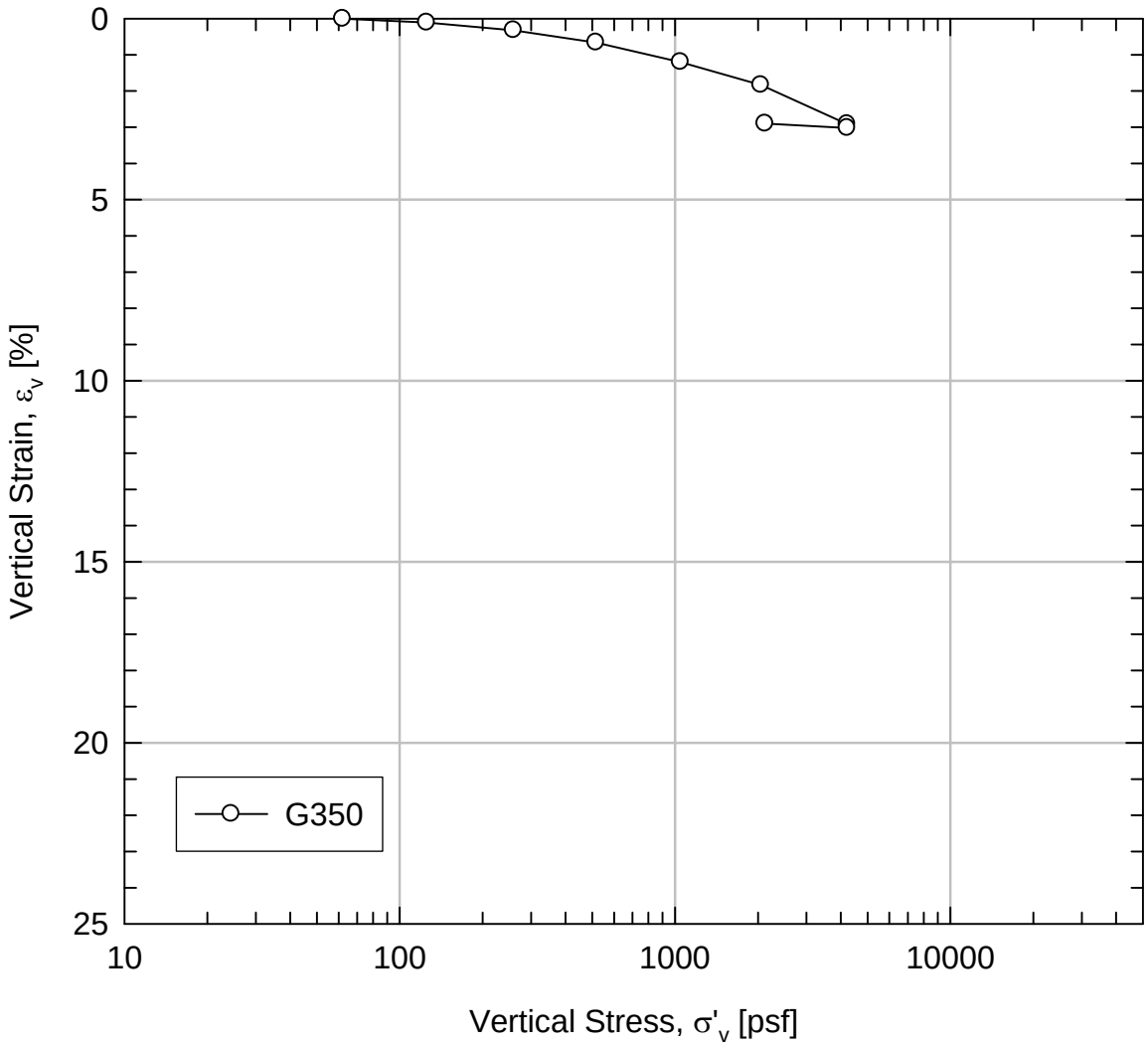

Figure 5.4.6 Vertical strain versus vertical effective stress for test DSS G350 on sample 09-101B S5 38.0-40.5 ft.

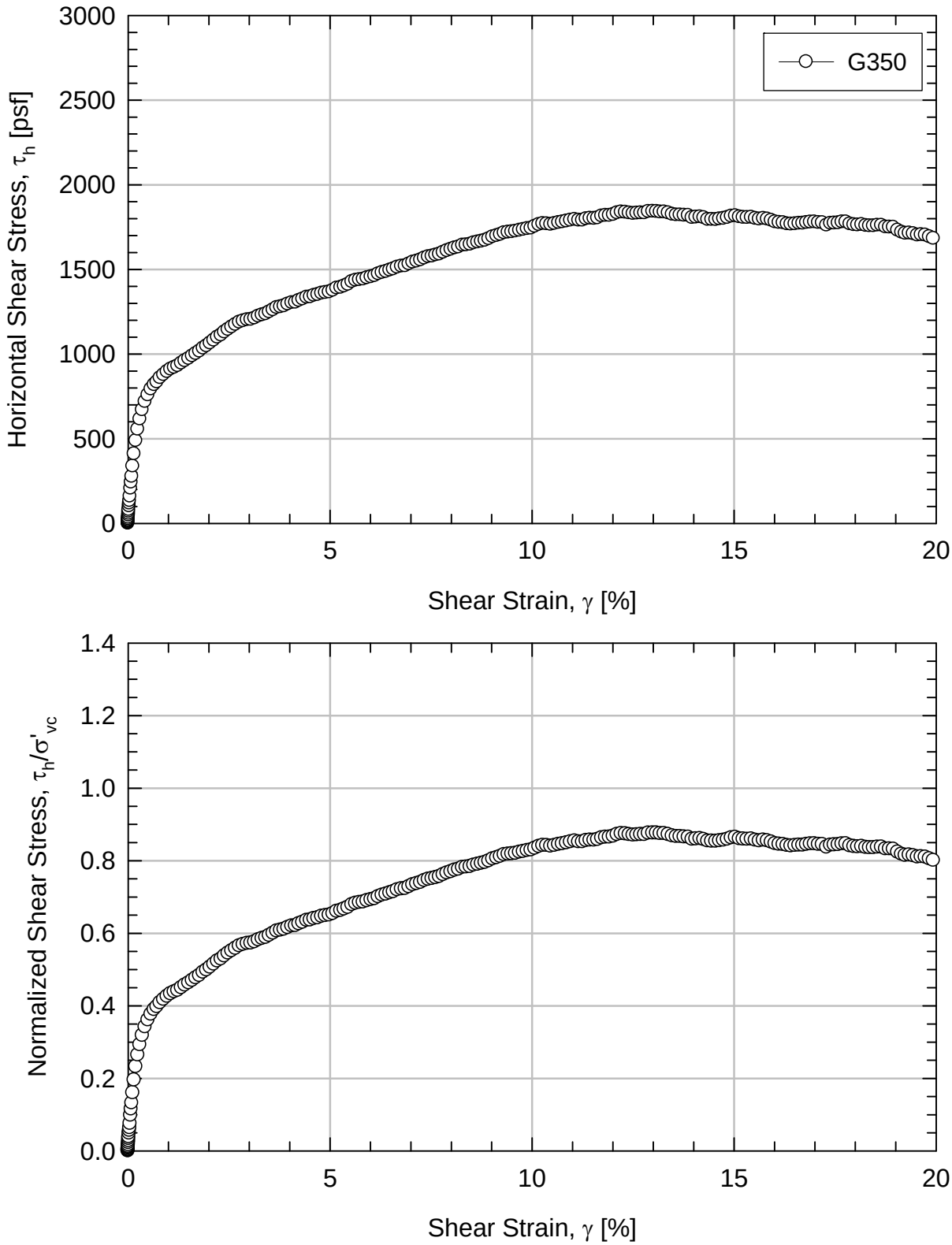

Figure 5.4.7 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G350 on sample 09-101B S5 38.0-40.5 ft.

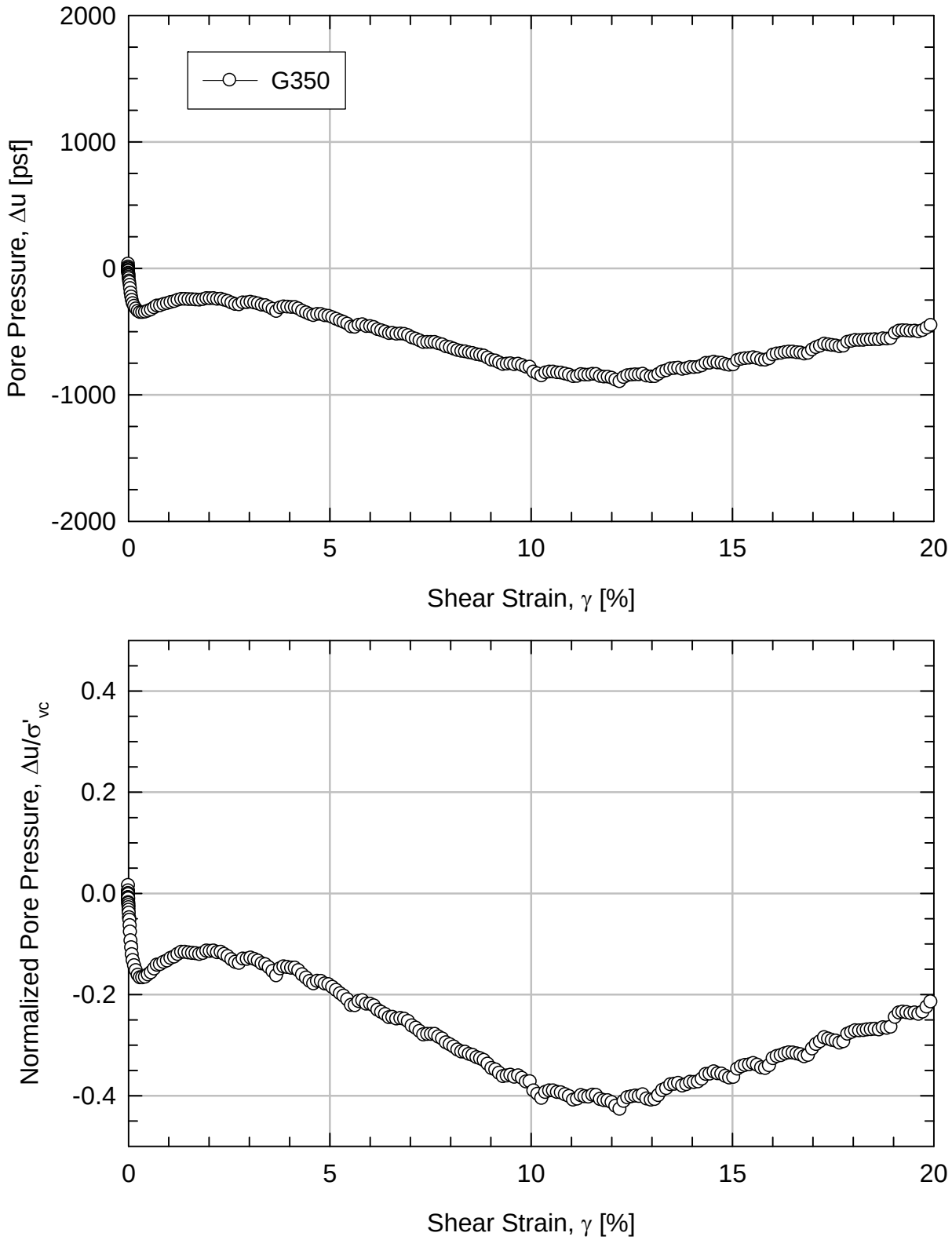

Figure 5.4.8 Pore pressure and normalized pore pressure versus shear strain for test DSS G350 on sample 09-101B S5 38.0-40.5 ft.

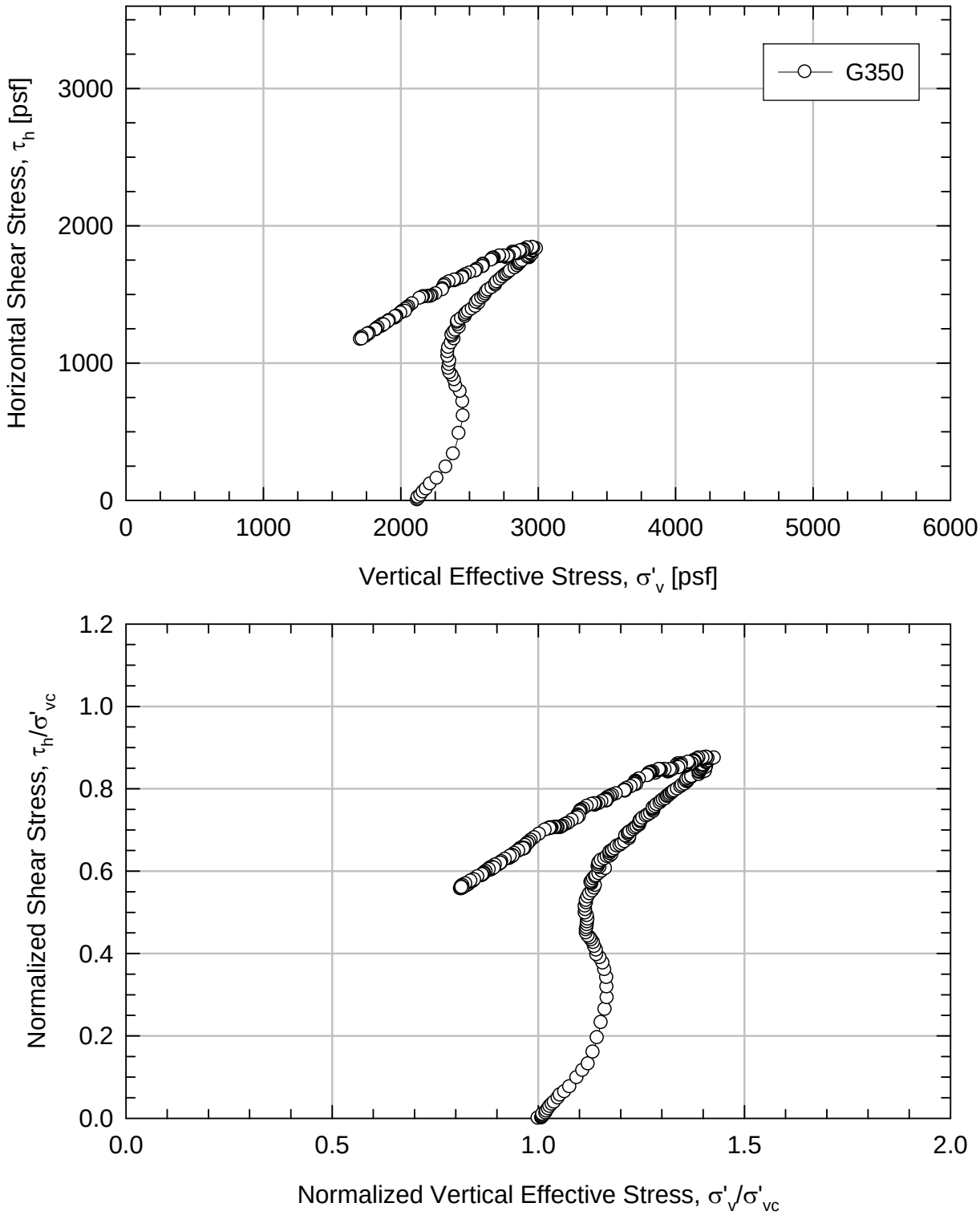

Figure 5.4.9 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G350 on sample 09-101B S5 38.0-40.5 ft.

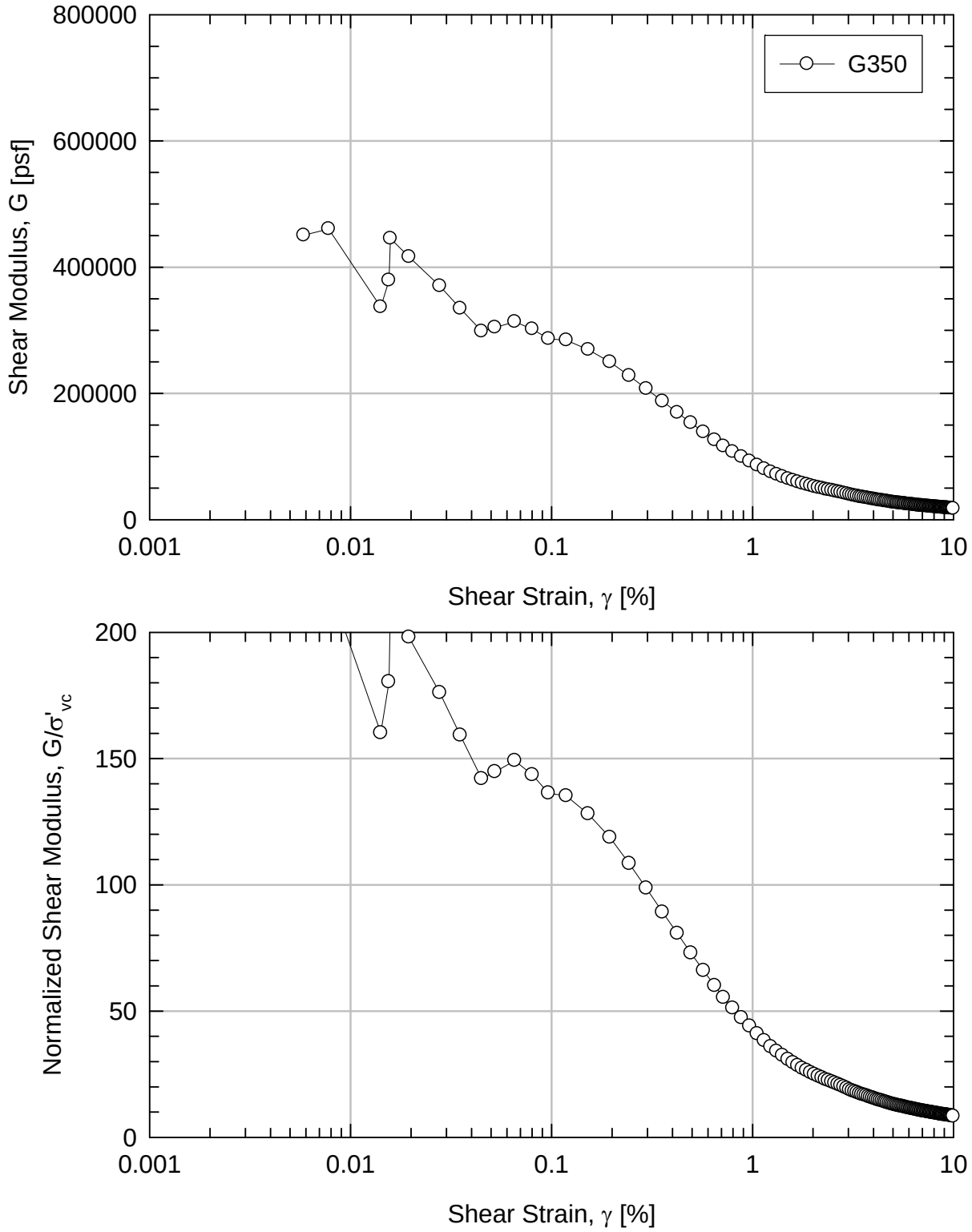

Figure 5.4.10 Shear modulus and normalized shear modulus versus shear strain for test DSS G350 on sample 09-101B S5 38.0-40.5 ft.

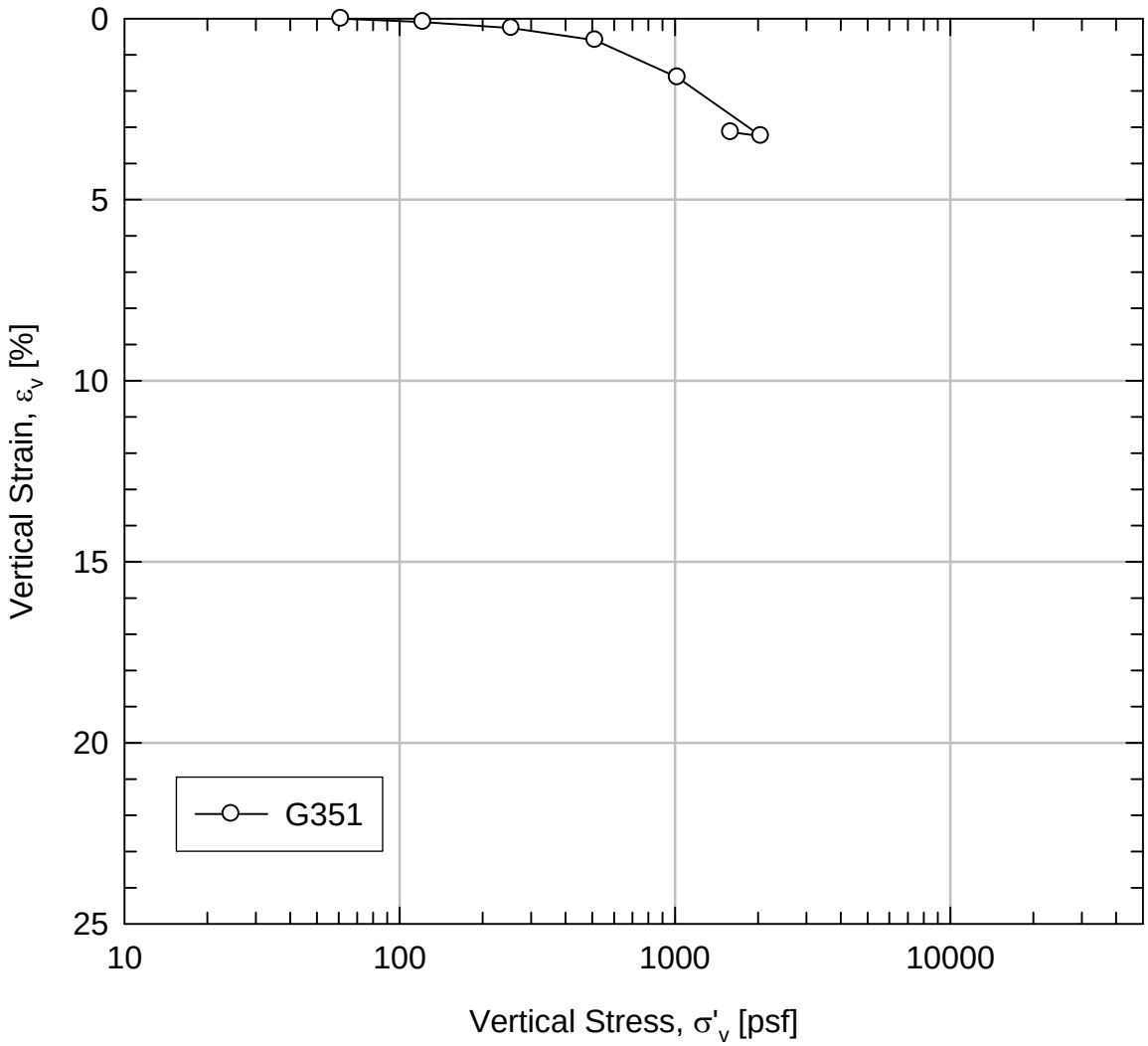

Figure 5.4.11 Vertical strain versus vertical effective stress for test DSS G351 on sample 09-108B S2 23.5-26.0 ft.

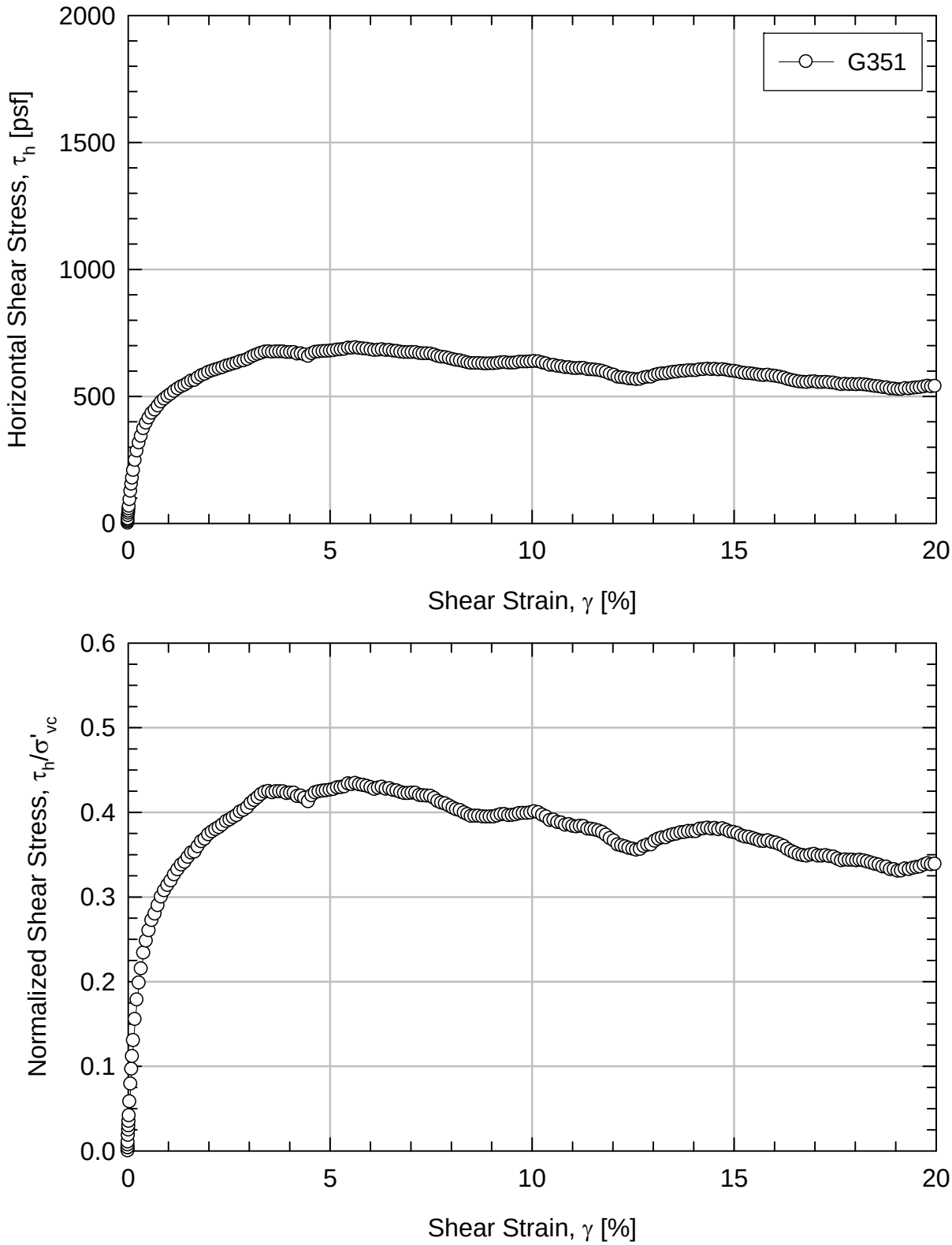

Figure 5.4.12 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G351 on sample 09-108B S2 23.5-26.0 ft.

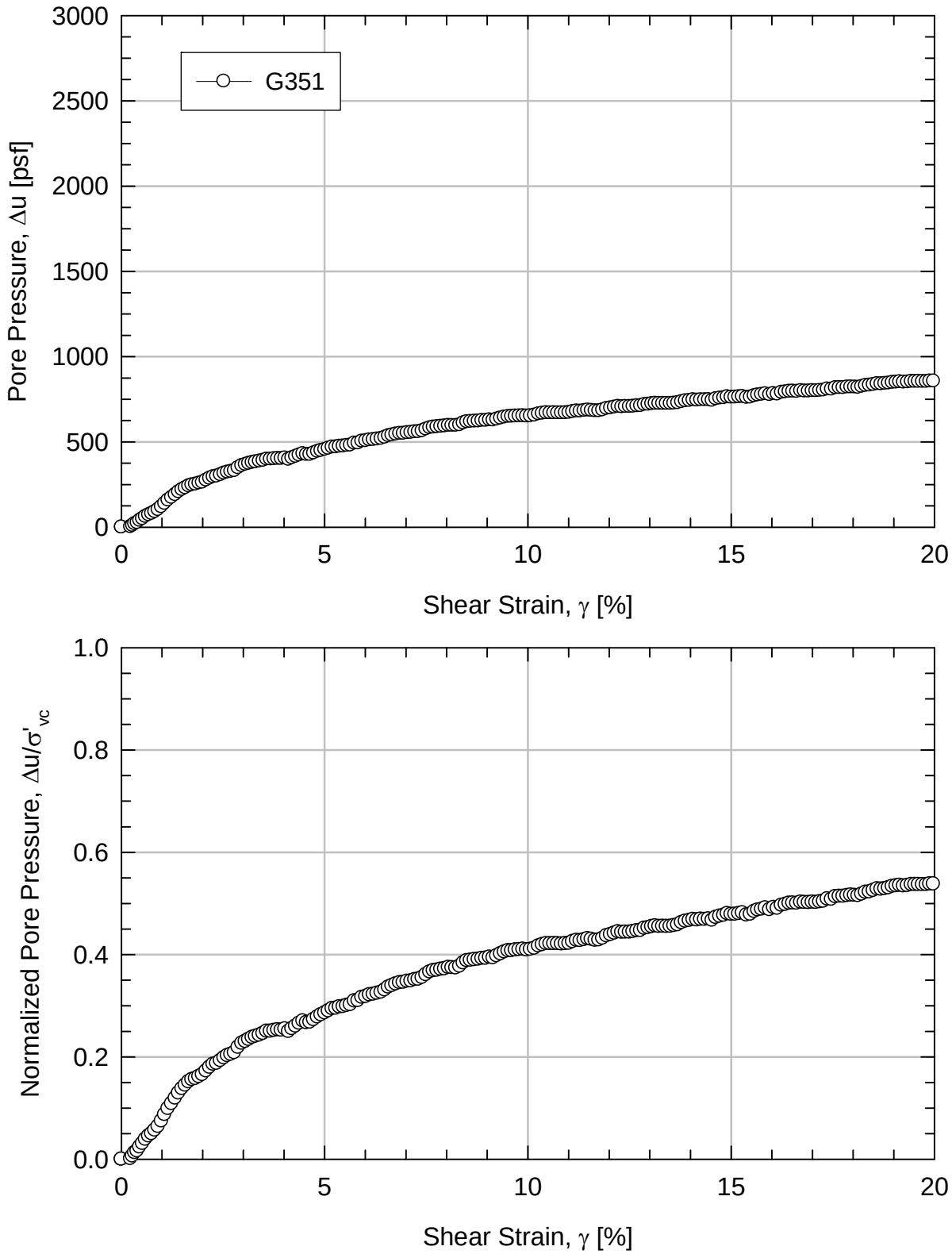

Figure 5.4.13 Pore pressure and normalized pore pressure versus shear strain for test DSS G351 on sample 09-108B S2 23.5-26.0 ft.

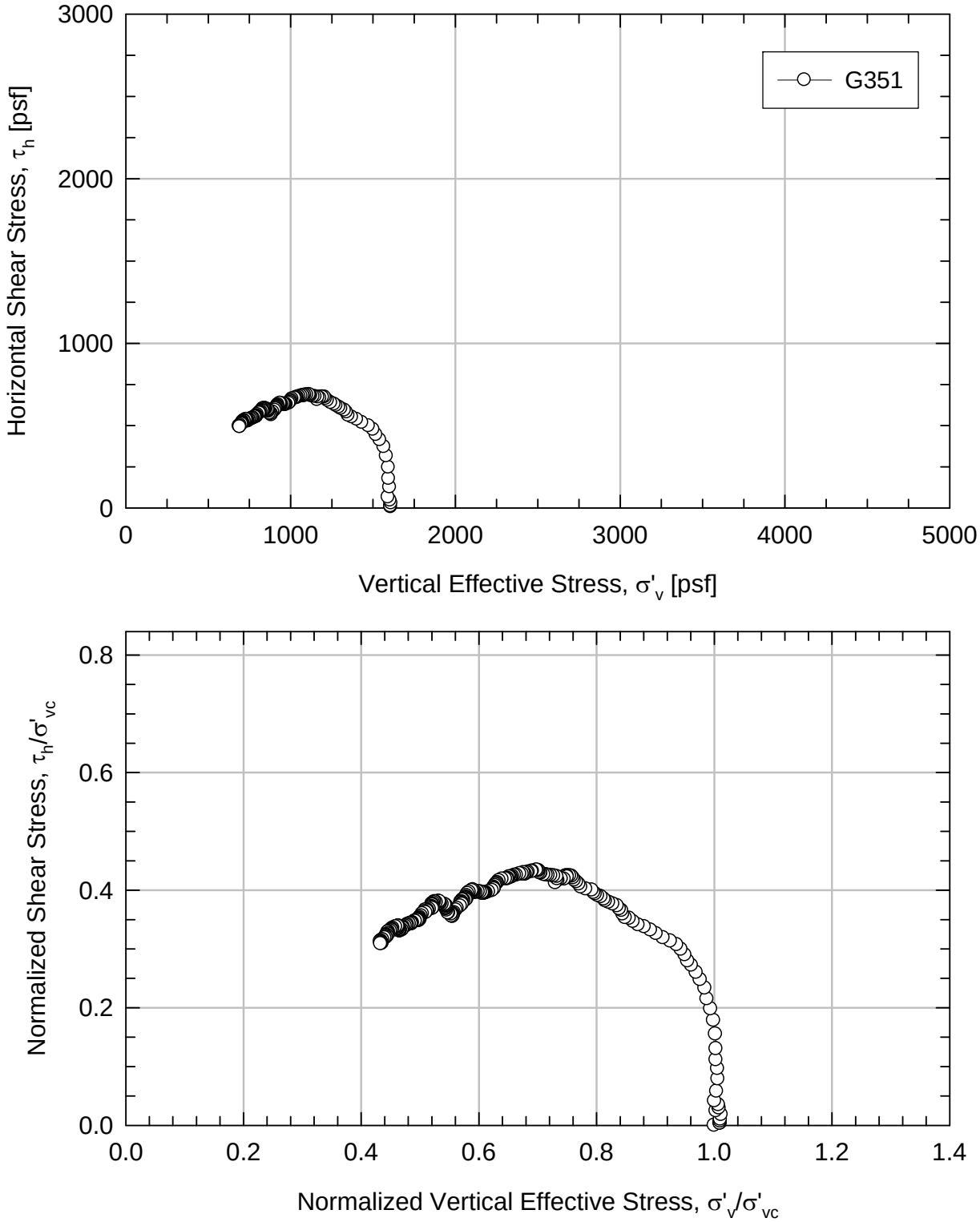

Figure 5.4.14 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G351 on sample 09-108B S2 23.5-26.0 ft.

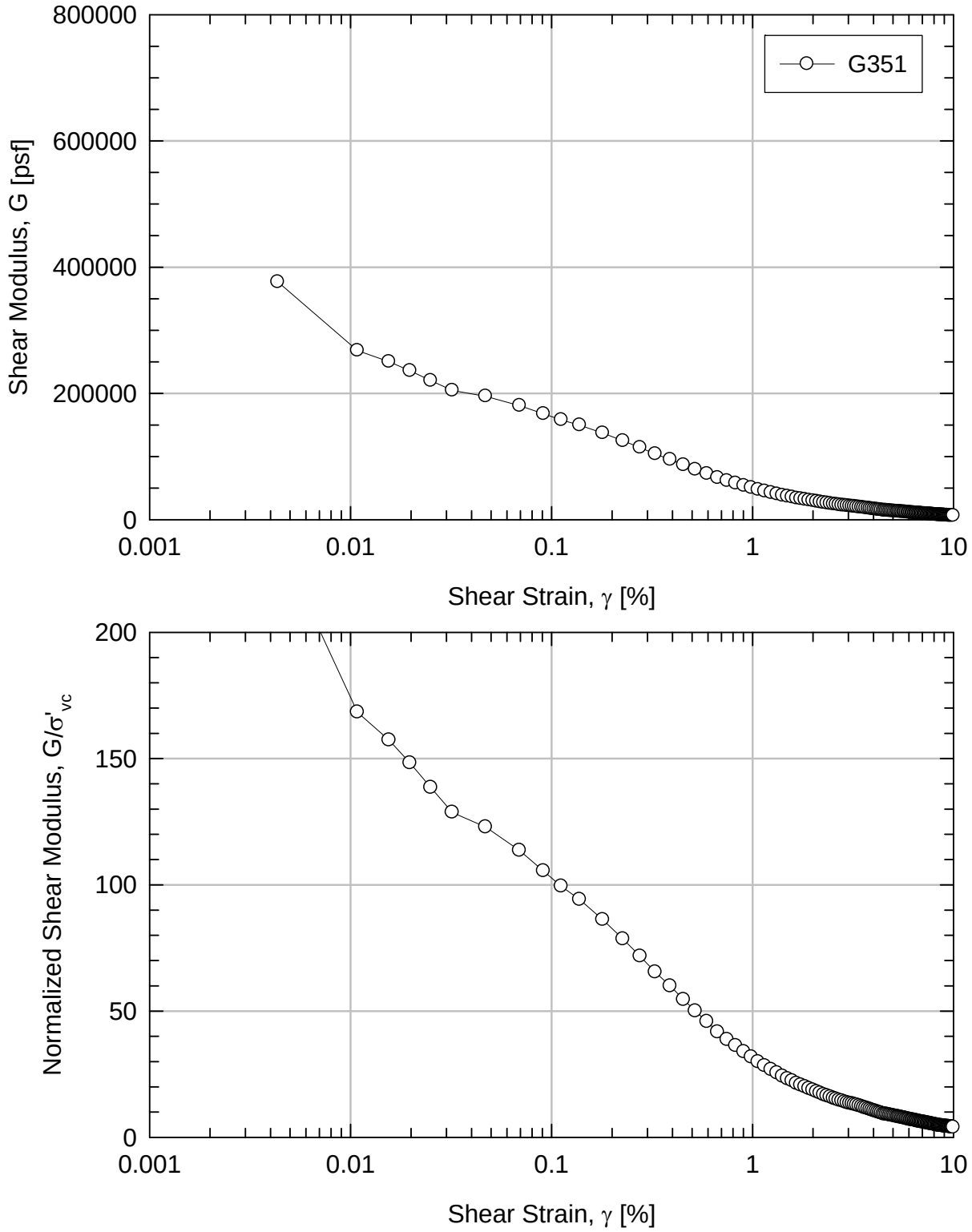

Figure 5.4.15 Shear modulus and normalized shear modulus versus shear strain for test DSS G351 on sample 09-108B S2 23.5-26.0 ft.

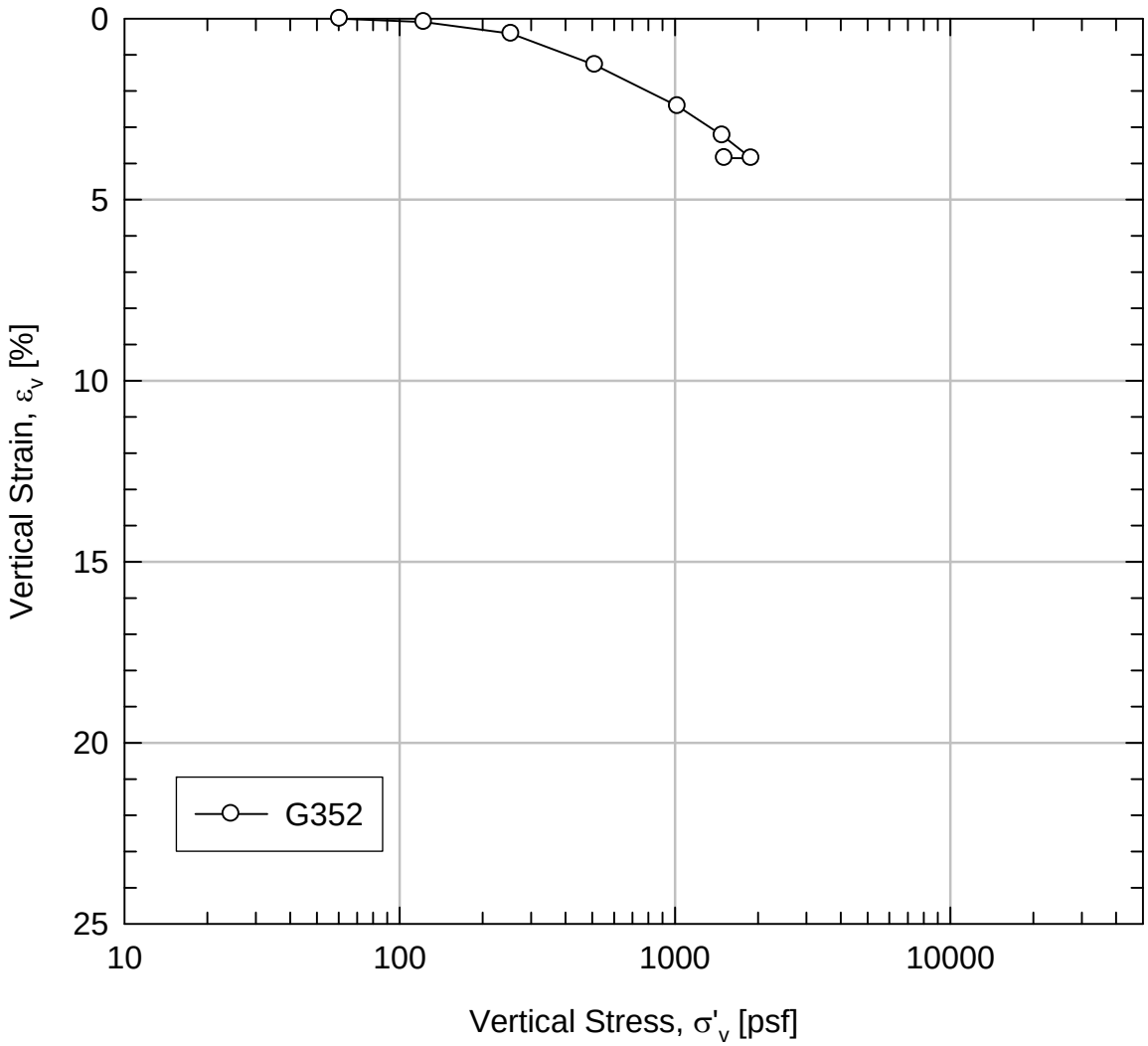

Figure 5.4.16 Vertical strain versus vertical effective stress for test DSS G352 on sample 09-109B S3 25.5-28.0 ft.

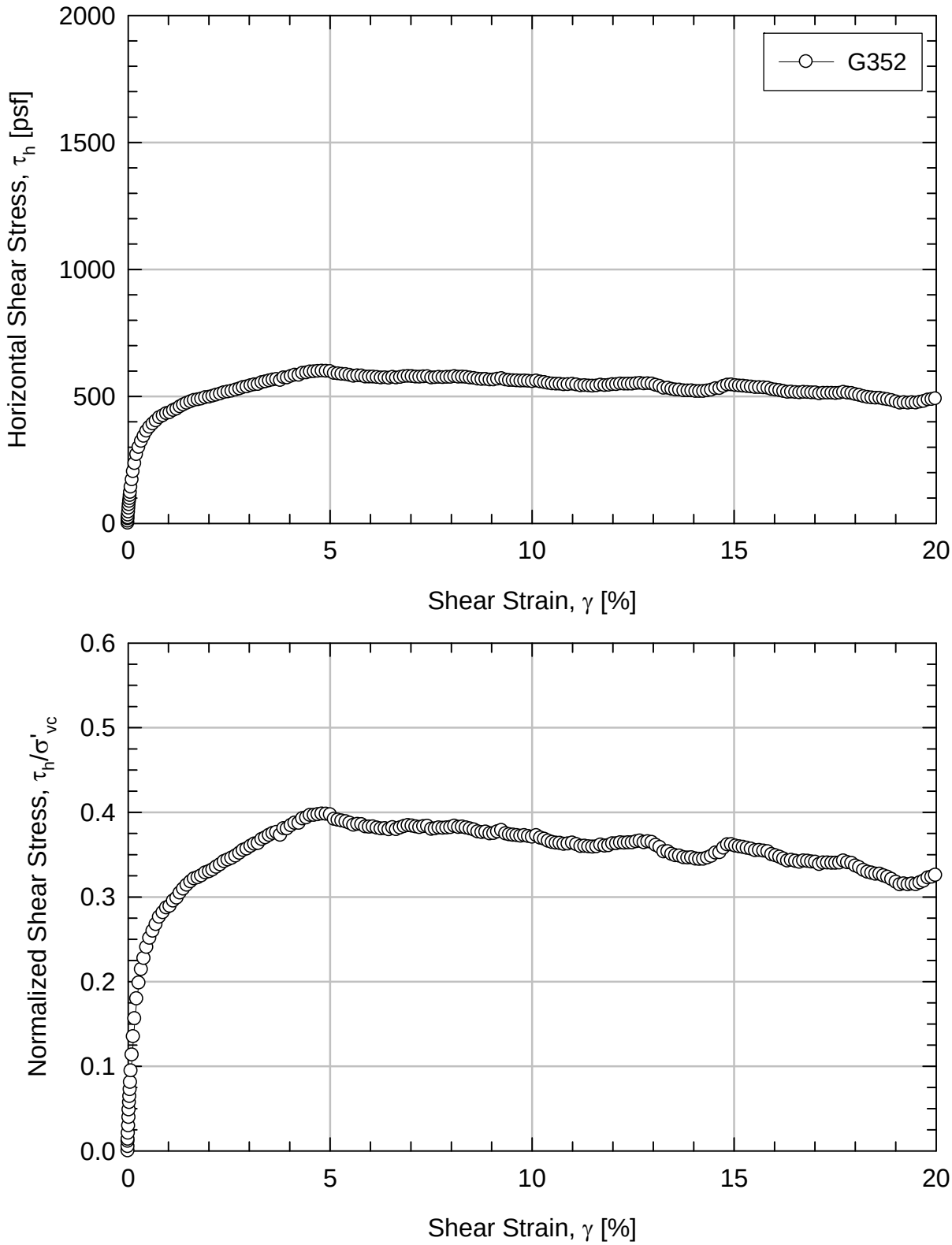

Figure 5.4.17 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G352 on sample 09-109B S3 25.5-28.0 ft.

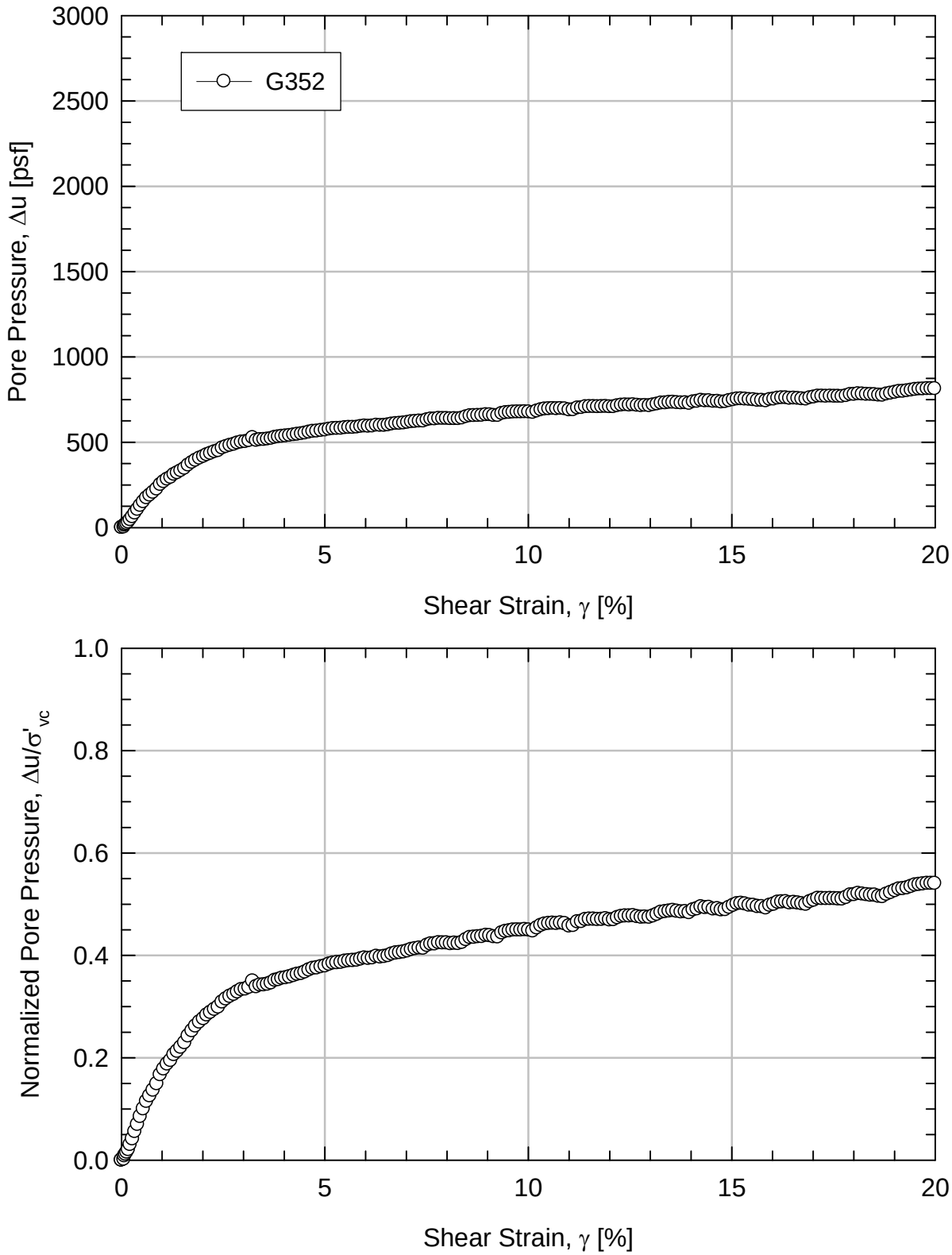

Figure 5.4.18 Pore pressure and normalized pore pressure versus shear strain for test DSS G352 on sample 09-109B S3 25.5-28.0 ft.

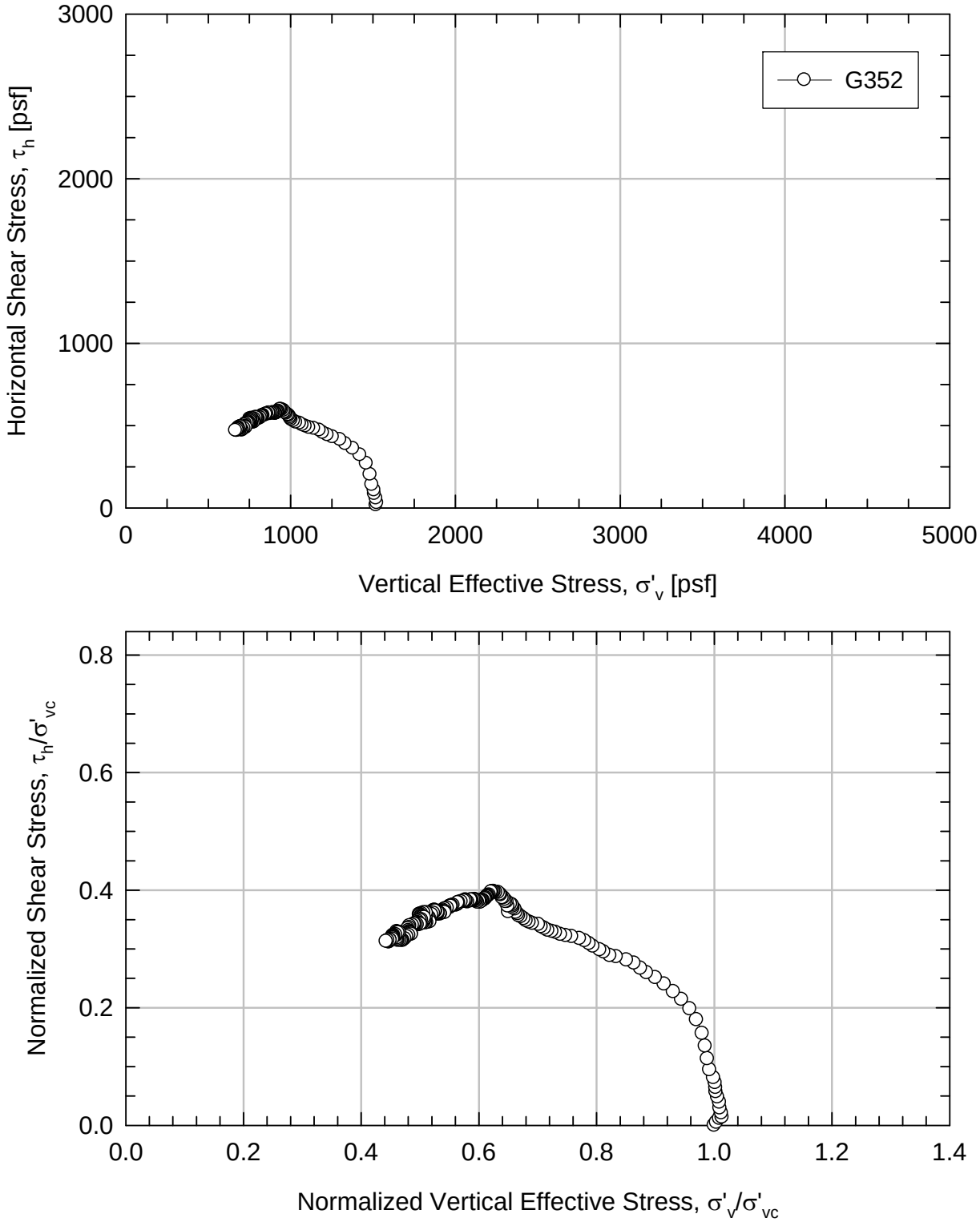

Figure 5.4.19 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G352 on sample 09-109B S3 25.5-28.0 ft.

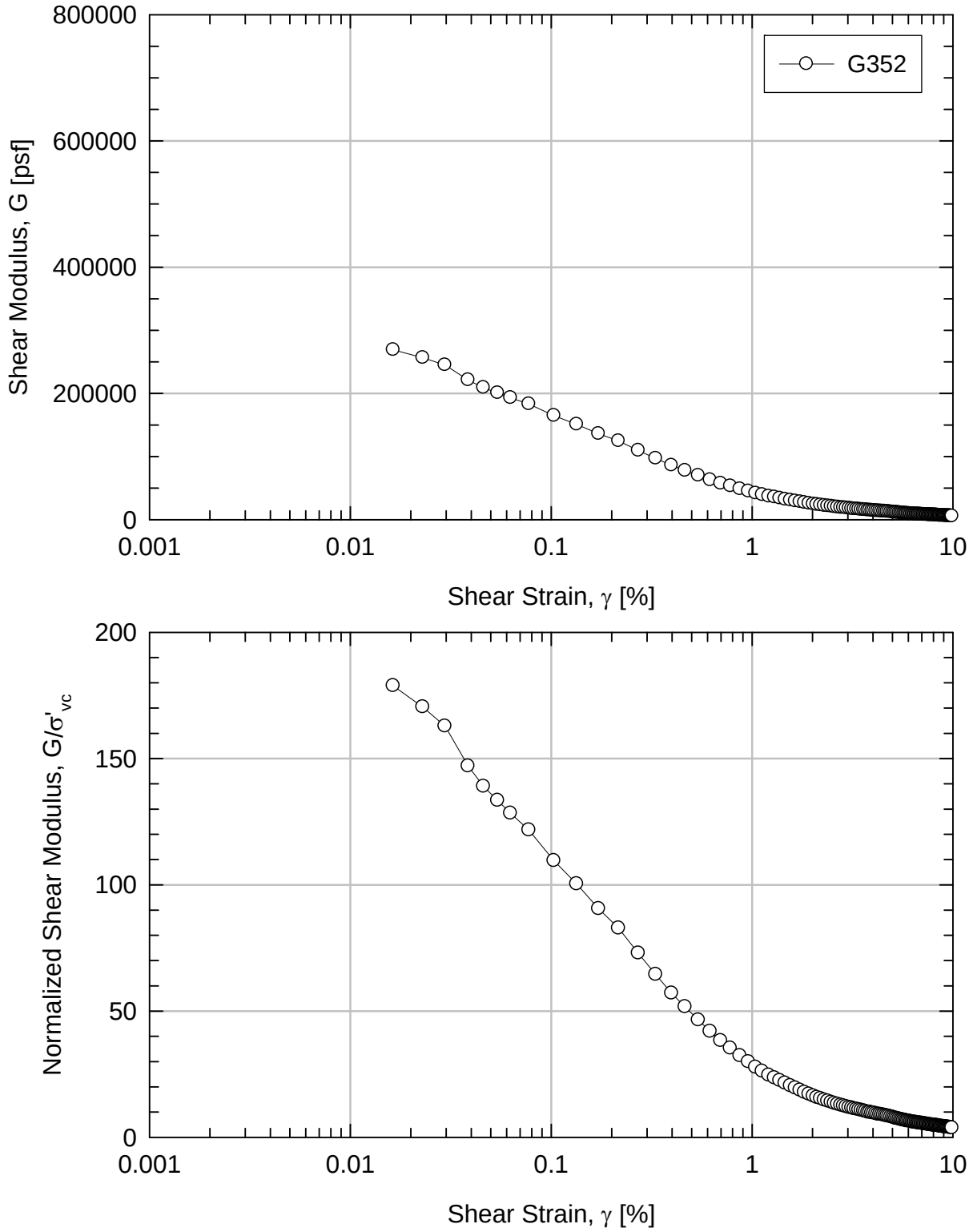

Figure 5.4.20 Shear modulus and normalized shear modulus versus shear strain for test DSS G352 on sample 09-109B S3 25.5-28.0 ft.

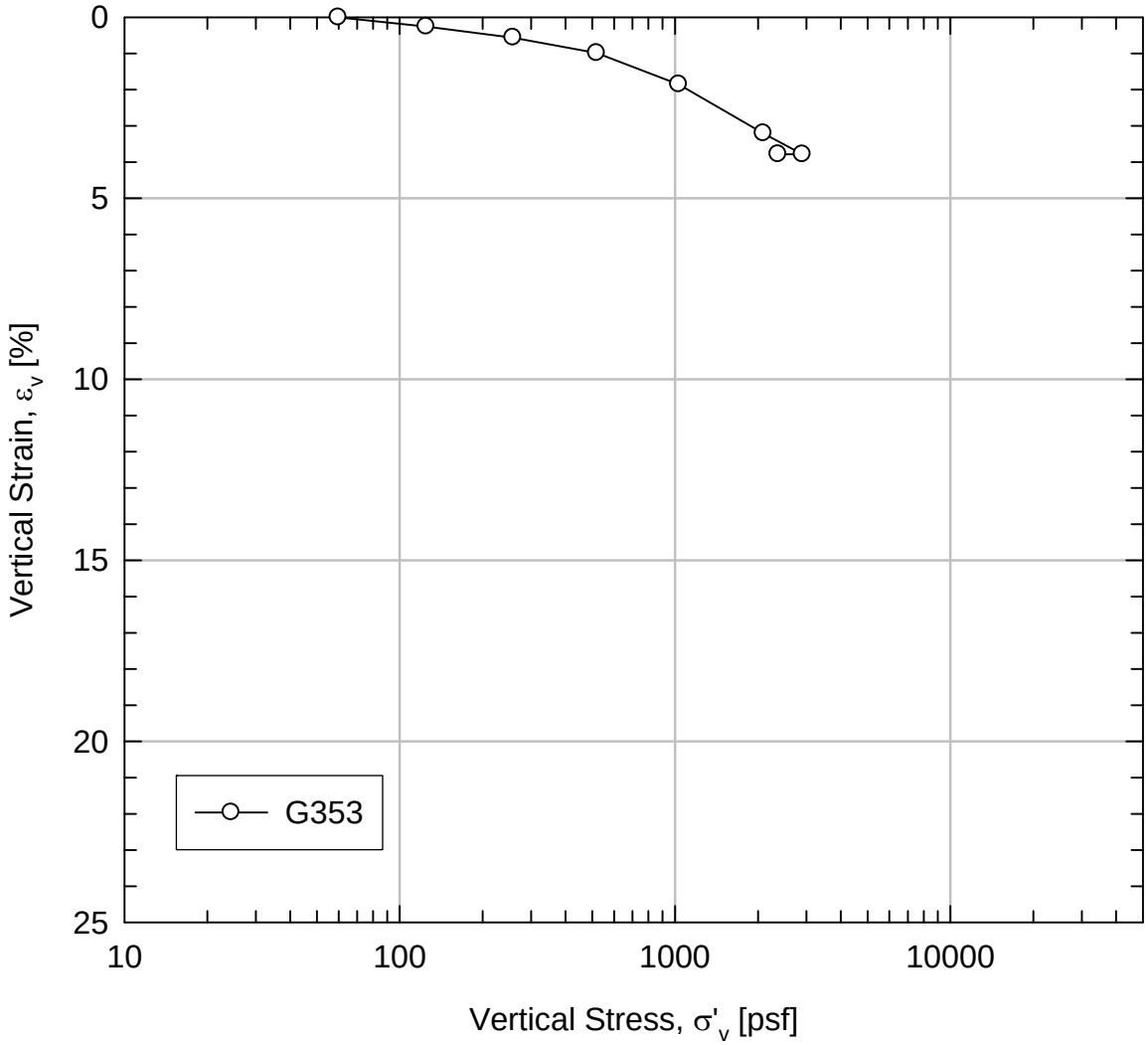

Figure 5.4.21 Vertical strain versus vertical effective stress for test DSS G353 on sample 09-605B S7 47.5-49.5 ft.

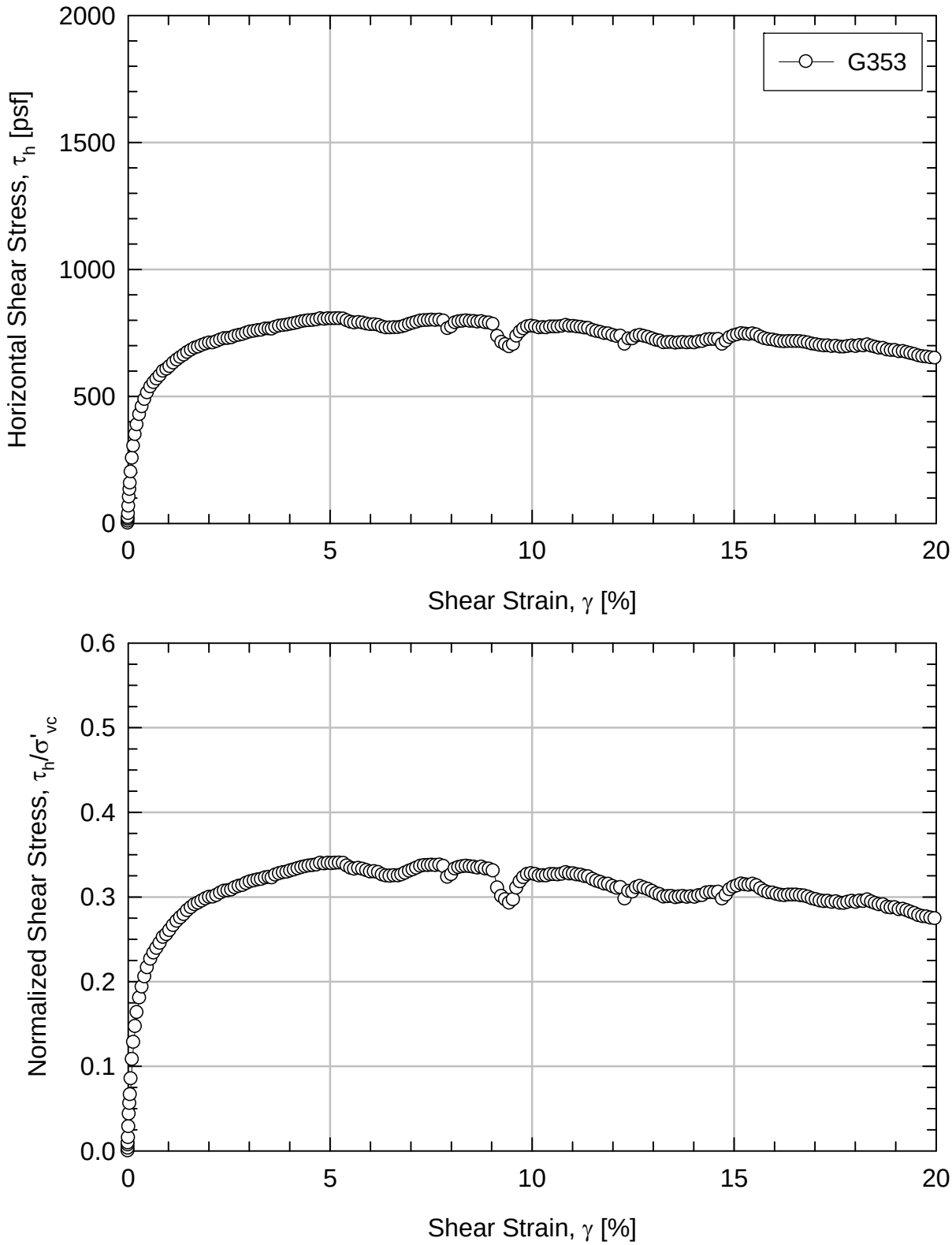

Figure 5.4.22 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G353 on sample 09-605B S7 47.5-49.5 ft.

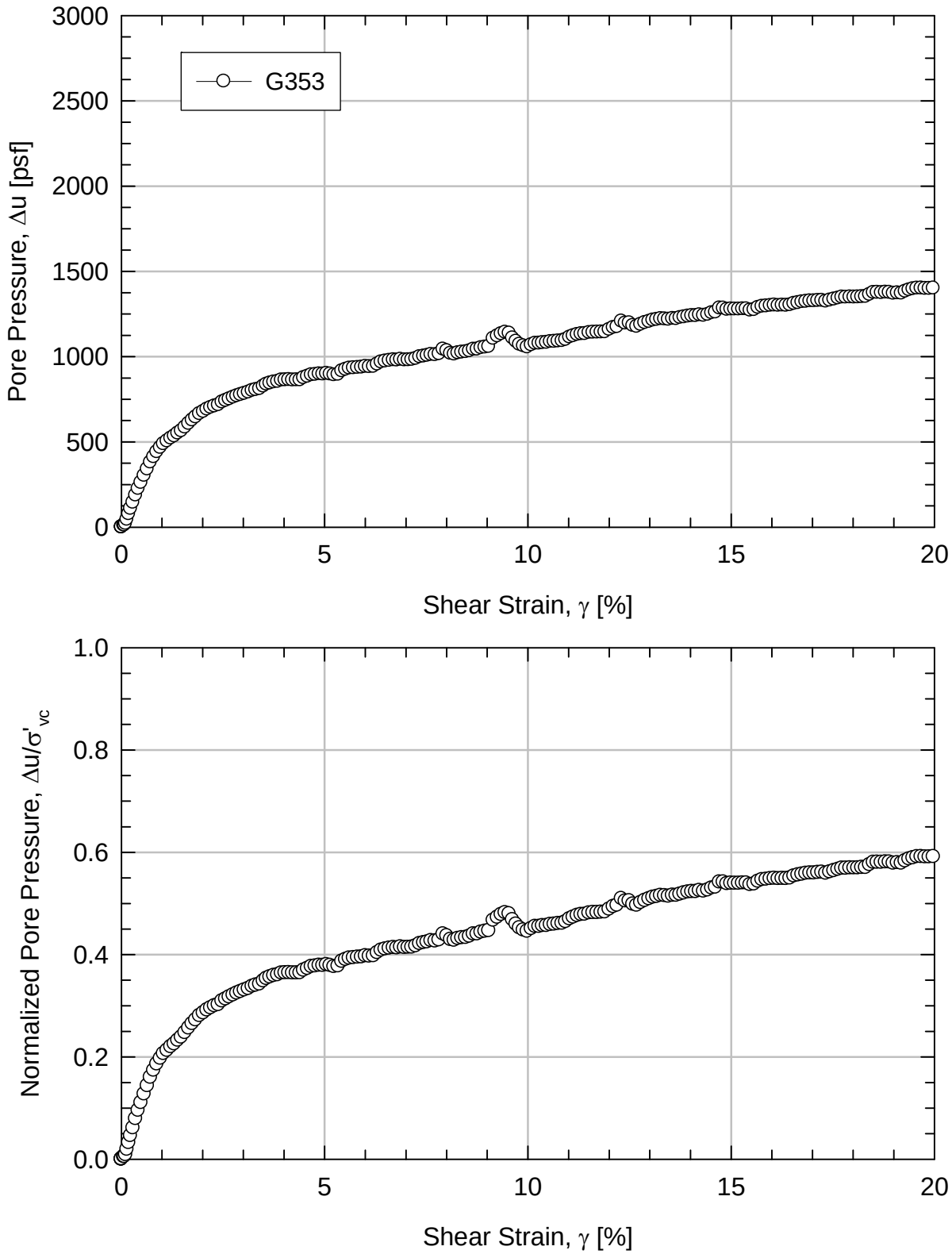

Figure 5.4.23 Pore pressure and normalized pore pressure versus shear strain for test DSS G353 on sample 09-605B S7 47.5-49.5 ft.

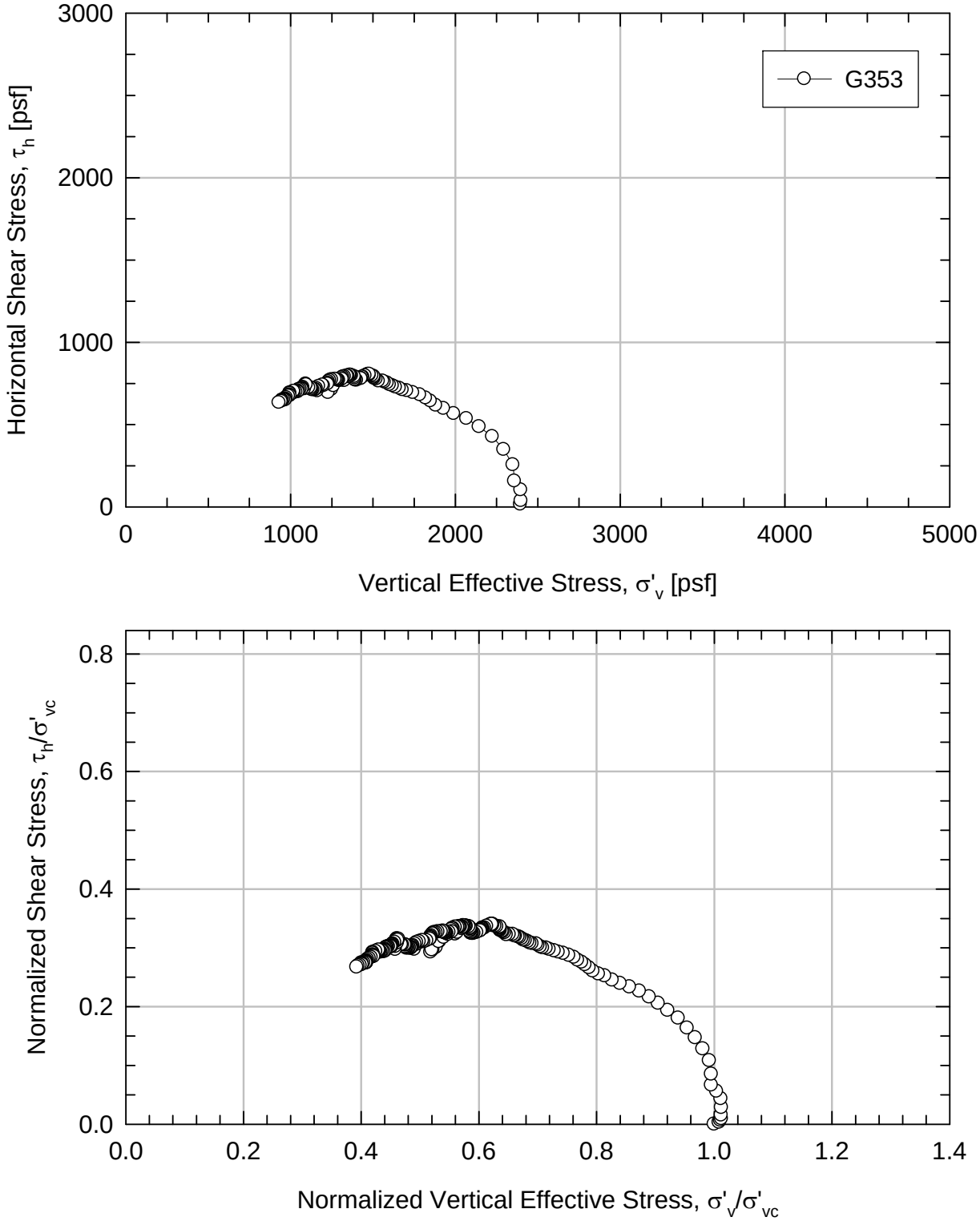

Figure 5.4.24 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G353 on sample 09-605B S7 47.5-49.5 ft.

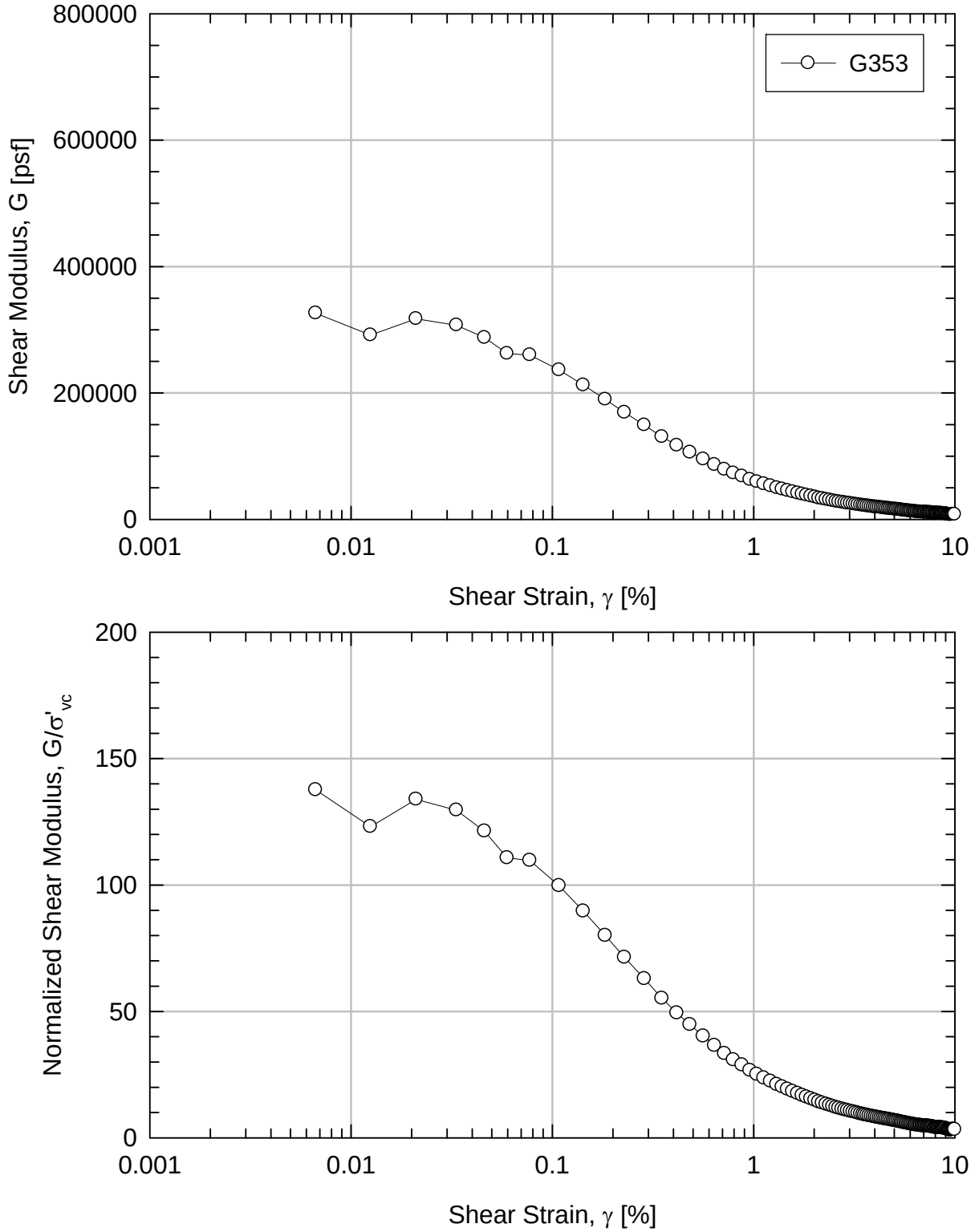

Figure 5.4.25 Shear modulus and normalized shear modulus versus shear strain for test DSS G353 on sample 09-605B S7 47.5-49.5 ft.

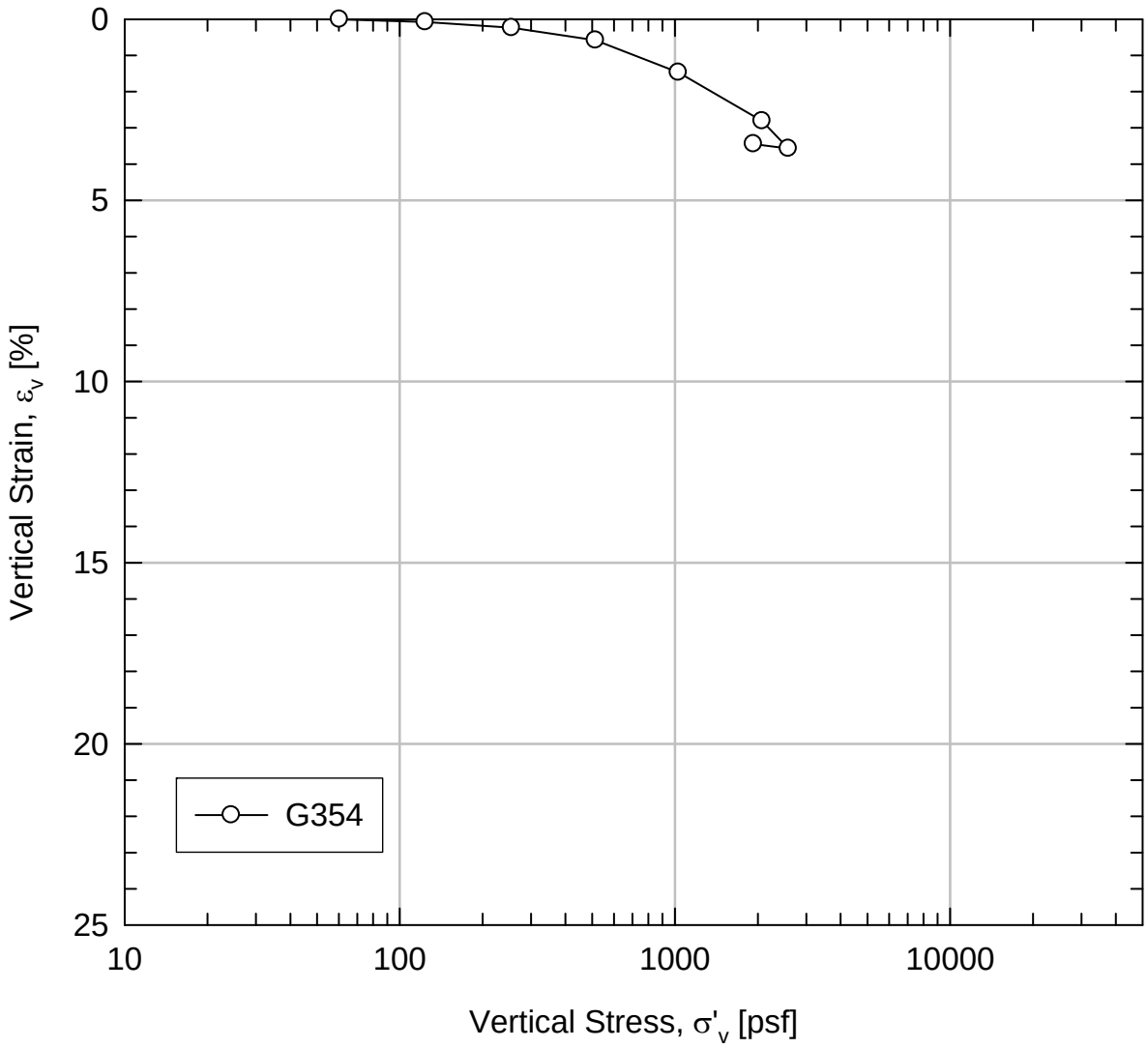

Figure 5.4.26 Vertical strain versus vertical effective stress for test DSS G354 on sample 09-103B S2 33.5-36.0 ft.

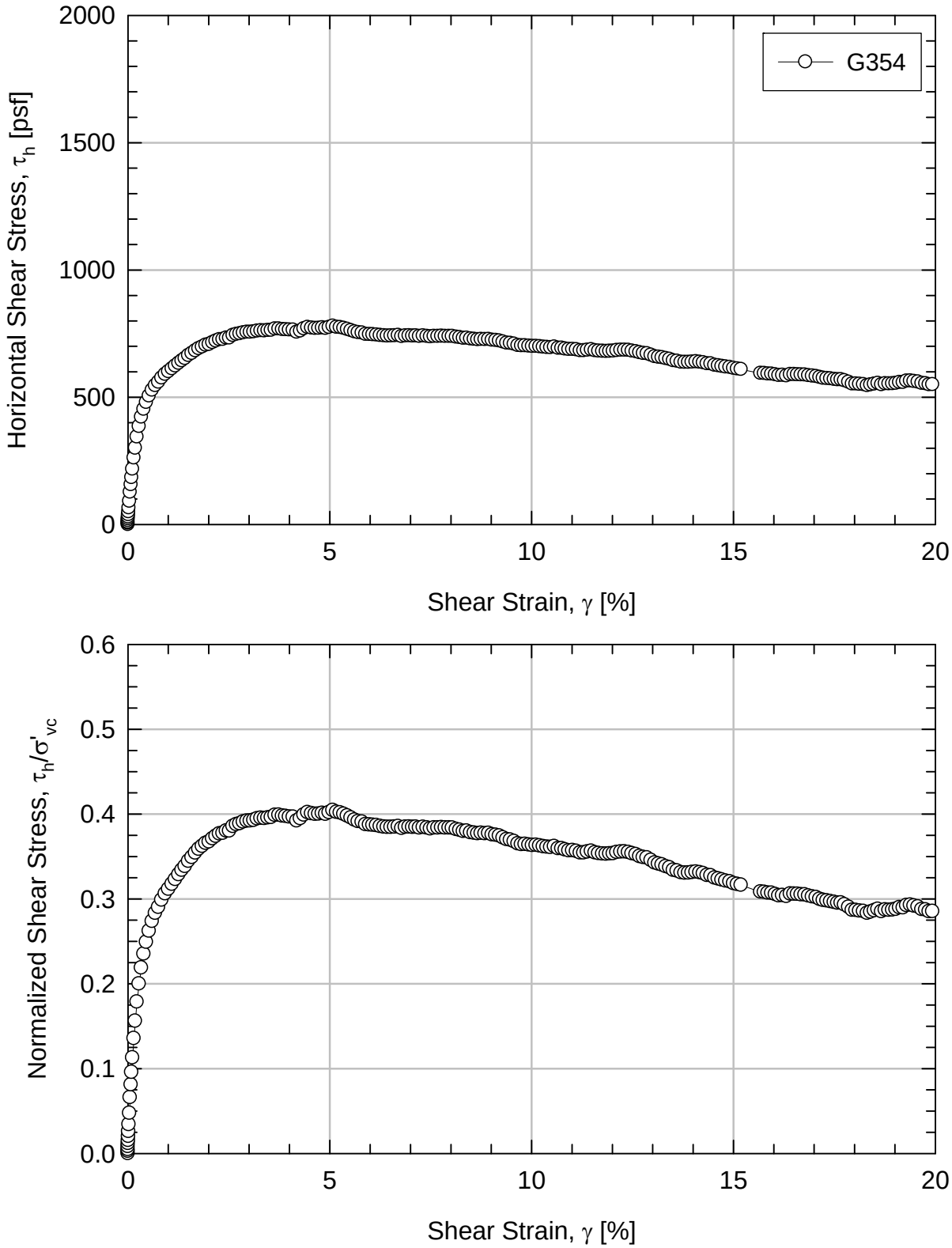

Figure 5.4.27 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G354 on sample 09-103B S2 33.5-36.0 ft.

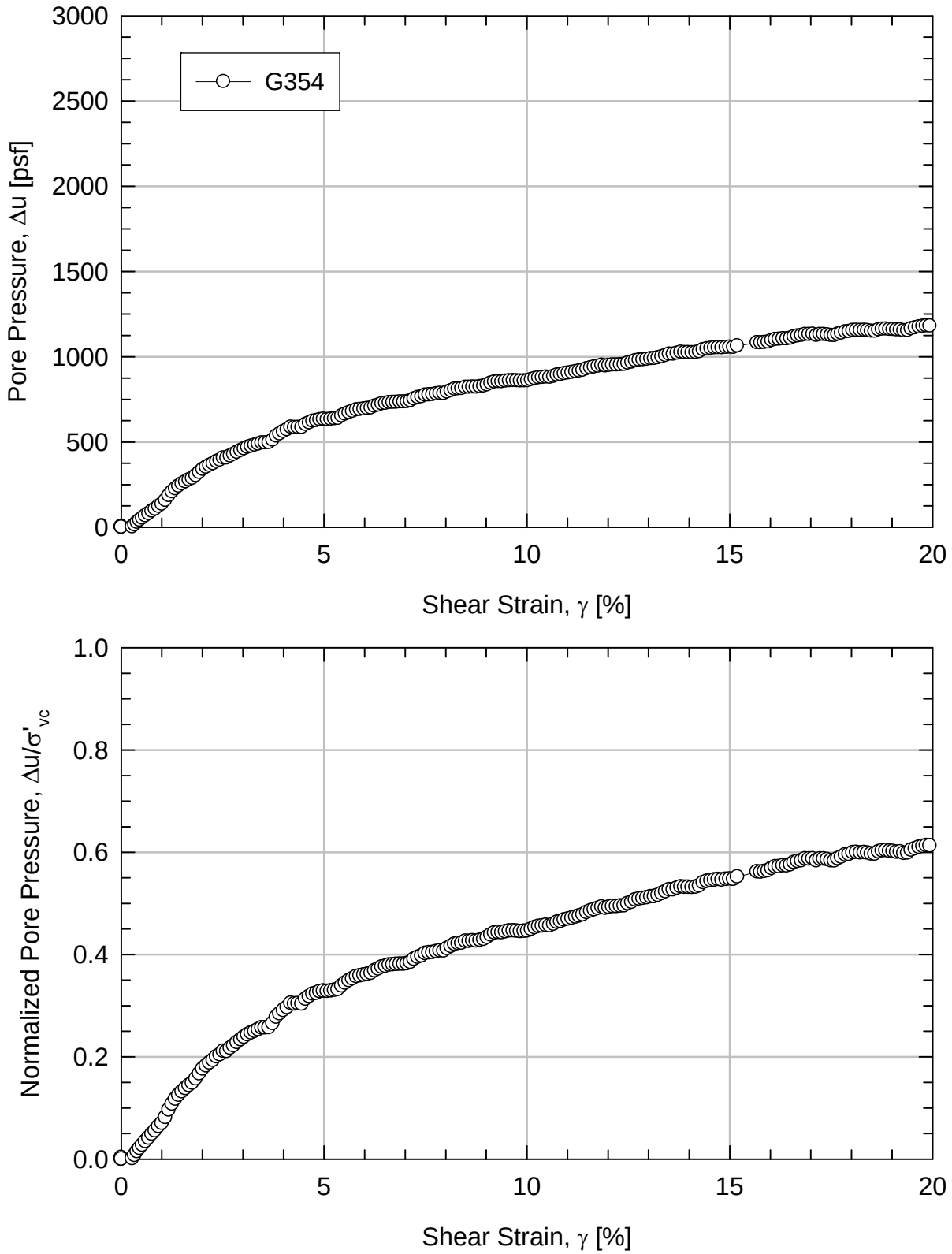

Figure 5.4.28 Pore pressure and normalized pore pressure versus shear strain for test DSS G354 on sample 09-103B S2 33.5-36.0 ft.

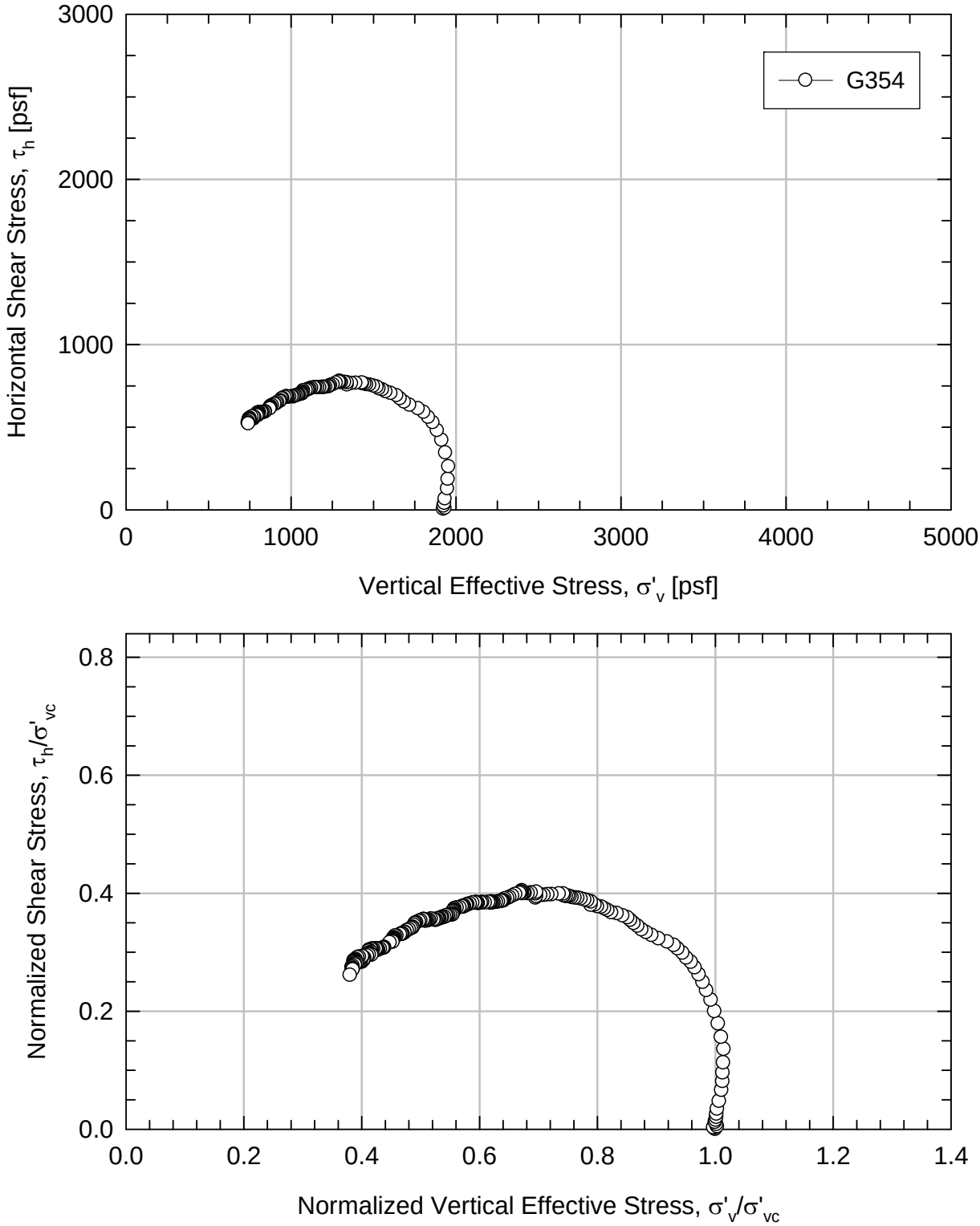

Figure 5.4.29 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G354 on sample 09-103B S2 33.5-36.0 ft.

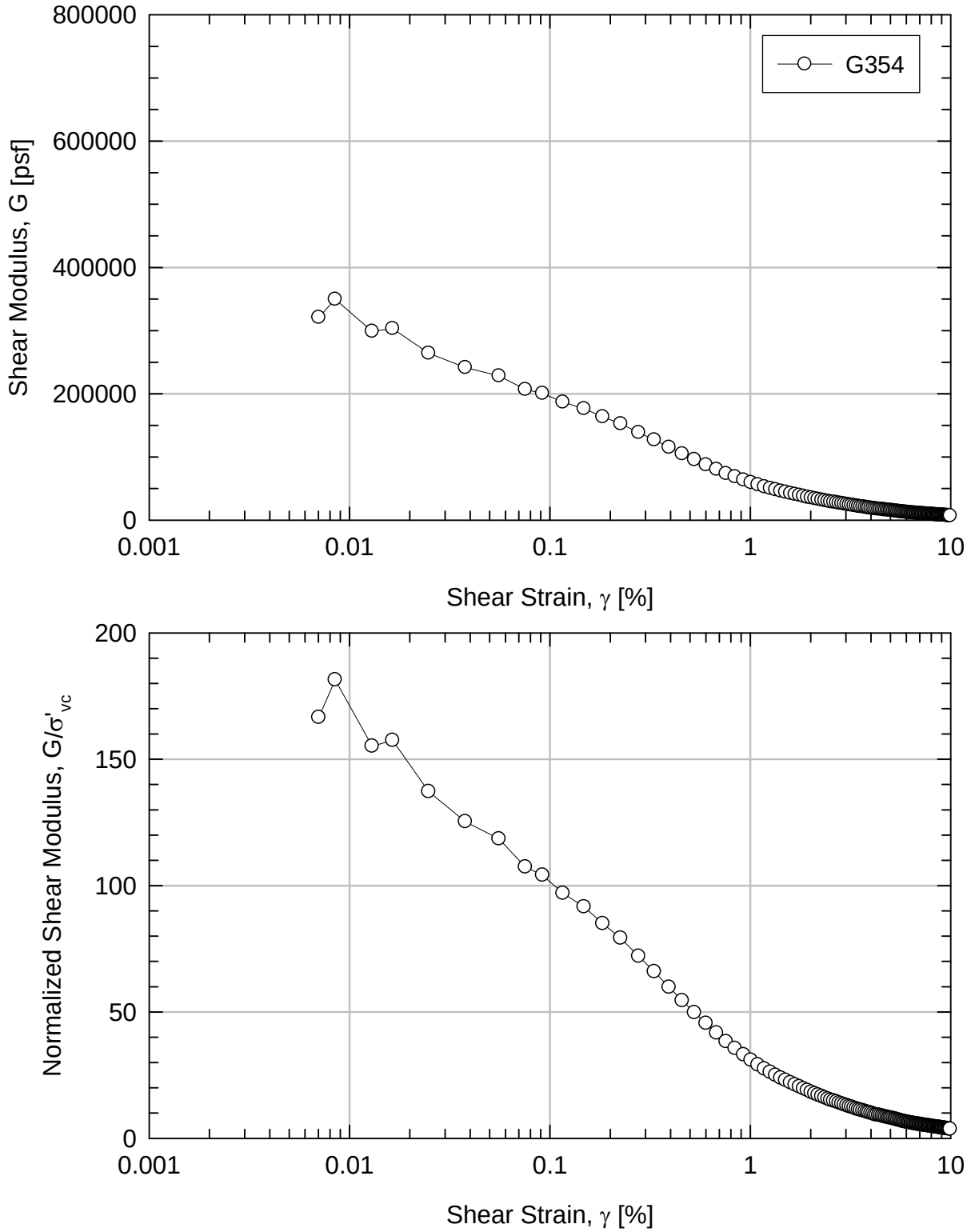

Figure 5.4.30 Shear modulus and normalized shear modulus versus shear strain for test DSS G354 on sample 09-103B S2 33.5-36.0 ft.

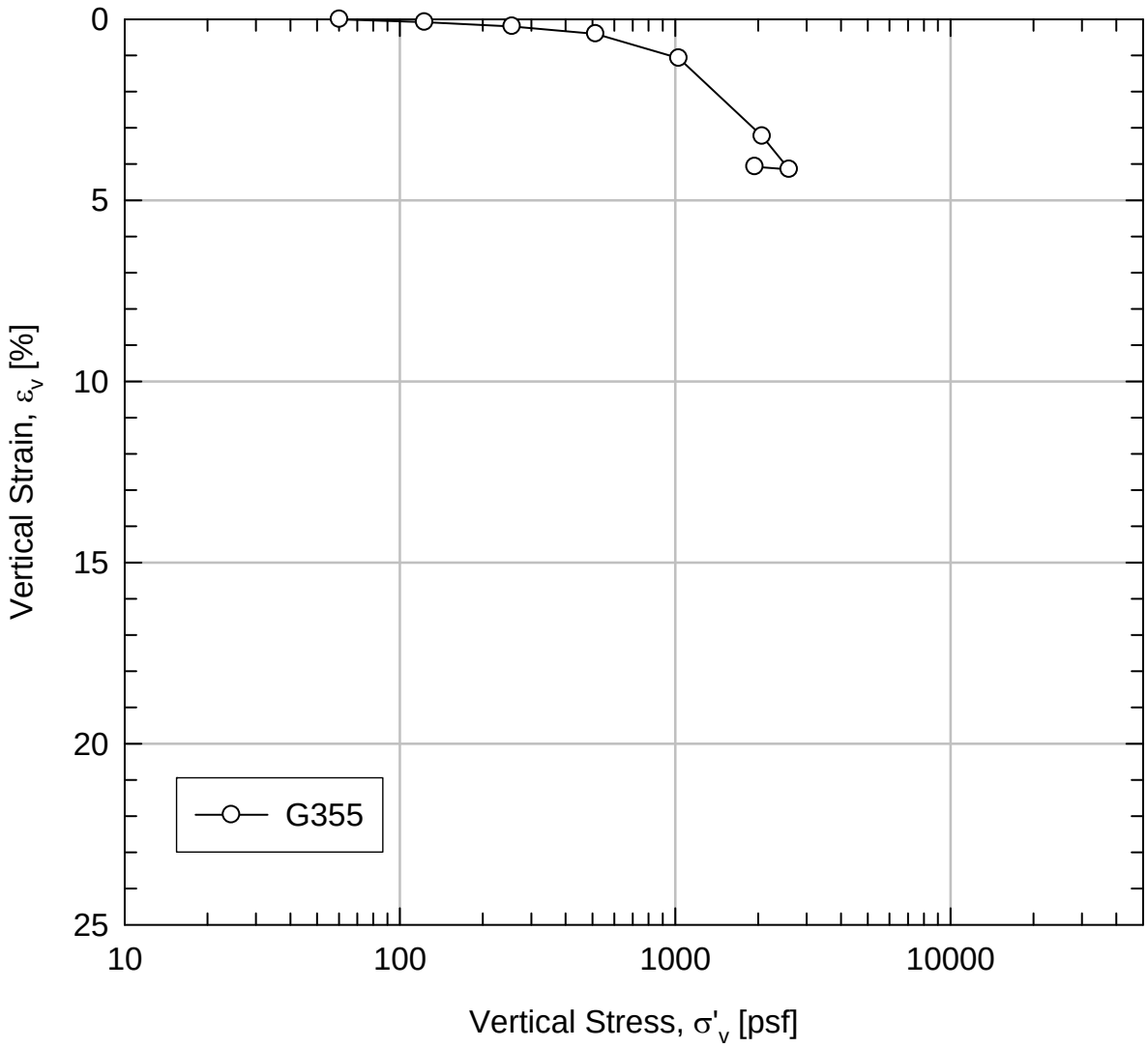

Figure 5.4.31 Vertical strain versus vertical effective stress for test DSS G355 on sample 09-103B S2 33.5-36.0 ft

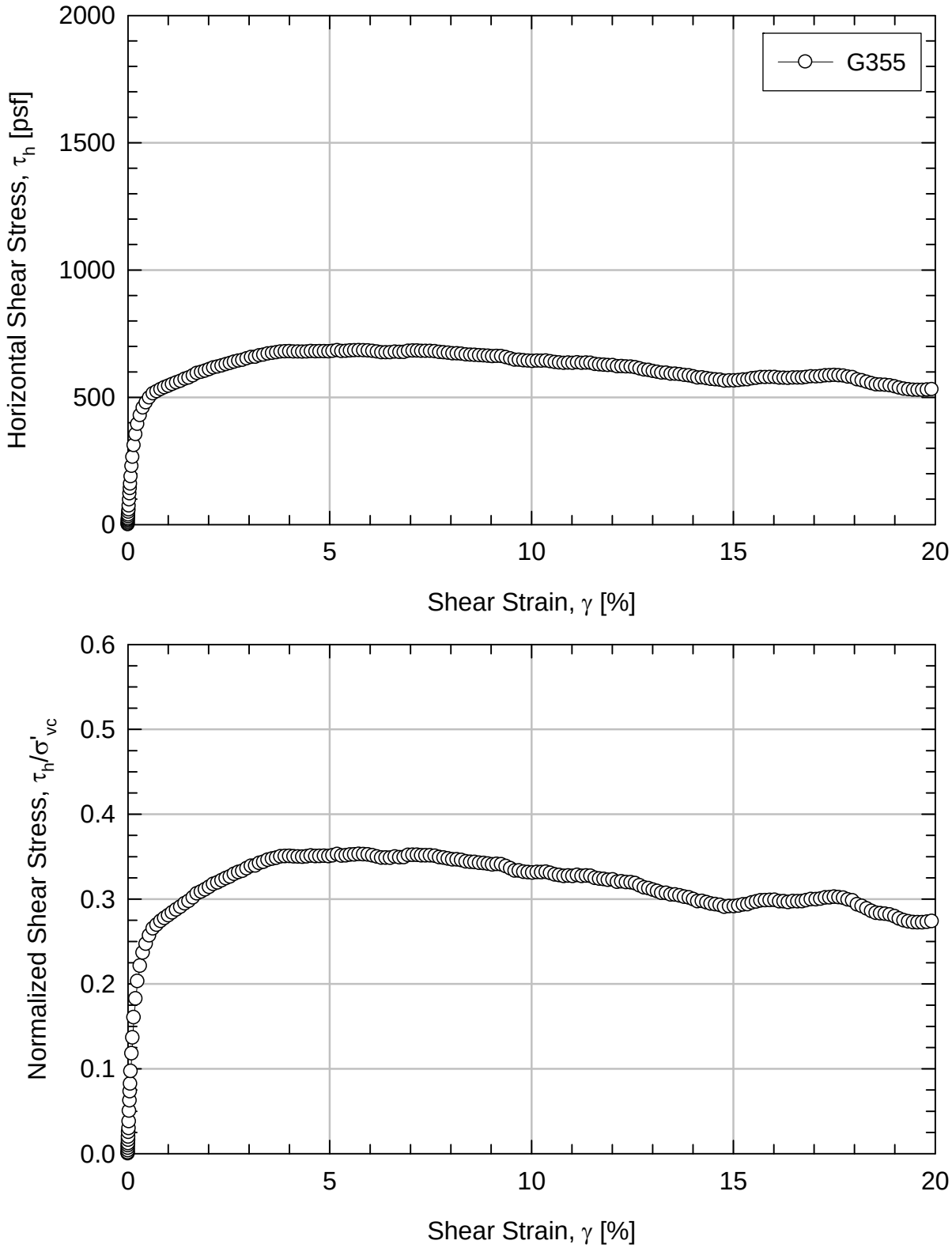

Figure 5.4.32 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G355 on sample 09-103B S2 33.5-36.0 ft

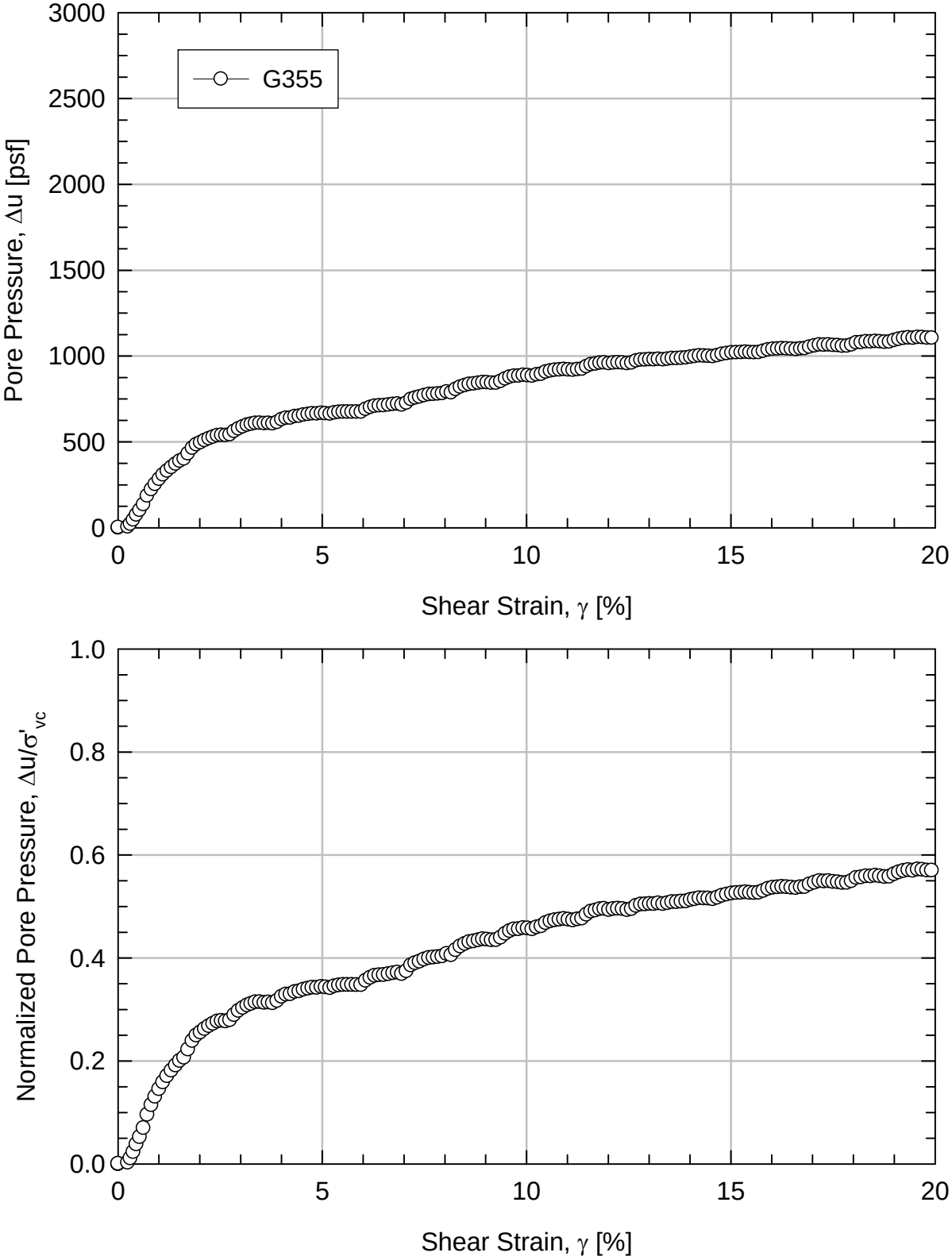

Figure 5.4.33 Pore pressure and normalized pore pressure versus shear strain for test DSS G355 on sample 09-103B S2 33.5-36.0 ft

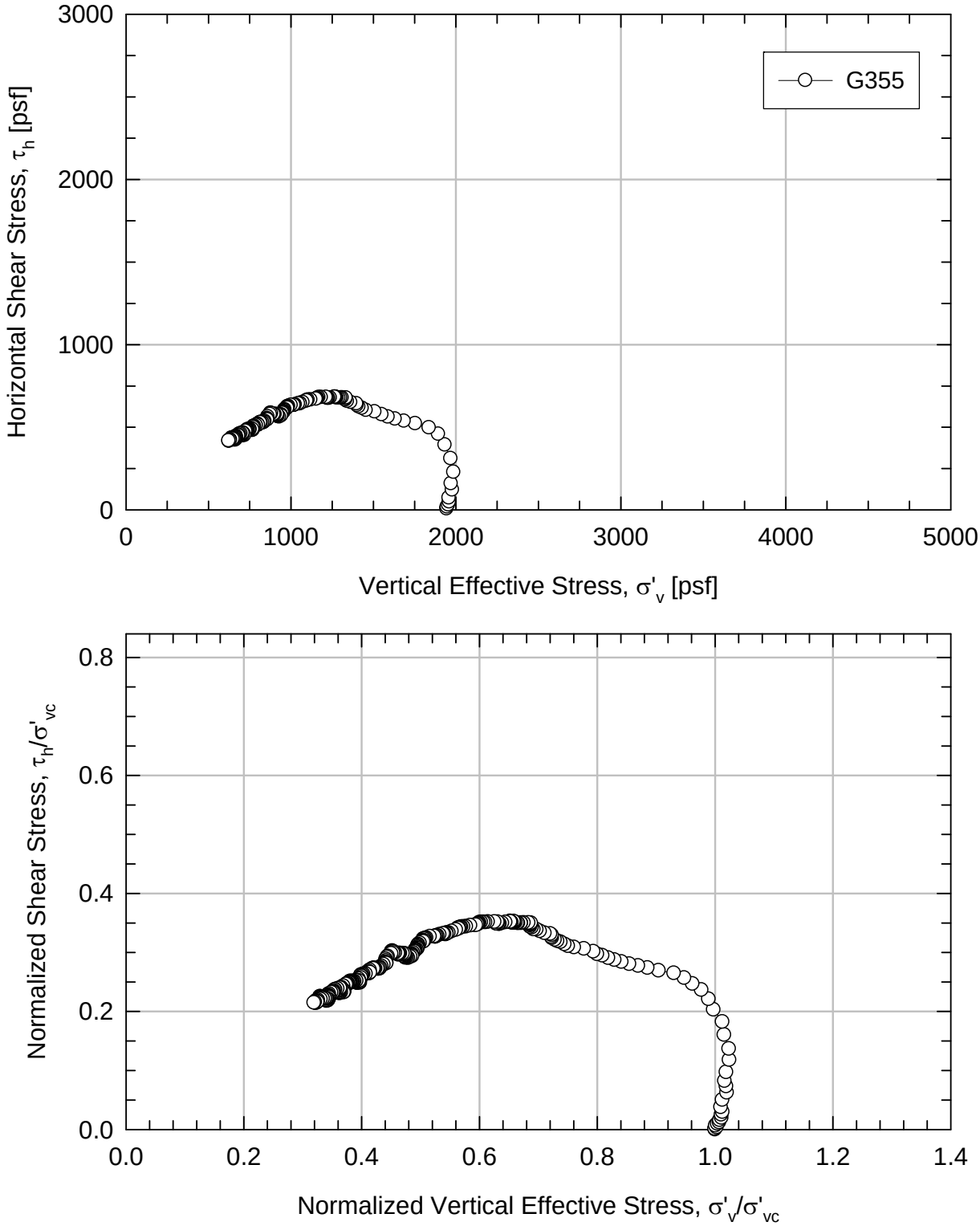

Figure 5.4.34 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G355 on sample 09-103B S2 33.5-36.0 ft

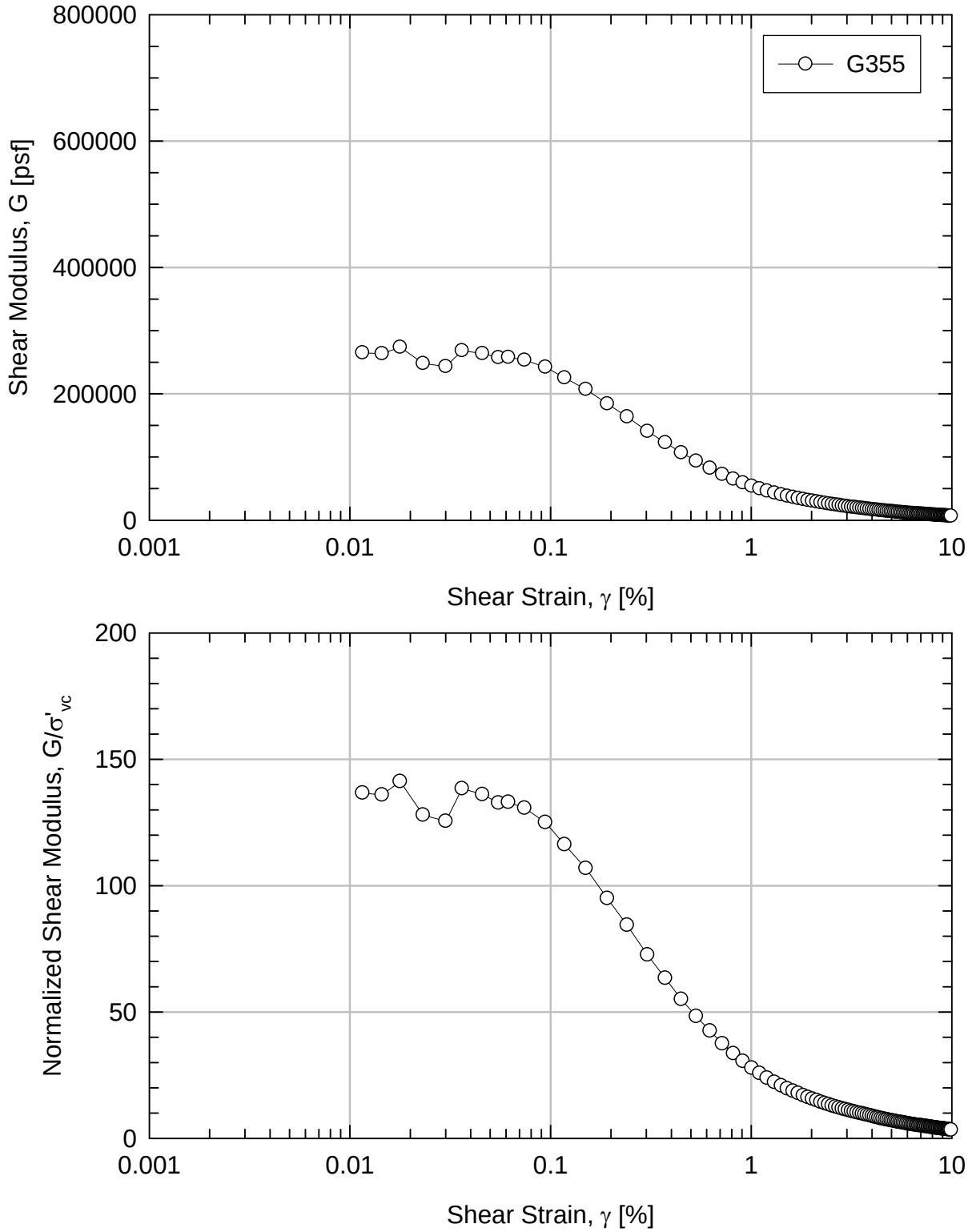

Figure 5.4.35 Shear modulus and normalized shear modulus versus shear strain for test DSS G355 on sample 09-103B S2 33.5-36.0 ft

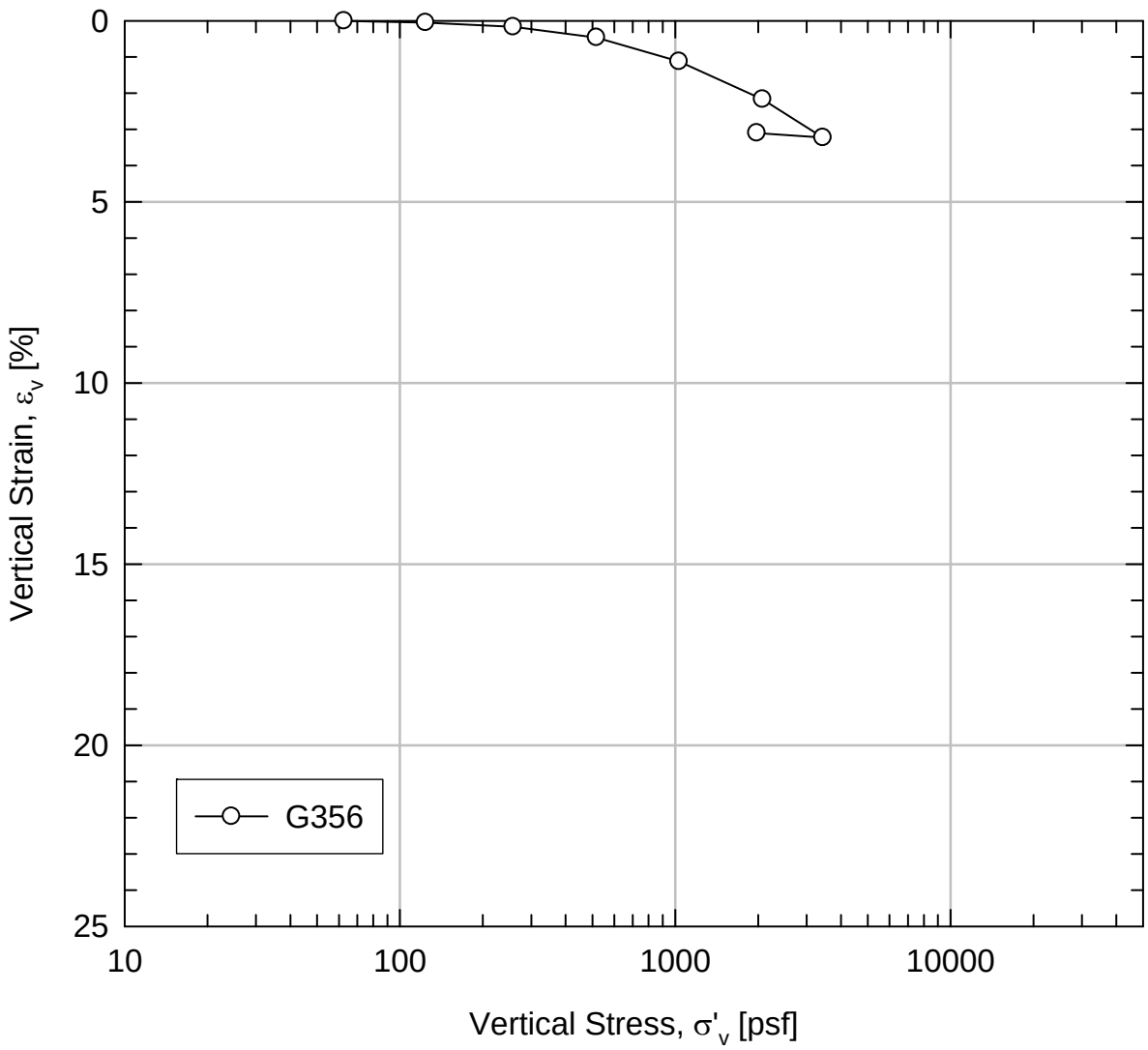

Figure 5.4.36 Vertical strain versus vertical effective stress for test DSS G356 on sample 09-100B S5 33.0-35.5 ft

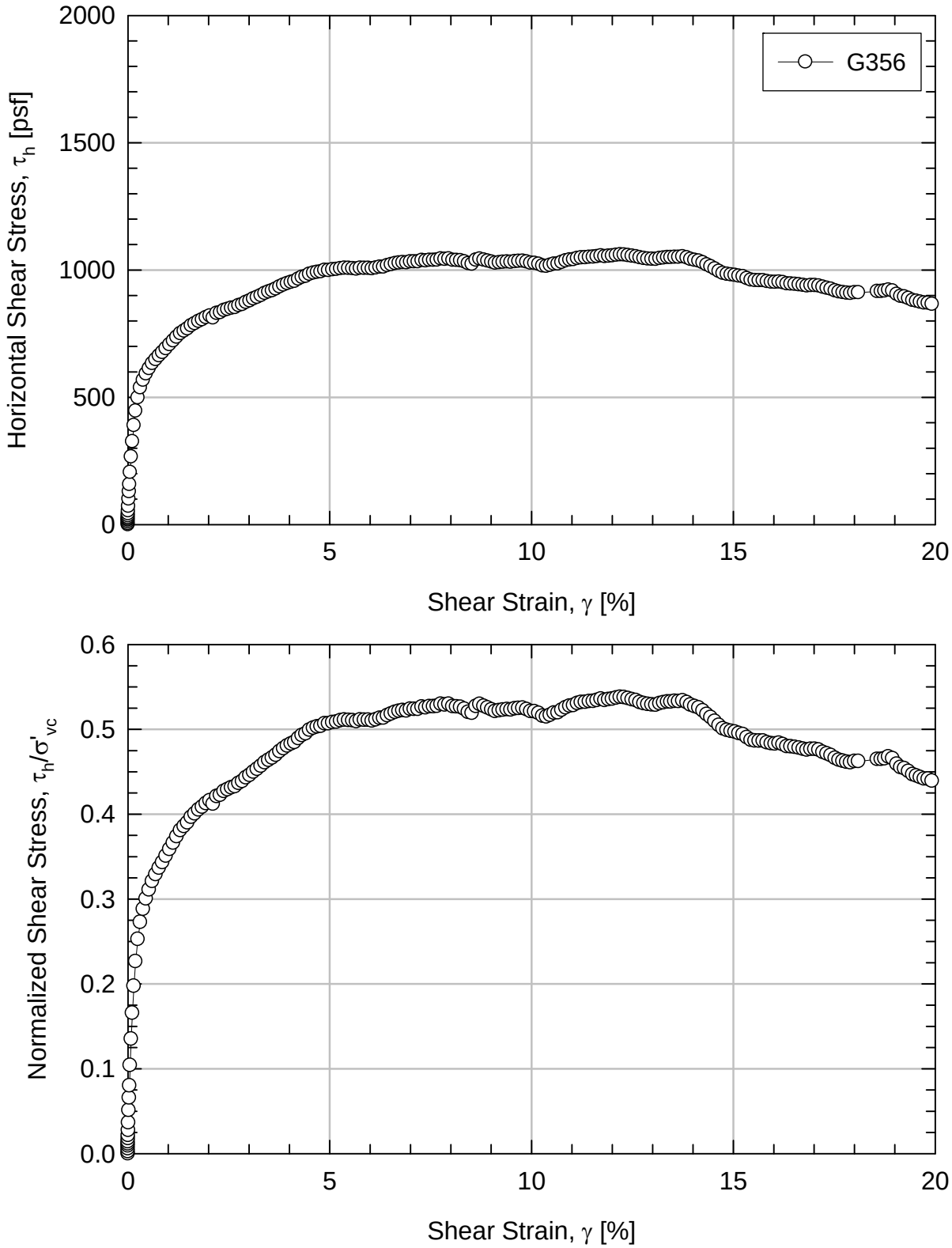

Figure 5.4.37 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G356 on sample 09-100B S5 33.0-35.5 ft

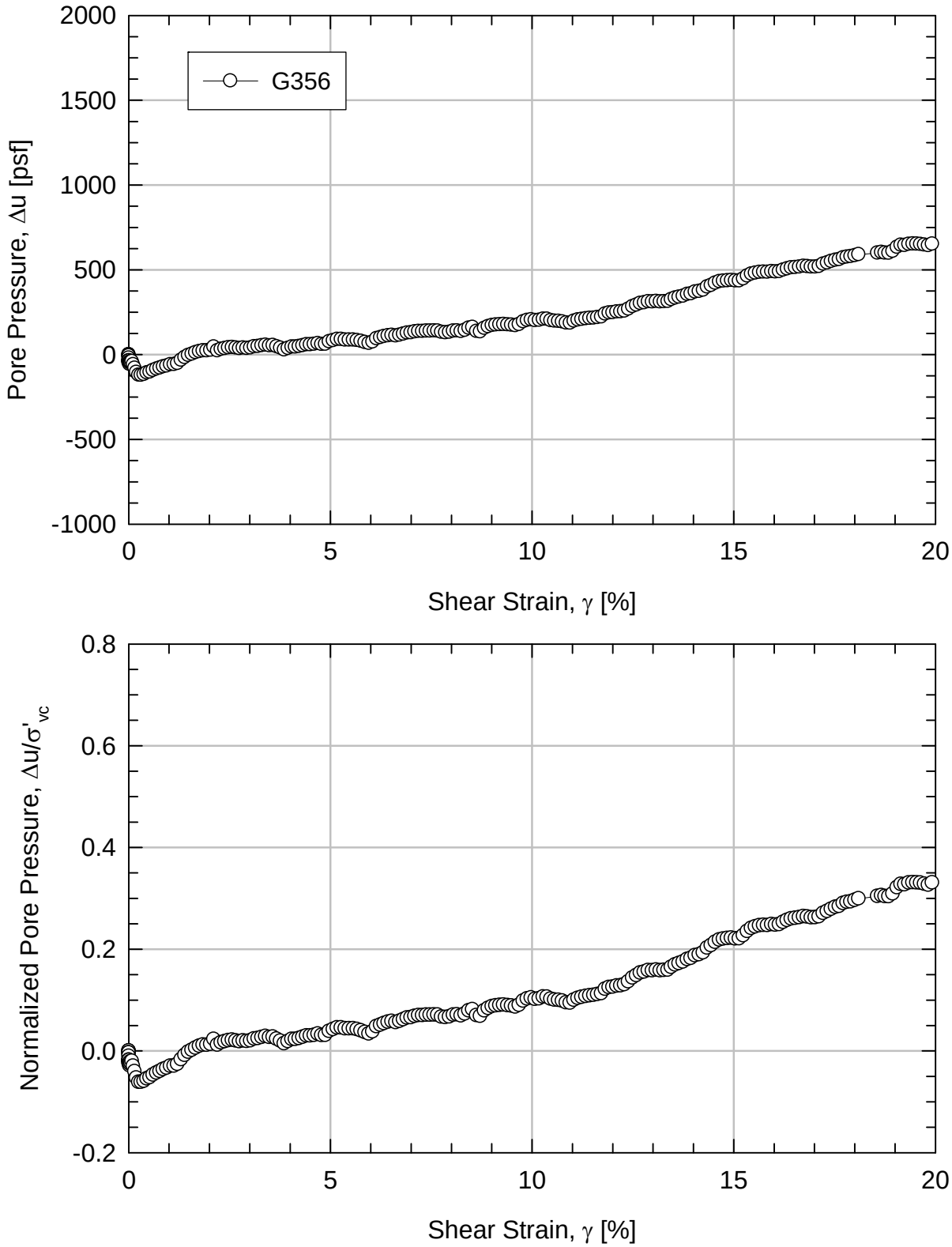

Figure 5.4.38 Pore pressure and normalized pore pressure versus shear strain for test DSS G356 on sample 09-100B S5 33.0-35.5 ft

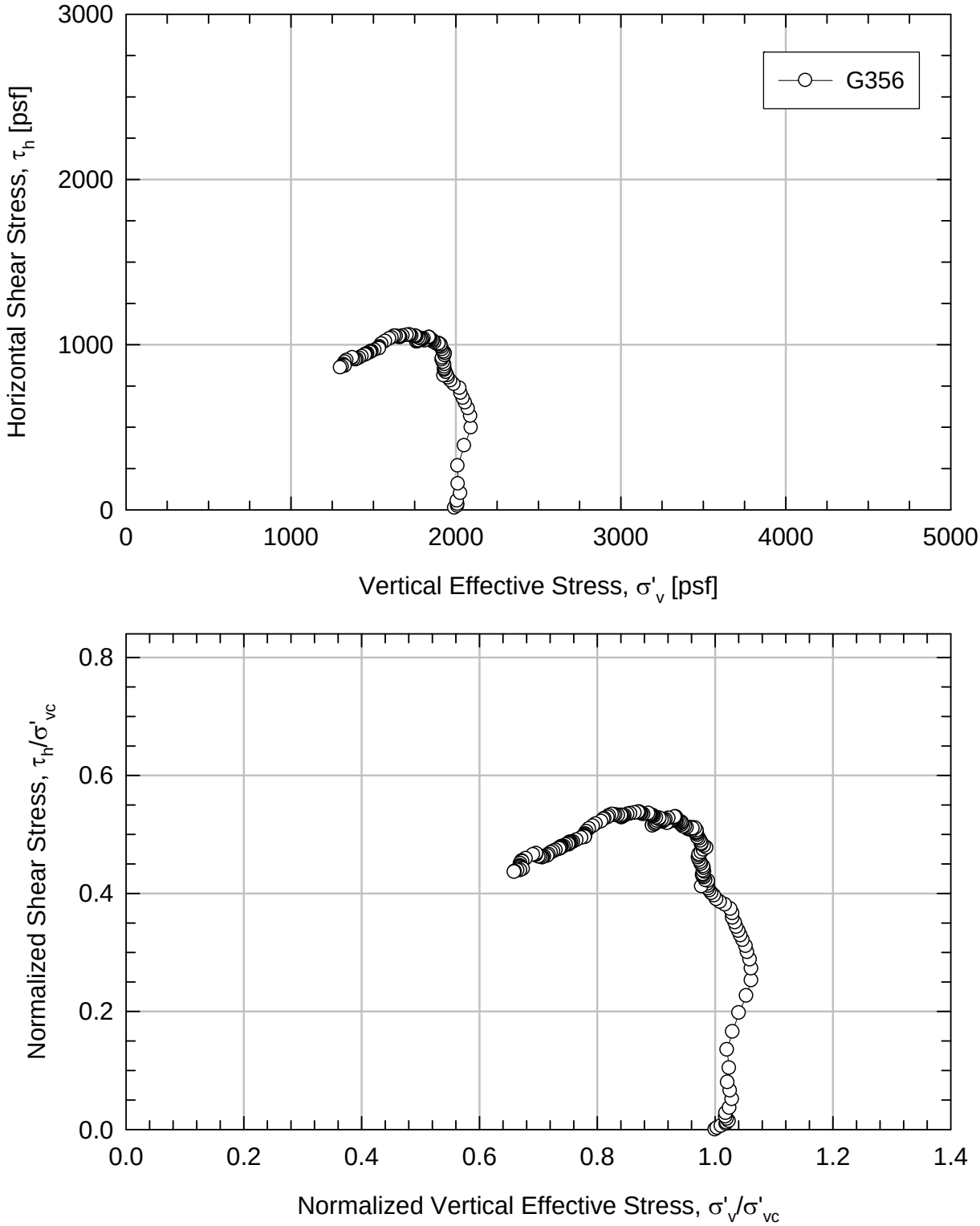

Figure 5.4.39 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G356 on sample 09-100B S5 33.0-35.5 ft

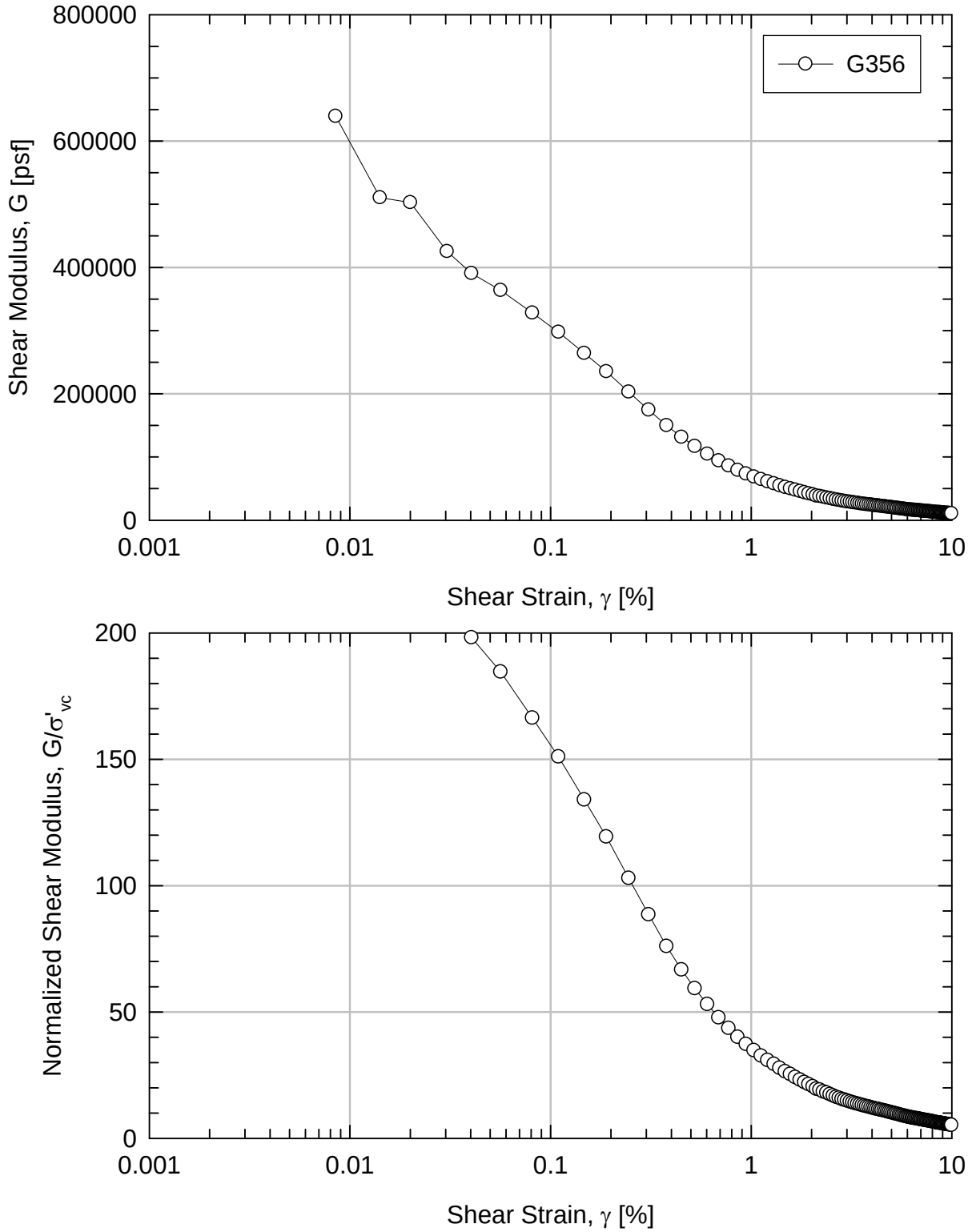

Figure 5.4.40 Shear modulus and normalized shear modulus versus shear strain for test DSS G356 on sample 09-100B S5 33.0-35.5 ft

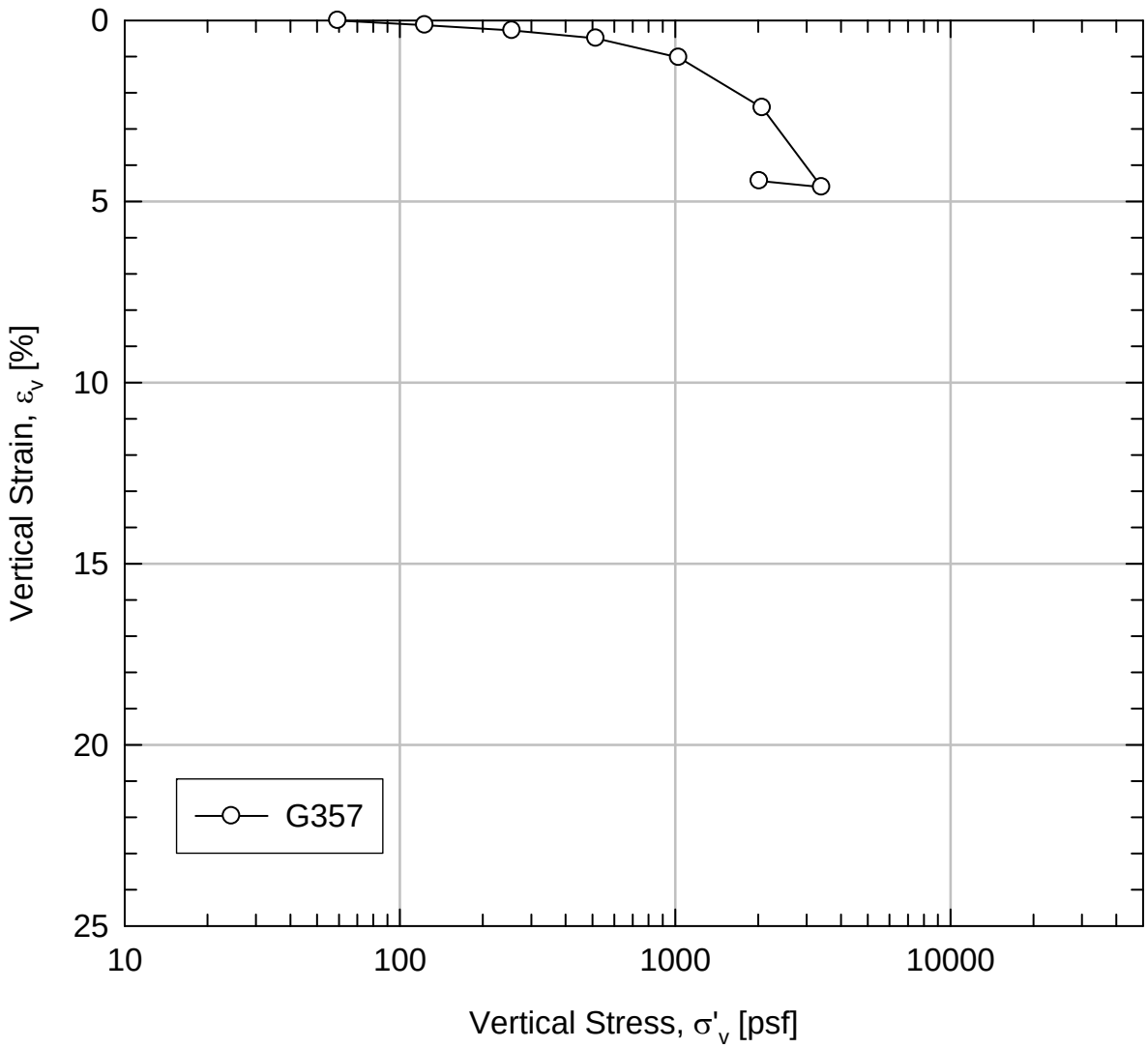

Figure 5.4.41 Vertical strain versus vertical effective stress for test DSS G357 on sample 09-100B S6 35.5-38.0 ft

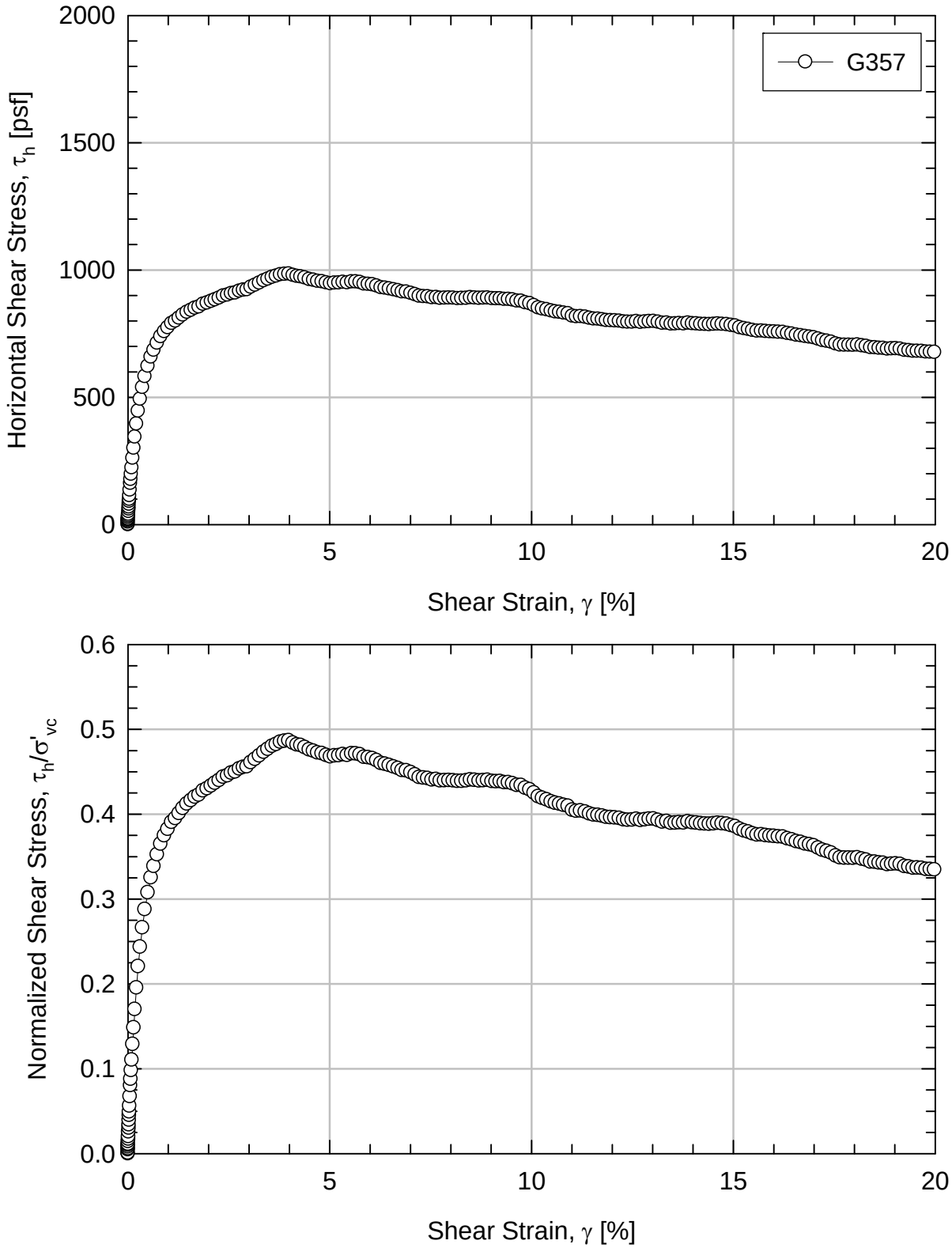

Figure 5.4.42 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G357 on sample 09-100B S6 35.5-38.0 ft

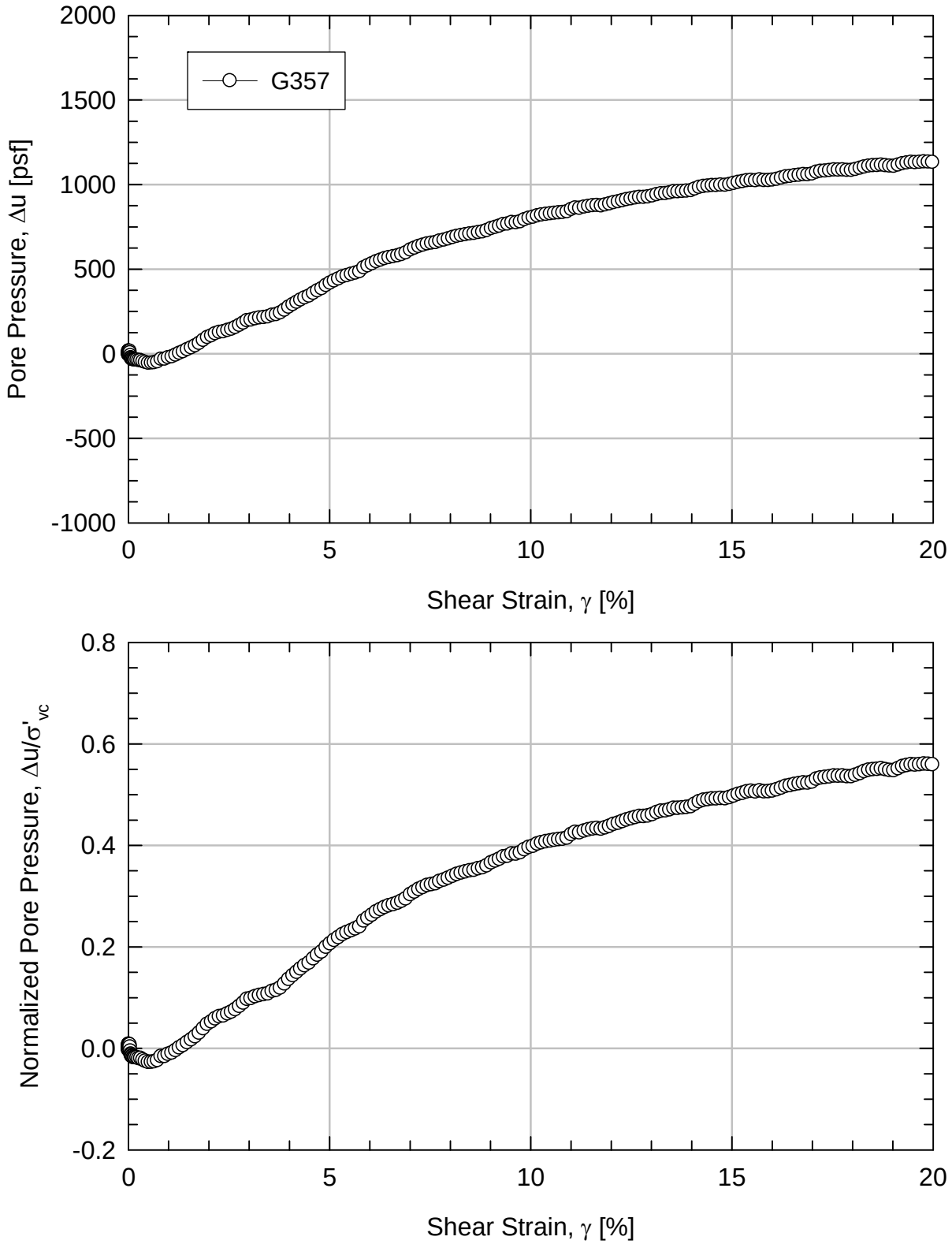

Figure 5.4.43 Pore pressure and normalized pore pressure versus shear strain for test DSS G357 on sample 09-100B S6 35.5-38.0 ft

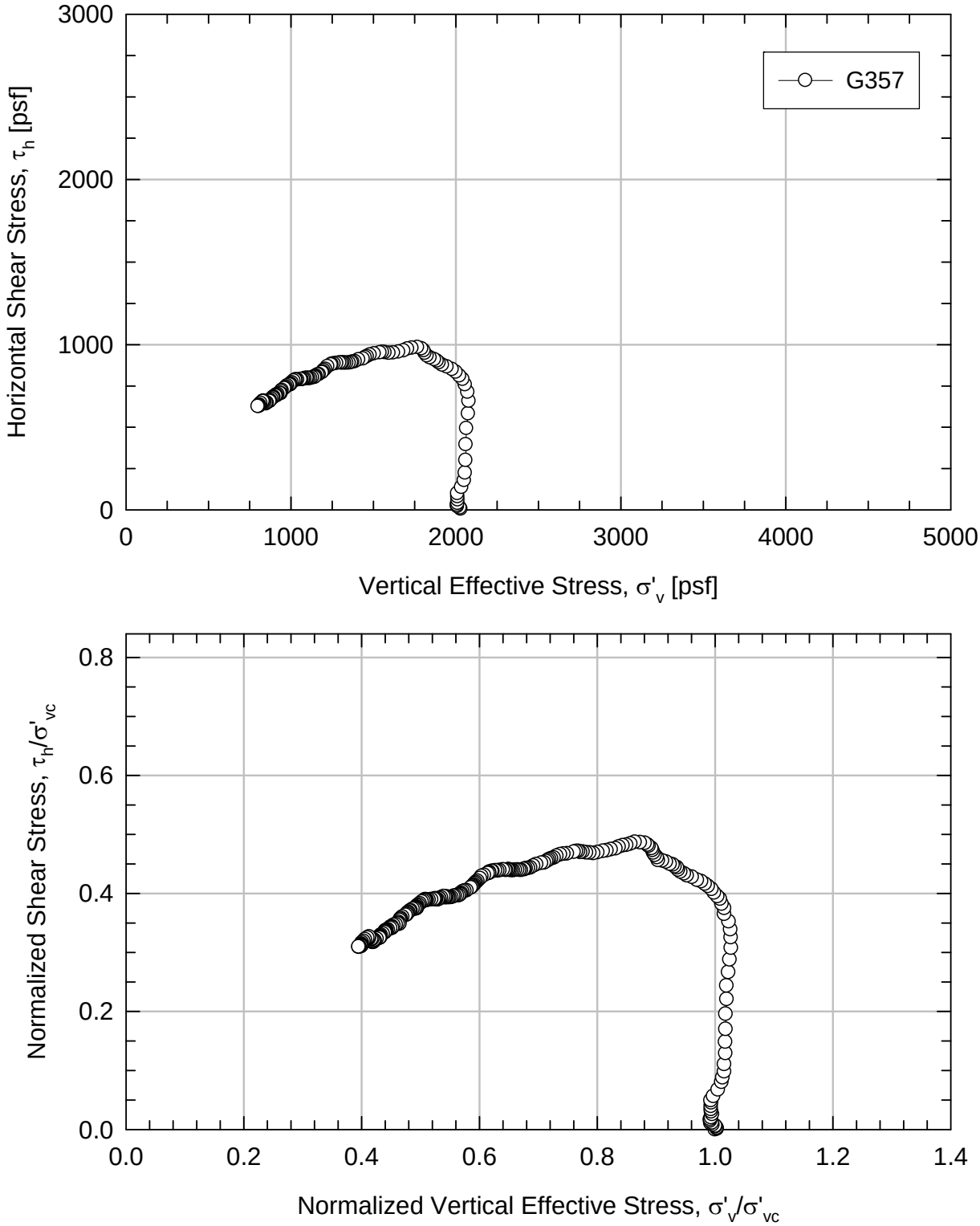

Figure 5.4.44 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G357 on sample 09-100B S6 35.5-38.0 ft

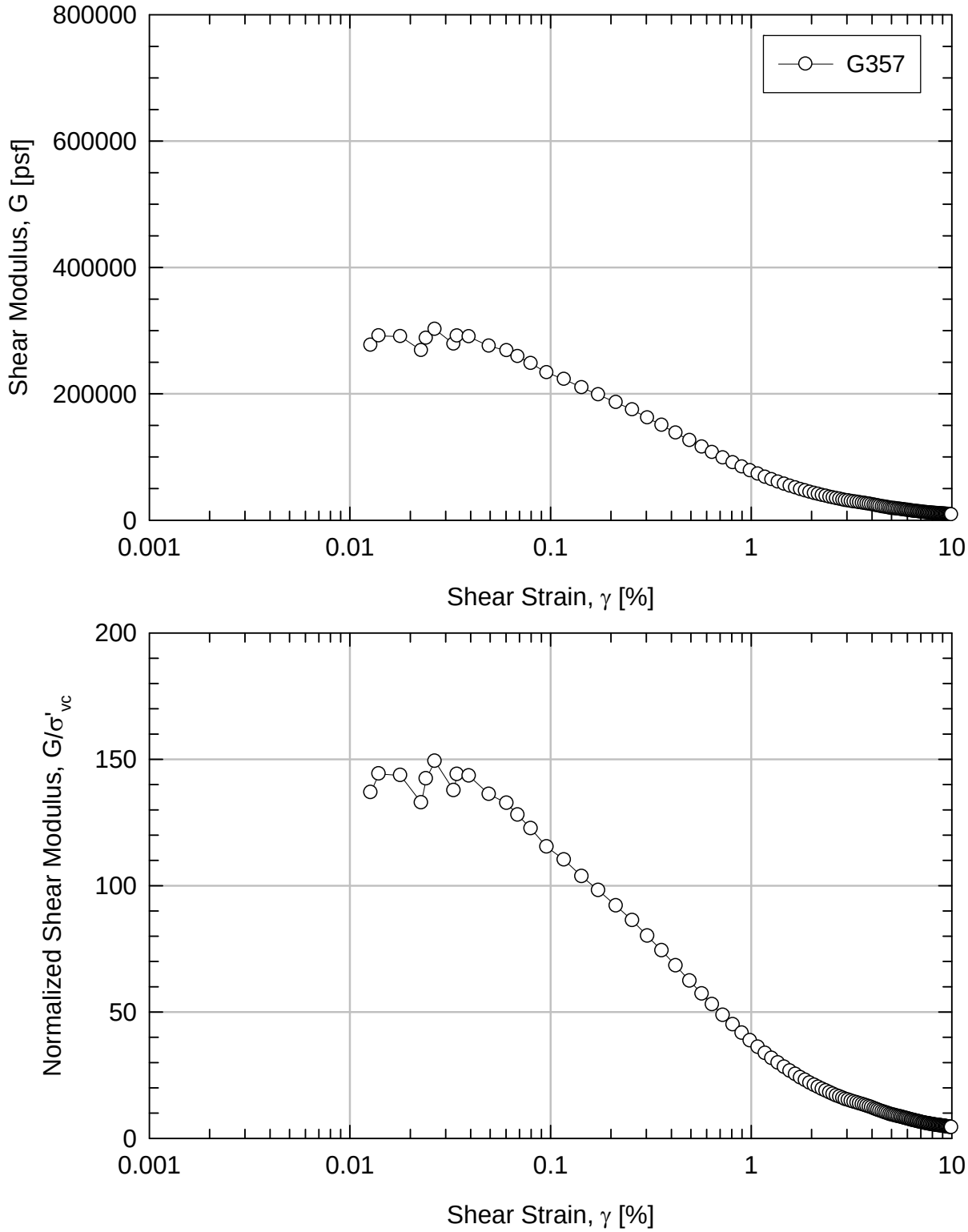

Figure 5.4.45 Shear modulus and normalized shear modulus versus shear strain for test DSS G357 on sample 09-100B S6 35.5-38.0 ft

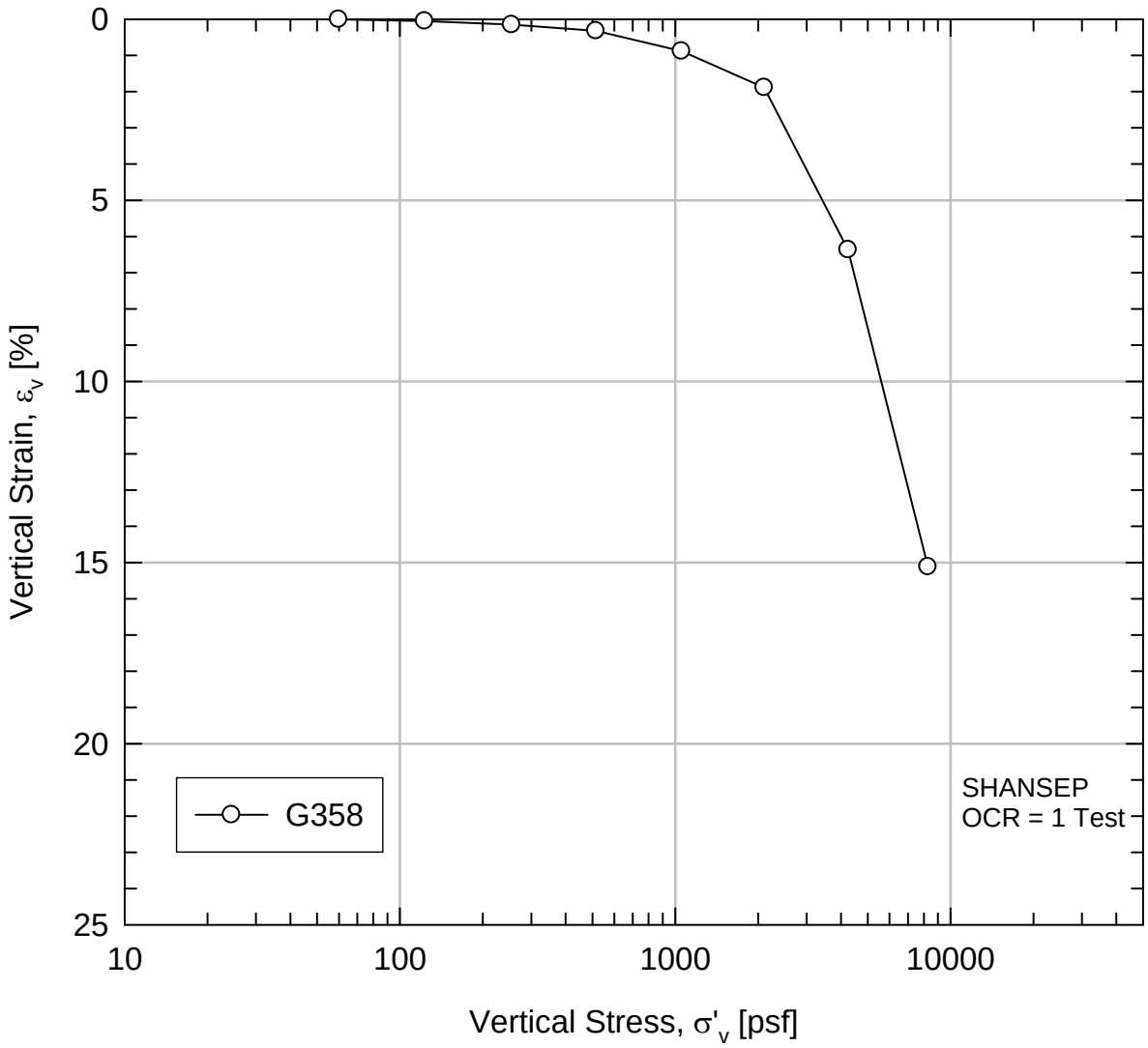

Figure 5.4.46 Vertical strain versus vertical effective stress for test DSS G358 on sample 09-108B S2 23.5-26.0 ft

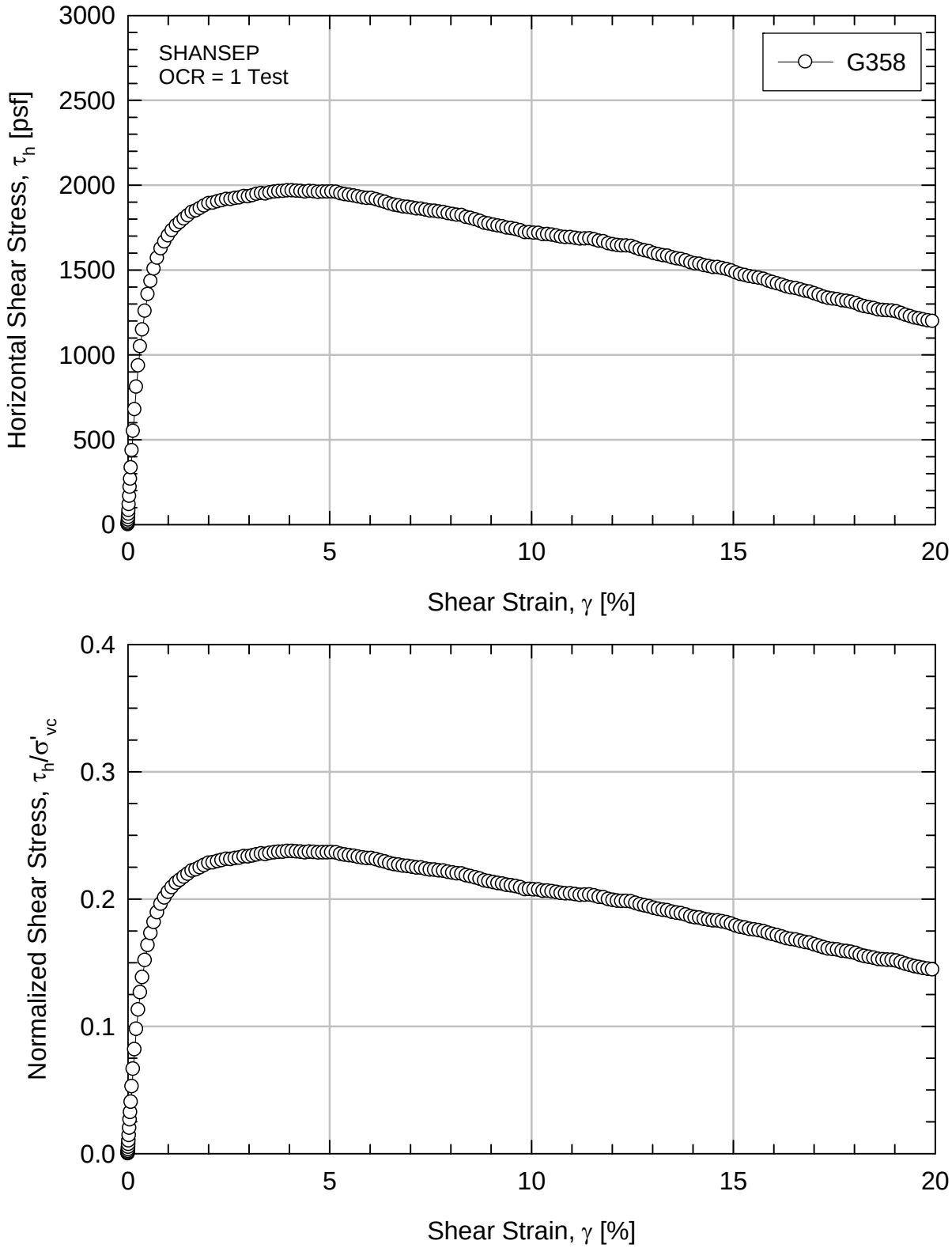

Figure 5.4.47 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G358 on sample 09-108B S2 23.5-26.0 ft

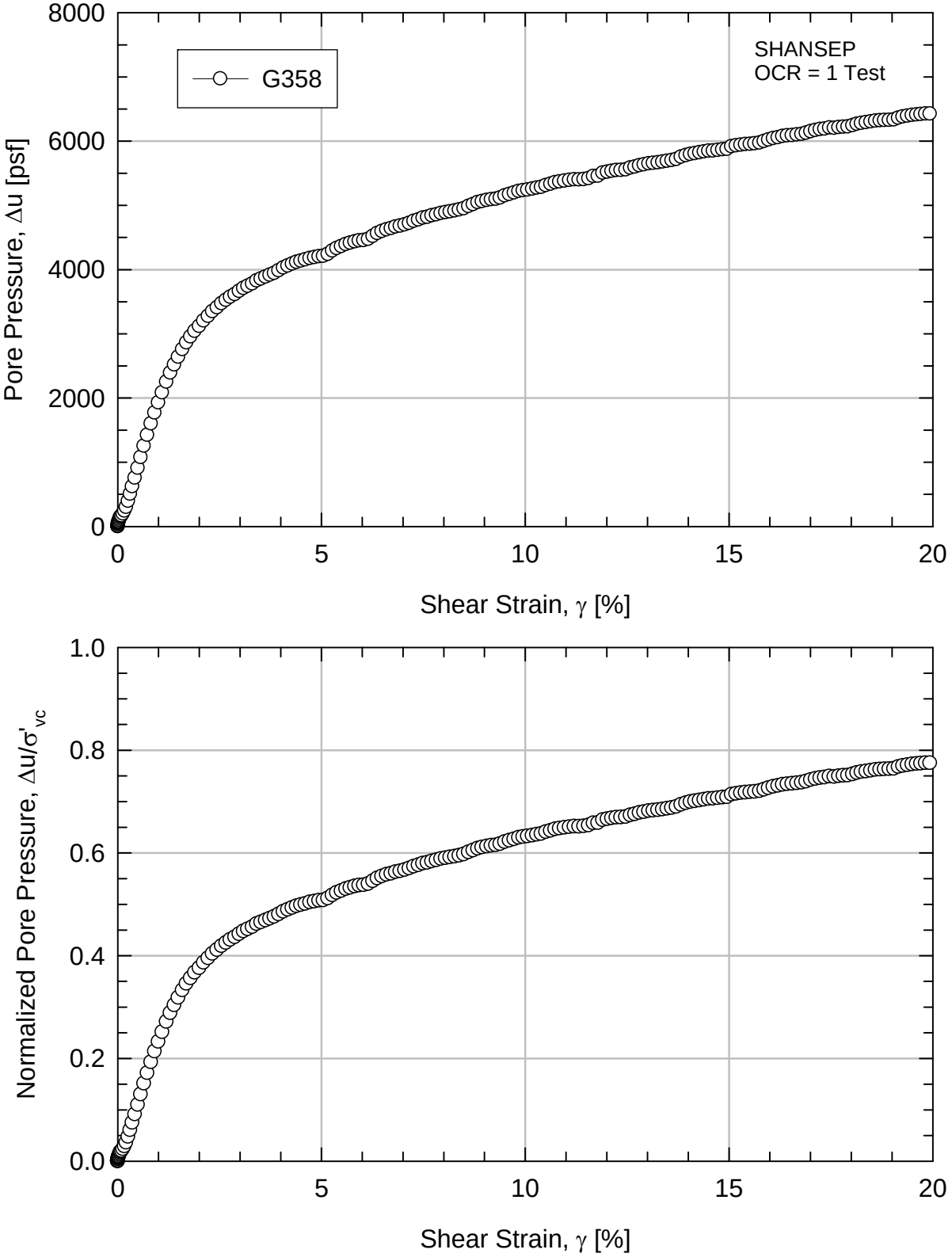

Figure 5.4.48 Pore pressure and normalized pore pressure versus shear strain for test DSS G358 on sample 09-108B S2 23.5-26.0 ft

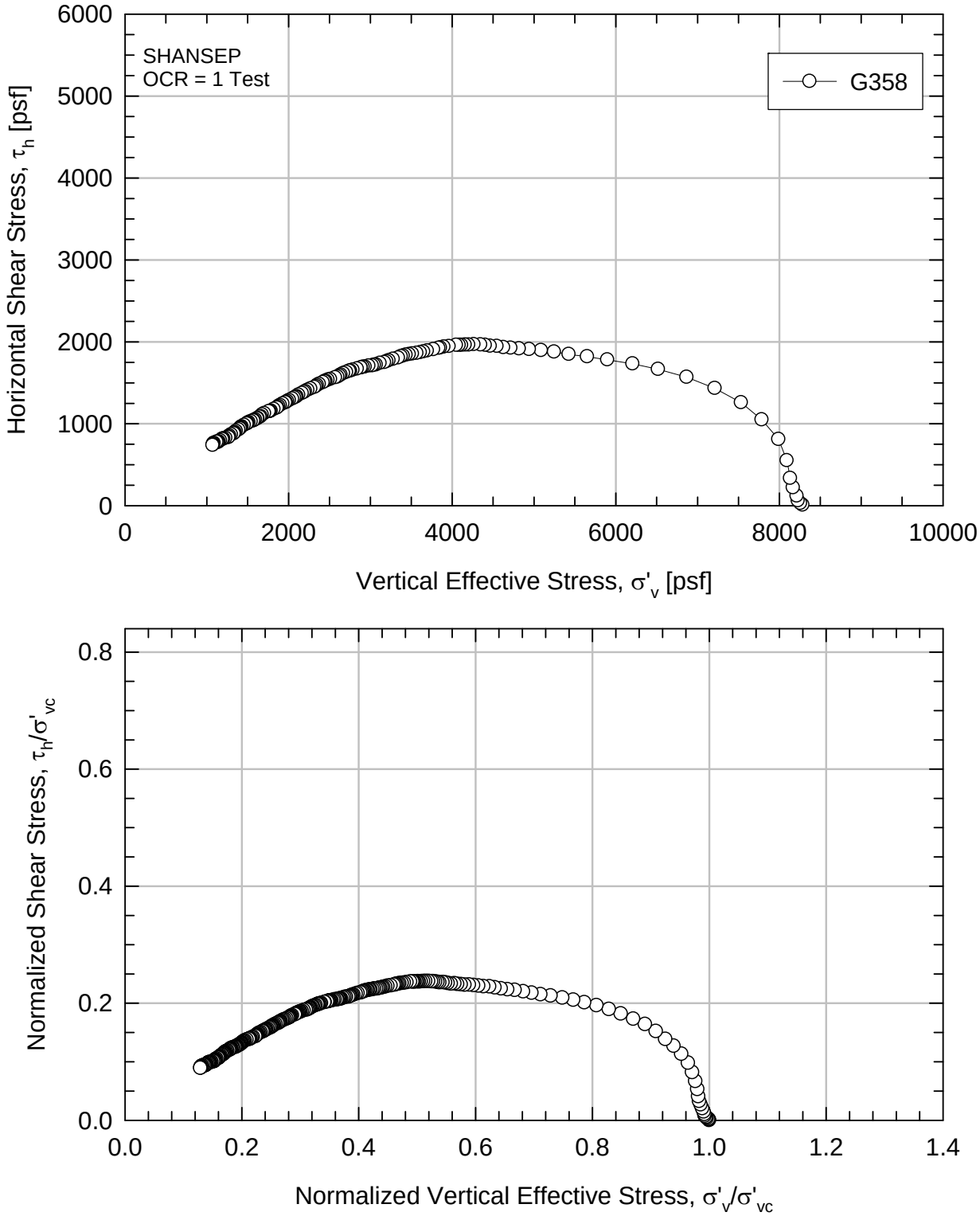

Figure 5.4.49 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G358 on sample 09-108B S2 23.5-26.0 ft

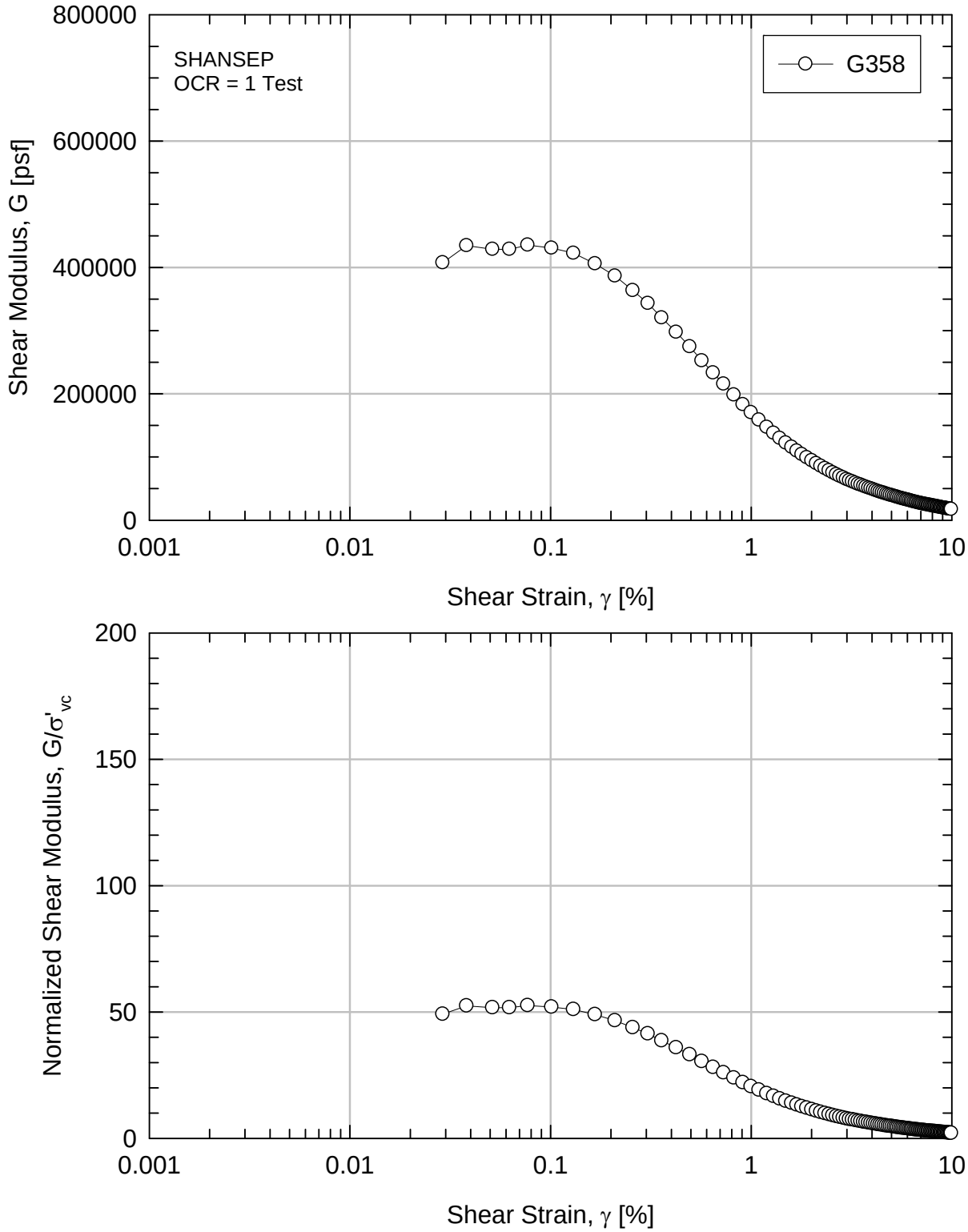

Figure 5.4.50 Shear modulus and normalized shear modulus versus shear strain for test DSS G358 on sample 09-108B S2 23.5-26.0 ft

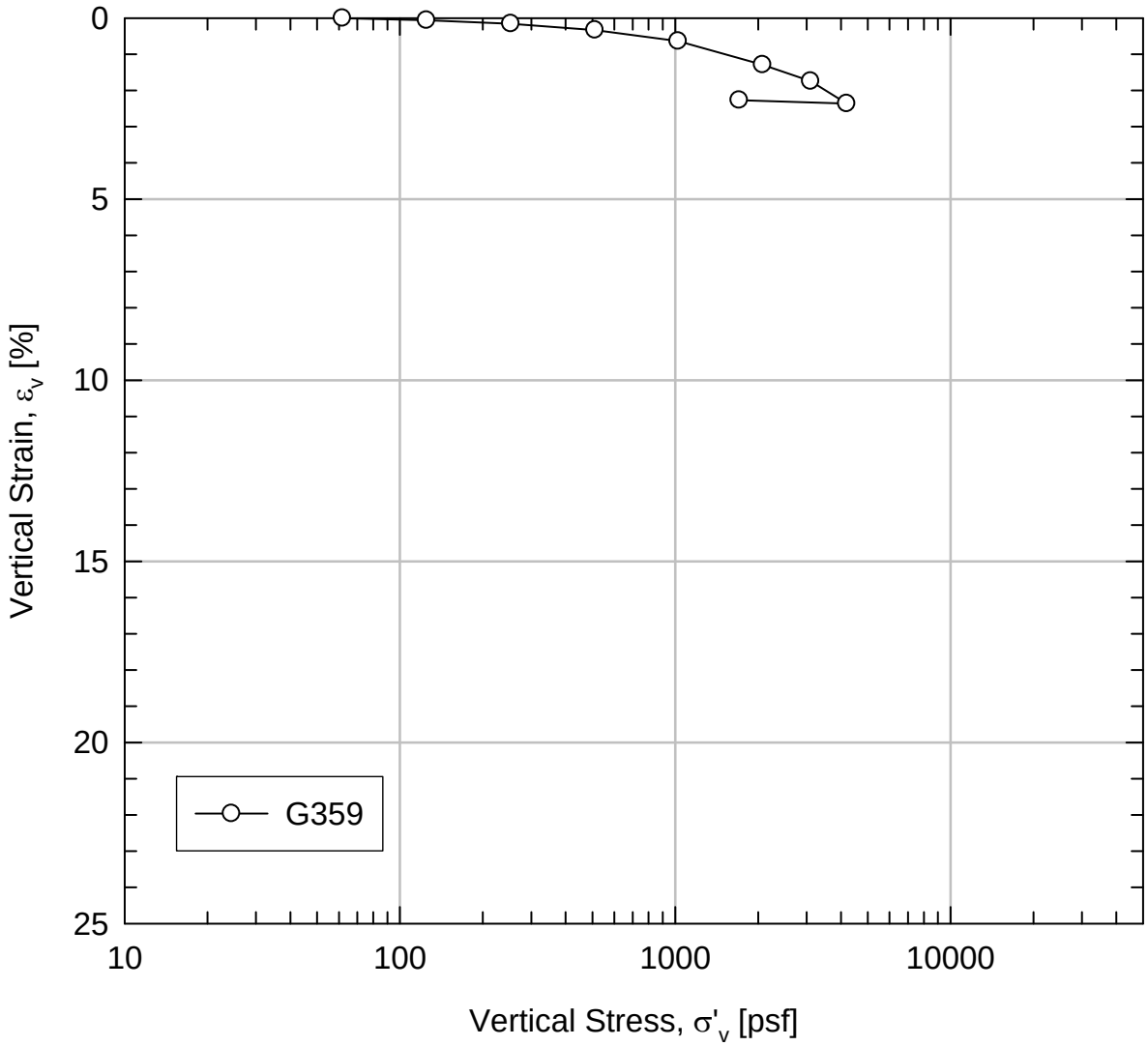

Figure 5.4.51 Vertical strain versus vertical effective stress for test DSS G359 on sample 09-408B S7 35.5-38.0 ft

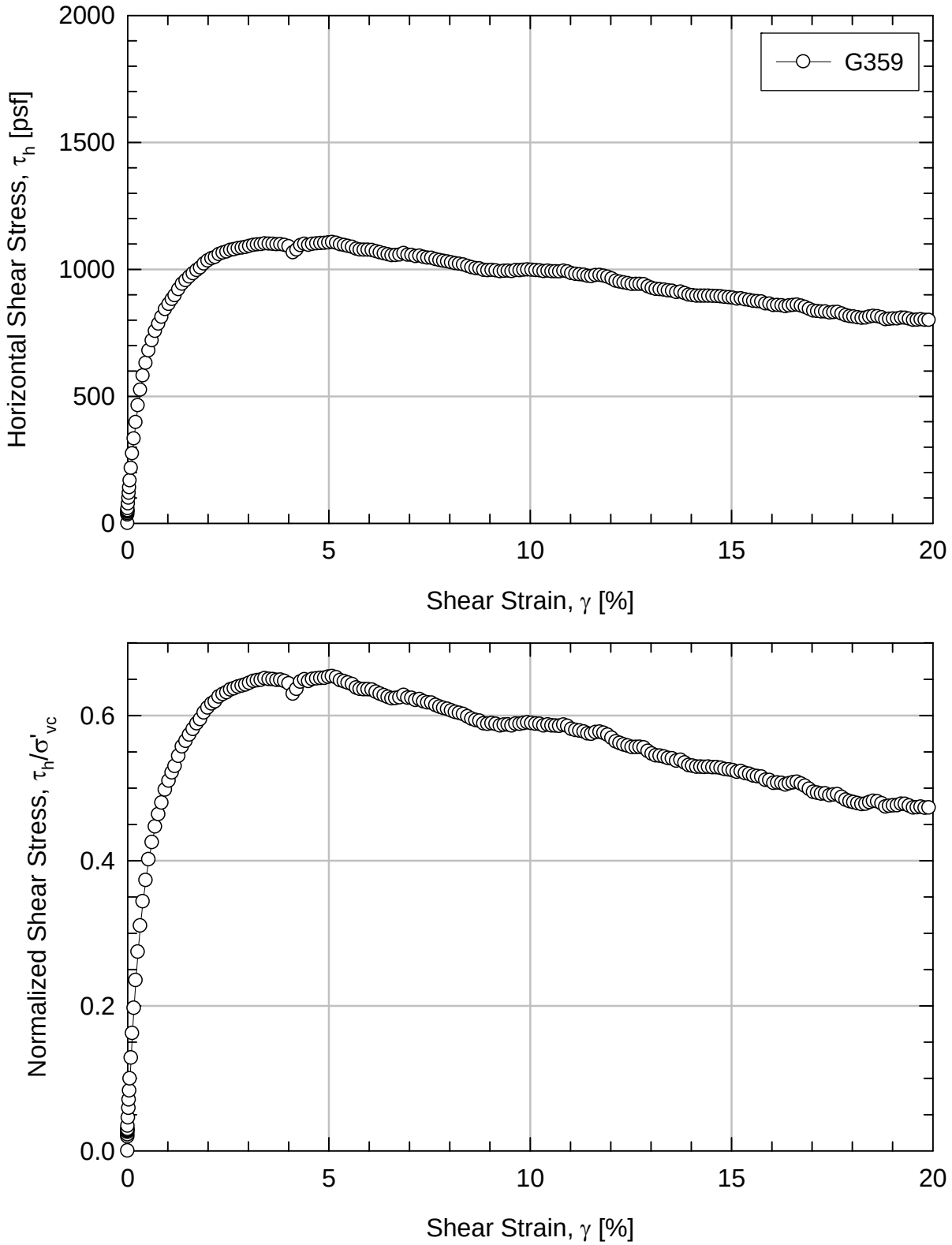

Figure 5.4.52 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G359 on sample 09-408B S7 35.5-38.0 ft

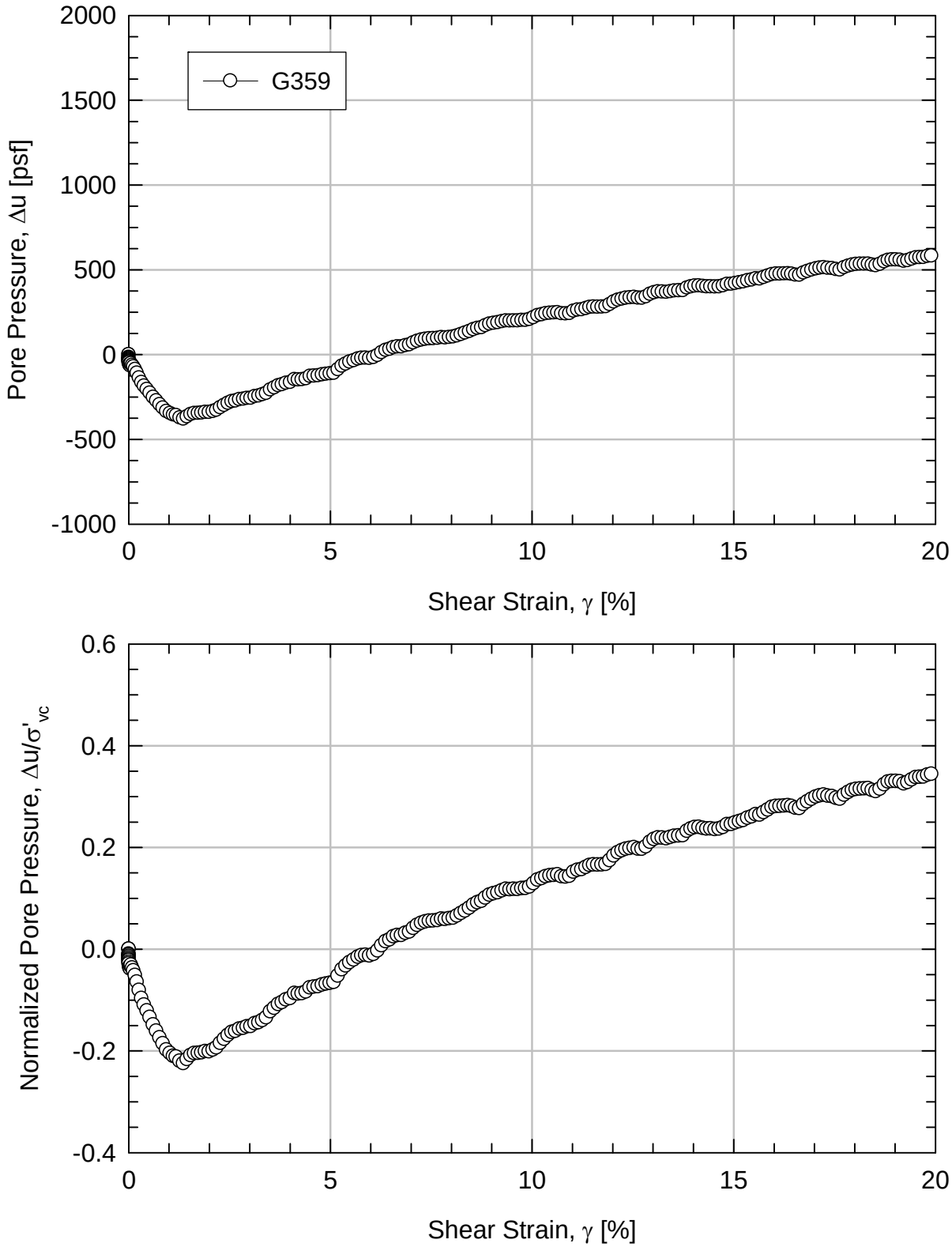

Figure 5.4.53 Pore pressure and normalized pore pressure versus shear strain for test DSS G359 on sample 09-408B S7 35.5-38.0 ft

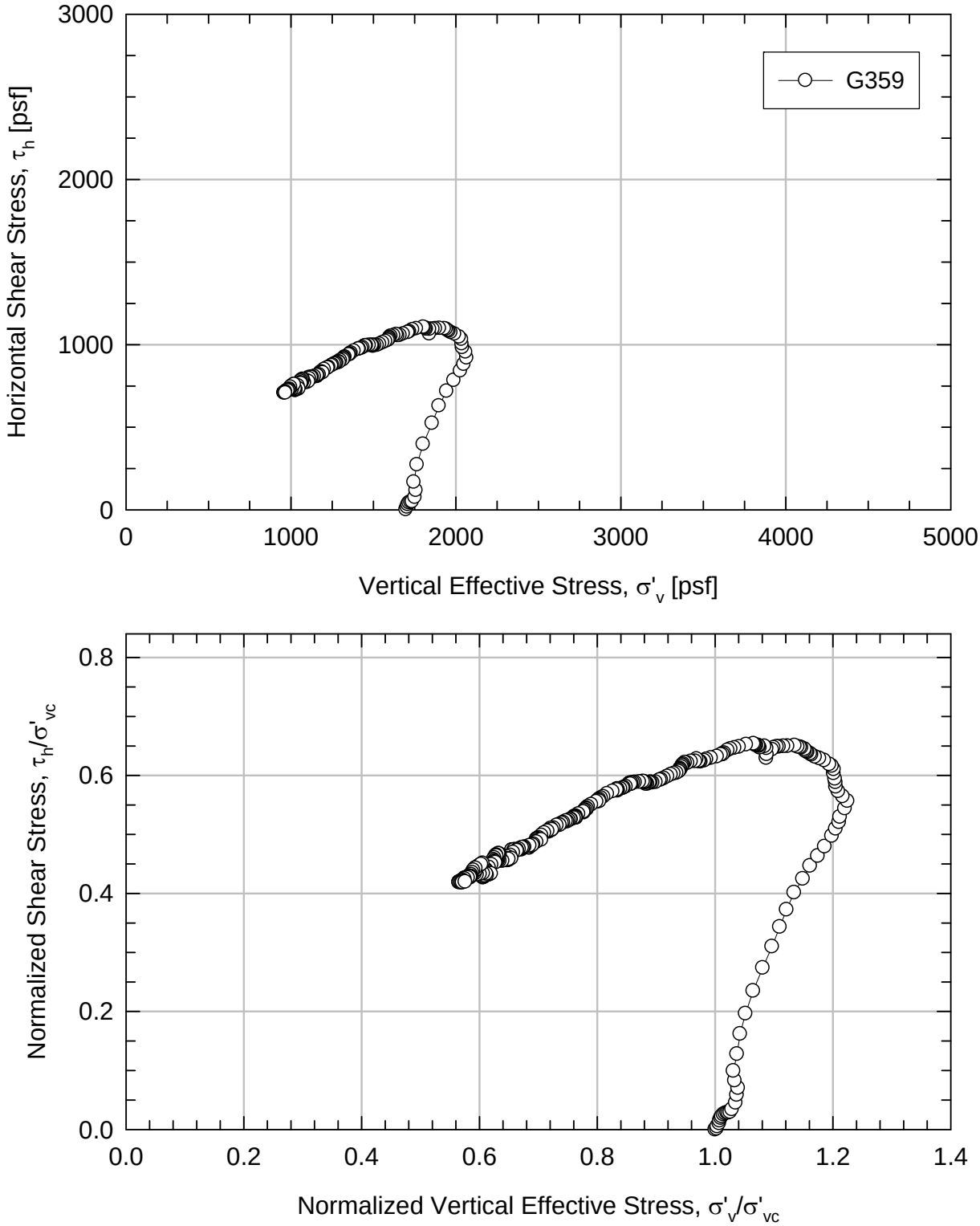

Figure 5.4.54 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G359 on sample 09-408B S7 35.5-38.0 ft

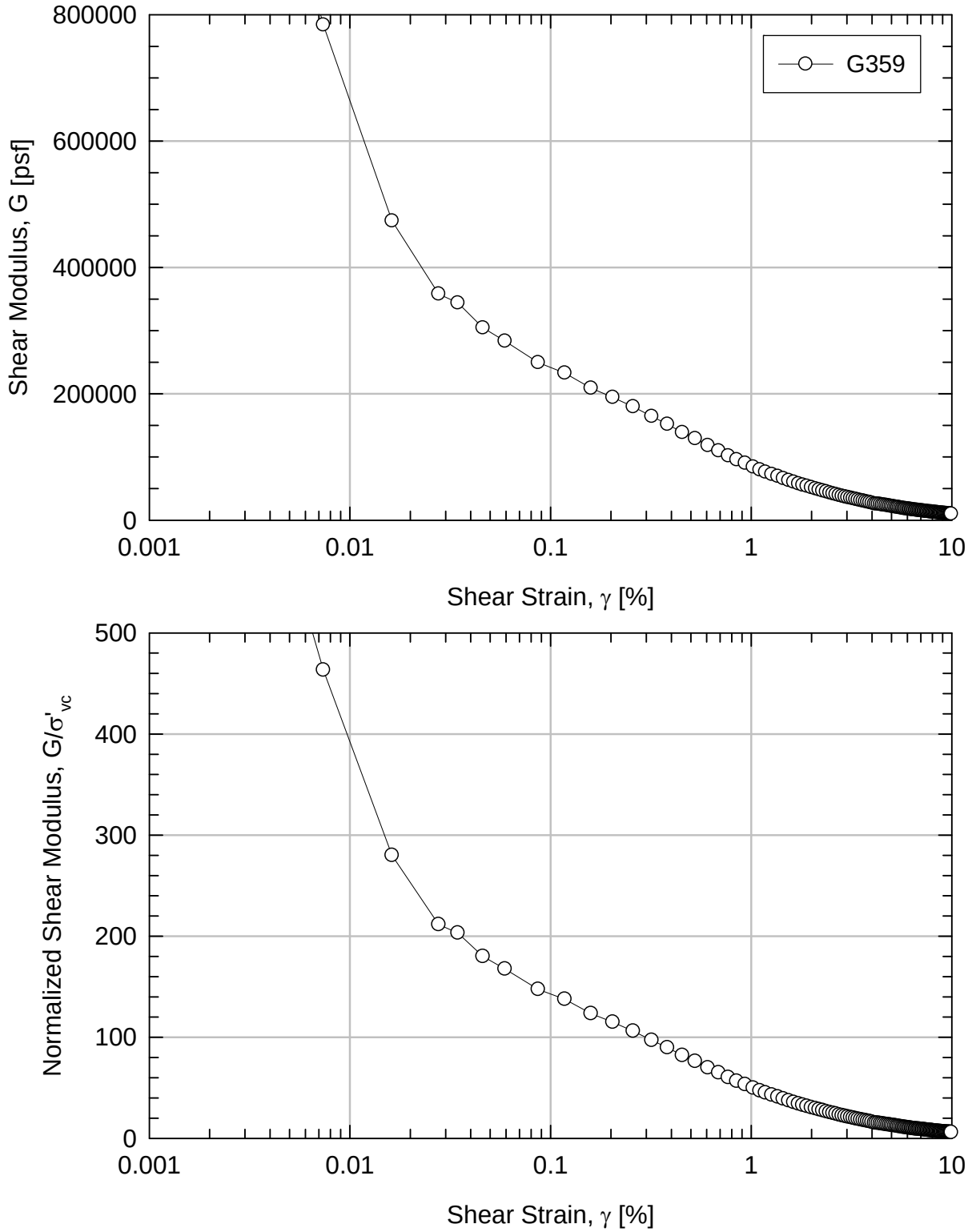

Figure 5.4.55 Shear modulus and normalized shear modulus versus shear strain for test DSS G359 on sample 09-408B S7 35.5-38.0 ft

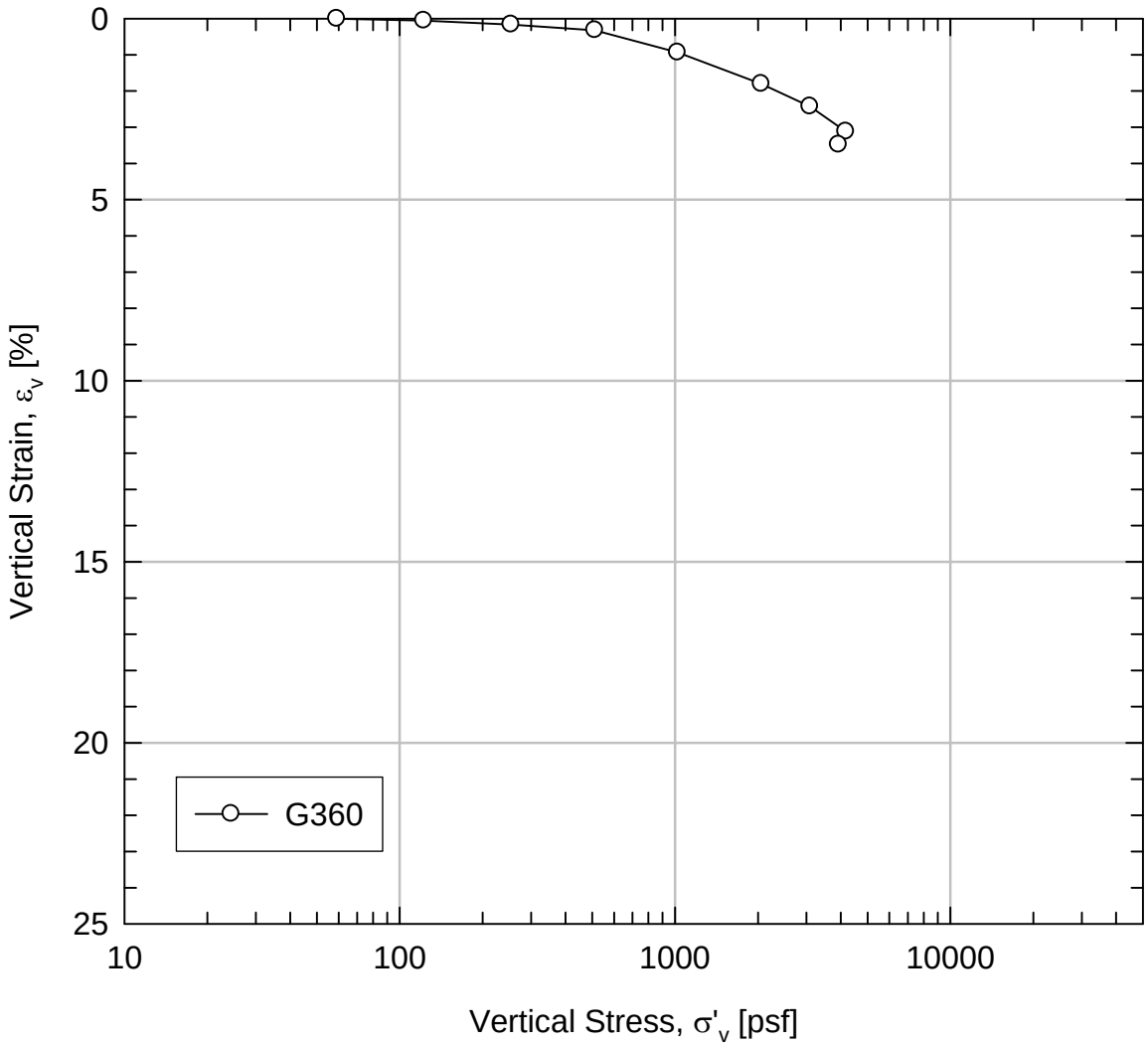

Figure 5.4.56 Vertical strain versus vertical effective stress for test DSS G360 on sample 09-503B S3 35.5-38.0 ft

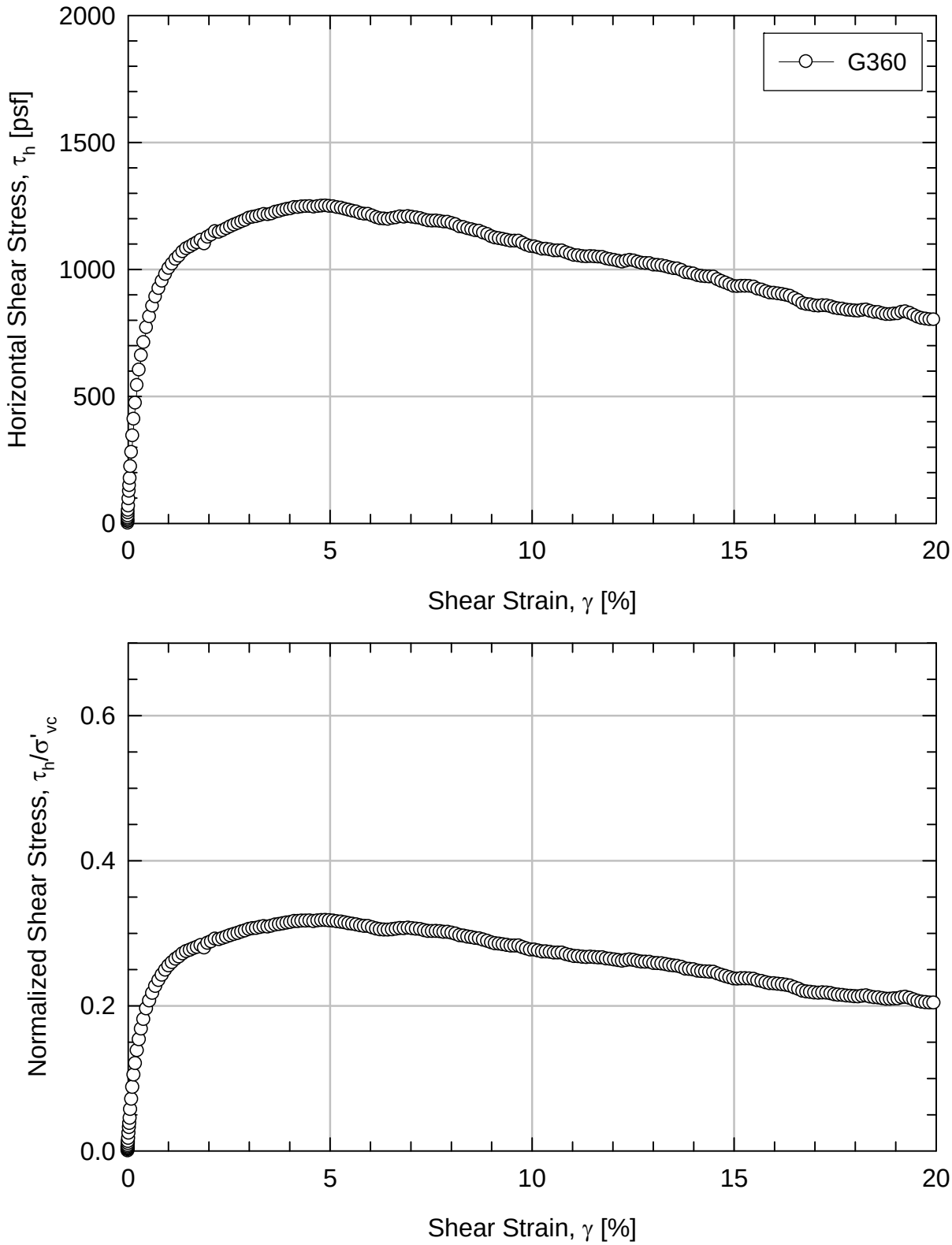

Figure 5.4.57 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G360 on sample 09-503B S3 35.5-38.0 ft

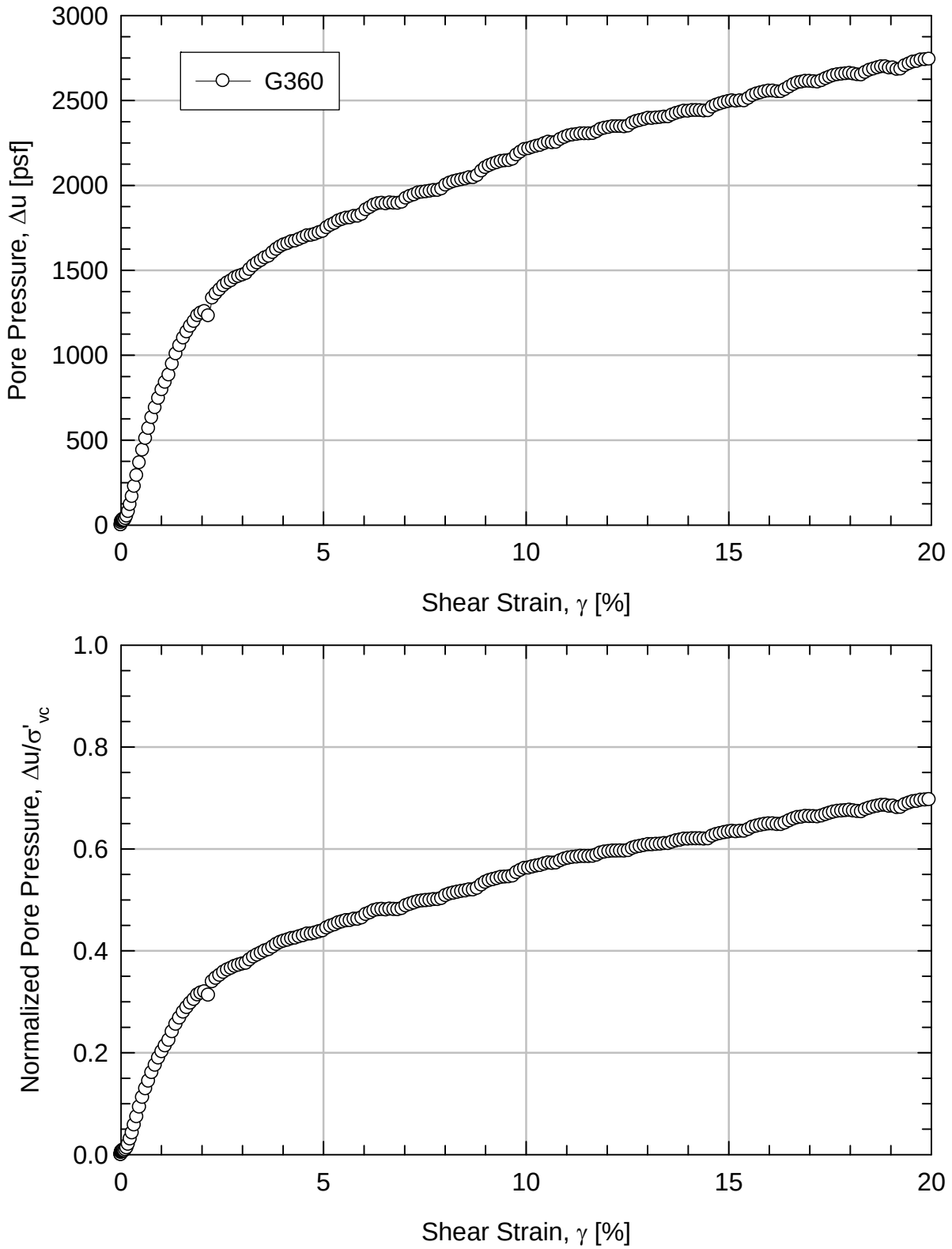

Figure 5.4.58 Pore pressure and normalized pore pressure versus shear strain for test DSS G360 on sample 09-503B S3 35.5-38.0 ft

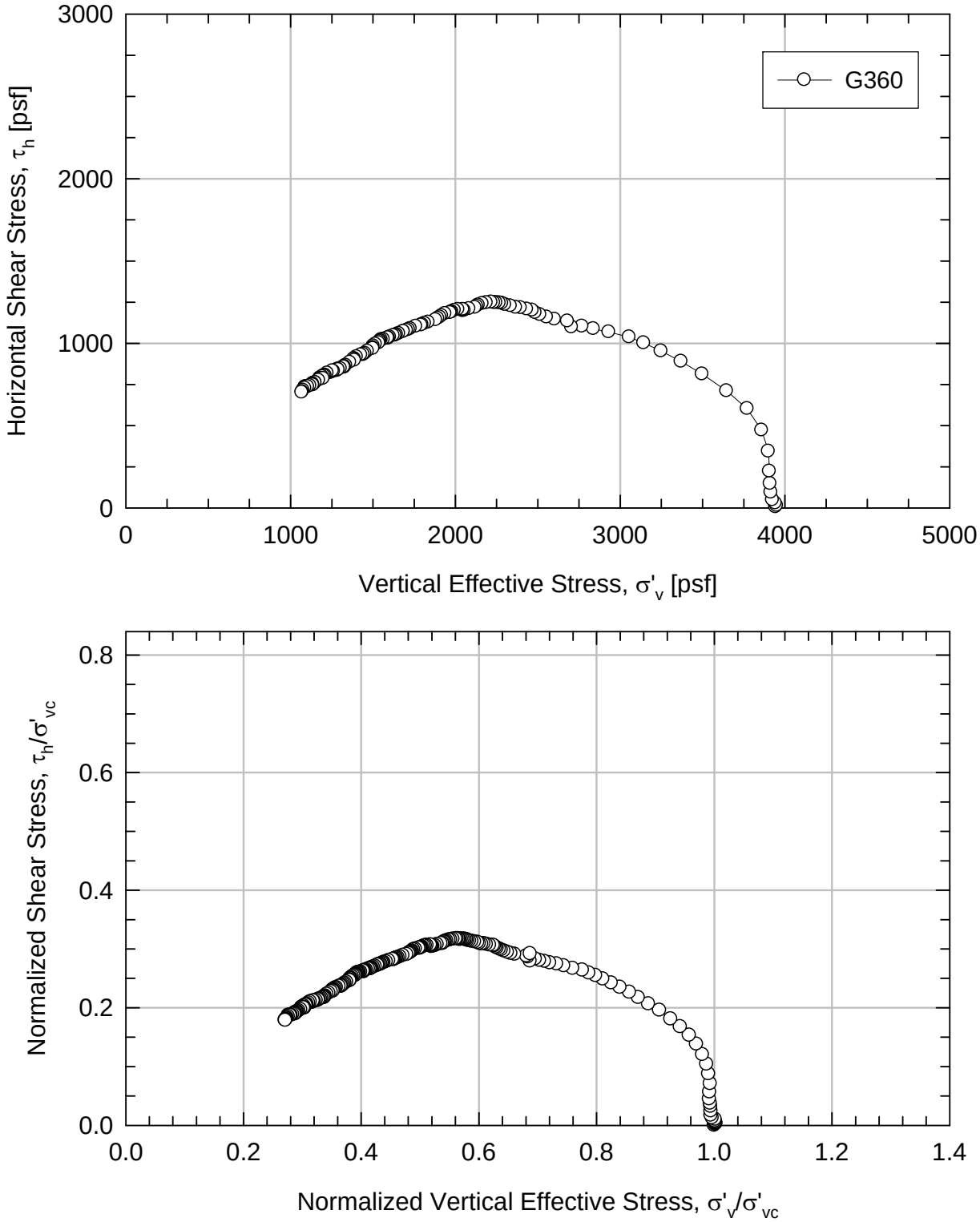

Figure 5.4.59 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G360 on sample 09-503B S3 35.5-38.0 ft

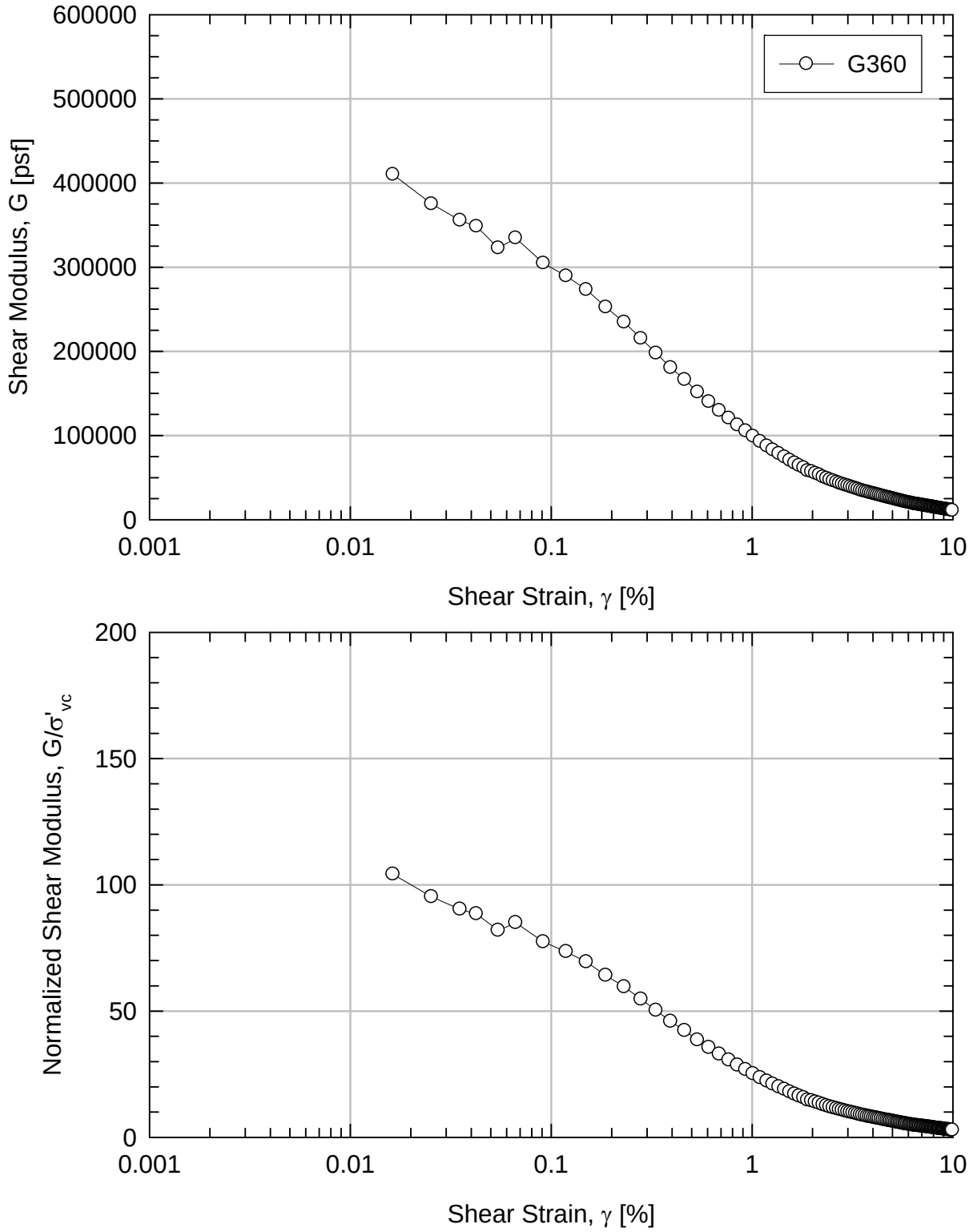

Figure 5.4.60 Shear modulus and normalized shear modulus versus shear strain for test DSS G360 on sample 09-503B S3 35.5-38.0 ft

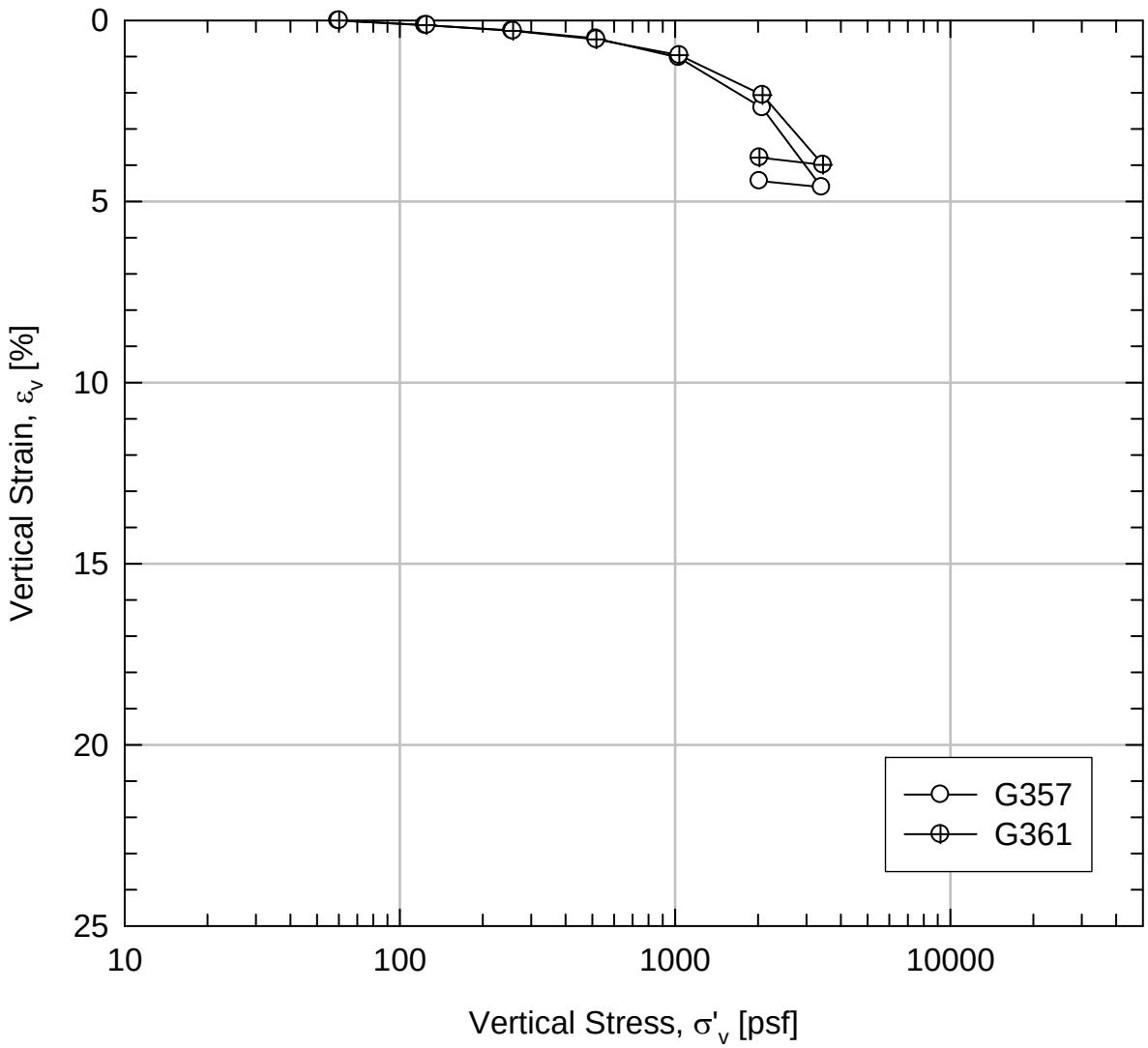

Figure 5.4.61 Vertical strain versus vertical effective stress for test DSS G357 and creep test G361 on sample 09-100B S6 35.5-38.0 ft

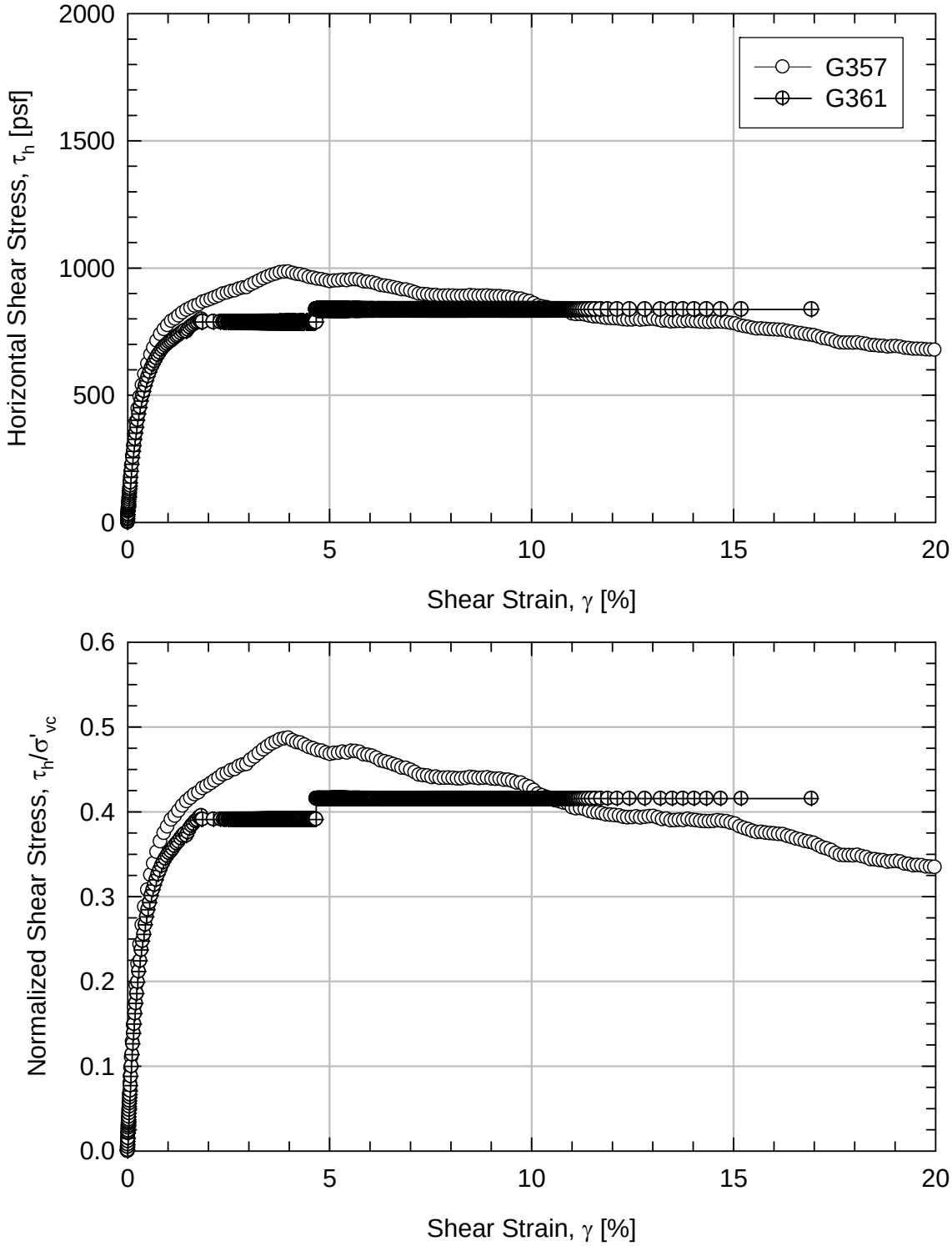

Figure 5.4.62 Horizontal shear stress and normalized shear stress versus shear strain for test DSS G357 and creep test G361 on sample 09-100B S6 35.5-38.0 ft

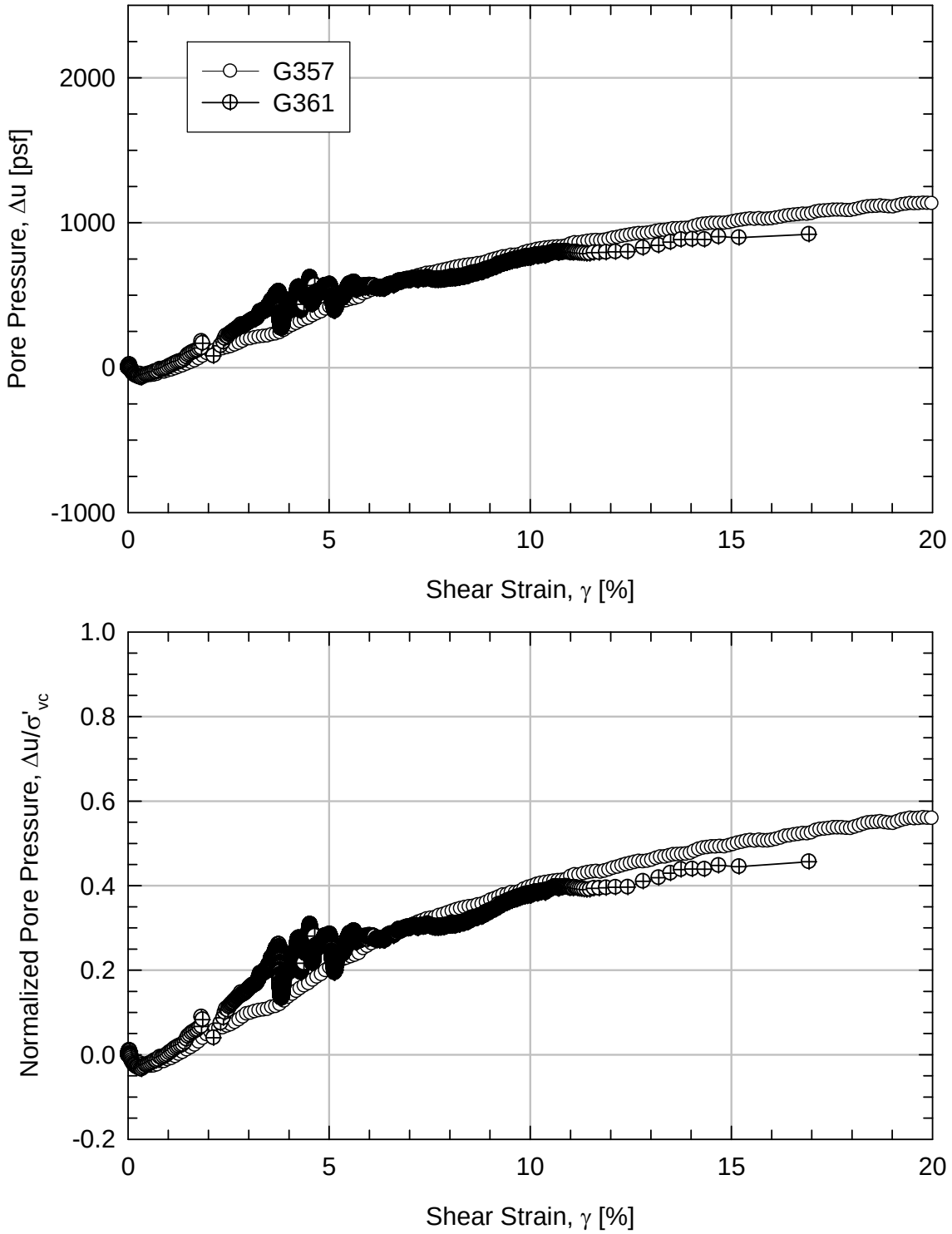

Figure 5.4.63 Pore pressure and normalized pore pressure versus shear strain for test DSS G357 and creep test G361 on sample 09-100B S6 35.5-38.0 ft

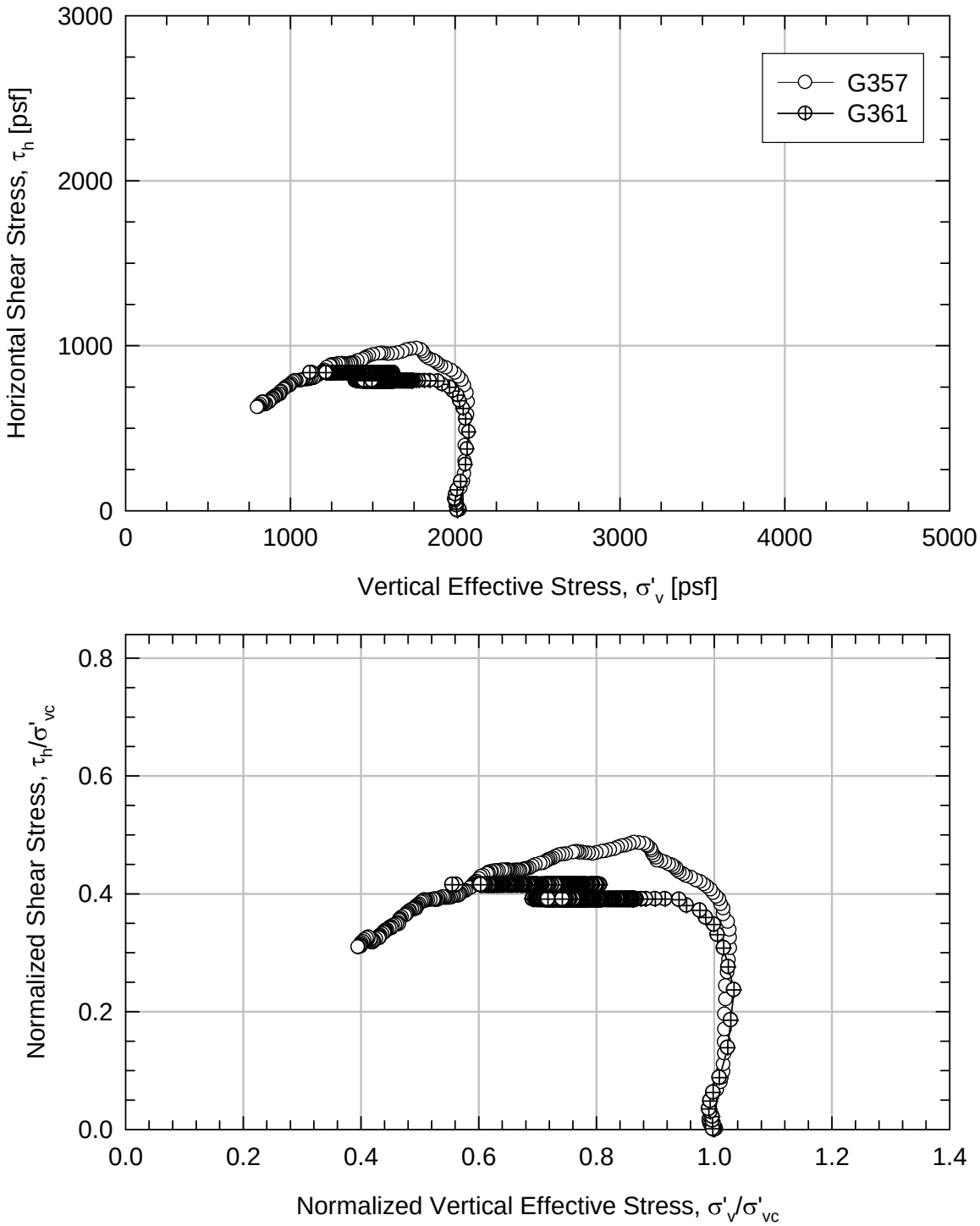

Figure 5.4.64 Horizontal shear stress versus vertical effective stress and normalized shear stress versus normalized vertical effective stress for test DSS G357 and creep test G361 on sample 09-100B S6 35.5-38.0 ft

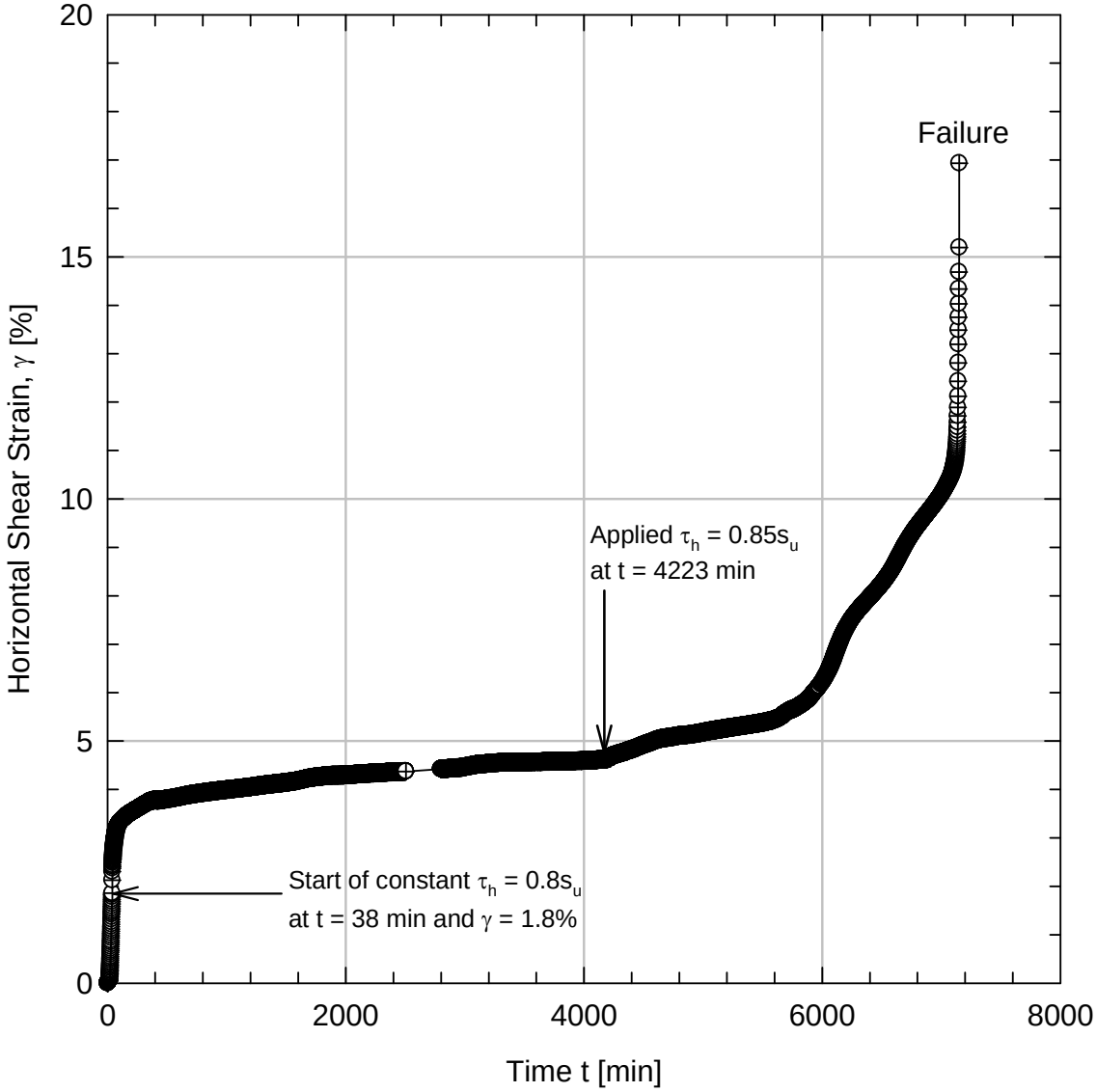

Figure 5.4.65 Horizontal shear strain versus time for DSS creep test G361 on sample 09-100B S6 35.5-38.0 ft

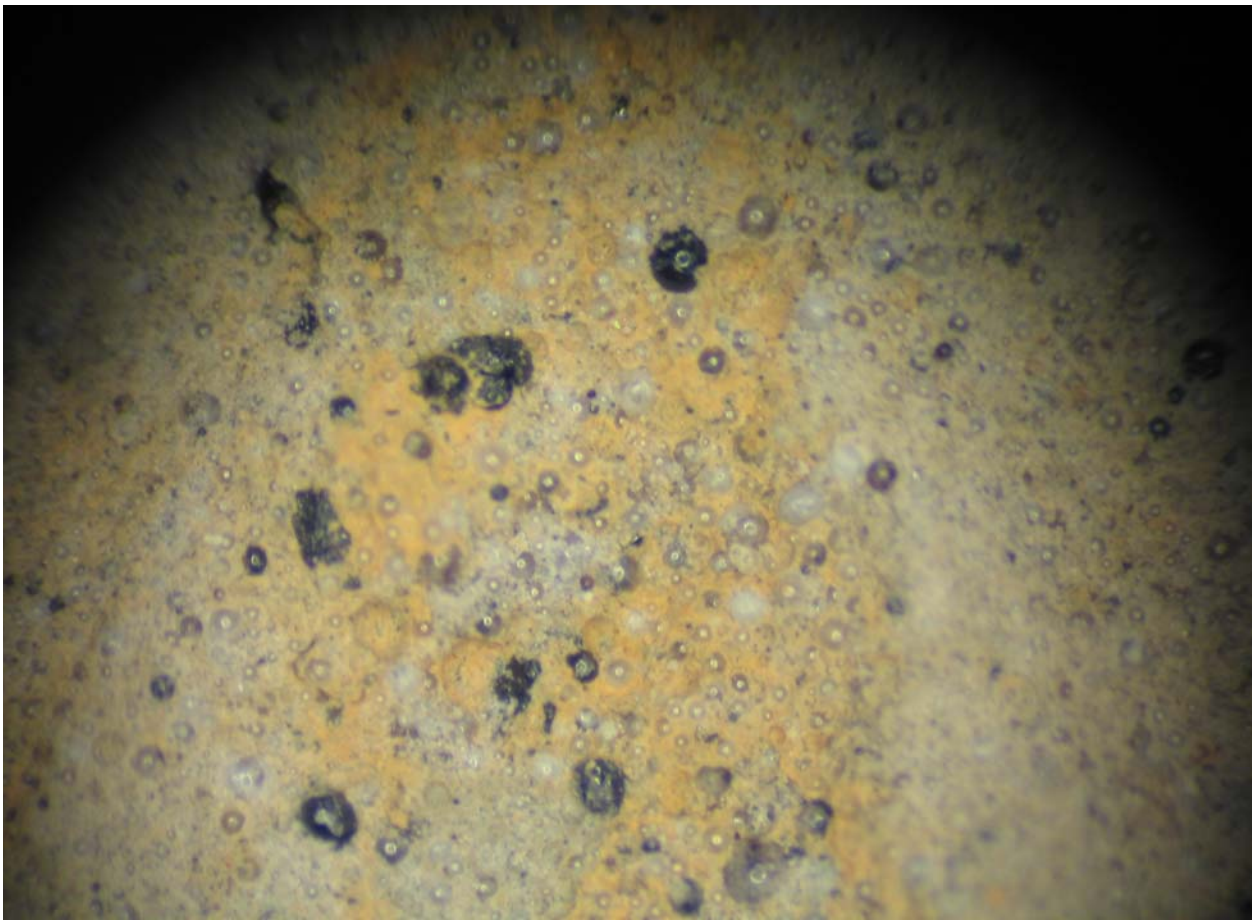

Figure 5.5.1 Photograph through a microscope of split open, oven dried, test specimen CRS167 on 09-100B S5.

Figure 5.5.2 Photograph through a microscope of split open, oven dried, test specimen DSS G357 on 09-100B S6.

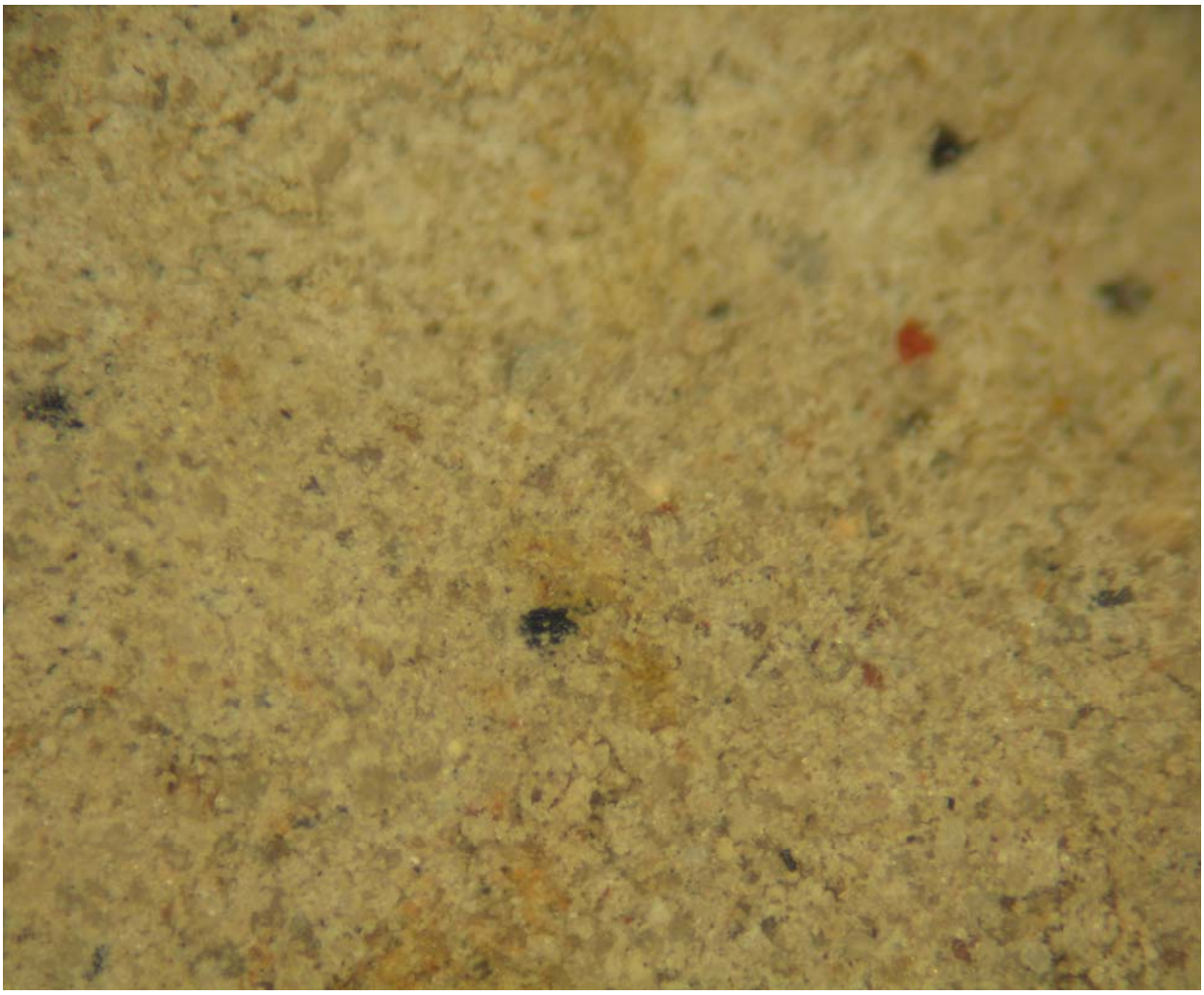

Figure 5.5.3 Photograph through a microscope of split open, oven dried, test specimen DSS G350 on 09-101B S5.

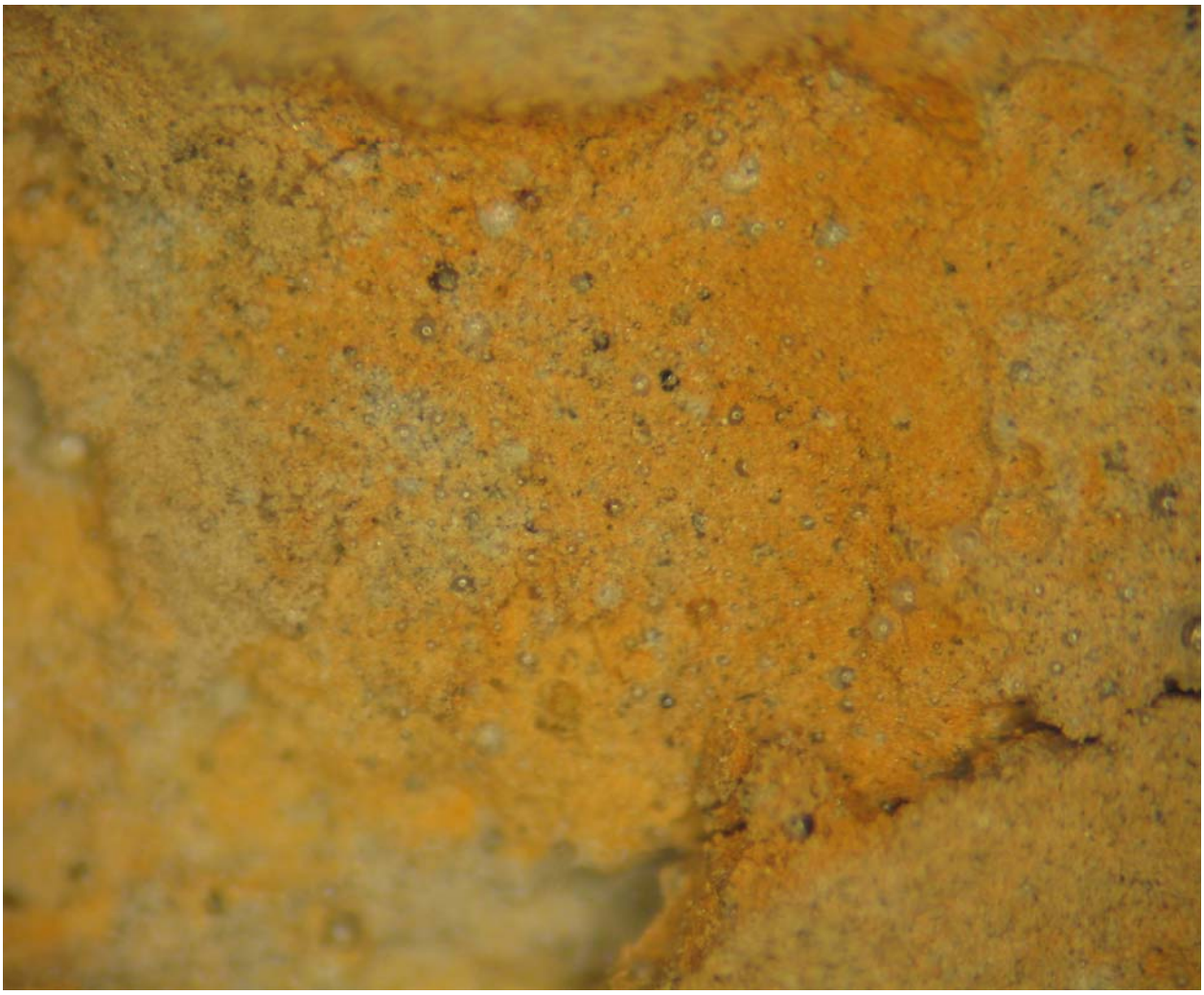

Figure 5.5.4 Photograph through a microscope of split open, oven dried, test specimen DSS G355 on 09-103B S2.

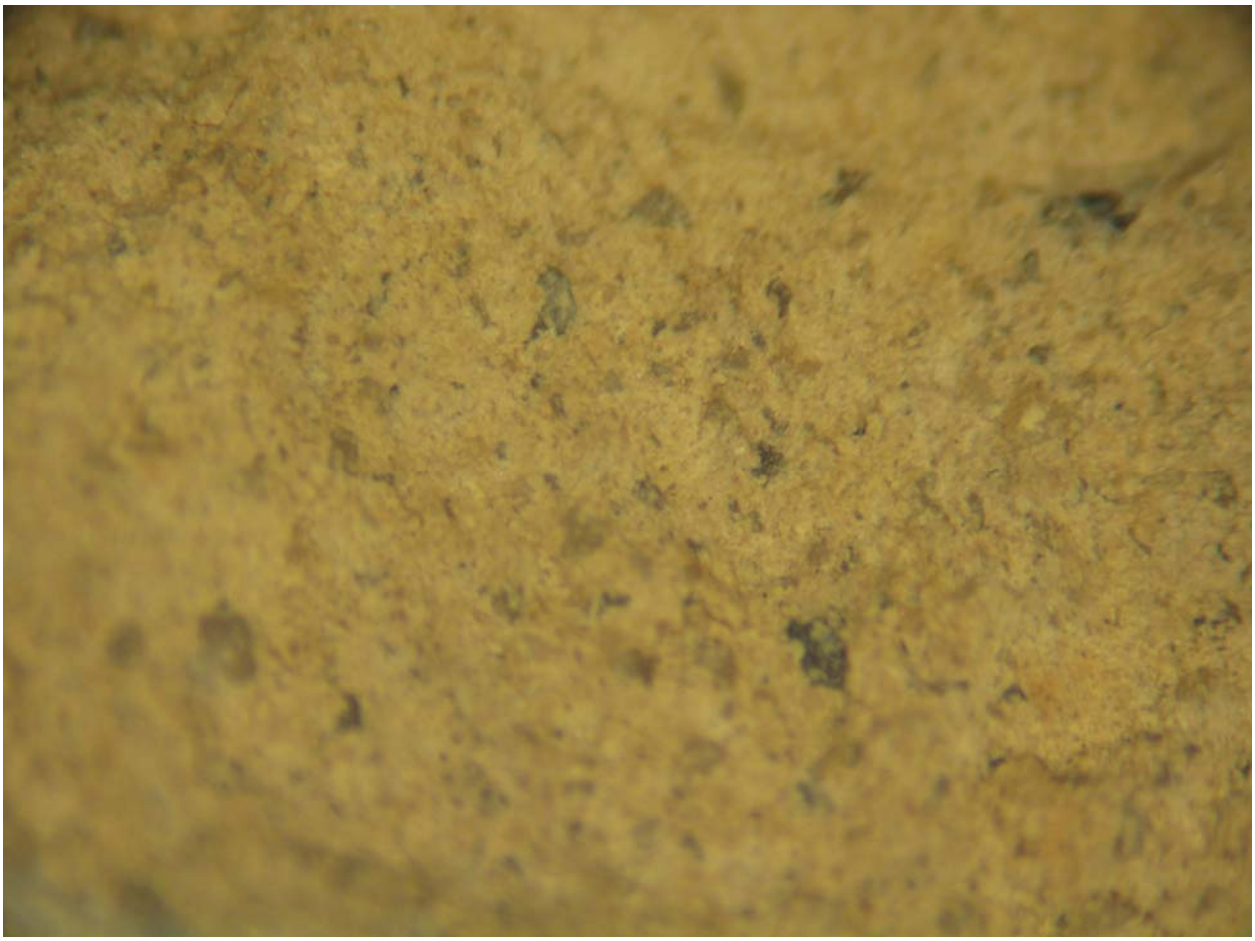

Figure 5.5.5 Photograph through a microscope of split open, oven dried, test specimen DSS G349 on 09-301B S6.

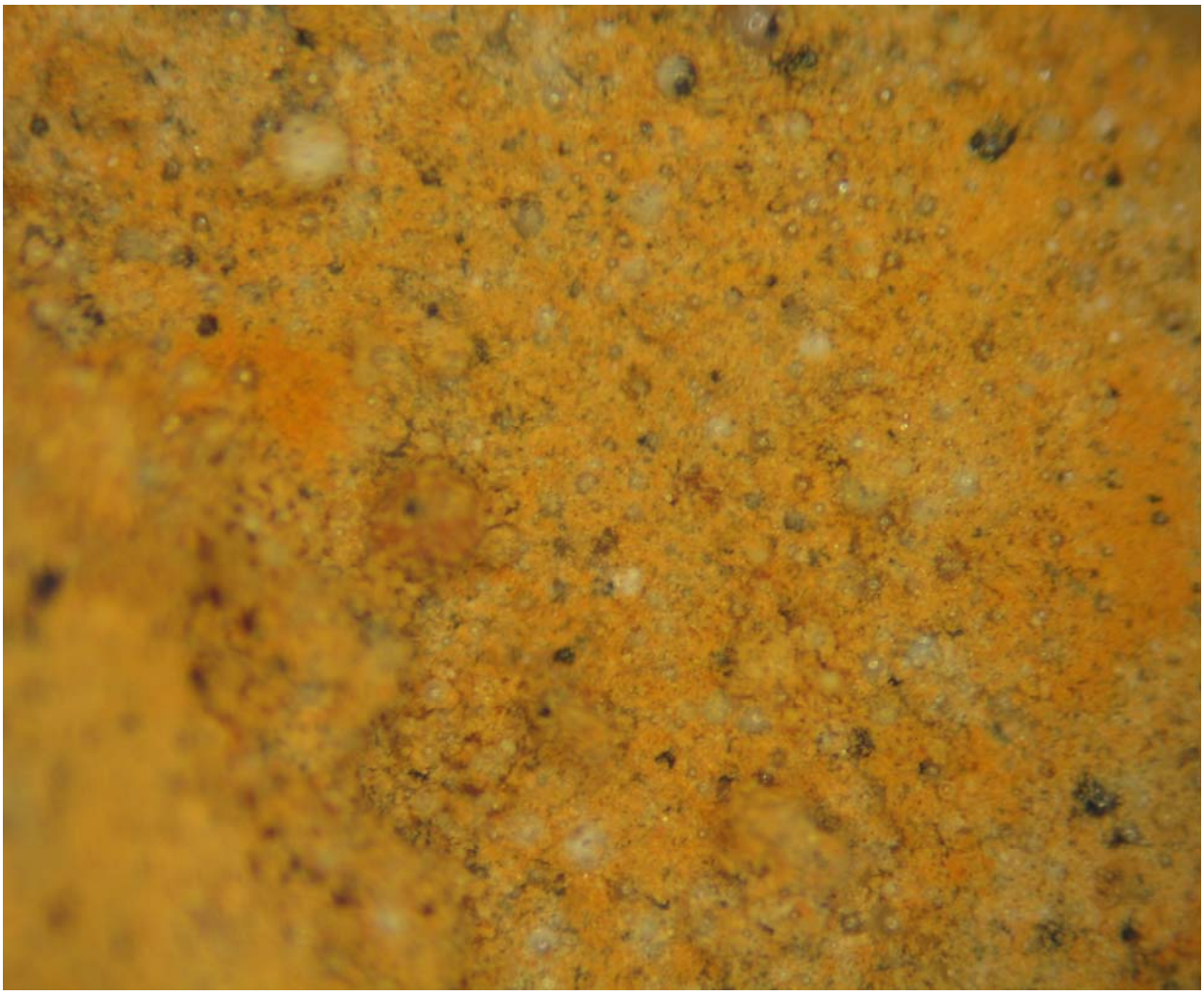

Figure 5.5.6 Photograph through a microscope of split open, oven dried, test specimen DSS G360 on 09-503B S3.