Osterberg Cell World Record Loadtest Review

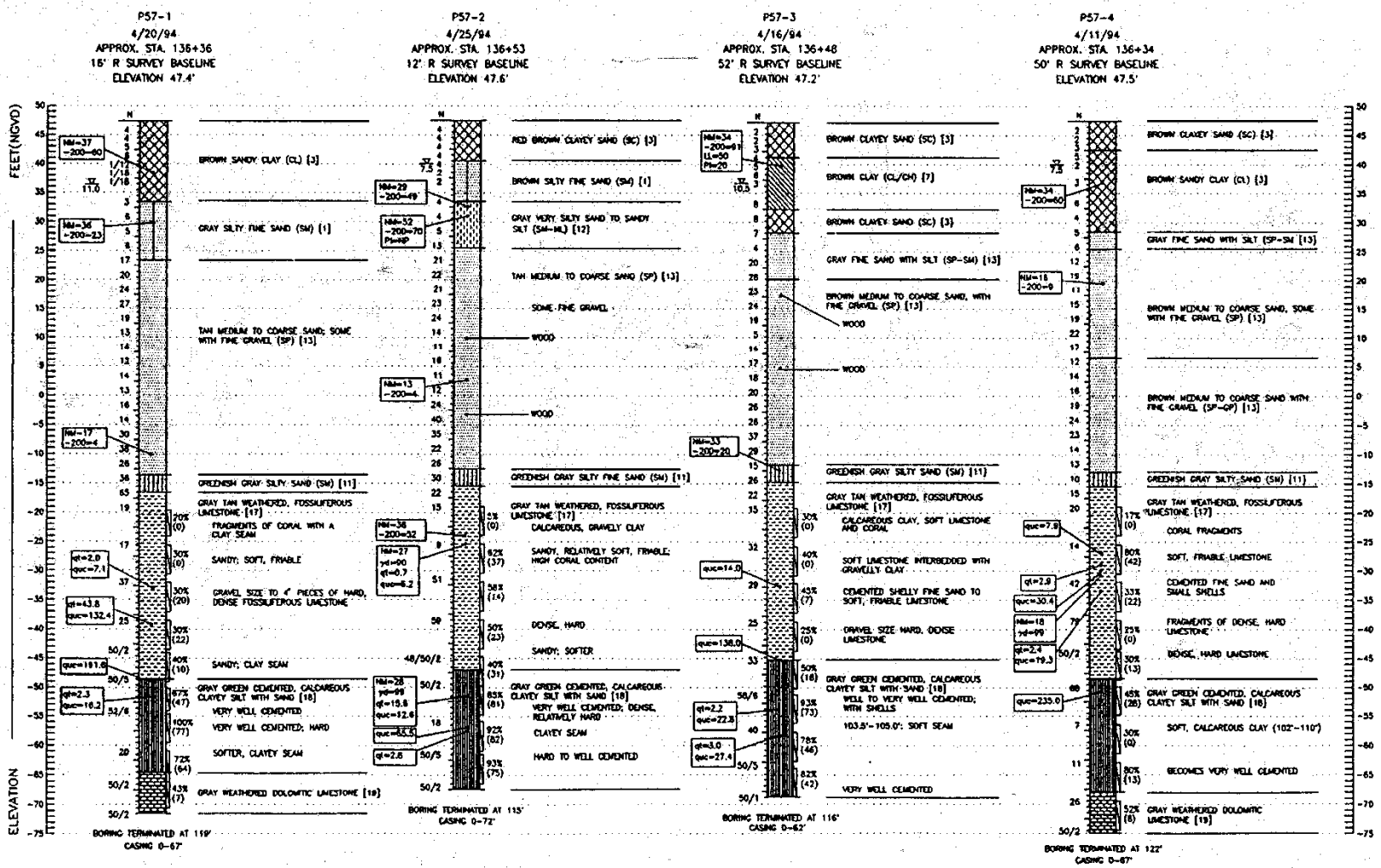
William F. “Bubba’ Knight, P.E.
Business Development Manager
Senior Engineer

O Cell Word Record Review

History

Location	Diameter	Depth	Maximum Load
Ohio River Bridge, Kentucky (1992)	1.8m (6 ft.)	36m (117 ft.)	**54 MN** (6,200 tons)
St. Mary's River, Georgia (1996)	1.5m (5 ft.)	23m (75 ft.)	**65 MN** (7,300 tons)
Penang, Malaysia (1996)	6x1m barrette	91m (300 ft.)	**97 MN** (11,000 tons)
Apalachicola River, Florida (1997)	2.75m (9 ft.)	39m (127 ft.)	**133 MN** (15,000 tons)
Tucson, Arizona (2001)	2.4m (7.9 ft.)	41m (135 ft.)	**151 MN** (17,000 tons)
Pomeroy - Mason WV, Ohio River	2.4m (8 ft.)	26m (86ft.)	**163 MN** (18,400 tons)
Incheon 2nd Crossing Korea (2005)	2.4m – 3.0m (8 ft. – 10ft.)	67m (220ft.)	**279 MN** (31,350 tons)
I-70 Mississippi Bridge, St Louis, Missouri (2010)	3.35m (11ft.)	35m (115ft.)	**320 MN** (36,000 tons)

STATE PROJ. NO.
47010-3518
56010-3520



DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION

DESIGNED BY	CED	02/95	CHECKED BY	TLB	02/95
DRAWN BY	WSJ	02/95	CHECKED BY		

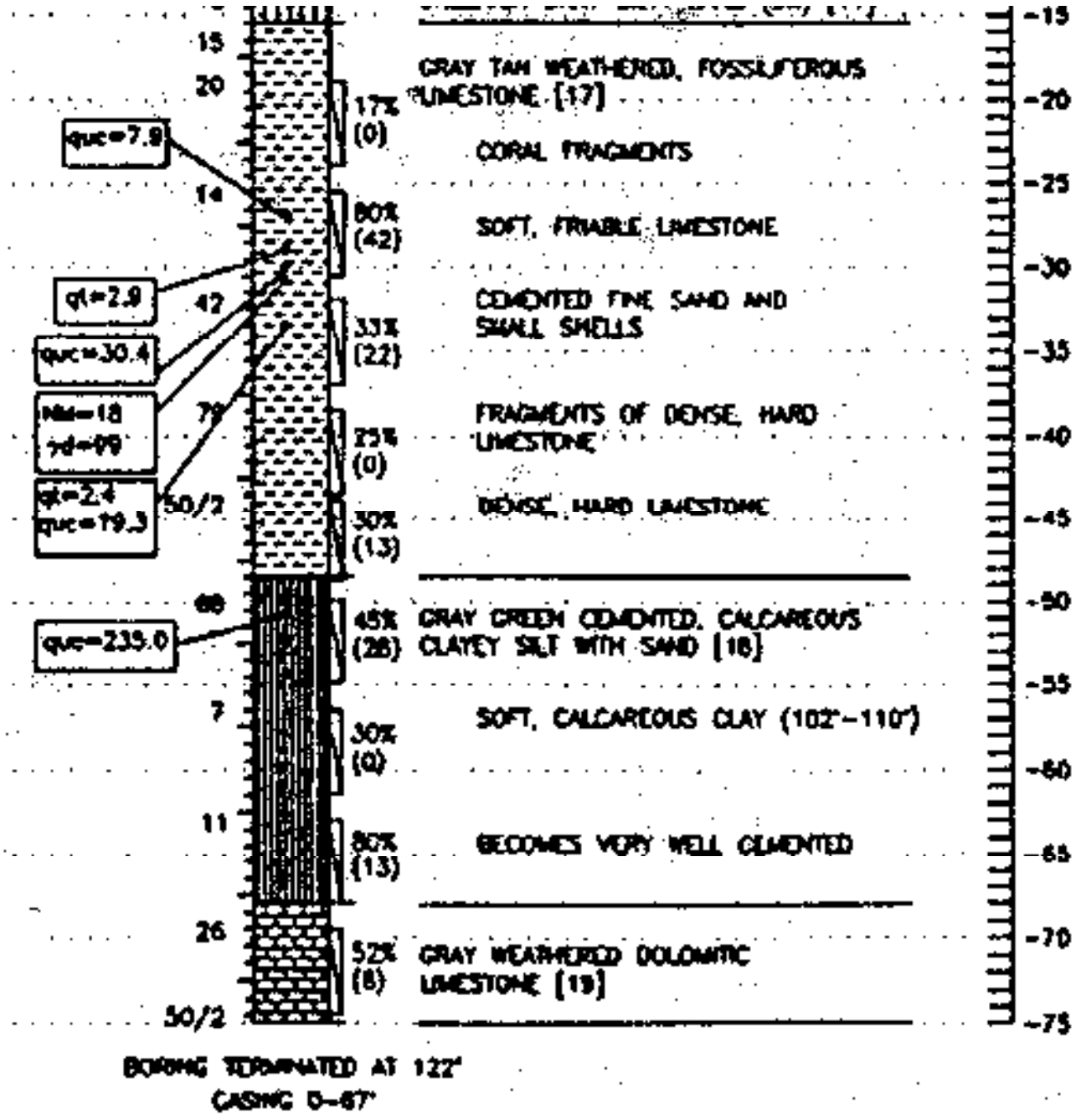
W.S. JORDAN

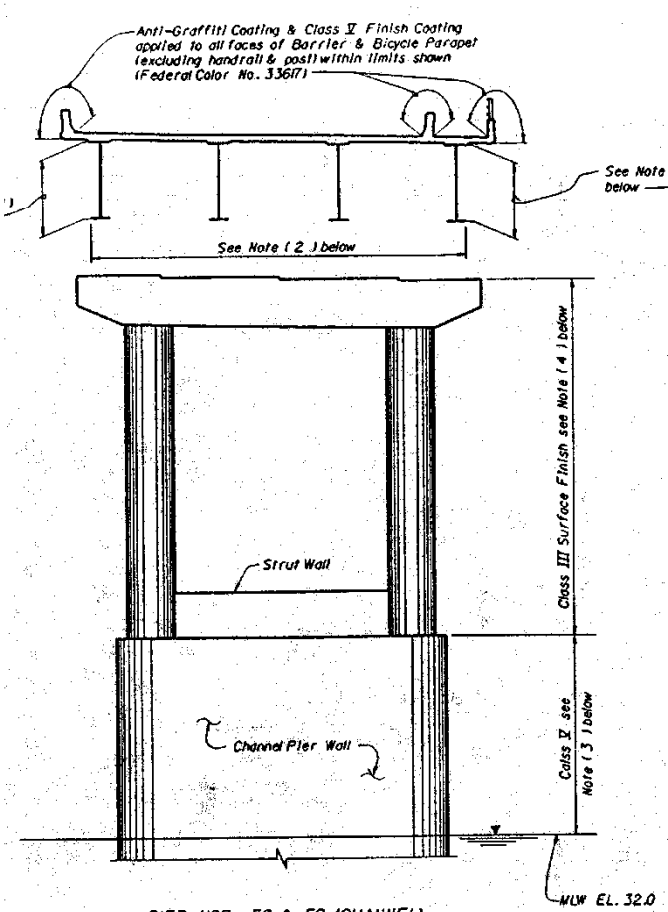
FLORIDA DEPARTMENT OF TRANSPORTATION

APPROVED BY

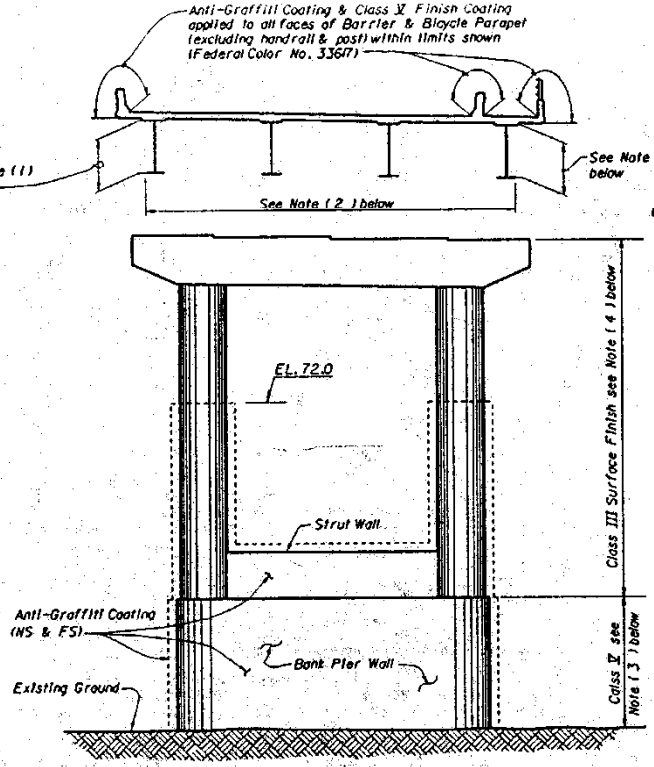
Anderson & Associates, Inc.

REPORT OF CORE BORI
SR 20 OVER APALACHICOLA R
CALHOUN & LIBERTY COUNTIES,

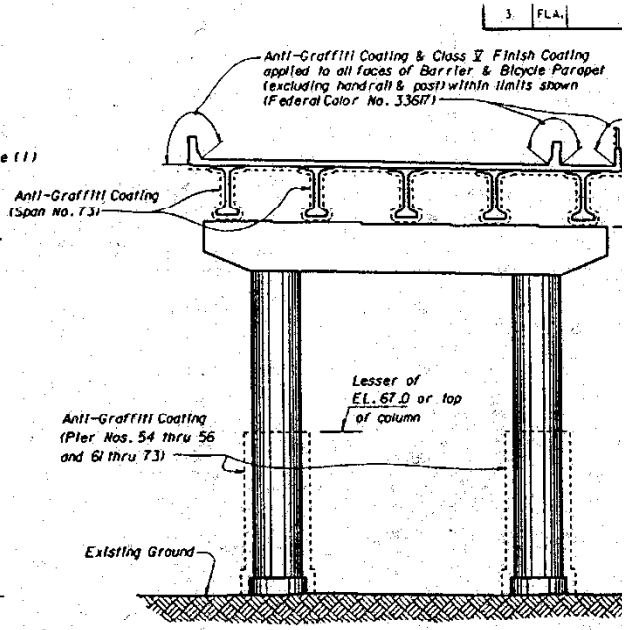

15
20
17%
(0)
GRAY TAN WEATHERED, FOSSILIFEROUS
LIMESTONE [17]
qu=7.8
CORAL FRAGMENTS
14
80%
(42)
SOFT, FRIABLE LIMESTONE
qt=2.9
42
33%
(22)
CEMENTED FINE SAND AND
SMALL SHELLS
qu=30.4
Nst=18
γd=99
79
FRAGMENTS OF DENSE, HARD
LIMESTONE
25%
(0)
qt=2.4
qu=19.3
50/2
DENSE, HARD LIMESTONE
30%
(13)
60
45%
(26)
GRAY GREEN CEMENTED, CALCAREOUS
CLAYEY SILT WITH SAND [18]
qu=235.0
7
30%
(0)
SOFT, CALCAREOUS CLAY (102'-110')
11
80%
(13)
BECOMES VERY WELL CEMENTED
26
52%
(8)
GRAY WEATHERED DOLOMITIC
LIMESTONE [19]
50/2
BORING TERMINATED AT 122'
CASING 0-67'
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
-75



PIER NOS. 58 & 59 (CHANNEL)



PIER NOS. 57 & 60 (BANK)



PIER NOS. 43 THRU 56 AND 61 THRU 73

NOTES:

(1) Field paint this area with a second coat of Inorganic Zinc primer and with a finish coat. See Technical Special Provisions.

(2) Field paint all Structural Steel within these limits with a second coat of Inorganic Zinc Primer. See Technical Special Provisions.

(3) All Sides of Bank Pier Wall (down to existing ground) & Channel Pier Wall (down to MLW) shall receive a Class V Finish Coating Federal Color No. 33448.

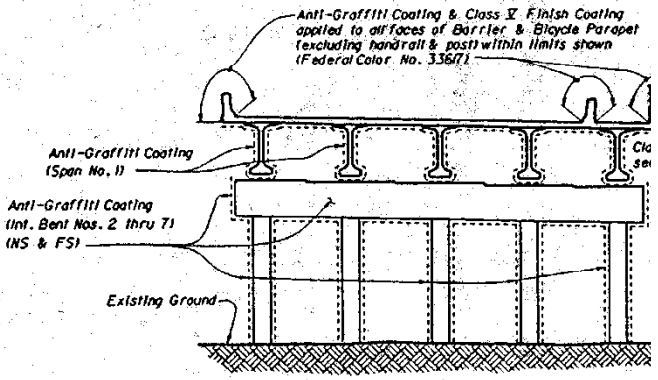
(4) Columns, Strut Wall & all surfaces of Pier Cap (except top) shall receive a Class III Surface Finish.

(5) Columns & all surfaces of Pier Cap (except top) shall receive a Class III Surface Finish.

(6) All surfaces of Intermediate Bent Caps (except top) shall receive a Class III Surface Finish.

(7) All exposed top, inside and outside surfaces of End Bent Nos. 1 & 74 shall receive a Class V Finish Coating Federal Color No. 33617.

(8) All exposed top, inside and outside surfaces of End Bent Nos. 1 & 74 and the diaphragms at Begin and End Bridge shall receive an Anti-Graffiti Coating.



INTERMEDIATE BENTS NOS. 2 THRU 42

REVISIONS									
Description	Date	By	Description						
				Drawn by	JLF	12-94	ENGINEER OF RECORD: STRUCTURES DESIGN OFFICE CENTRAL OFFICE 605 Suwannee Street, MS 33 Tallahassee, Florida 32399-0450	LOGO:	SEAL:
				Checked by	CEB	2-95			
				Designed by	CEB	12-94			
				Checked by	LWS	2-95			
				Approved by	HTB				

FLORIDA DEPARTMENT OF TRANSPORTATION
STRUCTURES DESIGN OFFICE

ROAD NO.	COUNTY	PROJECT NO.
20	CALHOUN & LIBERTY	47010-3519 & 56010-3520

SHEET TITLE: SURFACE FINISH D

PROJECT NAME: SR 20 OVER APALACHIC

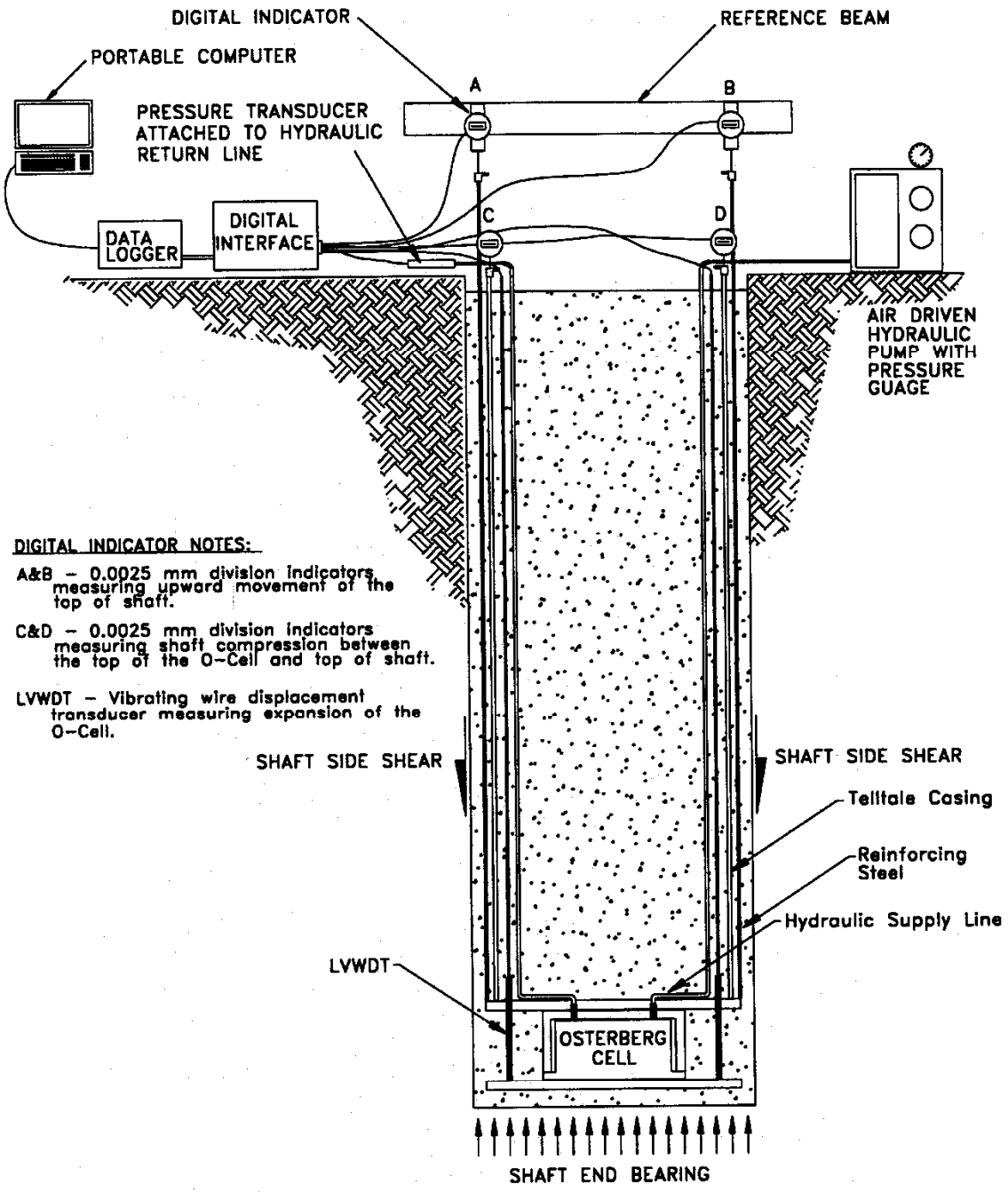
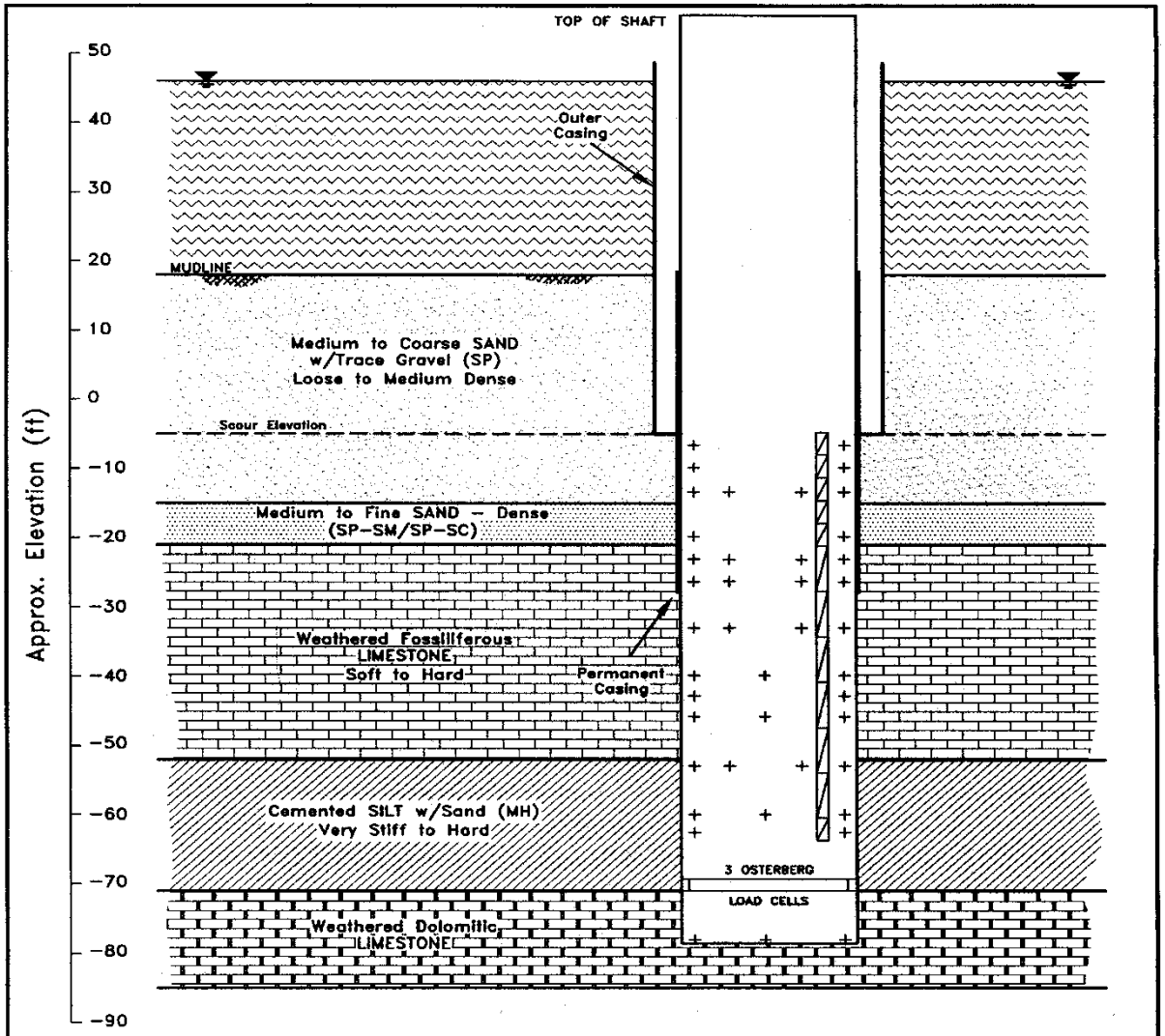


Fig. 2 Typical Osterberg cell test instrumentation



REFER TO LOGS FOR SOIL BORINGS P59-3 & P59-4 (APPENDIX B)
FOR SOIL AND ROCK STRENGTH DATA

NOT TO SCALE HORIZONTALLY

LEGEND

+ Strain Gauge Location

▯ EI Sensor, 1m or 2m long

NOTE: IN ADDITION TO THE STRAIN GAUGES, TELLTALE RODS WERE LOCATED AT THE TOP AND BOTTOM OF EACH OSTERBERG CELL.

Plate 54
TEST SHAFT #8
GENERALIZED STRATIGRAPHY AND TEST SHAFT SETUP
SR 20 over Apalachicola River
Blountstown, Florida

DAMES & MOORE


312.15.


A
B
LOADTEST


WORLD RECORD
LOADTEST

SR 20 OVER APALACHICOLA RIVER

TEST SHAFT #8 (9-ft) DIAM. - PIER #59

OSTERBERG CELL LOAD TEST

LOAD-MOVEMENT OF BOTTOM CELLS

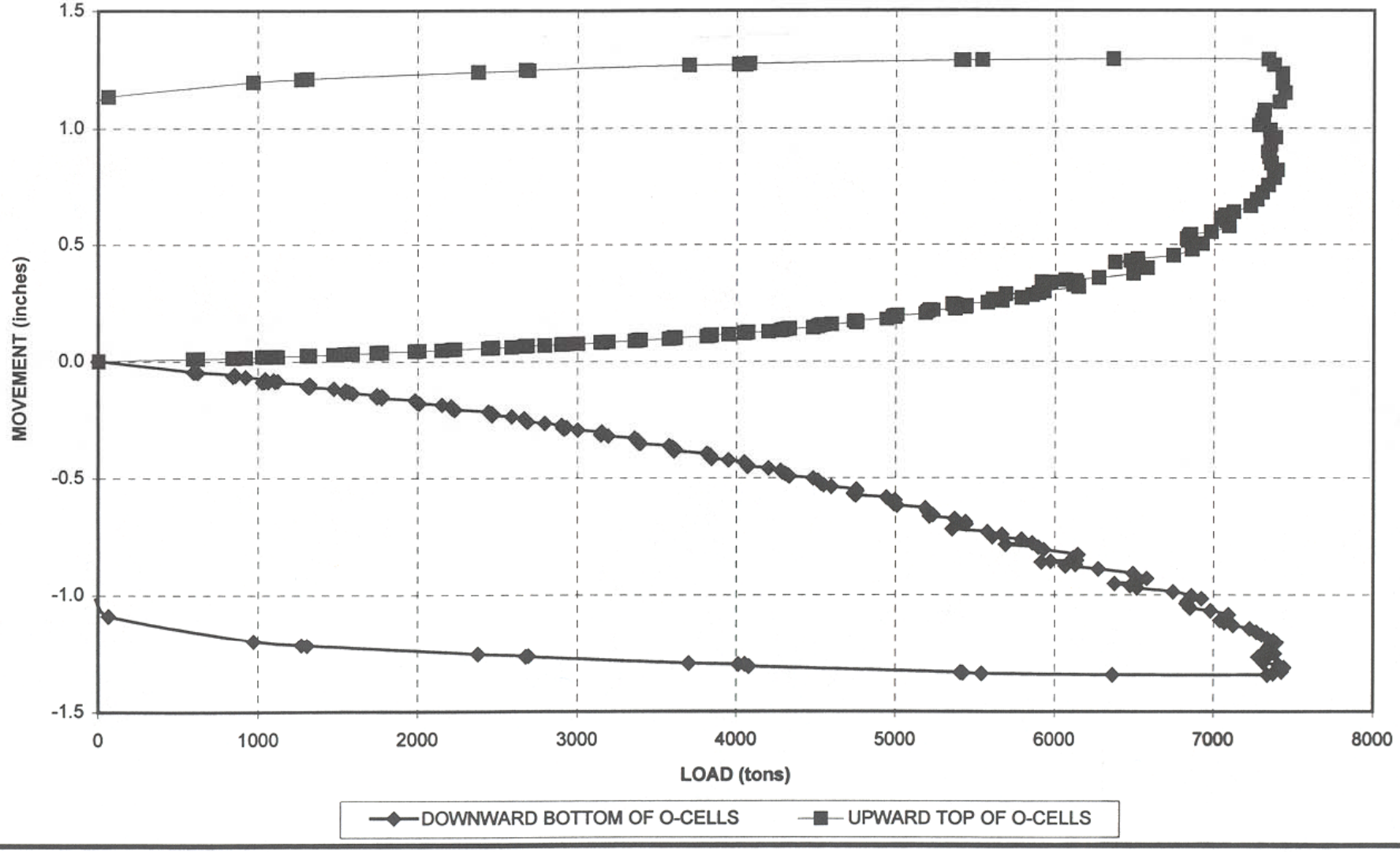
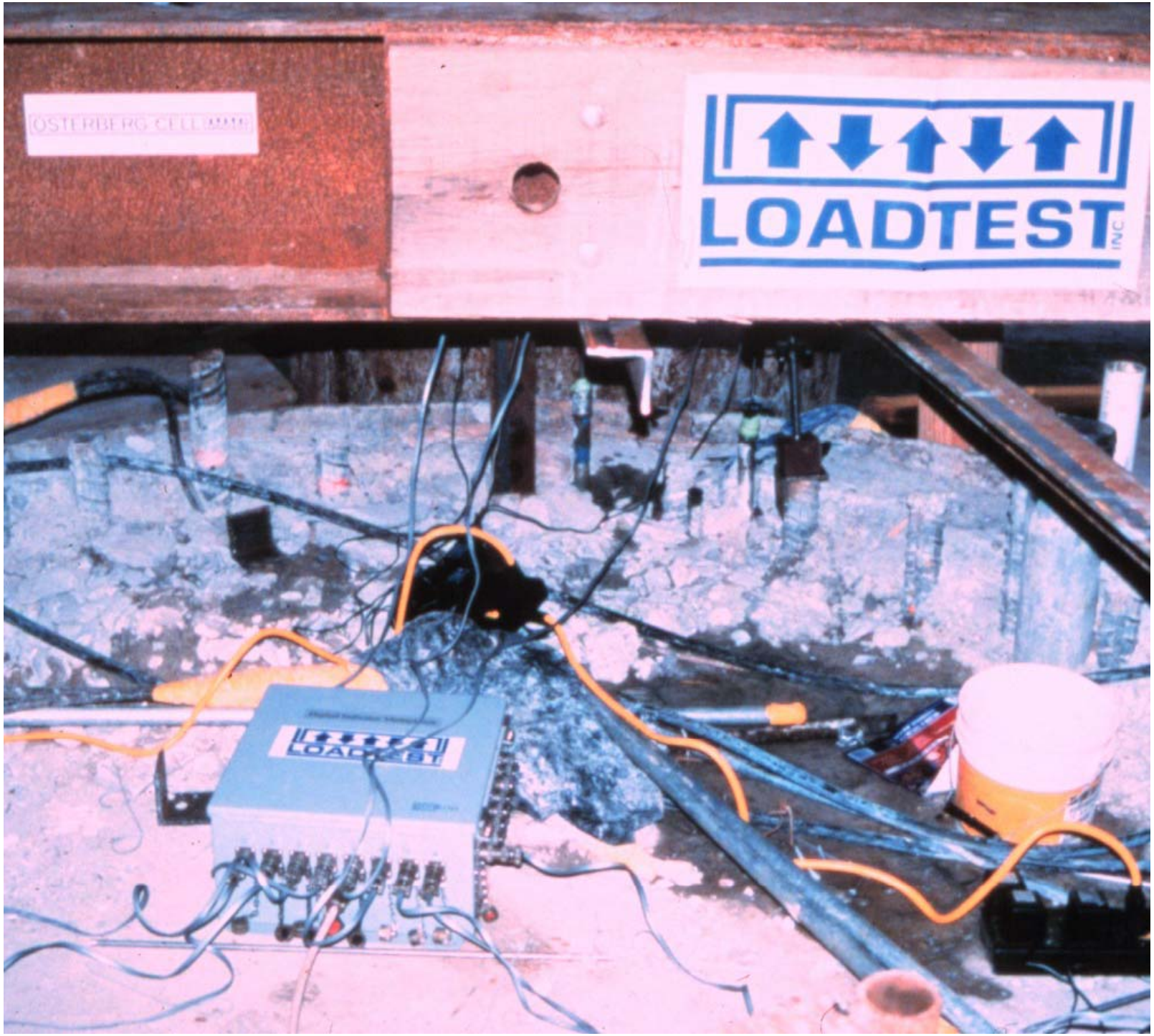


PLATE 55

DAMES & MOORE

A DAMES & MOORE GROUP COMPANY


LOADTEST
INC.

O Cell Word Record Review

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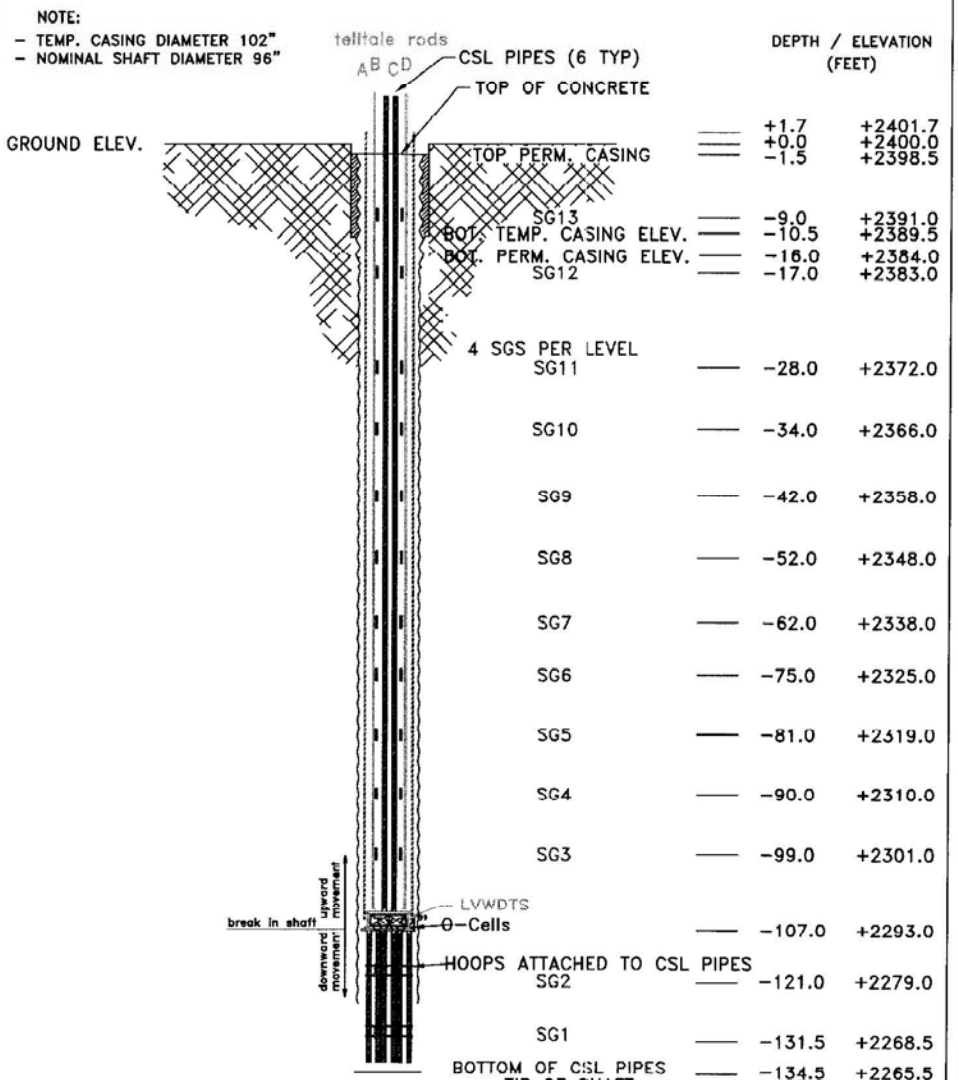


LOADTEST
2631-D NW 41st St.
Gainesville, FL 32606
Phone 800-368-1138
FAX (352) 378-3934

SCHEMATIC SECTION OF TEST SHAFT

LT-8595
I-10, I-19 Interchange
Tucson, AZ

FIGURE A

URS Greiner Woodward Clyde
A Division of URS Corporation

BORING LOG

BORING LOG: PM-1
SHEET 3 of 5
PROJECT #: E200000325.26

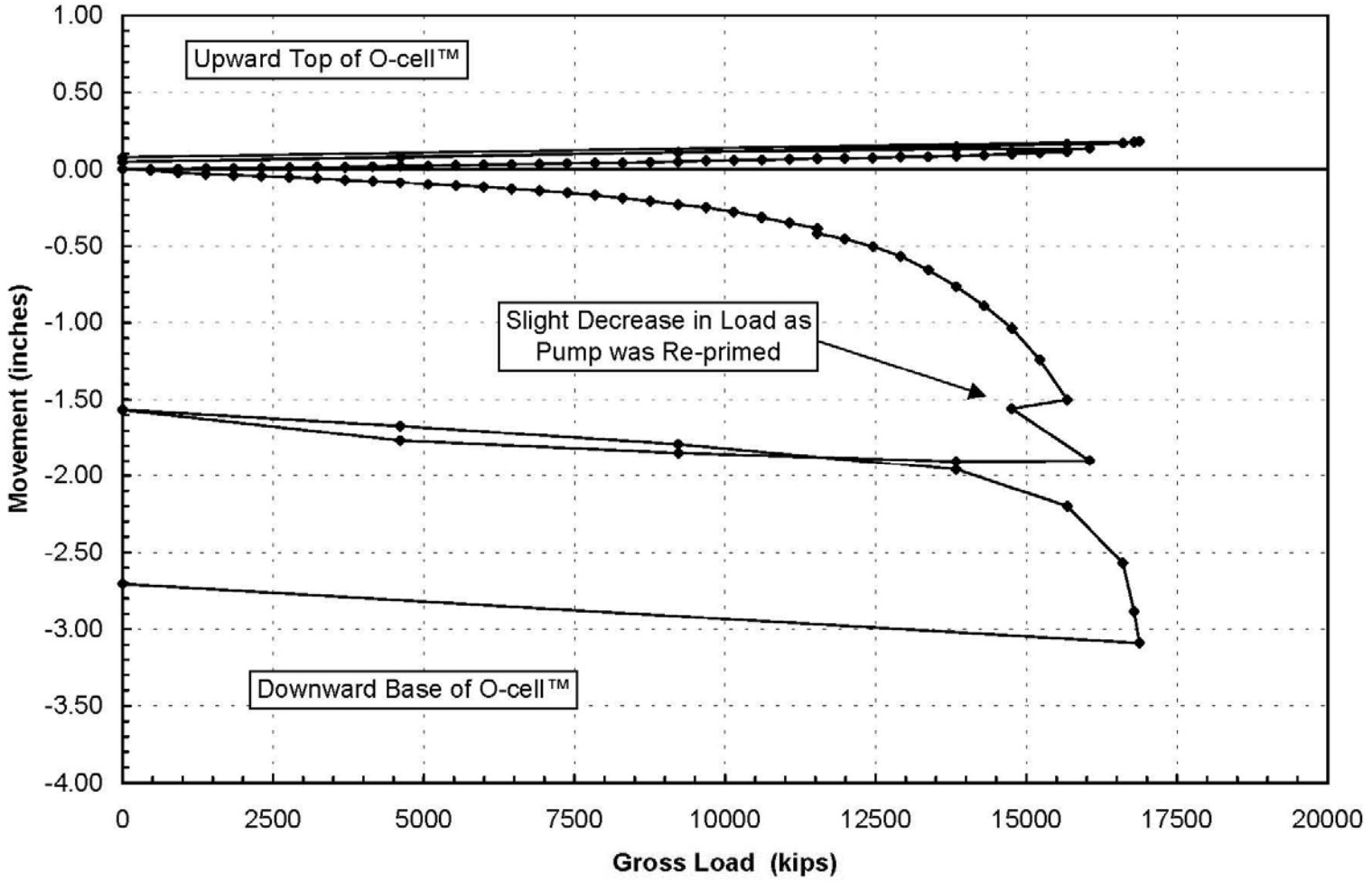
PROJECT: I10/I19 Interchange
LOCATION: Tucson, Arizona
CLIENT: ADOT

CONTRACTOR: GSI
DRILLER: Wayne J.
INSPECTOR: MLP

DEPTH BELOW SURFACE (FT)	SAMPLE: USCS	GRAPHIC	TYPE	NUMBER	SYMBOL	DEPTH (FT) FROM	DEPTH (FT) TO	MOISTURE, %	DRY DENSITY (PCF)	SOIL (Blows/6 in.) 0/6	6/12	12/18	N	REC. (in.)	ROCK CORING RUN (in.)	ROCK CORING REC (in.)	ROCK CORING REC (%)	ROCK CORING L>4" (in.)	ROCK CORING RQD (%)	VISUAL MATERIAL CLASSIFICATION AND REMARKS	SAMPLES SENT TO LAB
	CL		S	14		65	66.3			7	26	50/3"	76/9"	18						**Sandy Lean Clay**, hard, low to medium plasticity fines, some fine to coarse sand, few to little fine gravel, brown, moist. (Max. particles size 3/4"). End of sampler is about 2" in GP/SP-SC.	
70	SC		S	15		70	70.4			50/5"										**Clayey Sand with Gravel** Pressuremeter test from 67 to 69 feet. Pf=29.0 tsf Driller indicated last 12" of pressuremeter run felt like sandy clay. No gravelly drilling from 70 to 75'.	
75	CL		S	16		75	76.5			12	25	23	48	22						**Lean Clay with sand**, hard, low-plasticity clay, little fine to medium sand, trace fine gravel, light brown, moist. 1"- thick silt seams at top of sampler, light gray.	
80	CL		S	17		80	81.5			13	23	23	46	22						Frequent 1"- thick silt seams. Pressuremeter test from 81 to 83 feet. Pf=27.0 tsf	
85	SC		R	18		87	87.2			50/3"			50/3"	0						Drills gravelly, hard layer from 83 to 85'. Auger teeth worn off and replaced. Pressuremeter test tried from 84 to 86 feet - Hole diameter too large @85'. Moved it to 83 to 85 feet, still too large for testing. Auger teeth replaced second time.	
90	SC		S	19		90	90.08			50/1"				1						Some 2 to 3" soft zones indicated by the driller **Clayey Sand with gravel**, very dense, fine to medium sand, little fine gravel, little low-plasticity fines, brown, moist. (Max. particle size 3/4"). Drills gravelly from 90.5 to 95'.	
95																				Attempt for pressuremeter test from 95 to 98 feet. Probe stock in rockbit hole - No test performed. Auger teeth replaced again.	
100	SC		S	20		100	100.4			50/5"				5						Gravel content grades to fine to coarse. Driller added water, moderately cemented. (Max. particle size 1"). Labored drilling but no cobbles.	
105																					

Osterberg Cell Load-Movement Curves

I-10 / I-19 Interchange - Tucson, AZ - Test Shaft T1

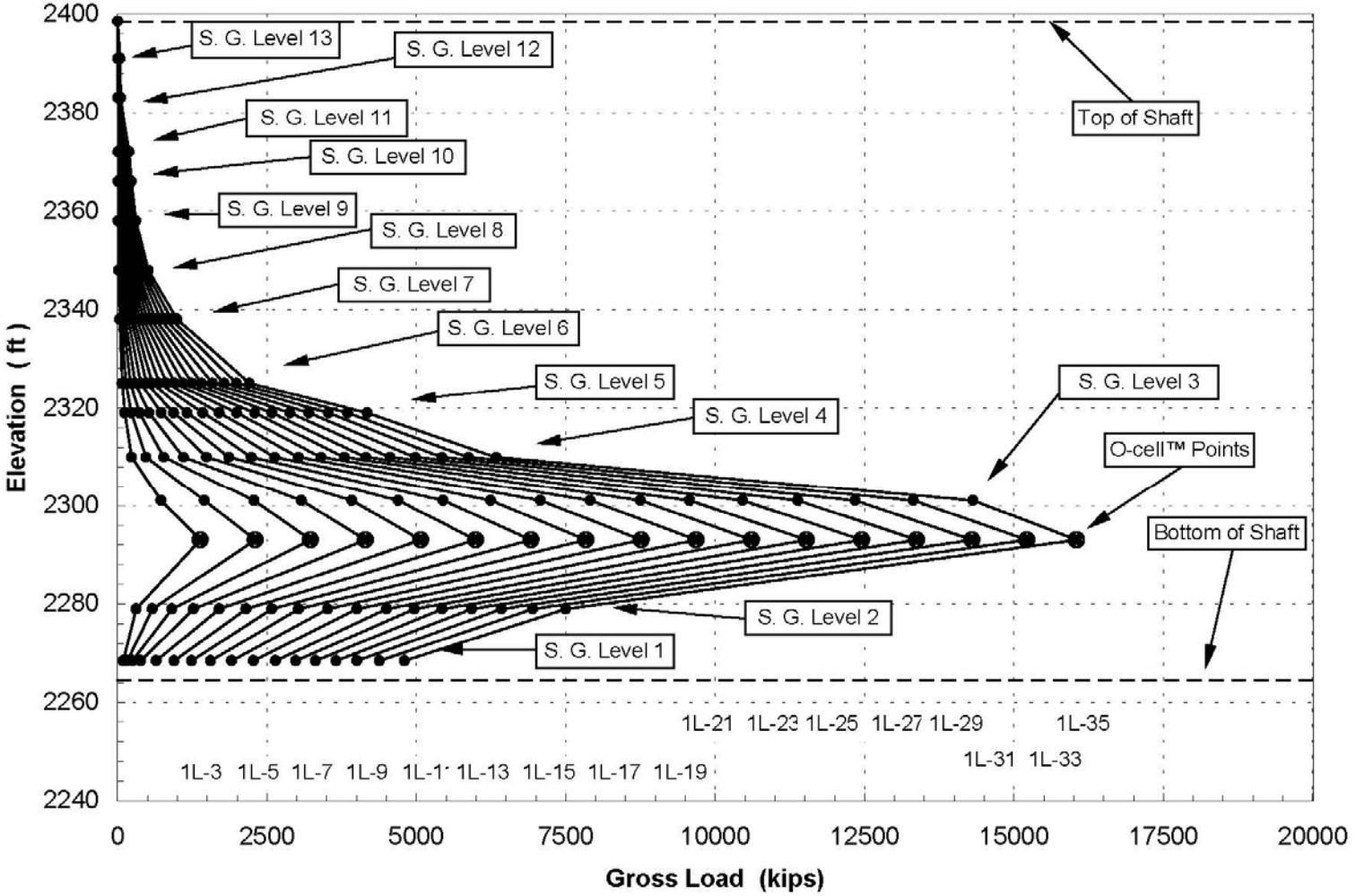


LOADTEST, Inc. Project No. LT-8595

Figure 1 of 5

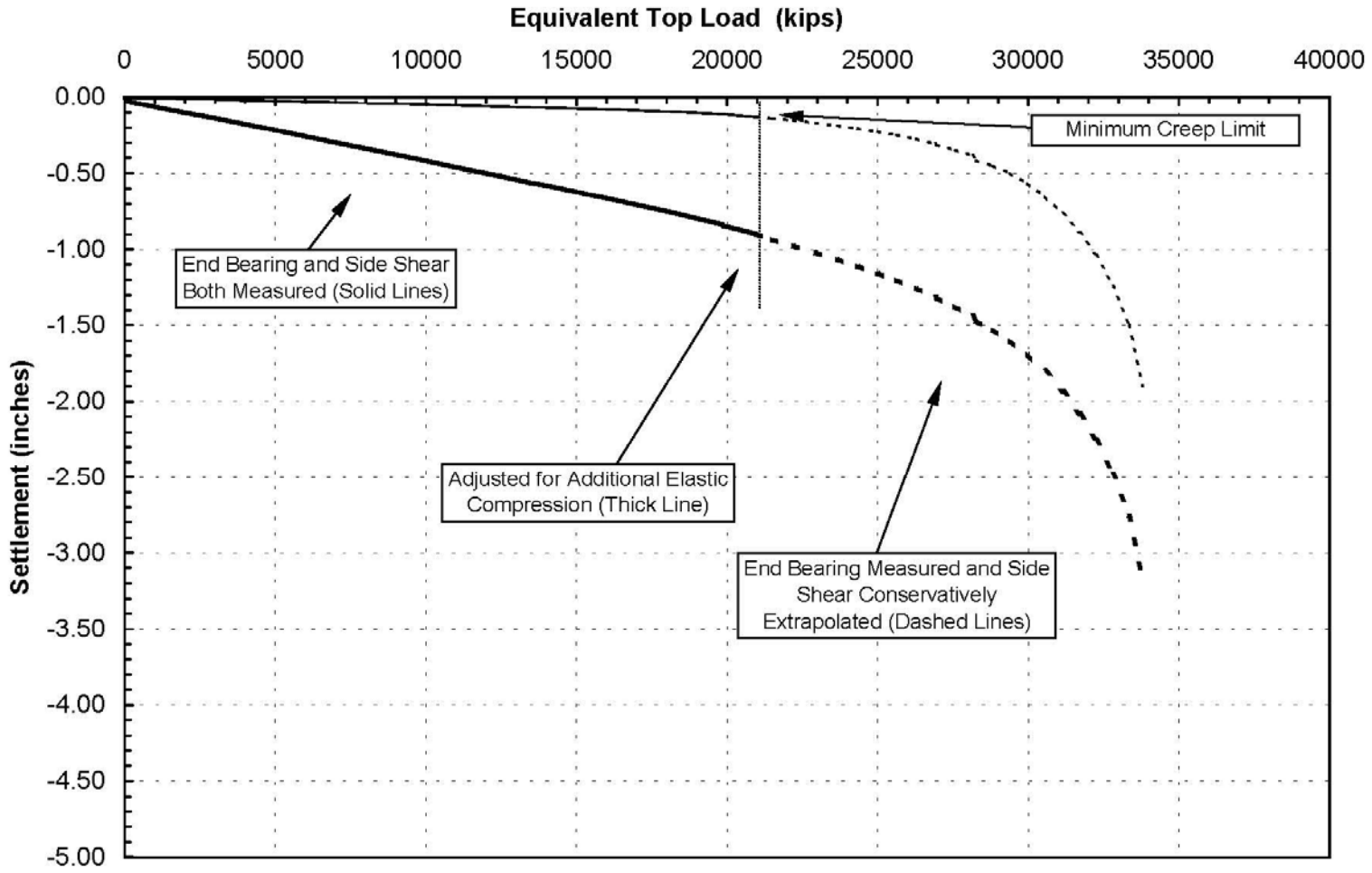
Strain Gage Load Distribution Curves

I-10 / I-19 Interchange - Tucson, AZ - Test Shaft T1



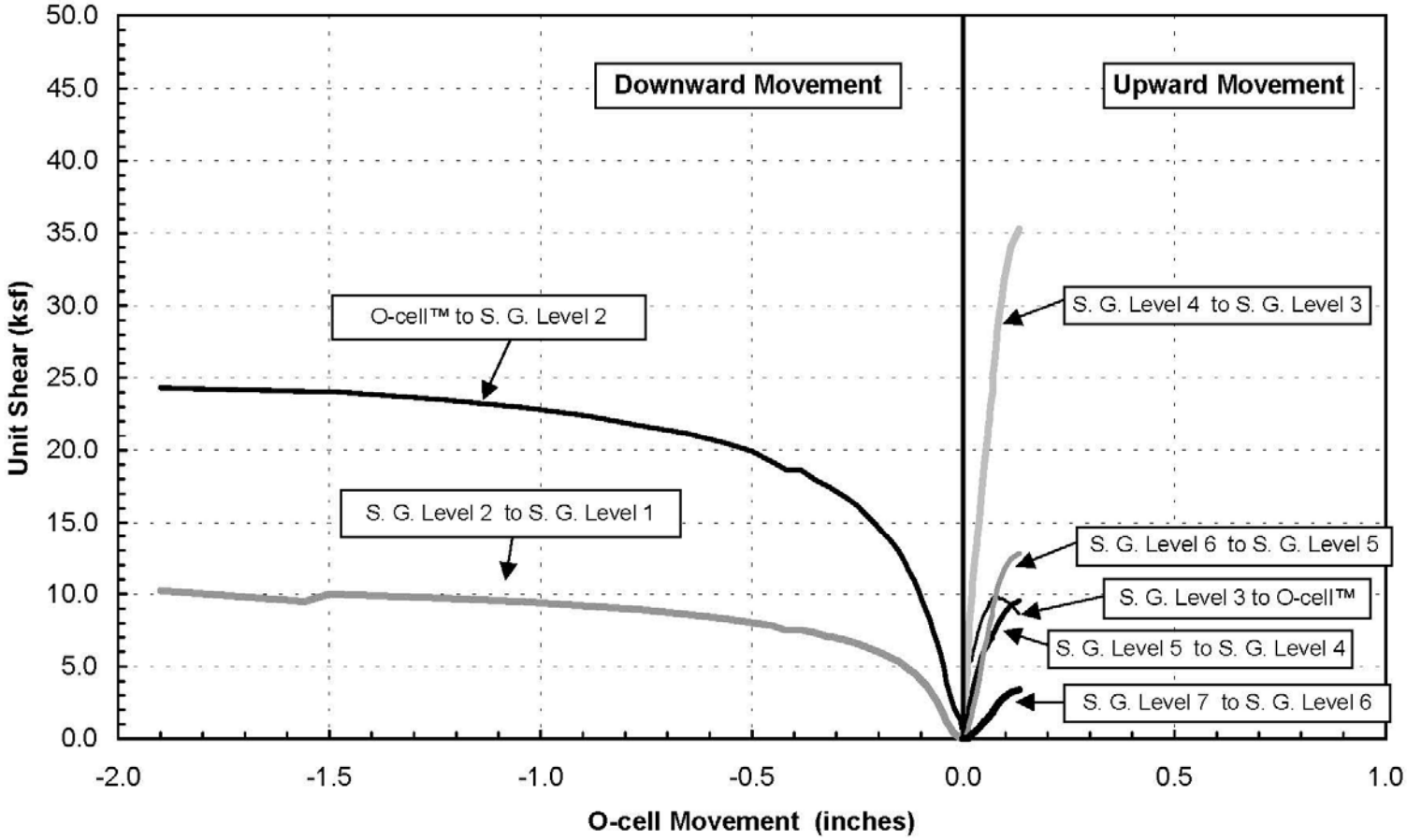
Equivalent Top Load-Movement Curves

I-10 / I-19 Interchange - Tucson, AZ - Test Shaft T1



Net Unit Shear vs. O-cell Movement

I-10 / I-19 Interchange - Tucson, AZ - Test Shaft T1



LOADTEST, Inc. Project No. LT-8595

Figure E1

O Cell Word Record Review

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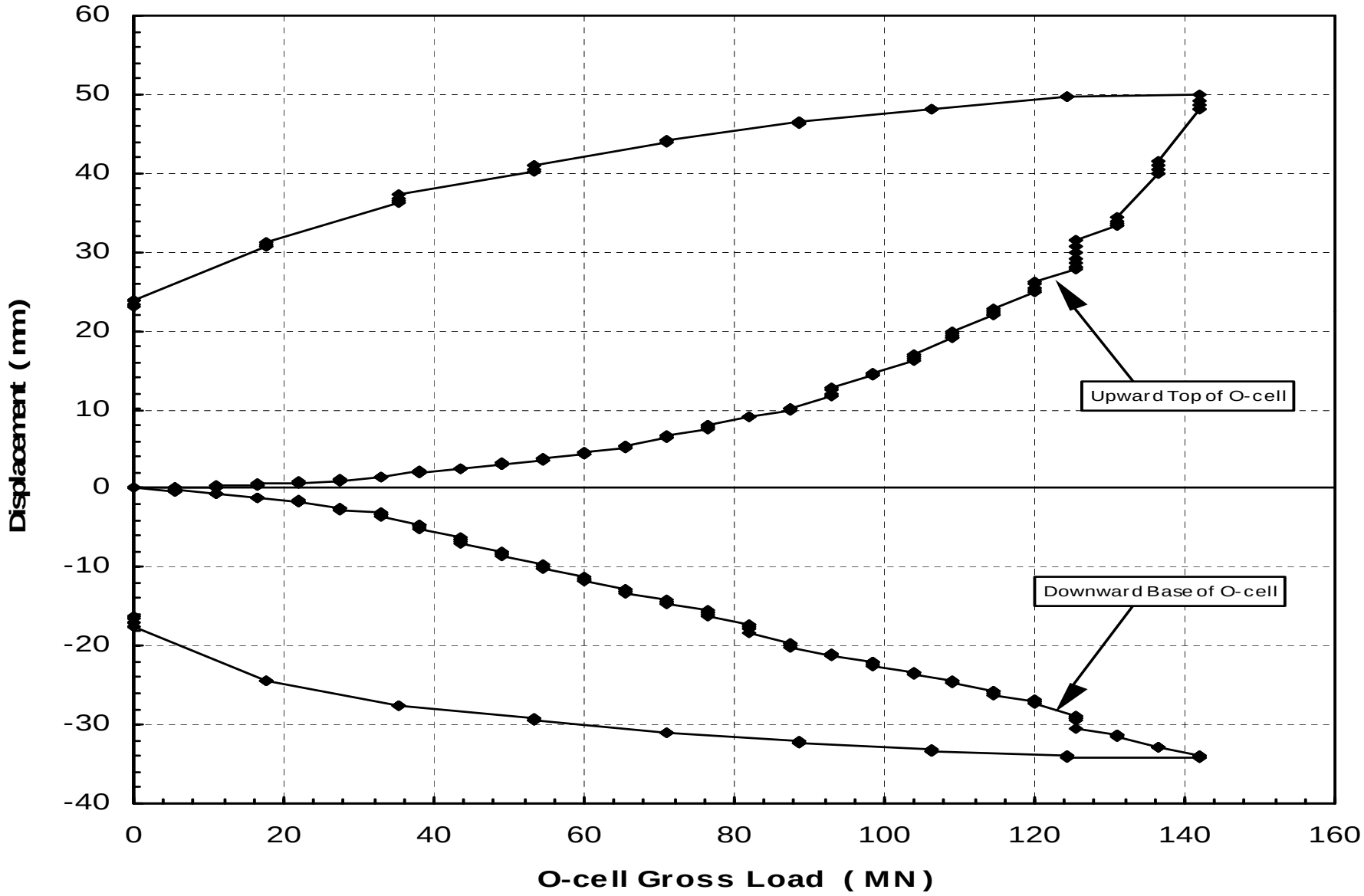
Incheon 2nd Link, Korea

Incheon 2nd Link, Korea

Incheon 2nd Link, Korea

Osterberg Cell Load-Movement Curves



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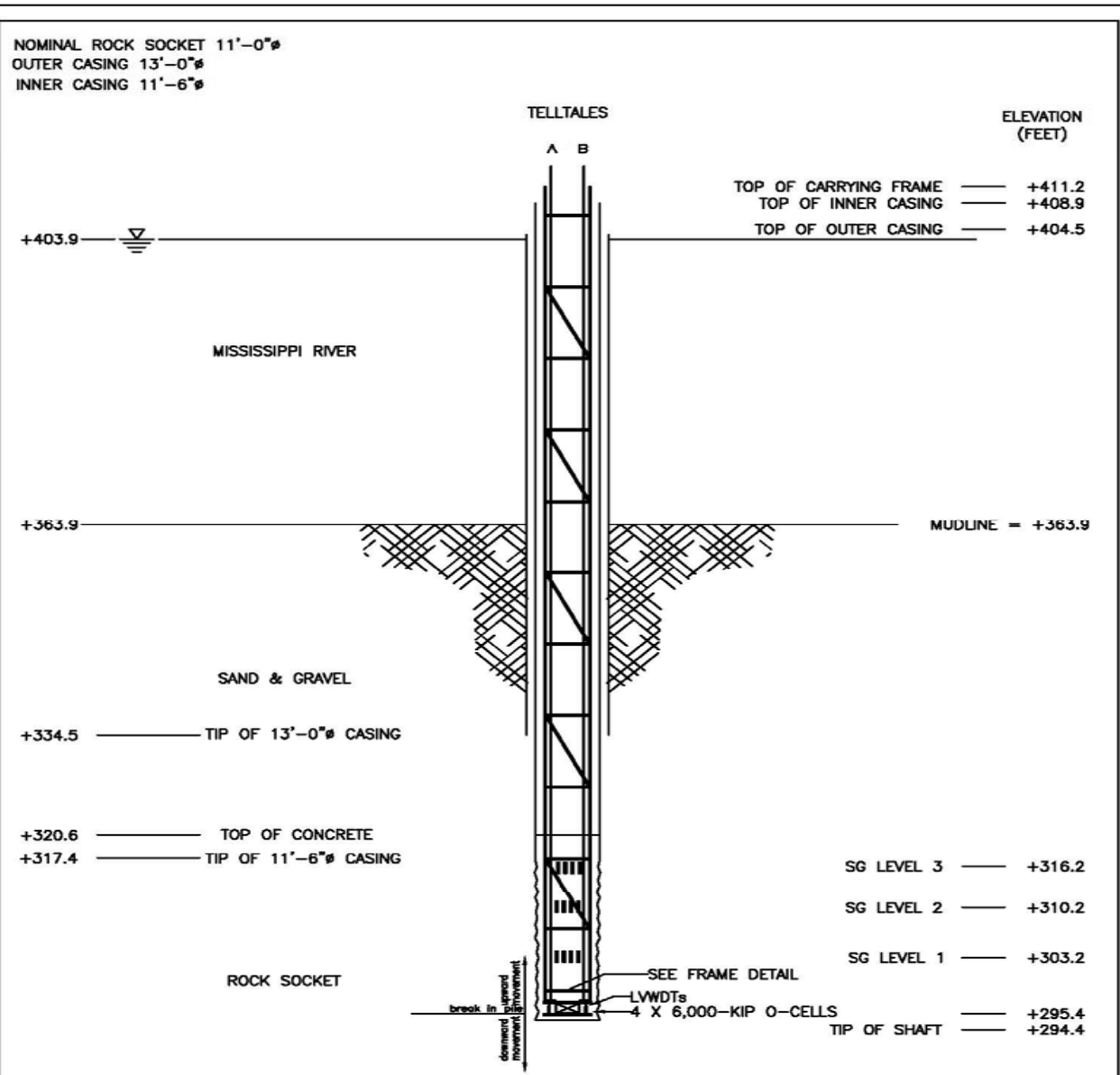
World Record Load Test in Mississippi River in St. Louis, USA

World record – Rock socket (320MN)

The rock socket was about 7m (23ft) deep and 3350mm (11ft) in diameter in very hard limestone. Four 870mm (34in) O-cells placed at the base of the shaft were loaded to 150% of their rated capacity to achieve the record load.



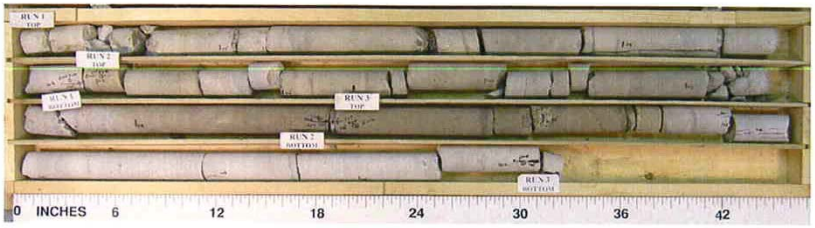
LOADTEST
www.LOADTEST.com
2631–D NW 41st St.
Gainesville, FL 32606
Phone: 800–368–1138
FAX: 352–378–3934

SCHEMATIC SECTION OF TEST SHAFT

I–70 MISSISSIPPI RIVER BRIDGE – ST. LOUIS, MISSOURI

DWN BY: AJS	DATE: 19 Nov 2009	CHECKED BY: MDA	LT–9646
REVISED BY: DJJ	DATE: 15 Jun 2010	SCALE: NTS	**FIGURE A**

El 297.7



BORING IL-2

Run	Depth, Ft.	Recovery, %	RQD, %
1	116.0-120.0	100	69
2	120.0-125.0	100	65
3	125.0-130.0	100	92

6700-7800 psi

EL 248.7

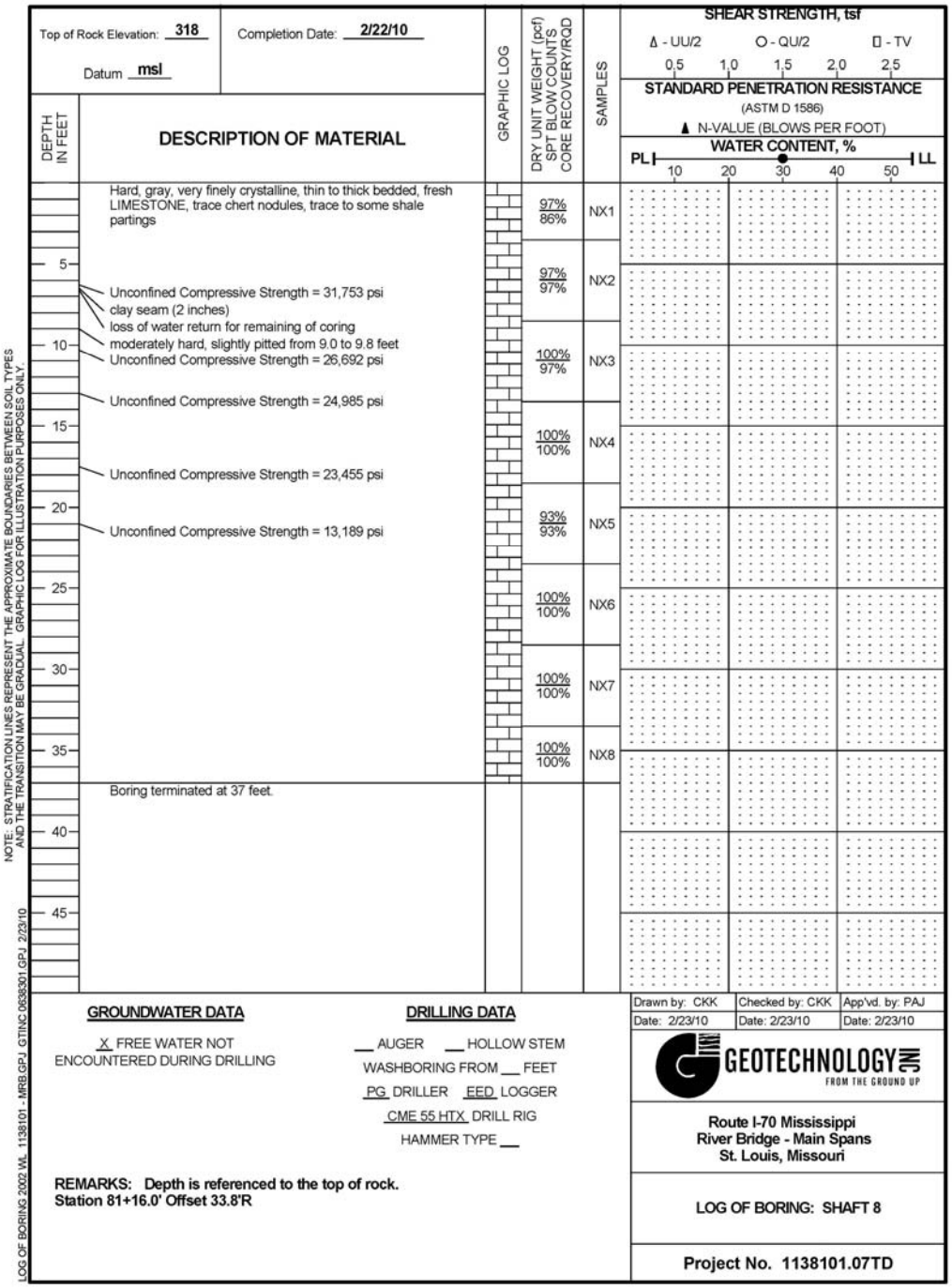
BORING IL-2

Run	Depth, Ft.	Recovery, %	RQD, %
4	130.0-135.0	100	95
5	135.0-140.0	100	92
6	140.0-145.0	100	98

11000-14500 psi

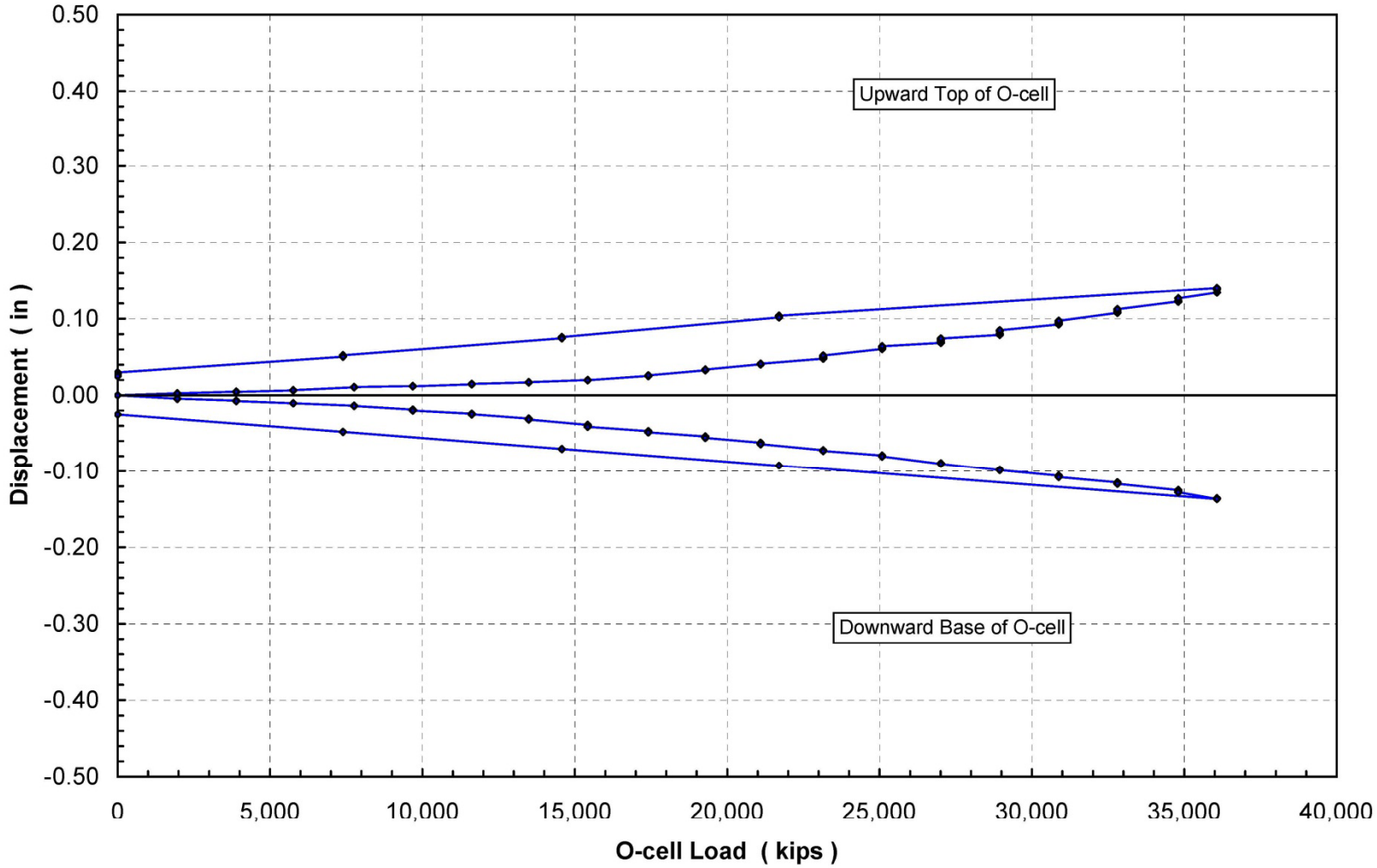
TSi engineering, inc.

I–70 MISSISSIPPI RIVER BRIDGE
TSi PROJECT #02008603.06
ROCK CORE SAMPLES


Top of Rock Elevation: 318
Completion Date: 2/22/10
Datum msl
DEPTH IN FEET
DESCRIPTION OF MATERIAL
GRAPHIC LOG
DRY UNIT WEIGHT (pcf)
SPT BLOW COUNTS
CORE RECOVERY/RQD
SAMPLES
SHEAR STRENGTH, tsf
Δ - UU/2
O - QU/2
□ - TV
0.5 1.0 1.5 2.0 2.5
STANDARD PENETRATION RESISTANCE
(ASTM D 1586)
▲ N-VALUE (BLOWS PER FOOT)
WATER CONTENT, %
PL
LL
10 20 30 40 50
Hard, gray, very finely crystalline, thin to thick bedded, fresh LIMESTONE, trace chert nodules, trace to some shale partings
97% 86% NX1
97% 97% NX2
100% 97% NX3
100% 100% NX4
93% 93% NX5
100% 100% NX6
100% 100% NX7
100% 100% NX8
Unconfined Compressive Strength = 31,753 psi
clay seam (2 inches)
loss of water return for remaining of coring
moderately hard, slightly pitted from 9.0 to 9.8 feet
Unconfined Compressive Strength = 26,692 psi
Unconfined Compressive Strength = 24,985 psi
Unconfined Compressive Strength = 23,455 psi
Unconfined Compressive Strength = 13,189 psi
Boring terminated at 37 feet.
5
10
15
20
25
30
35
40
45
NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.
LOG OF BORING 2002 WL 1138101 - MRB.GPJ GTINC.0638301.GPJ 2/23/10
GROUNDWATER DATA
X FREE WATER NOT ENCOUNTERED DURING DRILLING
DRILLING DATA
__ AUGER __ HOLLOW STEM
WASHBORING FROM __ FEET
PG DRILLER EED LOGGER
CME 55 HTX DRILL RIG
HAMMER TYPE __
REMARKS: Depth is referenced to the top of rock.
Station 81+16.0' Offset 33.8'R
Drawn by: CKK Date: 2/23/10
Checked by: CKK Date: 2/23/10
App'vd. by: PAJ Date: 2/23/10
GEOTECHNOLOGY INC
FROM THE GROUND UP
Route I-70 Mississippi
River Bridge - Main Spans
St. Louis, Missouri
LOG OF BORING: SHAFT 8
Project No. 1138101.07TD

Osterberg Cell Load-Displacement

Test Shaft 1 - I-70 Mississippi River Bridge - St. Louis, MO

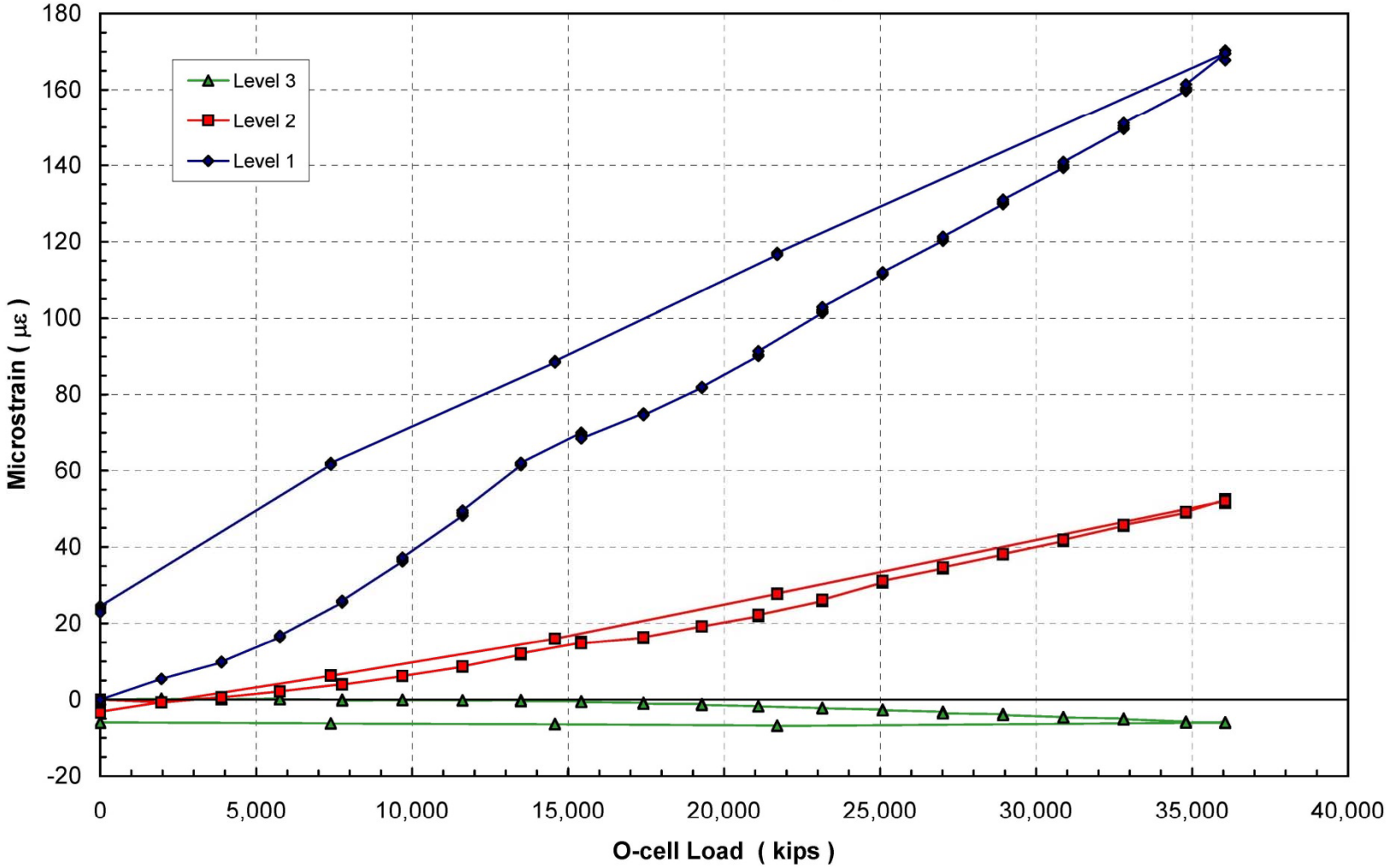


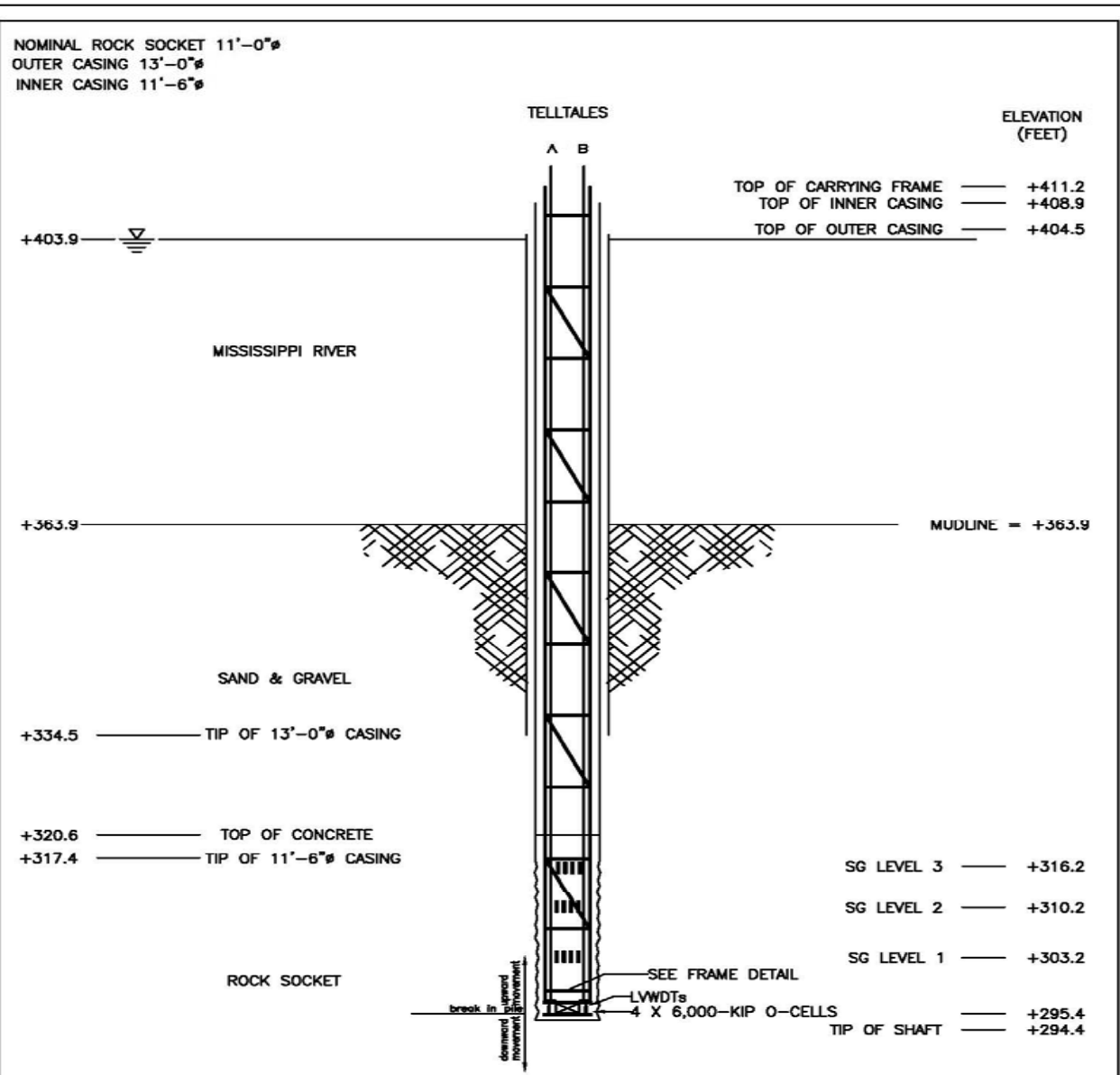
LOADTEST, Inc. Project No. LT-9646

LOADTEST

Osterberg Cell Load-Microstrain

Test Shaft 1 - I-70 Mississippi River Bridge - St. Louis, MO





LOADTEST
www.LOADTEST.com
2631–D NW 41st St.
Gainesville, FL 32606
Phone: 800–368–1138
FAX: 352–378–3934

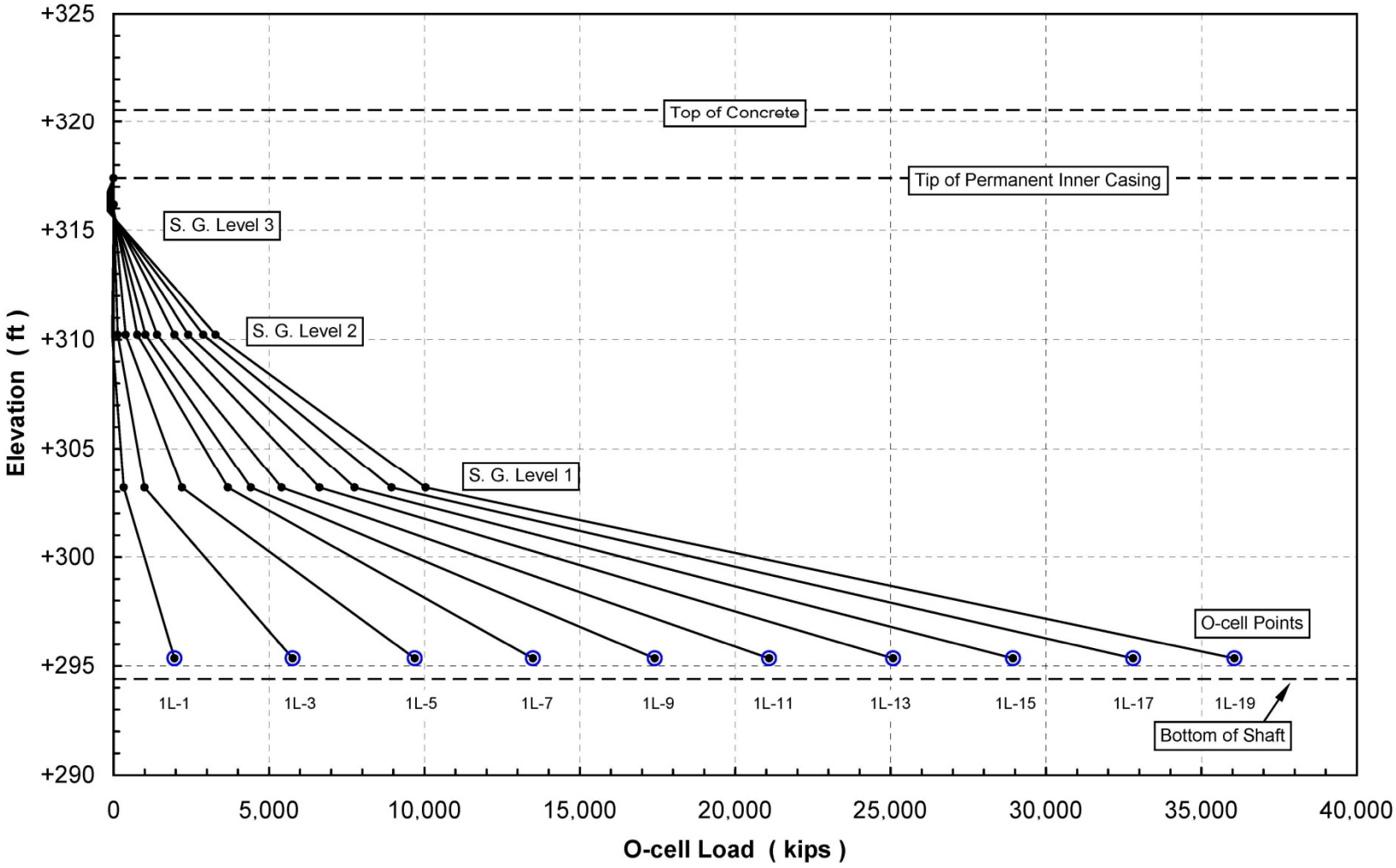
SCHEMATIC SECTION OF TEST SHAFT

I–70 MISSISSIPPI RIVER BRIDGE – ST. LOUIS, MISSOURI

DWN BY: AJS	DATE: 19 Nov 2009	CHECKED BY: MDA	LT–9646
REVISED BY: DJJ	DATE: 15 Jun 2010	SCALE: NTS	**FIGURE A**

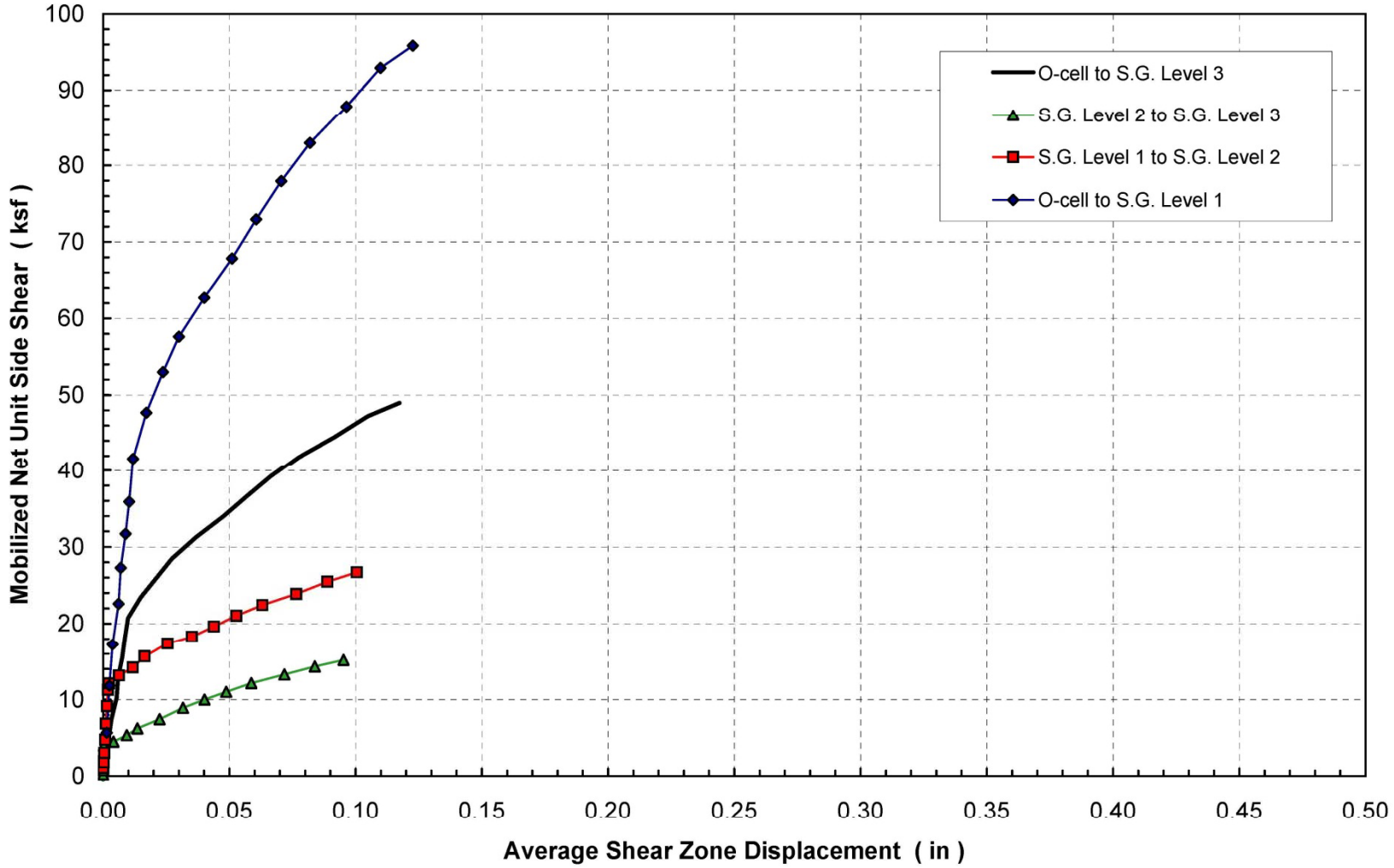
Strain Gage Load Distribution

Test Shaft 1 - I-70 Mississippi River Bridge - St. Louis, MO



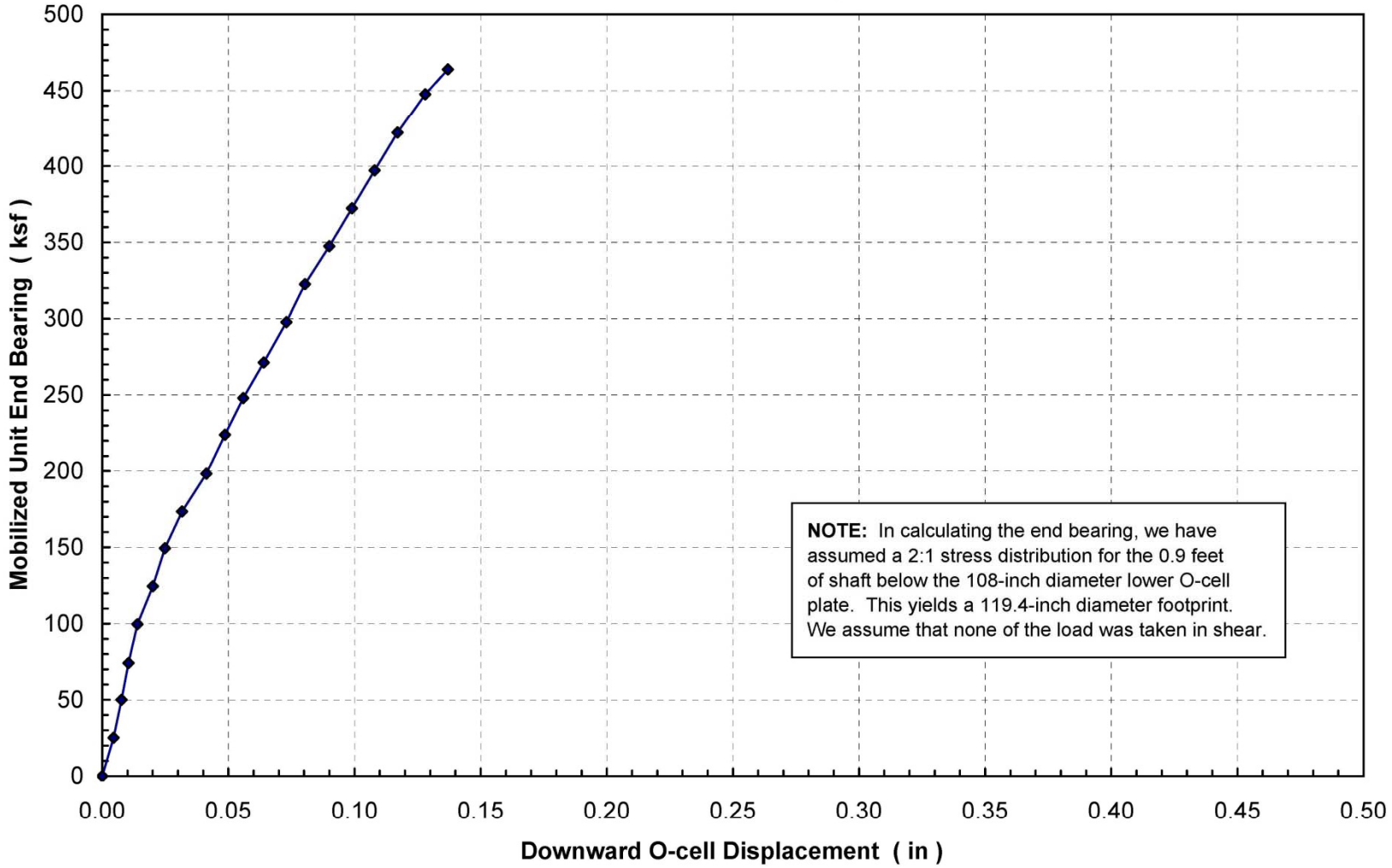
Mobilized Net Unit Side Shear

Test Shaft 1 - I-70 Mississippi River Bridge - St. Louis, MO



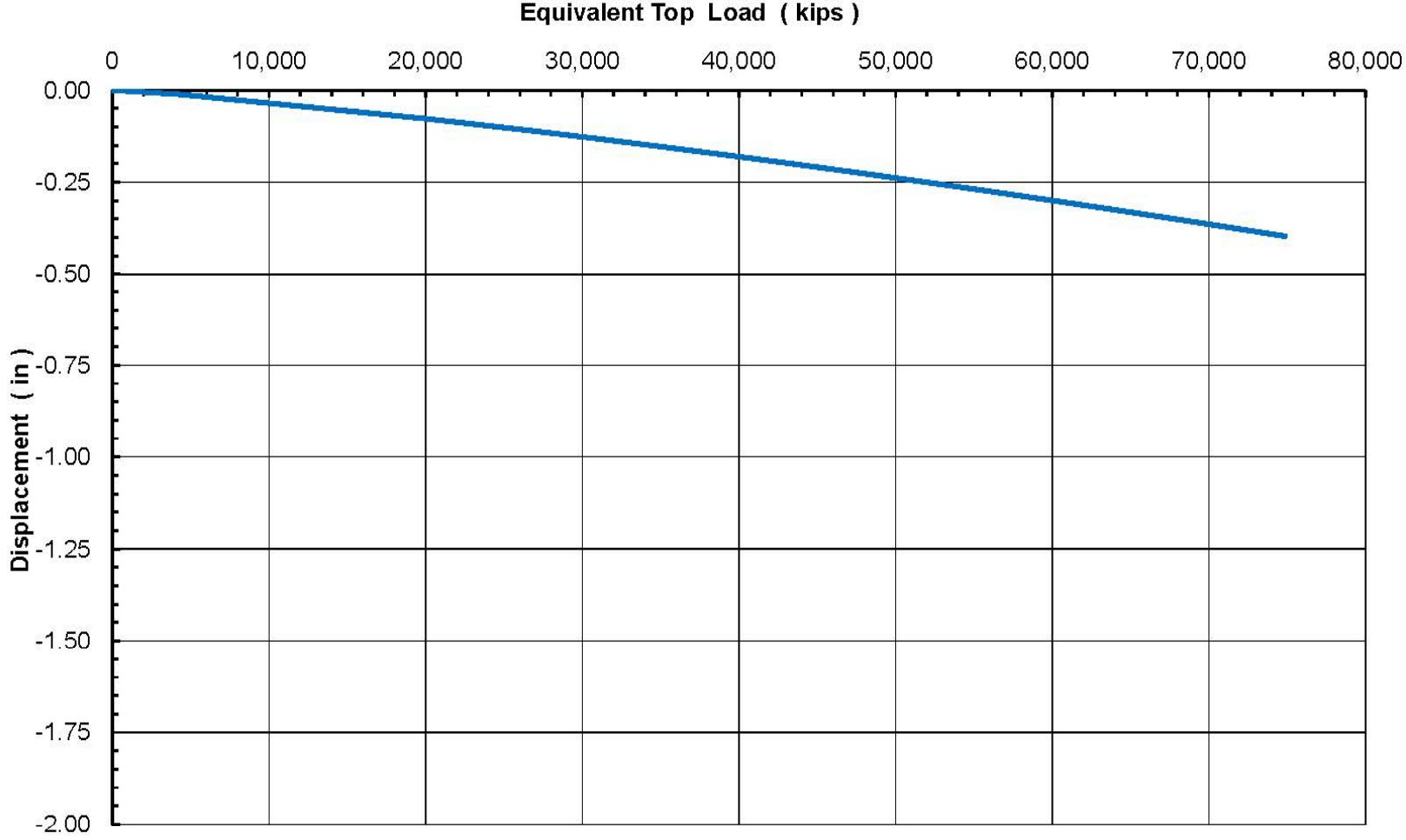
Mobilized Unit End Bearing

Test Shaft 1 - I-70 Mississippi River Bridge - St. Louis, MO



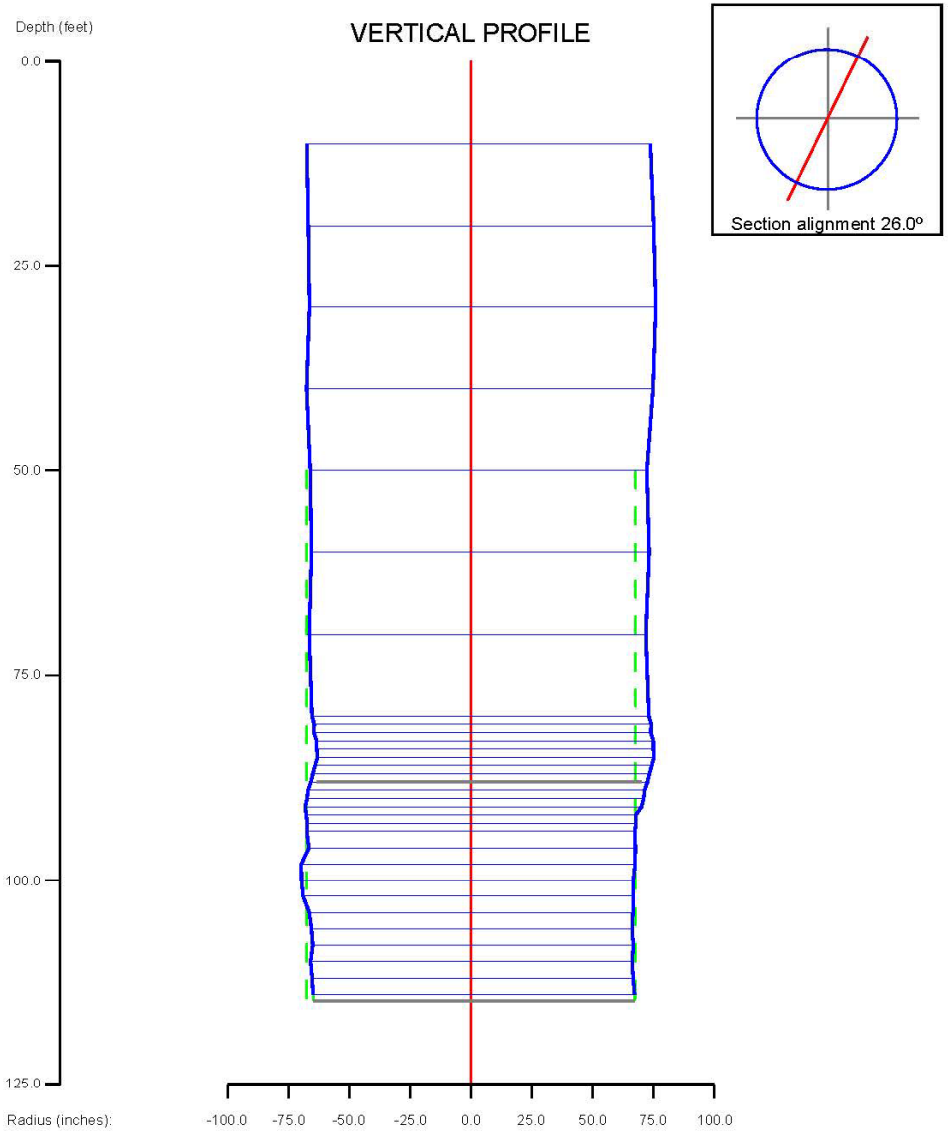
Equivalent Top Load-Displacement

Test Shaft 1 - I-70 Mississippi River Bridge - St. Louis, MO



I-70 Mississippi River Bridge - Test Shaft 1

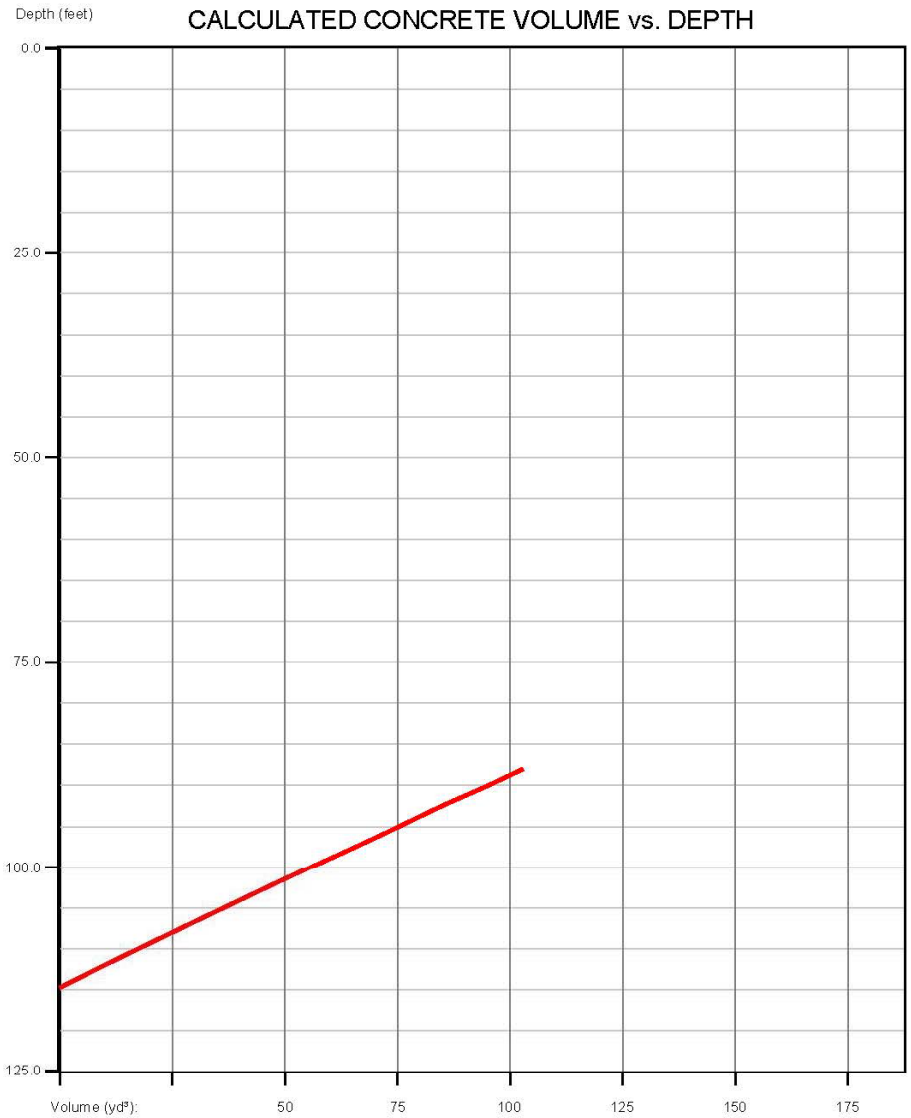
St. Louis, MO, 6/2/2010



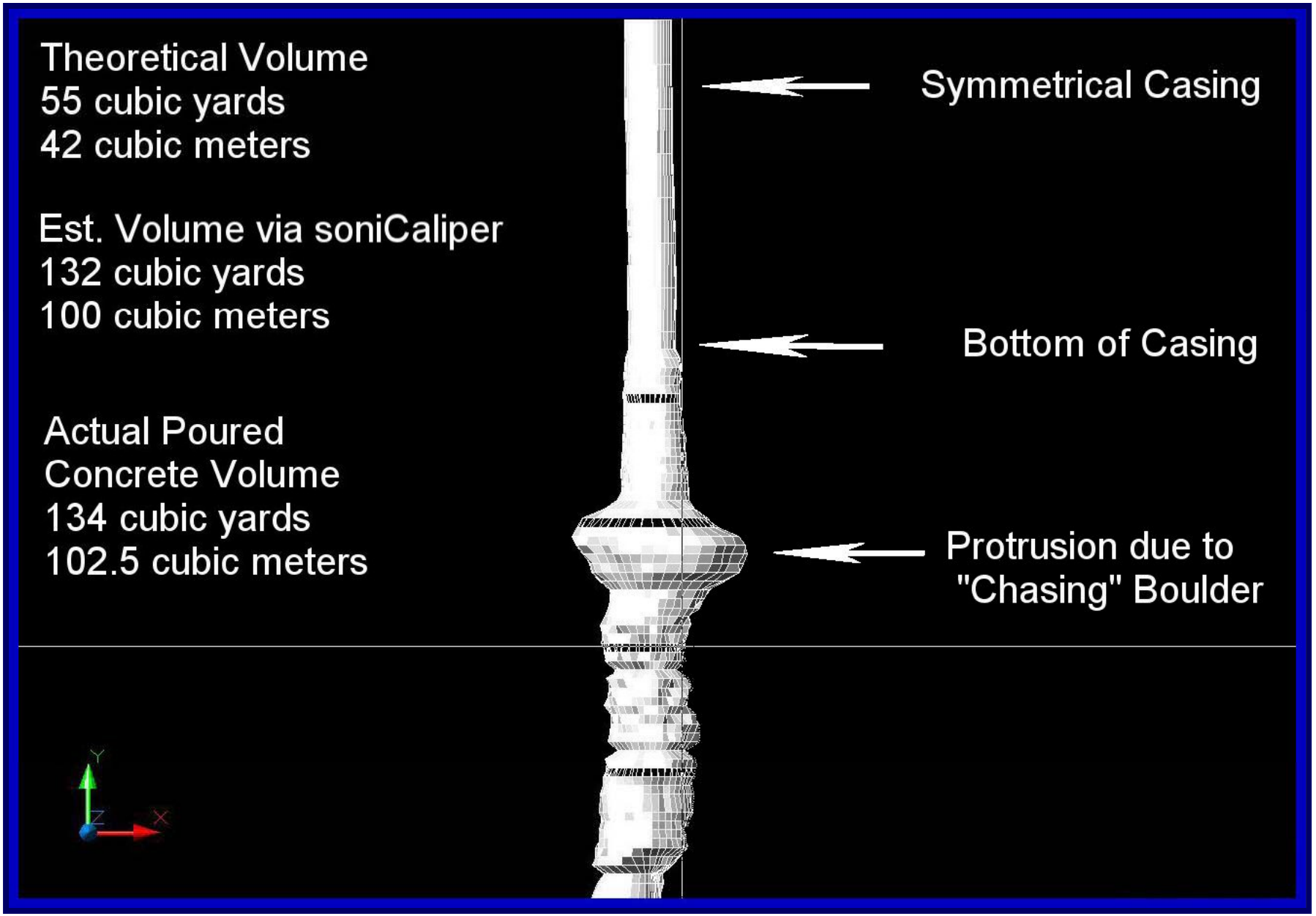
LOADTEST Project Number: 9646 SONICALIPER

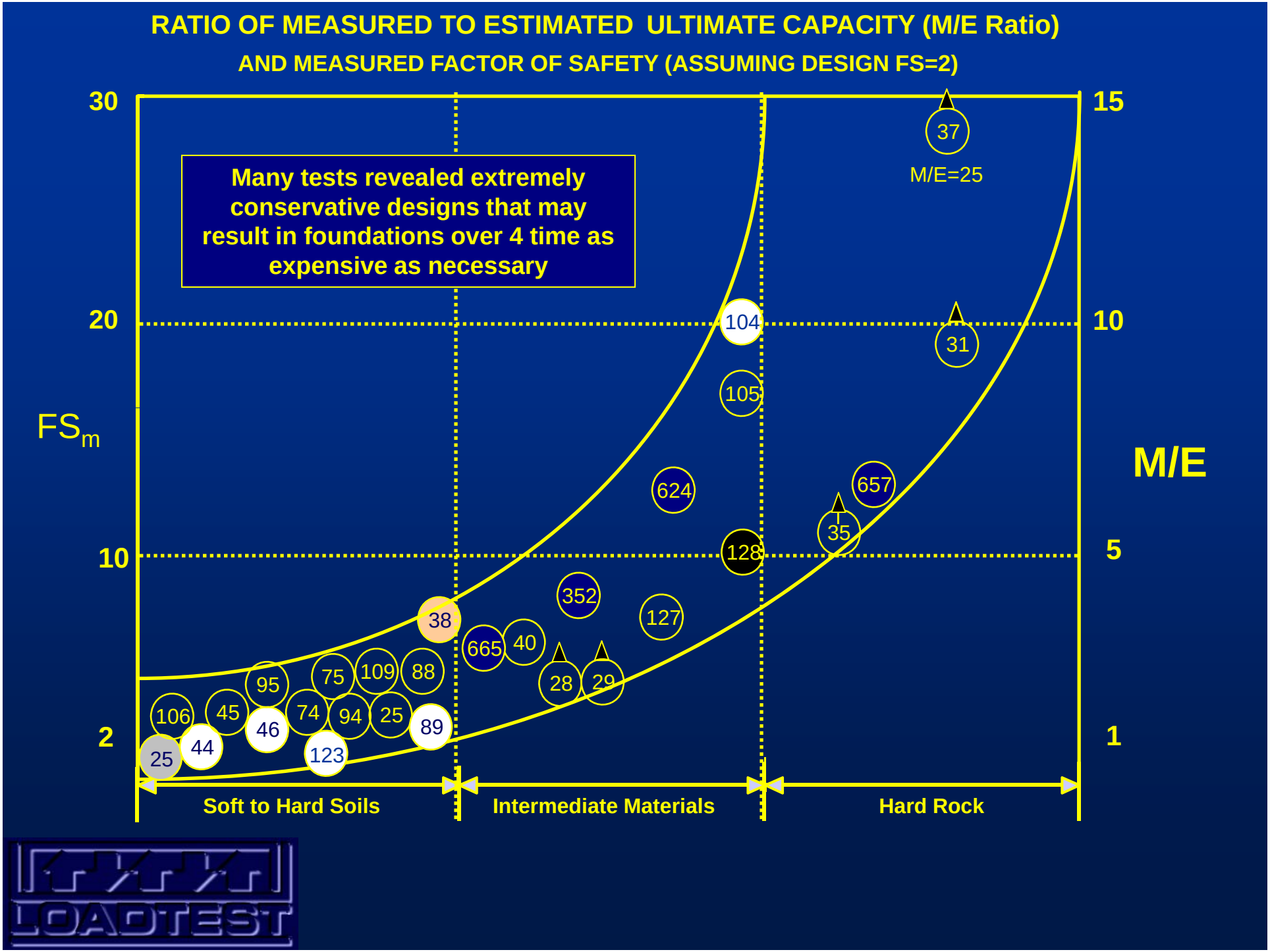
I-70 Mississippi River Bridge - Test Shaft 1

St. Louis, MO, 6/2/2010



Shaft Volume - SONICALIPER




RATIO OF MEASURED TO ESTIMATED ULTIMATE CAPACITY (M/E Ratio)
AND MEASURED FACTOR OF SAFETY (ASSUMING DESIGN FS=2)
Many tests revealed extremely conservative designs that may result in foundations over 4 time as expensive as necessary
30
20
10
2
15
10
5
1
FSm
M/E
37
M/E=25
104
31
105
624
657
35
128
352
127
38
665
40
28
29
95
75
109
88
106
45
74
94
25
46
89
44
123
25
Soft to Hard Soils
Intermediate Materials
Hard Rock
LOADTEST

Conclusions

- Foundations capacities underutilized
- Unused capacity – lost tax $$$
- Contractors recognizing value
  - ATC, VE, Design Build
- The sooner the better for LT results