Geotechnical Structure Report
New Britain – Hartford Busway
Overhead Sign Structure
State Project No. 63-H137
New Britain, Connecticut

Prepared for:

H. W. Lochner, Inc.
2110 Silas Deane Highway
Rocky Hill, Connecticut 06067

Prepared by:

Geo**Design**, Inc.
984 Southford Road
Middlebury, CT 06762

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Project No. 0331-014.2

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1.0 GENERAL INFORMATION

1.1 General

This Report provides geotechnical design and construction recommendations for a proposed overhead sign structure (sign) along the proposed New Britain-Hartford Busway. The New Britain-Hartford Busway Project (State Project No. 63-H137) entails the design and construction of a 9.4-mile corridor between downtown New Britain and downtown Hartford that follows an abandoned railroad right-of-way. The proposed busway will be part of the Bus Rapid Transit System and thus be dedicated for bus use only.

The proposed sign will be constructed at the entrance to the south bound busway from Asylum Street at approximate South Bound Station 904+94 in Hartford, Connecticut. The proposed sign location is shown on Figure 1 in Appendix 1.

H.W. Lochner, Inc. is the Prime Designer for the sign and Geo**Design**, Inc. (Geo**Design**) is the geotechnical sub-consultant. Geo**Design** was asked to review available subsurface information and provide geotechnical recommendations for the proposed sign foundation. Geo**Design** has prepared this report in general accordance with Section 405 of the Connecticut Department of Transportation (CTDOT) Consultant Design Manual.

1.2 Datum

All elevations referenced in this report are in feet and are based on NGVD 1929. The coordinates are based on the Connecticut Coordinate System, NAD 1983.

1.3 Design Criteria

The geotechnical recommendations provided herein are consistent with AASHTO Load and Resistance Factor Bridge Design Specifications 4th Edition, 2007 (AASHTO LRFD) with 2009 Interims, and the CTDOT Geotechnical Engineering Manual, 2005 Edition. These geotechnical recommendations also consider the CTDOT Standard Specifications for Roads, Bridges, and Incidental Construction, Form 816 (2004).

HWL provided us a “Tubular Arch Sign Support Foundation” drawing. This drawing was used as a reference; however, it does not address all the site conditions present at this sign structure. It does not consider the stepped grade on the north side of the sign structure, or the 20 foot high surcharge (Retaining Wall 110) on the south side. These conditions have been considered, and recommendations to modify this drawing are made herein.

1.4 Proposed Structure

The overhead sign structure will be constructed in general accordance with Section 12.02 in the CTDOT Standard Specifications. The proposed overhead sign structure will be supported on a 4.5-foot diameter drilled shaft, 20-foot long drilled shaft, embedded 16-feet below ground surface, with 24 - #11 vertical reinforcing bars. A maximum anticipated axial load applied at the top of the shaft is 9.2 kips. The maximum anticipated lateral loads imposed at the top of the shaft are 6.1 kips and 178 kip-ft in shear and moment, respectively.

The drilled shaft will be located about four feet north of an existing retaining wall, and in front of proposed Retaining Wall 110. Retaining Wall 110 will require a notch be cut into the wall footing during construction to prevent interference between the two structures. Construction of Retaining Wall 110 will occur after drilled shaft installation. Retaining Wall 110 will be about 20 feet high (bottom of footing to top of wall), with the bottom of footing proposed about eight-feet below the top of the drilled shaft.

2.0 GEOLOGY

Published surficial and bedrock geological maps [*Geology of the Hartford North Quadrangle, Connecticut, R.V. Cushman, 1963 (1:24,000 scale) and Bedrock Geological Map of Connecticut, John Rodgers, 1985 (1:125,000*)] were consulted to obtain information on the regional geology in area of the proposed sign. The surficial materials were mapped as artificial fill, consisting of at least five feet of reworked Till, obtained from ground moraine deposits, or sand, gravel, and silt, obtained form deltaic, lake-bottom, eolian, and flood-plain deposits. Ground-moraine and lake bottom deposits are mapped around the artificial fill deposits. Bedrock was mapped as reddish brown Arkose (brown stone).

3.0 EXISTING SUBSURFACE DATA

In October 2008, we observed six geotechnical borings (RW-107-2, RW-108-2, RW-110-1, RW-111-5, RW-111-6, RW-112-2) within about 40 to 100 feet of the proposed sign. The geotechnical borings were advanced between 6 to 17 feet below the existing ground surface. Borings locations are shown on Figure 1 in Appendix 1. Logs documenting the above geotechnical borings are contained in the report entitled “Geotechnical Engineer Roadway Report” for State Project 63-H137, dated March 2010, and are included in Appendix 2 for reference.

Representative soil samples were obtained and relative soil densities were estimated by split barrel sampling procedures in general accordance with ASTM Specification D-1586. Bedrock was not encountered within the limits explored in these borings.

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Profile

The generalized subsurface profile, as inferred from the available subsurface information and geology, is summarized as follows:

- Fill - 1 to 9 feet thick; over
- Glacial Till - Greater than 8 feet, but generally less than 30 thick; over
- Bedrock - Brown Arkose (brown stone)

Fill was observed in each of the six referenced borings, and generally consisted of medium dense to very dense (mostly dense to very dense), gray to reddish brown fine to coarse sand with varying amounts of gravel (5 to 35%) and fines (10 to 35%). The thickness and character of the Fill will vary between boring locations.

Glacial Till was encountered in each of the referenced borings. The stratum generally consisted of hard clayey silt with varying amounts of fine to coarse sand (35 to 50%) and gravel (0 to 20%).

The Portland Arkose formation, a sedimentary bedrock unit, is the dominating formation in this locale. Its texture ranges from coarse conglomerate to shale. Although bedrock cores were not performed in the nearby borings, rock data available from about 300 feet west indicates RockQuality Designations (RQDs) ranging from 0 to 75 percent for the top 10 feet.

4.2 Groundwater

Groundwater was not encountered during the subsurface explorations, which could be due to the fine grained nature of the soils and relatively short standing time. Groundwater conditions will vary depending on factors such as temperature, season, precipitation, construction activity, and other conditions, which may be different from those at the time the readings were made.

5.0 GEOTECHNICAL DESIGN ISSUES and RECOMMENDATIONS

5.1 Geotechnical Parameters and Recommendations

Based on the available information, we recommend the following geotechnical design parameters be used for the design of the proposed sign structure foundation:

Strata	Thickness (ft)	Total Unit Weight (pcf)	Friction Angle (degrees)
Fill	9	120	32
Glacial Till	9 to 30	135	38

We recommend the following geotechnical parameters based on AASHTO LRFD Table 10.5.5.2.4-1, be used for a drilled shaft embedded 16-feet into soil:

- Coefficient of Horizontal Subgrade Reaction for Soil Above the Water Table = 225 pci
- Coefficient of Horizontal Subgrade Reaction for Soil Below the Water Table = 125 pci
- Nominal End Bearing Resistance in Sands = 46 ksf
- End Bearing Resistance Factor in Sands = 0.50
- Factored End Bearing Resistance in Sands = 23 ksf
- Nominal Side Resistance in Sands = 2.0 ksf (for a 16' embedment)
- Side Resistance Factor in Sands (Compression) = 0.55
- Factored Side Resistance in Sands (Compression) = 1.1 ksf (for a 16' embedment)
- Side Resistance Factor in Sands (Uplift) = 0.45
- Factored Side Resistance in Sands (Uplift) = 0.9 ksf (for a 16' embedment)
- Lateral Movement = less than 0.25 inches (for a 16' embedment)
- Lateral Resistance Factor = 1.0
- Estimated Settlement = less than 0.25 inches

The side resistances provided above assume that permanent casing is not used. If the contractor opts to permanently case the shaft, a reduction factor of 0.6 should be applied to the side resistances.

We recommend the "Tubular Arch Sign Support Foundation" drawing be modified accordingly to account for the appropriate site conditions. The above parameters are based on a 20 foot long shaft, with the reference line at the top of shaft and a four foot stickup below the reference point at the top of shaft. This results in a design shaft length of 16-feet.

Due to limited rock data, we recommend modifying the rock socket depths such that: if bedrock is encountered between 13 and 19 feet below the reference point, the total length of the shaft remain at 20 feet, with a rock socket length ranging between 1 and 7 feet deep; and if bedrock is encountered less than 13 feet below the below the reference point, we recommend a minimum rock socket length of 8 feet.

5.2 L-Pile Analysis

An L-Pile analysis of the drilled shaft resulted in a deflection at the top of the shaft of 0.35 inches, a maximum bending moment of 216 kip-ft at about 6.5 feet below grade, and a maximum shear force of about 37 kips at about 13 feet below grade. L-Pile assumptions and calculations are provided in Appendix 3.

5.3 Interaction between Drilled Shaft and Retaining Wall 110

Due to the close proximity of the proposed Retaining Wall 110 to the proposed drilled shaft, we considered their interaction. The retained soil behind Wall 110 will act as a surcharge on the drilled shaft, creating an unbalance, lateral loading. To account for this loading, we distributed

this load over the length of the drilled shaft below the wall footing. The resulting estimated lateral displacement at the top of the shaft, estimated to be less than 0.35 inches, accounts for this loading.

5.4 Protect Drilled Shaft from RW 110

To prevent loading of the shaft by Retaining Wall 110, we recommend placing two-inches of low strength geofoam (i.e. EPS12 with density = 0.70 lb/ft^3) be placed between the drilled shaft Retaining Wall 110, from the ground surface to the bottom of footing. This precaution will prevent direct lateral loading to the drilled shaft.

5.5 Seismic Design

Due to the structure type, seismic loading need not be considered.

6.0 CONSTRUCTION CONSIDERATIONS

6.1 Protection of Structures

The Contractor must protect existing nearby structures during installation of the drilled shaft. Additionally, the drilled shaft must be protected during construction of Retaining Wall 110. If the drilled shaft sign support is installed prior to the construction of Wall 110, the excavation along the drilled shaft to reach bottom of retaining wall footings must be performed carefully to prevent damage to the shaft.

6.2 Contractors Means and Methods

The Contractor should submit means and methods for drilled shaft installation as necessary to provide ample strength to support all pressures and forces acting on the casing, including handling and installation stresses appropriate to the Contractor's means and methods and the subsurface conditions.

7.0 SPECIAL PROVISIONS

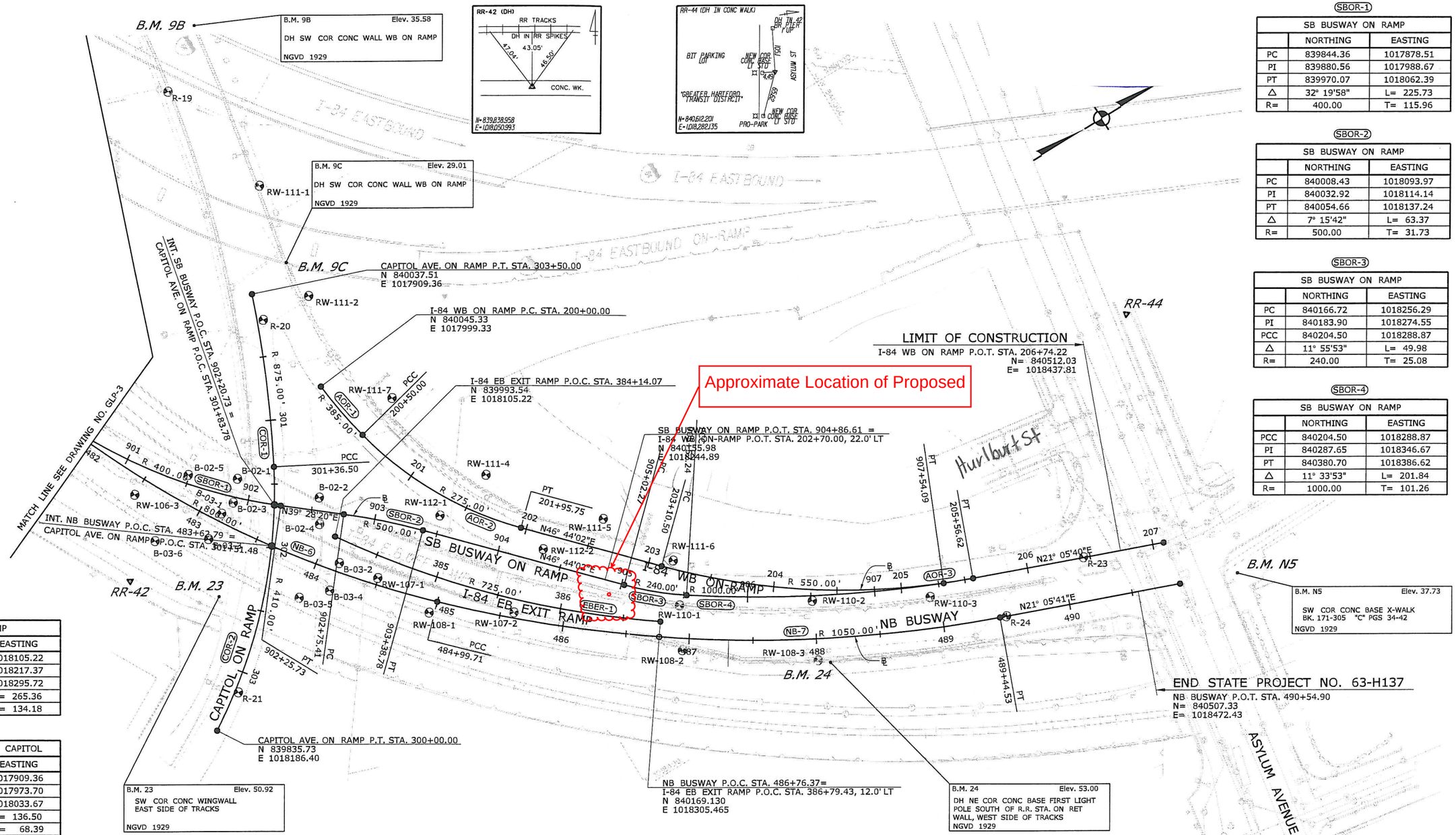
A Special Provision to Furnish and Install Drilled Shafts has been developed for inclusion with the construction documents.

8.0 LIMITATIONS

This report is subject to the limitations attached in Appendix 4.

APPENDIX 1

SITE AND BORING LOCATION PLAN



(SBOR-1)

SB BUSWAY ON RAMP		
	NORTHING	EASTING
PC	839844.36	1017878.51
PI	839880.56	1017988.67
PT	839970.07	1018062.39
△	32° 19'58"	L= 225.73
R=	400.00	T= 115.96

(SBOR-2)

SB BUSWAY ON RAMP		
	NORTHING	EASTING
PC	840008.43	1018093.97
PI	840032.92	1018114.14
PT	840054.66	1018137.24
△	7° 15'42"	L= 63.37
R=	500.00	T= 31.73

(SBOR-3)

SB BUSWAY ON RAMP		
	NORTHING	EASTING
PC	840166.72	1018256.29
PI	840183.90	1018274.55
PCC	840204.50	1018288.87
△	11° 55'53"	L= 49.98
R=	240.00	T= 25.08

(SBOR-4)

SB BUSWAY ON RAMP		
	NORTHING	EASTING
PCC	840204.50	1018288.87
PI	840287.65	1018346.67
PT	840380.70	1018386.62
△	11° 33'53"	L= 201.84
R=	1000.00	T= 101.26

(EBER-1)

I-84 EB EXIT RAMP		
	NORTHING	EASTING
PC	839993.53	1018105.22
PI	840067.20	1018217.37
PT	840176.13	1018295.72
△	20° 58'16"	L= 265.36
R=	725.00	T= 134.18

(COR-1)

I-84 WB ON RAMP FROM CAPITOL		
	NORTHING	EASTING
PC	840037.50	1017909.36
PI	840014.34	1017973.70
PCC	839981.45	1018033.67
△	8° 56'16"	L= 136.50
R=	875.00	T= 68.39

(COR-2)

I-84 WB ON RAMP FROM CAPITOL		
	NORTHING	EASTING
PCC	839981.45	1018033.67
PI	839928.93	1018129.44
PT	839835.73	1018186.39
△	29° 50'10"	L= 213.50
R=	410.00	T= 109.23

(NB-6)

NB BUSWAY		
	NORTHING	EASTING
PC	839839.33	1017862.66
PI	839896.85	1018050.78
PCC	840035.06	1018190.76
△	27° 37'45"	L= 385.77
R=	800.00	T= 196.71

(NB-7)

NB BUSWAY		
	NORTHING	EASTING
PCC	840035.06	1018190.76
PI	840193.69	1018351.45
PT	840404.36	1018432.71
△	24° 16'21"	L= 444.82
R=	1050.00	T= 225.80

(AOR-1)

I-84 WB ON RAMP FROM ASYLUM		
	NORTHING	EASTING
PC	840045.33	1017999.33
PI	840047.71	1018024.25
PCC	840053.30	1018048.65
△	7° 26'28"	L= 50.00
R=	385.00	T= 25.04

(AOR-2)

I-84 WB ON RAMP FROM ASYLUM		
	NORTHING	EASTING
PCC	840053.30	1018048.65
PI	840069.96	1018121.40
PT	840121.11	1018175.74
△	30° 22'01"	L= 145.75
R=	275.00	T= 74.63

(AOR-3)

I-84 WB ON RAMP FROM ASYLUM		
	NORTHING	EASTING
PC	840199.76	1018259.30
PI	840285.54	1018350.43
PT	840402.31	1018395.48
△	25° 38'21"	L= 246.12
R=	550.00	T= 125.16

FIGURE 1

REV.	DATE	REVISION DESCRIPTION	SHEET NO.

Plotted: 2/25/2010

DESIGNER/DRAFTER:
CHECKED BY:
SCALE IN FEET 0 40 80
SCALE 1"=40'

STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION

Filename: ...\HW_MSH_063_H137_GLP-004.dgn

SIGNATURE/BLOCK: LOCHNER
H.W. LOCHNER, INC
2110 Silas Deane Highway
Rocky Hill, CT 06067
APPROVED BY: DATE:

PROJECT TITLE: NEW BRITAIN - HARTFORD BUSWAY HARTFORD NORTH

TOWN: HARTFORD

DRAWING TITLE: SOIL BORING AND GEOMETRIC LAYOUT PLAN

PROJECT NO. 63-H137
DRAWING NO. GLP-4
SHEET NO.

APPENDIX 2

TEST BORING LOGS

Connecticut DOT Boring Report

Inspector: Ray Underwood	Town: Hartford	Hole No.: RW-107-2	
Engineer: Geo**Design**, Inc.	Project No.: 63-H137 / 0331-014.0	Stat./Offset:	
Start Date: 10-7-08	Route No.:	Northing: 840089.5	
Finish Date: 10-7-08	Bridge No.:	Easting: 1018226.4	
		Surface Elevation: 56.2	

Project Description: New Britain / Hartford Busway Retaining Wall 7

Casing Size/Type: 4"/HW	Sampler Type/Size: SS / 1 3/8"	Core Barrel Type:
Hammer Wt.: Fall:	Hammer Wt.: 140 lbs. Fall: 30"	

Groundwater Observations: @None observed

Depth (ft)	Sample Type/No.	Blows on Sampler per 6 inches	Pen. (in.)	Rec. (in.)	RQD %	Generalized Strata Description	Material Description and Notes	Elevation (ft)
0						Asphalt		
						Fill		55
	S-1	9 40 50 48	24	10			Very dense, red brown fine to coarse SAND, little Silt, trace fine Gravel, (moist)	
	S-2	49 50 50/4"	16	3			Very dense, gray fine to coarse SAND,some Silt, trace fine Gravel	
5								
	S-3	35 30 23 33	24	11			Very dense, red brown fine to coarse SAND,some Silt, trace fine Gravel (moist)	50
	S-4	34 33 12 11	24	13			Dense, red brown fine to coarse SAND, some Silt, trace fine Gravel	
						Glacial Till		
10								
	S-5	16 18 20 26	24	12			Hard, red brown Clayey SILT, some fine to coarse Sand, trace fine Gravel	45
	S-6	41 35 33 46	24	12			Hard, red brown Clayey SILT, some fine to coarse Sand, trace fine Gravel	
15								
	S-7	18 29 39 38	24	19			Hard, red brown Clayey SILT, some fine to medium Sand, trace fine Gravel	40
							END OF BORING 17ft	
20								
								35
25								

Sample Type: S = Split Spoon C = Core UP = Undisturbed Piston V = Vane Shear Test

Proportions Used: Trace = 1 - 10%, Little = 10 - 20%, Some = 20 - 35%, And = 35 - 50%

Total Penetration in Earth: 17ft Rock: 0ft	NOTES:	Sheet 1 of 1
No. of Soil Samples: 7 No. of Core Runs: 0		SM-001-M REV. 1/02

Connecticut DOT Boring Report

Inspector: Ray Underwood	Town: Hartford	Hole No.: RW-108-2	
Engineer: Geo**Design**, Inc.	Project No.: 63-H137 / 0331-014.0	Stat./Offset:	
Start Date: 10-7-08	Route No.:	Northing: 840184	
Finish Date: 10-7-08	Bridge No.:	Easting: 1018315.4	
		Surface Elevation: 49.0	

Project Description: New Britain / Hartford Busway Retaining Wall 8

Casing Size/Type: 3"/NW	Sampler Type/Size: SS / 1 3/8"	Core Barrel Type:
Hammer Wt.: Fall:	Hammer Wt.: 140 lbs. Fall: 30"	

Groundwater Observations: @None observed

Depth (ft)	Sample Type/No.	Blows on Sampler per 6 inches	Pen. (in.)	Rec. (in.)	RQD %	Generalized Strata Description	Material Description and Notes	Elevation (ft)
0						Asphalt		
						Fill		
	S-1	31 22 23 44	24	6			Dense, red brown fine to coarse SAND, little(-) fine Gravel, little Silt, (moist)	
	S-2	21 26 19 10	24	18			Dense, red brown fine to coarse SAND, some Silt, little fine Gravel	45
5							Medium dense, red brown	
	S-3	9 10 10 16	24	19		Glacial Till	Top 6": fine to coarse SAND and fine to coarse GRAVEL, trace Silt, (moist) Bottom 13": fine SAND and SILT, little fine Gravel	
								40
10	S-4	15 21 32 34	24	16			Hard, red brown Clayey SILT, some fine to coarse Sand, trace fine Gravel	
								35
15	S-5	32 100	12	11			Hard, red brown Clayey SILT, some fine to coarse Sand, trace fine Gravel	
							END OF BORING 16ft	
								30
20								
								25
25								

Sample Type: S = Split Spoon C = Core UP = Undisturbed Piston V = Vane Shear Test

Proportions Used: Trace = 1 - 10%, Little = 10 - 20%, Some = 20 - 35%, And = 35 - 50%

Total Penetration in Earth: 16ft Rock: 0ft	NOTES:	Sheet 1 of 1
No. of Soil Samples: 5 No. of Core Runs: 0		SM-001-M REV. 1/02

Connecticut DOT Boring Report

Inspector: Garry Jacobson	Town: Hartford	Hole No.: RW-110-1	
Engineer: Geo**Design**, Inc.	Project No.: 63-H137 / 0331-014.0	Stat./Offset:	
Start Date: 10-6-08	Route No.:	Northing: 840204.5	
Finish Date: 10-6-08	Bridge No.:	Easting: 1018290.2	
		Surface Elevation: 37.9	

Project Description: New Britain / Hartford Busway Retaining Wall 10

Casing Size/Type: 3 1/4" HSA	Sampler Type/Size: SS / 1 3/8"	Core Barrel Type:
Hammer Wt.: Fall:	Hammer Wt.: 140 lbs. Fall: 30"	

Groundwater Observations: @None observed

Depth (ft)	SAMPLES: Sample Type/No.	Blows on Sampler per 6 inches	Pen. (in.)	Rec. (in.)	RQD %	Generalized Strata Description	Material Description and Notes	Elevation (ft)
0						Asphalt		
						Crushed Stone		
	S-1	45 46 46 35	24	14		Fill	Very dense, red brown fine to coarse SAND, some fine to coarse Gravel, little Silt	35
	S-2	14 50/4"	10	5		Glacial Till	Very dense, red brown fine to coarse SAND and SILT, little fine to coarse Gravel	
5								30
							END OF BORING 9ft	
10								25
15								20
20								15
25								

Sample Type: S = Split Spoon C = Core UP = Undisturbed Piston V = Vane Shear Test

Proportions Used: Trace = 1 - 10%, Little = 10 - 20%, Some = 20 - 35%, And = 35 - 50%

Total Penetration in Earth: 9ft Rock: 0ft	NOTES:	Sheet 1 of 1
No. of Soil Samples: 2 No. of Core Runs: 0		SM-001-M REV. 1/02

Connecticut DOT Boring Report

Inspector: Garry Jacobson	Town: Hartford	Hole No.: RW-111-5	
Engineer: Geo**Design**, Inc.	Project No.: 63-H137 / 0331-014.0	Stat./Offset:	
Start Date: 10-6-08	Route No.:	Northing: 840152.9	
Finish Date: 10-6-08	Bridge No.:	Easting: 1018206.1	
		Surface Elevation: 33.5	

Project Description: New Britain / Hartford Busway Retaining Wall 11

Casing Size/Type: 3 1/4" HSA	Sampler Type/Size: SS / 1 3/8"	Core Barrel Type:
Hammer Wt.: Fall:	Hammer Wt.: 140 lbs. Fall: 30"	

Groundwater Observations: @None observed

Depth (ft)	Sample Type/No.	Blows on Sampler per 6 inches	Pen. (in.)	Rec. (in.)	RQD %	Generalized Strata Description	Material Description and Notes	Elevation (ft)
0						Fill		
	S-1	4 15 25 17	24	14		Glacial Till	Medium dense, Top 7": black to dark brown fine to medium SAND, some Silt	
	S-2	19 90	12	6			Bottom 7": red brown fine to coarse SAND, little fine Gravel, little Silt	30
							Medium dense, red brown fine to coarse SAND, little fine Gravel, little Silt	
5	S-3	100/4"	4	4			Very dense, red brown SILT and fine SAND	
								25
10	S-4	100/1"	1	1			Not recorded	
							END OF BORING 10.1ft	
								20
15								
								15
20								
								10
25								

Sample Type: S = Split Spoon C = Core UP = Undisturbed Piston V = Vane Shear Test

Proportions Used: Trace = 1 - 10%, Little = 10 - 20%, Some = 20 - 35%, And = 35 - 50%

Total Penetration in Earth: 10.1ft Rock: 0ft	NOTES: Auger refusal at approximately 10.1 feet.	Sheet 1 of 1
No. of Soil Samples: 4 No. of Core Runs: 0		SM-001-M REV. 1/02

Connecticut DOT Boring Report

Inspector: Garry Jacobson	Town: Hartford	Hole No.: RW-111-6	
Engineer: Geo**Design**, Inc.	Project No.: 63-H137 / 0331-014.0	Stat./Offset:	
Start Date: 10-6-08	Route No.:	Northing: 840205.7	
Finish Date: 10-6-08	Bridge No.:	Easting: 1018262.8	
		Surface Elevation: 35.9	

Project Description: New Britain / Hartford Busway Retaining Wall 11

Casing Size/Type: 3 1/4" HSA	Sampler Type/Size: SS / 1 3/8"	Core Barrel Type:
Hammer Wt.: Fall:	Hammer Wt.: 140 lbs. Fall: 30"	

Groundwater Observations: @None observed

Depth (ft)	SAMPLES: Sample Type/No.	Blows on Sampler per 6 inches	Pen. (in.)	Rec. (in.)	RQD %	Generalized Strata Description	Material Description and Notes	Elevation (ft)
0	S-1	6 10 15 20	24	14		Fill	Medium dense, brown and gray fine to coarse SAND, little fine to coarse Gravel, little Silt	35
	S-2	32 44 61 35	24	18		Glacial Till	Very dense, red brown fine to coarse SAND, some fine Gravel, little Silt	
5	S-3	50/1"	1	1			Very dense, red brown fine to coarse SAND and SILT	30
							END OF BORING 6ft	
10								25
15								20
20								15
25								

Sample Type: S = Split Spoon C = Core UP = Undisturbed Piston V = Vane Shear Test

Proportions Used: Trace = 1 - 10%, Little = 10 - 20%, Some = 20 - 35%, And = 35 - 50%

Total Penetration in Earth: 6ft Rock: 0ft	NOTES: Auger refusal at approximately 6 feet.	Sheet 1 of 1
No. of Soil Samples: 3 No. of Core Runs: 0		SM-001-M REV. 1/02

Connecticut DOT Boring Report

Inspector:	Garry Jacobson	Town:	Hartford	Hole No.:	RW-112-2
Engineer:	Geo**Design**, Inc.	Project No.:	63-H137 / 0331-014.0	Stat./Offset:	
Start Date:	10-6-08	Route No.:		Northing:	840130.1
Finish Date:	10-6-08	Bridge No.:		Easting:	1018191.6
				Surface Elevation:	32.9

Project Description: New Britain / Hartford Busway Retaining Wall 12

Casing Size/Type: 3 1/4" HSA	Sampler Type/Size: SS / 1 3/8"	Core Barrel Type:
Hammer Wt.: Fall:	Hammer Wt.: 140 lbs. Fall: 30"	

Groundwater Observations: @None observed

Depth (ft)	SAMPLES: Sample Type/No.	Blows on Sampler per 6 inches	Pen. (in.)	Rec. (in.)	RQD %	Generalized Strata Description	Material Description and Notes	Elevation (ft)
0						Asphalt		
						Sand Fill		
	S-1	19 35 51 59	24	12			Very dense, gray fine to coarse SAND, some fine Gravel, little Silt	
						Glacial Till		30
	S-2	45 90	12	3			Very dense, red brown fine to coarse SAND, some Silt, little fine Gravel	
5	S-3	100/2"	2	2			Very dense, red brown fine SAND and SILT	
								25
10	S-4	100/1"	1	1			Very dense, red brown fine SAND and SILT	
							END OF BORING 10.1ft	
								20
15								
								15
20								
								10
25								

Sample Type: S = Split Spoon C = Core UP = Undisturbed Piston V = Vane Shear Test

Proportions Used: Trace = 1 - 10%, Little = 10 - 20%, Some = 20 - 35%, And = 35 - 50%

Total Penetration in Earth: 10.1ft Rock: 0ft	NOTES:	Sheet 1 of 1
No. of Soil Samples: 4 No. of Core Runs: 0		SM-001-M REV. 1/02

APPENDIX 3

L-PILE CALCULATIONS

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Objective: Provides geotechnical design parameters for an overhead sign structure drilled shaft foundation along the proposed New Britain-Hartford Busway.

The recommendations include:

(1) Soil unit weights
(2) Soil angle of internal friction
(3) Coefficient of horizontal subgrade reactions
(4) Unit skin friction and end-bearing

References: "Busway Station 904+00 to 906+00, State Project 63-H137, New Britain, Connecticut, Drawing No. GLP-4 and boring logs, by H.W. Lochner, Inc.;

FHWA-IF-02-034 - Geotechnical Engineering Circular No. 5;

NAVFAC DM7;

LPile manual

AASHTO LRFD 4th Edition, Standard Specifications for Highway Bridges.

Methodology: 1. Review the geology, plans, specifications, and geotechnical borings provide in Reference 1;

2. Construct a generalized soil profile for the area using the geotechnical boring logs;

3. Estimate soil properties using tables and charts form FHWA-IF-02-034 - Geotechnical Engineering Circular No. 5, NAVFAC DM7, AASHTO LRFD 4th Edition, Standard Specifications for Highway Bridges, and the Lpile Manual.

4. Estimate drilled shaft capacity and lateral wall loads using AASHTO LRFD 4th Edition, Standard Specifications for Highway Bridges.

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JOB 0331-14.2 OSS
SHEET NO. 2 OF 25
CALCULATED BY DFL DATE 2/24/11
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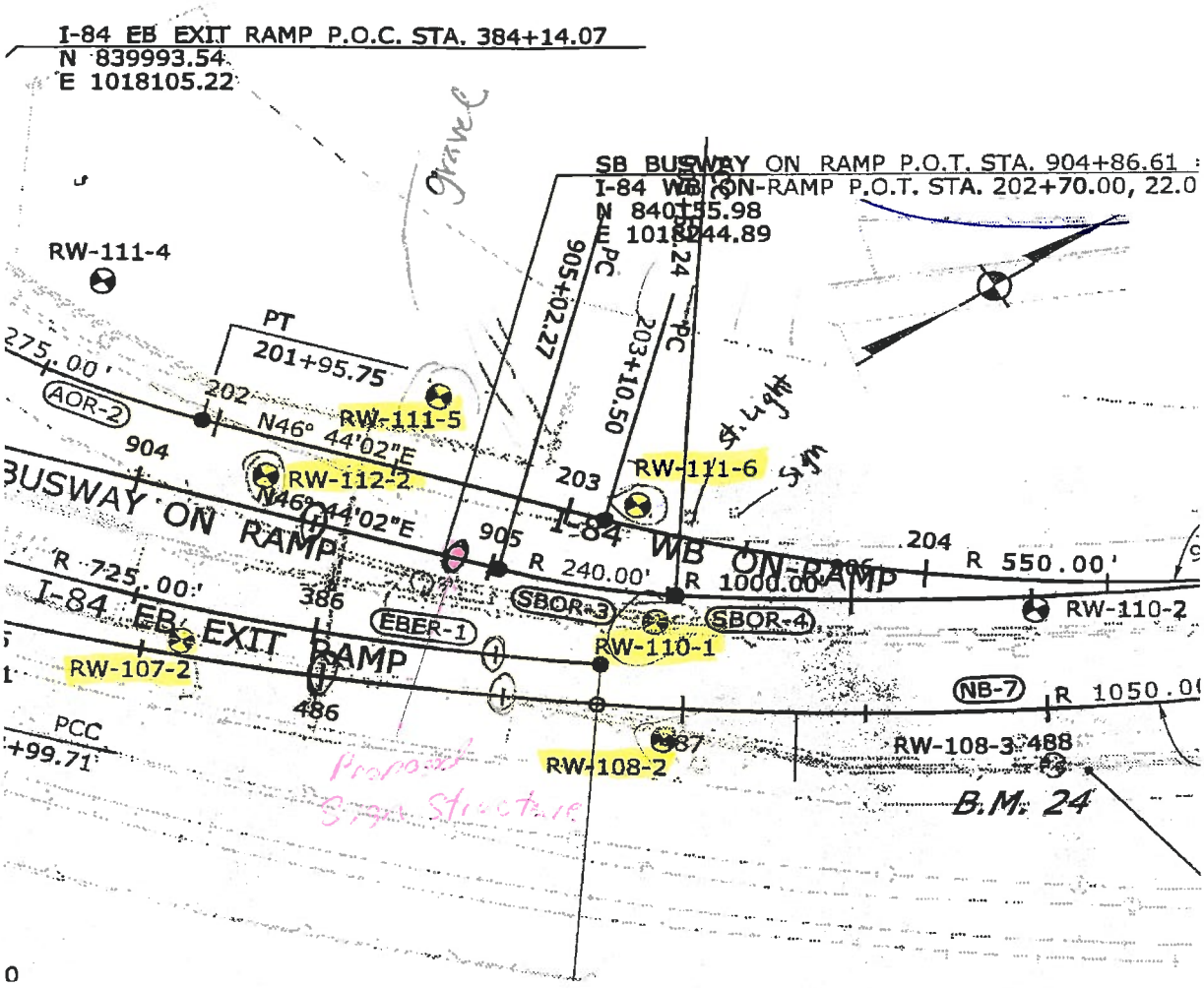
SCALE NTS



PROJECT TITLE	TOWN	PROJECT NO.
NEW BRITAIN - HARTFORD BUSWAY HARTFORD NORTH	HARTFORD	63-H137
	DRAWING TITLE: SOIL BORING AND GEOMETRIC LAYOUT PLAN	DRAWING NO. GLP-4
		SHEET NO.

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JOB 0371-142 OSS
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SCALE

Connecticut DOT Boring Report

Inspector: Ray Underwood	Town: Hartford	Hole No.: RW-107-2	
Engineer: GeoDesign, Inc.	Project No.: 63-H137 / 0331-014.0	Stat./Offset:	
Start Date: 10-7-08	Route No.:	Northing: 840089.5	
Finish Date: 10-7-08	Bridge No.:	Easting: 1018226.4	
		Surface Elevation: 56.2	

Project Description: New Britain / Hartford Busway - Retaining Wall 7

Casing Size/Type: 4"/HW	Sampler Type/Size: SS / 1 3/8"	Core Barrel Type:
Hammer Wt.: Fall:	Hammer Wt.: 140 lbs. Fall: 30"	

Groundwater Observations: @None observed

Depth (ft)	Sample Type/No.	Blows on Sampler per 6 inches	Pen. (in.)	Rec. (in.)	RQD %	Generalized Strata Description	Material Description and Notes	Elevation (ft)
0						Asphalt		
						Fill		55
	S-1	9 40 50 48	24	10			Very dense, red brown fine to coarse SAND, little Silt, trace fine Gravel, (moist)	
	S-2	49 50 50/4"	16	3			Very dense, gray fine to coarse SAND,some Silt, trace fine Gravel	
5								
	S-3	35 30 23 33	24	11			Very dense, red brown fine to coarse SAND,some Silt, trace fine Gravel (moist)	50
	S-4	34 33 12 11	24	13			Dense, red brown fine to coarse SAND, some Silt, trace fine Gravel	
						Glacial Till		
10								
	S-5	16 18 20 26	24	12			Hard, red brown Clayey SILT, some fine to coarse Sand, trace fine Gravel	45
	S-6	41 35 33 46	24	12			Hard, red brown Clayey SILT, some fine to coarse Sand, trace fine Gravel	
15								
	S-7	18 29 39 38	24	19			Hard, red brown Clayey SILT, some fine to medium Sand, trace fine Gravel	40
							END OF BORING 17ft	
20								
								35
25								

Sample Type: S = Split Spoon C = Core UP = Undisturbed Piston V = Vane Shear Test
Proportions Used: Trace = 1 - 10%, Little = 10 - 20%, Some = 20 - 35%, And = 35 - 50%

Total Penetration in Earth: 17ft Rock: 0ft	NOTES:	Sheet 1 of 1
No. of Soil Samples: 7 No. of Core Runs: 0		SM-001-M REV. 1/02

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Boring RW-107-2 Subsurface Profile

Elevation (ft)	Depth (ft)	Soil Description	Groundwater	Unit Weight (psf)	Buoyant Unit Weight (psf)	Total Vertical Stress (psf)	Static Pore Water Pressure (psf)	Effective Vertical Stress (psf)
56.0	0.0	Fill (SM)	No	0.0	0.0	0.0	0.0	0.0
55.0	1.0	Fill (SM)	No	120.0	120.0	120.0	0.0	120.0
54.0	2.0	Fill (SM)	No	120.0	120.0	240.0	0.0	240.0
53.0	3.0	Fill (SM)	No	120.0	120.0	360.0	0.0	360.0
52.0	4.0	Fill (SM)	No	120.0	120.0	480.0	0.0	480.0
51.0	5.0	Fill (SM)	No	120.0	120.0	600.0	0.0	600.0
50.0	6.0	Fill (SM)	No	120.0	120.0	720.0	0.0	720.0
49.0	7.0	Fill (SM)	No	120.0	120.0	840.0	0.0	840.0
48.0	8.0	Fill (SM)	No	120.0	120.0	960.0	0.0	960.0
47.0	9.0	Fill (SM)	No	120.0	120.0	1080.0	0.0	1080.0
46.0	10.0	Glacial Till (GM)	No	135.0	135.0	1215.0	0.0	1215.0
45.0	11.0	Glacial Till (GM)	No	135.0	135.0	1350.0	0.0	1350.0
44.0	12.0	Glacial Till (GM)	No	135.0	135.0	1485.0	0.0	1485.0
43.0	13.0	Glacial Till (GM)	No	135.0	135.0	1620.0	0.0	1620.0
42.0	14.0	Glacial Till (GM)	No	135.0	135.0	1755.0	0.0	1755.0
41.0	15.0	Glacial Till (GM)	No	135.0	135.0	1890.0	0.0	1890.0
40.0	16.0	Glacial Till (GM)	No	135.0	135.0	2025.0	0.0	2025.0
39.0	17.0	Glacial Till (GM)	No	135.0	135.0	2160.0	0.0	2160.0

Notes:

1. Subsurface data was obtained from Boring RW-107-2.
2. Unit weights were estimated using Figure 7 in NAVFAC DM 7.01.
3. Groundwater was assumed to be at El. 20 feet.

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RW-107-2 Standard Penetration Test Data and Correlated Strength Properties

Elevation (ft)	Depth (ft)	Soil Description	Uncorrected SPT N-Value	Hammer Correction	Borehole Correction	Sampler Correction	Rod Length Correction	Overburden Correction	Corrected SPT $(N1)_{60}$-Value	Relative Density (%)	Drained Friction Angel (°)
54.0	2.0	Fill (SM)	90	1.0	1.0	1.0	0.75	2.00	135	180	41
52.0	4.0	Fill (SM)	100	1.0	1.0	1.0	0.75	2.00	150	160	41
48.0	8.0	Fill (SM)	45	1.0	1.0	1.0	0.75	1.48	50	90	40
45.0	11.0	Glacial Till (GM)	38	1.0	1.0	1.0	0.75	1.25	36	76	38
43.0	13.0	Glacial Till (GM)	68	1.0	1.0	1.0	0.75	1.14	58	97	42
40.0	16.0	Glacial Till (GM)	68	1.0	1.0	1.0	0.85	1.02	59	98	42

The blow counts for the other borings are less than or equal to the one observed for Boring RW-107-2. 38 degress will be used for design

Notes:

1. Standard Penetration Test (SPT) data was obtained from Boring RW-107-2.
2. SPT N-Values were corrected using the following equation: $(N1)_{60} = N_m x C_N x C_E x C_B x C_s x C_r$ (FHWA-IF-02-034 - Geotechnical Engineering Circular No. 5)
3. Drained friction angles were estimated using Figure 7 in NAVFAC DM 7.01.

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Table 9. Corrections to the SPT (after Skempton, 1986).

Factor	Equipment Variable	Term	Correction
Energy Ratio	Donut Hammer Safety Hammer Automatic Hammer	$C_E = ER/60$	0.5 to 1.0[1] 0.7 to 1.2[1] 0.8 to 1.5[1]
Borehole Diameter	65 to 115 mm 150 mm 200 mm	C_B	1.0 1.05 1.15
Sampling method	Standard sampler Non-standard sampler	C_S	1.0 1.1 to 1.3
Rod Length	3 to 4 m 4 to 6 m 6 to 10 m 10 to >30 m	C_R	0.75 0.85 0.95 1.0

[1] Values presented are for guidance only. Actual ER values should be measured per ASTM D 4633

Since N-values of similar materials increase with increasing effective overburden stress, the corrected blowcount (N_{60}) is often normalized to 1-atmosphere (or about 100 kPa) effective overburden stress using overburden normalization schemes. The normalized corrected blowcount is referred to as $(N_1)_{60}$, and is equal to:

$$(N_1)_{60}=C_N N_{60} \qquad \text{(Equation 4)}$$

where C_N is the stress normalization parameter calculated as:

$$C_N = (P_a/\sigma_{vo}')^n \qquad \text{(Equation 5)}$$

where P_a is atmospheric pressure in the same units as σ_{vo}', and n is a stress exponent typically equal to 1 in clays (e.g., Olsen, 1997; Mayne & Kemper, 1988) and 0.5 to 0.6 in sands (e.g., Seed et al., 1983; Liao & Whitman, 1986; Olsen, 1997). Figure 11 illustrates a correlation for C_N that is used for sands. There exist several soil specific correlations for C_N, as reported in the literature. C_N may vary slightly from the general values identified previously, depending upon the specific correlation.

FHWA-IF-02-034

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SHEET NO. 7 OF 25
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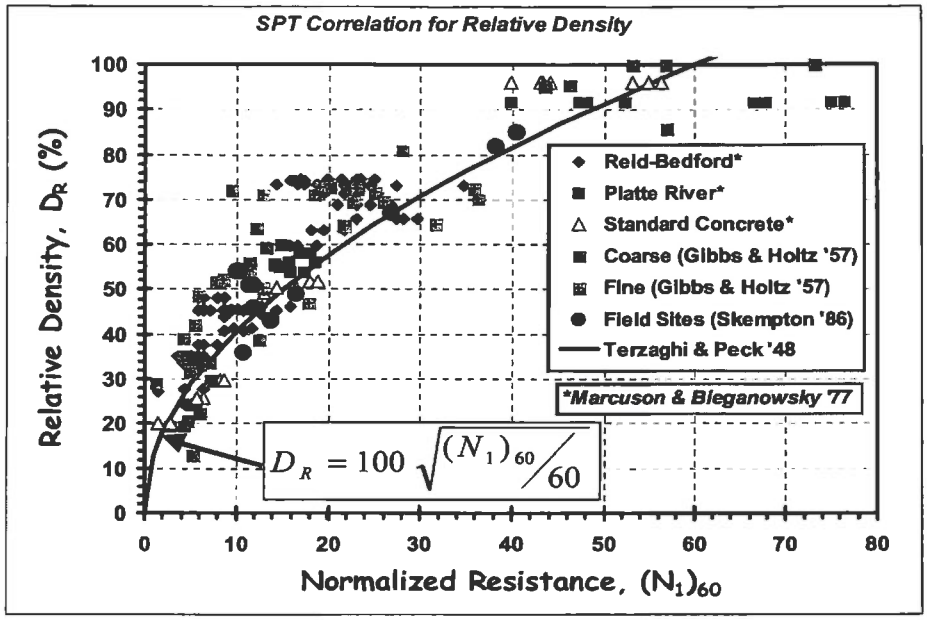

Figure 9-8. Relative Density of Clean Sands from Standard Penetration Test Data.
Note: normalized value $(N_1)_{60} = N_{60}/(\sigma_{vo}')^{0.5}$ where σ_{vo}' is in units of bars or tsf.

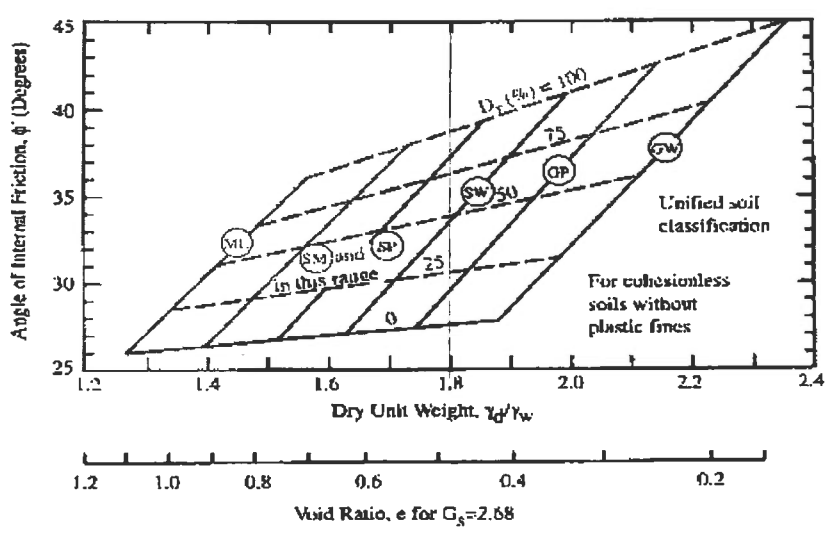

Figure 9-11. Typical Values of ϕ' and Unit Weight for Cohesionless Soils. (NAVFAC DM 7.1, 1982)

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Axial Resistance of a 20 foot Single Drilled Shaft with 4 foot stickup in Soil

q_p (Nominal tip resistance in Sand) (ksf) = 1.2 x N_{60} = 46 (Less than limiting value) OK

N_{60} (corrected only for hammer efficiency) = 38

φ_{qp} (Resistance factor for tip resistance) = 0.5

q_{Rp} (Factored tip resistance) (ksf) = φ_{qp} x q_p = 23

q_s (Nominal side resistance) (ksf) = β x σ'_v

$\beta_{(gravely\ sands)} = 1.5 - 0.135 \times (z)^{0.5}$

q_{Rs} (Factored side resistance) (ksf) = φ_{qs} x q_s

φ_{qsc} (Resistance factor for shaft resistance) = 0.55 (compression)

φ_{qst} (Resistance factor for shaft resistance) = 0.45 (Tension)

Elevation (ft)	Depth from Top of Shaft (ft)	Depth from Ground Surface, Z (ft)	γ (pcf)	σ'_v (ksf)	β	q_s (ksf)	q_{Rsc} (ksf)	q_{Rst} (ksf)
42	0	-4	0	0	0.00	0.0	0.0	0.0
40	2	-2	120	0	0.00	0.0	0.0	0.0
38	4	0	120	0	0.00	0.0	0.0	0.0
36	6	2	120	0.24	1.20	0.3	0.2	0.1
34	8	4	120	0.48	1.20	0.6	0.3	0.3
32	10	6	130	0.74	1.17	0.9	0.5	0.4
30	12	8	130	1	1.12	1.1	0.6	0.5
28	14	10	130	1.26	1.07	1.4	0.7	0.6
26	16	12	130	1.52	1.03	1.6	0.9	0.7
24	18	14	130	1.78	0.99	1.8	1.0	0.8
22	20	16	130	2.04	0.96	2.0	1.1	0.9

Notes:

1. Axial compression resistance of a single drilled shaft was estimated using the recommended tables and equations in Section 10 - Foundations, LRFD AASHTO, 4th Edition.

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Table 10.5.5.2.4-1 Resistance Factors for Geotechnical Resistance of Drilled Shafts.

Method/Soil/Condition			Resistance Factor
Nominal Axial Compressive Resistance of Single-Drilled Shafts, φ_{stat}	Side resistance in clay	α-method (*O'Neill and Reese, 1999*)	0.45
	Tip resistance in clay	Total Stress (*O'Neill and Reese, 1999*)	0.40
	Side resistance in sand	β-method (*O'Neill and Reese, 1999*)	0.55
	Tip resistance in sand	O'Neill and Reesé (*1999*)	0.50
	Side resistance in IGMs	O'Neill and Reese (*1999*)	0.60
	Tip resistance in IGMs	O'Neill and Reese (*1999*)	0.55
	Side resistance in rock	Horvath and Kenney (*1979*) O'Neill and Reese (*1999*)	0.55
	Side resistance in rock	Carter and Kulhawy (*1988*)	0.50
	Tip resistance in rock	Canadian Geotechnical Society (*1985*) Pressuremeter Method (*Canadian Geotechnical Society, 1985*) O'Neill and Reese (*1999*)	0.50
Block Failure, φ_{bl}	Clay		0.55
Uplift Resistance of Single-Drilled Shafts, φ_{up}	Clay	α-method (*O'Neill and Reese, 1999*)	0.35
	Sand	β-method (*O'Neill and Reese, 1999*)	0.45
	Rock	Horvath and Kenney (*1979*) Carter and Kulhawy (*1988*)	0.40
Group Uplift Resistance, φ_{ug}	Sand and clay		0.45
Horizontal Geotechnical Resistance of Single Shaft or Shaft Group	All materials		1.0
Static Load Test (compression), φ_{load}	All Materials		Values in Table 10.5.5.2.3-2, but no greater than 0.70
Static Load Test (uplift), φ_{upload}	All Materials		0.60

AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS

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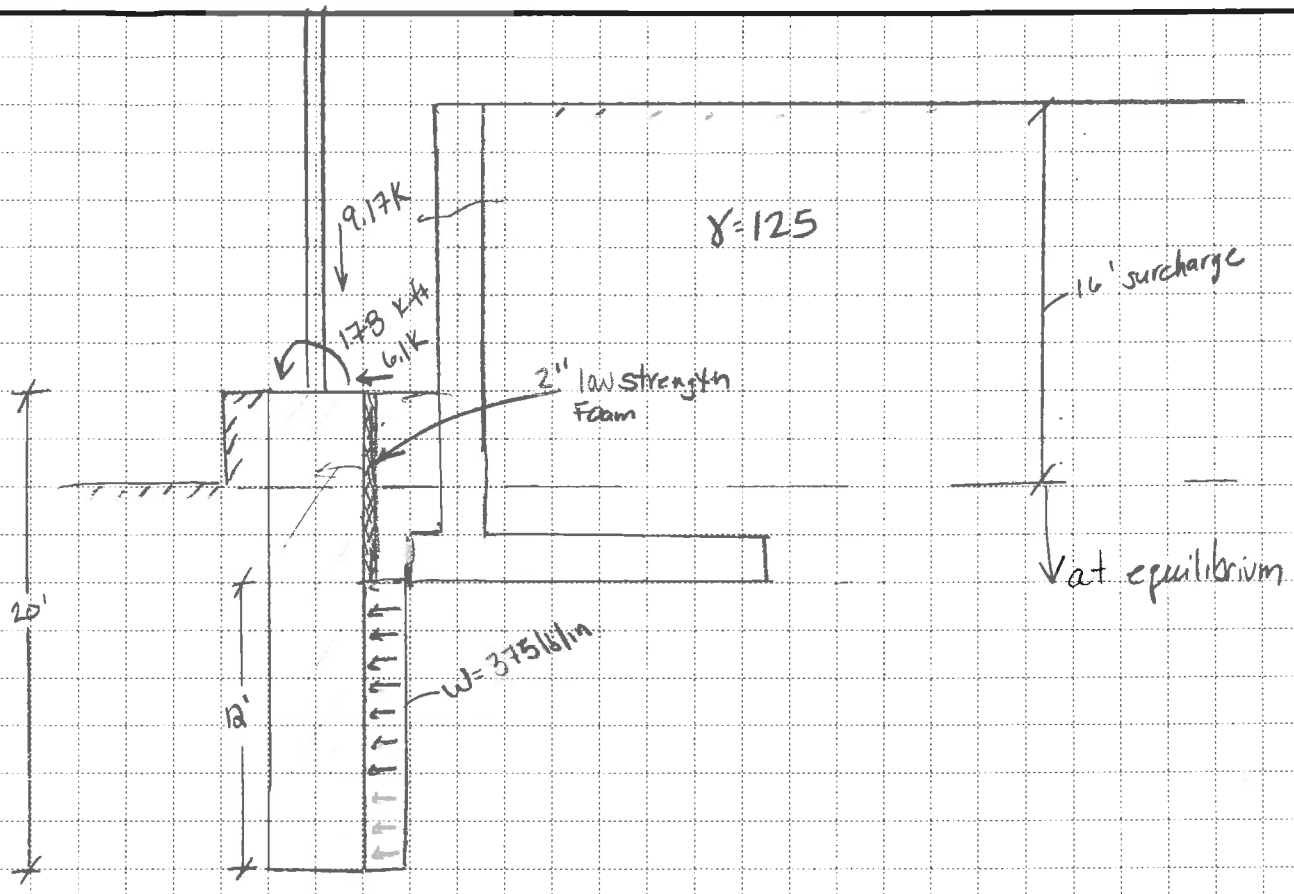

$$\sigma_H = K_o \gamma H = .5\,(125\ \tfrac{lb}{ft^3})(16\ ft) = 1000\ psf$$

$$w = 1000\ \tfrac{lb}{ft^2} \cdot 4.5\ ft = 4500\ lb/f = 375\ lb/in$$

Software licensed to H.W. Lochner	Job No 63-670	Sheet No 2	Rev
	Part		
Job Title New Britain-Hartford Busway	Ref		
	By CMF	Date 03/24/10	Chd
Client ConnDOT	File Sign Structure Model.std	Date/Time 24-Mar-2011 16:10	

*Provided by HWLochner

PROJECT 331-14.2 055
SHEET NO. 11 25
CALC. BY N/A* DATE
CHK. BY N/A

*Provided by H.W.L.

Reactions

Node	L/C	Horizontal FX (kip)	Vertical FY (kip)	Horizontal FZ (kip)	Moment MX (kip'ft)	MY (kip'ft)	MZ (kip'ft)
1	1:DEAD LOAD	-0.000	12.232	-0.000	-1.960	-0.093	76.464
	2:NORMAL WI	0.000	0.000	8.148	228.840	-110.453	0.000
	3:TRANSVERS	1.545	-0.000	0.000	0.000	0.586	-31.083
	4:ICE LOADS	-0.000	1.034	-0.000	-0.739	-0.035	12.306
	5:GALLOPING	-0.000	3.542	-0.000	-5.142	-0.244	54.807
	6:NATURAL W	0.000	0.000	1.147	32.050	-15.381	0.000
	7:TRUCK INDU	0.000	-0.403	0.000	0.207	0.010	-5.701
	10:GROUP 1	-0.000	12.232	-0.000	-1.960	-0.093	76.464
	21:GROUP 2 C	0.232	9.174	6.111	170.160	-82.821	52.686
	22:GROUP 2 C	0.348	9.174	3.667	101.508	-49.641	50.351
	31:GROUP 3 C	0.116	9.950	3.055	83.790	-41.472	64.246
	32:GROUP 3 C	0.174	9.950	1.833	49.464	-24.882	63.081
	41:GROUP 4 C	-0.000	15.775	-0.000	-7.102	-0.337	131.271
	42:GROUP 4 C	-0.000	12.232	1.147	30.090	-15.474	76.464
	43:GROUP 4 C	-0.000	11.830	-0.000	-1.753	-0.083	70.763

Controlling Load Case

Axial load 9174 lbs

Shear 6111 lbs

Sum of squares = 178 kip-ft = 2136,000 lb-in

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Recommended k	Relative Density Loose	Medium	Dense
MN/m³	5.4	16.3	34
(lb/in.³)	(20.0)	(60.0)	(125.0)

Table 3.6 Representative Values of k for Submerged Sand

Recommended k	Relative Density Loose	Medium	Dense
MN/m³	6.8	24.4	61.0
(lb/in.³)	(25.0)	(90.0)	(225.0)

Table 3.7 Representative Values of k for Sand Above the Water Table (Static and Cyclic Loading)

Relative Density of Sand (*)	Loose	Medium	Dense
Dry or moist, k, MN/m³	0.95-2.8	3.5-10.9	13.8-27.7
(lb/in.³)	(3.5 - 10.4)	(13.0 - 40.0)	(51.0 - 102.0)
Sub. sand, k, MN/m³	0.57-1.7	2.2- 7.3	8.7-17.9
(lb/in.³)	(2.1 - 6.4)	(8.0 - 27.0)	(32.0 - 64.0)

* Terzaghi's recommended k values for sand are believed to be overly conservative. Users of LPILE are encouraged to use the values recommended by Reese and Matlock presented later in this manual because those values are based on load tests of fully instrumented piles and are supported by soil investigations of good quality. Terzaghi's values were based on a literature review made at the time of writing. Terzaghi later acknowledged that he had some doubts about the source data and he stopped recommending their use.

Table 3.5 Terzaghi's Recommendations for Values of k for Laterally Loaded Piles in Sand

GEODESIGN INCORPORATED
PROJECT 331-14.2 055
SHEET NO. 13 OF 25
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CHK. BY MGB DATE 4/11/11

LPILE Plus for Windows, Version 5.0 (5.0.45)

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

(c) 1985-2010 by Ensoft, Inc.
All Rights Reserved

This program is licensed to:

GeoDesign
GeoDesign

Files Used for Analysis

Path to file locations: M:\CL\0331\14.02 (sign struct)\0331-14.2 Sign Structure Report and Analysis\
Name of input data file: Overhead Sign_MGB Revisions 4-11-11.lpd
Name of output file: Overhead Sign_MGB Revisions 4-11-11.lpo
Name of plot output file: Overhead Sign_MGB Revisions 4-11-11.lpp
Name of runtime file: Overhead Sign_MGB Revisions 4-11-11.lpr

Time and Date of Analysis

Date: April 11, 2011 Time: 17:26:44

Problem Title

Overhead Sign Structure

Program Options

Units Used in Computations - US Customary Units: Inches, Pounds

Basic Program Options:

Analysis Type 3:
- Computation of Nonlinear Bending Stiffness and Ultimate Bending Moment Capacity with Pile Response Computed Using Nonlinear EI

Computation Options:
- Only internally-generated p-y curves used in analysis
- Analysis does not use p-y multipliers (individual pile or shaft action only)
- Analysis assumes no shear resistance at pile tip
- Analysis includes automatic computation of pile-top deflection vs. pile embedment length
- No computation of foundation stiffness matrix elements
- Output summary table of values for pile-head deflection, maximum

bending moment, and shear force only
- Analysis assumes no soil movements acting on pile
- No additional p-y curves to be computed at user-specified depths

Solution Control Parameters:
- Number of pile increments = 100
- Maximum number of iterations allowed = 100
- Deflection tolerance for convergence = 1.0000E-05 in
- Maximum allowable deflection = 1.0000E+02 in

Printing Options:
- Only summary tables of pile-head deflection, maximum bending moment, and maximum shear force are to be printed in output file.

Pile Structural Properties and Geometry

Pile Length = 192.00 in

Depth of ground surface below top of pile = 48.00 in

Slope angle of ground surface = 0.00 deg.

Structural properties of pile defined using 2 points

Point No.	Point Depth in	Pile Diameter in	Moment of Inertia in**4	Pile Area Sq.in	Modulus of Elasticity lbs/Sq.in
1	0.0000	54.00000000	417392.8000	2290.0000	4350000.
2	240.0000	54.00000000	417392.8000	2290.0000	4350000.

Please note that because this analysis makes computations of ultimate moment capacity and pile response using nonlinear bending stiffness that the above values of moment of inertia and modulus of are not used for any computations other than total stress due to combined axial loading and bending.

Soil and Rock Layering Information

The soil profile is modelled using 2 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974
Distance from top of pile to top of layer = 48.000 in
Distance from top of pile to bottom of layer = 108.000 in
p-y subgrade modulus k for top of soil layer = 90.000 lbs/in**3
p-y subgrade modulus k for bottom of layer = 90.000 lbs/in**3

Layer 2 is sand, p-y criteria by Reese et al., 1974
Distance from top of pile to top of layer = 108.000 in
Distance from top of pile to bottom of layer = 240.000 in
p-y subgrade modulus k for top of soil layer = 225.000 lbs/in**3
p-y subgrade modulus k for bottom of layer = 225.000 lbs/in**3

(Depth of lowest layer extends 48.00 in below pile tip)

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Effective Unit Weight of Soil vs. Depth

Effective unit weight of soil with depth defined using 4 points

Point No.	Depth X in	Eff. Unit Weight lbs/in**3
1	48.00	0.06940
2	108.00	0.06940
3	108.00	0.07810
4	240.00	0.07810

Shear Strength of Soils

Shear strength parameters with depth defined using 4 points

Point No.	Depth X in	Cohesion c lbs/in**2	Angle of Friction Deg.	E50 or k_rm	RQD %
1	48.000	0.00000	32.00	------	------
2	108.000	0.00000	32.00	------	------
3	108.000	0.00000	38.00	------	------
4	240.000	0.00000	38.00	------	------

Notes:

(1) Cohesion = uniaxial compressive strength for rock materials.
(2) Values of E50 are reported for clay strata.
(3) Default values will be generated for E50 when input values are 0.
(4) RQD and k_rm are reported only for weak rock strata.

Loading Type

Static loading criteria was used for computation of p-y curves.

Distributed Lateral Loading

Distributed lateral load intensity defined using 2 points

Point No.	Depth X in	Dist. Load lbs/in
1	96.000	375.00000
2	192.000	375.00000

Number of loads specified = 1

Load Case Number 1

Pile-head boundary conditions are Shear and Moment (BC Type 1)
Shear force at pile head = 6111.000 lbs
Bending moment at pile head = 2136000.000 in-lbs
Axial load at pile head = 9174.000 lbs

Non-zero moment at pile head for this load case indicates the pile-head may rotate under the applied pile-head loading, but is not a free-head (zero moment) condition.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

Number of sections = 1

Pile Section No. 1

The sectional shape is a circular drilled shaft (bored pile).

Outside Diameter = 54.0000 in

Material Properties:

Compressive Strength of Concrete = 4.000 kip/in**2
Yield Stress of Reinforcement = 60. kip/in**2
Modulus of Elasticity of Reinforcement = 29000. kip/in**2
Number of Reinforcing Bars = 24
Area of Single Bar = 1.56000 in**2
Number of Rows of Reinforcing Bars = 13
Area of Steel = 37.440 in**2
Area of Shaft = 2290.221 in**2
Percentage of Steel Reinforcement = 1.635 percent
Cover Thickness (edge to bar center) = 4.000 in

Unfactored Axial Squash Load Capacity = 9905.86 kip

Distribution and Area of Steel Reinforcement

Row Number	Area of Reinforcement in**2	Distance to Centroidal Axis in
1	1.560	23.000
2	3.120	22.216
3	3.120	19.919
4	3.120	16.263
5	3.120	11.500
6	3.120	5.953
7	3.120	0.000
8	3.120	-5.953
9	3.120	-11.500
10	3.120	-16.263

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11	3.120	-19.919
12	3.120	-22.216
13	1.560	-23.000

Axial Thrust Force = 0.00 lbs

Bending Moment in-lbs	Bending Stiffness lb-in2	Bending Curvature rad/in	Maximum Strain in/in	Neutral Axis Position inches	Max. Concrete Stress psi	Max. Steel Stress psi
2249604.	1.799683E+12	0.00000125	0.00003385	27.08374125	119.99316	836.78562
4475864.	1.790346E+12	0.00000250	0.00006771	27.08349341	237.82854	1673.55327
6678779.	1.781008E+12	0.00000375	0.00010156	27.08324236	353.50621	2510.30261
8858349.	1.771670E+12	0.00000500	0.00013541	27.08298486	467.02620	3347.03281
8858349.	1.417336E+12	0.00000625	0.00009791	15.66523951	337.03146	6223.17534
8858349.	1.181113E+12	0.00000750	0.00011758	15.67782122	402.64946	7465.07388
8858349.	1.012383E+12	0.00000875	0.00013729	15.69047695	467.66538	8706.04147
8858349.	8.858349E+11	0.00001000	0.00015703	15.70320350	532.07645	9946.07099
8858349.	7.874088E+11	0.00001125	0.00017681	15.71600407	595.88005	11185.15367
8858349.	7.086679E+11	0.00001250	0.00019661	15.72887868	659.07343	12423.28148
8858349.	6.442436E+11	0.00001375	0.00021645	15.74183053	721.65393	13660.44508
8858349.	5.905566E+11	0.00001500	0.00023632	15.75485963	783.61874	14896.63606
8858349.	5.451292E+11	0.00001625	0.00025623	15.76796275	844.96481	16131.84755
9525712.	5.443264E+11	0.00001750	0.00027617	15.78114635	905.68957	17366.06823
10197512.	5.438673E+11	0.00001875	0.00029615	15.79441041	965.79006	18599.28934
10868118.	5.434059E+11	0.00002000	0.00031616	15.80775172	1025.26312	19831.50401
11537522.	5.429422E+11	0.00002125	0.00033620	15.82117349	1084.10587	21062.70184
12205714.	5.424762E+11	0.00002250	0.00035628	15.83467895	1142.31545	22292.87199
12872686.	5.420078E+11	0.00002375	0.00037640	15.84826809	1199.88872	23522.00535
13538427.	5.415371E+11	0.00002500	0.00039655	15.86194092	1256.82253	24750.09283
14202929.	5.410640E+11	0.00002625	0.00041674	15.87570065	1313.11388	25977.12288
14866180.	5.405884E+11	0.00002750	0.00043696	15.88954407	1368.75926	27203.08860
15528173.	5.401104E+11	0.00002875	0.00045722	15.90347761	1423.75585	28427.97554
16188894.	5.396298E+11	0.00003000	0.00047752	15.91749805	1478.10003	29651.77669

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16848336.	5.391467E+11	0.00003125	0.00049786	15.93160862	1531.78864
30874.47969					
17506486.	5.386611E+11	0.00003250	0.00051824	15.94580930	1584.81821
32096.07473					
18163336.	5.381729E+11	0.00003375	0.00053865	15.96010333	1637.18549
33316.54886					
18818870.	5.376820E+11	0.00003500	0.00055911	15.97448748	1688.88662
34535.89520					
19473084.	5.371885E+11	0.00003625	0.00057960	15.98896819	1739.91853
35754.09719					
20125964.	5.366924E+11	0.00003750	0.00060013	16.00354546	1790.27754
36971.14431					
20777498.	5.361935E+11	0.00003875	0.00062071	16.01821929	1839.95991
38187.02607					
21427673.	5.356918E+11	0.00004000	0.00064132	16.03298968	1888.96182
39401.73197					
22076479.	5.351874E+11	0.00004125	0.00066197	16.04785985	1937.27970
40615.24766					
22723906.	5.346801E+11	0.00004250	0.00068267	16.06283301	1984.90995
41827.55831					
23369940.	5.341701E+11	0.00004375	0.00070341	16.07790917	2031.84858
43038.65274					
24014565.	5.336570E+11	0.00004500	0.00072419	16.09308511	2078.09119
44248.52393					
24657776.	5.331411E+11	0.00004625	0.00074501	16.10837048	2123.63463
45457.14809					
25299552.	5.326221E+11	0.00004750	0.00076588	16.12375885	2168.47406
46664.52218					
25939889.	5.321003E+11	0.00004875	0.00078679	16.13925987	2212.60621
47870.62135					
27216170.	5.310472E+11	0.00005125	0.00082874	16.17058700	2298.72991
50278.96507					
28483097.	5.299181E+11	0.00005375	0.00087075	16.19999903	2381.71845
52685.75151					
29755063.	5.289789E+11	0.00005625	0.00091161	16.20648140	2459.27177
55125.67722					
31014045.	5.278986E+11	0.00005875	0.00095393	16.23711008	2536.41514
57523.52370					
32266852.	5.268057E+11	0.00006125	0.00099643	16.26817328	2610.57375
59916.15722					
33297810.	5.223186E+11	0.00006375	0.00103665	16.26122421	2677.60700
60000.00000					
34163337.	5.156730E+11	0.00006625	0.00107518	16.22905701	2738.93465
60000.00000					
34889358.	5.074816E+11	0.00006875	0.00111375	16.19999903	2797.62336
60000.00000					
35529711.	4.986626E+11	0.00007125	0.00114993	16.13930494	2850.08085
60000.00000					
36150766.	4.901799E+11	0.00007375	0.00118566	16.07680517	2899.54000
60000.00000					
36745933.	4.819139E+11	0.00007625	0.00122117	16.01535791	2946.36052
60000.00000					
37163613.	4.719189E+11	0.00007875	0.00125409	15.92491382	2987.60732
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37579139.	4.625125E+11	0.00008125	0.00128710	15.84120637	3027.00314
60000.00000					
37992485.	4.536416E+11	0.00008375	0.00132021	15.76364976	3064.53193
60000.00000					
38403615.	4.452593E+11	0.00008625	0.00135341	15.69172257	3100.17692
60000.00000					
38812514.	4.373241E+11	0.00008875	0.00138672	15.62497097	3133.92180
60000.00000					
39161789.	4.291703E+11	0.00009125	0.00141903	15.55100960	3164.70494

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60000.00000					
39416730.	4.204451E+11	0.00009375	0.00144967	15.46311790	3192.09203
60000.00000					
39670071.	4.121566E+11	0.00009625	0.00148039	15.38063675	3217.85360
60000.00000					
39921789.	4.042713E+11	0.00009875	0.00151119	15.30316383	3241.97628
60000.00000					
40188610.	3.969245E+11	0.00010125	0.00154541	15.26330405	3266.85941
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40434156.	3.897268E+11	0.00010375	0.00157586	15.18903691	3287.12855
60000.00000					
40678127.	3.828530E+11	0.00010625	0.00160640	15.11907631	3305.77707
60000.00000					
40920493.	3.762804E+11	0.00010875	0.00163703	15.05313259	3322.79061
60000.00000					
41161248.	3.699887E+11	0.00011125	0.00166774	14.99095148	3338.15509
60000.00000					
41400368.	3.639593E+11	0.00011375	0.00169855	14.93229479	3351.85564
60000.00000					
41574141.	3.576270E+11	0.00011625	0.00172768	14.86177093	3363.21288
60000.00000					
41709069.	3.512343E+11	0.00011875	0.00175585	14.78608435	3372.73095
60000.00000					
41842838.	3.450956E+11	0.00012125	0.00178409	14.71411854	3380.84670
60000.00000					
41975447.	3.391955E+11	0.00012375	0.00181240	14.64565784	3387.54889
60000.00000					
42106876.	3.335198E+11	0.00012625	0.00184079	14.58049947	3392.82591
60000.00000					
42237119.	3.280553E+11	0.00012875	0.00186925	14.51845998	3396.66602
60000.00000					
42366153.	3.227897E+11	0.00013125	0.00189779	14.45936555	3399.05717
60000.00000					
42493965.	3.177119E+11	0.00013375	0.00192641	14.40305847	3399.98716
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42641274.	3.129635E+11	0.00013625	0.00196080	14.39121383	3392.17321
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42762672.	3.081994E+11	0.00013875	0.00198897	14.33493251	3395.47589
60000.00000					
42883242.	3.035982E+11	0.00014125	0.00201722	14.28121966	3398.17405
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43002964.	2.991511E+11	0.00014375	0.00204555	14.22994655	3399.67172
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43121566.	2.948483E+11	0.00014625	0.00207399	14.18112284	3398.23431
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43238671.	2.906801E+11	0.00014875	0.00210255	14.13479358	3391.57931
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43470776.	2.827368E+11	0.00015375	0.00215989	14.04809600	3396.96022
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43699986.	2.752755E+11	0.00015875	0.00221754	13.96875626	3399.91204
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43810981.	2.675480E+11	0.00016375	0.00227021	13.86390549	3391.56901
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43919872.	2.602659E+11	0.00016875	0.00232311	13.76656061	3394.03460
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44027427.	2.533953E+11	0.00017375	0.00237620	13.67597169	3398.36696
60000.00000					
44133611.	2.469013E+11	0.00017875	0.00242950	13.59159154	3399.98863
60000.00000					
44237031.	2.407457E+11	0.00018375	0.00248315	13.51372594	3390.89321
60000.00000					
44366728.	2.350555E+11	0.00018875	0.00254697	13.49390227	3392.58351
60000.00000					

44463609.	2.294896E+11	0.00019375	0.00259953	13.41692179	3397.05556
60000.00000					
44559628.	2.241994E+11	0.00019875	0.00265225	13.34464055	3399.50523
60000.00000					
44654318.	2.191623E+11	0.00020375	0.00270519	13.27702636	3397.32142
60000.00000					
44747351.	2.143586E+11	0.00020875	0.00275842	13.21398264	3388.60847
60000.00000					
44839816.	2.097769E+11	0.00021375	0.00281177	13.15447623	3386.87860
60000.00000					
44931696.	2.054020E+11	0.00021875	0.00286525	13.09827214	3392.56617
60000.00000					
45022966.	2.012200E+11	0.00022375	0.00291885	13.04515475	3396.66336
60000.00000					
45113639.	1.972181E+11	0.00022875	0.00297259	12.99493736	3399.14872
60000.00000					
45196379.	1.933535E+11	0.00023375	0.00302750	12.95188469	3399.84907
60000.00000					
45273442.	1.896270E+11	0.00023875	0.00308330	12.91434878	3391.64530
60000.00000					
45350023.	1.860514E+11	0.00024375	0.00313921	12.87882775	3383.41095
60000.00000					
45426116.	1.826176E+11	0.00024875	0.00319525	12.84520894	3383.61400
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45481901.	1.792390E+11	0.00025375	0.00324927	12.80499190	3389.27105
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45509461.	1.758820E+11	0.00025875	0.00330038	12.75508994	3393.27252
60000.00000					
45525092.	1.726070E+11	0.00026375	0.00335404	12.71674293	3396.64198
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45536776.	1.694392E+11	0.00026875	0.00340858	12.68307906	3398.91018
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45548065.	1.663856E+11	0.00027375	0.00346325	12.65112430	3399.93691
60000.00000					
45558271.	1.634377E+11	0.00027875	0.00351822	12.62142581	3395.33220
60000.00000					
45558271.	1.605578E+11	0.00028375	0.00357525	12.59999925	3387.99257
60000.00000					
45558271.	1.577776E+11	0.00028875	0.00363825	12.59999925	3379.07479
60000.00000					
45558271.	1.550920E+11	0.00029375	0.00370125	12.59999925	3377.70096
60000.00000					
45596278.	1.526235E+11	0.00029875	0.00376425	12.59999925	3385.48345
60000.00000					
45621505.	1.501943E+11	0.00030375	0.00382060	12.57811564	3390.35764
60000.00000					

Unfactored (Nominal) Moment Capacity at Concrete Strain of 0.003 = 45154.93735 in-kip

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Computed Values of Load Distribution and Deflection
for Lateral Loading for Load Case Number 1

Pile-head boundary conditions are Shear and Moment (Pile-head Condition Type 1)
Specified shear force at pile head = 6111.000 lbs
Specified moment at pile head = 2136000.000 in-lbs
Specified axial load at pile head = 9174.000 lbs

Output Verification:

Computed forces and moments are within specified convergence limits.

Summary of Pile Response(s)

Definition of Symbols for Pile-Head Loading Conditions:

Type 1 = Shear and Moment, y = pile-head displacment in
Type 2 = Shear and Slope, M = Pile-head Moment lbs-in
Type 3 = Shear and Rot. Stiffness, V = Pile-head Shear Force lbs
Type 4 = Deflection and Moment, S = Pile-head Slope, radians
Type 5 = Deflection and Slope, R = Rot. Stiffness of Pile-head in-lbs/rad

Load Type	Pile-Head Condition 1	Pile-Head Condition 2	Axial Load lbs	Pile-Head Deflection in	Maximum Moment in-lbs	Maximum Shear lbs
1	V= 6111.000	M= 2.14E+06	9174.0000	0.3353876	2539471.	-37744.9057

Pile-head Deflection vs. Pile Length

Boundary Condition Type 1, Shear and Moment

Shear = 6111. lbs
Moment = 2136000. in-lbs
Axial Load = 9174. lbs

Pile Length in	Pile Head Deflection in	Maximum Moment in-lbs	Maximum Shear lbs
192.000	0.33538757	2539471.	-37744.90573
182.400	0.42283594	2536137.	-40505.98630
172.800	0.56838979	2533399.	-44301.56897
163.200	0.88699110	2529584.	-49908.32408
153.600	1.83973457	2525911.	-57525.71569
144.000	4.19765925	2527750.	-65811.46821

The analysis ended normally.

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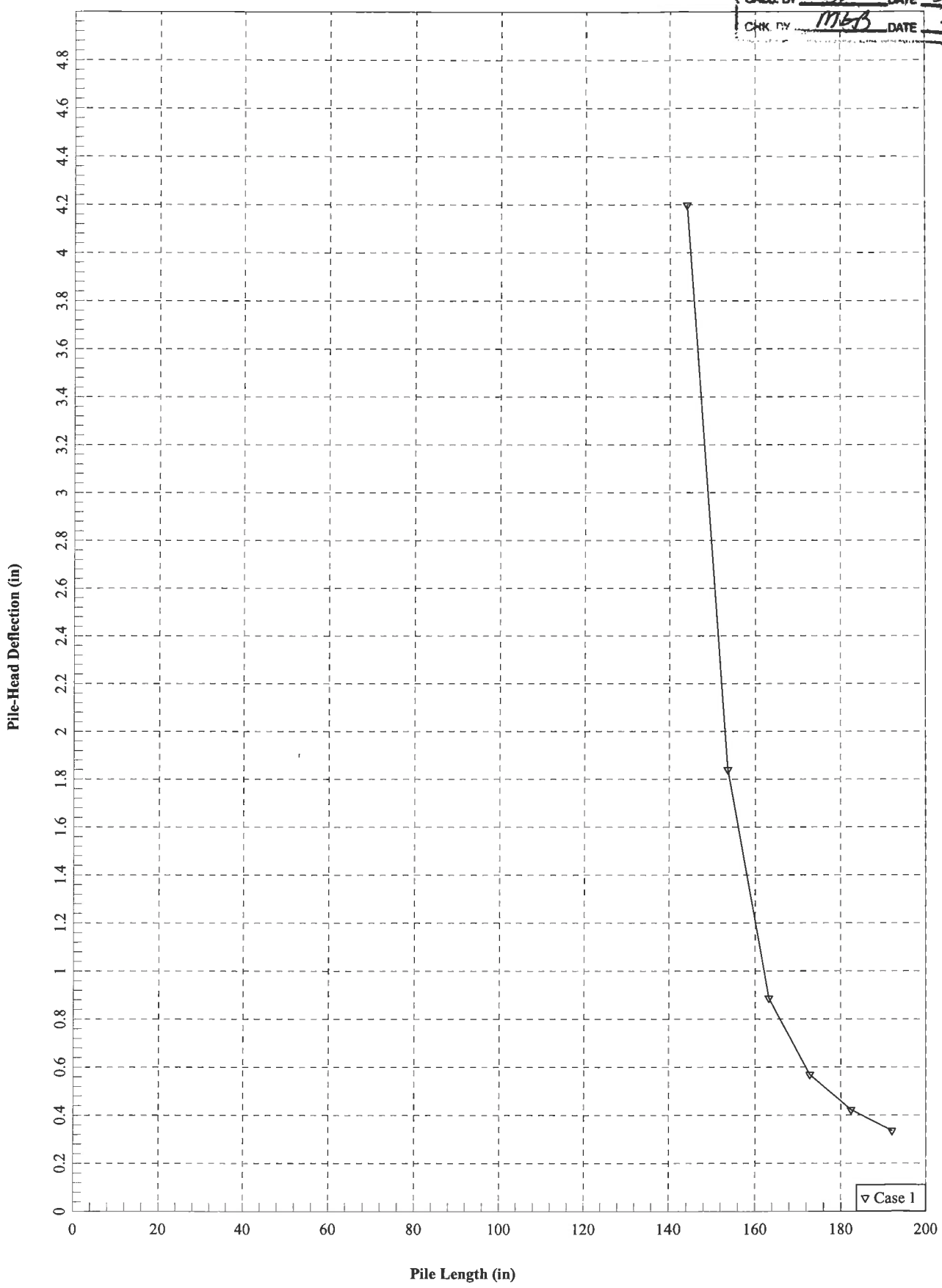

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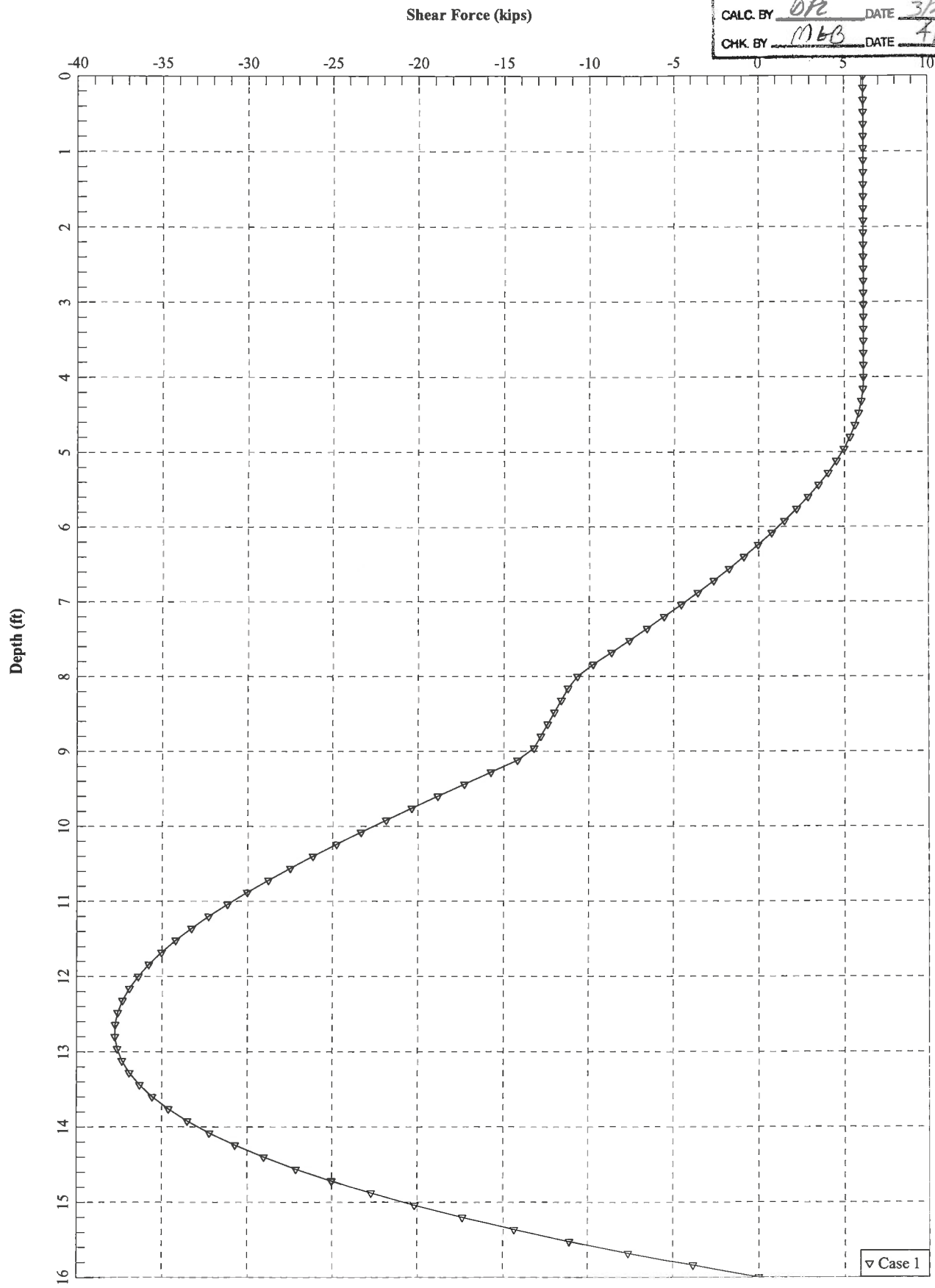
CHK. BY MBB DATE 4/11/11



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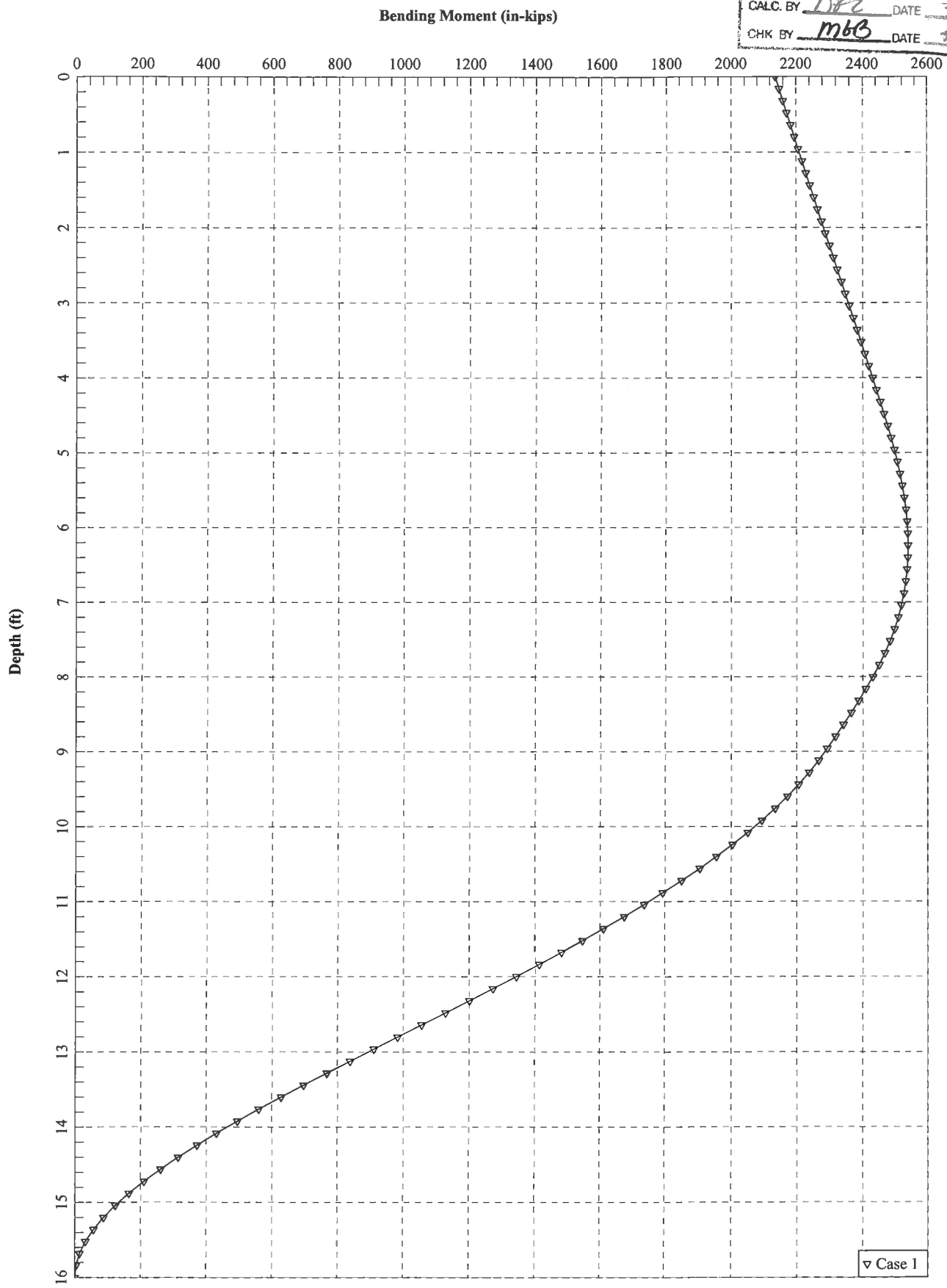

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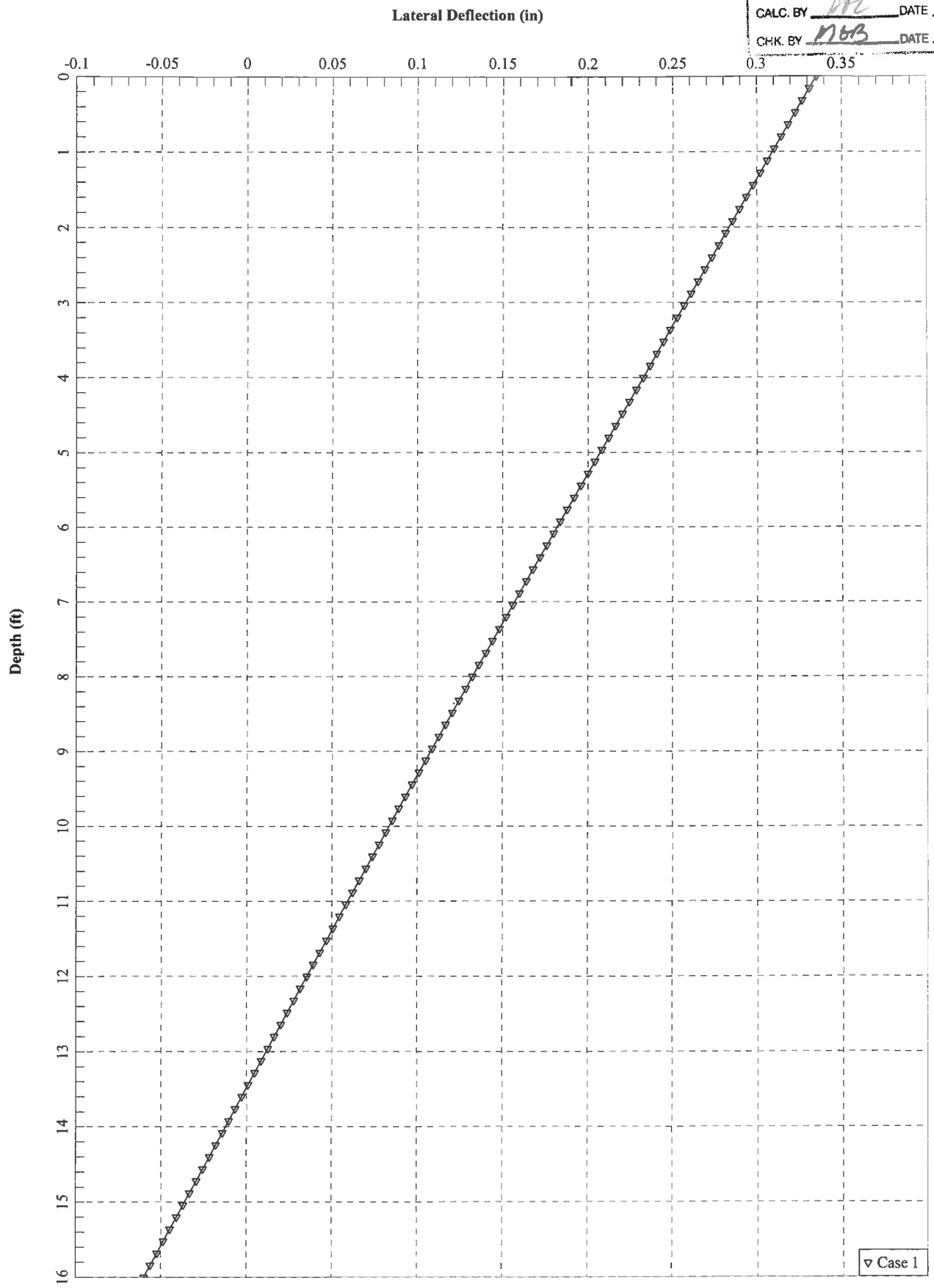
CALC. BY DPC DATE 3/22/11

CHK. BY MBB DATE 4/11/11



APPENDIX 4

LIMITATIONS

LIMITATIONS

Explorations

1. The analysis and recommendations submitted in this report are based in part upon the data obtained from widely spaced subsurface explorations. The nature and extent of variations between these explorations may not become evident until construction. If variations then appear evident, it will be necessary to reevaluate the recommendations of this report.

2. The generalized soil profile described in the text is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized and have been developed by interpretations of widely spaced explorations and samples; actual soil transitions are probably more erratic. For specific information, refer to the boring logs.

3. Water level readings have been made in the drill holes at times and under conditions stated on the logs. These data have been reviewed and interpretations made in the text of this report. However, it must be noted that fluctuations in the level of the groundwater may occur due to variations in rainfall, temperature and other factors occurring since the time measurements were made.

Review

4. In the event that any changes in the nature, design or location of the proposed sign structure is planned, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and conclusions of this report modified or verified in writing by GeoDesign, Inc. It is recommended that this firm be provided the opportunity for a general review of final design and specifications in order that earthwork and foundation recommendations may be properly interpreted and implemented in the design and specifications.

Uses of Report

5. This report has been prepared for the exclusive use of H.W. Lochner, Inc. for specific application to the proposed overheard sign structure along the New Britain-Hartford Busway in Hartford, Connecticut, in accordance with generally accepted soil and foundation engineering practices. No other warranty, express or implied, is made.