

**FRA-70-13.10 PHASE 6A  
FRA-70-1322L AND FRA-70-1323C  
I-70 WB AND RAMP D3  
OVER THE SCIOTO RIVER  
PID NO. 89464  
FRANKLIN COUNTY, OHIO**

**STRUCTURE FOUNDATION  
EXPLORATION REPORT  
(REV.1)**

***Prepared For:***  
**ms consultants, inc.**  
**2221 Schrock Road**  
**Columbus, OH 43229-1547**

***Prepared By:***  
**Resource International, Inc.**  
**6350 Presidential Gateway**  
**Columbus, Ohio 43231**

**Rii Project No. W-13-072**

**March 2021**



**RESOURCE INTERNATIONAL, INC.**

6350 Presidential Gateway  
Columbus, Ohio 43231  
T: 614.823.4949

May 6, 2015 (Revised March 30, 2021)

Mr. Thomas P. Mosure, P.E.  
ms consultants, inc.  
2221 Schrock Road  
Columbus, OH 43229-1547

**Re: Structure Foundation Exploration Report (Rev. 1)**  
**FRA-70-13.10 Phase 6A**  
**FRA-70-1322L – I-70 WB over the Scioto River**  
**FRA-70-1323C – Ramp D3 over the Scioto River**  
**PID No. 89464**  
**Rii Project No. W-13-072**

Mr. Mosure:

Resource International, Inc. (Rii) is pleased to submit this revised structure foundation exploration report for the above referenced project. Engineering logs have been prepared and are attached to this report along with the results of laboratory testing. This report includes recommendations for the design and construction of the proposed FRA-70-1322L and FRA-70-1323C bridge structures carrying I-70 westbound and Ramp D3, respectively, over the Scioto River as part of the FRA-70-13.10 Phase 6A (PID 89464) project in Columbus, Ohio.

We sincerely appreciate the opportunity to be of service to you on this project. If you have any questions regarding the structure foundation exploration or this report, please contact us.

Sincerely,

**RESOURCE INTERNATIONAL, INC.**

Brian R. Trenner, P.E.  
Director – Geotechnical Services

Jonathan P. Sterenberg, P.E.  
Vice President – Geotechnical Services

Enclosure: Structure Foundation Exploration Report (Rev. 1)

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## EXECUTIVE SUMMARY

Resource International, Inc. (Rii) has completed a structure foundation exploration for the design and construction of the proposed FRA-70-1322L and FRA-70-1323C bridge structures carrying I-70 westbound and Ramp D3, respectively, over the Scioto River, as shown on the vicinity map and boring plan presented in Appendix I. The existing structure is a nine-span bridge with a total length of approximately 890 feet. It is understood that the existing I-70 westbound structure will be completely removed and replaced with two (2) separate structures. Based on information provided by ms consultants, it is understood that the proposed FRA-70-1322L and FRA-70-1323C structures will be five-span continuous composite steel girder with reinforced concrete deck structures with capped pile abutments and multi-column piers and will have a total length of approximately 1,018 and 1,020 feet and width of approximately 43 and 53 feet, respectively. The proposed roadway profile grade will be elevated approximately 5 to 15 feet above the existing profile grade along the alignment of the bridge structures.

## Exploration and Findings

Between January 14 and May 28, 2014, eight (8) borings, designated as B-016-7-13 and B-113-4-13 through B-114-1-13, were drilled along the proposed bridge alignments at the locations shown on the boring plan provided in Appendix I of the full report. The borings were advanced to completion depths ranging from 48.7 to 88.3 feet below the existing ground surface at the respective boring location. In addition to the borings performed as part of the current exploration, five (5) historic borings, designated as B-001-S-57, B-005-S-57, B-009-S-57, B-013-S-57 and B-020-S-57, were obtained along the entire length of the existing bridge alignments carrying I-70 eastbound and westbound over the Scioto River. The borings were extended to depths ranging from 36.0 to 63.0 feet below the existing grade at the time of the exploration. On December 7, 2020, one (1) additional boring, designated as B-019-5-19, was obtained within the abandoned Mound Street just outside the limits of the approach slab of the abandoned bridge structure over I-70, and was extended to a depth of 60.0 feet below the existing ground surface.

Borings B-113-4-13 and B-113-5-13 were drilled in the grass area along the south side of McDowell Street, just west of the existing pump station, and encountered 6.0 inches of topsoil at the ground surface. Borings B-016-7-13, B-113-9-13 and B-114-1-13 were drilled adjacent to the existing bike path the runs along the east bank of the Scioto River, and encountered 3.0 to 5.0 inches of topsoil at the ground surface. Boring B-019-5-19 was drilled within the existing embankment supporting the abandoned Mound Street and encountered 3.0 inches of asphalt overlying 11.0 inches of concrete at the ground surface.

Beneath the surface materials in borings B-016-7-13, B-113-4-13, B-113-5-13, B-113-9-13 and B-114-1-13, material identified as existing fill or possible fill was encountered extending to depths ranging from 5.5 to 20.5 feet below the ground



surface. The fill material consisted of brown, dark brown, gray and black gravel and sand, gravel with sand and silt, gravel with sand, silt and clay, silt and clay and silty clay (ODOT A-1-b, A-2-4, A-2-6, A-6a, A-6b) and contained brick, concrete and slag fragments as well as root fibers throughout.

Beneath the pavement in boring B-019-5-13, existing embankment fill consisting of gray, dark gray and brown gravel with sand, silt and clay, silty clay and clay (ODOT A-1-b, A-6a, A-6b, A-7-6) was encountered extending to a depth of 37.0 feet, overlying existing fill material comprised of black, red and brown gravel with sand, silt and clay (ODOT A-2-6) extending to a depth of 47.0 feet.

Underlying the surficial materials and existing fill, where encountered, and from the existing ground surface in borings B-113-6-13 through B-113-8-13, natural granular soils were encountered with intermittent seams of cohesive material. The granular soils were generally described as brown, gray, grayish brown, brownish gray, dark brown and black gravel, gravel and sand, gravel with sand and silt, gravel with sand silt and clay, coarse and fine sand and sandy silt (ODOT A-1-a, A-1-b, A-2-4, A-2-6, A-3a, A-4a). The cohesive soils were generally described as gray, brown dark brown, dark gray and light brown sandy silt, silt and clay, silty clay and clay (ODOT A-4a, A-6a, A-6b, A-7-6).

A boulder zone was encountered in boring B-113-5-13 between elevations 668.7 and 674.7 feet msl and in boring B-113-8-13 between elevations 646.8 and 663.6 feet msl. Cobbles and boulders were generally encountered above the bedrock in borings B-113-4-13 through B-113-8-13 starting at elevations of approximately 700 feet msl in borings B-113-4-13 and B-113-5-13 and approximately 675 feet msl in borings B-113-6-13 through B-113-8-13.

Top of bedrock in the borings was encountered at elevations ranging from 644.0 to 660.8 feet msl. The upper portion of the bedrock encountered in the majority of the borings consists of gray shale and mudstone overlying competent limestone and dolomite bedrock. With the exception of boring B-113-8-13, shale/mudstone bedrock was encountered in the remaining borings at elevations ranging from 650.8 to 660.8 feet msl. With the exception of borings B-001-S-57, B-013-S-57 and B-020-S-57, limestone/dolomite bedrock was encountered in the remaining borings at elevations ranging from 634.8 to 650.8 feet msl.

## **Analyses and Recommendations**

Design details of the proposed structure were provided by ms consultants. Based on the information provided, it is understood that the proposed FRA-70-1322L and FRA-70-1323C structures will be five-span continuous composite steel girder with reinforced concrete deck structures with capped pile abutments and multi-column piers. The proposed roadway profile grade will be elevated approximately 5 to 15 feet above the existing profile grade along the alignment of the bridge structures.

### Drilled Shaft Recommendations

It is understood that drilled shafts will be utilized at the pier substructure units. Given the proposed loading per shaft at each of the pier locations, friction bearing drilled shafts within the overburden soils and drilled shafts bearing within the weak surficial shale bedrock are not economically feasible foundation options due to the size and number of shafts that would be required to support the proposed loading. Therefore, it is recommended that the drilled shafts be extended through the surficial soils and weak surficial shale bedrock to bear on or within the underlying limestone/dolomite bedrock at the pier locations.

The following table lists the estimated elevation of the top of bedrock as well as the proposed rock sock diameter and length from the design plans and corresponding nominal end bearing resistance to be utilized for the design of the drilled shaft foundations. A resistance factor of  $\phi_{qp} = 0.5$  at the strength limit state should be utilized for design.

**Drilled Shaft Recommendations**

Structure Reference	Substructure Unit (Boring)	Top of Bedrock Elevation (feet msl)	Top of Limestone Elevation (feet msl)	Rock Socket Diameter <sup>1</sup> (feet)	Required Socket Length to Top of Limestone / Dolomite (feet)	Proposed Socket Length <sup>1</sup> (feet)	Nominal End Bearing Resistance <sup>2</sup> (ksf)
FRA-70-1322L	Pier 1 (B-005-S-57)	652.1	651.5	5.0	0.6	5.0	765
	Pier 2 (B-009-S-57)	650.8	648.1	5.0	2.7	5.0	765
	Pier 3 (B-013-S-57 / B-113-8-13)	660.8	644.0	5.0	16.8	16.8	1,831
	Pier 4 (B-020-S-57 / B-113-9-13)	656.5	645.6	5.0	10.9	10.9	1,831
FRA-70-1323C	Pier 1 (B-113-6-13)	652.2	647.6	5.0	4.6	7.0	765
	Pier 2 (B-113-7-13)	659.4	648.8	5.0	10.6	10.6	1,831
	Pier 3 (B-013-S-57 / B-113-8-13)	663.6	644.0	5.0	16.8	19.6	1,831
	Pier 4 (B-113-9-13)	656.3	645.6	5.0	10.7	10.7	1,831

1. Proposed rock socket diameter and length at each substructure unit determined from proposed plan information provided by ms consultants.
2. Nominal end bearing resistance provided is the value that should be utilized in the determination of the end bearing resistance per drilled shaft based on the proposed rock socket length and diameter.

Given the factored end bearing resistances noted above for drilled shafts extended to bear on or within the limestone bedrock, it is anticipated that the axial resistance will be governed by structural resistance of the drilled shaft. Based on the cross section provided for the drilled shaft within the rock socket, which consists of a 5.0-foot diameter shaft with 28 No. 10 longitudinal reinforcement bars, the factored structural resistance is 7,412 kips, as determined in accordance with Section 5.6.4.4 of the 2020 AASHTO LRFD BDS. The factored resistance per shaft provided in the design sheets should be the limiting value between the factored geotechnical resistance and the factored axial compressive resistance of the shaft.

### Driven Pile Recommendations

It is understood that driven piles will be utilized at the rear and forward abutment substructure units. Given the depth of bedrock encountered in the borings performed and the required structural loading, it is recommended that steel H-piles (ODOT Item 507.06) driven to refusal on bedrock be employed for foundation support. Per Section 305.3.1.2 of the 2020 ODOT Bridge Design Manual, refusal is met during driving when the pile penetration is an inch or less after receiving at least 20 blows from the pile hammer. The following table shows recommended pile lengths and the corresponding factored structural axial resistance ( $R_{R \max}$ ) of steel H-piles.

**Driven Pile Recommendations**

Substructure Reference	Pile Size	Pile Elevation		Pile Length <sup>2</sup> (feet)	$R_{R \max}$ <sup>3</sup> (kips/pile)	$\phi$ <sup>4</sup>
		Top <sup>1</sup>	Tip			
Rear Abutment	HP 10x42 <sup>5</sup>	715.5	652.7	65	310	N/A
	HP 12x53 <sup>5</sup>	715.5	652.7	65	380	N/A
	HP 14x73 <sup>5</sup>	715.5	652.7	65	530	N/A
Forward Abutment	HP 10x42 <sup>5</sup>	710.0 / 720.0	662.1	50 / 60	310	N/A
	HP 12x53 <sup>5</sup>	710.0 / 720.0	662.1	50 / 60	380	N/A
	HP 14x73 <sup>5</sup>	710.0 / 720.0	662.1	50 / 60	530	N/A

1. The top of pile elevation corresponds to the pile cutoff elevation, which is considered to be 1.0-foot above the proposed bottom of footing elevation per Section 305.3.5.1 of the 2020 ODOT BDM. Multiple values indicate minimum and maximum pile cutoff elevation along the abutment substructure.
2. Per Section 305.3.5.2 of the 2020 ODOT BDM, the estimated pile length was determined as the pile cutoff elevation (top) minus the pile tip elevation, rounded up to the nearest 5.0 feet.
3. The factored structural axial resistance for H-piles is based on the structural limit state of the steel H-pile section per Section 305.3.3 of the 2020 ODOT BDM.
4. For H-piles driven to refusal on bedrock, no geotechnical resistance factor should be applied to the factored structural axial resistance values presented, as the values presented account for the structural resistance factor,  $\phi_c = 0.50$ , for H-piles subject to damage due to severe driving conditions.
5. A steel pile point is recommended to protect the tips of the H-piles during pile installation.



As noted in Section 4.2 of the full report, a boulder zone was encountered in boring B-113-5-13 between elevations 668.7 and 674.7 feet msl. Additionally, cobbles and boulders were encountered above the bedrock in borings B-113-4-13 and B-113-5-13 starting at an elevation of approximately 700 feet msl. Given the significant presence of cobbles and boulders at the rear abutment, the pile driving operations should be closely monitored to verify that the piles extend to the limestone bedrock. **If a pile cannot be extended through the cobbles and boulders to the estimated elevation of the limestone bedrock, then the pile should be considered a friction bearing pile that is driven to the maximum ultimate bearing value per Section 305.3.4 of the 2020 ODOT BDM.** In this instance, the resistance factor of 0.7 should be applied to the maximum ultimate bearing value provided for the respective pile size utilized.

Consideration was given to the use of friction piles using cast-in-place (CIP) pipe piles; however, given the presence of dense granular soils immediately below the bottom of footing elevation, it is anticipated that refusal will be encountered prior to achieving a sufficient embedment depth for lateral resistance.

Based on plan and profile information provided by ms consultants, approximately 5.5 and 10.0 feet of fill will be required to achieve the final grade elevation at the rear and forward abutment, respectively. The anticipated total settlement due to the embankment loading at the rear and forward abutment is 0.78 and 1.18 inches, respectively. The settlement of the soils beneath the proposed abutment footings is anticipated to be 0.11 and 0.40 inches, respectively, at the rear and forward abutment. Given that the anticipated settlement below the proposed footings will not exceed 0.40 inches, downdrag loads are not anticipated to develop along the piles.

Based on the results of this analysis, driving stresses induced on the H-piles at the forward abutment of both structures **would not exceed** 90 percent of the yield stress of the steel ( $f_y = 50$  ksi,  $0.9f_y = 45$  ksi) if driven through the overburden soils to the top of bedrock using a Delmag 19-42 hammer with a rated energy of approximately 43,000 ft-lbs. Based on the results of the analysis, driving stresses induced on the H-piles at the rear abutment of both structures **would not exceed** 90 percent of the yield stress of the steel ( $f_y = 50$  ksi,  $0.9f_y = 45$  ksi) if driven through the overburden soils to the top of bedrock using a Delmag 30-23 hammer with a rated energy of approximately 73,788 ft-lbs. However, for the piles at the rear abutment of the FRA-70-1322L structure, while the analysis indicates the driving stresses would not exceed 90 percent of the yield stress of the steel, it is anticipated that refusal will occur as the piles approach the bedrock elevation.

### CIP Wall Recommendations

Existing embankment fill consisting of very stiff to hard silt and clay and clay (ODOT A-6a, A-7-6) is anticipated at the bearing elevation along the wall alignment, overlying existing fill consisting of medium stiff to stiff silty clay (ODOT A-6b). CIP wall foundations bearing on these soils fill may be proportioned for a factored bearing resistance as indicated in the following table. A geotechnical resistance factor of  $\phi_b=0.55$  was considered in calculating the factored bearing resistance at the strength limit state.

**Forward Abutment Wingwall CIP Wall Design Parameters**

From Station <sup>1</sup>	To Station <sup>1</sup>	Panel ID	Wall Height Analyzed (feet)	Foundation Width (feet)	Bearing Resistance at Strength Limit (ksf)		Strength Limit Equivalent Bearing Pressure <sup>3</sup> (ksf)
					Nominal	Factored <sup>2</sup>	
3053+26.70	3053+57.53	3	24.3	18.5	7.36	4.05	4.03
3053+57.53	3053+88.35	4	19.2	14.0	7.23	3.98	3.62
3053+88.35	3054+19.31	5	14.2	11.0	6.57	3.61	2.57
3054+19.31	3054+50.00	6	9.3	8.8	5.92	3.26	1.63

1. Limits of wall determined from plan information provided by ms consultants. Stationing listed is referenced to Ramp D3.
2. A geotechnical resistance factor of  $\phi_b=0.55$  was considered in calculating the factored bearing resistance at the strength limit state.
3. The strength limit equivalent bearing pressure is the uniformly distributed pressure asserted by the wall over an effective base width based on the eccentricity of the wall system at the strength limit state.

Given that the existing Mound Street embankment will be excavate and removed to construct the wingwall, resulting in a profile grade along Ramp D3 at the top of the wall that is approximately 10.0 feet below the existing grade of the embankment, little to no settlement is anticipated under the loading from the proposed wall along the alignment.

Based on the results of the external and global stability analysis performed for the forward abutment wingwall, the wall sections provided in the design sheets meet all of the external and global stability requirements.

Please note that this executive summary does not contain all the information presented in the report. The unabridged subsurface exploration report should be read in its entirety to obtain a more complete understanding of the information presented.

## 1.0 INTRODUCTION

The overall purpose of this project is to provide detailed subsurface information and recommendations for the design and construction of the FRA-70/71-13.10/14.36 (Projects 6A/6R) project in Columbus, Ohio. The projects represent the central portion of the FRA-70-8.93 (PID 77369) I-70/71 south innerbelt improvements project, which includes all improvements along I-70 westbound from the I-71/SR-315 interchange to Front Street and along I-71 southbound from I-70 to Greenlawn Avenue. The FRA-70-13.10 (Project 6A) phase will consist of all work associated with the construction of I-70 westbound from SR 315 to Front Street, including Ramps D3 and D7. This project includes the design and construction of one (1) new bridge structure for Ramp D3 over the Scioto River (FRA-70-1323C) and the reconstruction of three (3) bridges, including I-70 westbound over the Scioto River (FRA-70-1322L), I-70 westbound over CSX and Norfolk Southern (NS) Railroad (FRA-70-1358L) and I-70 westbound over Short Street (FRA-70-1373L), as well as the construction of five (5) new retaining walls (Walls E2, E3, E4, E7 and E9) to accommodate the new configuration.

This report is a presentation of the structure foundation exploration performed for the design and construction of the proposed FRA-70-1322L and FRA-70-1323C bridge structures carrying I-70 westbound and Ramp D3, respectively, over the Scioto River, as shown on the vicinity map and boring plan presented in Appendix I. The proposed I-70 westbound will be a two-lane roadway that carries traffic westbound out of downtown Columbus, and the proposed Ramp D3 will be a three-lane ramp that carries traffic from the proposed Mound Street Ramp D7 to I-70 westbound, and will also serve to carry traffic from I-70 westbound to Sullivant Avenue and Rich Street.

The existing I-70 westbound structure is a nine-span bridge with a total length of approximately 890 feet. It is understood that the existing structure consists of a reinforced concrete deck on continuous steel girder beams, and will be completely removed and replaced with two (2) separate structures. Based on information provided by ms consultants, it is understood that both the proposed FRA-70-1322L and FRA-70-1323C structures will be five-span continuous composite steel girder with reinforced concrete deck structures with capped pile abutments and multi-column piers and will have a total length of approximately 1,018 and 1,020 feet and width of approximately 43 and 53 feet, respectively. The proposed roadway profile grade will be elevated approximately 5 to 15 feet above the existing profile grade along the alignment of the bridge structures.

## 2.0 GEOLOGY AND OBSERVATIONS OF THE PROJECT

### 2.1 Site Geology

Both the Illinoian and Wisconsinan glaciers advanced over two-thirds of the State of Ohio, leaving behind glacial features such as moraines, kame deposits, lacustrine



deposits and outwash terraces. The glacial and non-glacial regions comprise five physiographic sections based on geological age, depositional process and geomorphic occurrence (physical features or landforms). The project area lies within the Columbus Lowland District of the Till Plains Section. This area is characterized by flat to gently rolling ground moraine deposits from the Late Wisconsinan age. The site topography exhibits moderate to high relief. The ground moraine deposits are composed primarily of silty loam till (Darby, Bellefontaine, Centerburg, Grand Lake, Arcanum, Knightstown Tills), with smaller alluvium and outwash deposits bordering the Scioto River, its tributaries and floodplain areas. A ground moraine is the sheet of debris left after the steady retreat of glacial ice. The debris left behind ranges in composition from clay size particles to boulders (including silt, sand, and gravel). Outwash deposits consist of undifferentiated sand and gravel deposited by meltwater in front of glacial ice, and often occurs as valley terraces or low plains. Alluvium and alluvial terrace deposits range in composition from silty clay size particles to cobbles, usually deposited in present and former floodplain areas.

According to the bedrock geology and topography maps obtained from the Ohio Department of Natural Resources (ODNR), the underlying bedrock west of the Scioto River consists predominantly of the Middle to Lower Devonian-aged Columbus Limestone. This formation is further subdivided into two members in the central portion of the state, known as the Delhi and Bellepoint Members. The Delhi Member consists of light gray, finely to coarsely crystalline, irregularly bedded, fossiliferous limestone. The Bellepoint Member consists of variable brown, finely crystalline, massively bedded limy dolomite. Both of these members contain chert nodules. East of the Scioto River, the underlying bedrock consists of the Upper Devonian Ohio Shale Formation overlying the Middle Devonian-aged Delaware Limestone Formation. The Ohio Shale formation consists of brownish black to greenish gray, thinly bedded, fissile, carbonaceous shale. The Delaware Limestone consists of bluish gray, thin to medium bedded dolomitic limestone with nodules and layers of chert. Regionally, the bedrock surface forms a broad valley aligned roughly north-to-south beneath the Scioto River. According to bedrock topography mapping, the elevation of the bedrock surface ranges from approximately 600 feet mean sea level (msl) in the valley to approximately 625 feet msl near the project limits. Bedrock consisting of shale over limestone was encountered during this current investigation at elevations ranging from 644.0 to 660.9 feet msl.

## 2.2 Existing Conditions

The existing bridge structure carries four lanes of I-70 westbound over the Scioto River, and splits at the west end of the structure, where two lanes diverge at the south side of the structure that carry traffic to I-71 southbound and SR-315 northbound, two lanes continue west carrying the I-70 westbound traffic and one lane diverges at the north side of the bridge that carries traffic to SR-315 northbound and Rich Street. The Scioto River in the vicinity of the structure is approximately 450 feet wide with tree-lined banks and is aligned north-to-south underneath the bridge and bends to the northeast just north of the bridge crossing. The terrain at the east and west end of the existing

structure is elevated approximately 25 to 35 feet above the river channel and the surrounding area on either side of the river channel is relatively flat-lying.

### 3.0 EXPLORATION

Between January 14 and May 28, 2014, eight (8) borings, designated as B-016-7-13 and B-113-4-13 through B-114-1-13, were obtained along the portion of the proposed FRA-71-1503L structure that is adjacent to the proposed alignment of the FRA-70-1322L and FRA-70-1323C structures at the locations shown on the boring plan provided in Appendix I of this report and summarized in Table 1. Borings B-113-4-13 and B-113-5-13 were performed at the western bank of the Scioto River and were extended to a depth of 88.3 and 85.7 feet below existing grade, respectively; borings B-113-6-13 through B-113-8-13 were performed from a barge within the Scioto River and extended to depths ranging from 55.7 to 66.2 feet below the riverbed elevation; and borings B-016-7-13, B-113-9-13 and B-114-1-13 were performed at the eastern bank of the Scioto River, adjacent to the Lower Scioto Greenway bike trail, and were extended to depths of 48.7, 73.0 and 81.0 feet below existing grade, respectively. Based on the length and configuration of the forward abutment left wingwall, on December 7, 2020, one (1) additional boring, designated as B-019-5-19, was obtained within the abandoned Mound Street just outside the limits of the approach slab of the abandoned bridge structure over I-70, and was extended to a depth of 60.0 feet below the existing ground surface.

**Table 1. Test Boring Summary**

Boring Number	Reference Alignment	Station <sup>1</sup>	Offset <sup>1</sup>	Latitude	Longitude	Ground Elevation (feet msl)	Boring Depth (feet)
B-016-7-13	BL Ramp D3	3052+85.29	31.4' Lt.	39.953120632	-83.010292838	714.9	48.7
B-019-5-19	BL Ramp D3	3053+93.67	12.3' Lt.	39.953167673	-83.009902628	751.0	60.0
B-113-4-13	BL I-71 SB	249+37.84	28.1' Rt.	39.952169637	-83.013979325	725.2	88.3
B-113-5-13	BL I-71 SB	250+13.44	36.0' Rt.	39.952235986	-83.013728661	725.7	85.7
B-113-6-13	BL I-71 SB	251+93.56	37.3' Rt.	39.952409438	-83.013136525	691.5	63.7
B-113-7-13	BL I-71 SB	254+41.19	36.0' Rt.	39.952639679	-83.012306009	690.3	55.7
B-113-8-13	BL I-71 SB	256+62.64	36.0' Rt.	39.952842559	-83.011561408	691.0	66.2
B-113-9-13	BL I-71 SB	258+77.50	36.0' Rt.	39.953039408	-83.010838937	706.3	73.0
B-114-1-13	BL I-71 SB	260+75.33	40.2' Rt.	39.953209751	-83.010168725	716.6	81.0



The boring locations were determined and located in the field by Rii representatives. Rii utilized a handheld GPS unit to obtain northing and easting coordinates of the boring locations. Ground surface elevations at the boring locations were interpolated using topographic mapping information provided by ms consultants.

The borings were drilled using a truck or all-terrain vehicle (ATV) mounted rotary drilling machine, utilizing either a 3.25-inch or 4.25-inch inside diameter, hollow-stem auger to advance the holes. In general, standard penetration test (SPT) and split spoon sampling were performed at 2.5-foot increments of depth to approximately 20.0 to 30.0 feet and at 5.0-foot increments thereafter to the top of bedrock. For foundation elements subject to scour, continuous sampling and SPT testing were conducted in borings B-113-6-13 through B-113-8-13 for a 6.0-foot interval below the riverbed elevation. The SPT, per the American Society for Testing and Materials (ASTM) designation D1586, is conducted using a 140-pound hammer falling 30.0 inches to drive a 2.0-inch outside diameter split spoon sampler 18.0 inches. Rii utilized a calibrated automatic drop hammer to generate consistent energy transfer to the sampler. Driving resistance is recorded on the boring logs in terms of blow per 6.0-inch interval of the driving distance. The second and third intervals are added to obtain the number of blows per foot (N). Standard penetration blow counts aid in determining soil properties applicable in foundation system design. Measured blow count (N) values are corrected to an equivalent (60%) energy ratio,  $N_{60}$ , by the following equation. Both values are represented on boring logs in Appendix III.

$$N_{60} = N_m \cdot (ER/60)$$

Where:

$N_m$  = measured N value

ER = drill rod energy ratio, expressed as a percent, for the system used

The hammer for the Mobile B-53, CME 750X and CME 750 drill rigs used for the 2013 exploration borings were calibrated on April 26, 2013, and have drill rod energy ratios of 77.7, 86.8 and 82.6 percent, respectively. The hammer for the CME 750X drill rig used for the 2019 exploration boring was calibrated on September 14, 2020, and has a drill rod energy ratio of 86.2 percent. No calibration factor was applied to the blow counts presented on the historic boring logs, as these were performed using a manual hammer.

Hand penetrometer readings, which provide a rough estimate of the unconfined compressive strength of the soil, were reported on the boring logs in units of tons per square foot (tsf) and were utilized to classify the consistency of the cohesive soil in each layer. An indirect estimate of the unconfined compressive strength of the cohesive split spoon samples can also be made from a correlation with the blow counts ( $N_{60}$ ). Please note that split spoon samples are considered to be disturbed and the laboratory determination of their shear strengths may vary from undisturbed conditions.





The depth to bedrock was determined by split spoon sampler refusal or auger refusal. Split spoon sampler refusal is defined as exceeding 50 blows from the hammer with less than 6.0 inches of penetration by the split spoon sampler. Auger refusal is defined as no or insignificant observable advancement of the augers with the weight of the drill rig driving the augers.

Where borings were extended into the bedrock (after encountering auger refusal), an NQ or HQ-sized double-tube diamond bit core barrel (utilizing wire line equipment) was used to core the bedrock. Coring produced 1.85 and 2.45 inch diameter cores, from which the type of rock and its geological characteristics were determined.

Rock cores were logged in the field and visually classified in the laboratory. They were analyzed to identify the type of rock, color, mineral content, bedding planes and other geological and mechanical features of interest in this project. The Rock Quality Designation (RQD) for each rock core run was calculated according to the following equation:

$$RQD = \frac{\sum \text{segments equal to or longer than 4.0 inches}}{\text{core run length}} \times 100$$

During drilling, Rii personnel prepared field logs showing the encountered subsurface conditions. Soil and rock samples obtained from the drilling operation were preserved and sealed in glass jars or core boxes and delivered to the soil laboratory. In the laboratory, the soil and rock samples were visually classified and select samples were tested, as noted in Table 2.

**Table 2. Laboratory Test Schedule**

Laboratory Test	Test Designation	Number of Tests Performed
Natural Moisture Content	ASTM D2216	148
Plastic and Liquid Limits	AASHTO T89, T90	60
Gradation – Sieve/Hydrometer	AASHTO T88	66
Unconfined Compressive Strength of Intact Rock	ASTM D7012	15
Determination of the Point Load Strength Index of Rock	ASTM D5731	2

The tests performed are necessary to classify existing soil and rock according to the Ohio Department of Transportation (ODOT) classification system and to estimate engineering properties of importance in determining foundation design and construction recommendations. Results of the laboratory testing are presented on the boring logs in Appendix III. A description of the soil terms used throughout this report is presented in Appendix II.

In addition to the borings performed as part of the current exploration, historic borings performed in 1957 by the Department of Highways as part of the FRA-40-12.30 project were obtained from the construction documents on record. Five (5) borings, designated as B-001-S-57, B-005-S-57, B-009-S-57, B-013-S-57 and B-020-S-57, were obtained along the entire length of the existing bridge alignments carrying I-70 eastbound and westbound over the Scioto River. The borings were extended to depths ranging from 36.0 to 63.0 feet below the existing grade at the time of the exploration. Please note that the elevations provided on the historic boring logs are referenced to the North American Datum (NAD) 27. The current design survey is referenced to NAD 83. The NAD 27 datum is 0.6 feet lower than the NAD 83 datum. **Therefore, all elevations noted in this report with respect to the historic borings are adjusted to the current NAD 83 datum.** The historic boring locations are shown on the boring plan provided in Appendix I, and the historic boring logs are provided in Appendix IV.

## 4.0 FINDINGS

Interpreted engineering logs have been prepared based on the field logs, visual examination of samples and laboratory test results. Classification follows the respective version of the ODOT Specifications for Geotechnical Explorations (SGE) at the time the exploration borings were performed. The following is a summary of what was found in the test borings and what is represented on the boring logs.

### 4.1 Surface Materials

Borings B-113-4-13 and B-113-5-13 were drilled in the grass area along the south side of McDowell Street, just west of the existing pump station, and encountered 6.0 inches of topsoil at the ground surface. Borings B-016-7-13, B-113-9-13 and B-114-1-13 were drilled adjacent to the existing bike path that runs along the east bank of the Scioto River, and encountered 3.0 to 5.0 inches of topsoil at the ground surface. Boring B-019-5-19 was drilled within the existing embankment supporting the abandoned Mound Street and encountered 3.0 inches of asphalt overlying 11.0 inches of concrete at the ground surface. Surface materials were not noted in the 1957 boring logs.

### 4.2 Subsurface Soils

Beneath the surface materials in borings B-016-7-13, B-113-4-13, B-113-5-13, B-113-9-13 and B-114-1-13, material identified as existing fill or possible fill was encountered extending to depths ranging from 5.5 to 20.5 feet below the ground surface. The fill material consisted of brown, dark brown, gray and black gravel and sand, gravel with sand and silt, gravel with sand, silt and clay, silt and clay and silty clay (ODOT A-1-b, A-2-4, A-2-6, A-6a, A-6b) and contained brick, concrete and slag fragments as well as root fibers throughout.



Beneath the pavement in boring B-019-5-13, existing embankment fill consisting of gray, dark gray and brown gravel with sand, silt and clay, silty clay and clay (ODOT A-1-b, A-6a, A-6b, A-7-6) was encountered extending to a depth of 37.0 feet, overlying existing fill material comprised of black, red and brown silty clay (ODOT A-6b) extending to a depth of 47.0 feet, which contained asphalt and brick fragments throughout.

Underlying the surficial materials and existing fill, where encountered, and from the existing ground surface in borings B-113-6-13 through B-113-8-13, natural granular soils were encountered with intermittent seams of cohesive material. The granular soils were generally described as brown, gray, grayish brown, brownish gray, dark brown and black gravel, gravel and sand, gravel with sand and silt, gravel with sand silt and clay, coarse and fine sand and sandy silt (ODOT A-1-a, A-1-b, A-2-4, A-2-6, A-3a, A-4a). The cohesive soils were generally described as gray, brown dark brown, dark gray and light brown sandy silt, silt and clay, silty clay and clay (ODOT A-4a, A-6a, A-6b, A-7-6).

A boulder zone was encountered in boring B-113-5-13 between elevations 668.7 and 674.7 feet msl and in boring B-113-8-13 between elevations 646.8 and 663.6 feet msl. Cobbles and boulders were generally encountered above the bedrock in borings B-113-4-13 through B-113-8-13 starting at elevations of approximately 700 feet msl in borings B-113-4-13 and B-113-5-13 and approximately 675 feet msl in borings B-113-6-13 through B-113-8-13.

The relative density of granular soils is primarily derived from SPT blow counts ( $N_{60}$ ). Based on the SPT blow counts obtained, the granular soil encountered ranged from very loose ( $N_{60} < 5$  blows per foot [bpf]) to very dense ( $N_{60} > 50$  bpf). Overall blow counts recorded from the SPT sampling ranged from 3 bpf to split spoon sampler refusal. The shear strength and consistency of the cohesive soils are primarily derived from the hand penetrometer values (HP). The cohesive soil encountered ranged from very soft ( $HP \leq 0.25$  tsf) to hard ( $HP > 4.0$  tsf). The unconfined compressive strength of the cohesive soil samples tested, obtained from the hand penetrometer, ranged from 0.25 to over 4.5 tsf (limit of instrument).

Natural moisture contents of the soil samples tested ranged from 4 to 53 percent. The natural moisture content of the cohesive soil samples tested for plasticity index ranged from 8 percent below to 18 percent above their corresponding plastic limits. In general, the soil exhibited natural moisture contents considered to be significantly below to significantly above optimum moisture levels.

### 4.3 Bedrock

Bedrock was encountered in the borings as presented in Table 3.

**Table 3. Top of Bedrock Elevations**

Boring Number	Ground Surface Elevation (feet msl)	Top of Bedrock		Top of Bedrock Core (Auger Refusal)	
		Depth (feet)	Elevation (feet msl)	Depth (feet)	Elevation (feet msl)
B-001-S-57	723.4	N/A	N/A	N/A	N/A
B-113-4-13	725.2	72.5	652.7	73.3	651.9
B-113-5-13	725.7	73.5	652.2	73.7	652.0
B-005-S-57	681.1	29.0	652.1	29.6	651.5
B-113-6-13	691.5	39.3	652.2	43.9	647.6
B-009-S-57	685.5	34.7	650.8	34.7	650.8
B-113-7-13	690.3	30.9	659.4	30.9	659.4
B-013-S-57	690.8	30.0	660.8	30.5	660.3
B-113-8-13	691.0	47.0	644.0	47.0	644.0
B-020-S-57	725.4	N/A	N/A	N/A	N/A
B-113-9-13	706.3	50.0	656.3	55.5	650.8
B-016-7-13	714.9	N/A	N/A	N/A	N/A
B-114-1-13	716.6	54.5	662.1	61.0	655.6
B-019-5-19	751.0	N/A	N/A	N/A	N/A

Top of bedrock in the borings was encountered at elevations ranging from 644.0 to 662.1 feet msl. The upper portion of the bedrock encountered in the majority of the borings consists of gray shale and mudstone overlying competent limestone and dolomite bedrock. Table 4 tabulates the depth and elevation that the surficial shale/mudstone bedrock was encountered as well as the top of competent limestone/dolomite bedrock. With the exception of boring B-113-8-13, shale/mudstone bedrock was encountered in the remaining borings at elevations ranging from 650.8 to 660.8 feet msl. With the exception of borings B-001-S-57, B-013-S-57 and B-020-S-57, limestone/dolomite bedrock was encountered in the remaining borings at elevations ranging from 634.8 to 650.8 feet msl.

**Table 4. Bedrock Types**

Boring Number	Ground Surface Elevation (feet msl)	Top of Shale/Mudstone		Top of Limestone/Dolomite	
		Depth (feet)	Elevation (feet msl)	Depth (feet)	Elevation (feet msl)
B-001-S-57	723.4	N/A	N/A	N/A	N/A
B-113-4-13	725.2	72.5	652.7	76.0	649.2
B-113-5-13	725.7	73.5	652.2	74.9	650.8
B-005-S-57	681.1	29.0	652.1	29.6	651.5
B-113-6-13	691.5	39.3	652.2	43.9	647.6
B-009-S-57	685.5	34.7	650.8	37.4	648.1
B-113-7-13	690.3	30.9	659.4	41.5	648.8
B-013-S-57	690.8	30.0	660.8	N/A	N/A
B-113-8-13	691.0	N/A	N/A	47.0	644.0
B-020-S-57	725.4	N/A	N/A	N/A	N/A
B-113-9-13	706.3	50.0	656.3	60.7	645.6
B-016-7-13	714.9	N/A	N/A	N/A	N/A
B-114-1-13	716.6	54.5	662.1	75.0	641.6
B-019-5-19	751.0	N/A	N/A	N/A	N/A

The cored bedrock recovered from the current exploration borings consists of shale, mudstone, dolomite and limestone. The mudstone is described as gray, highly weathered, very weak, medium bedded, friable, pyritic, and highly fractured with open, very rough apertures. The shale is described as gray and dark gray, unweathered to highly weathered, very weak to weak, very thin to thin bedded, calcareous, argillaceous, friable, micaceous, fissile and moderately to highly fractured with tight to open, slickensided to rough apertures. The dolomite is described as brown and gray, unweathered to slightly weathered, strong to very strong, medium to very thick bedded, calcareous, crystalline, siliceous, cherty, pyritic and slightly to highly fractured with tight to open, slightly rough apertures. The limestone is generally described as gray and brown, unweathered to slightly weathered, moderately strong to very strong, thin to very thick bedded, arenaceous, calcareous, siliceous, crystalline, dolomitic, cherty, pyritic, stylolitic and intact to highly fractured with tight to open, slightly to very rough apertures.

The percent recovery, RQD values and unconfined compressive strengths of the bedrock core runs from the current exploration borings are summarized in Table 5.

**Table 5. Rock Core Summary**

Boring	Core No.	Depth (feet)	Recovery (%)	RQD (%)	Unconfined Compressive Strength
B-113-4-13	RC-1	73.3 to 78.3	98	34	N/A
	RC-2	78.3 to 83.3	100	97	$q_u @ 78.3' = 7,676 \text{ psi}$
	RC-3	83.3 to 88.3	100	100	N/A
B-113-5-13	RC-3	73.7 to 75.7	92	21	N/A
	RC-4	75.7 to 80.7	100	94	$q_u @ 75.7' = 8,702 \text{ psi}$
	RC-5	80.7 to 85.7	78	60	$q_u @ 80.7' = 7,992 \text{ psi}$
B-113-6-13	RC-1	43.9 to 48.7	79	79	$q_u @ 45.9' = 9,906 \text{ psi}$
	RC-2	48.7 to 53.7	100	88	$q_u @ 50.7' = 11,448 \text{ psi}$
	RC-3	53.7 to 58.7	100	93	$q_u @ 54.8' = 5,140 \text{ psi}$
	RC-4	58.7 to 63.7	100	90	N/A
B-113-7-13	RC-3	30.9 to 35.7	53	45	$q_u @ 30.9' \text{ to } 35.7' = 73 \text{ psi}^1$
	RC-4	35.7 to 40.7	0	0	N/A
	RC-5	40.7 to 45.7	76	58	$q_u @ 42.2' = 11,119 \text{ psi}$
	RC-6	45.7 to 50.7	100	90	$q_u @ 50.2' = 9,850 \text{ psi}$
	RC-7	50.7 to 55.7	100	100	$q_u @ 51.2' = 10,087 \text{ psi}$
B-113-8-13	RC-4	47.0 to 51.2	46	30	$q_u @ 47.1' = 12,942 \text{ psi}$
	RC-5	51.2 to 56.2	100	99	$q_u @ 52.3' = 9,438 \text{ psi}$
	RC-6	56.2 to 61.2	100	97	$q_u @ 56.8' = 9,657 \text{ psi}$
	RC-7	61.2 to 66.2	97	83	N/A
B-113-9-13	RC-1	55.5 to 58.0	7	0	N/A
	RC-2	58.0 to 63.0	70	40	$q_u @ 60.3' = 11,594 \text{ psi}$
	RC-3	63.0 to 68.0	100	100	$q_u @ 63.0' = 5,086 \text{ psi}$
	RC-4	68.0 to 73.0	100	94	N/A
B-114-1-13	RC-1	61.0 to 66.0	95	76	N/A
	RC-2	66.0 to 71.0	100	23	N/A
	RC-3	71.0 to 76.0	75	23	$q_u @ 73.0' = 520 \text{ psi}^1$
	RC-4	76.0 to 81.0	96	94	$q_u @ 76.0' = 11,340 \text{ psi}$

1. Represents the mean unconfined compressive strength of shale sample based on correlations with the mean point load strength index.

It should be noted that bedrock experiences mechanical breaks during the drilling and coring processes. Rii attempted to account for fresh, manmade breaks during tabulation of the RQD analysis. The zones within borings B-113-5-13, B-113-7-13 and B-113-8-13 where boulders were encountered that required rock coring techniques to advance through these zones are not included in the RQD tabulation above. The quality of the cored bedrock, according to the RQD values, ranged from poor ( $25 < \text{RQD} \leq 50\%$ ) to excellent ( $\text{RQD} > 90\%$ ). Please note that core run RC-4 in boring B-113-7-13 did not have any recovery due to a piece of rock that become stuck in the core barrel during the coring process. This resulted in the bedrock becoming pulverized and washing out with the circulation fluid. Also, the first core run in boring B-113-9-13 was only 2.5-feet in length and resulted in an RQD of 0 percent. Due to the short length of the core run, this RQD value is likely not representative of this bedrock stratum.

#### 4.4 Groundwater

Groundwater was encountered in the borings as presented in Table 6.

**Table 6. Groundwater**

Boring Number	Ground Elevation (feet msl)	Initial Groundwater		Upon Completion	
		Depth (feet)	Elevation (feet msl)	Depth (feet)	Elevation (feet msl)
B-016-7-13	714.9	19.0	695.9	N/A <sup>1</sup>	-
B-019-5-19	751.0	48.5	702.5	57.0	694.0
B-113-4-13	725.2	38.5	686.7	N/A <sup>1</sup>	-
B-113-5-13	725.7	38.5	687.2	N/A <sup>1</sup>	-
B-113-6-13	691.5	N/A <sup>2</sup>	699.2	N/A <sup>1</sup>	-
B-113-7-13	690.3	N/A <sup>2</sup>	700.7	N/A <sup>1</sup>	-
B-113-8-13	691.0	N/A <sup>2</sup>	699.8	N/A <sup>1</sup>	-
B-113-9-13	706.3	21.0	685.3	N/A <sup>1</sup>	-
B-114-1-13	716.6	28.5	688.1	N/A <sup>1</sup>	-

1. The groundwater level at completion could not be obtained due to the addition of mud or water as a drilling fluid.
2. Water elevation listed is the surface elevation of the Scioto River at the respective boring location; therefore, no depth is associated with the elevation listed.

Groundwater was encountered initially during drilling in borings B-016-7-13, B-019-5-19, B-113-4-13, B-113-5-13, B-113-9-13 and B-114-1-13 at depths ranging from 19.0 to 48.5 feet below the existing ground surface, which corresponds elevations ranging from 685.3 to 702.5 feet msl. As previously noted, borings B-113-6-13 through B-113-8-13

were performed within the Scioto River. The elevation of the Scioto River surface ranged from 699.2 to 700.7 feet msl at the time of the drilling. At the completion of the drilling and prior to removing the auger in boring B-019-5-19, groundwater accumulated in the auger stems to a depth of 57.0 feet below grade, which corresponds to an elevation of 694.0 feet msl. The groundwater level at the completion of drilling in the remaining borings could not be measured due to the addition of mud to counteract heaving sands or water as a circulating fluid during the rock coring process in the remaining borings.

Please note that short-term water level readings, especially in cohesive soils, are not necessarily an accurate indication of the actual groundwater level. In addition, groundwater levels or the presence of groundwater are considered to be dependent on seasonal fluctuations in precipitation.

A more comprehensive description of what was encountered during the drilling process may be found on the boring logs in Appendix III.

#### **4.5 Historic Borings**

In general, the historic borings encountered granular soils with intermittent seams of cohesive material overlying shale and limestone bedrock. The granular soils were generally described as loose to very dense brown and gray gravel, gravel and sand, gravel with sand and silt, fine sand and coarse and fine sand (ODOT A-1-a, A-1-b, A-2-4, A-3, A-3a), and the cohesive soils were generally described as hard gray and brown sandy silt and silt and clay (ODOT A-4a, A-6a). Shale bedrock was encountered in borings B-005-S-57, B-009-S-57 and B-013-S-57 at an elevation of 652.0, 651.4 and 661.4 feet msl, respectively. Limestone bedrock was encountered below the shale bedrock in borings B-005-S-57 and B-009-S-57 at an elevation of 652.1 and 648.7 feet msl, respectively. A boulder zone was encountered in boring B-001-S-57 between elevations 661.0 and 667.0 feet msl. Groundwater levels were not noted in the borings performed during the 1957 investigation. In general, the subsurface conditions encountered in the historic borings matched relatively closely with the subsurface conditions encountered in the current exploration borings.

### **5.0 ANALYSES AND RECOMMENDATIONS**

Data obtained from the review of existing geotechnical information and from the current exploration have been used to determine the foundation support capabilities and the settlement potential for the soil encountered at the site. These parameters have been used to provide guidelines for the design of foundation systems for the subject bridge, as well as the construction specifications related to the placement of foundation systems and general earthwork recommendations, which are discussed in the following paragraphs.

Design details of the proposed structure were provided by ms consultants. Based on the information provided, it is understood that the proposed FRA-70-1322L and FRA-70-1323C structures will be five-span continuous composite steel girder with reinforced concrete deck structures with capped pile abutments and multi-column piers. The proposed roadway profile grade will be elevated approximately 5 to 15 feet above the existing profile grade along the alignment of the bridge structures.

Proposed structural data was obtained from design details provided by ms consultants and are included in Table 7.

**Table 7. Structure and Bridge Design Elevations**

Structure Reference	Substructure Unit (Boring)	Structure Component	Elevation <sup>1</sup> (feet msl)	Design Maximum Factored Load
FRA-70-1322L	Rear Abutment (B-001-S-57 / B-113-5-13)	Bottom of Footing	714.5	174 kips/pile
	Pier 1 (B-005-S-57)	Top of Shaft	697.6	2,270 kips/shaft
	Pier 2 (B-009-S-57)	Top of Shaft	697.6	2,630 kips/shaft
	Pier 3 (B-013-S-57 / B-113-8-13)	Top of Shaft	697.6	2,550 kips/shaft
	Pier 4 (B-020-S-57 / B-113-9-13)	Top of Shaft	706.0	2,475 kips/shaft
	Forward Abutment (B-020-S-57 / B-114-1-13)	Bottom of Footing	719.0	194 kips/pile
FRA-70-1323C	Rear Abutment (B-113-4-13 / B-113-5-13)	Bottom of Footing	714.5	226 kips/pile
	Pier 1 (B-113-6-13)	Top of Shaft	697.6	2,523 kips/shaft
	Pier 2 (B-113-7-13)	Top of Shaft	697.6	2,872 kips/shaft
	Pier 3 (B-113-8-13)	Top of Shaft	697.6	2,772 kips/shaft
	Pier 4 (B-113-9-13)	Top of Shaft	704.0	2,676 kips/shaft
	Forward Abutment (B-114-1-13)	Bottom of Footing	709.0 / 719.0	305 kips/pile

1. Proposed bottom of footing and top of shaft elevations and structural loading based on structure information provided by ms consultants.

Borings B-015-7-13 through B-015-9-13 and B-016-3-13 through B-016-5-13, which were performed for the FRA-70-1321A bridge structure as part of the FRA-70-12.68 Phase 4A project, were also referenced to further delineate the bedrock stratigraphy at the site. A copy of these logs is also provided in Appendix III.



## 5.1 Drilled Shaft Recommendations

It is understood that drilled shafts will be utilized at the pier substructure units. Given the proposed loading per shaft at each of the pier locations, friction bearing drilled shafts within the overburden soils and drilled shafts bearing within the weak surficial shale bedrock are not economically feasible foundation options due to the size and number of shafts that would be required to support the proposed loading. Therefore, it is recommended that the drilled shafts be extended through the surficial soils and weak surficial shale bedrock to bear on or within the underlying limestone/dolomite bedrock at the pier locations.

Per Section 10.8.3.5.4c of the 2020 AASHTO LRDF Bridge Design Specifications (BDS), a minimum rock socket length of 1.5 times the diameter of the drilled shaft within the rock socket ( $1.5B_{RS}$ ) is required to utilize the full end bearing resistance within the bedrock unit that the shafts are end bearing in/on. However, based on discussions with the ODOT Office of Geotechnical Engineering (OGE), a reduced tip resistance can be utilized for shafts not extended to the required minimum socket length of  $1.5B_{RS}$  into bedrock.

Using equation 10.8.3.5.4c-1 of the 2020 AASHTO LRFD BDS, the nominal end bearing resistance for drilled shafts socketed a minimum of  $1.5B_{RS}$  into intact rock is 2.5 times the unconfined compressive strength of the bedrock unit that the shaft tip is bearing on or within. Based on unconfined compression tests performed on limestone rock cores obtained from the borings, the unconfined compressive strength ranges from 5,086 to 12,942 psi. Using equation 10.8.3.5.4c-1 and the limiting unconfined compressive strength from the given range for the limestone bedrock, it is recommended that drilled shaft foundations socketed a minimum of  $1.5B_{RS}$  into the bedrock to bear on or within the competent limestone bedrock be proportioned for a nominal end bearing resistance of 1,831 ksf at the strength limit state.

Where lateral load demands do not require a rock socket length of  $1.5B_{RS}$ , the socket length can be reduced or the shaft can bear on the bedrock surface with no rock socket. If the rock socket is reduced to a length less than  $1.5B_{RS}$ , a reduced nominal end bearing resistance should be utilized based on equations 10.8.3.5.4c-2 and 10.8.3.5.4c-3 of the AASHTO LRFD BDS, which is as follows:



$$q_p = A + q_u \left[ m_b \left( \frac{A}{q_u} \right) + s \right]^a$$

In which:

$$A = \sigma'_{vb} + q_u \left[ m_b \left( \frac{\sigma'_{vb}}{q_u} \right) + s \right]^a$$

Where:

- $\sigma'_{vb}$  = vertical effective stress at the socket bearing (tip) elevation (ksf)
- $s$ ,  $a$  and  $m_b$  = Hoek-Brown strength parameters for fractured rock mass determined from GSI in accordance with Section 10.4.6.4 of the AASHTO LRFD BDS
- $q_u$  = unconfined compressive strength of intact rock (ksf)

Based on discussions with ODOT OGE, the condition of the rock mass for the determination of the GSI rating should consider the limestone to have a “closed” joint condition, a “blocky” structure and a “good” joint surface condition. Using this description for the structure and surface conditions of the rock mass, a GSI rating of 70 was determined from Figure 10.4.6.4-1 of the 2020 AASHTO LRFD BDS, and the Hoek-Brown strength parameters  $s$ ,  $a$  and  $m_b$  were calculated as 0.036, 0.50 and 3.08, respectively. The vertical effective stress was estimated considering 45 feet of soil overburden with a buoyant unit weight of 57.6 pcf. Using the above noted equations and the limiting unconfined compressive strength from the given range for the limestone bedrock, it is recommended that drilled shaft foundations bearing on or within the competent limestone bedrock with a socket length less than  $1.5B_{RS}$  into the bedrock be proportioned for a nominal end bearing resistance of 765 ksf at the strength limit state.

Based on plan information provided by ms consults, the shaft diameter within the overburden soils will be 5.5 feet, and the shaft diameter within the rock socket will be 5.0 feet. Table 8 lists the estimated elevation of the top of bedrock as well as the proposed rock sock diameter and length from the design plans and corresponding nominal end bearing resistance to be utilized for the design of the drilled shaft foundations. A resistance factor of  $\phi_{qp} = 0.5$  at the strength limit state should be utilized for design.

**Table 8. Drilled Shaft Recommendations**

Structure Reference	Substructure Unit (Boring)	Top of Bedrock Elevation (feet msl)	Top of Limestone Elevation (feet msl)	Rock Socket Diameter <sup>1</sup> (feet)	Required Socket Length to Top of Limestone / Dolomite (feet)	Proposed Socket Length <sup>1</sup> (feet)	Nominal End Bearing Resistance <sup>2</sup> (ksf)
FRA-70-1322L	Pier 1 (B-005-S-57)	652.1	651.5	5.0	0.6	5.0	765
	Pier 2 (B-009-S-57)	650.8	648.1	5.0	2.7	5.0	765
	Pier 3 (B-013-S-57 / B-113-8-13)	660.8	644.0	5.0	16.8	16.8	1,831
	Pier 4 (B-020-S-57 / B-113-9-13)	656.5	645.6	5.0	10.9	10.9	1,831
FRA-70-1323C	Pier 1 (B-113-6-13)	652.2	647.6	5.0	4.6	7.0	765
	Pier 2 (B-113-7-13)	659.4	648.8	5.0	10.6	10.6	1,831
	Pier 3 (B-013-S-57 / B-113-8-13)	663.6	644.0	5.0	16.8	19.6	1,831
	Pier 4 (B-113-9-13)	656.3	645.6	5.0	10.7	10.7	1,831

1. Proposed rock socket diameter and length at each substructure unit determined from proposed plan information provided by ms consultants.
2. Nominal end bearing resistance provided is the value that should be utilized in the determination of the end bearing resistance per drilled shaft based on the proposed rock socket length and diameter.

If lateral analysis of the drilled shaft foundations indicates that the rock socket length can be reduced based on the lateral load demands, then the rock socket length may be reduced from those shown in the current design plans. If the rock socket is reduced to a length less than  $1.5B_{RS}$ , then the reduced bearing resistance of 765 ksf should be utilized for design.

Given the factored end bearing resistances noted above for drilled shafts extended to bear on or within the limestone bedrock, it is anticipated that the axial resistance will be governed by structural resistance of the drilled shaft. Based on the cross section provided for the drilled shaft within the rock socket, which consists of a 5.0-foot diameter shaft with 28 No. 10 longitudinal reinforcement bars, the factored structural resistance is 7,412 kips, as determined in accordance with Section 5.6.4.4 of the 2020 AASHTO LRFD BDS. The factored resistance per shaft provided in the design sheets should be the limiting value between the factored geotechnical resistance and the factored axial compressive resistance of the shaft.

Drilled shafts designed in accordance with the requirements presented above should experience a maximum settlement estimated to be less than 0.5 inches. Group settlement of the shafts, socketed into bedrock, is considered negligible for a minimum spacing of 2.0 shaft diameters center-to-center. Drilled shaft calculations are provided in Appendix VI.

### **5.1.1 Drilled Shaft Considerations**

The minimum requirements for proper inspection of drilled shaft construction are as follows:

- A qualified inspector should record the material types being removed from the hole as excavation proceeds.
- When the bearing material has been encountered and identified and/or the design tip elevation has been reached, the shaft walls and base should be observed for anomalies, unexpected soft soil conditions, obstructions or caving.
- Concrete placed freefall should not be allowed to hit the sidewalls of the excavation or the rebar cage and should not pass through any water.
- Structural stability of the rebar cage should be maintained during the concrete pour to prevent buckling.
- The volume of concrete should be checked to ensure voids did not result during extraction of the casing (if utilized).
- The placement of all concrete for the drilled shafts shall follow the American Concrete Institute's Design and Construction of Drilled Piers (ACI 336.3R-93).
- If concrete is placed by tremie method, it must be done so with an adequate head to displace water or slurry if groundwater has entered the caisson (all tremie procedures shall follow applicable ACI specifications).
- Pulling casing with insufficient concrete inside should be restricted.
- The bottom of drilled shaft excavation should be clean and free of loose material. Any loose material observed should be removed using a clean-out bucket (muck bucket).

The use of casing for drilled shafts is recommended under any of the following conditions:

- Caving material is encountered at any time during the drilling of the shaft.
- Groundwater is encountered at any time during the drilling of the shaft, or groundwater seepage occurs in the drilled shaft.
- Down hole inspection is planned (casing is required for this instance).

In addition, it is recommended that if casing is used, it be pulled immediately after the concrete is placed, allowing for re-use of the casing and eliminating reduction of side resistance (between soil and concrete).

It is anticipated that conventional drilled shaft equipment (with a standard soil bit) will be able to penetrate the upper soils to the bedrock depths provided in Table 3. However, depending on the conditions encountered, additional effort may be needed at or above this depth, and within the noted cobble and boulder zones. Below the depths noted, it will likely be necessary to employ more specialized drilling techniques, such as the use of rock teeth or a rock bit. The ability to penetrate the bedrock will be entirely dependent on the drilled shaft contractor and the equipment employed. It is the responsibility of the contractor to determine the most effective excavation procedures. The elevation and hardness of bedrock is subject to change within the project area.

## 5.2 Driven Pile Recommendations

It is understood that driven piles will be utilized at the rear and forward abutment substructure units. Given the depth of bedrock encountered in the borings performed and the required structural loading, it is recommended that steel H-piles (ODOT Item 507.06) driven to refusal on bedrock be employed for foundation support. Per Section 305.3.1.2 of the 2020 ODOT Bridge Design Manual, refusal is met during driving when the pile penetration is an inch or less after receiving at least 20 blows from the pile hammer. Table 9 shows recommended pile lengths and the corresponding factored structural axial resistance ( $R_{R \max}$ ) of steel H-piles. For H-piles driven to refusal on bedrock, no geotechnical resistance factor should be applied to the factored structural axial resistance values presented, as the values presented account for the structural resistance factor,  $\phi_c = 0.50$ , for H-piles subject to damage due to severe driving conditions.

**Table 9. Driven Pile Recommendations**

Substructure Reference	Pile Size	Pile Elevation		Pile Length <sup>2</sup> (feet)	R <sub>R max</sub> <sup>3</sup> (kips/pile)	$\phi$ <sup>4</sup>
		Top <sup>1</sup>	Tip			
Rear Abutment	HP 10x42 <sup>5</sup>	715.5	652.7	65	310	N/A
	HP 12x53 <sup>5</sup>	715.5	652.7	65	380	N/A
	HP 14x73 <sup>5</sup>	715.5	652.7	65	530	N/A
Forward Abutment	HP 10x42 <sup>5</sup>	710.0 / 720.0	662.1	50 / 60	310	N/A
	HP 12x53 <sup>5</sup>	710.0 / 720.0	662.1	50 / 60	380	N/A
	HP 14x73 <sup>5</sup>	710.0 / 720.0	662.1	50 / 60	530	N/A

1. The top of pile elevation corresponds to the pile cutoff elevation, which is considered to be 1.0-foot above the proposed bottom of footing elevation per Section 305.3.5.1 of the 2020 ODOT BDM. Multiple values indicate minimum and maximum pile cutoff elevation along the abutment substructure.
2. Per Section 305.3.5.2 of the 2020 ODOT BDM, the estimated pile length was determined as the pile cutoff elevation (top) minus the pile tip elevation, rounded up to the nearest 5.0 feet.
3. The factored structural axial resistance for H-piles is based on the structural limit state of the steel H-pile section per Section 305.3.3 of the 2020 ODOT BDM.
4. For H-piles driven to refusal on bedrock, no geotechnical resistance factor should be applied to the factored structural axial resistance values presented, as the values presented account for the structural resistance factor,  $\phi_c = 0.50$ , for H-piles subject to damage due to severe driving conditions.
5. A steel pile point is recommended to protect the tips of the H-piles during pile installation.

Per Section 305.3.3 of the 2020 ODOT BDM, the factored resistance of H-piles driven to refusal on bedrock is typically governed by the structural resistance of the pile element. The factored structural axial resistances listed in Table 9 consider an axially loaded pile with negligible moment, no appreciable loss of section due to deterioration throughout the life of the structure, a steel yield strength of 50 ksi, a structural resistance factor for H-piles subject to damage due to severe driving conditions ( $\phi_c = 0.50$  per Section 6.5.4.2 of the 2020 AASHTO LRFD BDS) and a pile fully braced along its length. **These bearing values should not be used for piles that are subjected to bending moments or are not supported by soil for their entire length.** Static or dynamic load testing is not required for H-piles driven to refusal on bedrock. It is anticipated that the piles will be able to be driven a short distance into the shale bedrock at the forward abutment before satisfying the driving conditions that meet the refusal criterion. Settlement is estimated to be less than 1.0 inch for H-piles driven to refusal on bedrock.

As noted in Section 4.2, a boulder zone was encountered in boring B-113-5-13 between elevations 668.7 and 674.7 feet msl. Additionally, cobbles and boulders were encountered above the bedrock in borings B-113-4-13 and B-113-5-13 starting at an elevation of approximately 700 feet msl. Given the significant presence of cobbles and boulders at the rear abutment, the pile driving operations should be closely monitored to verify that the piles extend to the limestone bedrock. **If a pile cannot be extended through the cobbles and boulders to the estimated elevation of the limestone bedrock, then the pile should be considered a friction bearing pile that is driven to the maximum ultimate bearing value per Section 305.3.4 of the 2020 ODOT BDM.** In this instance, the resistance factor of 0.7 should be applied to the maximum ultimate bearing value provided for the respective pile size utilized.

Consideration was given to the use of friction piles using cast-in-place (CIP) pipe piles; however, given the presence of dense granular soils immediately below the bottom of footing elevation, it is anticipated that refusal will be encountered prior to achieving a sufficient embedment depth for lateral resistance.

### **5.2.1 Downdrag Considerations**

Per the traditional method for calculating the depth of downdrag, downdrag loads will develop along the portion of the pile above the interface where the relative soil movement from consolidation with respect to the pile is greater 0.40 inches. Based on plan and profile information provided by ms consultants, approximately 5.5 and 10.0 feet of fill will be required to achieve the final grade elevation at the rear and forward abutment, respectively. The anticipated total settlement due to the embankment loading at the rear and forward abutment is 0.78 and 1.18 inches, respectively. The settlement of the soils beneath the proposed abutment footings is anticipated to be 0.11 and 0.40 inches, respectively, at the rear and forward abutment. Given that the anticipated settlement below the proposed footings will not exceed 0.40 inches, downdrag loads are not anticipated to develop along the piles. Settlement calculations are provided in Appendix VIII.

### **5.2.2 Driveability**

A drivability analysis was performed in accordance with Section 10.7.8 of the 2020 AASHTO LRFD BDS using the GRLWEAP software program, and the results are provided in Appendix VI. In the driveability analysis, a Delmag 19-42 hammer with a rated energy of approximately 43,000 ft-lbs was used in conjunction with H-pile sections at the forward abutment of both structures. Based on the results of this analysis, driving stresses induced on the H-piles **would not exceed** 90 percent of the yield stress of the steel ( $f_y = 50$  ksi,  $0.9f_y = 45$  ksi) if driven through the overburden soils to the bedrock depths provided in Table 9.

For the rear abutment of both structures, a larger pile hammer system is required to advance the piles through the overburden soils and boulder field to bear on the top of bedrock. Therefore, a Delmag 30-23 hammer with a rated energy of approximately 73,788 ft-lbs was used in conjunction with H-pile sections at the rear abutment of both structures. Based on the results of the analysis, driving stresses **would not exceed** 90 percent of the yield stress of the steel ( $f_y = 50$  ksi,  $0.9f_y = 45$  ksi) if driven through the overburden soils to the bedrock depths provided in Table 9 at the rear abutment of the FRA-70-1323C structure. However, for the piles at the rear abutment of the FRA-70-1322L structure, while the analysis indicates the driving stresses would not exceed 90 percent of the yield stress of the steel, it is anticipated that refusal will occur as the piles approach the bedrock elevation.

Care should be taken during pile driving operations when approaching the bedrock, and when extending the piles into the surficial bedrock material, to ensure that the driving stresses induced on the pile elements do not exceed the maximum allowable value of 90 percent of the yield stress of the steel, subsequently damaging the pile elements. Pile driving should be terminated upon achieving the required 20 blows from the pile hammer with an inch or less of penetration to reduce the possibility of damaging the pile element.

As noted in Section 5.2, if a pile cannot be extended through the cobbles and boulders to the estimated elevation of the limestone bedrock at the rear abutment of the FRA-70-1322L and FRA-70-1323C structures, then the pile should be considered a friction bearing pile that is driven to the maximum ultimate bearing value per Section 305.3.4 of the 2020 ODOT BDM.

Per Section 305.3.5.6 of the 2020 ODOT BDM, steel pile points **shall be used** when the piles are driven to bear on strong bedrock (unconfined compressive strength greater than 7.5 ksi) and is extended through overburden containing layers of very dense granular soils as well as boulders.

### 5.3 Lateral Design

If lateral load or moments are expected to be applied on the foundation elements, they should be analyzed to verify the shaft or pile has enough lateral and bending resistance against these loads. A boring-by-boring tabulation of parameters that should be used for lateral loading design is provided in Appendix IX. In order to evaluate the lateral capacity, it is recommended that a derivation of COM624, such as LPILE, be utilized to determine the proper embedment depth and cross section (for drilled shafts) required to resist the lateral load for a given end condition and deflection. Table 10 lists the eleven different soil types internal to the LPILE program. These strata were utilized to define the soil strata in the soil profile for each boring provided in Appendix IX.



**Table 10. Subsurface Strata Description**

<b>Strata</b>	<b>Description</b>
1	Soft Clay
2	Stiff Clay with Water
3	Stiff Clay without Free Water
4	Sand (Reese)
5	User Defined
6	Vuggy Limestone (Strong Rock)
7	Silt (with cohesion and internal friction angle)
8	API Sand
9	Weak Rock
10	Liquefiable Sand (Rollins)
11	Stiff Clay without free water with a specified initial K (Brown)

#### **5.4 CIP Wall Recommendations (Forward Abutment Wingwall)**

It is understood that a cast-in-place (CIP) retaining wall that is being supported on a shallow spread foundation is being utilized for a portion of the wingwall at the forward abutment between Sta. 3053+26.70 and 3054+50.00 (BL Ramp D3).

Based on the proposed plan and cross section information provided by ms consultants, the wall height ranges from 9.3 to 24.3 feet along this section of the wingwall. The wingwall alignment is situated along the existing supporting the former Mound Street, which will be removed to facilitate the construction of the wall. Based on the cross sections provided, the profile grade of Ramp D3 is approximately 10.0 feet below the existing grade of the embankment.

For CIP walls bearing on earthen foundations, footings should be proportioned such that the factored equivalent bearing pressure exerted at the front of the wall will not exceed the factored bearing resistance at the strength limit state. Further, the footings should also be proportioned such that the entire footing width remains in compression (no tensile stresses form under the footing, pulling the footing up and away from the bearing surface). It is understood that the foundations for CIP walls will bear approximately 4.0 feet below the finished grade. In general, the typical width of a CIP wall foundation (B) is equal to 50 to 70 percent the wall height.



Existing embankment fill was encountered in boring B-019-5-19 extending to an elevation 714.0 feet msl, overlying existing fill consisting of medium stiff to stiff silty clay (ODOT A-6b) overlying natural stiff silt and clay (ODOT A-6a). The existing embankment fill generally consisted of very stiff to hard silt and clay, silty clay and clay (ODOT A-6a, A-6b, A-7-6) with intermittent seams of medium dense to very dense gravel with sand (ODOT A-1-b). Based on the condition of the existing embankment fill encountered in the borings, it is anticipated that the embankment fill was placed and compacted in a controlled manner. Therefore, this soil in its current condition is considered adequate for support of the proposed wingwall.

#### 5.4.1 Strength Parameters Utilized in External and Global Stability Analyses

The shear strength parameters utilized in the external and global stability analyses for the wingwall are provided in Table 11.

**Table 11. Shear Strength Parameters Utilized in Stability Analyses**

Material Type	$\gamma$ (pcf)	$\phi'$ <sup>(1)</sup> (°)	$c'$ <sup>(2)</sup> (psf)	$S_u$ <sup>(3)</sup> (psf)
Item 203 Embankment (Retained Soil)	120	30	0	2,000
Existing Embankment Fill: Medium Dense Gravel with Sand (ODOT A-1-b)	125	39	0	N/A
Existing Embankment Fill: Very Stiff Silt and Clay (ODOT A-6a)	120	27	15	2,250
Existing Embankment Fill: Very Stiff Clay (ODOT A-7-6)	120	25	30	2,125
Existing Fill: Medium Stiff to Stiff Silty Clay (ODOT A-6b)	120	26	20	1,250
Stiff Silt and Clay (ODOT A-6a)	115	27	15	1,500
Stiff Sandy Silt (ODOT A-4a)	115	27	0	1,625
Medium Dense Gravel (ODOT A-1-a)	125	37	0	N/A

1. Per Figure 7-45, Section 7.6.9 of FHWA GEC 5 for cohesive soils and Table 10.4.6.2.4-1 of the 2020 AASHTO LRFS BDS for granular soils.
2. Estimated based on overconsolidated nature of soil.
3.  $S_u = 125(N_{60})$ , Terzaghi and Peck (1967).

The shear strength parameters for the existing embankment, fill materials and natural soils were assigned using correlations provided in FHWA Geotechnical Engineering Circular (GEC) No. 5 (FHWA-NHI-16-072) Evaluation of Soil and Rock Properties and based on past experience in the vicinity of the site with projects performed in similar subsurface profiles.

### 5.4.2 Bearing Stability

Existing embankment fill consisting of very stiff to hard silt and clay and clay (ODOT A-6a, A-7-6) is anticipated at the bearing elevation along the wall alignment, overlying existing fill consisting of medium stiff to stiff silty clay (ODOT A-6b) followed by natural stiff silt and clay (ODOT A-6a). CIP wall foundations bearing on these soils may be proportioned for a factored bearing resistance as indicated in Table 12. A geotechnical resistance factor of  $\phi_b=0.55$  was considered in calculating the factored bearing resistance at the strength limit state. The foundation width presented in the following table is based on the wall section provided in the design sheets.

**Table 12. Forward Abutment Wingwall CIP Wall Design Parameters**

From Station <sup>1</sup>	To Station <sup>1</sup>	Panel ID	Wall Height Analyzed (feet)	Foundation Width (feet)	Bearing Resistance at Strength Limit (ksf)		Strength Limit Equivalent Bearing Pressure <sup>3</sup> (ksf)
					Nominal	Factored <sup>2</sup>	
3053+26.70	3053+57.53	3	24.3	18.5	7.36	4.05	4.03
3053+57.53	3053+88.35	4	19.2	14.0	7.23	3.98	3.62
3053+88.35	3054+19.31	5	14.2	11.0	6.57	3.61	2.57
3054+19.31	3054+50.00	6	9.3	8.8	5.92	3.26	1.63

1. Limits of wall determined from plan information provided by ms consultants. Stationing listed is referenced to Ramp D3.
2. A geotechnical resistance factor of  $\phi_b=0.55$  was considered in calculating the factored bearing resistance at the strength limit state.
3. The strength limit equivalent bearing pressure is the uniformly distributed pressure asserted by the wall over an effective base width based on the eccentricity of the wall system at the strength limit state.

Rii performed a verification of the bearing pressure exerted on the subgrade material for the maximum specified wall height indicated in Table 12. Based on the minimum footing widths presented, the factored equivalent bearing pressure exerted below the wall **will not exceed** the factored bearing resistance at the strength limit state.

### 5.4.3 Settlement Considerations

Given that the existing Mound Street embankment will be excavate and removed to construct the wingwall, resulting in a profile grade along Ramp D3 at the top of the wall that is approximately 10.0 feet below the existing grade of the embankment, little to no settlement is anticipated under the loading from the proposed wall along the alignment.

#### 5.4.4 Eccentricity (Overturning Stability)

The resistance of the CIP wall to overturning will be dependent on the on the location of the resultant force at the bottom of the wall due to the overturning and resisting moments acting on the wall. For CIP walls, overturning stability is determined by calculating the eccentricity of the resultant force from the midpoint of the base of the wall and comparing this value to a limiting eccentricity value. Per Section 11.6.3.3 of the 2020 AASHTO LRFD BDS, for foundations bearing on soil, the location of the resultant of the reaction forces shall be within the middle two-thirds ( $\frac{2}{3}$ ) of the base width. Therefore, the limiting eccentricity is one-third ( $\frac{1}{3}$ ) of the base width of the wall. Based on the required foundation width presented in Table 12 and utilizing the soil parameters listed in Section 5.4.1 for the retained embankment material, the calculated eccentricity of the resultant force **will not exceed** the limiting eccentricity at the strength limit state.

#### 5.4.5 Sliding Stability

The resistance of the CIP wall to sliding was evaluated per Section 11.6.3.6 of the 2020 AASHTO LRFD BDS. Given that the bearing soils consist of cohesive material, the sliding resistance was evaluated under both drained and undrained conditions. For drained conditions, the sliding resistance is determined by multiplying a coefficient of sliding friction “f” times the total vertical force at the base of the wall. The coefficient of sliding friction is determined based on the friction angle of the foundation soil. Based on the soil parameters listed in Section 5.4.1, a coefficient of sliding friction of 0.47 to 0.49 was utilized for design. For undrained conditions, the sliding resistance is taken as the limiting value between the undrained shear strength of the bearing soil and half of the vertical stress applied by the wall multiplied by the width of the wall. Based on the soil parameters listed in Section 5.4.1, the undrained shear strength of the bearing material is estimated to range from 1.25 to 2.125 ksf.

A geotechnical resistance factor of  $\phi_r=1.0$  was considered in calculating the factored shear resistance along the base of the wall. Based on the foundation widths presented in Table 12 and utilizing the soil parameters listed in Section 5.4.1 for the retained embankment material, the resultant horizontal forces on the back of the CIP wall **will not exceed** the factored shear resistance at the strength limit state under drained or undrained conditions.

#### 5.4.6 Global (Overall) Stability

A slope stability analysis was performed to check the global stability of the wall along the alignment. As per 2020 AASHTO LRFD BDS, safety against soil failure shall be evaluated at the service limit state by assuming the concrete and soil backfill to be a rigid body. Soil parameters utilized in external stability analyses are presented Section 5.4.1. For the global stability condition, it was considered that the failure plane will not cross through any portion of the supported soil mass above the concrete or through the

concrete footing itself. The computer software program Slide, manufactured by Rocscience Inc., was utilized to perform the analyses.

Per Section 11.6.2.3 of the 2020 AASHTO LRFD BDS, overall (global) stability for CIP walls that are not supporting structural foundations or elements is satisfied if the product of the factor of safety from the slope stability output multiplied by the resistance factor  $\phi=0.75$  is greater than 1.0. Therefore, global stability is satisfied when a minimum factor of safety of 1.3 is obtained. Based on the recommended footing dimensions listed in Table 12, the resulting factor of safety under drained conditions (long-term stability) and undrained conditions (short-term stability) using the Spencer's analysis method was greater than 1.3.

#### 5.4.7 Final CIP Wall Considerations

Based on the results of the external and global stability analysis performed for the forward abutment wingwall, the wall sections provided in the design sheets meet all of the external and global stability requirements.

Calculations for external (bearing and sliding resistance and limiting eccentricity) and overall (global) stability of the CIP walls are provided in Appendix X.

### 5.5 Lateral Earth Pressure

For the soil types encountered in the borings, the "in-situ" unit weight ( $\gamma$ ), cohesion ( $c$ ), effective angle of friction ( $\phi$ ), and lateral earth pressure coefficients for at-rest conditions ( $k_o$ ), active conditions ( $k_a$ ), and passive conditions ( $k_p$ ) have been estimated and are provided in Table 13 and Table 14.

**Table 13. Estimated Undrained (Short-term) Soil Parameters for Design**

Soil Type	$\gamma$ (pcf) <sup>1</sup>	$c$ (psf)	$\phi$	$k_a$	$k_o$	$k_p$
Soft to Stiff Cohesive Soil	115	1,000	0°	N/A	N/A	N/A
Very Stiff to Hard Cohesive Soil	125	3,000	0°	N/A	N/A	N/A
Loose Granular Soil	120	0	28°	0.32	0.53	5.07
Medium Dense to Dense Granular Soil	130	0	32°	0.27	0.47	6.82
Very Dense Granular Soil	135	0	35°	0.24	0.43	8.56
Compacted Cohesive Engineered Fill	120	2,000	0°	N/A	N/A	N/A
Compacted Granular Engineered Fill	120	0	32°	0.27	0.47	6.82

1. When below groundwater table, use effective unit weight,  $\gamma' = \gamma - 62.4$  pcf and add hydrostatic water pressure.

**Table 14. Estimated Drained (Long-term) Soil Parameters for Design**

Soil Type	$\gamma$ (pcf) <sup>1</sup>	$c$ (psf)	$\phi'$	$k_a$	$k_o$	$k_p$
Soft to Stiff Cohesive Soil	115	0	24°	0.37	0.59	3.97
Very Stiff to Hard Cohesive Soil	125	50	28°	0.32	0.53	5.07
Loose Granular Soil	120	0	28°	0.32	0.53	5.07
Medium Dense to Dense Granular Soil	130	0	32°	0.27	0.47	6.82
Very Dense Granular Soil	135	0	35°	0.24	0.43	8.56
Compacted Cohesive Engineered Fill	120	0	28°	0.32	0.53	5.07
Compacted Granular Engineered Fill	120	0	32°	0.27	0.47	6.82

1. When below groundwater table, use effective unit weight,  $\gamma' = \gamma - 62.4$  pcf and add hydrostatic water pressure.

These parameters are considered appropriate for the design of all subsurface structures and any excavation support systems. Subsurface structures (where the top of the structure is restrained from movement) should be designed based on at-rest conditions ( $k_o$ ). For proposed temporary retaining structures (where the top of the structure is allowed to move), earth pressure distributions should be based on active ( $k_a$ ) and passive ( $k_p$ ) conditions. Active earth pressure is developed as the structure moves away from the backfill or retained soil, while passive pressure is developed as the structure moves towards the backfill. A relatively small amount of lateral movement is needed to reach the active condition ( $\geq 0.1$  percent of the height), whereas the movements required to engage the passive condition are approximately ten times greater than those required to develop active earth pressure. The values in this table have been estimated from correlation charts based on minimum standards specified for compacted engineered fill materials.

These recommendations do not take into consideration the effect of any surcharge loading or a sloped ground surface (a flat surface is assumed). Earth pressures on excavation support systems will be dependent on the type of sheeting and method of bracing or anchorage. Surcharge loads, such as that imposed by traffic loading, will create additional lateral loading on the subsurface structures and excavation support systems. The resulting lateral earth pressure should be evaluated based on active ( $k_a$ ) and at-rest ( $k_o$ ) conditions and the anticipated magnitude of the loading.

Where necessary, temporary retaining structures such as sheet pile system should be designed using the undrained soil parameters provided in Table 13, and the design should follow all applicable guidelines for the type of retaining structure utilized. Permanent retaining and subsurface structures should be designed using the drained soil parameters provided in Table 14. Regardless of whether the retaining structure is temporary or permanent, the effective unit weight ( $\gamma' = \gamma - 62.4$  pcf) plus the hydrostatic water pressure ( $\gamma_w * h_w$ , where  $h_w$  is the height of water behind the wall above the base of

the wall) should be utilized below the design groundwater level. The lateral earth pressure coefficients should only be applied to the horizontal pressure resulting from the effective overburden pressure, and should not be applied to the hydrostatic water pressure.

## 5.6 Scour Data

Continuous sampling was performed starting at the top of the riverbed elevation in borings B-113-6-13 through B-113-8-13 for a minimum 6.0-foot interval to determine the  $D_{50}$  of the riverbed soil. The riverbed soils are classified as gravel, gravel and sand, gravel with sand and silt, gravel with sand, silt and clay and sandy silt (ODOT A-1-a, A-1-b, A-2-4, A-2-6, A-4a). Based upon the grain size analysis performed, the  $D_{50}$  of the riverbed material is summarized in Table 15.

**Table 15. Scour Data Summary**

Soil Type	Range of $D_{50}$ (millimeters)
A-1-a	3.264 – 7.385
A-1-b	0.463 – 1.471
A-2-4	0.902 – 2.424
A-2-6	0.902 – 2.424
A-4a	0.121

## 5.7 Construction Considerations

All site work shall conform to local codes and to the latest ODOT Construction and Materials Specifications (CMS), including that all excavation and embankment preparation and construction should follow ODOT Item 200 (Earthwork).

### 5.7.1 Excavation Considerations

All excavations should be shored / braced or laid back at a safe angle in accordance to Occupational Safety and Health Administration (OSHA) guidelines. During excavation, if slopes cannot be laid back to OSHA Standards due to adjacent structures or other obstructions, sheeting boxes may be required. The following table should be utilized as a general guide for implementing OSHA guidelines when estimating excavation back slopes at the various boring locations. Actual excavation back slopes must be field verified by qualified personnel at the time of excavation in strict accordance with OSHA guidelines.



**Table 16. Excavation Back Slopes**

Soil	Maximum Back Slope	Notes
Soft to Medium Stiff Cohesive	1.5 : 1.0	Above Ground Water Table and No Seepage
Stiff Cohesive	1.0 : 1.0	Above Ground Water Table and No Seepage
Very Stiff to Hard Cohesive	0.75 : 1.0	Above Ground Water Table and No Seepage
All Granular & Cohesive Soil Below Ground Water Table or with Seepage	1.5 : 1.0	None
Rock to 3.0' +/- below Auger Refusal	0.75 : 1.0	Above Ground Water Table and No Seepage
Stable Rock	Vertical	Above Ground Water Table and No Seepage

### 5.7.2 Groundwater Considerations

Based on the groundwater observations made during drilling, groundwater is anticipated during construction of the drilled shafts. Where groundwater is encountered, proper groundwater control should be employed and maintained to prevent disturbance to excavation bottoms consisting of cohesive soil, and to prevent the possible development of a quick or "boiling" condition where soft silts and/or fine sands are encountered. It is preferable that the groundwater level, if encountered, be maintained at least 36 inches below the deepest excavation. In the case of drilled shafts, the utilization of casing will be required below the water table to maintain an open hole and prevent the sidewalls from collapse. In addition, concrete placed below the water table should be placed by tremie method using a rigid tremie pipe. Note that mitigating the water during construction and protecting the excavation is the responsibility of the contractor.

## 6.0 LIMITATIONS OF STUDY

The above recommendations are predicated upon construction inspection by a qualified soil technician under the direct supervision of a professional geotechnical engineer. Adequate testing and inspection during construction are considered necessary to assure an adequate foundation system and are part of these recommendations.

The recommendations for this project were developed utilizing soil and bedrock information obtained from the test borings that were made at the proposed site for the current investigation. Resource International is not responsible for the data, conclusions, opinions or recommendations made by others during previous investigations at this site. At this time we would like to point out that soil borings only depict the soil and bedrock conditions at the specific locations and time at which they were made. The conditions at other locations on the site may differ from those occurring at the boring locations.

The conclusions and recommendations herein have been based upon the available soil and bedrock information and the design details furnished by a representative of the owner of the proposed project. Any revision in the plans for the proposed construction from those anticipated in this report should be brought to the attention of the geotechnical engineer to determine whether any changes in the foundation or earthwork recommendations are necessary. If deviations from the noted subsurface conditions are encountered during construction, they should also be brought to the attention of the geotechnical engineer.

The scope of our services does not include any environmental assessment or investigation for the presence or absence of hazardous or toxic materials in the soil, groundwater or surface water within or beyond the site studied. Any statements in this report or on the test boring logs regarding odors, staining of soils or other unusual conditions observed are strictly for the information of our client.

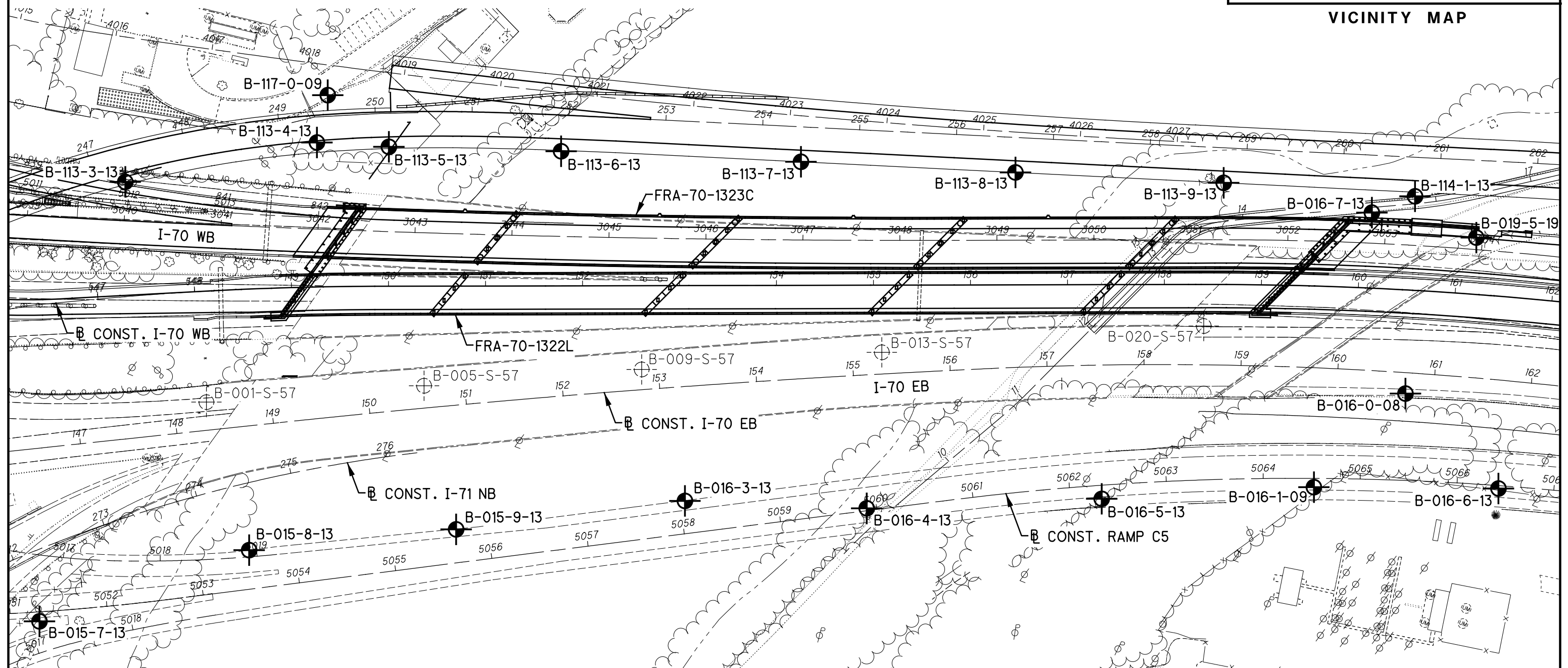
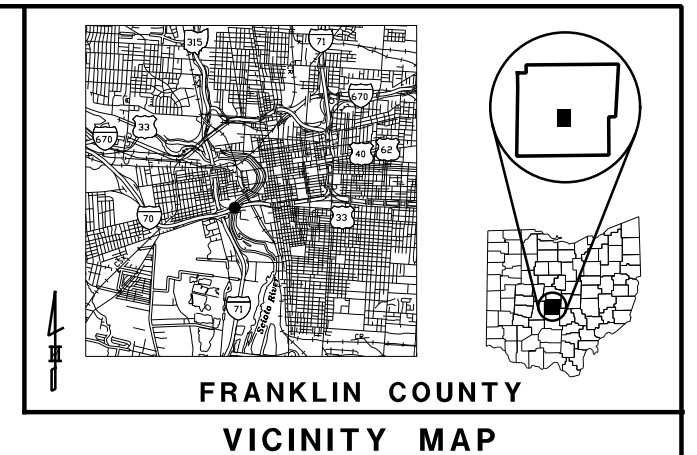
Our professional services have been performed, our findings obtained and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. Resource International is not responsible for the conclusions, opinions or recommendations made by others based upon the data included.







## **APPENDIX I**

### **VICINITY MAP AND BORING PLAN**



**BORING PLAN**  
**FRA-70-1322L AND FRA-70-1323C**  
**FRANKLIN COUNTY, OHIO**

PROJECT NO. Rii W-13-072	DRAWN RRM		
SCALE: 1"=100'	REVIEWED BRT		
0 50 100	DATE 3/8/2021		

## **APPENDIX II**

### **DESCRIPTION OF SOIL TERMS**

### **DESCRIPTION OF SOIL TERMS**

The following terminology was used to describe soils throughout this report and is generally adapted from ASTM 2487/2488 and ODOT Specifications for Geotechnical Explorations.

#### **Granular Soils** – ODOT A-1, A-2, A-3, A-4 (non-plastic)

The relative compactness of granular soils is described as:

<u>Description</u>	<u>Blows per foot – SPT (N<sub>60</sub>)</u>	
Very Loose	Below	5
Loose	5	- 10
Medium Dense	11	- 30
Dense	31	- 50
Very Dense	Over	50

#### **Cohesive Soils** – ODOT A-4, A-5, A-6, A-7, A-8

The relative consistency of cohesive soils is described as:

<u>Description</u>	<u>Unconfined Compression (tsf)</u>	
Very Soft	Less than	0.25
Soft	0.25	- 0.5
Medium Stiff	0.5	- 1.0
Stiff	1.0	- 2.0
Very Stiff	2.0	- 4.0
Hard	Over	4.0

#### **Gradation** - The following size-related denominations are used to describe soils:

<u>Soil Fraction</u>	<u>Size</u>
Boulders	Larger than 12"
Cobbles	12" to 3"
Gravel coarse	3" to ¾"
fine	¾" to 2.0 mm (¾" to #10 Sieve)
Sand coarse	2.0 mm to 0.42 mm (#10 to #40 Sieve)
fine	0.42 mm to 0.074 mm (#40 to #200 Sieve)
Silt	0.074 mm to 0.005 mm (#200 to 0.005 mm)
Clay	Smaller than 0.005 mm

#### **Modifiers of Components** - The following modifiers indicate the range of percentages of the minor soil components:

<u>Term</u>	<u>Range</u>	
Trace	0%	- 10%
Little	10%	- 20%
Some	20%	- 35%
And	35%	- 50%

#### **Moisture Table** - The following moisture-related denominations are used to describe cohesive soils:

<u>Term</u>	<u>Range - ODOT</u>
Dry	Well below Plastic Limit
Damp	Below Plastic Limit
Moist	Above PL to 3% below LL
Wet	3% below LL to above LL

#### **Organic Content** – The following terms are used to describe organic soils:

<u>Term</u>	<u>Organic Content (%)</u>
Slightly organic	2-4
Moderately organic	4-10
Highly organic	>10

#### **Bedrock** – The following terms are used to describe the relative strength of bedrock:

<u>Description</u>	<u>Field Parameter</u>
Very Weak	Can be carved with knife and scratched by fingernail. Pieces 1 in. thick can be broken by finger pressure.
Weak	Can be grooved or gouged with knife readily. Small, thin pieces can be broken by finger pressure.
Slightly Strong	Can be grooved or gouged 0.05 in deep with knife. 1 in. size pieces from hard blows of geologist hammer.
Moderately Strong	Can be scratched with knife or pick. 1/4 in. size grooves or gouges from blows of geologist hammer.
Strong	Can be scratched with knife or pick with difficulty. Hard hammer blows to detach hand specimen.
Very Strong	Cannot be scratched by knife or pick. Hard repeated blows of geologist hammer to detach hand specimen.
Extremely Strong	Cannot be scratched by knife or pick. Hard repeated blows of geologist hammer to chip hand specimen.

## **DESCRIPTION OF ROCK TERMS**

The following terminology was used to describe the rock throughout this report and is generally adapted from ASTM D5878 and the ODOT Specifications for Geotechnical Explorations.

**Weathering** – Describes the degree of weathering of the rock mass:

<u>Description</u>	<u>Field Parameter</u>
Unweathered	No evidence of any chemical or mechanical alteration of the rock mass. Mineral crystals have a right appearance with no discoloration. Fractures show little or not staining on surfaces.
Slightly Weathered	Slight discoloration of the rock surface with minor alterations along discontinuities. Less than 10% of the rock volume presents alteration.
Moderately Weathered	Portions of the rock mass are discolored as evident by a dull appearance. Surfaces may have a pitted appearance with weathering "halos" evident. Isolated zones of varying rock strengths due to alteration may be present. 10 to 15% of the rock volume presents alterations.
Highly Weathered	Entire rock mass appears discolored and dull. Some pockets of slightly to moderately weathered rock may be present and some areas of severely weathered materials may be present.
Severely Weathered	Majority of the rock mass reduced to a soil-like state with relic rock structure discernable. Zones of more resistant rock may be present but the material can generally be molded and crumbled by hand pressures.

**Strength of Bedrock** – The following terms are used to describe the relative strength of bedrock:

<u>Description</u>	<u>Field Parameter</u>
Very Weak	Can be carved with knife and scratched by fingernail. Pieces 1 in. thick can be broken by finger pressure.
Weak	Can be grooved or gouged with knife readily. Small, thin pieces can be broken by finger pressure.
Slightly Strong	Can be grooved or gouged 0.05 in deep with knife. 1 in. size pieces from hard blows of geologist hammer.
Moderately Strong	Can be scratched with knife or pick. 1/4 in. size grooves or gouges from blows of geologist hammer.
Strong	Can be scratched with knife or pick with difficulty. Hard hammer blows to detach hand specimen.
Very Strong	Cannot be scratched by knife or pick. Hard repeated blows of geologist hammer to detach hand specimen.
Extremely Strong	Cannot be scratched by knife or pick. Hard repeated blows of geologist hammer to chip hand specimen.

**Bedding Thickness** – Description of bedding thickness as the average perpendicular distances between bedding surfaces:

<u>Description</u>	<u>Thickness</u>
Very Thick	Greater than 36 inches
Thick	18 to 36 inches
Medium	10 to 18 inches
Thin	2 to 10 inches
Very Thin	0.4 to 2 inches
Laminated	0.1 to 0.4 inches
Thinly Laminated	Less than 0.1 inches

**Fracturing** – Describes the degree and condition of fracturing (fault, joint, or shear):

### **Degree of Fracturing**

<u>Description</u>	<u>Spacing</u>
Unfractured	Greater than 10 feet
Intact	3 to 10 feet
Slightly Fractured	1 to 3 feet
Moderately Fractured	

### **Aperture Width**

<u>Description</u>	<u>Width</u>
Open	Greater than 0.2 inches
Narrow	0.05 to 0.2 inches
Tight	Less than 0.05 inches

### **Surface Roughness**

<u>Description</u>	<u>Criteria</u>
Very Rough	Near vertical steps and ridges occur on surface
Slightly Rough	Asperities on the surfaces distinguishable
Slickensided	Surface has smooth, glassy finish, evidence of Striations

**RQD** – Rock Quality Designation (calculation shown in report) and Rock Quality (ODOT, GB 3, January 13, 2006):





















<u>RQD %</u>	<u>Rock Index Property Classification (based on RQD, not slake durability index)</u>
0 – 25%	Very Poor
26 – 50%	Poor
51 – 70%	Fair
71 – 85%	Good
86 – 100%	Very Good



# CLASSIFICATION OF SOILS

Ohio Department of Transportation

(The classification of a soil is found by proceeding from top to bottom of the chart.  
The first classification that the test data fits is the correct classification.)

SYMBOL	DESCRIPTION	Classification		LL <sub>O</sub> /LL x 100*	% Pass #40	% Pass #200	Liquid Limit (LL)	Plastic Index (PI)	Group Index Max.	REMARKS
		AASHTO	OHIO							
	Gravel and/or Stone Fragments	A-1-a			30 Max.	15 Max.		6 Max.	0	Min. of 50% combined gravel, cobble and boulder sizes
	Gravel and/or Stone Fragments with Sand	A-1-b			50 Max.	25 Max.		6 Max.	0	
	Fine Sand	A-3			51 Min.	10 Max.	NON-PLASTIC		0	
	Coarse and Fine Sand	--	A-3a			35 Max.		6 Max.	0	Min. of 50% combined coarse and fine sand sizes
	Gravel and/or Stone Fragments with Sand and Silt	A-2-4				35 Max.	40 Max.	10 Max.	0	
		A-2-5			41 Min.					
	Gravel and/or Stone Fragments with Sand, Silt and Clay	A-2-6				35 Max.	40 Max.	11 Min.	4	
		A-2-7			41 Min.					
	Sandy Silt	A-4	A-4a	76 Min.		36 Min.	40 Max.	10 Max.	8	Less than 50% silt sizes
	Silt	A-4	A-4b	76 Min.		50 Min.	40 Max.	10 Max.	8	50% or more silt sizes
	Elastic Silt and Clay	A-5		76 Min.		36 Min.	41 Min.	10 Max.	12	
	Silt and Clay	A-6	A-6a	76 Min.		36 Min.	40 Max.	11 - 15	10	
	Silty Clay	A-6	A-6b	76 Min.		36 Min.	40 Max.	16 Min.	16	
	Elastic Clay	A-7-5		76 Min.		36 Min.	41 Min.	≤ LL-30	20	
	Clay	A-7-6		76 Min.		36 Min.	41 Min.	> LL-30	20	
	Organic Silt	A-8	A-8a	75 Max.		36 Min.				W/o organics would classify as A-4a or A-4b
	Organic Clay	A-8	A-8b	75 Max.		36 Min.				W/o organics would classify as A-5, A-6a, A-6b, A-7-5 or A-7-6
MATERIAL CLASSIFIED BY VISUAL INSPECTION										
	Sod and Topsoil			Uncontrolled Fill (Describe)			Bouldery Zone			Peat
	Pavement or Base									

\* Only perform the oven-dried liquid limit test and this calculation if organic material is present in the sample.

## **APPENDIX III**

### **PROJECT BORING LOGS:**

**B-015-7-13 through B-015-9-13,  
B-016-3-13 through B-016-5-13,  
B-016-7-13, B-019-5-19 and  
B-113-4-13 through B-114-1-13**



# BORING LOGS

## Definitions of Abbreviations

AS	=	Auger sample
GI	=	Group index as determined from the Ohio Department of Transportation classification system
HP	=	Unconfined compressive strength as determined by a hand penetrometer (tons per square foot)
LL <sub>o</sub>	=	Oven-dried liquid limit as determined by ASTM D4318. Per ASTM D2487, if LL <sub>o</sub> /LL is less than 75 percent, soil is classified as "organic".
LOI	=	Percent organic content (by weight) as determined by ASTM D2974 (loss on ignition test)
PID	=	Photo-ionization detector reading (parts per million)
QR	=	Unconfined compressive strength of intact rock core sample as determined by ASTM D2938 (pounds per square inch)
QU	=	Unconfined compressive strength of soil sample as determined by ASTM D2166 (pounds per square foot)
RC	=	Rock core sample
REC	=	Ratio of total length of recovered soil or rock to the total sample length, expressed as a percentage
RQD	=	Rock quality designation – estimate of the degree of jointing or fracture in a rock mass, expressed as a percentage:

$$\frac{\sum \text{segments equal to or longer than 4.0 inches}}{\text{core run length}} \times 100$$

S	=	Sulfate content (parts per million)
SPT	=	Standard penetration test blow counts, per ASTM D1586. Driving resistance recorded in terms of blows per 6-inch interval while letting a 140-pound hammer free fall 30 inches to drive a 2-inch outer diameter (O.D.) split spoon sampler a total of 18 inches. The second and third intervals are added to obtain the number of blows per foot (N <sub>m</sub> ).
N <sub>60</sub>	=	Measured blow counts corrected to an equivalent (60 percent) energy ratio (ER) by the following equation: N <sub>60</sub> = N <sub>m</sub> *(ER/60)
SS	=	Split spoon sample
2S	=	For instances of no recovery from standard SS interval, a 2.5 inch O.D. split spoon is driven the full length of the standard SS interval plus an additional 6.0 inches to obtain a representative sample. Only the final 6.0 inches of sample is retained. Blow counts from 2S sampling are not correlated with N <sub>60</sub> values.
3S	=	Same as 2S, but using a 3.0 inch O.D. split spoon sampler.
TR	=	Top of rock
W	=	Initial water level measured during drilling
▼	=	Water level measured at completion of drilling


### Classification Test Data

Gradation (as defined on Description of Soil Terms):

GR	=	% Gravel
SA	=	% Sand
SI	=	% Silt
CL	=	% Clay


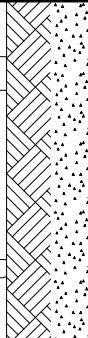

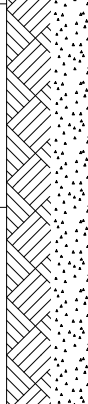
Atterberg Limits:

LL	=	Liquid limit
PL	=	Plastic limit
PI	=	Plasticity Index
WC	=	Water content (%)

	PROJECT: FRA-70-12.68 - PHASE 4A	DRILLING FIRM / OPERATOR: RII / S.M.	DRILL RIG: CME-750 (SN 98048)	STATION / OFFSET: 5051+29.66 / 9.8' RT	<b>EXPLORATION ID</b> <b>B-015-7-13</b>
	TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / A.D.	HAMMER: CME AUTOMATIC	ALIGNMENT: BL RAMP C5	
	PID: 77372 BR ID: FRA-70-1301A	DRILLING METHOD: 3.25" HSA / RC	CALIBRATION DATE: 4/26/13	ELEVATION: 721.8 (MSL) EOB: 80.5 ft.	PAGE 1 OF 3
	START: 6/10/13 END: 6/13/13	SAMPLING METHOD: SPT / NQ	ENERGY RATIO (%): 82.6	LAT / LONG: 39.950618516, -83.014254653	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N <sub>60</sub>	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
								GR	CS	FS	SI	CL	LL	PL	PI			
0.4' - TOPSOIL (5.0")	721.8																	
HARD, BROWN <b>CLAY</b> , SOME FINE GRAVEL, SOME FINE TO COARSE SAND, LITTLE SILT, DRY.	721.4	1	4															
		2	15	37	50	SS-1	4.5+	24	14	13	15	34	43	19	24	9	A-7-6 (8)	
	718.8	3																
DENSE, GRAY <b>GRAVEL</b> , LITTLE FINE TO COARSE SAND, TRACE SILT, TRACE CLAY, DAMP.		4	9															
		5	11	32	17	SS-2	-	-	-	-	-	-	-	-	-	6	A-1-a (V)	
	716.3	6																
STIFF TO VERY STIFF, DARK BROWN TO BROWNISH GRAY <b>SILT AND CLAY</b> , SOME COARSE TO FINE SAND, SOME FINE GRAVEL, DAMP TO MOIST.		7	3	8	61	SS-3	2.00	-	-	-	-	-	-	-	-	15	A-6a (V)	
		8	4															
		9	2															
		10	4	11	67	SS-4	2.50	26	15	15	16	28	32	17	15	13	A-6a (3)	
		11																
		12	3	15	56	SS-5	2.00	-	-	-	-	-	-	-	-	20	A-6a (V)	
	708.8	13																
LOOSE TO DENSE, BROWN <b>GRAVEL WITH SAND, SILT, AND CLAY</b> , DAMP.		14	2	8	72	SS-6	-	-	-	-	-	-	-	-	-	17	A-2-6 (V)	
		15	3															
		16																
		17	3	19	44	SS-7	-	30	20	15	11	24	30	18	12	17	A-2-6 (0)	
	703.8	18																
DENSE TO VERY DENSE, GRAY <b>GRAVEL AND SAND</b> , LITTLE TO SOME SILT, TRACE CLAY, DAMP TO MOIST.		19			0	ST-8	-	-	-	-	-	-	-	-	-	-		
		20																
		21																
		22	5	50	72	SS-9	-	-	-	-	-	-	-	-	-	7	A-1-b (V)	
		23	18															
		24	11	55	67	SS-10	-	49	18	9	23	1	NP	NP	NP	7	A-1-b (0)	
		25	21															
		26	12	67	83	SS-11	-	-	-	-	-	-	-	-	-	8	A-1-b (V)	
		27	27															
		28	22															
		29	8	41	11	SS-12	-	-	-	-	-	-	-	-	-	10	A-1-b (V)	
			13															
			17															

[illegible]

PID: 77372	BR ID: FRA-70-1301A	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 5051+29.66 / 9.8 RT					START: 6/10/13		END: 6/13/13		PG 3 OF 3		B-015-7-13												
MATERIAL DESCRIPTION AND NOTES			ELEV. 659.7	DEPTHS		SPT/ RQD	N <sub>60</sub>	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	BACK FILL					
VERY DENSE, GRAY GRAVEL AND SAND, LITTLE SILT, TRACE CLAY, MOIST TO WET. (same as above)				659.7	TR	63																				
						64	42	-	100	SS-19	-	54	17	10	16	3	22	17	5	10	A-1-b (0)					
						65																				
						66																				
						67																				
						68																				
						69	50/5"	-	20	SS-20	-	-	-	-	-	-	-	-	-	24	A-1-b (V)					
						70																				
						71																				
						72																				
DOLOMITE : BROWN AND GRAY, SLIGHTLY WEATHERED, STRONG, VERY THIN TO MEDIUM BEDDED, CHERTY, CRYSTALLINE,, SILICEOUS, CALCITE/PYRITE DEPOSITS, CHERT NODULES AND LENSES, MODERATELY FRACTURED TO FRACTURED, OPEN APERTURE, SLIGHTLY ROUGH TO ROUGH; RQD 58%, REC 96%. -CHERT NODULE @ 71.1' -QU @ 72.1' = 12,300 PSI				651.3	TR	73	58		97	RC-1										CORE						
						74																				
						75																				
						76																				
						77																				
						78	58		95	RC-2												CORE				
						79																				
						80																				
									641.3	EOB	80															

NOTES: GROUNDWATER INITIALLY ENCOUNTERED @ 30.0'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 188 LBS CEMENT / 50 LBS BNTONITE POWDER / 50 GAL WATER



B-015-7-13 – RC-1 – Depth from 70.5 to 75.5 feet



B-015-7-13 – RC-2 – Depth from 75.5 to 80.5 feet



PROJECT: FRA-70-12.68 - PHASE 4A  
 TYPE: STRUCTURE  
 PID: 77372 BR ID: FRA-70-1321A  
 START: 5/3/14 END: 5/3/14

DRILLING FIRM / OPERATOR: RII / T.F.  
 SAMPLING FIRM / LOGGER: RII / S.B.  
 DRILLING METHOD: 4.25" HSA / HQ  
 SAMPLING METHOD: SPT / RC

DRILL RIG: CME-750X (SN 310218)  
 HAMMER: CME AUTOMATIC  
 CALIBRATION DATE: 4/26/13  
 ENERGY RATIO (%): 86.8

STATION / OFFSET: 5053+52.86 / 39.9' LT  
 ALIGNMENT: BL RAMP C5  
 ELEVATION: 692.5 (MSL) EOB: 56.0 ft.  
 LAT / LONG: 39.951030, -83.013641

EXPLORATION ID  
**B-015-8-13**

PAGE  
 1 OF 2

MATERIAL DESCRIPTION AND NOTES	ELEV. 692.5	DEPTHS	SPT/ RQD	N <sub>60</sub>	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
								GR	CS	FS	SI	CL	LL	PL	PI			
MEDIUM DENSE, BROWN <b>GRAVEL</b> , SOME COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, WET.	691.0	1	12 10 2	17	33	SS-1	-	62	19	8	6	5	-	-	-	23	A-1-a (V)	
MEDIUM STIFF, BROWN <b>SILTY CLAY</b> , SOME COARSE TO FINE SAND, SOME FINE GRAVEL, MOIST.		2	WOH WOH 4	6	33	SS-2	1.00	20	10	11	26	33	38	19	19	25	A-6b (8)	
		3	1															
	688.0	4	2 3	7	33	SS-3	1.00	30	12	12	23	23	-	-	-	29	A-6b (V)	
LOOSE, BROWN <b>GRAVEL WITH SAND, SILT, AND CLAY</b> , MOIST.		5	1 2 3	7	33	SS-4	-	54	12	9	14	11	33	20	13	20	A-2-6 (0)	
	685.5	6																
MEDIUM DENSE TO VERY DENSE, BROWN <b>GRAVEL</b> , SOME COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, WET.		7																
-LARGE ROCK RECOVERED IN 3S-5A		8	1 9 10	27	0	SS-5	-	-	-	-	-	-	-	-	-	-		
		9	13	-	50	3S-5A	-	-	-	-	-	-	-	-	-	-	A-1-a (V)	
		10																
-ROCK FRAGMENTS PRESENT IN SS-6 AND SS-7		11	20 50/3"	-	100	SS-6	-	66	16	8	7	3	NP	NP	NP	19	A-1-a (0)	
		12																
	678.0	13	1 5 7	17	33	SS-7	-	-	-	-	-	-	-	-	-	20	A-1-a (V)	
		14																
HARD, DARK BROWN <b>SILTY CLAY</b> , SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP TO MOIST.		15	5															
		16	7 12	27	72	SS-8	4.5+	3	7	16	40	34	32	15	17	14	A-6b (11)	
		17																
		18	15 17 17	49	44	SS-9	4.5+	-	-	-	-	-	-	-	-	16	A-6b (V)	
		19																
		20	10 15 14	42	94	SS-10	4.5+	-	-	-	-	-	-	-	-	14	A-6b (V)	
	670.5	21																
		22																
HARD, DARK BROWN <b>SILT AND CLAY</b> , SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP.		23	23 23 25	69	56	SS-11	4.5+	7	8	21	34	30	28	15	13	16	A-6a (7)	
		24																
		25	14 50/3"	-	100	SS-12	4.5+	-	-	-	-	-	-	-	-	13	A-6a (V)	
	665.5	26																
		27																
VERY DENSE, BROWN <b>GRAVEL AND SAND</b> , LITTLE SILT, TRACE CLAY, MOIST.		28	50/2"	-	0	SS-13	-	-	-	-	-	-	-	-	-	-		
		29																

[illegible]

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 188 LBS CEMENT / 50 LBS BENTONITE POWDER / 40 GAL WATER





B-015-8-13 – RC-1 and RC-2 – Depth from 40.3 to 48.0 feet



B-015-8-13 – RC-3 and RC-4 – Depth from 48.0 to 56.0 feet



PROJECT: FRA-70-12.68 - PHASE 4A  
 TYPE: STRUCTURE  
 PID: 77372 BR ID: FRA-70-1321A  
 START: 5/1/14 END: 5/3/14

DRILLING FIRM / OPERATOR: RII / T.F.  
 SAMPLING FIRM / LOGGER: RII / S.B.  
 DRILLING METHOD: 4.25" HSA / RC  
 SAMPLING METHOD: SPT / HQ

DRILL RIG: CME-750X (SN 310218)  
 HAMMER: CME AUTOMATIC  
 CALIBRATION DATE: 4/26/13  
 ENERGY RATIO (%): 86.8

STATION / OFFSET: 5055+67.30 / 34.3' LT  
 ALIGNMENT: BL RAMP C5  
 ELEVATION: 691.2 (MSL) EOB: 65.2 ft.  
 LAT / LONG: 39.951307453, -83.012965722

EXPLORATION ID  
**B-015-9-13**

PAGE  
 1 OF 3

MATERIAL DESCRIPTION AND NOTES	ELEV. 691.2	DEPTHS	SPT/ RQD	N <sub>60</sub>	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
								GR	CS	FS	SI	CL	LL	PL	PI			
SOFT, BROWN AND BLACK <b>SILT AND CLAY</b> , LITTLE FINE GRAVEL, LITTLE COARSE TO FINE SAND, MOIST. -ROOT FIBERS PRESENT IN SS-1	689.7	1	WOH 1	4	33	SS-1	0.50	28	21	13	22	16	-	-	-	23	A-6a (V)	
LOOSE, BROWN <b>GRAVEL WITH SAND, SILT, AND CLAY</b> , MOIST. -BRICK FRAGMENTS PRESENT IN SS-3	686.7	2	6 4	9	56	SS-2	-	39	15	11	20	15	34	19	15	19	A-2-6 (1)	
		3	1 3	9	39	SS-3	-	34	21	11	19	15	-	-	-	18	A-2-6 (V)	
VERY SOFT, BROWN <b>SILT AND CLAY</b> , SOME COARSE TO FINE SAND, SOME FINE GRAVEL, MOIST.	684.7	4	3 3	7	44	SS-4	0.25	31	18	12	23	16	34	19	15	20	A-6a (2)	
		5	1 3	7	44	SS-4	0.25	31	18	12	23	16	34	19	15	20	A-6a (2)	
MEDIUM DENSE, BROWN TO GRAY <b>GRAVEL WITH SAND, SILT, AND CLAY</b> , MOIST.	681.0	6	5 4	12	44	SS-5	-	47	16	9	17	11	-	-	-	15	A-2-6 (V)	
		7	4 4	12	44	SS-5	-	47	16	9	17	11	-	-	-	15	A-2-6 (V)	
		8																
		9																
VERY SOFT TO SOFT, DARK BROWN TO BLACK <b>SILTY CLAY</b> , LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.	677.7	10			83	ST-6	0.50	-	-	-	-	-	-	-	-	19	A-2-6 (V)	
		11	1 1	3	100	SS-7	0.25	-	-	-	-	-	-	-	-	33	A-6b (V)	
		12	1 1	3	100	SS-7	0.25	-	-	-	-	-	-	-	-	53	A-6b (V)	
LOOSE, DARK BROWN <b>GRAVEL WITH SAND AND SILT</b> , LITTLE CLAY, WET. -INTRODUCED MUD @ 14.0'	672.7	13																
		14	1 2	7	44	SS-8	-	20	6	42	17	15	27	21	6	26	A-2-4 (0)	
		15	2 3															
		16																
		17	2 2	7	89	SS-9	-	-	-	-	-	-	-	-	-	46	A-2-4 (V)	
		18	2 3															
LOOSE, BROWN <b>COARSE AND FINE SAND</b> , LITTLE FINE GRAVEL, TRACE SILT, TRACE CLAY, WET. -WOOD FRAGMENTS PRESENT IN SS-10 -HEAVING SAND ENCOUNTERED @ 20.5'	670.2	19	2 3	10	67	SS-10	-	20	25	38	10	7	NP	NP	NP	42	A-3a (0)	
		20	3 4															
STIFF TO VERY STIFF, GRAY AND BLACK <b>SILT AND CLAY</b> , SOME COARSE TO FINE SAND, WET. -WOOD FRAGMENTS AND ORGANICS PRESENT THROUGHOUT	665.2	21	6 5	13	33	SS-11	-	-	-	-	-	-	-	-	-	51	A-6a (V)	
		22	6 5	13	33	SS-11	-	-	-	-	-	-	-	-	-	51	A-6a (V)	
		23																
		24	7 10	27	33	SS-12	-	-	-	-	-	-	-	-	-	72	A-6a (V)	
		25	7 10	27	33	SS-12	-	-	-	-	-	-	-	-	-	72	A-6a (V)	
		26																
HARD, GRAY <b>SILT</b> , LITTLE CLAY, LITTLE COARSE TO FINE SAND, WET.	662.7	27	9 11	42	67	SS-13	4.5+	0	1	21	56	22	20	15	5	20	A-4b (8)	
		28	9 18															
VERY DENSE, BROWN <b>GRAVEL AND SAND</b> , TRACE SILT, TRACE CLAY, MOIST.		29	50/1"	-	0	SS-14	-	-	-	-	-	-	-	-	-	-		

[illegible]

2014 ODOT BORING LOG-RI NE BRIDGE ID - OH DOT GDT - 3/14/15 17:33 - U:\GIS\PROJECTS\2013\W-13-045.GPJ

PID: 77372		BR ID: FRA-70-1321A		PROJECT: FRA-70-12.68 - PHASE 4A		STATION / OFFSET: 5055+67.30 / 34.3 LT				START: 5/1/14		END: 5/3/14		PG 3 OF 3		B-015-9-13							
<b>MATERIAL DESCRIPTION AND NOTES</b>				ELEV.	DEPTHS		SPT/ RQD	N <sub>60</sub>	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	HOLE SEALED	
<b>LIMESTONE</b> : GRAY AND BROWN, UNWEATHERED, STRONG, THICK TO VERY THICK BEDDED, DOLOMITIC, CALCAREOUS, CHERTY, PYRITIC, FOSSILIFEROUS, STYOLITIC, SLIGHTLY TO HIGHLY FRACTURED, OPEN APERTURES, SLIGHTLY ROUGH; RQD 78%, REC 84%. (same as above)				629.1								GR	CS	FS	SI	CL	LL	PL	PI	WC	CORE		
				626.0		EOB																	
NOTES: ELEVATION OF SCIOTO RIVER SURFACE @ 700.7																							
ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 188 LBS CEMENT / 50 LBS BENTONITE POWDER / 40 GAL WATER																							



B-015-9-13 – RC-1, RC-2, and RC-3 – Depth from 35.5 to 45.2 feet




B-015-9-13 – RC-4 and RC-5 – Depth from 45.2 to 55.2 feet





B-015-9-13 – RC-6 and RC-7 – Depth from 55.2 to 65.2 feet

	PROJECT: FRA-70-12.68 - PHASE 4A	DRILLING FIRM / OPERATOR: RII / T.F.	DRILL RIG: CME-750X (SN 310218)	STATION / OFFSET: 5058+05.01 / 33.7' LT	EXPLORATION ID <b>B-016-3-13</b>
	TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / S.B.	HAMMER: CME AUTOMATIC	ALIGNMENT: BL RAMP C5	
	PID: 77372 BR ID: FRA-70-1321A	DRILLING METHOD: 4.25" HSA / RC	CALIBRATION DATE: 4/26/13	ELEVATION: 685.0 (MSL) EOB: 58.6 ft.	PAGE 1 OF 2
	START: 4/30/14 END: 5/1/14	SAMPLING METHOD: SPT / HQ	ENERGY RATIO (%): 86.8	LAT / LONG: 39.951627935, -83.012227140	

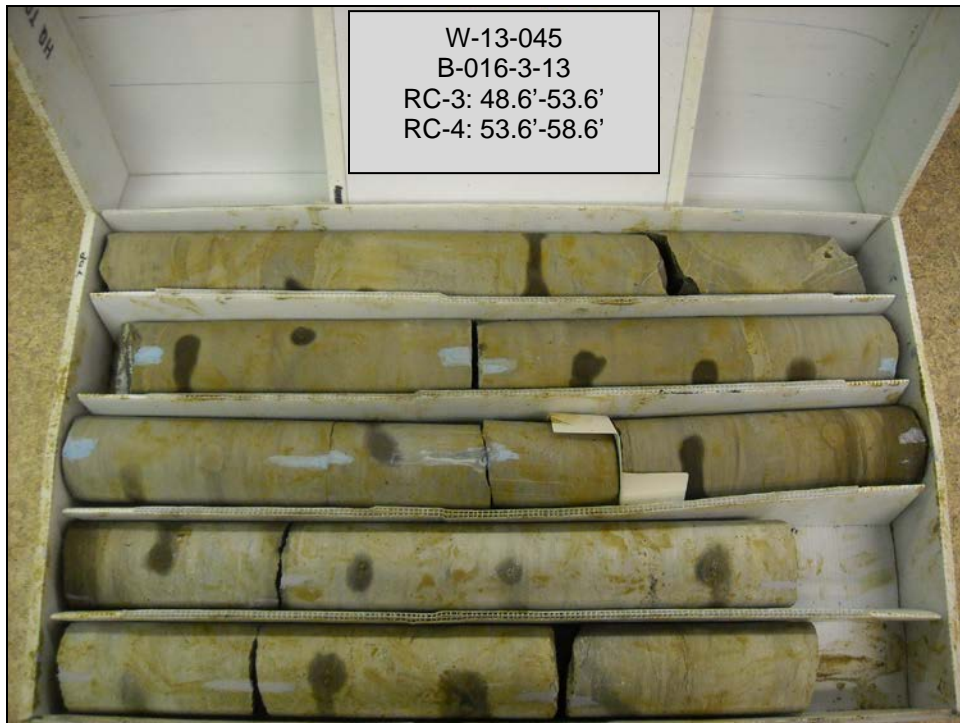
MATERIAL DESCRIPTION AND NOTES	ELEV. 685.0	DEPTHS	SPT/ RQD	N <sub>60</sub>	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
								GR	CS	FS	SI	CL	LL	PL	PI			
VERY LOOSE, BROWNISH GRAY <b>GRAVEL</b> , SOME COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, WET. -BRICK FRAGMENTS PRESENT IN SS-1	683.5	1	3 2	4	67	SS-1	-	66	16	8	7	3	NP	NP	NP	19	A-1-a (0)	
SOFT, BROWNISH GRAY AND BLACK <b>SANDY SILT</b> , SOME FINE GRAVEL, LITTLE CLAY, MOIST TO WET. -ORGANIC ODOR PRESENT IN SS-3 -INTRODUCED MUD @ 4.2'	680.5	2	1 2	4	50	SS-2	0.50	24	13	21	27	15	-	-	-	19	A-4a (V)	
LOOSE TO MEDIUM DENSE, GRAY <b>GRAVEL AND SAND</b> , LITTLE SILT, TRACE CLAY, MOIST TO WET.  -ORGANIC ODOR PRESENT IN SS-5	674.5	3	3 5	12	50	SS-3	0.50	24	13	20	28	15	27	18	9	24	A-4a (2)	
		4	1 2	7	33	SS-4	-	42	16	17	16	9	-	-	-	18	A-1-b (V)	
		5	14 5	16	44	SS-5	-	56	9	11	16	8	31	25	6	21	A-1-b (0)	
		6	6															
		7	5 6	19	56	SS-6	-	-	-	-	-	-	-	-	-	22	A-1-b (V)	
MEDIUM DENSE, GRAY <b>GRAVEL</b> , LITTLE COARSE TO FINE SAND, LITTLE SILT, TRACE CLAY, MOIST.	672.0	8	5 6	26	100	SS-7	-	69	11	6	10	4	NP	NP	NP	11	A-1-a (0)	
		9	22 9															
MEDIUM DENSE, GRAYISH BROWN <b>SANDY SILT</b> , LITTLE FINE GRAVEL, LITTLE CLAY, WET.	669.5	10	5 2	12	100	SS-8	-	12	19	20	38	11	NP	NP	NP	29	A-4a (3)	
		11	6															
VERY DENSE, BROWN <b>GRAVEL AND SAND</b> , TRACE SILT, WET.	668.3	12	7 13	72	61	SS-9	-	-	-	-	-	-	-	-	-	9	A-1-b (V)	
VERY STIFF, GRAY <b>SANDY SILT</b> , LITTLE CLAY, TRACE FINE GRAVEL, DAMP.	666.5	13	37 3				4.00	-	-	-	-	-	-	-	-	12	A-4a (V)	
		14																
VERY DENSE, BROWN <b>GRAVEL</b> , SOME COARSE TO FINE SAND, TRACE SILT, MOIST. -COBBLES ENCOUNTERED @ 18.7'	664.5	15	50/5"	-	100	SS-10	-	-	-	-	-	-	-	-	-	9	A-1-a (V)	
		16																
MEDIUM DENSE TO DENSE, GRAY <b>GRAVEL WITH SAND AND SILT</b> , TRACE CLAY, MOIST.  -HEAVING SAND ENCOUNTERED @ 23.7'	659.0	17	10 12	41	33	SS-11	-	-	-	-	-	-	21	15	6	11	A-2-4 (V)	
		18	16															
		19	14 8	22	33	SS-12	-	-	-	-	-	-	-	-	-	10	A-2-4 (V)	
		20	7															
VERY DENSE, GRAY <b>GRAVEL</b> , LITTLE COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, MOIST. -ROCK FRAGMENTS PRESENT IN SS-13		21	50/1"	-	100	SS-13	-	-	-	-	-	-	-	-	-	5	A-1-a (V)	
		22																
		23																
		24																
		25																
		26																
		27																
		28																
		29																




[illegible]



B-016-3-13 – RC-1 and RC-2 – Depth from 41.2 to 48.6 feet



B-016-3-13 – RC-3 and RC-4 – Depth from 48.6 to 58.6 feet

	PROJECT: FRA-70-12.68 - PHASE 4A	DRILLING FIRM / OPERATOR: RII / S.M./J.B.	DRILL RIG: CME-750 (SN 98048)	STATION / OFFSET: 5059+89.96 / 2.4' RT	EXPLORATION ID <b>B-016-4-13</b>
	TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / K.R./A.D.	HAMMER: CME AUTOMATIC	ALIGNMENT: BL RAMP C5	
	PID: 77372 BR ID: FRA-70-1321A	DRILLING METHOD: 3.25" HSA / RC	CALIBRATION DATE: 4/26/13	ELEVATION: 705.0 (MSL) EOB: 61.5 ft.	PAGE 1 OF 3
	START: 8/7/13 END: 8/22/13	SAMPLING METHOD: SPT / NQ	ENERGY RATIO (%): 82.6	LAT / LONG: 39.951803928, -83.011598406	

MATERIAL DESCRIPTION AND NOTES	ELEV. 705.0	DEPTHS	SPT/ RQD	N <sub>60</sub>	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
								GR	CS	FS	SI	CL	LL	PL	PI			
1.0' - TOPSOIL (12.0")	704.0																	
<b>FILL: STIFF, BROWN AND DARK BROWN SILT AND CLAY, LITTLE COARSE TO FINE SAND, LITTLE FINE GRAVEL, MOIST.</b> -BRICK AND COAL FRAGMENTS PRESENT IN SS-1	702.0	1	4															
		2	3	10	58	SS-1	1.75	-	-	-	-	-	-	-	-	16	A-6a (V)	
		3																
<b>FILL: MEDIUM DENSE, BROWN AND GRAY GRAVEL WITH SAND AND SILT, LITTLE CLAY, DAMP TO MOIST.</b> -TRACE ROOT FIBERS AND BRICK FRAGMENTS PRESENT IN SS-3	697.0	4	3	17	78	SS-2	-	25	20	23	14	18	19	12	7	10	A-2-4 (0)	
		5	5															
		6	4															
	697.0	7	4	11	89	SS-3	-	-	-	-	-	-	-	-	-	14	A-2-4 (V)	
		8																
		9	2	7	83	SS-4	0.75	1	1	7	45	46	40	18	22	29	A-6b (13)	
VERY SOFT TO MEDIUM STIFF, BROWN <b>SILTY CLAY</b> , TRACE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -TRACE ORGANICS PRESENT IN SS-4	691.0	10																
		11	WOH															
		12	1	3	100	SS-5	0.75	-	-	-	-	-	-	-	-	30	A-6b (V)	
MEDIUM DENSE, BROWN <b>GRAVEL AND SAND</b> , LITTLE SILT, TRACE CLAY, MOIST TO WET.	691.0	13																
		14		96		ST-6	0.25	-	-	-	-	-	-	-	-	34	A-6b (V)	
		15					-	-	-	-	-	-	-	-	-	27	A-1-b (V)	
-INTRODUCED MUD @ 18.5' -COBBLES ENCOUNTERED @ 20.0'	677.0	16	7															
		17	8	22	33	SS-7	-	-	-	-	-	-	-	-	-	19	A-1-b (V)	
		18																
	677.0	19	6	17	33	SS-8	-	-	-	-	-	-	-	-	-	26	A-1-b (V)	
		20	6															
		21																
MEDIUM DENSE, BROWN <b>GRAVEL</b> , SOME COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, MOIST. -COBBLES ENCOUNTERED @ 30.0'	677.0	22	4	12	61	SS-9	-	64	12	6	12	6	22	22	NP	14	A-1-b (0)	
		23																
		24	4	12	33	SS-10	-	-	-	-	-	-	-	-	-	22	A-1-b (V)	
	677.0	25	5															
		26	4															
		27	4	14	39	SS-11	-	-	-	-	-	-	-	-	-	14	A-1-b (V)	
	677.0	28																
		29	13	29	100	SS-12	-	55	23	9	3	10	23	18	5	17	A-1-a (0)	
			13															

[illegible]

2014 ODOT BORING LOG-RII NE BRIDGE ID - OH DOT GDT - 3/14/15 17:33 - U:\GIS\PROJECTS\2013\W-13-045.GPJ

PID: 77372	BR ID: FRA-70-1321A	PROJECT: FRA-70-12.68 - PHASE 4A	STATION / OFFSET: 5059+89.96 / 2.4 RT	START: 8/7/13	END: 8/22/13	PG 3 OF 3	B-016-4-13											
<b>MATERIAL DESCRIPTION AND NOTES</b>			ELEV. 642.9	DEPTHS	SPT/ RQD	N <sub>60</sub>	REC SAMPLE (%) ID	HP (tsf)	GRADATION (%)					ATTERBERG			ODOT CLASS (GI)	BACK FILL
-QU @ 59.8' = 12,760 PSI																		
NOTES: GROUNDWATER INITIALLY ENCOUNTERED @ 15.5'																		
ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 188 LBS CEMENT / 50 LBS BNTONITE POWDER / 50 GAL WATER																		



B-016-4-13 – RC-1 – Depth from 35.5 to 40.5 feet



B-016-4-13 – RC-2, RC-3, and RC-4 – Depth from 45.5 to 56.5 feet





B-016-4-13 – RC-5 – Depth from 56.5 to 61.5 feet





PROJECT: FRA-70-12.68 - PHASE 4A  
 TYPE: STRUCTURE  
 PID: 77372 BR ID: FRA-70-1321A  
 START: 8/9/13 END: 8/13/13

DRILLING FIRM / OPERATOR: RII / T.F.  
 SAMPLING FIRM / LOGGER: RII / A.D.  
 DRILLING METHOD: 4.25" HSA / RC  
 SAMPLING METHOD: SPT / HQ

DRILL RIG: CME-750X (SN 310218)  
 HAMMER: CME AUTOMATIC  
 CALIBRATION DATE: 4/26/13  
 ENERGY RATIO (%): 86.8

STATION / OFFSET: 5062+32.40 / 14' RT  
 ALIGNMENT: BL RAMP C5  
 ELEVATION: 740.1 (MSL) EOB: 94.9 ft.  
 LAT / LONG: 39.952081479, -83.010812274

EXPLORATION ID  
**B-016-5-13**

PAGE  
 1 OF 4

MATERIAL DESCRIPTION AND NOTES	ELEV. 740.1	DEPTHS	SPT/ RQD	N <sub>60</sub>	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
								GR	CS	FS	SI	CL	LL	PL	PI			
0.3' - ASPHALT (4.0")	739.8																	
0.5' - CONCRETE (6.0")	739.3																	
0.2' - AGGREGATE BASE (2.0")	739.1																	
FILL: VERY STIFF, DARK BROWNISH GRAY TO DARK GRAYISH BROWN <b>SILTY CLAY</b> , SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, MOIST.		1	4	7	22	56	SS-1	2.75	-	-	-	-	-	-	-	17	A-6b (V)	
		2		8														
		3																
		4	4	6	22	61	SS-2	2.50	19	8	13	36	24	33	17	16	A-6b (7)	
		5		9														
		6	11	12	35	61	SS-3	3.00	-	-	-	-	-	-	-	13	A-6b (V)	
		7		12														
		8																
		9	8	10	33	72	SS-4	2.50	-	-	-	-	-	-	-	17	A-6b (V)	
	729.6	10		13														
FILL: MEDIUM DENSE TO DENSE, DARK BROWN <b>GRAVEL WITH SAND, SILT, AND CLAY</b> , MOIST.		11	8	10	30	78	SS-5	-	28	16	24	4	28	40	19	21	A-2-6 (2)	
		12		11														
		13																
		14	5	8	27	83	SS-6	-	-	-	-	-	-	-	-	15	A-2-6 (V)	
		15		11														
		16																
		17	9	9	33	78	SS-7	-	-	-	-	-	-	-	-	20	A-2-6 (V)	
		18		14														
	722.1	19	4	6	13	56	SS-8	1.50	27	18	19	22	14	28	18	10	A-4a (0)	
		20		3														
FILL: STIFF, DARK BROWN <b>SANDY SILT</b> , SOME FINE GRAVEL, LITTLE SILT, DAMP. -COBBLES ENCOUNTERED @ 18.5'  -SLAG FRAGMENTS PRESENT IN SS-8 -BRICK AND CONCRETE FRAGMENTS PRESENT IN SS-9		21	2	4	19	61	SS-9	-	-	-	-	-	-	-	-	14	A-4a (V)	
		22		9														
	717.1	23																
		24	18	9	27	39	SS-10	-	-	-	-	-	-	-	-	8	A-2-4 (V)	
		25		10														
		26	7	4	13	72	SS-11	-	40	20	13	18	9	26	19	7	A-2-4 (0)	
		27		5														
	712.1	28																
		29	7	4	13	72	SS-12	-	-	-	-	-	-	-	-	28	A-2-6 (V)	
				5														
MEDIUM DENSE, BROWN <b>GRAVEL WITH SAND, SILT, AND CLAY</b> , WET.																		

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[illegible]

2014 ODOT BORING LOG-RII NE BRIDGE ID - OH DOT GDT - 3/14/15 17:34 - U:\GIS\PROJECTS\2013\W-13-045.GPJ

PID: 77372		BR ID: FRA-70-1321A		PROJECT: FRA-70-12.68 - PHASE 4A		STATION / OFFSET: 5062+32.40 / 14 RT				START: 8/9/13		END: 8/13/13		PG 4 OF 4		B-016-5-13							
MATERIAL DESCRIPTION AND NOTES				ELEV.	DEPTHS	SPT/ RQD	N <sub>60</sub>	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL		
				645.8							GR	CS	FS	SI	CL	LL	PL	PI					
				645.2	EOB																		
NOTES: GROUNDWATER INITIALLY ENCOUNTERED @ 48.5'																							
ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 188 LBS CEMENT / 50 LBS BENTONITE POWDER / 50 GAL WATER																							



B-016-5-13 – RC-1, RC-2, and RC-3 – Depth from 84.9 to 94.9 feet

	PROJECT: FRA-70-13.10 - PHASE 6A	DRILLING FIRM / OPERATOR: RII / J.B.	DRILL RIG: CME-750 (SN 98048)	STATION / OFFSET: 3052+85.29 / 31.4' LT	<b>EXPLORATION ID</b> <b>B-016-7-13</b>
	TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / C.V.	HAMMER: CME AUTOMATIC	ALIGNMENT: BL RAMP D3	
	PID: 89464 BR ID: N/A	DRILLING METHOD: 4.25" HSA	CALIBRATION DATE: 4/26/13	ELEVATION: 714.9 (MSL) EOB: 48.7 ft.	PAGE 1 OF 2
	START: 1/14/14 END: 1/15/14	SAMPLING METHOD: SPT	ENERGY RATIO (%): 82.6	LAT / LONG: 39.953121, -83.010293	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N <sub>60</sub>	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
								GR	CS	FS	SI	CL	LL	PL	PI			
0.3' - TOPSOIL (3.0") <b>FILL:</b> MEDIUM DENSE, DARK BROWN AND BLACK <b>GRAVEL WITH SAND, SILT, AND CLAY</b> , MOIST TO WET. -ROOT FIBERS PRESENT IN SS-1 -COBBLES ENCOUNTERED @ 2.5' -CONCRETE AND LIMESTONE FRAGMENTS PRESENT THROUGHOUT	714.9																	
	714.6	1	8															
		2	6	19	33	SS-1	-	-	-	-	-	-	-	-	-	21	A-2-6 (V)	
		3																
		4	6															
		5	7	17	50	SS-2	-	55	9	7	15	14	35	19	16	10	A-2-6 (1)	
	709.4	6																
<b>FILL:</b> VERY STIFF, BROWN <b>SILTY CLAY</b> , LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -STONE FRAGMENTS PRESENT IN SS-3		7	4	12	56	SS-3	2.75	-	-	-	-	-	-	-	-	17	A-6b (V)	
	706.9	8																
<b>FILL:</b> DENSE, GRAY <b>GRAVEL WITH SAND AND SILT</b> , TRACE CLAY, DAMP. -COBBLES ENCOUNTERED @ 8.0' -LIMESTONE FRAGMENTS PRESENT THROUGHOUT -ROOT FIBERS PRESENT IN SS-5		9	8	45	33	SS-4	-	-	-	-	-	-	-	-	-	5	A-2-4 (V)	
		10	18															
		11	18															
		12	17	37	44	SS-5	-	64	14	7	10	5	30	22	8	6	A-2-4 (0)	
	701.9	13																
<b>FILL:</b> STIFF TO VERY STIFF, DARK BROWN TO DARK BROWNISH GRAY <b>SILT AND CLAY</b> , LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -ROOT FIBERS AND BRICK FRAGMENTS PRESENT IN SS-6		14	5	19	61	SS-6	2.50	-	-	-	-	-	-	-	-	17	A-6a (V)	
		15	7															
		16	4															
		17	5	12	78	SS-7	1.75	-	-	-	-	-	-	-	-	23	A-6a (V)	
	697.4	18																
STIFF, DARK BROWN AND BLACK <b>SILTY CLAY</b> , LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -QU @ 17.9' = 1.29 TSF		19			88	ST-8	2.00	1	2	18	40	39	40	21	19	31	A-6b (12)	
		20																
		21																
	692.9	22																
VERY LOOSE, DARK GRAY <b>GRAVEL WITH SAND AND SILT</b> , LITTLE CLAY, WET.		23																
		24	WOH															
		25	2	4	100	SS-9	-	3	24	39	20	14	29	21	8	40	A-2-4 (0)	
		26	1															
		27																
	687.9	28																
VERY DENSE, GRAY <b>GRAVEL WITH SAND</b> , TRACE SILT, TRACE CLAY, MOIST. -COBBLES ENCOUNTERED @ 27.0' -ROCK FRAGMENTS PRESENT IN SS-10		29	11	80	36	SS-10	-	-	-	-	-	-	-	-	-	10	A-1-b (V)	
			37															
			21															

PID: 89464	BR ID: N/A	PROJECT: FRA-70-13.10 - PHASE 6A	STATION / OFFSET: 3052+85.29 / 31.4 LT					START: 1/14/14		END: 1/15/14		PG 2 OF 2		B-016-7-13								
MATERIAL DESCRIPTION AND NOTES			ELEV.	DEPTHS		SPT/ RQD	N <sub>60</sub>	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL	
			684.9								GR	CS	FS	SI	CL	LL	PL	PI				
VERY DENSE, GRAY <b>GRAVEL WITH SAND</b> , TRACE SILT, TRACE CLAY, MOIST. <i>(same as above)</i>			682.9	31																		
HARD, GRAY <b>SILT AND CLAY</b> , LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, DRY.			677.9	32																		
-ROCK FRAGMENTS PRESENT IN SS-11				33																		
				34		20	58	94	SS-11	4.5+	-	-	-	-	-	-	-	-	9	A-6a (V)		
				35		21	21															
				36																		
VERY DENSE, GRAY <b>GRAVEL WITH SAND</b> , TRACE SILT, TRACE CLAY, WET.			672.9	37																		
-INTORDUCED MUD @ 37.0'				38																		
-ROCK FRAGMENTS PRESENT IN SS-12				39		7	54	61	SS-12	-	26	31	25	10	8	NP	NP	NP	23	A-1-b (0)		
				40		14	25															
				41																		
-COBBLES ENCOUNTERED @ 41.0'			667.9	42																		
HARD, GRAY <b>SILT AND CLAY</b> , LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP.				43																		
-ROCK FRAGMENTS PRESENT IN SS-13				44		3	78	89	SS-13	4.5+	-	-	-	-	-	-	-	-	16	A-6a (V)		
				45		35	22															
				46																		
VERY DENSE, GRAYISH BROWN <b>GRAVEL WITH SAND</b> , LITTLE SILT, TRACE CLAY, MOIST.			666.2	47																		
				48		60/2"	-	100	SS-14	-	-	-	-	-	-	-	-	-	11	A-1-b (V)		
EOB																						
NOTES: GROUNDWATER ENCOUNTERED INITIALLY @ 19.0'; CAVE-IN DEPTH @ 35.0'																						
ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS																						



PROJECT: FRA-70-13.10 - PHASE 6A  
 TYPE: STRUCTURE  
 PID: 89464 BR ID: FRA-70-1323C  
 START: 12/7/20 END: 12/7/20

DRILLING FIRM / OPERATOR: RII / S.B.  
 SAMPLING FIRM / LOGGER: RII / K.S.  
 DRILLING METHOD: 3.25" HSA  
 SAMPLING METHOD: SPT

DRILL RIG: CME-750X SN 310218  
 HAMMER: CME AUTOMATIC  
 CALIBRATION DATE: 9/14/20  
 ENERGY RATIO (%): 86.2

STATION / OFFSET: 3053+93.67 / 12.3' LT  
 ALIGNMENT: BL RAMP D3  
 ELEVATION: 751.0 (MSL) EOB: 60.0 ft.  
 COORD: 39.953168, -83.009903

EXPLORATION ID  
**B-019-5-19**

PAGE  
 1 OF 2


MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N <sub>60</sub>	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
								GR	CS	FS	SI	CL	LL	PL	PI			
0.3' - ASPHALT (3.0")	751.0																	
0.9' - CONCRETE (11.0")	750.7																	
FILL: HARD, BROWN <b>SILTY CLAY</b> , "AND" FINE GRAVEL, LITTLE FINE TO COARSE SAND, DAMP. -ROCK FRAGMENTS PRESENT IN SS-1	749.8	1	7	37	67	SS-1	4.50	-	-	-	-	-	-	-	-	14	A-6b (V)	
		2	9															
		3	17															
		4	4	27	61	SS-2	4.50	37	12	5	23	23	39	17	22	14	A-6b (6)	
		5	7															
	745.5	6	12															
FILL: MEDIUM DENSE, GRAY <b>GRAVEL WITH SAND</b> , LITTLE SILT, TRACE CLAY, DAMP.		7	9	23	50	SS-3	-	-	-	-	-	-	-	-	-	4	A-1-b (V)	
		8	6															
	743.0	9	10															
FILL: HARD, DARK GRAY TO BROWN <b>SILTY CLAY</b> , SOME FINE GRAVEL, LITTLE COARSE TO FINE SAND, MOIST. -ROCK FRAGMENTS PRESENT IN SS-4		10	7	-	81	SS-4	4.50	-	-	-	-	-	-	-	-	18	A-6b (V)	
		11	11															
	740.5	12	50/4"															
FILL: VERY DENSE, LIGHT BROWN TO GRAY <b>GRAVEL WITH SAND</b> , LITTLE SILT, TRACE CLAY, DAMP.		13	26	-	100	SS-5	-	52	19	10	11	8	29	23	6	9	A-1-b (0)	
		14	48															
		15	50/2"															
-COBBLES @ 13.5'		16		-	100	SS-6	-	-	-	-	-	-	-	-	-	5	A-1-b (V)	
		17	50/3"															
-ROCK FRAGMENTS PRESENT THROUGHOUT		18		-	100	SS-7	-	-	-	-	-	-	-	-	-	9	A-1-b (V)	
		19	50/5"															
	733.5	20		-	100	SS-8	4.00	-	-	-	-	-	-	-	-	17	A-6a (V)	
FILL: VERY STIFF, BROWN <b>SILT AND CLAY</b> , SOME FINE GRAVEL, LITTLE COARSE TO FINE SAND, MOIST. -ROCK FRAGMENTS PRESENT IN SS-8		21	3	17	83													
		22	5															
		23	7															
		24	6	22	33	SS-9	2.50	-	-	-	-	-	-	-	-	15	A-6a (V)	
		25	7															
		26	8															
	724.0	27																
FILL: HARD, BROWN <b>CLAY</b> , SOME SILT, TRACE COARSE TO FINE SAND, MOIST.		28																
		29	3	17	67	SS-10	4.50	0	3	5	24	68	46	23	23	24	A-7-6 (14)	
			5															
			7															



[illegible]

NOTES: GROUNDWATER ENCOUNTERED INITIALLY @ 48.5' AND AT COMPLETION @ 57.0'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS. PAVEMENT PATCHED WITH ASPHALT COLD PATCH.

	PROJECT: FRA-70-13.10 - PHASE 6A		DRILLING FIRM / OPERATOR: RII / J.K.		DRILL RIG: CME-55 (SN 386345)		STATION / OFFSET: 249+37.84 / 28.1' RT		EXPLORATION ID B-113-4-13												
	TYPE: STRUCTURE		SAMPLING FIRM / LOGGER: RII / S.B.		HAMMER: AUTOMATIC		ALIGNMENT: BL I-71 SB														
	PID: 89464 BR ID: FRA-71-1503L		DRILLING METHOD: 3.25" HSA / NQ		CALIBRATION DATE: 10/20/14		ELEVATION: 725.2 (MSL) EOB: 88.3 ft.		PAGE 1 OF 3												
	START: 5/29/14 END: 6/3/14		SAMPLING METHOD: SPT / RC		ENERGY RATIO (%): 92		LAT / LONG: 39.952170, -83.013979														
	MATERIAL DESCRIPTION AND NOTES			ELEV.	DEPTHS	SPT/ RQD	N <sub>60</sub>	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	HOLE SEALED
			725.2								GR	CS	FS	SI	CL	LL	PL	PI	WC		
0.5' - TOPSOIL (6.0")			724.7																		
POSSIBLE FILL: VERY STIFF TO HARD, DARK BROWN SILT AND CLAY, SOME COARSE TO FINE SAND, SOME FINE GRAVEL, DAMP.				1	6																
				2	11	26	78	SS-1	4.50	-	-	-	-	-	-	-	-	-	15	A-6a (V)	
				3																	
-ROCK, COAL AND BRICK FRAGMENTS PRESENT THROUGHOUT				4	2																
				5	6	18	61	SS-2	2.75	32	14	13	21	20	35	20	15	12	A-6a (3)		
			719.7																		
DENSE, BROWN GRAVEL WITH SAND, TRACE SILT, TRACE CLAY, DAMP.				6	11																
				7	6	20	44	SS-3	-	-	-	-	-	-	-	-	-	5	A-1-b (V)		
				8																	
-ROCK FRAGMENTS PRESENT THROUGHOUT				9	6	20	33	SS-4	-	-	-	-	-	-	-	-	-	4	A-1-b (V)		
			714.7																		
VERY STIFF, BROWN SILT AND CLAY, SOME COARSE TO FINE SAND, SOME FINE GRAVEL, DAMP.				10																	
				11	3	14	67	SS-5	2.50	25	14	14	27	20	28	17	11	16	A-6a (3)		
			712.2																		
LOOSE, BROWN GRAVEL WITH SAND, SILT, AND CLAY, MOIST.				12																	
				13																	
				14	5	11	83	SS-6	-	54	13	7	15	11	30	18	12	13	A-2-6 (0)		
			709.7																		
LOOSE, BROWN GRAVEL WITH SAND, TRACE SILT, TRACE CLAY, DAMP.				15																	
				16	8																
			707.9																		
MEDIUM STIFF TO STIFF, DARK BROWN SANDY SILT, LITTLE CLAY, TRACE FINE GRAVEL, MOIST.				17	4	11	56	SS-7	-	-	-	-	-	-	-	-	-	4	A-1-b (V)		
				18					1.50	-	-	-	-	-	-	-	-	16	A-4a (V)		
-TRACE ORGANICS PRESENT THROUGHOUT				19	2	6	72	SS-8	1.00	6	13	20	41	20	32	24	8	23	A-4a (5)		
			704.7																		
MEDIUM DENSE TO VERY DENSE, BROWN GRAVEL WITH SAND, LITTLE SILT, TRACE CLAY, MOIST.				20																	
				21	11																
				22	8	30	0	SS-9	-	-	-	-	-	-	-	-	-	-			
				23	12	-	67	2S-9A	-	-	-	-	-	-	-	-	-	8	A-1-b (V)		
				24	15	-	80	SS-10	-	57	18	6	13	6	23	18	5	8	A-1-b (0)		
				25	17																
-BOULDER PRESENT FROM 25.0' TO 25.5'			699.7																		
VERY DENSE, GRAY GRAVEL, SOME COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, DAMP.				26	50/3"	-	100	SS-11	-	-	-	-	-	-	-	-	-	-	A-1-a (V)		
				27																	
				28																	
				29	33	71	100	SS-12	-	63	17	7	9	4	NP	NP	NP	4	A-1-a (0)		
					25																
					22																

[illegible]

[illegible]


ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 188 LBS CEMENT / 50 LBS BENTONITE POWDER / 40 GAL WATER



B-113-4-13 – RC-1 and RC-2 – Depth from 73.3 to 83.3 feet



B-113-4-13 – RC-3 – Depth from 83.3 to 88.3 feet

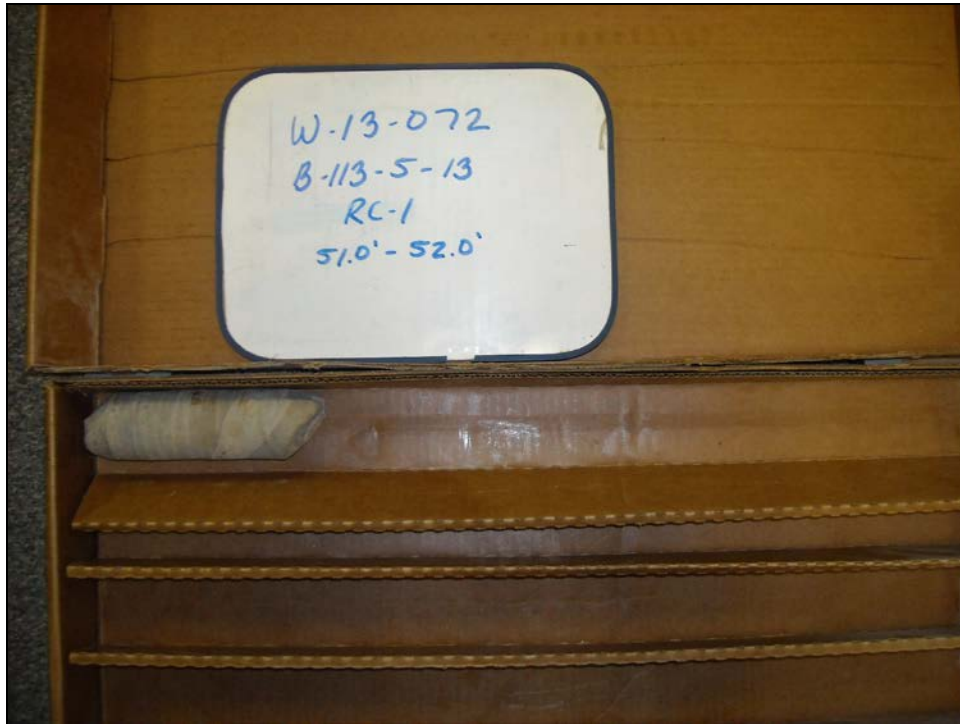
	PROJECT: FRA-70-13.10 - PHASE 6A	DRILLING FIRM / OPERATOR: RII / J.K.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: 250+13.44 / 36.0' RT	EXPLORATION ID <b>B-113-5-13</b>
	TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / S.B.	HAMMER: AUTOMATIC	ALIGNMENT: BL I-71 SB	
	PID: 89464 BR ID: FRA-71-1503L	DRILLING METHOD: 3.25" HSA / NQ	CALIBRATION DATE: 4/26/13	ELEVATION: 725.7 (MSL) EOB: 85.7 ft.	PAGE 1 OF 3
	START: 5/27/14 END: 5/28/14	SAMPLING METHOD: SPT / RC	ENERGY RATIO (%): 77.7	LAT / LONG: 39.952236, -83.013729	

MATERIAL DESCRIPTION AND NOTES	ELEV. 725.7	DEPTHS	SPT/ RQD	N <sub>60</sub>	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
								GR	CS	FS	SI	CL	LL	PL	PI			
0.5' - TOPSOIL (6.0")	725.2																	
<b>FILL: HARD, DARK BROWN SILT AND CLAY</b> , SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, DRY TO DAMP.  -BRICK FRAGMENTS PRESENT THROUGHOUT		1	8															
		2	9 10	25	44	SS-1	4.25	20	13	14	30	23	33	19	14	14	A-6a (5)	
		3																
		4	8 7	17	67	SS-2	4.25	-	-	-	-	-	-	-	-	11	A-6a (V)	
	720.2	5	6															
<b>FILL: LOOSE TO MEDIUM DENSE, BROWN TO DARK BROWN GRAVEL WITH SAND</b> , LITTLE SILT, LITTLE CLAY, MOIST. -ROCK FRAGMENTS PRESENT IN SS-3		6	7															
		7	3 7	13	44	SS-3	-	39	12	24	13	12	22	16	6	11	A-1-b (0)	
		8																
		9	3 4	9	39	SS-4	-	-	-	-	-	-	-	-	-	13	A-1-b (V)	
	715.2	10																
MEDIUM DENSE, DARK BROWN TO GRAY <b>GRAVEL</b> , TRACE COARSE TO FINE SAND, TRACE SILT, DAMP TO MOIST.		11	7															
		12	9 9	23	33	SS-5	-	-	-	-	-	-	-	-	-	8	A-1-a (V)	
		13																
		14	9 8	21	0	SS-6	-	-	-	-	-	-	-	-	-	-		
	707.7	15	5 8	-	83	2S-6A	-	-	-	-	-	-	-	-	-	5	A-1-a (V)	
		16	14 11	23	33	SS-7	-	-	-	-	-	-	-	-	-	3	A-1-a (V)	
		17	7															
		18																
MEDIUM DENSE, BROWN <b>GRAVEL WITH SAND</b> , TRACE SILT, TRACE CLAY, DAMP. -ROCK FRAGMENTS PRESENT IN 2S-8A		19	10 11	30	0	SS-8	-	-	-	-	-	-	-	-	-	-		
		20	9 12	-	100	2S-8A	-	63	15	6	9	7	23	17	6	6	A-1-b (0)	
VERY STIFF, BROWN <b>SILT AND CLAY</b> , SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP.		21	7															
		22	8 9	22	94	SS-9	3.00	-	-	-	-	-	-	-	-	11	A-6a (V)	
	705.2	23																
MEDIUM DENSE TO VERY DENSE, BROWNISH GRAY <b>GRAVEL</b> , SOME COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, DAMP TO MOIST.		24	6 5	13	0	SS-10	-	-	-	-	-	-	-	-	-	-		
		25	6 5	-	0	2S-10A	-	-	-	-	-	-	-	-	-	-		
		26	6															
		27	8 12	26	44	SS-11	-	-	-	-	-	-	-	-	-	9	A-1-a (V)	
	702.7	28																
-COBBLES PRESENT THROUGHOUT		29	9 15	58	89	SS-12	-	64	16	5	10	5	22	16	6	6	A-1-a (0)	
			30															

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B-113-5-13 – RC-1 – Depth from 51.0 to 52.0 feet



B-113-5-13 – RC-2, RC-3, and RC-4 – Depth from 52.0 to 80.7 feet



B-113-5-13 – RC-5 - Depth from 80.7 to 85.7 feet



PROJECT: FRA-70-13.10 - PHASE 6A  
 TYPE: STRUCTURE  
 PID: 89464 BR ID: FRA-71-1503L  
 START: 4/23/14 END: 4/23/14

DRILLING FIRM / OPERATOR: RII / T.F.  
 SAMPLING FIRM / LOGGER: RII / S.B.  
 DRILLING METHOD: 4.25" HSA / HQ  
 SAMPLING METHOD: SPT / RC

DRILL RIG: CME-750X (SN 310218)  
 HAMMER: CME AUTOMATIC  
 CALIBRATION DATE: 4/26/13  
 ENERGY RATIO (%): 86.8

STATION / OFFSET: 251+93.56 / 37.3' RT  
 ALIGNMENT: BL I-71 SB  
 ELEVATION: 691.5 (MSL) EOB: 63.7 ft.  
 LAT / LONG: 39.952409, -83.013137

EXPLORATION ID  
**B-113-6-13**

PAGE  
 1 OF 3

MATERIAL DESCRIPTION AND NOTES	ELEV. 691.5	DEPTHS	SPT/ RQD	N <sub>60</sub>	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
								GR	CS	FS	SI	CL	LL	PL	PI			
VERY LOOSE TO LOOSE, BLACK TO BROWN AND GRAY <b>GRAVEL WITH SAND, SILT, AND CLAY</b> , MOIST. -ORGANICS AND PLANT MATERIAL PRESENT IN SS-1	691.5	1	1	4	33	SS-1	-	42	17	18	14	9	-	-	-	26	A-2-6 (V)	
		2	1	6	56	SS-2	1.50	45	12	11	19	13	31	19	12	17	A-2-6 (0)	
		3	2	6	61	SS-3	1.50	43	14	11	19	13	32	19	13	18	A-2-6 (1)	
		4	2	6	61	SS-3	1.50	43	14	11	19	13	32	19	13	18	A-2-6 (1)	
		5	1	2	7	0	SS-4	-	-	-	-	-	-	-	-	-		
		6	6	3	-	100	3S-4A	2.00	53	17	9	13	8	-	-	-	18	
LOOSE TO MEDIUM DENSE, BLACK AND GRAY <b>GRAVEL</b> , LITTLE COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, MOIST.  -INTRODUCED MUD @ 12.0'	681.7	7																
		8	2															
		9	1	3	0	SS-5	-	-	-	-	-	-	-	-	-	-		
DENSE TO VERY DENSE, BROWN AND GRAY TO BROWN <b>GRAVEL</b> , SOME COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, MOIST.	678.7	10	6	-	50	3S-5A	-	-	-	-	-	-	-	-	-	13	A-1-a (V)	
		11	8															
		12	6	14	33	SS-6	-	72	13	6	5	4	NP	NP	NP	14	A-1-a (0)	
		13																
		14	13															
		15	32	100	0	SS-7	-	-	-	-	-	-	-	-	-	-		
		16	37															
		17	50	-	100	3S-7A	-	-	-	-	-	-	-	-	-	8	A-1-a (V)	
		18																
		19	10	49	78	SS-8	-	-	-	-	-	-	-	-	-	9	A-1-a (V)	
		20	17															
		21	18															
		22	24	69	89	SS-9	-	66	17	6	7	4	NP	NP	NP	9	A-1-a (0)	
		23	24															
		24																
		25	20															
		26	40	94	67	SS-10	-	-	-	-	-	-	-	-	-	8	A-1-a (V)	
		27	25															
		28	45															
		29	47	127	100	SS-11	-	-	-	-	-	-	-	-	-	9	A-1-a (V)	
		30	41															
				31	6													
32	37			123	89	SS-12	-	64	16	6	10	4	NP	NP	NP	9	A-1-a (0)	
33	48																	
		34																
		35	20															
		36	36	107	61	SS-13	-	-	-	-	-	-	-	-	8	A-1-a (V)		
		37	38															

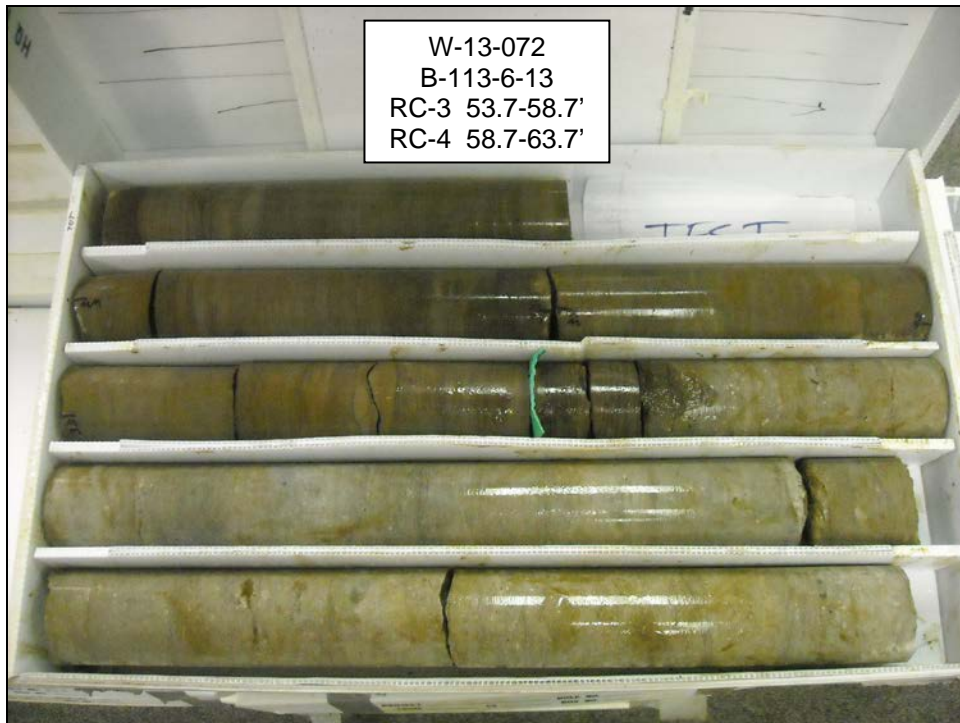
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B-113-6-13 – RC-1 and RC-2 – Depth from 43.9 to 53.7 feet



B-113-6-13 – RC-3 and RC-4 – Depth from 53.7 to 63.7 feet

	PROJECT: FRA-70-13.10 - PHASE 6A		DRILLING FIRM / OPERATOR: RII / T.F.		DRILL RIG: CME-750X (SN 310218)		STATION / OFFSET: 254+41.19 / 36.0' RT		EXPLORATION ID B-113-7-13													
	TYPE: STRUCTURE		SAMPLING FIRM / LOGGER: RII / S.B.		HAMMER: CME AUTOMATIC		ALIGNMENT: BL I-71 SB															
	PID: 89464 BR ID: FRA-71-1503L		DRILLING METHOD: 4.25" HSA / HQ		CALIBRATION DATE: 4/26/13		ELEVATION: 690.3 (MSL) EOB: 55.7 ft.		PAGE 1 OF 2													
	START: 4/24/14 END: 4/25/14		SAMPLING METHOD: SPT / RC		ENERGY RATIO (%): 86.8		LAT / LONG: 39.952640, -83.012306															
	MATERIAL DESCRIPTION AND NOTES			ELEV.	DEPTHS		SPT/ RQD	N <sub>60</sub>	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	HOLE SEALED
			690.3									GR	CS	FS	SI	CL	LL	PL	PI	WC		
VERY LOOSE, GRAYISH BROWN <b>GRAVEL WITH SAND AND SILT</b> , TRACE CLAY, WET.			688.8			1	WOH 2	3	33	SS-1	-	24	17	29	20	10	NP	NP	NP	22	A-2-4 (0)	
VERY LOOSE TO LOOSE, DARK GRAYISH BROWN TO BLACK <b>GRAVEL WITH SAND</b> , TRACE SILT, TRACE CLAY, WET.			684.3			2	2	6	44	SS-2	-	8	47	34	8	3	-	-	-	31	A-1-b (V)	
						3	1															
						4	1	3	44	SS-3	-	12	40	37	8	3	NP	NP	NP	32	A-1-b (0)	
						5	1															
						6	2	4	100	SS-4	-	5	47	36	10	2	-	-	-	28	A-1-b (V)	
VERY LOOSE TO LOOSE, DARK GRAY <b>SANDY SILT</b> , LITTLE CLAY, TRACE FINE GRAVEL, WET. -INTRODUCED MUD @ 6.4'			680.2			7	1	3	67	SS-5	-	6	9	48	26	11	NP	NP	NP	53	A-4a (0)	
						8	2															
						9	1	6	33	SS-6	-	-	-	-	-	-	-	-	45	A-4a (V)		
						10	3															
						11	8															
DENSE, GRAYISH BROWN <b>GRAVEL</b> , SOME COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, MOIST. -COBBLES PRESENT @ 10.6'			675.2			12	10	36	89	SS-7	-	56	24	7	10	3	NP	NP	NP	12	A-1-a (0)	
						13	15															
						14	5	35	100	SS-8	-	-	-	-	-	-	-	-	13	A-1-a (V)		
						15	8	16														
						16	4															
VERY DENSE, GRAY <b>GRAVEL WITH SAND</b> , TRACE SILT, TRACE CLAY, DAMP TO MOIST.			670.5			17	35	101	89	SS-9	-	38	38	12	8	4	NP	NP	NP	11	A-1-b (0)	
						18	35															
						19	60/3"	-	100	SS-10	-	-	-	-	-	-	-	-	8	A-1-b (V)		
						20	0		75	RC-1										CORE		
						21	35	-	100	SS-11	-	60	13	11	12	4	NP	NP	NP	5	A-1-b (0)	
-AUGER REFUSAL @ 19.8', SWITCHED TO ROCK CORING AND CORED THROUGH 0.8' THICK LIMESTONE BOULDER, CONTINUED SAMPLING @ 20.8'. <b>LIMESTONE BOULDER</b>			664.7			22	50/3"															
						23	60/2"	-	100	SS-12	-	-	-	-	-	-	-	-	9	A-1-b (V)		
						24																
						25																
						26	28															
VERY DENSE, BROWN <b>GRAVEL WITH SAND AND SILT</b> , TRACE CLAY, MOIST.			662.7			27	30	94	67	SS-13	-	-	-	-	-	-	-	-	11	A-2-4 (V)		
						28	35															
HARD, BROWN AND GRAY <b>SILTY CLAY</b> , SOME FINE GRAVEL, LITTLE COARSE TO FINE SAND, DAMP.			660.5			29	48	-	80	SS-14	4.50	25	8	11	20	36	36	17	19	13	A-6b (8)	
AUGER REFUSAL @ 29.8 FEET							50															
							50/3"															



[illegible]

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 188 LBS CEMENT / 50 LBS BENTONITE POWDER / 40 GAL WATER



B-113-7-13 – RC-1 – Depth from 19.6 to 20.6 feet



B-113-7-13 – RC-2 and RC-3 – Depth from 29.8 to 35.7 feet




B-113-7-13 – RC-4 – Depth from 35.7 to 40.7 feet



B-113-7-13 – RC-5 and RC-6 – Depth from 40.7 to 50.7 feet



B-113-7-13 – RC-7 – Depth from 50.7 to 55.7 feet

	PROJECT: FRA-70-13.10 - PHASE 6A	DRILLING FIRM / OPERATOR: RII / T.F.	DRILL RIG: CME-750X (SN 310218)	STATION / OFFSET: 256+62.64 / 36.0' RT	EXPLORATION ID <b>B-113-8-13</b>
	TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / S.B.	HAMMER: CME AUTOMATIC	ALIGNMENT: BL I-71 SB	
	PID: 89464 BR ID: FRA-71-1503L	DRILLING METHOD: 4.25" HSA / HQ	CALIBRATION DATE: 4/26/13	ELEVATION: 691.0 (MSL) EOB: 66.2 ft.	PAGE 1 OF 3
	START: 4/28/14 END: 4/29/14	SAMPLING METHOD: SPT / RC	ENERGY RATIO (%): 86.8	LAT / LONG: 39.952843, -83.011561	

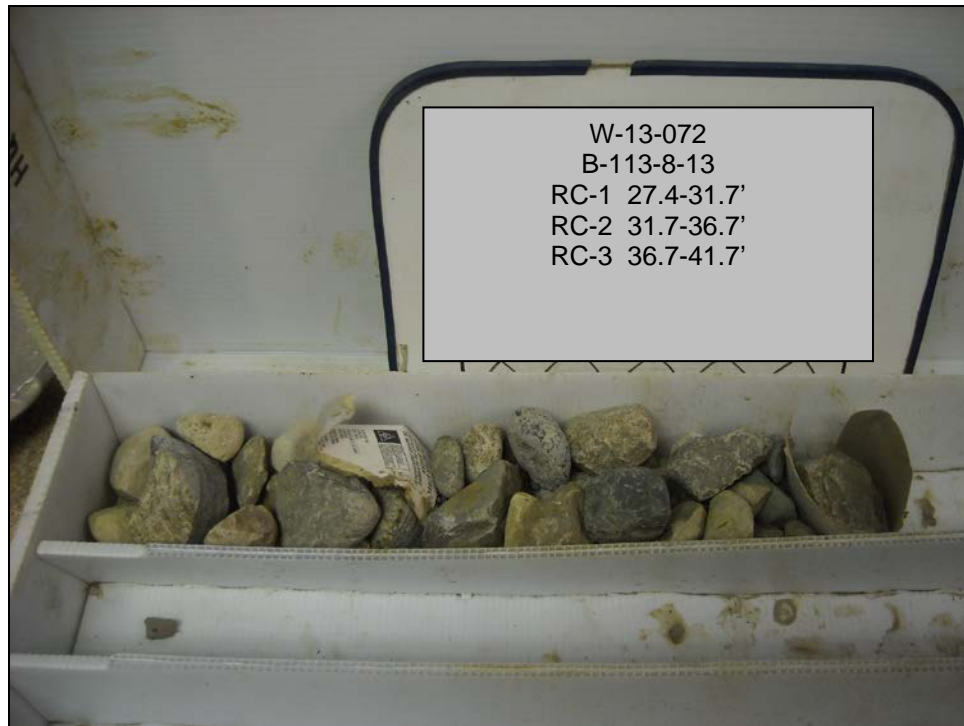
MATERIAL DESCRIPTION AND NOTES	ELEV. 691.0	DEPTHS	SPT/ RQD	N <sub>60</sub>	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
								GR	CS	FS	SI	CL	LL	PL	PI			
MEDIUM DENSE, BROWNISH GRAY <b>GRAVEL</b> WITH <b>SAND</b> , TRACE CLAY, TRACE SILT, WET.	689.5	1	4 6	17	33	SS-1	-	43	33	19	2	3	-	-	-	20	A-1-b (V)	
LOOSE TO MEDIUM DENSE, BROWNISH GRAY <b>GRAVEL</b> , SOME COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, MOIST.		2	5 6	16	33	SS-2	-	57	19	11	8	5	NP	NP	NP	14	A-1-a (0)	
		3	5 4	9	44	SS-3	3.00	56	18	11	9	6	-	-	-	14	A-1-a (V)	
		4	2															
		5	3 6	17	44	SS-4	-	60	17	10	8	5	NP	NP	NP	15	A-1-a (0)	
		6	6															
		7																
-INTRODUCED MUD @ 7.2'		8	7 8	22	11	SS-5	-	-	-	-	-	-	-	-	-	17	A-1-a (V)	
MEDIUM DENSE, BROWN <b>COARSE AND FINE SAND</b> , LITTLE FINE GRAVEL, TRACE SILT, WET.	681.8	9	10	-	100	3S-5A	-	70	16	6	6	2	NP	NP	NP	13	A-1-a (0)	
	679.8	10	2 7	25	100	SS-6	-	-	-	-	-	-	-	-	-	21	A-3a (V)	
MEDIUM DENSE TO DENSE, BROWN <b>GRAVEL</b> , LITTLE COARSE TO FINE SAND, TRACE SILT, TRACE CLAY, MOIST.		11	10															
		12																
		13	9 6	19	44	SS-7	-	-	-	-	-	-	-	-	-	13	A-1-a (V)	
		14	7															
		15	9 17	38	67	SS-8	-	79	11	3	5	2	NP	NP	NP	14	A-1-a (0)	
		16																
VERY DENSE, BROWN AND GRAY <b>SANDY SILT</b> , LITTLE CLAY, TRACE TO LITTLE FINE GRAVEL, MOIST TO WET.		17	11 15	45	50	SS-9	-	-	-	-	-	-	-	-	-	15	A-1-a (V)	
		18	16															
		19																
		20	22 22	74	94	SS-10	-	6	3	27	47	17	NP	NP	NP	15	A-4a (6)	
		21	29															
		22	19 20	85	56	SS-11	-	-	-	-	-	-	-	-	-	19	A-4a (V)	
AUGER REFUSAL @ 27.4 FEET		23	39															
		24																
		25	18 20	-	100	SS-12	-	16	10	25	34	15	NP	NP	NP	15	A-4a (3)	
		26	50/5"															
		27																
		28	50/3"	-	0	SS-13	-	-	-	-	-	-	-	-	-	-		
GRANITE, LIMESTONE AND DOLOMITE BOULDERS	663.6	29	0	14		RC-1											CORE	

[illegible]

2014 ODOT BORING LOG-RILENE BRIDGE ID - OH DOT GDT - 7/12/19 13:02 - U:\GIS\PROJECTS\2013\W-13-072.GPJ

PID: 89464		BR ID: FRA-71-1503L		PROJECT: FRA-70-13.10 - PHASE 6A		STATION / OFFSET: 256+62.64 / 36.0 RT				START: 4/28/14		END: 4/29/14		PG 3 OF 3		B-113-8-13							
<b>MATERIAL DESCRIPTION AND NOTES</b>				ELEV. 628.9	DEPTHS		SPT/ RQD	N <sub>60</sub>	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	HOLE SEALED	
<b>LIMESTONE</b> : BROWN, SLIGHTLY WEATHERED, MODERATELY STRONG, THIN TO MEDIUM BEDDED, DOLOMITIC, SILICEOUS, CHERTY, MODERATELY TO SLIGHTLY FRACTURED, TIGHT TO NARROW APERTURES, ROUGH; RQD 90%, REC 92%. <i>(same as above)</i>						63	83	97	RC-7												CORE		
						64																	
						65																	
						66																	
				624.8	EOB																		
<div>NOTES: ELEVATION OF SCIOTO RIVER SURFACE @ 699.8</div> <div>ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 188 LBS CEMENT / 50 LBS BENTONITE POWDER / 40 GAL WATER</div>																							






B-113-8-13 – RC-1, RC-2, and RC-3 – Depth from 27.4 to 41.7 feet



B-113-8-13 – RC-4 and RC-5 – Depth from 46.2 to 56.2 feet



B-113-8-13 – RC-6 and RC-7 – Depth from 56.2 to 66.2 feet

	PROJECT: FRA-70-13.10 - PHASE 6A	DRILLING FIRM / OPERATOR: RII / T.F.	DRILL RIG: MOBILE B-53 (SN 624400)	STATION / OFFSET: 258+77.50 / 36.0' RT	EXPLORATION ID <b>B-113-9-13</b>
	TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / S.B.	HAMMER: AUTOMATIC	ALIGNMENT: BL I-71 SB	
	PID: 89464 BR ID: FRA-71-1503L	DRILLING METHOD: 4.25" HSA / HQ	CALIBRATION DATE: 4/26/13	ELEVATION: 706.3 (MSL) EOB: 73.0 ft.	PAGE 1 OF 3
	START: 4/1/14 END: 4/3/14	SAMPLING METHOD: SPT / RC	ENERGY RATIO (%): 77.7	LAT / LONG: 39.953039, -83.010839	

MATERIAL DESCRIPTION AND NOTES	ELEV. 706.3	DEPTHS	SPT/ RQD	N <sub>60</sub>	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
								GR	CS	FS	SI	CL	LL	PL	PI			
0.5' - TOPSOIL (6.0")	705.8																	
<b>FILL: VERY STIFF, DARK BROWN SILT AND CLAY,</b> SOME FINE GRAVEL, SOME COARSE TO FINE SAND, DAMP. -ROOT FIBER AND WOOD FRAGMENTS PRESENT IN SS-1 -ROCK FRAGMENTS PRESENT THROUGHOUT -SLAG FRAGMENTS PRESENT IN SS-2	700.8	1	5															
		2	3	8	61	SS-1	3.50	-	-	-	-	-	-	-	-	12	A-6a (V)	
		3																
		4	5	12	44	SS-2	3.25	33	14	13	23	17	34	21	13	16	A-6a (2)	
<b>FILL: VERY DENSE, BROWN AND GRAY GRAVEL WITH SAND,</b> TRACE SILT, MOIST. -ROCK AND SLAG FRAGMENTS PRESENT IN SS-3	698.3	5																
		6	18															
<b>FILL: MEDIUM STIFF TO STIFF, GRAY SILTY CLAY,</b> SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, MOIST. -BRICK AND CONCRETE FRAGMENTS PRESENT IN SS-4 -TRACE ROCK FRAGMENTS PRESENT THROUGHOUT	691.3	7	34	54	67	SS-3	-	-	-	-	-	-	-	-	-	12	A-1-b (V)	
		8																
		9	5	8	22	50	SS-4	1.25	-	-	-	-	-	-	-	18	A-6b (V)	
		10																
<b>FILL: MEDIUM STIFF TO STIFF, DARK BROWN TO GRAY SILT AND CLAY,</b> SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, MOIST TO WET. -CONSOLIDATION TEST PERFORMED @ 16.3' -QU @ 16.4' = 1,531 PSF (0.77 TSF) -CONCRETE AND SLAG FRAGMENTS PRESENT IN SS-8	685.8	11	4															
		12	4	17	67	SS-5	0.75	19	12	14	31	24	34	18	16	19	A-6b (6)	
		13																
		14	6	3	8	67	SS-6	1.00	-	-	-	-	-	-	-	19	A-6b (V)	
<b>STIFF, BROWN AND BLACK SANDY SILT,</b> SOME CLAY, LITTLE FINE GRAVEL, MOIST TO WET. -SS-9: LL (OVEN DRIED) = 23%; LOI = 5.6%	683.3	15																
		16			69	ST-7	1.50	19	10	13	31	27	32	18	14	18	A-6a (6)	
		17																
		18																
<b>MEDIUM DENSE, BROWN SANDY SILT,</b> LITTLE FINE GRAVEL, TRACE CLAY, MOIST. -ORGANICS PRESENT THROUGHOUT -ROCK FRAGMENTS PRESENT IN SS-10	680.8	19	3	2	5	39	SS-8	0.75	-	-	-	-	-	-	-	26	A-6a (V)	
		20																
		21	2	4	10	100	SS-9	-	10	4	19	46	21	32	22	10	40	A-4a (6)
		22																
<b>VERY DENSE, GRAY SANDY SILT,</b> LITTLE FINE GRAVEL, TRACE CLAY, DAMP TO MOIST.		23																
		24	7	8	23	56	SS-10	-	-	-	-	-	-	-	-	12	A-4a (V)	
		25																
		26	10	17	56	61	SS-11	-	13	15	30	32	10	NP	NP	NP	12	A-4a (1)
		27																
		28																
		29	8	22	61	78	SS-12	-	-	-	-	-	-	-	-	9	A-4a (V)	
				25														

[illegible]








B-113-9-13 – RC-1, RC-2, and RC-3 – Depth from 55.5 to 68.0 feet



B-113-9-13 – RC-4 – Depth from 68.0 to 73.0 feet

	PROJECT: FRA-70-13.10 - PHASE 6A	DRILLING FIRM / OPERATOR: RII / J.K.	DRILL RIG: CME-750X (SN 310218)	STATION / OFFSET: 260+75.33 / 40.2' RT	EXPLORATION ID <b>B-114-1-13</b>
	TYPE: STRUCTURE	SAMPLING FIRM / LOGGER: RII / J.P.	HAMMER: CME AUTOMATIC	ALIGNMENT: BL I-71 SB	
	PID: 89464 BR ID: FRA-71-1503L	DRILLING METHOD: 4.25" HSA / NQ	CALIBRATION DATE: 4/26/13	ELEVATION: 716.6 (MSL) EOB: 81.0 ft.	PAGE 1 OF 3
	START: 5/13/14 END: 5/14/14	SAMPLING METHOD: SPT / RC	ENERGY RATIO (%): 86.8	LAT / LONG: 39.953210, -83.010169	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N <sub>60</sub>	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
								GR	CS	FS	SI	CL	LL	PL	PI			
0.3' - TOPSOIL (4.0") <b>FILL:</b> STIFF, BROWN <b>SILTY CLAY</b> , LITTLE COARSE TO FINE SAND, LITTLE FINE GRAVEL, MOIST. -ROOT FIBERS PRESENT IN SS-1	716.6 716.3		3															
		1	4	10	61	SS	2.00	-	-	-	-	-	-	-	-	15	A-6b (V)	
	713.6	2	3															
<b>FILL:</b> VERY DENSE, BROWN <b>GRAVEL WITH SAND</b> , TRACE SILT, TRACE CLAY, MOIST. -ROCK FRAGMENTS PRESENT IN SS-2		3	50/1"	-	100	SS	-	-	-	-	-	-	-	-	-	10	A-1-b (V)	
	711.1	4																
		5																
<b>FILL:</b> STIFF, BROWN TO DARK BROWN <b>SILTY CLAY</b> , SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, DAMP TO MOIST. -ROOT FIBERS AND ROCK FRAGMENTS PRESENT IN SS-3		6	8															
		7	4	12	22	SS	1.50	14	10	12	39	25	35	19	16	18	A-6b (8)	
		8																
		9	4															
	706.1	10	6	13	56	SS	1.50	-	-	-	-	-	-	-	-	21	A-6b (V)	
		11																
<b>FILL:</b> STIFF TO VERY STIFF, DARK BROWN TO BROWN <b>SILT AND CLAY</b> , SOME COARSE TO FINE SAND, SOME TO AND FINE GRAVEL, DAMP. -CONCRETE FRAGMENTS PRESENT IN SS-5		12	5	7	33	SS	1.50	33	15	13	24	15	33	20	13	13	A-6a (2)	
		13																
		14	4															
		15	3	12	56	SS	4.00	-	-	-	-	-	-	-	-	13	A-6a (V)	
		16																
		17	5	22	39	SS	2.00	38	11	13	24	14	33	20	13	13	A-6a (1)	
		18	7															
-BRICK FRAGMENTS AND ROOT FIBERS PRESENT IN SS-8		19	6	19	56	SS	2.75	-	-	-	-	-	-	-	-	17	A-6a (V)	
	696.1	20	7															
		21																
VERY SOFT TO MEDIUM STIFF, BROWN TO DARK BROWN <b>SILTY CLAY</b> , LITTLE COARSE TO FINE SAND, MOIST.		22	3	7	89	SS	1.00	0	1	10	60	29	37	21	16	29	A-6b (10)	
		23	2															
		24	4															
	691.6	25	3	9	89	SS	0.25	-	-	-	-	-	-	-	-	25	A-6b (V)	
		26																
MEDIUM DENSE TO DENSE, BROWN <b>GRAVEL</b> , SOME COARSE TO FINE SAND, LITTLE SILT, TRACE CLAY, MOIST.		27																
		28																
	W 688.1	29	3															
			4	17	67	SS	-	55	23	9	10	3	22	18	4	14	A-1-a (0)	
			8															



[illegible]

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N <sub>60</sub>	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
								GR	CS	FS	SI	CL	LL	PL	PI			
<b>SHALE</b> : GRAY, UNWEATHERED TO SLIGHTLY WEATHERED, VERY WEAK TO WEAK, VERY THICK BEDDED, CALCAREOUS, ARGILLACEOUS, FRIABLE, MICACEOUS, FISSILE, MODERATELY TO HIGHLY FRACTURED, TIGHT TO OPEN APERTURES, SLICKENSIDED TO SLIGHTLY ROUGH; RQD 37%, REC 89%. <i>(continued)</i>  -POINT LOAD STRENGTH @ 73.0' TO 74.0' -MEAN QU = 255 PSI	654.5	63	76		95	RC										CORE		
	64																	
	65																	
		641.6	66	23		100	RC									CORE		
			67															
			68															
			69															
	<b>LIMESTONE</b> : GRAY AND BROWN, UNWEATHERED TO SLIGHTLY WEATHERED, VERY STRONG, VERY THICK BEDDED, DOLOMITIC, CALCAREOUS, CRYSTALLINE, CHERTY, PYRITIC, SILICEOUS, SLIGHTLY TO HIGHLY FRACTURED, OPEN APERTURES, SLIGHTLY ROUGH; RQD 95%, REC 96%. -QU @ 76.0' = 11,340 PSI	635.6	70	23		75	RC										CORE	
			71															
			72															
73																		
74																		
75																		
		76	94		96	RC										CORE		
		77																
		78																
		79																
		80																
		81																



B-114-1-13 – RC-1 and RC-2 – Depth from 61.0 to 71.0 feet



B-114-1-13 – RC-3 and RC-4 – Depth from 71.0 to 81.0 feet

## **APPENDIX IV**

### **HISTORIC BORING LOGS:**

**B-001-S-57 through B-020-S-57**

STATE OF OHIO  
DEPARTMENT OF HIGHWAYS  
TESTING LABORATORY

## LOG OF BORING

CO., RT. NO. SEC. FRA-40-12.30 BRIDGE NO. FRA-40-1230  
REAR ABUTMENT OVER SCIOTO RIVER  
 LOCATION: T.H. 1 STA. 21+75 OFFSET C.L. FED. NO.

ELEV.	DEPTH	NO. BLOWS	SAMPLE NO.	DESCRIPTION
724.0	0			
	2			
	4			
	6			
	8			
714.0	10			
	12	18	67403	GRAY AND BROWN SILTY GRAVEL
	14			
709.0	16	45	67404	GRAVEL
	18			
704.0	20	30	67405	BROWN CLAY
	22			
	24			
699.0	26	70	67406	GRAY AND BROWN SILTY SANDY GRAVEL
	28			
694.0	30			
	32	52	67407	GRAVEL
	34			
689.0	36	38	67408	GRAVEL

## LOG OF BORING (CONTINUED)

BRIDGE NO. FRA-40-1230 T.H. 1

ELEV.	DEPTH	NO. BLOWS	SAMPLE NO.	DESCRIPTION
684.0	38	74	67409	SANDY GRAVEL
	40			
	42			
680.0	44	90	67410	SILTY SANDY GRAVEL
	46			
	48			
674.0	50	155	67411	GRAY GRAVELLY SANDY CLAY
	52			
	54			
667.0	56			BOULDERS
	58			
	60			
661.0	62			LARGE BOULDERS
	64			
	66			
	68			BOTTOM OF HOLE
	70			
	72			
	74			
	76			
	78			
	80			
	82			

STATE OF OHIO  
DEPARTMENT OF HIGHWAYS  
TESTING LABORATORY

## LOG OF BORING

CO., RT. NO., SEC. FRA-40-12,30 BRIDGE NO. FRA-40-1230  
SECOND PIER OVER SCIOTO RIVER  
 LOCATION: T.H. 5 STA. 24+00 OFFSET C.L. FED. NO.

ELEV.	DEPTH	NO. BLOWS	SAMPLE NO.	DESCRIPTION
681.7	0			
	2			
	4			
676.4	6	24	66517	GRAY SANDY GRAVEL
	8			
671.4	10			
	12	73	66518	GRAY SILTY GRAVELLY SAND
	14			
666.4	16	180	66519	GRAY SILTY SANDY GRAVEL
	18	--	---	COARSE SAND
663.4	20			
661.4	22	117	66520	GRAY SILTY GRAVEL
	24			
656.4	26	20	----	FINE SAND, SILT AND SMALL GRAVEL
	28			
652.7	30	600	66521	WEATHERED SHALE
652.1				TOP OF ROCK
	32			
	34			HARD DENSE GRAY LIMESTONE
645.7	36			BOTTOM OF HOLE



STATE OF OHIO  
DEPARTMENT OF HIGHWAYS  
TESTING LABORATORY

## LOG OF BORING

CO., RT. NO. SEC. FRA-40-12.30 BRIDGE NO. FRA-40-1230  
FOURTH PIER OVER SCIOTO RIVER  
 LOCATION: T.H. 2 STA. 26+25 OFFSET C.L. FED. NO.

ELEV.	DEPTH	NO. BLOWS	SAMPLE NO.	DESCRIPTION
686.1	0			
	2			
	4			
	6			
	8			
677.4	10	39	67412	GRAY SILTY GRAVELLY SAND
	12			
672.4	14	171	67413	GRAY AND BROWN SILTY GRAVELLY SAND
	16			
669.4	18		67414	GRAVEL AND STONE FRAGMENTS
	20			
	22			
	24			
662.4	26	39	67415	SANDY GRAVEL
660.4	28	190	67416	SANDY GRAVEL
	30			
654.4	32	70	67417	GRAVEL
	34			TOP OF ROCK
651.4				
	36			FIRM GRAY CLAY SHALE

## LOG OF BORING (CONTINUED)

BRIDGE NO. PA-45-1230T.H. 9

ELEV.	DEPTH	NO. BLOWS	SAMPLE NO.	DESCRIPTION
648.7	38			FIRM GRAY CLAY SHALE
646.0	40			DENSE GRAY LIMESTONE WITH DARK WAVY PARTINGS
	42			↖ BOTTOM OF HOLE
	44			
	46			
	48			
	50			
	52			
	54			
	56			
	58			
	60			
	62			
	64			
	66			
	68			
	70			
	72			
	74			
	76			
	78			
	80			
	82			

STATE OF OHIO  
DEPARTMENT OF HIGHWAYS  
TESTING LABORATORY

## LOG OF BORING

CO., RT. NO. SEC. FRA -40-12.30 BRIDGE NO. FRA-40-1230  
SIXTH PIER OVER SCIOTO RIVER  
 LOCATION: T.H. 13 STA. 28+73 OFFSET C.L. FED. NO.

ELEV.	DEPTH	NO. BLOWS	SAMPLE NO.	DESCRIPTION
691.4	0			
	2			
	4			
686.9	6	15	66522	GRAVEL
682.9	8	90	66523	BROWN SANDY GRAVEL
	10			
	12			
	14			
676.9	16	27	66524	GRAY AND BROWN GRAVELLY SAND
	18			
672.9	20	30	66525	BROWN AND GRAY SANDY GRAVEL
	22			
	24			
666.9	26	200	66526	BROWN AND GRAY SANDY GRAVEL
665.9	28		66527	STONE FRAGMENTS
	30	200	66528	GRAY SOFT SHALE TOP OF ROCK
660.9	32		66529	SHALE
	34			
	36			

## LOG OF BORING (CONTINUED)

BRIDGE NO. EBA-40-1230 T.H. 13

ELEV.	DEPTH	NO. BLOWS	SAMPLE NO.	DESCRIPTION
652.4	38			SHALE
	40			↖ BOTTOM OF HOLE
	42			
	44			
	46			
	48			
	50			
	52			
	54			
	56			
	58			
	60			
	62			
	64			
	66			
	68			
	70			
	72			
	74			
	76			
	78			
	80			
	82			

STATE OF OHIO  
DEPARTMENT OF HIGHWAYS  
TESTING LABORATORY

## LOG OF BORING

CO., RT. NO. SEC. FRA-40-12.30 BRIDGE NO. FRA-40-1230  
FORWARD ABUTMENT OVER SCIOTO RIVER

LOCATION: T.H. 20 STA. 32+05 OFFSET 19' LT FED. NO.

ELEV.	DEPTH	NO. BLOWS	SAMPLE NO.	DESCRIPTION
726.0	0			
	2			
	4			
721.0	6	----	----	SAND & SMALL GRAVEL
	8			
	10			
715.0	12	10	67937	SANDY GRAVEL
	14			
	16			
709.0	18	17	----	SANDY GRAVELLY SILT
	20			
705.0	22	25	67938	SANDY GRAVELLY SILT
	24			
	26			
700.0	28	15	67939	BROWN CLAY
	30			
695.0	32	23	67940	BROWN SILTY GRAVEL
	34			
690.0	36	25	67941	GRAVEL

## LOG OF BORING (CONTINUED)

BRIDGE NO. FRA-40-1230T.H. 20

ELEV.	DEPTH	NO. BLOWS	SAMPLE NO.	DESCRIPTION
	38			
	40			
650.5		75	67942	SILTY GRAVEL
	42			↑ BOTTOM OF HOLE
	44			
	46			
	48			
	50			
	52			
	54			
	56			
	58			
	60			
	62			
	64			
	66			
	68			
	70			
	72			
	74			
	76			
	78			
	80			
	82			

## **APPENDIX V**

### **LABORATORY TEST RESULTS**





6350 Presidential Gateway  
Columbus, Ohio 43231  
Telephone: (614) 823-4949  
Fax Number: (614) 823-4990

## UNCONFINED COMPRESSION

ASTM D -2166

PROJECT

FRA-70-13.10 - Phase 6A

JOB No.

W-13-072

BORING / SAMPLE No.

B-016-7-13 / ST-8

SAMPLE DEPTH

17.9 ft.

DATE OF TESTING

1/30/2014

TESTED BY

JJH

Soil Description: Dark brown SILTY CLAY, little coarse to fine sand, trace fine gravel.  
Soil Classification: ODOT A-6b

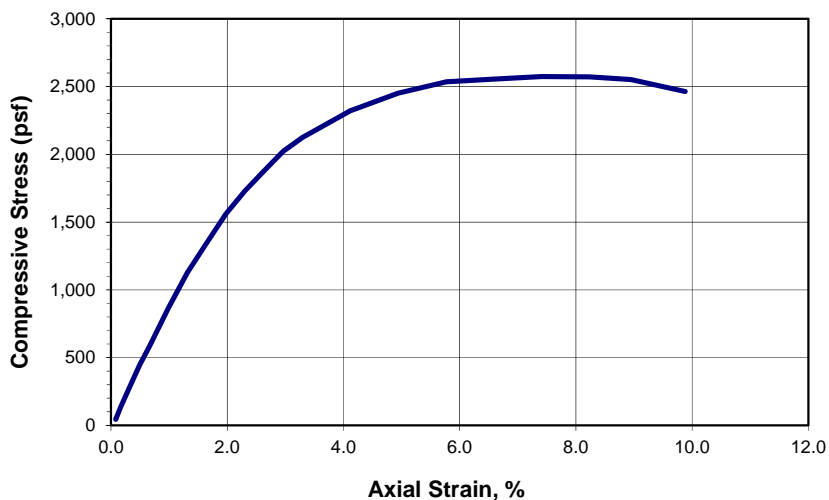
Physical Characteristics	L.L.	P.L.	P.I.	Gravel%	C. Sand%	F. Sand%	Silt%	Clay%
	40	23	19	1	2	18	40	39

DIAMETER, $D_0$	2.860 in	72.6 mm	STRAIN RATE	1.00	%/min
AREA, $A_0$	6.424 in <sup>2</sup>	41.4 cm <sup>2</sup>	WET SOIL + PAN MASS	1300.4	g
HEIGHT, $L_0$	6.073 in	154.3 mm	PAN MASS	77.9	g
VOLUME, $V_0$	39.015 in <sup>3</sup>	639.3 cm <sup>3</sup>	DRY SOIL + PAN MASS	1026.8	g
MACH. RATE	0.607	in/min	WET DENSITY	119.37	lb/ft <sup>3</sup>
WATER CONT.	28.83	%	DRY DENSITY	92.65	lb/ft <sup>3</sup>
UNCONFINED COMPRESSION STRESS, $q_u$	2,574 psf			1.29	tsf
HAND PENETROMETER				2.00	tsf

Failure Sketch



Unconfined Compression Test





6350 Presidential Gateway  
Columbus, Ohio 43231  
Telephone: (614) 823-4949  
Fax Number: (614) 823-4990

## UNCONFINED COMPRESSION

ASTM D -2166

PROJECT

FRA-70-13.10 - Phase 6A

JOB No.

W-13-072

BORING / SAMPLE No.

B-113-9-13 / ST-7

SAMPLE DEPTH

16.4 ft

DATE OF TESTING

4/15/2014

TESTED BY

T.P.

Soil Description: Dark brown SILT AND CLAY, little coarse to fine sand, little fine gravel.  
Soil Classification: ODOT A-6a

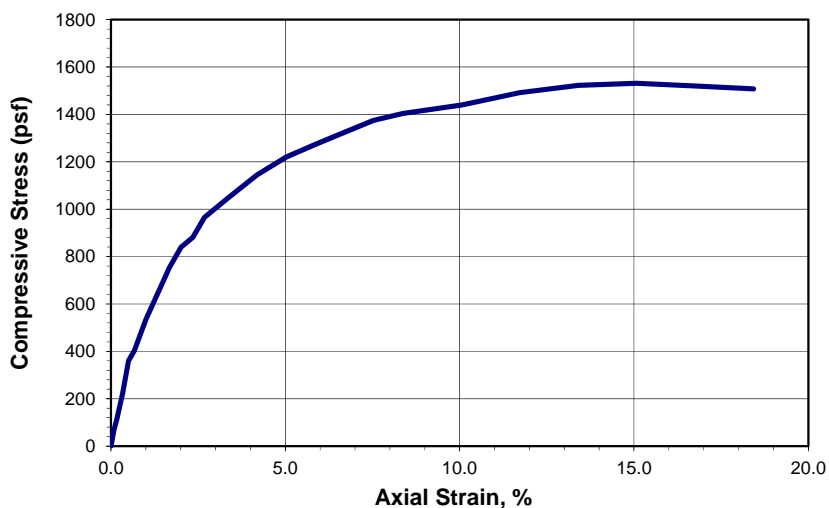
Physical Characteristics	L.L.	P.L.	P.I.	Gravel%	C. Sand%	F. Sand%	Silt%	Clay%
	32	18	14	19	10	13	31	27

DIAMETER, D <sub>0</sub>	2.852 in	72.4 mm	STRAIN RATE	1.00	%/min
AREA, A <sub>0</sub>	6.388 in <sup>2</sup>	41.2 cm <sup>2</sup>	WET SOIL + PAN MASS	1367.7	g
HEIGHT, L <sub>0</sub>	5.969 in	151.61 mm	PAN MASS	89	g
VOLUME, V <sub>0</sub>	38.132 in <sup>3</sup>	624.87 cm <sup>3</sup>	DRY SOIL + PAN MASS	1149.7	g
MACH. RATE	0.597	in/min	WET DENSITY	127.75	lb/ft <sup>3</sup>
WATER CONT.	20.55	%	DRY DENSITY	105.97	lb/ft <sup>3</sup>
UNCONFINED COMPRESSION STRESS, q <sub>u</sub>	1,531 psf			0.77	tsf
HAND PENETROMETER				1.50	tsf

Failure Sketch



Unconfined Compression Test





# One-Dimensional Consolidation Test Report (ASTM D2435)

Project Number: W-13-072

Boring Number: B-113-9-13

Project Name: FRA-70-13.10 - Phase 6A

Sample No. / Depth: ST-7 / 16.3

Project Location: Columbus, Ohio

Date of Testing: 04/07/2014 to 04/25/2014

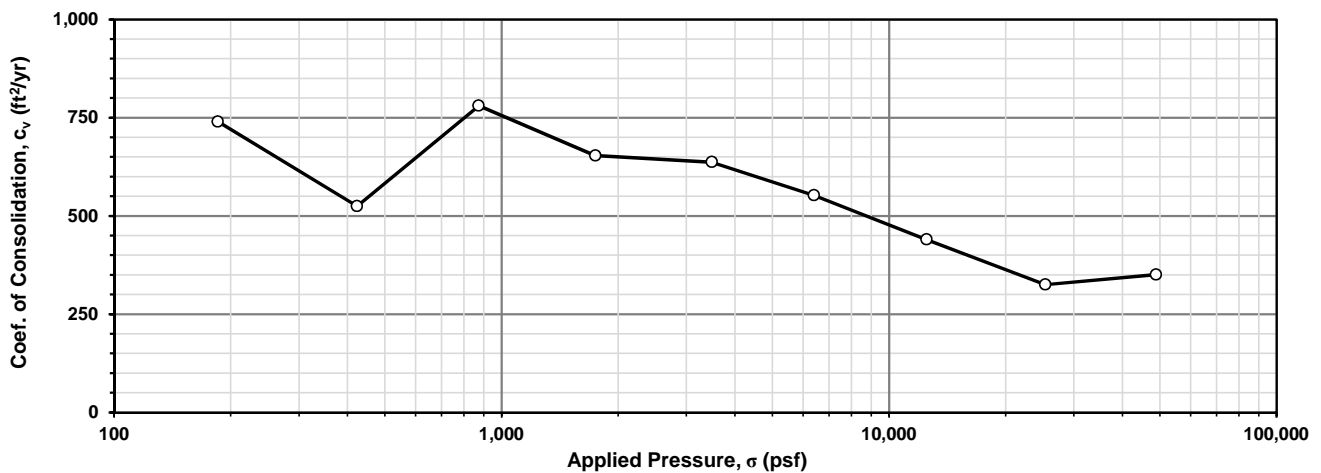
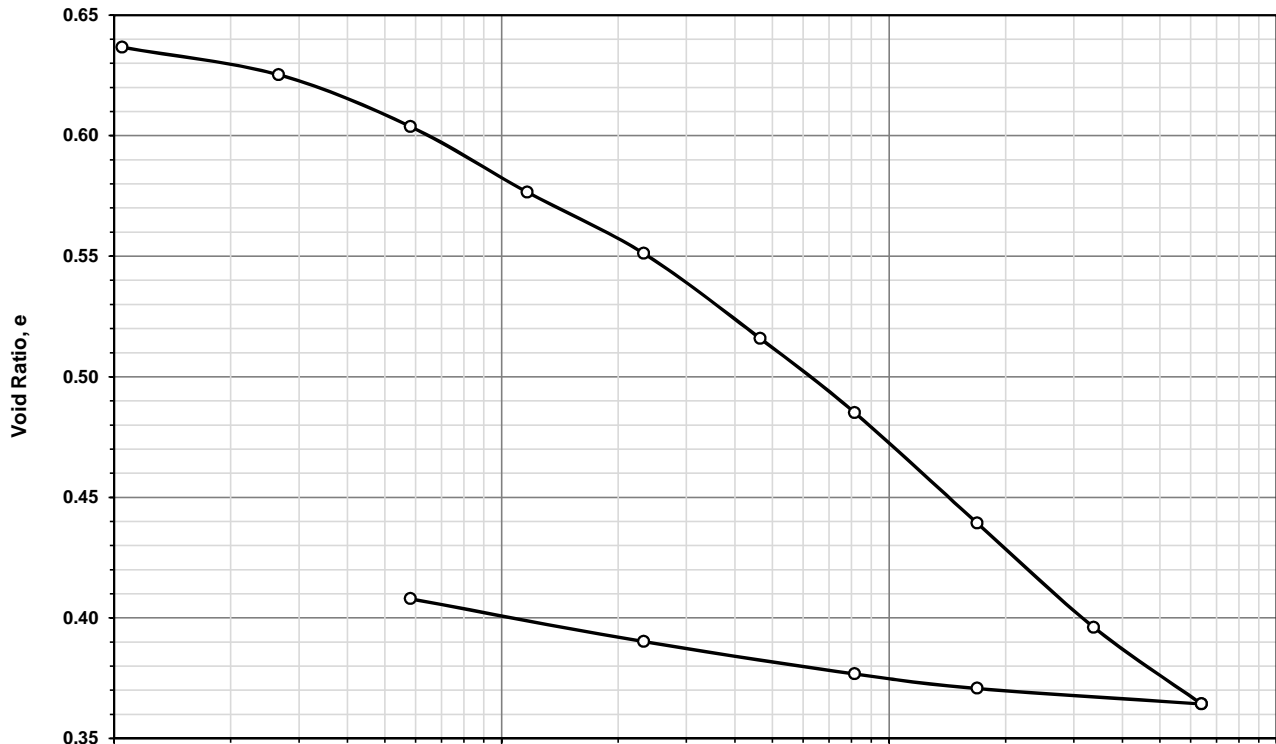
Client: ms consultants, inc.

Technician: Hoyt

Soil Description: Dark brown SILT AND CLAY, little coarse to fine sand, little fine gravel.  
 Soil Classification: ODOT A-6a

Physical Characteristics	L.L.	P.L.	P.I.	Gravel%	C. Sand%	F. Sand%	Silt%	Clay%
	32	18	14	19	10	13	31	27

Natural		$\gamma_d$ (pcf)	$\gamma_{sat}$ (pcf)	$\sigma_{vo}'$ (psf)	$S_G$	$e_o$	$\sigma_p'$ (psf)	$c_c$	$c_r$
$S_o$	$w_o$								
91.2%	18.3%	101.7	123.9	1,793	2.67	0.638	1,973	0.165	0.022





**RESOURCE INTERNATIONAL, INC.**  
*Engineering Consultants*

**Unconfined Compressive Strength  
of Intact Rock Core Specimens (ASTM D 7012-04)**

6350 Presidential Gateway.

Columbus, OH 43231

Phone (614) 823-4949

9885 Rockside Road

Cleveland, OH 44125

Phone (216) 573-0955

4480 Lake Forest Drive

Cincinnati, Ohio 45242

Phone (513) 769-6998

Project: FRA-70-13.10 - Project 6A

Project No.: W-13-072

Date of Testing: 6/23/2014

Test Performed by: K.R./T.K.

Rock Description: Dolomitic Limestone

Boring No.: B-113-4-13

Sample No.: RC-2

Depth (ft): 78.3

Moisture condition: As received

Average Length: 3.967 in

Average Diameter: 1.859 in

Length to diameter ratio: 2.134

Cross Sectional Area: 2.713 in<sup>2</sup>

Rate of Loading: 56.3 lbs/sec

Testing Time: 370 sec

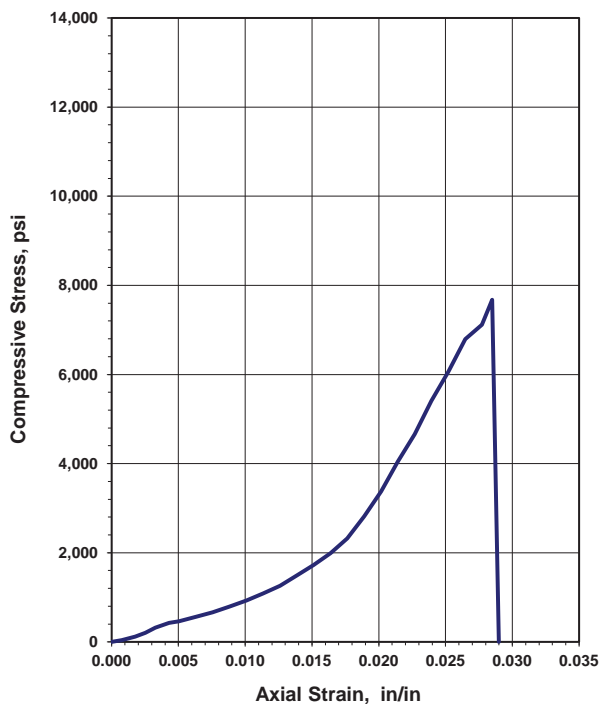
(Rate 2-15 minutes to failure)

Failure Load: 20,830 lbs

Axial Strain at Failure: 0.0285 in/in

Stress: 7,676 psi

**Unconfined Compression Test**



**Before Testing**



**After Failure**



REMARKS: \_\_\_\_\_



**RESOURCE INTERNATIONAL, INC.**  
*Engineering Consultants*

**Unconfined Compressive Strength  
of Intact Rock Core Specimens (ASTM D 7012-04)**

6350 Presidential Gateway.

Columbus, OH 43231

Phone (614) 823-4949

9885 Rockside Road

Cleveland, OH 44125

Phone (216) 573-0955

4480 Lake Forest Drive

Cincinnati, Ohio 45242

Phone (513) 769-6998

Project: FRA-70-13.10 - Project 6A

Project No.: W-13-072

Date of Testing: 6/20/2014

Test Performed by: K.R./T.K.

Rock Description: Dolomitic Limestone

Boring No.: B-113-5-13

Sample No.: RC-4

Depth (ft): 75.7

Moisture condition: As received

Average Length: 4.047 in

Average Diameter: 1.849 in

Length to diameter ratio: 2.189

Cross Sectional Area: 2.684 in<sup>2</sup>

Rate of Loading: 49.5 lbs/sec

Testing Time: 472 sec

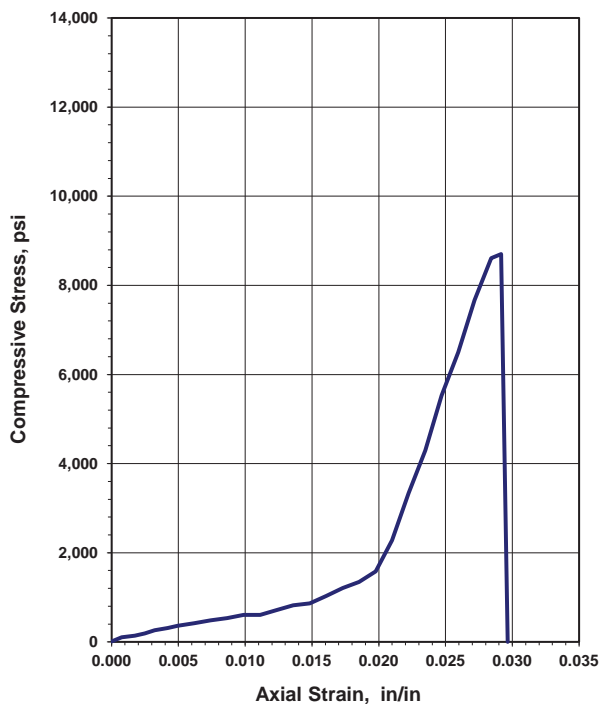
(Rate 2-15 minutes to failure)

Failure Load: 23,360 lbs

Axial Strain at Failure: 0.0292 in/in

Stress: 8,702 psi

**Unconfined Compression Test**



**Before Testing**



**After Failure**



REMARKS: \_\_\_\_\_



**RESOURCE INTERNATIONAL, INC.**  
*Engineering Consultants*

**Unconfined Compressive Strength  
of Intact Rock Core Specimens (ASTM D 7012-04)**

6350 Presidential Gateway.

Columbus, OH 43231

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9885 Rockside Road

Cleveland, OH 44125

Phone (216) 573-0955

4480 Lake Forest Drive

Cincinnati, Ohio 45242

Phone (513) 769-6998

Project: FRA-70-13.10 - Project 6A

Project No.: W-13-072

Date of Testing: 6/20/2014

Test Performed by: K.R./T.K.

Rock Description: Dolomitic Limestone

Boring No.: B-113-5-13

Sample No.: RC-5

Depth (ft): 80.7

Moisture condition: As received

Average Length: 4.05 in

Average Diameter: 1.862 in

Length to diameter ratio: 2.175

Cross Sectional Area: 2.722 in<sup>2</sup>

Rate of Loading: 49.1 lbs/sec

Testing Time: 443 sec

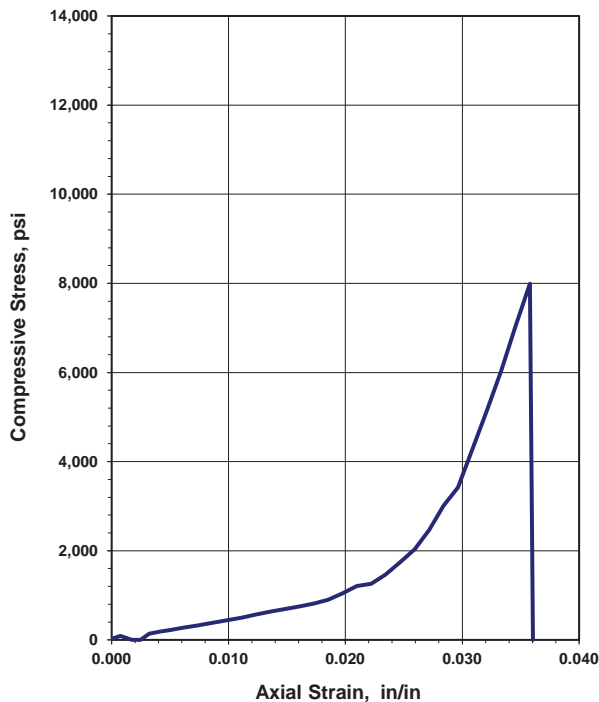
(Rate 2-15 minutes to failure)

Failure Load: 21,760 lbs

Axial Strain at Failure: 0.0358 in/in

Stress: 7,992 psi

**Unconfined Compression Test**



**Before Testing**



**After Failure**



REMARKS: \_\_\_\_\_



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**Unconfined Compressive Strength  
of Intact Rock Core Specimens (ASTM D 7012-04)**

6350 Presidential Gateway.  
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9885 Rockside Road  
Cleveland, OH 44125  
Phone (216) 573-0955

4480 Lake Forest Drive  
Cincinnati, Ohio 45242  
Phone (513) 769-6998

Project: FRA-70-13.10 - Project 6A

Project No.: W-13-072

Date of Testing: 5/7/2014

Test Performed by: K.R./T.K.

Rock Description: Dolomitic Limestone

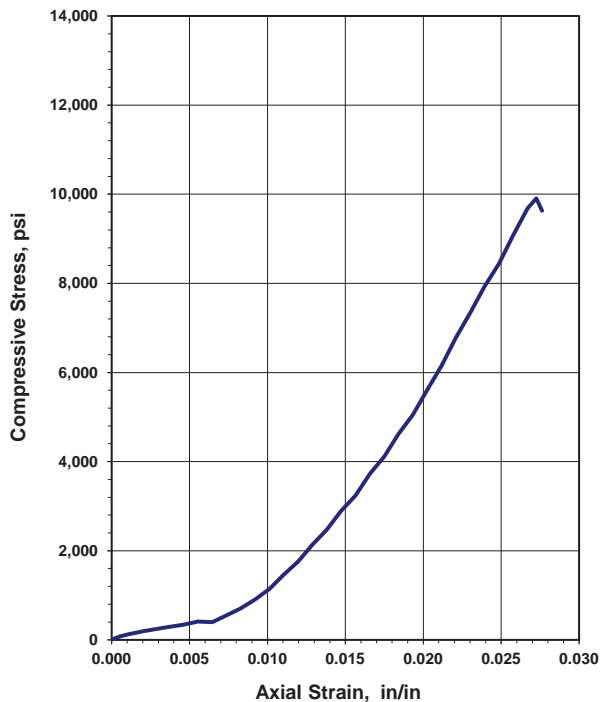
Boring No.: B-113-6-13  
Sample No.: RC-1  
Depth (ft): 45.9  
Moisture condition: As received

Average Length: 5.431 in  
Average Diameter: 2.468 in  
Length to diameter ratio: 2.201  
Cross Sectional Area: 4.781 in<sup>2</sup>

Rate of Loading: 76.1 lbs/sec  
Testing Time: 623 sec  
(Rate 2-15 minutes to failure)

Failure Load: 47,380 lbs  
Axial Strain at Failure: 0.0273 in/in  
Stress: 9,906 psi

**Unconfined Compression Test**



**Before Testing**



**After Failure**



REMARKS: \_\_\_\_\_





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Phone (513) 769-6998

Project: FRA-70-13.10 - Project 6A

Project No.: W-13-072

Date of Testing: 5/7/2014

Test Performed by: K.R./T.K.

Rock Description: Dolomitic Limestone

Boring No.: B-113-6-13

Sample No.: RC-2

Depth (ft): 50.7

Moisture condition: As received

Average Length: 5.305 in

Average Diameter: 2.485 in

Length to diameter ratio: 2.135

Cross Sectional Area: 4.848 in<sup>2</sup>

Rate of Loading: 79.3 lbs/sec

Testing Time: 700 sec

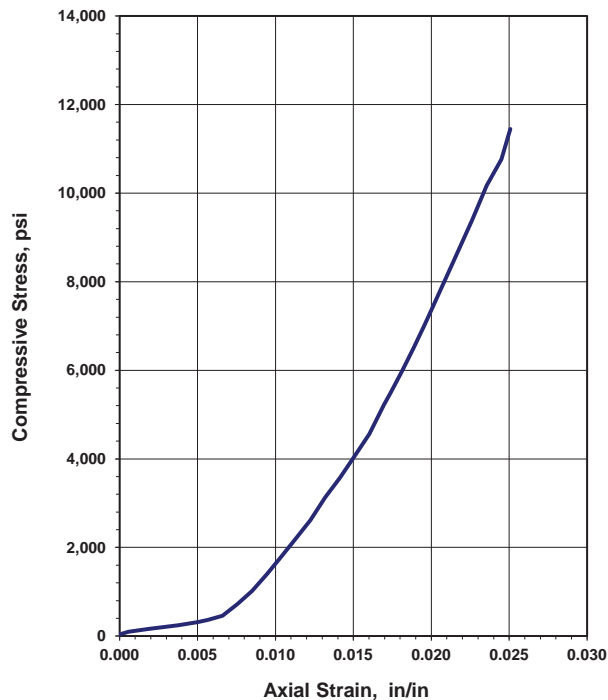
(Rate 2-15 minutes to failure)

Failure Load: 55,510 lbs

Axial Strain at Failure: 0.0251 in/in

Stress: 11,448 psi

**Unconfined Compression Test**



**Before Testing**



**After Failure**



REMARKS: \_\_\_\_\_



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Phone (513) 769-6998

Project: FRA-70-13.10 - Project 6A

Project No.: W-13-072

Date of Testing: 5/7/2014

Test Performed by: K.R./T.K.

Rock Description: Dolomitic Limestone

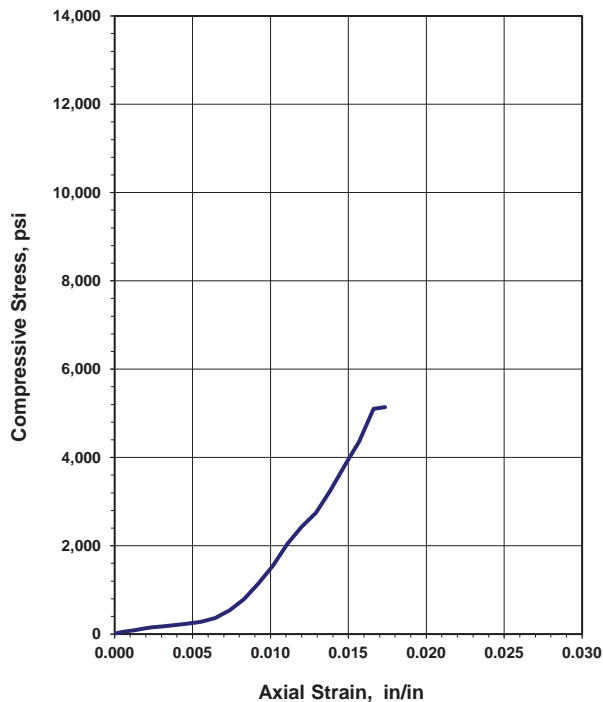
Boring No.: B-113-6-13  
Sample No.: RC-3  
Depth (ft): 54.8  
Moisture condition: As received

Average Length: 5.417 in  
Average Diameter: 2.493 in  
Length to diameter ratio: 2.173  
Cross Sectional Area: 4.879 in<sup>2</sup>

Rate of Loading: 69.7 lbs/sec  
Testing Time: 360 sec  
(Rate 2-15 minutes to failure)

Failure Load: 25,080 lbs  
Axial Strain at Failure: 0.0174 in/in  
Stress: 5,140 psi

**Unconfined Compression Test**



**Before Testing**

Photo Not Available

**After Failure**



REMARKS: \_\_\_\_\_



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**Unconfined Compressive Strength  
of Intact Rock Core Specimens (ASTM D 7012-04)**

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Phone (216) 573-0955

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Cincinnati, Ohio 45242  
Phone (513) 769-6998

Project: FRA-70-13.10 - Project 6A  
Project No.: W-13-072  
Date of Testing: 5/7/2014  
Test Performed by: K.R./T.K.

Rock Description: Limestone

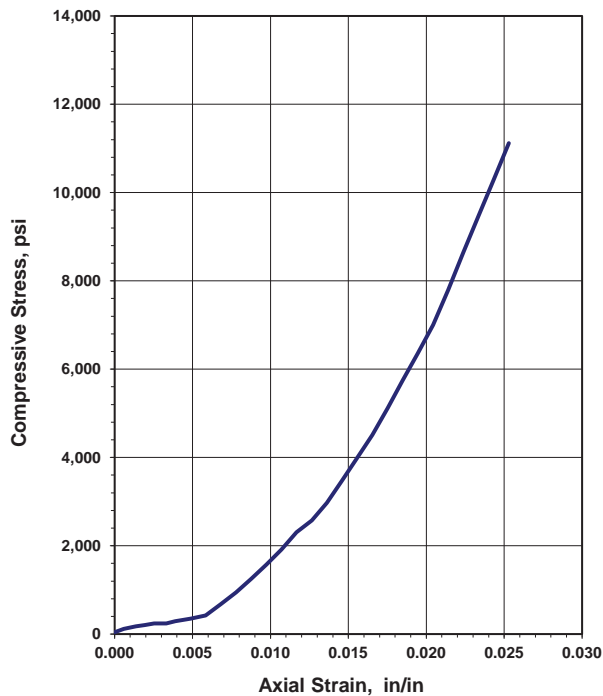
Boring No.: B-113-7-13  
Sample No.: RC-5  
Depth (ft): 42.2  
Moisture condition: As received

Average Length: 5.139 in  
Average Diameter: 2.478 in  
Length to diameter ratio: 2.074  
Cross Sectional Area: 4.820 in<sup>2</sup>

Rate of Loading: 82.5 lbs/sec  
Testing Time: 650 sec  
(Rate 2-15 minutes to failure)

Failure Load: 53,610 lbs  
Axial Strain at Failure: 0.0253 in/in  
Stress: 11,119 psi

**Unconfined Compression Test**



**Before Testing**



**After Failure**



REMARKS: \_\_\_\_\_



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**Unconfined Compressive Strength  
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Phone (513) 769-6998

Project: FRA-70-13.10 - Project 6A

Project No.: W-13-072

Date of Testing: 5/7/2014

Test Performed by: K.R./T.K.

Rock Description: Dolomitic Limestone

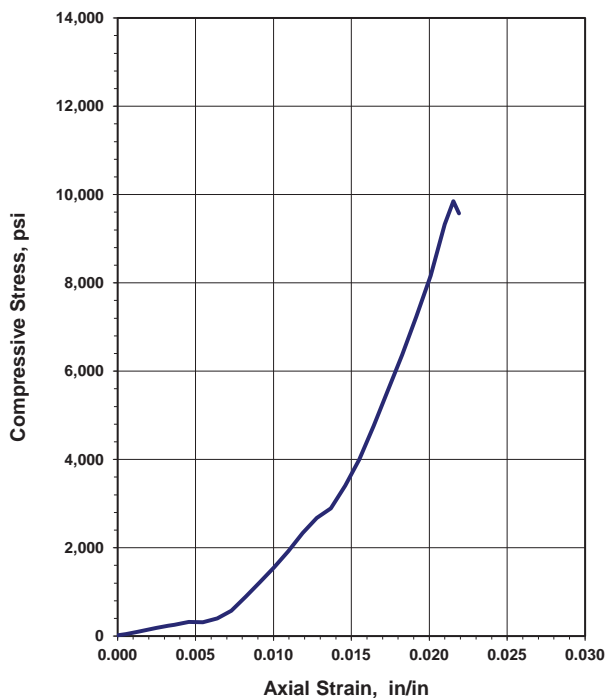
Boring No.: B-113-7-13  
Sample No.: RC-6  
Depth (ft): 50.2  
Moisture condition: As received

Average Length: 5.478 in  
Average Diameter: 2.483 in  
Length to diameter ratio: 2.206  
Cross Sectional Area: 4.840 in<sup>2</sup>

Rate of Loading: 72.5 lbs/sec  
Testing Time: 658 sec  
(Rate 2-15 minutes to failure)

Failure Load: 47,680 lbs  
Axial Strain at Failure: 0.0215 in/in  
Stress: 9,850 psi

**Unconfined Compression Test**



**Before Testing**



**After Failure**



REMARKS: \_\_\_\_\_



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**Unconfined Compressive Strength  
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Phone (513) 769-6998

Project: FRA-70-13.10 - Project 6A

Project No.: W-13-072

Date of Testing: 5/7/2014

Test Performed by: K.R./T.K.

Rock Description: Dolomitic Limestone

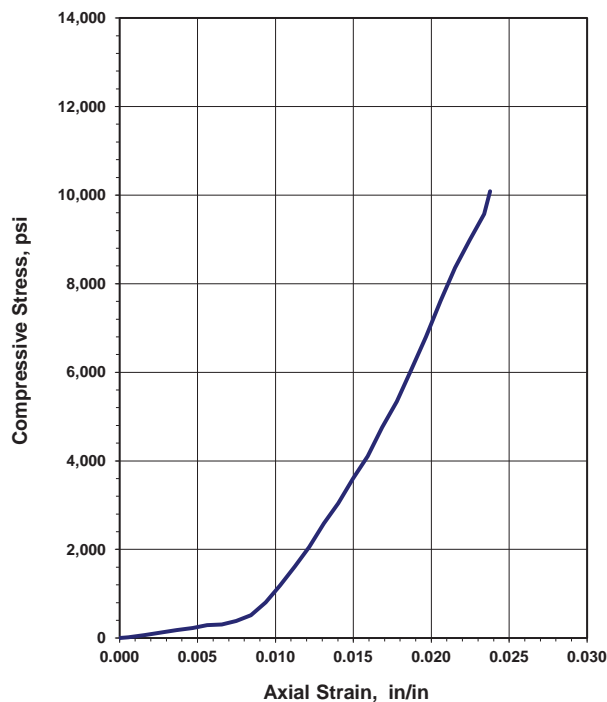
Boring No.: B-113-7-13  
Sample No.: RC-7  
Depth (ft): 51.2  
Moisture condition: As received

Average Length: 5.342 in  
Average Diameter: 2.483 in  
Length to diameter ratio: 2.151  
Cross Sectional Area: 4.840 in<sup>2</sup>

Rate of Loading: 73.5 lbs/sec  
Testing Time: 664 sec  
(Rate 2-15 minutes to failure)

Failure Load: 48,830 lbs  
Axial Strain at Failure: 0.0238 in/in  
Stress: 10,087 psi

**Unconfined Compression Test**



**Before Testing**



**After Failure**



REMARKS: \_\_\_\_\_



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**Unconfined Compressive Strength  
of Intact Rock Core Specimens (ASTM D 7012-04)**

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4480 Lake Forest Drive  
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Phone (513) 769-6998

Project: FRA-70-13.10 - Project 6A

Project No.: W-13-072

Date of Testing: 5/15/2014

Test Performed by: C.S./T.K.

Rock Description: Dolomitic Limestone

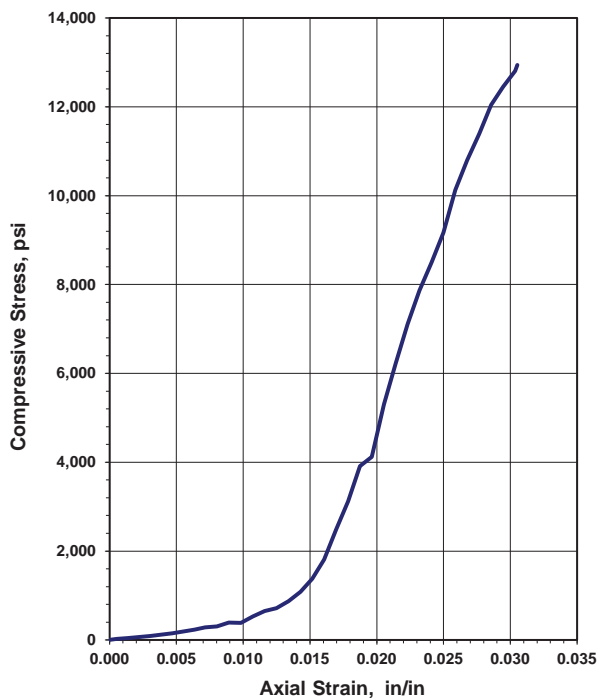
Boring No.: B-113-8-13  
Sample No.: RC-4  
Depth (ft): 47.1  
Moisture condition: Dry

Average Length: 5.602 in  
Average Diameter: 2.475 in  
Length to diameter ratio: 2.263  
Cross Sectional Area: 4.809 in<sup>2</sup>

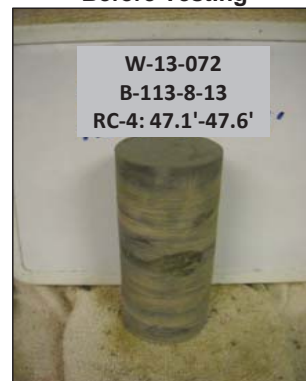
Rate of Loading: 75.2 lbs/sec  
Testing Time: 828 sec  
(Rate 2-15 minutes to failure)

Failure Load: 62,250 lbs  
Axial Strain at Failure: 0.0305 in/in  
Stress: 12,942 psi

**Unconfined Compression Test**



**Before Testing**



**After Failure**



REMARKS: \_\_\_\_\_



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**Unconfined Compressive Strength  
of Intact Rock Core Specimens (ASTM D 7012-04)**

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Project: FRA-70-13.10 - Project 6A

Project No.: W-13-072

Date of Testing: 5/15/2014

Test Performed by: C.S./T.K.

Rock Description: Dolomitic Limestone

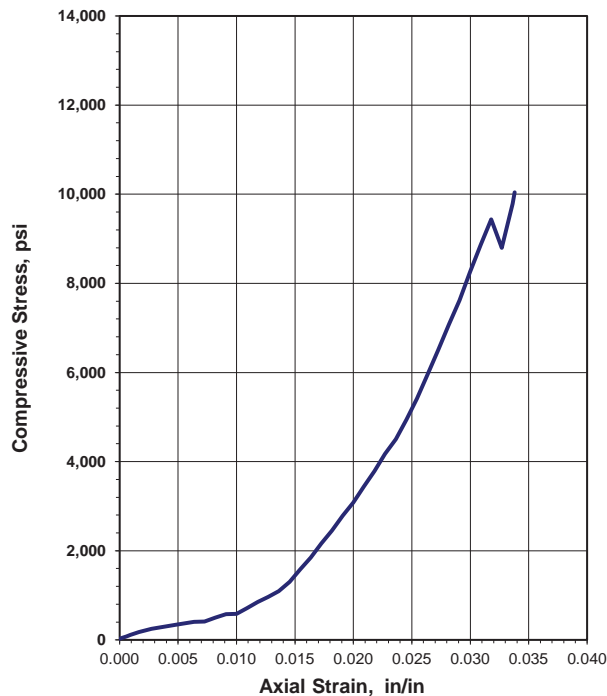
Boring No.: B-113-8-13  
Sample No.: RC-5  
Depth (ft): 52.3  
Moisture condition: Dry

Average Length: 5.503 in  
Average Diameter: 2.481 in  
Length to diameter ratio: 2.218  
Cross Sectional Area: 4.832 in<sup>2</sup>

Rate of Loading: 60.3 lbs/sec  
Testing Time: 757 sec  
(Rate 2-15 minutes to failure)

Failure Load: 45,620 lbs  
Axial Strain at Failure: 0.0318 in/in  
Stress: 9,438 psi

**Unconfined Compression Test**



**Before Testing**



**After Failure**



REMARKS: \_\_\_\_\_





**RESOURCE INTERNATIONAL, INC.**  
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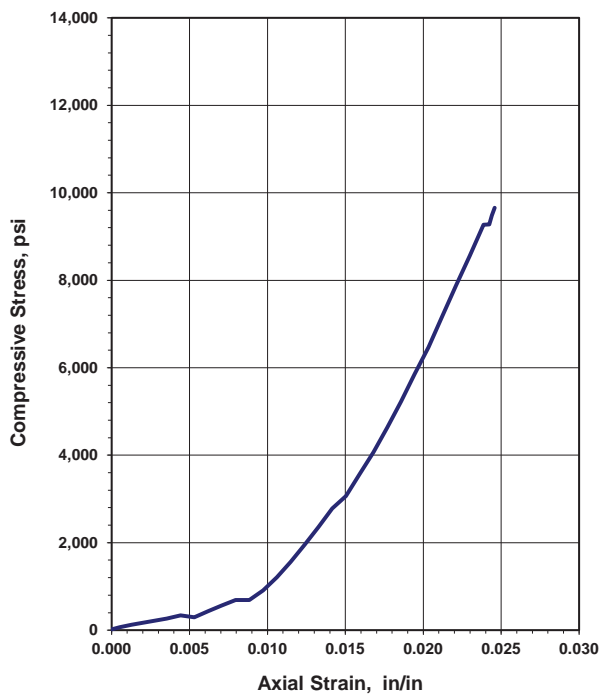
**Unconfined Compressive Strength  
of Intact Rock Core Specimens (ASTM D 7012-04)**

6350 Presidential Gateway.	9885 Rockside Road	4480 Lake Forest Drive	Project: <u>FRA-70-13.10 - Project 6A</u>
Columbus, OH 43231	Cleveland, OH 44125	Cincinnati, Ohio 45242	Project No.: <u>W-13-072</u>
Phone (614) 823-4949	Phone (216) 573-0955	Phone (513) 769-6998	Date of Testing: <u>5/15/2014</u>
			Test Performed by: <u>C.S./T.K.</u>

Rock Description: Dolomitic Limestone

Boring No.: <u>B-113-8-13</u>	Average Length: <u>5.655 in</u>
Sample No.: <u>RC-6</u>	Average Diameter: <u>2.486 in</u>
Depth (ft): <u>56.8</u>	Length to diameter ratio: <u>2.275</u>
Moisture condition: <u>Dry</u>	Cross Sectional Area: <u>4.851 in<sup>2</sup></u>
Rate of Loading: <u>73.6 lbs/sec</u>	Failure Load: <u>46,860 lbs</u>
Testing Time: <u>637 sec</u>	Axial Strain at Failure: <u>0.0246 in/in</u>
(Rate 2-15 minutes to failure)	Stress: <u>9,657 psi</u>

**Unconfined Compression Test**



**Before Testing**



**After Failure**



REMARKS: \_\_\_\_\_



**RESOURCE INTERNATIONAL, INC.**  
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**Unconfined Compressive Strength  
of Intact Rock Core Specimens (ASTM D 7012-04)**

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Cincinnati, Ohio 45242  
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Project: FRA-70-13.10 - Project 6A

Project No.: W-13-072

Date of Testing: 4/7/2014

Test Performed by: K.R./T.K.

Rock Description: Dolomitic Limestone

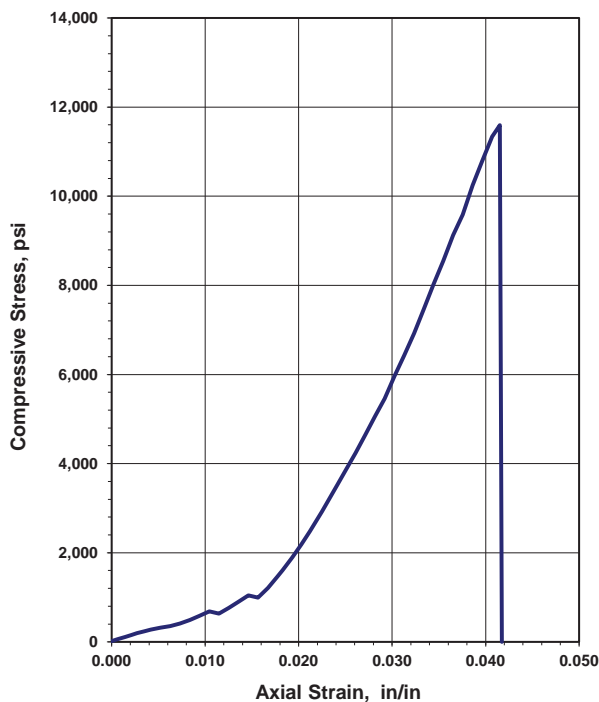
Boring No.: B-113-9-13  
Sample No.: RC-2  
Depth (ft): 61.8  
Moisture condition: As received

Average Length: 4.792 in  
Average Diameter: 2.396 in  
Length to diameter ratio: 2.000  
Cross Sectional Area: 4.507 in<sup>2</sup>

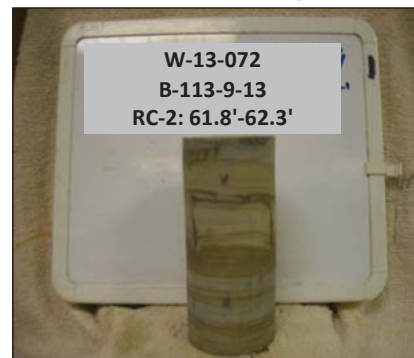
Rate of Loading: 106.7 lbs/sec  
Testing Time: 490 sec  
(Rate 2-15 minutes to failure)

Failure Load: 52,270 lbs  
Axial Strain at Failure: 0.0415 in/in  
Stress: 11,594 psi

**Unconfined Compression Test**



**Before Testing**



**After Failure**



REMARKS: \_\_\_\_\_



**RESOURCE INTERNATIONAL, INC.**  
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**Unconfined Compressive Strength  
of Intact Rock Core Specimens (ASTM D 7012-04)**

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Phone (614) 823-4949

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Cleveland, OH 44125

Phone (216) 573-0955

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Cincinnati, Ohio 45242

Phone (513) 769-6998

Project: FRA-70-13.10 - Project 6A

Project No.: W-13-072

Date of Testing: 4/7/2014

Test Performed by: K.R./T.K.

Rock Description: Dolomitic Limestone

Boring No.: B-113-9-13

Sample No.: RC-3

Depth (ft): 64.5

Moisture condition: As received

Average Length: 5.221 in

Average Diameter: 2.399 in

Length to diameter ratio: 2.176

Cross Sectional Area: 4.518 in<sup>2</sup>

Rate of Loading: 70.5 lbs/sec

Testing Time: 326 sec

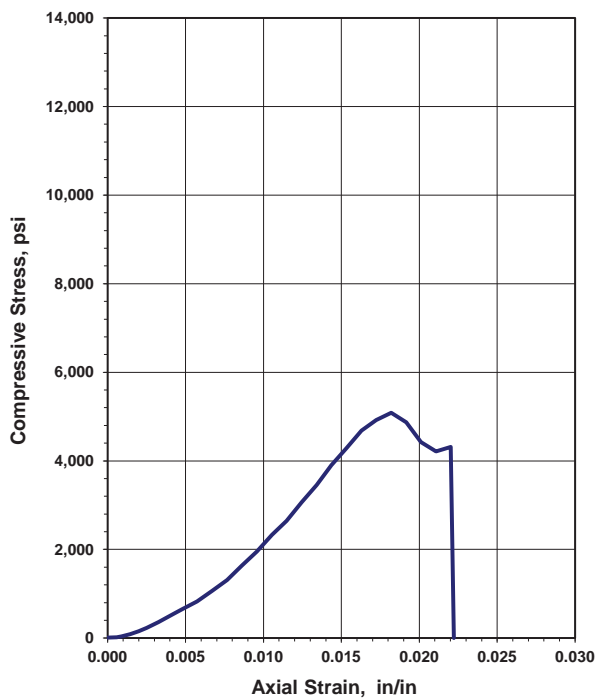
(Rate 2-15 minutes to failure)

Failure Load: 22,980 lbs

Axial Strain at Failure: 0.0182 in/in

Stress: 5,086 psi

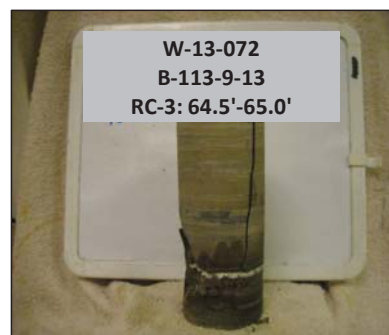
**Unconfined Compression Test**



**Before Testing**



**After Failure**



REMARKS: \_\_\_\_\_



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**Unconfined Compressive Strength  
of Intact Rock Core Specimens (ASTM D 7012-04)**

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Phone (513) 769-6998

Project: FRA-70-13.10 - Project 6A

Project No.: W-13-072

Date of Testing: 6/20/2014

Test Performed by: K.R./T.K.

Rock Description: Dolomitic Limestone

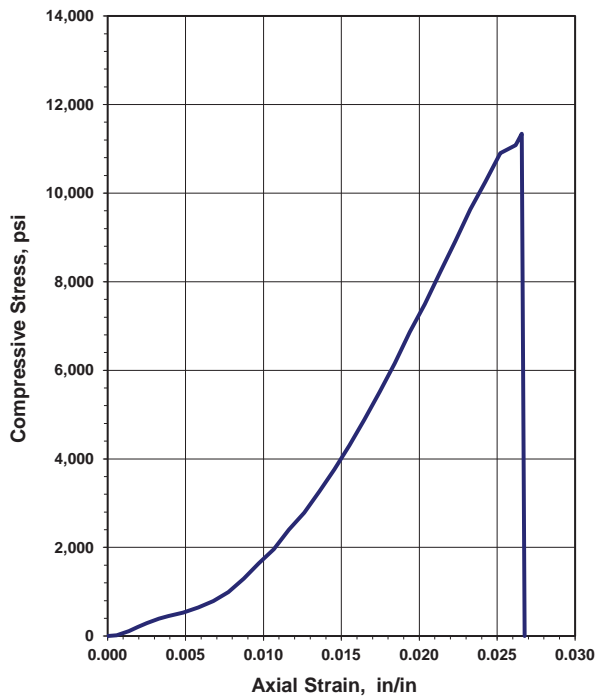
Boring No.: B-114-1-13  
Sample No.: RC-4  
Depth (ft): 76.0  
Moisture condition: As received

Average Length: 5.157 in  
Average Diameter: 2.4 in  
Length to diameter ratio: 2.149  
Cross Sectional Area: 4.522 in<sup>2</sup>

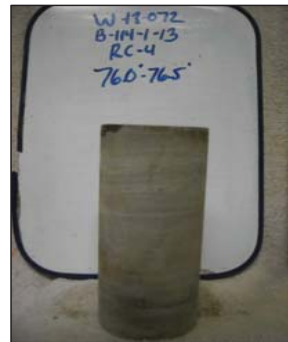
Rate of Loading: 88.3 lbs/sec  
Testing Time: 581 sec  
(Rate 2-15 minutes to failure)

Failure Load: 51,290 lbs  
Axial Strain at Failure: 0.0266 in/in  
Stress: 11,340 psi

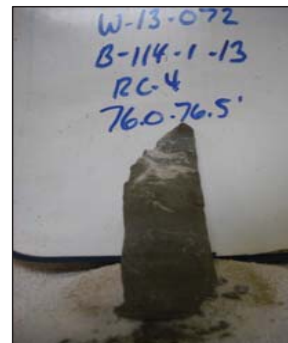
**Unconfined Compression Test**



**Before Testing**



**After Failure**



REMARKS: \_\_\_\_\_



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**Point Load Strength Index  
of Rock Specimens  
(ASTM D 5731-08)**

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Project: FRA-70 6A  
Project No.: W-13-072  
Date of Testing: 5/2/2014  
Test Performed by: E.M.

Rock Description: Gray Shale

Boring No.: B-113-7-13  
Sample No.: RC-3  
Moisture condition: As received

Test Apparatus: Forney-LA 0080  
Serial Number: A125/AZ/0014  
Date of Calibration: 8/10/2013

Sample No.	Test Type	Depth (ft)	Width (mm)	Diameter (mm)	Load (N)	$D_e^2$ (mm <sup>2</sup> )	$D_e$ (mm)	F	Is (MPa)	Is <sub>(50)</sub> (MPa)	$\sigma_c$ (MPa)
1	a $\perp$	30.9-35.7	35.4	57.3	50	2,583	50.8	1.01	0.02	0.02	0.47
2	a $\perp$	30.9-35.7	42.5	63.0	50	3,409	58.4	1.07	0.01	0.02	0.36
3	a $\perp$	30.9-35.7	46.4	62.8	70	3,711	60.9	1.09	0.02	0.02	0.46
4	a $\perp$	30.9-35.7	48.0	64.9	90	3,967	63.0	1.11	0.02	0.03	0.56
5	a $\perp$	30.9-35.7	46.6	63.1	100	3,747	61.2	1.10	0.03	0.03	0.65
6											
7											
8											
9											
10											

**Specific Specimen Shape:**

d = diametrical  
a = axial  
b = block  
i = irregular lump  
 $\perp$  = perpendicular to bedding plane  
 $\parallel$  = parallel to bedding plane

**Estimated Uniaxial Compression,  $\sigma_c = K \cdot Is$**

$$K = \frac{24.5}{\text{Per Table 1 of ASTM D5731}}$$

$$\text{Mean } \sigma_c = \boxed{0.50 \text{ MPa (73 psi)}}$$

**STATISTICS**

Mean Is <sub>(50)</sub> $\perp$	0.02 MPa (3 psi)
Mean Is <sub>(50)</sub> $\parallel$	
Is <sub>(50)</sub>	

Remarks: \_\_\_\_\_



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**Point Load Strength Index  
of Rock Specimens  
(ASTM D 5731-08)**

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Phone (216) 573-0955

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Phone (513) 769-6998

Project: FRA-70-13.10 - PHASE 6A

Project No.: W-13-072

Date of Testing: 6/19/2014

Test Performed by: E.M.

Rock Description: Gray Shale

Boring No.: B-114-1-13

Sample No.: RC-3

Moisture condition: As received

Test Apparatus: Forney-LA 0080

Serial Number: A125/AZ/0014

Date of Calibration: 8/10/2013

Sample No.	Test Type	Depth (ft)	Width (mm)	Diameter (mm)	Load (N)	$D_e^2$ (mm <sup>2</sup> )	$D_e$ (mm)	F	$I_s$ (MPa)	$I_{s(50)}$ (MPa)	$\sigma_c$ (MPa)
1	a $\perp$	73.0-74.0	26.6	61.0	350	2,066	45.5	0.96	0.17	0.16	4.15
2	a $\perp$	73.0-74.0	28.0	61.0	290	2,177	46.7	0.97	0.13	0.13	3.26
3	a $\perp$	73.0-74.0	25.0	61.0	275	1,941	44.1	0.94	0.14	0.13	3.47
4	a $\perp$	73.0-74.0	27.0	60.7	295	2,086	45.7	0.96	0.14	0.14	3.46
6											
7											
8											
9											
10											

**STATISTICS**

Mean  $I_{s(50)} \perp$

**0.14 MPa (20 psi)**

Mean  $I_{s(50)} \parallel$

$I_{a(50)}$

**Specific Specimen Shape:**

d = diametrical

a = axial

b = block

i = irregular lump

$\perp$  = perpendicular to bedding plane

$\parallel$  = parallel to bedding plane

**Estimated Uniaxial Compression,  $\sigma_c = K \cdot I_s$**

$K = \frac{24.5}{\text{mm}}$

\*Per Table 1 of ASTM D5731

Mean  $\sigma_c = \boxed{3.59 \text{ MPa (520 psi)}}$

Remarks: \_\_\_\_\_

## **APPENDIX VI**

### **DRILLED SHAFT CALCULATIONS**



End Bearing Resistance in Bedrock: AASHTO LRFD Section 10.8.3.5.4

Intact Rock (Minimum Embedment  $\geq 1.5B$ ): End Bearing on/in Limestone

$$q_p = 2.5q_u \quad \text{Equation 10.8.3.5.4c-1}$$

$$q_u = 732 \quad \text{ksf}$$

$$q_p = 1,831 \quad \text{ksf}$$

Jointed Rock (or Shafts with Embedment Depth  $< 1.5B$ ): End Bearing on/in Limestone

$$q_p = A + q_u \left[ m_b \left( \frac{A}{q_u} \right) + s \right]^a \quad \text{Equation 10.8.3.5.4c-2:}$$

$$A = \sigma'_{vb} + q_u \left[ m_b \frac{\sigma'_{vb}}{q_u} + s \right]^a \quad \text{Equation 10.8.3.5.4c-3}$$

$$q_u = 732 \quad \text{ksf}$$

$$GSI = 70 \quad \text{Per Figure 10.4.6.4-1}$$

$$D = 0.0 \quad \text{Per Section 10.4.6.4 for undisturbed foundation excavation}$$

$$m_i = 9 \quad \text{Per Table 10.4.6.4-1}$$

$$s = 0.036 \quad \text{Per Equation 10.4.6.4-2}$$

$$a = 0.50 \quad \text{Per Equation 10.4.6.4-3}$$

$$m_b = 3.08 \quad \text{Per Equation 10.4.6.4-4}$$

$$\sigma'_{vb} = 2.10 \quad \text{ksf} \quad \text{Considering overburden depth of 33.5 feet and bouyant unit weight of overburden of 62.6 psf}$$

$$A = 155.9 \quad \text{ksf} \quad \text{Per Equation 10.8.3.5.4c-3}$$

$$q_p = 765 \quad \text{ksf}$$

Axial Geotechnical Resistance:

$$\text{Shaft Diameter, } D_s = 5.0 \quad \text{ft}$$

End Bearing on/within Limestone with Rock Socket Length  $\geq 1.5B$ :

$$R_R = \phi_p R_n = \phi_p R_p = \phi_p q_p A_p = 17,975 \quad \text{kips}$$

$$q_p = 1,831 \quad \text{ksf}$$

$$A_p = 19.6 \quad \text{ft}^2$$

$$\phi_p = 0.5$$

End Bearing on/within Limestone with Rock Socket Length  $< 1.5B$ :

$$R_R = \phi_p R_n = \phi_p R_p = \phi_p q_p A_p = 7,510 \quad \text{kips}$$

$$q_p = 765 \quad \text{ksf}$$

$$A_p = 19.6 \quad \text{ft}^2$$

$$\phi_p = 0.5$$

Axial Structural Resistance of Drilled Shaft within Rock Socket: AASHTO LRFD Section 5.6.4.4

Shaft Diameter,  $D_s = 5.0$  ft

Reinforcing Steel Size: No. 10 Bars

$$A_{bar} = 1.27 \text{ in}^2$$

$$N_{bar} = 28 \text{ (Number of Bars)}$$

$$A_{st} = A_{bar}N_{bar} = 35.56 \text{ in}^2$$

$$P_r = \phi_c P_n \quad \text{Equation 5.6.4.4-1}$$

$$P_n = 0.85[k_c f'_c (A_g - A_{st}) + f_y A_{st}] \quad \text{Equation 5.6.4.4-2}$$

$$k_c = 0.85 \quad (\text{For concrete strength less than 10.0 ksi})$$

$$f'_c = 4.0 \text{ ksi}$$

$$A_g = A_p = 19.6 \text{ ft}^2 = 2,827.43 \text{ in}^2$$

$$A_{st} = 35.56 \text{ in}^2$$

$$f_y = 60 \text{ ksi}$$

$$P_n = 9,882 \text{ kips}$$

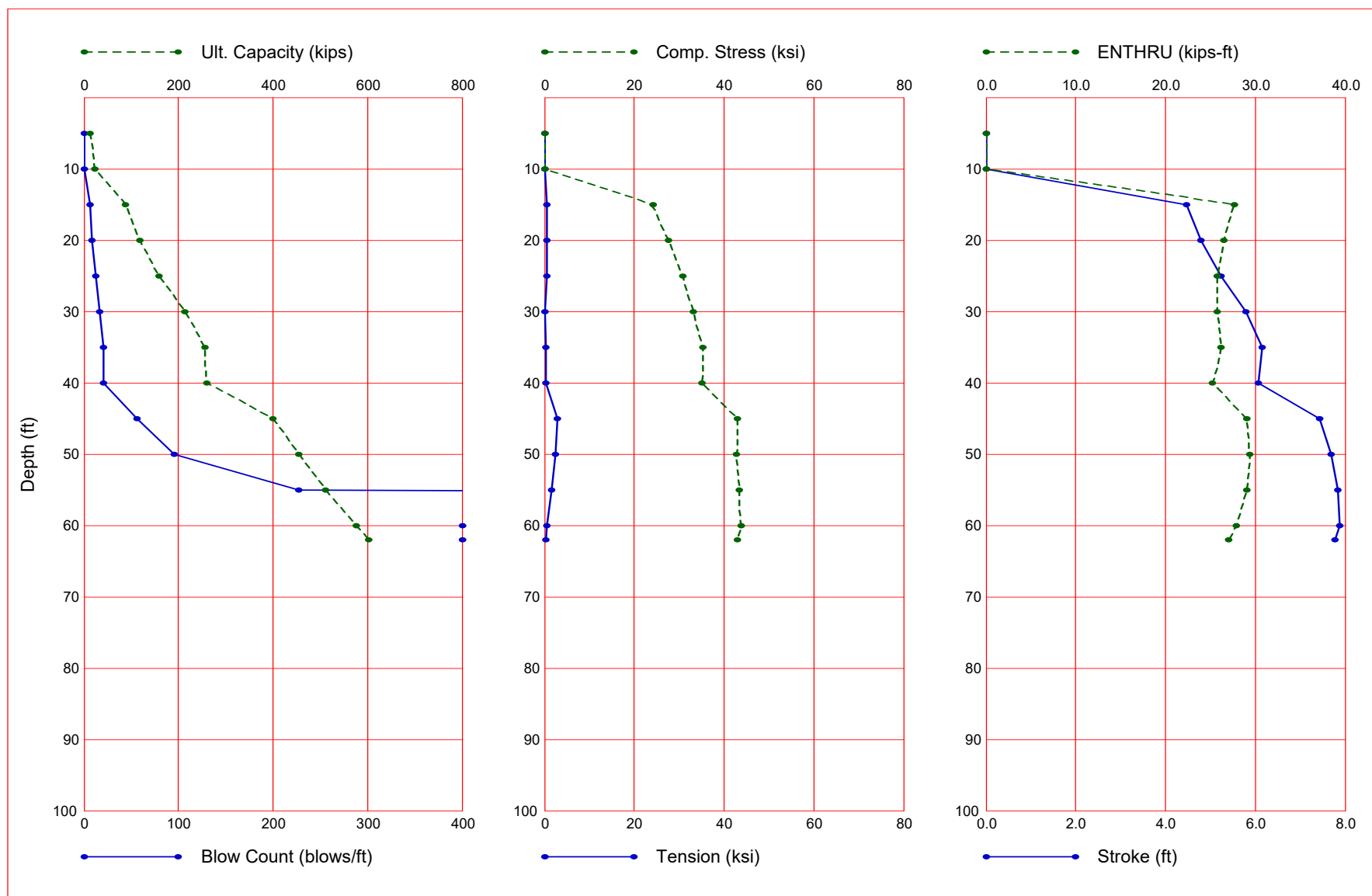
$$\phi_p = 0.75$$

$$P_r = 7,412 \text{ kips}$$

## **APPENDIX VII**

### **GRLWEAP DRIVEABILITY ANALYSIS OUTPUTS**

Gain/Loss 3 at Shaft and Toe 0.670 / 1.000



Gain/Loss 3 at Shaft and Toe 0.670 / 1.000

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
5.0	12.3	3.7	8.6	-1.0	0.000	0.000	0.00	0.0
10.0	22.6	19.7	2.9	-1.0	0.000	0.000	0.00	0.0
15.0	89.0	57.6	31.4	6.8	24.308	-0.546	4.47	27.7
20.0	118.0	83.6	34.5	9.0	27.643	-0.630	4.78	26.5
25.0	159.2	116.8	42.3	12.3	30.734	-0.443	5.24	25.8
30.0	213.8	155.5	58.3	16.9	33.200	0.000	5.80	25.8
35.0	257.1	198.8	58.3	20.8	35.219	-0.366	6.15	26.2
40.0	259.6	253.4	6.2	20.9	35.089	-0.301	6.07	25.2
45.0	399.1	335.6	63.5	56.7	42.913	-2.876	7.43	29.1
50.0	455.6	392.1	63.5	95.5	42.818	-2.385	7.70	29.4
55.0	511.3	453.0	58.3	227.6	43.422	-1.546	7.85	29.1
60.0	575.9	517.6	58.3	9999.0	43.743	-0.622	7.88	27.9
62.0	603.0	544.6	58.3	9999.0	43.082	-0.303	7.77	27.0

Refusal occurred; no driving time output possible

GRLWEAP - Version 2010  
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.  
Copyright (c) 1998-2010, Pile Dynamics, Inc.

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

Input File: J:\GEOTECH\PROJECTS\2013\W-13-072 FRA-70-13.10 PROJECT 6A\ANALYSIS\FRA-70-1322L AND 1323C\DRIVEABILITY\FRA-70-1322L\REAR ABUTMENT\HP 10X42\1322L-RA-10X42.GW  
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW  
Hammer File Version: 2003 (12/4/2018)

Input File Contents

FRA-70-1322L - Rear Abutment - HP10x42  
OUT OSG HAM STR FUL PEL N SPL N-U P-D %SK ISM 0 PHI RSA ITR H-D MXT DEX  
-100 0 14 0 3 0 0 0 0 1 0 1 0 0 0 0 0 0 0.000  
Pile g Hammer g Toe Area Pile Size Pile Type  
32.170 32.170 144.000 10.000 Unknown  
W Cp A Cp E Cp T Cp CoR ROut StCp  
1.900 227.000 530.0 2.000 0.800 0.010 0.0  
A Cu E Cu T Cu CoR ROut StCu  
0.000 0.0 0.000 0.000 0.000 0.0  
LPle APle EPle WPle Peri CI CoR ROut  
62.000 12.40 29000.0 492.000 3.300 0 0.850 0.010  
FFatigue F0 0-Bottom  
0 0.000 0.000  
Manufac Hmr Name HmrType No Seg-s  
DELMAG D 30-23 1 5  
Ram Wt Ram L Ram Dia MaxStrk RtdStrk Efficy  
6.60 118.10 16.51 13.44 11.18 0.80  
IB. Wt IB. L IB. Dia IB CoR IB R0  
1.20 25.00 16.51 0.900 0.010  
CompStrk A Chamber V Chamber C Delay C Duratn Exp Coeff VolCStart Vol CEnd  
16.30 214.03 280.90 0.0010 0.0020 1.250 0.00 0.00  
P atm P1 P2 P3 P4 P5  
14.70 1550.00 1395.00 1255.00 1130.00 0.00  
Stroke Effic. Pressure R-Weight T-Delay Exp-Coeff Eps-Str Total-AW  
11.1800 0.8000 1255.0000 0.0000 0.0000 0.0000 0.0100 0.0000  
Qs Qt Js Jt Qx Jx Rati Dept  
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000  
Research Soil Model: Atoe, Plug, Gap, Q-fac

0.000 0.000 0.000 0.000  
 Research Soil Model: RD-skn: m, d, toe: m, d  
 0.000 0.000 0.000 0.000  
 Research Toe Plug: Res-int, Q-int, D-int, Res-plug, Q-plug, D-plug  
 0.000 0.000 0.000 0.000 0.000 0.000  
 Research Toe Plug: RD plug toe: m, d  
 0.000 0.000  
 Research Toe Plug: New Toe Plug Model is NOT applied  
 Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimL	TSf0
0.01	0.00	0.02	0.10	0.10	0.05	0.15	1.00	6.00	1.000
9.01	0.81	15.53	0.10	0.10	0.05	0.15	1.00	6.00	1.000
9.09	0.81	15.66	0.10	0.10	0.05	0.15	1.00	6.00	1.000
9.11	3.75	2.91	0.10	0.10	0.20	0.15	1.49	6.00	168.000
14.09	3.75	2.91	0.10	0.10	0.20	0.15	1.49	6.00	168.000
14.11	1.26	29.42	0.10	0.10	0.05	0.15	1.00	6.00	1.000
19.09	1.73	40.36	0.10	0.10	0.05	0.15	1.00	6.00	1.000
19.11	1.71	32.93	0.10	0.10	0.05	0.15	1.00	6.00	1.000
24.49	2.19	42.20	0.10	0.10	0.05	0.15	1.00	6.00	1.000
24.51	2.20	42.22	0.10	0.10	0.05	0.15	1.00	6.00	1.000
29.09	2.41	43.36	0.10	0.10	0.05	0.15	1.00	6.00	1.000
29.11	2.45	58.35	0.10	0.10	0.05	0.15	1.00	6.00	1.000
38.11	2.91	58.35	0.10	0.10	0.05	0.15	1.00	6.00	1.000
39.09	2.96	58.35	0.10	0.10	0.05	0.15	1.00	6.00	1.000
39.11	8.00	6.20	0.10	0.10	0.20	0.15	1.49	6.00	168.000
44.09	8.00	6.20	0.10	0.10	0.20	0.15	1.49	6.00	168.000
44.11	3.24	63.52	0.10	0.10	0.05	0.15	1.00	6.00	1.000
53.11	3.73	63.52	0.10	0.10	0.05	0.15	1.00	6.00	1.000
54.49	3.81	63.52	0.10	0.10	0.05	0.15	1.00	6.00	1.000
54.51	3.76	58.35	0.10	0.10	0.05	0.15	1.00	6.00	1.000
62.00	4.14	58.35	0.10	0.10	0.05	0.15	1.00	6.00	1.000

Gain/Loss factors: shaft and toe  
 0.60400 0.63700 0.67000 0.70300 0.73600  
 1.00000 1.00000 1.00000 1.00000 1.00000

Dpth	L	Wait	Strk	Pmx%	Eff.	Stiff	CoR
5.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
10.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
15.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
20.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
25.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
30.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
35.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
40.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
45.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
50.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
55.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
60.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
62.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
0.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000

▲ GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS  
 Version 2010  
 English Units

FRA-70-1322L - Rear Abutment - HP10x42

Hammer Model: D 30-23		Made by: DELMAG	
No.	Weight kips	Stiffn k/inch	CoR
1	1.320		
2	1.320	262846.5	1.000
3	1.320	262846.5	1.000
4	1.320	262846.5	1.000
5	1.320	262846.5	1.000
Imp Block	1.200	127693.0	0.900
Helmet	1.900	60155.0	0.800
Combined Pile Top		9183.3	

HAMMER OPTIONS:  
 Hammer File ID No. 14 Hammer Type OE Diesel  
 Stroke Option FxdP-VarS Stroke Convergence Crit. 0.010  
 Fuel Pump Setting Max - 2

HAMMER DATA:  
 Ram Weight (kips) 6.60 Ram Length (inch) 118.10  
 Maximum Stroke (ft) 13.44  
 Rated Stroke (ft) 11.18 Efficiency 0.800  
 Maximum Pressure (psi) 1550.00 Actual Pressure (psi) 1255.00  
 Compression Exponent 1.350 Expansion Exponent 1.250

1322L-RA-10X42

Ram Diameter	(inch)	16.51		
Combustion Delay	(s)	0.00100	Ignition Duration	(s) 0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION			PILE CUSHION		
Cross Sect. Area	(in2)	227.00	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	530.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	2.00	Thickness	(inch)	0.00
Coeff of Restitution		0.8	Coeff of Restitution		1.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	60155.0	Stiffness	(kips/in)	0.0

FRA-70-1322L - Rear Abutment - HP10x42  
 Resource International Inc

02/28/2021  
 GRLWEAP Version 2010

Depth	(ft)	5.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	10.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	12.3
	kips	Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D	Quake	LbTop Perim Area
		k/in ft ft	kips	s/ft	inch	ft ft in2
1	0.138	9183 0.010 0.000 0.85	0.0	0.000	0.100	3.26 3.3 12.4
2	0.138	9183 0.000 0.000 1.00	0.0	0.000	0.100	6.53 3.3 12.4
18	0.138	9183 0.000 0.000 1.00	0.4	0.050	0.100	58.74 3.3 12.4
19	0.138	9183 0.000 0.000 1.00	3.2	0.050	0.100	62.00 3.3 12.4
Toe			8.6	0.150	0.100	

2.627 kips total unreduced pile weight (g= 32.17 ft/s2)

2.627 kips total reduced pile weight (g= 32.17 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile		Pile Segments: Automatic
No. of Slacks/Splices	0	Pile Damping (%) 1
		Pile Damping Fact.(k/ft/s) 0.435

Driveability Analysis	
Soil Damping Option	Smith
Max No Analysis Iterations	0 Time Increment/Critical 160
Output Time Interval	1 Analysis Time-Input (ms) 0
Output Level: Normal	
Gravity Mass, Pile, Hammer:	32.170 32.170 32.170
Output Segment Generation: Automatic	

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
5.00	11.18	0.81	0.800

FRA-70-1322L - Rear Abutment - HP10x42  
 Resource International Inc

02/28/2021  
 GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i t Comp Str	i t ENTHRU	Bl Rt
kips	b/ft	down up	ksi	ksi	kip-ft	b/min
12.3	Hammer did not run					
12.3	Hammer did not run					
12.3	Hammer did not run					
12.3	Hammer did not run					
12.3	Hammer did not run					

FRA-70-1322L - Rear Abutment - HP10x42  
 Resource International Inc

02/28/2021  
 GRLWEAP Version 2010

Depth	(ft)	10.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
----------	-------	---------	-----------	---------



Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model					Total Capacity Rut (kips)					21.9	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.138	9183	0.010	0.000	0.85	0.0	0.000	0.100	3.26	3.3	12.4
2	0.138	9183	0.000	0.000	1.00	0.0	0.000	0.100	6.53	3.3	12.4
16	0.138	9183	0.000	0.000	1.00	0.0	0.050	0.100	52.21	3.3	12.4
17	0.138	9183	0.000	0.000	1.00	1.8	0.050	0.100	55.47	3.3	12.4
18	0.138	9183	0.000	0.000	1.00	4.9	0.050	0.100	58.74	3.3	12.4
19	0.138	9183	0.000	0.000	1.00	12.3	0.150	0.100	62.00	3.3	12.4
Toe						2.9	0.150	0.100			

2.627 kips total unreduced pile weight (g= 32.17 ft/s2)

2.627 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
10.00	11.18	0.81	0.800

▲

FRA-70-1322L - Rear Abutment - HP10x42  
Resource International Inc02/28/2021  
GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp	Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi		kip-ft	b/min
21.9	Hammer	did not run							
22.3	Hammer	did not run							
22.6	Hammer	did not run							
23.0	Hammer	did not run							
23.4	Hammer	did not run							

▲

FRA-70-1322L - Rear Abutment - HP10x42  
Resource International Inc02/28/2021  
GRLWEAP Version 2010

Depth	(ft)	15.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor
			1.000

## PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	10.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model					Total Capacity Rut (kips)					84.9	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.138	9183	0.010	0.000	0.85	0.0	0.000	0.100	3.26	3.3	12.4
2	0.138	9183	0.000	0.000	1.00	0.0	0.000	0.100	6.53	3.3	12.4
15	0.138	9183	0.000	0.000	1.00	0.6	0.050	0.100	48.95	3.3	12.4
16	0.138	9183	0.000	0.000	1.00	3.5	0.050	0.100	52.21	3.3	12.4
17	0.138	9183	0.000	0.000	1.00	6.6	0.050	0.100	55.47	3.3	12.4
18	0.138	9183	0.000	0.000	1.00	21.4	0.193	0.100	58.74	3.3	12.4
19	0.138	9183	0.000	0.000	1.00	21.5	0.182	0.100	62.00	3.3	12.4
Toe						31.4	0.150	0.100			

2.627 kips total unreduced pile weight (g= 32.17 ft/s2)

2.627 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
15.00	11.18	0.81	0.800

▲

FRA-70-1322L - Rear Abutment - HP10x42  
Resource International Inc02/28/2021  
GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp	Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi		kip-ft	b/min

1322L-RA-10X42													
84.9	6.5	4.34	4.38	-0.34	16	50	23.33	16	5	27.7	55.9		
86.9	6.7	4.38	4.42	-0.47	16	50	23.71	16	5	27.6	55.7		
89.0	6.8	4.47	4.45	-0.55	16	50	24.31	16	5	27.7	55.3		
91.0	7.1	4.46	4.50	-0.60	16	50	24.40	16	5	27.3	55.1		
93.0	7.3	4.50	4.54	-0.61	16	50	24.76	16	5	27.2	54.9		

FRA-70-1322L - Rear Abutment - HP10x42  
 Resource International Inc  
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Depth (ft) 20.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model										Total Capacity Rut (kips)	114.0
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
kips	k/in	ft	ft			kips	s/ft	inch	ft	ft	in2
1	0.138	9183	0.010	0.000	0.85	0.0	0.000	0.100	3.26	3.3	12.4
2	0.138	9183	0.000	0.000	1.00	0.0	0.000	0.100	6.53	3.3	12.4
13	0.138	9183	0.000	0.000	1.00	0.0	0.050	0.100	42.42	3.3	12.4
14	0.138	9183	0.000	0.000	1.00	2.0	0.050	0.100	45.68	3.3	12.4
15	0.138	9183	0.000	0.000	1.00	5.1	0.050	0.100	48.95	3.3	12.4
16	0.138	9183	0.000	0.000	1.00	13.4	0.159	0.100	52.21	3.3	12.4
17	0.138	9183	0.000	0.000	1.00	24.4	0.200	0.100	55.47	3.3	12.4
18	0.138	9183	0.000	0.000	1.00	16.7	0.108	0.100	58.74	3.3	12.4
19	0.138	9183	0.000	0.000	1.00	17.8	0.050	0.100	62.00	3.3	12.4
Toe						34.5	0.150	0.100			

2.627 kips total unredacted pile weight (g= 32.17 ft/s2)  
 2.627 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
20.00	11.18	0.81	0.800

FRA-70-1322L - Rear Abutment - HP10x42  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	b/min	
114.0	8.5	4.71	4.75	-0.72	14 45	27.06	16 5	26.7
116.0	8.8	4.74	4.79	-0.69	14 45	27.32	16 5	26.6
118.0	9.0	4.78	4.82	-0.63	14 45	27.64	16 5	26.5
120.1	9.2	4.82	4.85	-0.61	14 43	27.99	16 5	26.5
122.1	9.4	4.86	4.88	-0.59	14 43	28.30	16 5	26.4

FRA-70-1322L - Rear Abutment - HP10x42  
 Resource International Inc  
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 GRLWEAP Version 2010

Depth (ft) 25.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model										Total Capacity Rut (kips)	155.1
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
kips	k/in	ft	ft			kips	s/ft	inch	ft	ft	in2
1	0.138	9183	0.010	0.000	0.85	0.0	0.000	0.100	3.26	3.3	12.4
2	0.138	9183	0.000	0.000	1.00	0.0	0.000	0.100	6.53	3.3	12.4
12	0.138	9183	0.000	0.000	1.00	0.7	0.050	0.100	39.16	3.3	12.4
13	0.138	9183	0.000	0.000	1.00	3.7	0.050	0.100	42.42	3.3	12.4
14	0.138	9183	0.000	0.000	1.00	6.8	0.050	0.100	45.68	3.3	12.4

1322L-RA-10X42											
15	0.138	9183	0.000	0.000	1.00	22.4	0.195	0.100	48.95	3.3	12.4
16	0.138	9183	0.000	0.000	1.00	20.9	0.177	0.100	52.21	3.3	12.4
17	0.138	9183	0.000	0.000	1.00	16.3	0.050	0.100	55.47	3.3	12.4
18	0.138	9183	0.000	0.000	1.00	19.4	0.050	0.100	58.74	3.3	12.4
19	0.138	9183	0.000	0.000	1.00	22.5	0.050	0.100	62.00	3.3	12.4
Toe						42.3	0.150	0.100			

2.627 kips total unreduced pile weight (g= 32.17 ft/s2)  
2.627 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
25.00	11.18	0.81	0.800

↑  
FRA-70-1322L - Rear Abutment - HP10x42 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
155.1	11.8	5.17	5.18	-0.64	13	39	30.18	15	5	25.9
157.1	12.0	5.20	5.22	-0.55	13	39	30.43	15	5	25.8
159.2	12.3	5.24	5.25	-0.44	13	38	30.73	15	5	25.8
161.2	12.5	5.27	5.28	-0.33	13	38	31.03	15	5	25.8
163.2	12.8	5.30	5.31	-0.20	12	38	31.29	15	5	25.7

↑  
FRA-70-1322L - Rear Abutment - HP10x42 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth	(ft)	30.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor
			1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	10.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model										Total Capacity	Rut	(kips)	209.8
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area		
kips		k/in	ft	ft		kips	s/ft	inch	ft	ft	in2		
1	0.138	9183	0.010	0.000	0.85	0.0	0.000	0.100	3.26	3.3	12.4		
2	0.138	9183	0.000	0.000	1.00	0.0	0.000	0.100	6.53	3.3	12.4		
10	0.138	9183	0.000	0.000	1.00	0.1	0.050	0.100	32.63	3.3	12.4		
11	0.138	9183	0.000	0.000	1.00	2.2	0.050	0.100	35.89	3.3	12.4		
12	0.138	9183	0.000	0.000	1.00	5.3	0.050	0.100	39.16	3.3	12.4		
13	0.138	9183	0.000	0.000	1.00	14.6	0.166	0.100	42.42	3.3	12.4		
14	0.138	9183	0.000	0.000	1.00	24.4	0.200	0.100	45.68	3.3	12.4		
15	0.138	9183	0.000	0.000	1.00	16.2	0.092	0.100	48.95	3.3	12.4		
16	0.138	9183	0.000	0.000	1.00	18.0	0.050	0.100	52.21	3.3	12.4		
17	0.138	9183	0.000	0.000	1.00	21.1	0.050	0.100	55.47	3.3	12.4		
18	0.138	9183	0.000	0.000	1.00	23.9	0.050	0.100	58.74	3.3	12.4		
19	0.138	9183	0.000	0.000	1.00	25.7	0.050	0.100	62.00	3.3	12.4		
Toe						58.3	0.150	0.100					

2.627 kips total unreduced pile weight (g= 32.17 ft/s2)  
2.627 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
30.00	11.18	0.81	0.800

↑  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
209.8	16.5	5.75	5.75	0.00	1	0	32.78	13	4	25.7
211.8	16.7	5.78	5.77	0.00	1	0	32.99	13	4	25.7
213.8	16.9	5.80	5.80	0.00	1	0	33.20	13	4	25.8
215.9	17.2	5.82	5.82	0.00	1	0	33.43	13	4	25.8
217.9	17.6	5.80	5.85	0.00	1	0	33.43	13	4	25.6

↑  
FRA-70-1322L - Rear Abutment - HP10x42 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth (ft) 35.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

## PILE PROFILE:

Toe Area (in<sup>2</sup>) 144.000 Pile Type Unknown  
 Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in <sup>2</sup>	ksi	lb/ft <sup>3</sup>	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)			253.1		
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in <sup>2</sup>
1	0.138	9183	0.010	0.000	0.85	0.0	0.000	0.100	3.26	3.3	12.4
2	0.138	9183	0.000	0.000	1.00	0.0	0.000	0.100	6.53	3.3	12.4
9	0.138	9183	0.000	0.000	1.00	0.8	0.050	0.100	29.37	3.3	12.4
10	0.138	9183	0.000	0.000	1.00	3.9	0.050	0.100	32.63	3.3	12.4
11	0.138	9183	0.000	0.000	1.00	7.0	0.050	0.100	35.89	3.3	12.4
12	0.138	9183	0.000	0.000	1.00	23.4	0.198	0.100	39.16	3.3	12.4
13	0.138	9183	0.000	0.000	1.00	20.3	0.171	0.100	42.42	3.3	12.4
14	0.138	9183	0.000	0.000	1.00	16.5	0.050	0.100	45.68	3.3	12.4
15	0.138	9183	0.000	0.000	1.00	19.6	0.050	0.100	48.95	3.3	12.4
16	0.138	9183	0.000	0.000	1.00	22.7	0.050	0.100	52.21	3.3	12.4
17	0.138	9183	0.000	0.000	1.00	24.8	0.050	0.100	55.47	3.3	12.4
18	0.138	9183	0.000	0.000	1.00	26.9	0.050	0.100	58.74	3.3	12.4
19	0.138	9183	0.000	0.000	1.00	28.7	0.050	0.100	62.00	3.3	12.4
Toe						58.3	0.150	0.100			

2.627 kips total unredused pile weight (g= 32.17 ft/s<sup>2</sup>)

2.627 kips total reduced pile weight (g= 32.17 ft/s<sup>2</sup>)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
35.00	11.18	0.81	0.800

⬆  
 FRA-70-1322L - Rear Abutment - HP10x42 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp	Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi		kip-ft	b/min
253.1	20.3	6.09	6.08	0.00	1	0	34.64	12	4 26.0
255.1	20.5	6.12	6.10	-0.10	10	50	34.95	12	4 26.1
257.1	20.8	6.15	6.13	-0.37	10	50	35.22	12	4 26.2
259.2	21.0	6.18	6.15	-0.61	10	50	35.56	12	4 26.3
261.2	21.3	6.21	6.18	-0.85	10	50	35.83	12	4 26.3

⬆  
 FRA-70-1322L - Rear Abutment - HP10x42 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth (ft) 40.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

## PILE PROFILE:

Toe Area (in<sup>2</sup>) 144.000 Pile Type Unknown  
 Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in <sup>2</sup>	ksi	lb/ft <sup>3</sup>	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)			253.9		
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in <sup>2</sup>
1	0.138	9183	0.010	0.000	0.85	0.0	0.000	0.100	3.26	3.3	12.4
2	0.138	9183	0.000	0.000	1.00	0.0	0.000	0.100	6.53	3.3	12.4
7	0.138	9183	0.000	0.000	1.00	0.1	0.050	0.100	22.84	3.3	12.4
8	0.138	9183	0.000	0.000	1.00	2.4	0.050	0.100	26.11	3.3	12.4
9	0.138	9183	0.000	0.000	1.00	5.5	0.050	0.100	29.37	3.3	12.4
10	0.138	9183	0.000	0.000	1.00	15.7	0.172	0.100	32.63	3.3	12.4
11	0.138	9183	0.000	0.000	1.00	24.4	0.200	0.100	35.89	3.3	12.4
12	0.138	9183	0.000	0.000	1.00	15.7	0.072	0.100	39.16	3.3	12.4
13	0.138	9183	0.000	0.000	1.00	18.2	0.050	0.100	42.42	3.3	12.4

1322L-RA-10X42												
14	0.138	9183	0.000	0.000	1.00	21.3	0.050	0.100	45.68	3.3	12.4	
15	0.138	9183	0.000	0.000	1.00	24.0	0.050	0.100	48.95	3.3	12.4	
16	0.138	9183	0.000	0.000	1.00	25.9	0.050	0.100	52.21	3.3	12.4	
17	0.138	9183	0.000	0.000	1.00	27.9	0.050	0.100	55.47	3.3	12.4	
18	0.138	9183	0.000	0.000	1.00	29.7	0.050	0.100	58.74	3.3	12.4	
19	0.138	9183	0.000	0.000	1.00	37.0	0.127	0.100	62.00	3.3	12.4	
Toe						6.2	0.150	0.100				

2.627 kips total unreduced pile weight (g= 32.17 ft/s2)  
2.627 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
40.00	11.18	0.81	0.800

▲  
FRA-70-1322L - Rear Abutment - HP10x42 02/28/2021  
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Rut kips	Bl Ct b/ft	Stroke down	(ft) up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
253.9	20.1	6.00	6.04	0.00	1	0	34.50	6	7	25.2	47.8
256.7	20.4	6.04	6.07	-0.05	8	50	34.83	6	7	25.2	47.6
259.6	20.9	6.07	6.11	-0.30	8	50	35.09	6	7	25.2	47.5
262.4	21.2	6.11	6.13	-0.51	8	50	35.49	6	7	25.3	47.4
265.2	21.6	6.14	6.17	-0.69	8	50	35.77	6	7	25.3	47.2

▲  
FRA-70-1322L - Rear Abutment - HP10x42 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth	(ft)	45.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor
			1.000

#### PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	10.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model										Total Capacity Rut (kips)	386.3
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.138	9183	0.010	0.000	0.85	0.0	0.000	0.100	3.26	3.3	12.4
2	0.138	9183	0.000	0.000	1.00	0.0	0.000	0.100	6.53	3.3	12.4
6	0.138	9183	0.000	0.000	1.00	1.0	0.050	0.100	19.58	3.3	12.4
7	0.138	9183	0.000	0.000	1.00	4.1	0.050	0.100	22.84	3.3	12.4
8	0.138	9183	0.000	0.000	1.00	7.3	0.051	0.100	26.11	3.3	12.4
9	0.138	9183	0.000	0.000	1.00	24.4	0.200	0.100	29.37	3.3	12.4
10	0.138	9183	0.000	0.000	1.00	19.7	0.164	0.100	32.63	3.3	12.4
11	0.138	9183	0.000	0.000	1.00	16.7	0.050	0.100	35.89	3.3	12.4
12	0.138	9183	0.000	0.000	1.00	19.8	0.050	0.100	39.16	3.3	12.4
13	0.138	9183	0.000	0.000	1.00	22.9	0.050	0.100	42.42	3.3	12.4
14	0.138	9183	0.000	0.000	1.00	24.9	0.050	0.100	45.68	3.3	12.4
15	0.138	9183	0.000	0.000	1.00	27.0	0.050	0.100	48.95	3.3	12.4
16	0.138	9183	0.000	0.000	1.00	28.8	0.050	0.100	52.21	3.3	12.4
17	0.138	9183	0.000	0.000	1.00	30.6	0.050	0.100	55.47	3.3	12.4
18	0.138	9183	0.000	0.000	1.00	48.2	0.188	0.100	58.74	3.3	12.4
19	0.138	9183	0.000	0.000	1.00	47.4	0.180	0.100	62.00	3.3	12.4
Toe						63.5	0.150	0.100			

2.627 kips total unreduced pile weight (g= 32.17 ft/s2)  
2.627 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
45.00	11.18	0.81	0.800

▲  
FRA-70-1322L - Rear Abutment - HP10x42 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt	
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min	
386.3	50.5	7.31	7.28	-2.73	7	42	41.99	9	8	28.8	43.5
392.7	53.2	7.37	7.34	-2.83	7	42	42.50	9	8	29.1	43.3
399.1	56.7	7.43	7.40	-2.88	7	41	42.91	9	7	29.1	43.2

1322L-RA-10X42  
 405.5 60.2 7.48 7.46 -2.95 7 41 43.35 9 7 29.3 43.0  
 411.9 63.8 7.55 7.51 -3.02 7 41 43.84 9 7 29.5 42.8

▲  
 FRA-70-1322L - Rear Abutment - HP10x42 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth (ft) 50.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:  
 Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	442.8
	kips	Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D	Quake	LbTop Perim Area
		k/in ft ft	kips	s/ft	inch	ft ft in2
1	0.138	9183 0.010 0.000 0.85	0.0	0.000	0.100	3.26 3.3 12.4
2	0.138	9183 0.000 0.000 1.00	0.0	0.000	0.100	6.53 3.3 12.4
4	0.138	9183 0.000 0.000 1.00	0.2	0.050	0.100	13.05 3.3 12.4
5	0.138	9183 0.000 0.000 1.00	2.6	0.050	0.100	16.32 3.3 12.4
6	0.138	9183 0.000 0.000 1.00	5.7	0.050	0.100	19.58 3.3 12.4
7	0.138	9183 0.000 0.000 1.00	16.8	0.177	0.100	22.84 3.3 12.4
8	0.138	9183 0.000 0.000 1.00	24.4	0.200	0.100	26.11 3.3 12.4
9	0.138	9183 0.000 0.000 1.00	15.2	0.050	0.100	29.37 3.3 12.4
10	0.138	9183 0.000 0.000 1.00	18.4	0.050	0.100	32.63 3.3 12.4
11	0.138	9183 0.000 0.000 1.00	21.5	0.050	0.100	35.89 3.3 12.4
12	0.138	9183 0.000 0.000 1.00	24.1	0.050	0.100	39.16 3.3 12.4
13	0.138	9183 0.000 0.000 1.00	26.0	0.050	0.100	42.42 3.3 12.4
14	0.138	9183 0.000 0.000 1.00	28.0	0.050	0.100	45.68 3.3 12.4
15	0.138	9183 0.000 0.000 1.00	29.8	0.050	0.100	48.95 3.3 12.4
16	0.138	9183 0.000 0.000 1.00	38.4	0.138	0.100	52.21 3.3 12.4
17	0.138	9183 0.000 0.000 1.00	52.0	0.200	0.100	55.47 3.3 12.4
18	0.138	9183 0.000 0.000 1.00	38.8	0.104	0.100	58.74 3.3 12.4
19	0.138	9183 0.000 0.000 1.00	37.4	0.050	0.100	62.00 3.3 12.4
Toe			63.5	0.150	0.100	

2.627 kips total unreduced pile weight (g= 32.17 ft/s2)  
 2.627 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
50.00	11.18	0.81	0.800

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 FRA-70-1322L - Rear Abutment - HP10x42 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down up	ksi		ksi		kip-ft	b/min
442.8	81.9	7.61 7.58	-2.30	6 39	42.06	7 7	29.2	42.7
449.2	87.9	7.66 7.63	-2.35	6 39	42.48	7 7	29.3	42.6
455.6	95.5	7.70 7.67	-2.39	6 39	42.82	7 7	29.4	42.4
462.0	103.3	7.75 7.71	-2.42	6 38	43.20	7 7	29.6	42.3
468.4	113.0	7.80 7.75	-2.45	6 38	43.52	7 7	29.7	42.2

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Depth (ft) 55.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:  
 Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	498.6
		Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D	Quake	LbTop Perim Area

1322L-RA-10X42

	kips	k/in	ft	ft	kips	s/ft	inch	ft	ft	in2	
1	0.138	9183	0.010	0.000	0.85	0.0	0.000	0.100	3.26	3.3	12.4
2	0.138	9183	0.000	0.000	1.00	0.0	0.000	0.100	6.53	3.3	12.4
3	0.138	9183	0.000	0.000	1.00	1.1	0.050	0.100	9.79	3.3	12.4
4	0.138	9183	0.000	0.000	1.00	4.3	0.050	0.100	13.05	3.3	12.4
5	0.138	9183	0.000	0.000	1.00	8.5	0.091	0.100	16.32	3.3	12.4
6	0.138	9183	0.000	0.000	1.00	24.4	0.200	0.100	19.58	3.3	12.4
7	0.138	9183	0.000	0.000	1.00	19.1	0.156	0.100	22.84	3.3	12.4
8	0.138	9183	0.000	0.000	1.00	17.0	0.050	0.100	26.11	3.3	12.4
9	0.138	9183	0.000	0.000	1.00	20.0	0.050	0.100	29.37	3.3	12.4
10	0.138	9183	0.000	0.000	1.00	23.1	0.050	0.100	32.63	3.3	12.4
11	0.138	9183	0.000	0.000	1.00	25.0	0.050	0.100	35.89	3.3	12.4
12	0.138	9183	0.000	0.000	1.00	27.1	0.050	0.100	39.16	3.3	12.4
13	0.138	9183	0.000	0.000	1.00	29.0	0.050	0.100	42.42	3.3	12.4
14	0.138	9183	0.000	0.000	1.00	30.7	0.050	0.100	45.68	3.3	12.4
15	0.138	9183	0.000	0.000	1.00	49.5	0.192	0.100	48.95	3.3	12.4
16	0.138	9183	0.000	0.000	1.00	46.3	0.174	0.100	52.21	3.3	12.4
17	0.138	9183	0.000	0.000	1.00	36.5	0.050	0.100	55.47	3.3	12.4
18	0.138	9183	0.000	0.000	1.00	38.4	0.050	0.100	58.74	3.3	12.4
19	0.138	9183	0.000	0.000	1.00	40.3	0.050	0.100	62.00	3.3	12.4
Toe						58.3	0.150	0.100			

2.627 kips total unredused pile weight (g= 32.17 ft/s2)

2.627 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
55.00	11.18	0.81	0.800

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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt	
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min	
498.6	174.1	7.77	7.74	-1.52	4	36	42.81	6	7	28.8	42.3
504.9	198.8	7.81	7.77	-1.52	4	36	43.10	6	7	28.9	42.2
511.3	227.6	7.85	7.79	-1.55	4	36	43.42	6	7	29.1	42.1
517.7	274.6	7.88	7.83	-1.52	4	36	43.60	6	7	29.1	42.0
524.1	331.9	7.91	7.85	-1.54	4	36	43.87	6	7	29.1	42.0

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Depth	(ft)	60.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	10.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)						563.2
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area	
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2	
1	0.138	9183	0.010	0.000	0.85	0.2	0.050	0.100	3.26	3.3	12.4	
2	0.138	9183	0.000	0.000	1.00	2.8	0.050	0.100	6.53	3.3	12.4	
3	0.138	9183	0.000	0.000	1.00	5.9	0.050	0.100	9.79	3.3	12.4	
4	0.138	9183	0.000	0.000	1.00	17.9	0.182	0.100	13.05	3.3	12.4	
5	0.138	9183	0.000	0.000	1.00	23.7	0.196	0.100	16.32	3.3	12.4	
6	0.138	9183	0.000	0.000	1.00	15.4	0.050	0.100	19.58	3.3	12.4	
7	0.138	9183	0.000	0.000	1.00	18.6	0.050	0.100	22.84	3.3	12.4	
8	0.138	9183	0.000	0.000	1.00	21.7	0.050	0.100	26.11	3.3	12.4	
9	0.138	9183	0.000	0.000	1.00	24.3	0.050	0.100	29.37	3.3	12.4	
10	0.138	9183	0.000	0.000	1.00	26.1	0.050	0.100	32.63	3.3	12.4	
11	0.138	9183	0.000	0.000	1.00	28.1	0.050	0.100	35.89	3.3	12.4	
12	0.138	9183	0.000	0.000	1.00	29.9	0.050	0.100	39.16	3.3	12.4	
13	0.138	9183	0.000	0.000	1.00	39.7	0.148	0.100	42.42	3.3	12.4	
14	0.138	9183	0.000	0.000	1.00	52.0	0.200	0.100	45.68	3.3	12.4	
15	0.138	9183	0.000	0.000	1.00	37.8	0.089	0.100	48.95	3.3	12.4	
16	0.138	9183	0.000	0.000	1.00	37.5	0.050	0.100	52.21	3.3	12.4	
17	0.138	9183	0.000	0.000	1.00	39.4	0.050	0.100	55.47	3.3	12.4	
18	0.138	9183	0.000	0.000	1.00	41.0	0.050	0.100	58.74	3.3	12.4	
19	0.138	9183	0.000	0.000	1.00	42.6	0.050	0.100	62.00	3.3	12.4	
Toe						58.3	0.150	0.100				

2.627 kips total unreduced pile weight (g= 32.17 ft/s2)  
 2.627 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
60.00	11.18	0.81	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
563.2	9999.0	7.85	7.78	-0.65	3	34	43.46	4	6	28.2	42.2
569.5	9999.0	7.80	7.78	-0.64	3	34	43.49	4	6	27.8	42.2
575.9	9999.0	7.88	7.80	-0.62	3	33	43.74	4	6	27.9	42.1
582.3	9999.0	7.82	7.79	-0.64	3	33	43.85	4	6	27.7	42.2
588.7	9999.0	7.83	7.81	-0.60	3	33	44.07	4	4	27.6	42.2

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Depth ft	Stroke ft	Pressure Ratio	Efficy
62.0	11.18	0.81	0.800

## PILE PROFILE:

Toe Area in <sup>2</sup>	Pile Type	Unknown
144.000		

L b Top ft	Area in <sup>2</sup>	E-Mod ksi	Spec Wt lb/ft <sup>3</sup>	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake in	Rut ft	Perim ft	Area in <sup>2</sup>
1	0.138	9183	0.010	0.000	0.85	1.6	0.050	0.100	3.26	3.3	12.4
2	0.138	9183	0.000	0.000	1.00	4.7	0.050	0.100	6.53	3.3	12.4
3	0.138	9183	0.000	0.000	1.00	11.1	0.138	0.100	9.79	3.3	12.4
4	0.138	9183	0.000	0.000	1.00	24.4	0.200	0.100	13.05	3.3	12.4
5	0.138	9183	0.000	0.000	1.00	17.8	0.135	0.100	16.32	3.3	12.4
6	0.138	9183	0.000	0.000	1.00	17.4	0.050	0.100	19.58	3.3	12.4
7	0.138	9183	0.000	0.000	1.00	20.5	0.050	0.100	22.84	3.3	12.4
8	0.138	9183	0.000	0.000	1.00	23.4	0.050	0.100	26.11	3.3	12.4
9	0.138	9183	0.000	0.000	1.00	25.3	0.050	0.100	29.37	3.3	12.4
10	0.138	9183	0.000	0.000	1.00	27.4	0.050	0.100	32.63	3.3	12.4
11	0.138	9183	0.000	0.000	1.00	29.2	0.050	0.100	35.89	3.3	12.4
12	0.138	9183	0.000	0.000	1.00	31.4	0.057	0.100	39.16	3.3	12.4
13	0.138	9183	0.000	0.000	1.00	52.0	0.200	0.100	42.42	3.3	12.4
14	0.138	9183	0.000	0.000	1.00	43.9	0.158	0.100	45.68	3.3	12.4
15	0.138	9183	0.000	0.000	1.00	36.7	0.050	0.100	48.95	3.3	12.4
16	0.138	9183	0.000	0.000	1.00	38.7	0.050	0.100	52.21	3.3	12.4
17	0.138	9183	0.000	0.000	1.00	40.5	0.050	0.100	55.47	3.3	12.4
18	0.138	9183	0.000	0.000	1.00	41.9	0.050	0.100	58.74	3.3	12.4
19	0.138	9183	0.000	0.000	1.00	43.7	0.050	0.100	62.00	3.3	12.4
Toe						58.3	0.150	0.100			

2.627 kips total unreduced pile weight (g= 32.17 ft/s2)  
 2.627 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
62.00	11.18	0.81	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
590.2	9999.0	7.75	7.73	-0.31	2	33	42.80	3	6	27.1	42.4
596.6	9999.0	7.77	7.74	-0.31	2	33	42.98	3	6	27.1	42.3
603.0	9999.0	7.77	7.75	-0.30	2	32	43.08	3	6	27.0	42.3
609.3	9999.0	7.78	7.76	-0.28	2	32	43.39	3	4	27.0	42.3
615.7	9999.0	7.83	7.78	-0.22	2	32	43.79	3	4	27.0	42.2

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 FRA-70-1322L - Rear Abutment - HP10x42 02/28/2021



## SUMMARY OVER DEPTHS

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: Bl Ct	0.604 Com Str	1.000 Ten Str	Stroke	ENTHRU
ft	kip	kip	kip	bl/ft	ksi	ksi	ft	kip-ft
5.0	12.3	3.7	8.6	Hammer	did not	run		
10.0	21.9	19.0	2.9	Hammer	did not	run		
15.0	84.9	53.5	31.4	6.5	23.326	-0.339	4.34	27.7
20.0	114.0	79.5	34.5	8.5	27.058	-0.721	4.71	26.7
25.0	155.1	112.7	42.3	11.8	30.175	-0.637	5.17	25.9
30.0	209.8	151.4	58.3	16.5	32.776	0.000	5.75	25.7
35.0	253.1	194.7	58.3	20.3	34.640	0.000	6.09	26.0
40.0	253.9	247.7	6.2	20.1	34.505	0.000	6.00	25.2
45.0	386.3	322.8	63.5	50.5	41.992	-2.732	7.31	28.8
50.0	442.8	379.3	63.5	81.9	42.062	-2.297	7.61	29.2
55.0	498.6	440.2	58.3	174.1	42.812	-1.518	7.77	28.8
60.0	563.2	504.8	58.3	9999.0	43.458	-0.651	7.85	28.2
62.0	590.2	531.8	58.3	9999.0	42.795	-0.314	7.75	27.1

Refusal occurred; no driving time output possible

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: Bl Ct	0.637 Com Str	1.000 Ten Str	Stroke	ENTHRU
ft	kip	kip	kip	bl/ft	ksi	ksi	ft	kip-ft
5.0	12.3	3.7	8.6	Hammer	did not	run		
10.0	22.3	19.4	2.9	Hammer	did not	run		
15.0	86.9	55.5	31.4	6.7	23.709	-0.472	4.38	27.6
20.0	116.0	81.5	34.5	8.8	27.324	-0.693	4.74	26.6
25.0	157.1	114.8	42.3	12.0	30.433	-0.548	5.20	25.8
30.0	211.8	153.5	58.3	16.7	32.991	0.000	5.78	25.7
35.0	255.1	196.7	58.3	20.5	34.951	-0.098	6.12	26.1
40.0	256.7	250.5	6.2	20.4	34.829	-0.052	6.04	25.2
45.0	392.7	329.2	63.5	53.2	42.495	-2.826	7.37	29.1
50.0	449.2	385.7	63.5	87.9	42.480	-2.352	7.66	29.3
55.0	504.9	446.6	58.3	198.8	43.099	-1.521	7.81	28.9
60.0	569.5	511.2	58.3	9999.0	43.491	-0.644	7.80	27.8
62.0	596.6	538.2	58.3	9999.0	42.977	-0.313	7.77	27.1

Refusal occurred; no driving time output possible

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## SUMMARY OVER DEPTHS

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: Bl Ct	0.670 Com Str	1.000 Ten Str	Stroke	ENTHRU
ft	kip	kip	kip	bl/ft	ksi	ksi	ft	kip-ft
5.0	12.3	3.7	8.6	Hammer	did not	run		
10.0	22.6	19.7	2.9	Hammer	did not	run		
15.0	89.0	57.6	31.4	6.8	24.308	-0.546	4.47	27.7
20.0	118.0	83.6	34.5	9.0	27.643	-0.630	4.78	26.5
25.0	159.2	116.8	42.3	12.3	30.734	-0.443	5.24	25.8
30.0	213.8	155.5	58.3	16.9	33.200	0.000	5.80	25.8
35.0	257.1	198.8	58.3	20.8	35.219	-0.366	6.15	26.2
40.0	259.6	253.4	6.2	20.9	35.089	-0.301	6.07	25.2
45.0	399.1	335.6	63.5	56.7	42.913	-2.876	7.43	29.1
50.0	455.6	392.1	63.5	95.5	42.818	-2.385	7.70	29.4
55.0	511.3	453.0	58.3	227.6	43.422	-1.546	7.85	29.1
60.0	575.9	517.6	58.3	9999.0	43.743	-0.622	7.88	27.9
62.0	603.0	544.6	58.3	9999.0	43.082	-0.303	7.77	27.0

Refusal occurred; no driving time output possible

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: Bl Ct	0.703 Com Str	1.000 Ten Str	Stroke	ENTHRU
ft	kip	kip	kip	bl/ft	ksi	ksi	ft	kip-ft
5.0	12.3	3.7	8.6	Hammer	did not	run		
10.0	23.0	20.1	2.9	Hammer	did not	run		
15.0	91.0	59.6	31.4	7.1	24.396	-0.603	4.46	27.3
20.0	120.1	85.6	34.5	9.2	27.994	-0.605	4.82	26.5
25.0	161.2	118.9	42.3	12.5	31.034	-0.325	5.27	25.8
30.0	215.9	157.5	58.3	17.2	33.426	0.000	5.82	25.8
35.0	259.2	200.8	58.3	21.0	35.563	-0.612	6.18	26.3
40.0	262.4	256.2	6.2	21.2	35.490	-0.514	6.11	25.3
45.0	405.5	342.0	63.5	60.2	43.354	-2.949	7.48	29.3
50.0	462.0	398.4	63.5	103.3	43.198	-2.421	7.75	29.6
55.0	517.7	459.4	58.3	274.6	43.597	-1.521	7.88	29.1
60.0	582.3	524.0	58.3	9999.0	43.854	-0.641	7.82	27.7

1322L-RA-10X42  
62.0 609.3 551.0 58.3 9999.0 43.385 -0.281 7.78 27.0

Refusal occurred; no driving time output possible

↑  
FRA-70-1322L - Rear Abutment - HP10x42 02/28/2021  
Resource International Inc GRLWEAP Version 2010

#### SUMMARY OVER DEPTHS

Depth	Rut	G/L at Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	12.3	3.7	8.6	Hammer	did not	run		
10.0	23.4	20.4	2.9	Hammer	did not	run		
15.0	93.0	61.7	31.4	7.3	24.762	-0.610	4.50	27.2
20.0	122.1	87.6	34.5	9.4	28.302	-0.586	4.86	26.4
25.0	163.2	120.9	42.3	12.8	31.294	-0.201	5.30	25.7
30.0	217.9	159.6	58.3	17.6	33.432	0.000	5.80	25.6
35.0	261.2	202.9	58.3	21.3	35.829	-0.848	6.21	26.3
40.0	265.2	259.0	6.2	21.6	35.767	-0.690	6.14	25.3
45.0	411.9	348.4	63.5	63.8	43.841	-3.017	7.55	29.5
50.0	468.4	404.8	63.5	113.0	43.524	-2.447	7.80	29.7
55.0	524.1	465.8	58.3	331.9	43.871	-1.539	7.91	29.1
60.0	588.7	530.4	58.3	9999.0	44.066	-0.600	7.83	27.6
62.0	615.7	557.4	58.3	9999.0	43.786	-0.221	7.83	27.0

Refusal occurred; no driving time output possible

↑  
FRA-70-1322L - Rear Abutment - HP10x42 02/28/2021  
Resource International Inc GRLWEAP Version 2010

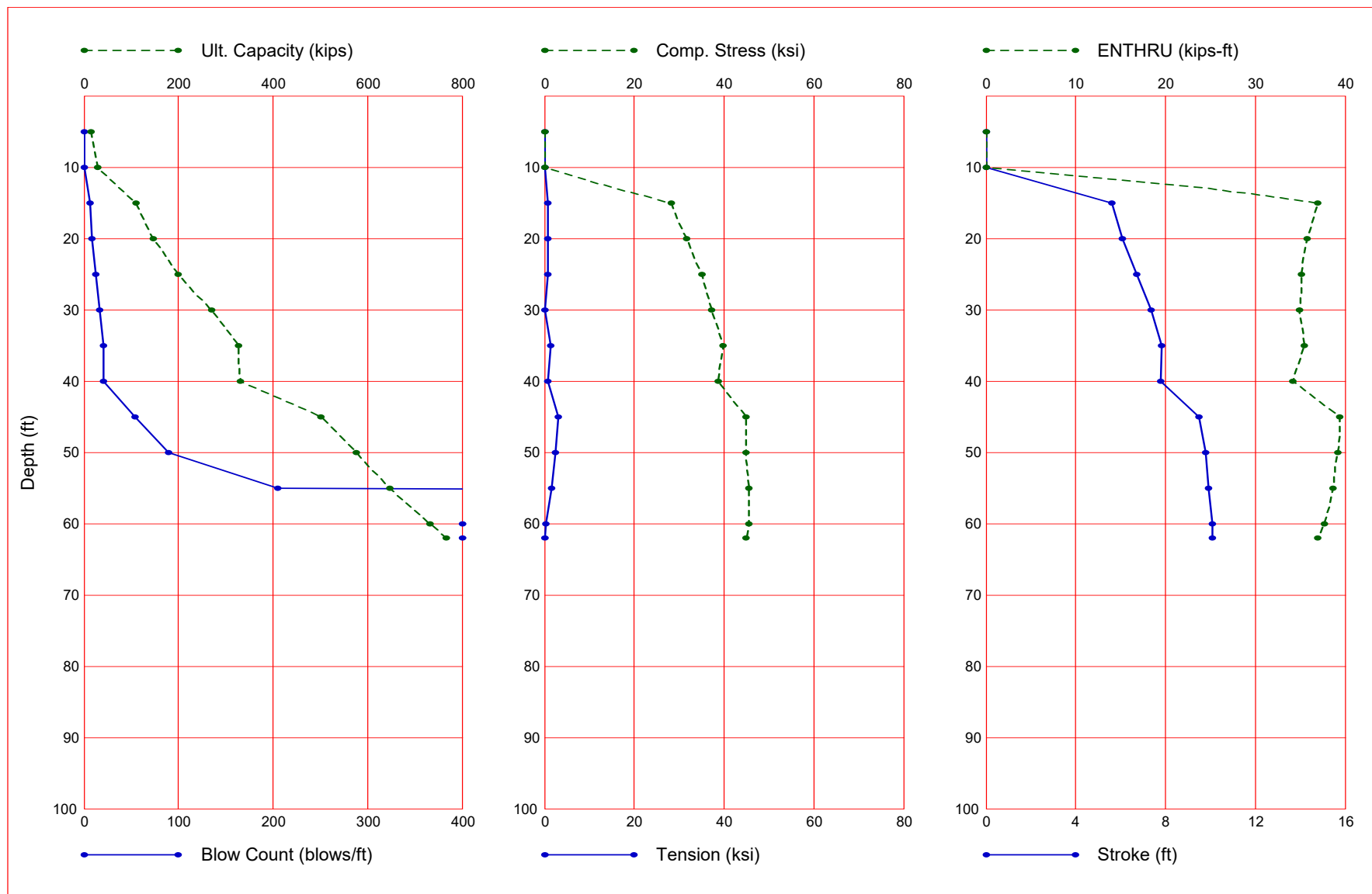
#### Table of Depths Analyzed with Driving System Modifiers

Depth	Temp. Length	Wait Time	Equivalent Stroke	Pressure Ratio	Efficy.	Stiffn. Factor	Cushion CoR
ft	ft	hr	ft				
5.00	62.00	0.00	11.18	0.81	0.80	1.00	1.00
10.00	62.00	0.00	11.18	0.81	0.80	1.00	1.00
15.00	62.00	0.00	11.18	0.81	0.80	1.00	1.00
20.00	62.00	0.00	11.18	0.81	0.80	1.00	1.00
25.00	62.00	0.00	11.18	0.81	0.80	1.00	1.00
30.00	62.00	0.00	11.18	0.81	0.80	1.00	1.00
35.00	62.00	0.00	11.18	0.81	0.80	1.00	1.00
40.00	62.00	0.00	11.18	0.81	0.80	1.00	1.00
45.00	62.00	0.00	11.18	0.81	0.80	1.00	1.00
50.00	62.00	0.00	11.18	0.81	0.80	1.00	1.00
55.00	62.00	0.00	11.18	0.81	0.80	1.00	1.00
60.00	62.00	0.00	11.18	0.81	0.80	1.00	1.00
62.00	62.00	0.00	11.18	0.81	0.80	1.00	1.00

#### Soil Layer Resistance Values

Depth	Shaft Res.	End Bearing	Shaft Quake	Toe Quake	Shaft Damping	Toe Damping	Soil Setup	Limit Distance	Setup Time
ft	k/ft2	kips	inch	inch	s/ft	s/ft	Normlzd	ft	hrs
0.01	0.00	0.02	0.100	0.100	0.050	0.150	0.000	6.000	1.000
9.01	0.81	15.53	0.100	0.100	0.050	0.150	0.000	6.000	1.000
9.09	0.81	15.66	0.100	0.100	0.050	0.150	0.000	6.000	1.000
9.11	3.75	2.91	0.100	0.100	0.200	0.150	1.000	6.000	168.000
14.09	3.75	2.91	0.100	0.100	0.200	0.150	1.000	6.000	168.000
14.11	1.26	29.42	0.100	0.100	0.050	0.150	0.000	6.000	1.000
19.09	1.73	40.36	0.100	0.100	0.050	0.150	0.000	6.000	1.000
19.11	1.71	32.93	0.100	0.100	0.050	0.150	0.000	6.000	1.000
24.49	2.19	42.20	0.100	0.100	0.050	0.150	0.000	6.000	1.000
24.51	2.20	42.22	0.100	0.100	0.050	0.150	0.000	6.000	1.000
29.09	2.41	43.36	0.100	0.100	0.050	0.150	0.000	6.000	1.000
29.11	2.45	58.35	0.100	0.100	0.050	0.150	0.000	6.000	1.000
38.11	2.91	58.35	0.100	0.100	0.050	0.150	0.000	6.000	1.000
39.09	2.96	58.35	0.100	0.100	0.050	0.150	0.000	6.000	1.000
39.11	8.00	6.20	0.100	0.100	0.200	0.150	1.000	6.000	168.000
44.09	8.00	6.20	0.100	0.100	0.200	0.150	1.000	6.000	168.000
44.11	3.24	63.52	0.100	0.100	0.050	0.150	0.000	6.000	1.000
53.11	3.73	63.52	0.100	0.100	0.050	0.150	0.000	6.000	1.000
54.49	3.81	63.52	0.100	0.100	0.050	0.150	0.000	6.000	1.000
54.51	3.76	58.35	0.100	0.100	0.050	0.150	0.000	6.000	1.000
62.00	4.14	58.35	0.100	0.100	0.050	0.150	0.000	6.000	1.000

Gain/Loss 3 at Shaft and Toe 0.670 / 1.000



Gain/Loss 3 at Shaft and Toe 0.670 / 1.000

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
5.0	15.5	4.8	10.8	-1.0	0.000	0.000	0.00	0.0
10.0	28.5	24.8	3.6	-1.0	0.000	0.000	0.00	0.0
15.0	110.0	70.7	39.2	6.9	28.269	-0.753	5.60	37.0
20.0	147.5	104.4	43.1	8.9	31.751	-0.705	6.07	35.8
25.0	200.4	147.5	52.9	12.2	35.149	-0.657	6.70	35.1
30.0	270.5	197.5	72.9	16.9	37.242	0.000	7.37	34.9
35.0	326.6	253.6	72.9	20.7	39.699	-1.311	7.85	35.5
40.0	330.7	322.9	7.8	20.5	38.752	-0.801	7.78	34.2
45.0	502.1	422.8	79.4	54.3	44.920	-3.074	9.48	39.4
50.0	575.5	496.1	79.4	89.6	44.855	-2.484	9.78	39.2
55.0	648.1	575.2	72.9	204.6	45.635	-1.543	9.93	38.7
60.0	731.9	658.9	72.9	9999.0	45.609	-0.364	10.10	37.7
62.0	766.9	694.0	72.9	9999.0	44.862	-0.135	10.09	37.0

Refusal occurred; no driving time output possible

GRLWEAP - Version 2010  
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.  
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ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

Input File: J:\GEOTECH\PROJECTS\2013\W-13-072 FRA-70-13.10 PROJECT 6A\ANALYSIS\FRA-70-1322L AND 1323C\DRIVEABILITY\FRA-70-1322L\REAR ABUTMENT\HP 12X53\1322L-RA-12X53.GMW  
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW  
Hammer File Version: 2003 (12/4/2018)

Input File Contents

FRA-70-1322L - Rear Abutment - HP12x53  
OUT OSG HAM STR FUL PEL N SPL N-U P-D %SK ISM 0 PHI RSA ITR H-D MXT DEX  
-100 0 14 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0.000  
Pile g Hammer g Toe Area Pile Size Pile Type  
32.170 32.170 144.000 12.000 Unknown  
W Cp A Cp E Cp T Cp CoR ROut StCp  
1.900 227.000 530.0 2.000 0.800 0.010 0.0  
A Cu E Cu T Cu CoR ROut StCu  
0.000 0.0 0.000 0.000 0.000 0.0  
LPle APle EPle WPle Peri CI CoR ROut  
62.000 15.50 29000.0 492.000 3.970 0 0.850 0.010  
FFatigue F0 0-Bottom  
0 0.000 0.000  
Manufac Hmr Name HmrType No Seg-s  
DELMAG D 30-23 1 5  
Ram Wt Ram L Ram Dia MaxStrk RtdStrk Efficy  
6.60 118.10 16.51 13.44 11.18 0.80  
IB. Wt IB. L IB. Dia IB CoR IB R0  
1.20 25.00 16.51 0.900 0.010  
CompStrk A Chamber V Chamber C Delay C Duratn Exp Coeff VolCStart Vol CEnd  
16.30 214.03 280.90 0.0010 0.0020 1.250 0.00 0.00  
P atm P1 P2 P3 P4 P5  
14.70 1550.00 1395.00 1255.00 1130.00 0.00  
Stroke Effic. Pressure R-Weight T-Delay Exp-Coeff Eps-Str Total-AW  
11.1800 0.8000 1550.0000 0.0000 0.0000 0.0000 0.0100 0.0000  
Qs Qt Js Jt Qx Jx Rati Dept  
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000  
Research Soil Model: Atoe, Plug, Gap, Q-fac

0.000 0.000 0.000 0.000  
 Research Soil Model: RD-skn: m, d, toe: m, d  
 0.000 0.000 0.000 0.000  
 Research Toe Plug: Res-int, Q-int, D-int, Res-plug, Q-plug, D-plug  
 0.000 0.000 0.000 0.000 0.000 0.000  
 Research Toe Plug: RD plug toe: m, d  
 0.000 0.000  
 Research Toe Plug: New Toe Plug Model is NOT applied

Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimL	TSf0
0.01	0.00	0.02	0.10	0.10	0.05	0.15	1.00	6.00	1.000
9.01	0.87	19.41	0.10	0.10	0.05	0.15	1.00	6.00	1.000
9.09	0.88	19.58	0.10	0.10	0.05	0.15	1.00	6.00	1.000
9.11	3.75	3.63	0.10	0.10	0.20	0.15	1.49	6.00	168.000
14.09	3.75	3.63	0.10	0.10	0.20	0.15	1.49	6.00	168.000
14.11	1.36	36.78	0.10	0.10	0.05	0.15	1.00	6.00	1.000
19.09	1.86	50.45	0.10	0.10	0.05	0.15	1.00	6.00	1.000
19.11	1.84	41.16	0.10	0.10	0.05	0.15	1.00	6.00	1.000
24.49	2.36	52.75	0.10	0.10	0.05	0.15	1.00	6.00	1.000
24.51	2.36	52.78	0.10	0.10	0.05	0.15	1.00	6.00	1.000
29.09	2.59	54.20	0.10	0.10	0.05	0.15	1.00	6.00	1.000
29.11	2.64	72.94	0.10	0.10	0.05	0.15	1.00	6.00	1.000
38.11	3.13	72.94	0.10	0.10	0.05	0.15	1.00	6.00	1.000
39.09	3.19	72.94	0.10	0.10	0.05	0.15	1.00	6.00	1.000
39.11	8.00	7.75	0.10	0.10	0.20	0.15	1.49	6.00	168.000
44.09	8.00	7.75	0.10	0.10	0.20	0.15	1.49	6.00	168.000
44.11	3.49	79.39	0.10	0.10	0.05	0.15	1.00	6.00	1.000
53.11	4.03	79.39	0.10	0.10	0.05	0.15	1.00	6.00	1.000
54.49	4.11	79.39	0.10	0.10	0.05	0.15	1.00	6.00	1.000
54.51	4.05	72.94	0.10	0.10	0.05	0.15	1.00	6.00	1.000
62.00	4.47	72.94	0.10	0.10	0.05	0.15	1.00	6.00	1.000

Gain/Loss factors: shaft and toe  
 0.60400 0.63700 0.67000 0.70300 0.73600  
 1.00000 1.00000 1.00000 1.00000 1.00000

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR
5.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
10.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
15.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
20.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
25.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
30.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
35.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
40.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
45.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
50.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
55.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
60.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
62.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
0.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000

▲ GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS  
 Version 2010  
 English Units

FRA-70-1322L - Rear Abutment - HP12x53

Hammer Model: D 30-23		Made by: DELMAG	
No.	Weight kips	Stiffn k/inch	CoR
1	1.320		
2	1.320	262846.5	1.000
3	1.320	262846.5	1.000
4	1.320	262846.5	1.000
5	1.320	262846.5	1.000
Imp Block	1.200	127693.0	0.900
Helmet	1.900	60155.0	0.800
Combined Pile Top		11479.2	

HAMMER OPTIONS:  
 Hammer File ID No. 14 Hammer Type OE Diesel  
 Stroke Option FxdP-VarS Stroke Convergence Crit. 0.010  
 Fuel Pump Setting Maximum

HAMMER DATA:  
 Ram Weight (kips) 6.60 Ram Length (inch) 118.10  
 Maximum Stroke (ft) 13.44  
 Rated Stroke (ft) 11.18 Efficiency 0.800  
 Maximum Pressure (psi) 1550.00 Actual Pressure (psi) 1550.00  
 Compression Exponent 1.350 Expansion Exponent 1.250

1322L-RA-12X53

Ram Diameter	(inch)	16.51		
Combustion Delay	(s)	0.00100	Ignition Duration	(s) 0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION			PILE CUSHION		
Cross Sect. Area	(in2)	227.00	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	530.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	2.00	Thickness	(inch)	0.00
Coeff of Restitution		0.8	Coeff of Restitution		1.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	60155.0	Stiffness	(kips/in)	0.0

FRA-70-1322L - Rear Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	5.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	12.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	15.5
	kips	Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D	Quake	LbTop Perim Area
		k/in ft ft	kips	s/ft	inch	ft ft in2
1	0.173	11479 0.010 0.000 0.85	0.0	0.000	0.100	3.26 4.0 15.5
2	0.173	11479 0.000 0.000 1.00	0.0	0.000	0.100	6.53 4.0 15.5
18	0.173	11479 0.000 0.000 1.00	0.6	0.050	0.100	58.74 4.0 15.5
19	0.173	11479 0.000 0.000 1.00	4.2	0.050	0.100	62.00 4.0 15.5
Toe			10.8	0.150	0.100	

3.283 kips total unreduced pile weight (g= 32.17 ft/s2)  
 3.283 kips total reduced pile weight (g= 32.17 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile		Pile Segments: Automatic
No. of Slacks/Splices	0	Pile Damping (%) 1
		Pile Damping Fact.(k/ft/s) 0.544

Driveability Analysis	
Soil Damping Option	Smith
Max No Analysis Iterations	0 Time Increment/Critical 160
Output Time Interval	1 Analysis Time-Input (ms) 0
Output Level: Normal	
Gravity Mass, Pile, Hammer:	32.170 32.170 32.170
Output Segment Generation: Automatic	

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
5.00	11.18	1.00	0.800

FRA-70-1322L - Rear Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i t Comp Str	i t ENTHRU	Bl Rt
kips	b/ft	down up	ksi	ksi	kip-ft	b/min
15.5	Hammer did not run					
15.5	Hammer did not run					
15.5	Hammer did not run					
15.5	Hammer did not run					
15.5	Hammer did not run					

FRA-70-1322L - Rear Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	10.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
----------	-------	---------	-----------	---------

Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model				Total Capacity Rut (kips)				27.6			
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.173	11479	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.0	15.5
2	0.173	11479	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.0	15.5
16	0.173	11479	0.000	0.000	1.00	0.0	0.050	0.100	52.21	4.0	15.5
17	0.173	11479	0.000	0.000	1.00	2.3	0.050	0.100	55.47	4.0	15.5
18	0.173	11479	0.000	0.000	1.00	6.4	0.050	0.100	58.74	4.0	15.5
19	0.173	11479	0.000	0.000	1.00	15.3	0.147	0.100	62.00	4.0	15.5
Toe						3.6	0.150	0.100			

3.283 kips total unreduced pile weight (g= 32.17 ft/s2)

3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
10.00	11.18	1.00	0.800

FRA-70-1322L - Rear Abutment - HP12x53 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp	Str	i	t ENTHRU	Bl Rt
kips	b/ft	down up	ksi			ksi		kip-ft	b/min
27.6	Hammer	did not run							
28.0	Hammer	did not run							
28.5	Hammer	did not run							
28.9	Hammer	did not run							
29.3	1.4	3.52	3.54	0.00	1	0	14.30	1	6 45.9 62.9

FRA-70-1322L - Rear Abutment - HP12x53 02/28/2021  
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Depth	(ft)	15.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor
			1.000

## PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	12.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model				Total Capacity Rut (kips)				105.1			
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.173	11479	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.0	15.5
2	0.173	11479	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.0	15.5
15	0.173	11479	0.000	0.000	1.00	0.7	0.050	0.100	48.95	4.0	15.5
16	0.173	11479	0.000	0.000	1.00	4.5	0.050	0.100	52.21	4.0	15.5
17	0.173	11479	0.000	0.000	1.00	8.5	0.050	0.100	55.47	4.0	15.5
18	0.173	11479	0.000	0.000	1.00	25.8	0.192	0.100	58.74	4.0	15.5
19	0.173	11479	0.000	0.000	1.00	26.3	0.181	0.100	62.00	4.0	15.5
Toe						39.2	0.150	0.100			

3.283 kips total unreduced pile weight (g= 32.17 ft/s2)

3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
15.00	11.18	1.00	0.800

FRA-70-1322L - Rear Abutment - HP12x53 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp	Str	i	t ENTHRU	Bl Rt
kips	b/ft	down up	ksi			ksi		kip-ft	b/min



1322L-RA-12X53													
105.1	6.5	5.49	5.54	-0.81	16	50	27.71	16	5	37.2	50.1		
107.5	6.7	5.55	5.59	-0.79	16	50	28.04	16	5	37.1	49.8		
110.0	6.9	5.60	5.64	-0.75	16	48	28.27	16	5	37.0	49.6		
112.4	7.1	5.65	5.69	-0.72	16	48	28.53	16	5	36.8	49.4		
114.9	7.3	5.70	5.73	-0.67	16	48	28.78	17	5	36.8	49.2		

FRA-70-1322L - Rear Abutment - HP12x53  
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Depth (ft) 20.0  
 Shaft Gain/Loss Factor 0.604  
 Standard Soil Setup  
 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000  
 Pile Type Unknown  
 Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model										Total Capacity	Rut (kips)	142.6
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area	
kips	k/in	ft	ft			kips	s/ft	inch	ft	ft	in2	
1	0.173	11479	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.0	15.5	
2	0.173	11479	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.0	15.5	
13	0.173	11479	0.000	0.000	1.00	0.0	0.050	0.100	42.42	4.0	15.5	
14	0.173	11479	0.000	0.000	1.00	2.6	0.050	0.100	45.68	4.0	15.5	
15	0.173	11479	0.000	0.000	1.00	6.6	0.050	0.100	48.95	4.0	15.5	
16	0.173	11479	0.000	0.000	1.00	16.6	0.157	0.100	52.21	4.0	15.5	
17	0.173	11479	0.000	0.000	1.00	29.3	0.200	0.100	55.47	4.0	15.5	
18	0.173	11479	0.000	0.000	1.00	21.2	0.106	0.100	58.74	4.0	15.5	
19	0.173	11479	0.000	0.000	1.00	23.1	0.050	0.100	62.00	4.0	15.5	
Toe						43.1	0.150	0.100				

3.283 kips total unredacted pile weight (g= 32.17 ft/s2)  
 3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft 20.00  
 Stroke ft 11.18  
 Pressure Ratio 1.00  
 Efficy 0.800

FRA-70-1322L - Rear Abutment - HP12x53  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
142.6	8.5	5.98	6.00	-0.74	14	43	31.16	16	5	36.0
145.0	8.7	6.03	6.04	-0.70	14	41	31.47	16	5	35.9
147.5	8.9	6.07	6.08	-0.71	14	41	31.75	16	5	35.8
149.9	9.2	6.11	6.13	-0.71	15	40	32.05	16	5	35.8
152.4	9.4	6.16	6.16	-0.74	14	40	32.33	16	5	35.7

FRA-70-1322L - Rear Abutment - HP12x53  
 Resource International Inc  
 02/28/2021  
 GRLWEAP Version 2010

Depth (ft) 25.0  
 Shaft Gain/Loss Factor 0.604  
 Standard Soil Setup  
 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000  
 Pile Type Unknown  
 Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model										Total Capacity	Rut (kips)	195.5
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area	
kips	k/in	ft	ft			kips	s/ft	inch	ft	ft	in2	
1	0.173	11479	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.0	15.5	
2	0.173	11479	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.0	15.5	
12	0.173	11479	0.000	0.000	1.00	0.9	0.050	0.100	39.16	4.0	15.5	
13	0.173	11479	0.000	0.000	1.00	4.7	0.050	0.100	42.42	4.0	15.5	
14	0.173	11479	0.000	0.000	1.00	8.8	0.050	0.100	45.68	4.0	15.5	

1322L-RA-12X53

15	0.173	11479	0.000	0.000	1.00	27.0	0.195	0.100	48.95	4.0	15.5
16	0.173	11479	0.000	0.000	1.00	25.6	0.175	0.100	52.21	4.0	15.5
17	0.173	11479	0.000	0.000	1.00	21.1	0.050	0.100	55.47	4.0	15.5
18	0.173	11479	0.000	0.000	1.00	25.2	0.050	0.100	58.74	4.0	15.5
19	0.173	11479	0.000	0.000	1.00	29.2	0.050	0.100	62.00	4.0	15.5
Toe						52.9	0.150	0.100			

3.283 kips total unreduced pile weight (g= 32.17 ft/s2)  
 3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
25.00	11.18	1.00	0.800

▲  
 FRA-70-1322L - Rear Abutment - HP12x53 02/28/2021  
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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
195.5	11.7	6.62	6.58	-0.86	13	35	34.53	15	5	35.3
197.9	12.0	6.66	6.63	-0.80	13	35	34.81	15	5	35.2
200.4	12.2	6.70	6.67	-0.66	13	35	35.15	15	5	35.1
202.8	12.4	6.74	6.71	-0.49	13	35	35.43	15	5	35.0
205.3	12.6	6.78	6.75	-0.31	13	35	35.78	15	5	35.0

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 FRA-70-1322L - Rear Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth (ft)	30.0	Standard Soil Setup
Shaft Gain/Loss Factor	0.604	Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2)	144.000	Pile Type	Unknown
Pile Size (inch)	12.000		

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips) 265.5					
No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.173	11479	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.0	15.5
2	0.173	11479	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.0	15.5
10	0.173	11479	0.000	0.000	1.00	0.1	0.050	0.100	32.63	4.0	15.5
11	0.173	11479	0.000	0.000	1.00	2.8	0.050	0.100	35.89	4.0	15.5
12	0.173	11479	0.000	0.000	1.00	6.9	0.050	0.100	39.16	4.0	15.5
13	0.173	11479	0.000	0.000	1.00	17.9	0.164	0.100	42.42	4.0	15.5
14	0.173	11479	0.000	0.000	1.00	29.3	0.200	0.100	45.68	4.0	15.5
15	0.173	11479	0.000	0.000	1.00	20.7	0.090	0.100	48.95	4.0	15.5
16	0.173	11479	0.000	0.000	1.00	23.3	0.050	0.100	52.21	4.0	15.5
17	0.173	11479	0.000	0.000	1.00	27.3	0.050	0.100	55.47	4.0	15.5
18	0.173	11479	0.000	0.000	1.00	30.9	0.050	0.100	58.74	4.0	15.5
19	0.173	11479	0.000	0.000	1.00	33.3	0.050	0.100	62.00	4.0	15.5
Toe						72.9	0.150	0.100			

3.283 kips total unreduced pile weight (g= 32.17 ft/s2)  
 3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
30.00	11.18	1.00	0.800

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 FRA-70-1322L - Rear Abutment - HP12x53 02/28/2021  
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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
265.5	16.5	7.28	7.33	0.00	1	0	36.68	13	4	34.7
268.0	16.7	7.33	7.36	0.00	1	0	36.99	13	4	34.9
270.5	16.9	7.37	7.39	0.00	1	0	37.24	13	4	34.9
272.9	17.1	7.41	7.43	0.00	1	0	37.48	13	4	34.9
275.4	17.3	7.45	7.46	0.00	1	0	37.74	13	4	35.0

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 FRA-70-1322L - Rear Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth (ft) 35.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

## PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)			321.7		
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.173	11479	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.0	15.5
2	0.173	11479	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.0	15.5
9	0.173	11479	0.000	0.000	1.00	1.1	0.050	0.100	29.37	4.0	15.5
10	0.173	11479	0.000	0.000	1.00	5.0	0.050	0.100	32.63	4.0	15.5
11	0.173	11479	0.000	0.000	1.00	9.1	0.050	0.100	35.89	4.0	15.5
12	0.173	11479	0.000	0.000	1.00	28.2	0.198	0.100	39.16	4.0	15.5
13	0.173	11479	0.000	0.000	1.00	24.9	0.169	0.100	42.42	4.0	15.5
14	0.173	11479	0.000	0.000	1.00	21.4	0.050	0.100	45.68	4.0	15.5
15	0.173	11479	0.000	0.000	1.00	25.4	0.050	0.100	48.95	4.0	15.5
16	0.173	11479	0.000	0.000	1.00	29.4	0.050	0.100	52.21	4.0	15.5
17	0.173	11479	0.000	0.000	1.00	32.1	0.050	0.100	55.47	4.0	15.5
18	0.173	11479	0.000	0.000	1.00	34.8	0.050	0.100	58.74	4.0	15.5
19	0.173	11479	0.000	0.000	1.00	37.2	0.050	0.100	62.00	4.0	15.5
Toe						72.9	0.150	0.100			

3.283 kips total unreduced pile weight (g= 32.17 ft/s2)

3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
35.00	11.18	1.00	0.800

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 FRA-70-1322L - Rear Abutment - HP12x53 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	b/min	
321.7	20.0	7.78	7.76	-1.42	10 49	39.07	12 4	35.5
324.1	20.3	7.82	7.79	-1.36	10 49	39.38	12 4	35.5
326.6	20.7	7.85	7.83	-1.31	10 48	39.70	12 4	35.5
329.0	20.9	7.89	7.85	-1.29	10 48	39.97	12 4	35.6
331.5	21.2	7.92	7.89	-1.28	10 47	40.29	12 4	35.6

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 FRA-70-1322L - Rear Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth (ft) 40.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

## PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)			323.9		
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.173	11479	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.0	15.5
2	0.173	11479	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.0	15.5
7	0.173	11479	0.000	0.000	1.00	0.1	0.050	0.100	22.84	4.0	15.5
8	0.173	11479	0.000	0.000	1.00	3.1	0.050	0.100	26.11	4.0	15.5
9	0.173	11479	0.000	0.000	1.00	7.2	0.050	0.100	29.37	4.0	15.5
10	0.173	11479	0.000	0.000	1.00	19.3	0.171	0.100	32.63	4.0	15.5
11	0.173	11479	0.000	0.000	1.00	29.3	0.200	0.100	35.89	4.0	15.5
12	0.173	11479	0.000	0.000	1.00	20.2	0.071	0.100	39.16	4.0	15.5
13	0.173	11479	0.000	0.000	1.00	23.6	0.050	0.100	42.42	4.0	15.5

1322L-RA-12X53											
14	0.173	11479	0.000	0.000	1.00	27.6	0.050	0.100	45.68	4.0	15.5
15	0.173	11479	0.000	0.000	1.00	31.1	0.050	0.100	48.95	4.0	15.5
16	0.173	11479	0.000	0.000	1.00	33.5	0.050	0.100	52.21	4.0	15.5
17	0.173	11479	0.000	0.000	1.00	36.2	0.050	0.100	55.47	4.0	15.5
18	0.173	11479	0.000	0.000	1.00	38.5	0.050	0.100	58.74	4.0	15.5
19	0.173	11479	0.000	0.000	1.00	46.6	0.124	0.100	62.00	4.0	15.5
Toe						7.8	0.150	0.100			

3.283 kips total unreduced pile weight (g= 32.17 ft/s2)  
3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
40.00	11.18	1.00	0.800

▲  
FRA-70-1322L - Rear Abutment - HP12x53 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt	
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min	
323.9	19.7	7.69	7.71	-0.83	8	50	38.25	10	4	34.2	42.5
327.3	20.0	7.73	7.74	-0.80	8	49	38.55	10	4	34.3	42.4
330.7	20.5	7.78	7.79	-0.80	8	48	38.75	10	3	34.2	42.2
334.1	20.8	7.82	7.83	-0.83	8	48	39.06	10	3	34.3	42.1
337.4	21.1	7.86	7.86	-0.87	8	47	39.37	10	4	34.6	42.0

▲  
FRA-70-1322L - Rear Abutment - HP12x53 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth	(ft)	45.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	12.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)						486.8
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area	
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2	
1	0.173	11479	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.0	15.5	
2	0.173	11479	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.0	15.5	
6	0.173	11479	0.000	0.000	1.00	1.3	0.050	0.100	19.58	4.0	15.5	
7	0.173	11479	0.000	0.000	1.00	5.3	0.050	0.100	22.84	4.0	15.5	
8	0.173	11479	0.000	0.000	1.00	9.4	0.051	0.100	26.11	4.0	15.5	
9	0.173	11479	0.000	0.000	1.00	29.3	0.200	0.100	29.37	4.0	15.5	
10	0.173	11479	0.000	0.000	1.00	24.3	0.162	0.100	32.63	4.0	15.5	
11	0.173	11479	0.000	0.000	1.00	21.7	0.050	0.100	35.89	4.0	15.5	
12	0.173	11479	0.000	0.000	1.00	25.7	0.050	0.100	39.16	4.0	15.5	
13	0.173	11479	0.000	0.000	1.00	29.6	0.050	0.100	42.42	4.0	15.5	
14	0.173	11479	0.000	0.000	1.00	32.3	0.050	0.100	45.68	4.0	15.5	
15	0.173	11479	0.000	0.000	1.00	35.0	0.050	0.100	48.95	4.0	15.5	
16	0.173	11479	0.000	0.000	1.00	37.4	0.050	0.100	52.21	4.0	15.5	
17	0.173	11479	0.000	0.000	1.00	39.7	0.050	0.100	55.47	4.0	15.5	
18	0.173	11479	0.000	0.000	1.00	58.5	0.187	0.100	58.74	4.0	15.5	
19	0.173	11479	0.000	0.000	1.00	57.9	0.178	0.100	62.00	4.0	15.5	
Toe						79.4	0.150	0.100				

3.283 kips total unreduced pile weight (g= 32.17 ft/s2)  
3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
45.00	11.18	1.00	0.800

▲  
FRA-70-1322L - Rear Abutment - HP12x53 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt	
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min	
486.8	48.8	9.34	9.33	-2.96	7	38	44.04	9	3	39.0	38.7
494.5	51.1	9.40	9.38	-3.07	7	38	44.51	9	3	39.4	38.5
502.1	54.3	9.48	9.46	-3.07	7	38	44.92	9	3	39.4	38.4

1322L-RA-12X53  
509.8 57.1 9.53 9.51 -3.18 7 38 45.33 9 3 39.7 38.3  
517.5 60.8 9.60 9.59 -3.17 7 38 45.72 9 3 39.8 38.1

▲  
FRA-70-1322L - Rear Abutment - HP12x53 02/28/2021  
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Depth (ft) 50.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:  
Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	560.1
	kips	Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D	Quake	LbTop Perim Area
		k/in ft ft	kips	s/ft	inch	ft ft in2
1	0.173	11479 0.010 0.000 0.85	0.0	0.000	0.100	3.26 4.0 15.5
2	0.173	11479 0.000 0.000 1.00	0.0	0.000	0.100	6.53 4.0 15.5
4	0.173	11479 0.000 0.000 1.00	0.2	0.050	0.100	13.05 4.0 15.5
5	0.173	11479 0.000 0.000 1.00	3.3	0.050	0.100	16.32 4.0 15.5
6	0.173	11479 0.000 0.000 1.00	7.4	0.050	0.100	19.58 4.0 15.5
7	0.173	11479 0.000 0.000 1.00	20.5	0.176	0.100	22.84 4.0 15.5
8	0.173	11479 0.000 0.000 1.00	29.3	0.200	0.100	26.11 4.0 15.5
9	0.173	11479 0.000 0.000 1.00	19.7	0.050	0.100	29.37 4.0 15.5
10	0.173	11479 0.000 0.000 1.00	23.8	0.050	0.100	32.63 4.0 15.5
11	0.173	11479 0.000 0.000 1.00	27.8	0.050	0.100	35.89 4.0 15.5
12	0.173	11479 0.000 0.000 1.00	31.2	0.050	0.100	39.16 4.0 15.5
13	0.173	11479 0.000 0.000 1.00	33.7	0.050	0.100	42.42 4.0 15.5
14	0.173	11479 0.000 0.000 1.00	36.3	0.050	0.100	45.68 4.0 15.5
15	0.173	11479 0.000 0.000 1.00	38.6	0.050	0.100	48.95 4.0 15.5
16	0.173	11479 0.000 0.000 1.00	48.1	0.135	0.100	52.21 4.0 15.5
17	0.173	11479 0.000 0.000 1.00	62.6	0.200	0.100	55.47 4.0 15.5
18	0.173	11479 0.000 0.000 1.00	49.4	0.102	0.100	58.74 4.0 15.5
19	0.173	11479 0.000 0.000 1.00	48.5	0.050	0.100	62.00 4.0 15.5
Toe			79.4	0.150	0.100	

3.283 kips total unreduced pile weight (g= 32.17 ft/s2)  
3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
50.00	11.18	1.00	0.800

▲  
FRA-70-1322L - Rear Abutment - HP12x53 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down up	ksi		ksi		kip-ft	b/min
560.1	77.2	9.67 9.65	-2.47	6	36	44.26	7 3 39.0	38.0
567.8	83.2	9.71 9.70	-2.49	6	36	44.53	7 3 39.1	37.9
575.5	89.6	9.78 9.76	-2.48	6	35	44.85	7 3 39.2	37.8
583.1	96.9	9.81 9.80	-2.51	6	35	45.14	7 3 39.4	37.7
590.8	106.0	9.87 9.86	-2.49	6	35	45.44	7 3 39.4	37.6

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FRA-70-1322L - Rear Abutment - HP12x53 02/28/2021  
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Depth (ft) 55.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:  
Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	632.7
		Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D	Quake	LbTop Perim Area

1322L-RA-12X53

	kips	k/in	ft	ft	kips	s/ft	inch	ft	ft	in2	
1	0.173	11479	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.0	15.5
2	0.173	11479	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.0	15.5
3	0.173	11479	0.000	0.000	1.00	1.5	0.050	0.100	9.79	4.0	15.5
4	0.173	11479	0.000	0.000	1.00	5.5	0.050	0.100	13.05	4.0	15.5
5	0.173	11479	0.000	0.000	1.00	10.8	0.089	0.100	16.32	4.0	15.5
6	0.173	11479	0.000	0.000	1.00	29.3	0.200	0.100	19.58	4.0	15.5
7	0.173	11479	0.000	0.000	1.00	23.7	0.154	0.100	22.84	4.0	15.5
8	0.173	11479	0.000	0.000	1.00	22.0	0.050	0.100	26.11	4.0	15.5
9	0.173	11479	0.000	0.000	1.00	25.9	0.050	0.100	29.37	4.0	15.5
10	0.173	11479	0.000	0.000	1.00	29.9	0.050	0.100	32.63	4.0	15.5
11	0.173	11479	0.000	0.000	1.00	32.4	0.050	0.100	35.89	4.0	15.5
12	0.173	11479	0.000	0.000	1.00	35.2	0.050	0.100	39.16	4.0	15.5
13	0.173	11479	0.000	0.000	1.00	37.5	0.050	0.100	42.42	4.0	15.5
14	0.173	11479	0.000	0.000	1.00	39.9	0.050	0.100	45.68	4.0	15.5
15	0.173	11479	0.000	0.000	1.00	59.9	0.192	0.100	48.95	4.0	15.5
16	0.173	11479	0.000	0.000	1.00	56.9	0.172	0.100	52.21	4.0	15.5
17	0.173	11479	0.000	0.000	1.00	47.3	0.050	0.100	55.47	4.0	15.5
18	0.173	11479	0.000	0.000	1.00	49.9	0.050	0.100	58.74	4.0	15.5
19	0.173	11479	0.000	0.000	1.00	52.3	0.050	0.100	62.00	4.0	15.5
Toe						72.9	0.150	0.100			

3.283 kips total unredused pile weight (g= 32.17 ft/s2)

3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
55.00	11.18	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke down	(ft) up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
632.7	161.3	9.86	9.86	-1.51	4	33	45.01	6	3	38.4	37.7
640.4	177.7	9.91	9.88	-1.54	4	33	45.40	6	3	38.7	37.6
648.1	204.6	9.93	9.91	-1.54	4	33	45.63	6	3	38.7	37.6
655.8	241.5	9.96	9.94	-1.52	4	33	45.93	6	3	38.6	37.5
663.5	281.6	10.01	9.97	-1.51	4	33	46.23	6	3	38.7	37.4

FRA-70-1322L - Rear Abutment - HP12x53  
 Resource International Inc  
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Depth	(ft)	60.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	12.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)						716.5
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area	
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2	
1	0.173	11479	0.010	0.000	0.85	0.3	0.050	0.100	3.26	4.0	15.5	
2	0.173	11479	0.000	0.000	1.00	3.6	0.050	0.100	6.53	4.0	15.5	
3	0.173	11479	0.000	0.000	1.00	7.7	0.050	0.100	9.79	4.0	15.5	
4	0.173	11479	0.000	0.000	1.00	21.8	0.181	0.100	13.05	4.0	15.5	
5	0.173	11479	0.000	0.000	1.00	28.6	0.196	0.100	16.32	4.0	15.5	
6	0.173	11479	0.000	0.000	1.00	20.0	0.050	0.100	19.58	4.0	15.5	
7	0.173	11479	0.000	0.000	1.00	24.1	0.050	0.100	22.84	4.0	15.5	
8	0.173	11479	0.000	0.000	1.00	28.1	0.050	0.100	26.11	4.0	15.5	
9	0.173	11479	0.000	0.000	1.00	31.4	0.050	0.100	29.37	4.0	15.5	
10	0.173	11479	0.000	0.000	1.00	33.8	0.050	0.100	32.63	4.0	15.5	
11	0.173	11479	0.000	0.000	1.00	36.5	0.050	0.100	35.89	4.0	15.5	
12	0.173	11479	0.000	0.000	1.00	38.8	0.050	0.100	39.16	4.0	15.5	
13	0.173	11479	0.000	0.000	1.00	49.6	0.145	0.100	42.42	4.0	15.5	
14	0.173	11479	0.000	0.000	1.00	62.6	0.200	0.100	45.68	4.0	15.5	
15	0.173	11479	0.000	0.000	1.00	48.4	0.087	0.100	48.95	4.0	15.5	
16	0.173	11479	0.000	0.000	1.00	48.7	0.050	0.100	52.21	4.0	15.5	
17	0.173	11479	0.000	0.000	1.00	51.2	0.050	0.100	55.47	4.0	15.5	
18	0.173	11479	0.000	0.000	1.00	53.2	0.050	0.100	58.74	4.0	15.5	
19	0.173	11479	0.000	0.000	1.00	55.3	0.050	0.100	62.00	4.0	15.5	
Toe						72.9	0.150	0.100				

3.283 kips total unreduced pile weight (g= 32.17 ft/s2)  
 3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
60.00	11.18	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
716.5	2830.0	10.04	9.95	-0.59	3	31	45.16	4	2	37.8
724.2	9999.0	10.07	10.03	-0.42	3	31	45.34	4	2	37.7
731.9	9999.0	10.10	10.08	-0.36	3	31	45.61	4	2	37.7
739.6	9999.0	10.13	10.09	-0.35	3	31	45.88	4	2	37.9
747.2	9999.0	10.16	10.13	-0.29	3	31	46.03	4	2	37.8

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Depth ft	Stroke ft	Pressure Ratio	Efficy
62.0	11.18	1.00	0.800

## PILE PROFILE:

Toe Area in2	Pile Type	Unknown
144.000		

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

No.	Weight kips	Pile and Soil Model Stiffn C-Slk T-Slk k/in ft ft	CoR	Total Capacity Soil-S kips	Rut (kips) Soil-D Quake s/ft inch	751.5 LbTop Perim ft ft	Area in2
1	0.173	11479 0.010 0.000 0.85	0.85	2.0	0.050 0.100	3.26 4.0	15.5
2	0.173	11479 0.000 0.000 1.00	1.00	6.1	0.050 0.100	6.53 4.0	15.5
3	0.173	11479 0.000 0.000 1.00	1.00	13.9	0.135 0.100	9.79 4.0	15.5
4	0.173	11479 0.000 0.000 1.00	1.00	29.3	0.200 0.100	13.05 4.0	15.5
5	0.173	11479 0.000 0.000 1.00	1.00	22.3	0.132 0.100	16.32 4.0	15.5
6	0.173	11479 0.000 0.000 1.00	1.00	22.6	0.050 0.100	19.58 4.0	15.5
7	0.173	11479 0.000 0.000 1.00	1.00	26.5	0.050 0.100	22.84 4.0	15.5
8	0.173	11479 0.000 0.000 1.00	1.00	30.3	0.050 0.100	26.11 4.0	15.5
9	0.173	11479 0.000 0.000 1.00	1.00	32.8	0.050 0.100	29.37 4.0	15.5
10	0.173	11479 0.000 0.000 1.00	1.00	35.6	0.050 0.100	32.63 4.0	15.5
11	0.173	11479 0.000 0.000 1.00	1.00	37.9	0.050 0.100	35.89 4.0	15.5
12	0.173	11479 0.000 0.000 1.00	1.00	40.6	0.056 0.100	39.16 4.0	15.5
13	0.173	11479 0.000 0.000 1.00	1.00	62.6	0.200 0.100	42.42 4.0	15.5
14	0.173	11479 0.000 0.000 1.00	1.00	54.5	0.156 0.100	45.68 4.0	15.5
15	0.173	11479 0.000 0.000 1.00	1.00	47.7	0.050 0.100	48.95 4.0	15.5
16	0.173	11479 0.000 0.000 1.00	1.00	50.2	0.050 0.100	52.21 4.0	15.5
17	0.173	11479 0.000 0.000 1.00	1.00	52.5	0.050 0.100	55.47 4.0	15.5
18	0.173	11479 0.000 0.000 1.00	1.00	54.4	0.050 0.100	58.74 4.0	15.5
19	0.173	11479 0.000 0.000 1.00	1.00	56.7	0.050 0.100	62.00 4.0	15.5
Toe				72.9	0.150 0.100		

3.283 kips total unreduced pile weight (g= 32.17 ft/s2)  
 3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
62.00	11.18	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
751.5	9999.0	10.07	10.05	-0.17	2	30	44.48	4	2	37.1
759.2	9999.0	10.08	10.06	-0.17	2	30	44.72	4	2	37.2
766.9	9999.0	10.09	10.09	-0.14	2	31	44.86	4	2	37.0
774.6	9999.0	10.09	10.08	-0.11	2	31	45.17	3	4	36.9
782.3	9999.0	10.09	10.07	-0.07	2	49	45.49	3	4	36.8

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## SUMMARY OVER DEPTHS

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: 0.604	1.000	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ksi	ft	kip-ft
5.0	15.5	4.8	10.8	Hammer	did not	run			
10.0	27.6	24.0	3.6	Hammer	did not	run			
15.0	105.1	65.8	39.2	6.5	27.715	-0.812		5.49	37.2
20.0	142.6	99.5	43.1	8.5	31.157	-0.745		5.98	36.0
25.0	195.5	142.5	52.9	11.7	34.529	-0.856		6.62	35.3
30.0	265.5	192.6	72.9	16.5	36.685	0.000		7.28	34.7
35.0	321.7	248.7	72.9	20.0	39.074	-1.416		7.78	35.5
40.0	323.9	316.1	7.8	19.7	38.250	-0.830		7.69	34.2
45.0	486.8	407.4	79.4	48.8	44.043	-2.958		9.34	39.0
50.0	560.1	480.7	79.4	77.2	44.258	-2.466		9.67	39.0
55.0	632.7	559.8	72.9	161.3	45.009	-1.508		9.86	38.4
60.0	716.5	643.6	72.9	2830.0	45.165	-0.587		10.04	37.8
62.0	751.5	678.6	72.9	9999.0	44.483	-0.171		10.07	37.1

Refusal occurred; no driving time output possible

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: 0.637	1.000	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ksi	ft	kip-ft
5.0	15.5	4.8	10.8	Hammer	did not	run			
10.0	28.0	24.4	3.6	Hammer	did not	run			
15.0	107.5	68.3	39.2	6.7	28.038	-0.786		5.55	37.1
20.0	145.0	101.9	43.1	8.7	31.467	-0.704		6.03	35.9
25.0	197.9	145.0	52.9	12.0	34.812	-0.797		6.66	35.2
30.0	268.0	195.1	72.9	16.7	36.986	0.000		7.33	34.9
35.0	324.1	251.2	72.9	20.3	39.379	-1.360		7.82	35.5
40.0	327.3	319.5	7.8	20.0	38.548	-0.797		7.73	34.3
45.0	494.5	415.1	79.4	51.1	44.512	-3.068		9.40	39.4
50.0	567.8	488.4	79.4	83.2	44.531	-2.486		9.71	39.1
55.0	640.4	567.5	72.9	177.7	45.404	-1.542		9.91	38.7
60.0	724.2	651.2	72.9	9999.0	45.337	-0.417		10.07	37.7
62.0	759.2	686.3	72.9	9999.0	44.718	-0.169		10.08	37.2

Refusal occurred; no driving time output possible

▲

FRA-70-1322L - Rear Abutment - HP12x53

02/28/2021

Resource International Inc

GRLWEAP Version 2010

## SUMMARY OVER DEPTHS

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: 0.670	1.000	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ksi	ft	kip-ft
5.0	15.5	4.8	10.8	Hammer	did not	run			
10.0	28.5	24.8	3.6	Hammer	did not	run			
15.0	110.0	70.7	39.2	6.9	28.269	-0.753		5.60	37.0
20.0	147.5	104.4	43.1	8.9	31.751	-0.705		6.07	35.8
25.0	200.4	147.5	52.9	12.2	35.149	-0.657		6.70	35.1
30.0	270.5	197.5	72.9	16.9	37.242	0.000		7.37	34.9
35.0	326.6	253.6	72.9	20.7	39.699	-1.311		7.85	35.5
40.0	330.7	322.9	7.8	20.5	38.752	-0.801		7.78	34.2
45.0	502.1	422.8	79.4	54.3	44.920	-3.074		9.48	39.4
50.0	575.5	496.1	79.4	89.6	44.855	-2.484		9.78	39.2
55.0	648.1	575.2	72.9	204.6	45.635	-1.543		9.93	38.7
60.0	731.9	658.9	72.9	9999.0	45.609	-0.364		10.10	37.7
62.0	766.9	694.0	72.9	9999.0	44.862	-0.135		10.09	37.0

Refusal occurred; no driving time output possible

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: 0.703	1.000	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ksi	ft	kip-ft
5.0	15.5	4.8	10.8	Hammer	did not	run			
10.0	28.9	25.3	3.6	Hammer	did not	run			
15.0	112.4	73.2	39.2	7.1	28.531	-0.717		5.65	36.8
20.0	149.9	106.9	43.1	9.2	32.050	-0.714		6.11	35.8
25.0	202.8	149.9	52.9	12.4	35.428	-0.490		6.74	35.0
30.0	272.9	200.0	72.9	17.1	37.481	0.000		7.41	34.9
35.0	329.0	256.1	72.9	20.9	39.967	-1.290		7.89	35.6
40.0	334.1	326.3	7.8	20.8	39.055	-0.830		7.82	34.3
45.0	509.8	430.4	79.4	57.1	45.327	-3.178		9.53	39.7
50.0	583.1	503.8	79.4	96.9	45.143	-2.507		9.81	39.4
55.0	655.8	582.9	72.9	241.5	45.928	-1.517		9.96	38.6
60.0	739.6	666.6	72.9	9999.0	45.883	-0.348		10.13	37.9



1322L-RA-12X53  
62.0 774.6 701.6 72.9 9999.0 45.171 -0.111 10.09 36.9

Refusal occurred; no driving time output possible

↑  
FRA-70-1322L - Rear Abutment - HP12x53 02/28/2021  
Resource International Inc GRLWEAP Version 2010

#### SUMMARY OVER DEPTHS

Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	15.5	4.8	10.8	Hammer	did not	run		
10.0	29.3	25.7	3.6	1.4	14.297	0.000	3.52	45.9
15.0	114.9	75.7	39.2	7.3	28.777	-0.668	5.70	36.8
20.0	152.4	109.3	43.1	9.4	32.328	-0.739	6.16	35.7
25.0	205.3	152.4	52.9	12.6	35.777	-0.309	6.78	35.0
30.0	275.4	202.4	72.9	17.3	37.744	0.000	7.45	35.0
35.0	331.5	258.6	72.9	21.2	40.293	-1.285	7.92	35.6
40.0	337.4	329.7	7.8	21.1	39.366	-0.868	7.86	34.6
45.0	517.5	438.1	79.4	60.8	45.723	-3.173	9.60	39.8
50.0	590.8	511.4	79.4	106.0	45.442	-2.487	9.87	39.4
55.0	663.5	590.6	72.9	281.6	46.232	-1.513	10.01	38.7
60.0	747.2	674.3	72.9	9999.0	46.032	-0.290	10.16	37.8
62.0	782.3	709.3	72.9	9999.0	45.494	-0.067	10.09	36.8

Refusal occurred; no driving time output possible

↑  
FRA-70-1322L - Rear Abutment - HP12x53 02/28/2021  
Resource International Inc GRLWEAP Version 2010

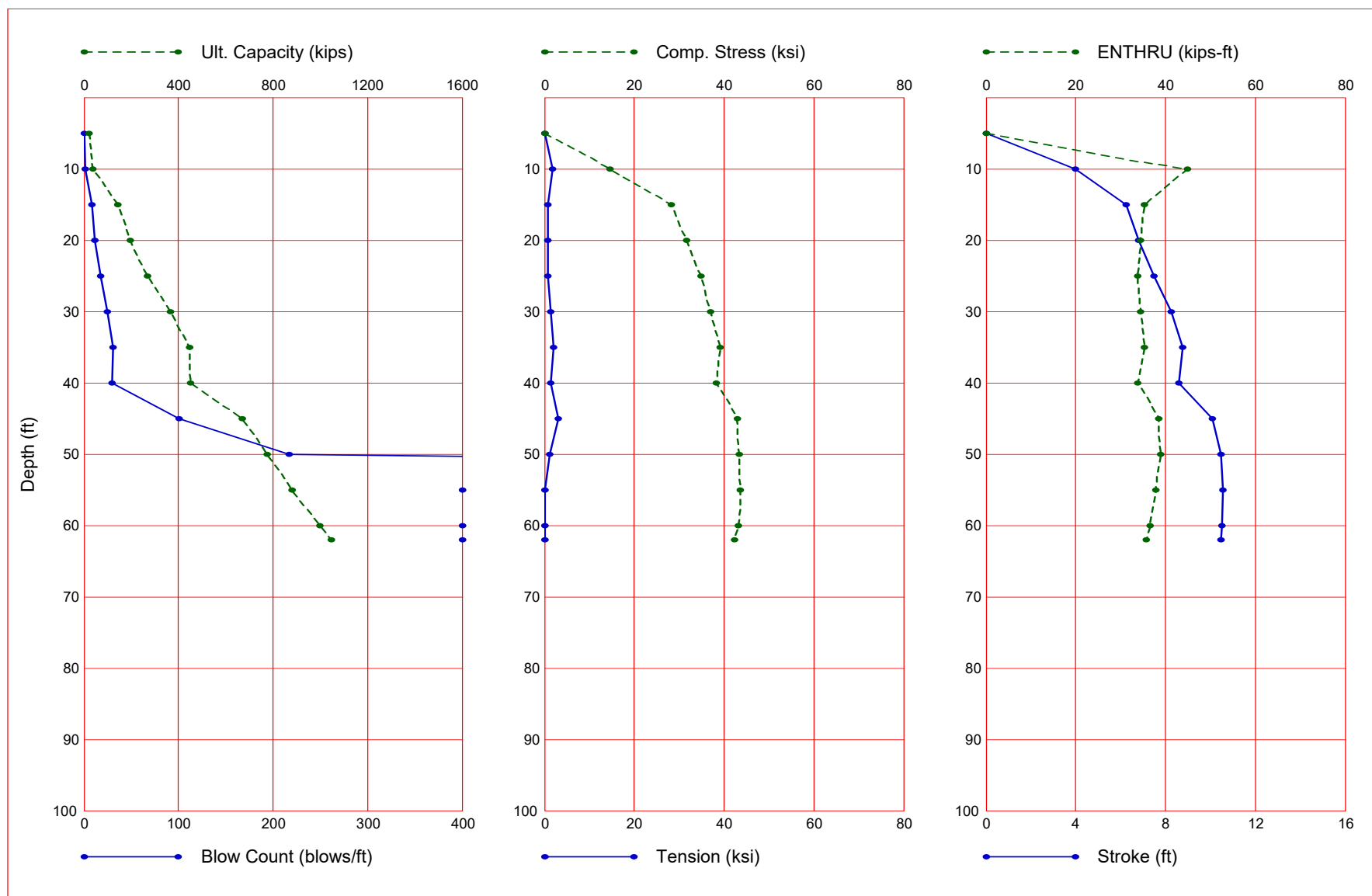
#### Table of Depths Analyzed with Driving System Modifiers

Depth	Temp. Length	Wait Time	Equivalent Stroke	Pressure Ratio	Efficy.	Stiffn. Factor	Cushion CoR
ft	ft	hr	ft				
5.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
10.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
15.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
20.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
25.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
30.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
35.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
40.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
45.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
50.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
55.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
60.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
62.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00

#### Soil Layer Resistance Values

Depth	Shaft Res.	End Bearing	Shaft Quake	Toe Quake	Shaft Damping	Toe Damping	Soil Setup	Limit Distance	Setup Time
ft	k/ft2	kips	inch	inch	s/ft	s/ft	Normlzd	ft	hrs
0.01	0.00	0.02	0.100	0.100	0.050	0.150	0.000	6.000	1.000
9.01	0.87	19.41	0.100	0.100	0.050	0.150	0.000	6.000	1.000
9.09	0.88	19.58	0.100	0.100	0.050	0.150	0.000	6.000	1.000
9.11	3.75	3.63	0.100	0.100	0.200	0.150	1.000	6.000	168.000
14.09	3.75	3.63	0.100	0.100	0.200	0.150	1.000	6.000	168.000
14.11	1.36	36.78	0.100	0.100	0.050	0.150	0.000	6.000	1.000
19.09	1.86	50.45	0.100	0.100	0.050	0.150	0.000	6.000	1.000
19.11	1.84	41.16	0.100	0.100	0.050	0.150	0.000	6.000	1.000
24.49	2.36	52.75	0.100	0.100	0.050	0.150	0.000	6.000	1.000
24.51	2.36	52.78	0.100	0.100	0.050	0.150	0.000	6.000	1.000
29.09	2.59	54.20	0.100	0.100	0.050	0.150	0.000	6.000	1.000
29.11	2.64	72.94	0.100	0.100	0.050	0.150	0.000	6.000	1.000
38.11	3.13	72.94	0.100	0.100	0.050	0.150	0.000	6.000	1.000
39.09	3.19	72.94	0.100	0.100	0.050	0.150	0.000	6.000	1.000
39.11	8.00	7.75	0.100	0.100	0.200	0.150	1.000	6.000	168.000
44.09	8.00	7.75	0.100	0.100	0.200	0.150	1.000	6.000	168.000
44.11	3.49	79.39	0.100	0.100	0.050	0.150	0.000	6.000	1.000
53.11	4.03	79.39	0.100	0.100	0.050	0.150	0.000	6.000	1.000
54.49	4.11	79.39	0.100	0.100	0.050	0.150	0.000	6.000	1.000
54.51	4.05	72.94	0.100	0.100	0.050	0.150	0.000	6.000	1.000
62.00	4.47	72.94	0.100	0.100	0.050	0.150	0.000	6.000	1.000

Gain/Loss 3 at Shaft and Toe 0.670 / 1.000



Gain/Loss 3 at Shaft and Toe 0.670 / 1.000

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
5.0	21.6	6.7	14.9	-1.0	0.000	0.000	0.00	0.0
10.0	38.0	33.0	5.0	1.7	14.602	-1.882	4.00	45.0
15.0	142.7	88.5	54.2	9.1	28.335	-0.838	6.23	35.4
20.0	195.6	136.2	59.5	12.1	31.675	-0.803	6.80	34.5
25.0	270.1	197.0	73.1	17.4	34.983	-0.737	7.48	33.9
30.0	368.5	267.8	100.7	24.4	37.043	-1.490	8.25	34.5
35.0	448.0	347.3	100.7	31.3	39.207	-2.062	8.75	35.3
40.0	451.6	440.9	10.7	30.2	38.231	-1.295	8.61	33.9
45.0	671.7	562.1	109.6	101.0	43.020	-3.091	10.08	38.4
50.0	775.8	666.2	109.6	217.4	43.314	-1.070	10.49	39.0
55.0	879.1	778.4	100.7	3540.7	43.712	0.000	10.58	37.9
60.0	997.8	897.1	100.7	9999.0	43.138	0.000	10.52	36.6
62.0	1047.4	946.7	100.7	9999.0	42.275	0.000	10.48	35.8

Refusal occurred; no driving time output possible

GRLWEAP - Version 2010  
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.  
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ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

Input File: J:\GEOTECH\PROJECTS\2013\W-13-072 FRA-70-13.10 PROJECT 6A\ANALYSIS\FRA-70-1322L AND 1323C\DRIVEABILITY\FRA-70-1322L\REAR ABUTMENT\HP 14X73\1322L-RA-14X73.GW  
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW  
Hammer File Version: 2003 (12/4/2018)

Input File Contents

FRA-70-1322L - Rear Abutment - HP14x73  
OUT OSG HAM STR FUL PEL N SPL N-U P-D %SK ISM 0 PHI RSA ITR H-D MXT DEX  
-100 0 14 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0.000  
Pile g Hammer g Toe Area Pile Size Pile Type  
32.170 32.170 144.000 14.000 Unknown  
W Cp A Cp E Cp T Cp CoR ROut StCp  
1.900 227.000 530.0 2.000 0.800 0.010 0.0  
A Cu E Cu T Cu CoR ROut StCu  
0.000 0.0 0.000 0.000 0.000 0.0  
LPle APle EPle WPle Peri CI CoR ROut  
62.000 21.40 29000.0 492.000 4.700 0 0.850 0.010  
FFatigue F0 0-Bottom  
0 0.000 0.000  
Manufac Hmr Name HmrType No Seg-s  
DELMAG D 30-23 1 5  
Ram Wt Ram L Ram Dia MaxStrk RtdStrk Efficy  
6.60 118.10 16.51 13.44 11.18 0.80  
IB. Wt IB. L IB. Dia IB CoR IB R0  
1.20 25.00 16.51 0.900 0.010  
CompStrk A Chamber V Chamber C Delay C Duratn Exp Coeff VolCStart Vol CEnd  
16.30 214.03 280.90 0.0010 0.0020 1.250 0.00 0.00  
P atm P1 P2 P3 P4 P5  
14.70 1550.00 1395.00 1255.00 1130.00 0.00  
Stroke Effic. Pressure R-Weight T-Delay Exp-Coeff Eps-Str Total-AW  
11.1800 0.8000 1550.0000 0.0000 0.0000 0.0000 0.0100 0.0000  
Qs Qt Js Jt Qx Jx Rati Dept  
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000  
Research Soil Model: Atoe, Plug, Gap, Q-fac

0.000 0.000 0.000 0.000  
 Research Soil Model: RD-skn: m, d, toe: m, d  
 0.000 0.000 0.000 0.000  
 Research Toe Plug: Res-int, Q-int, D-int, Res-plug, Q-plug, D-plug  
 0.000 0.000 0.000 0.000 0.000 0.000  
 Research Toe Plug: RD plug toe: m, d  
 0.000 0.000  
 Research Toe Plug: New Toe Plug Model is NOT applied  
 Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimL	TSf0
0.01	0.00	0.03	0.10	0.10	0.05	0.15	1.00	6.00	1.000
9.01	1.04	26.79	0.10	0.10	0.05	0.15	1.00	6.00	1.000
9.09	1.05	27.03	0.10	0.10	0.05	0.15	1.00	6.00	1.000
9.11	3.75	5.02	0.10	0.10	0.20	0.15	1.49	6.00	168.000
14.09	3.75	5.02	0.10	0.10	0.20	0.15	1.49	6.00	168.000
14.11	1.62	50.78	0.10	0.10	0.05	0.15	1.00	6.00	1.000
19.09	2.22	69.65	0.10	0.10	0.05	0.15	1.00	6.00	1.000
19.11	2.20	56.83	0.10	0.10	0.05	0.15	1.00	6.00	1.000
24.49	2.82	72.83	0.10	0.10	0.05	0.15	1.00	6.00	1.000
24.51	2.82	72.87	0.10	0.10	0.05	0.15	1.00	6.00	1.000
29.09	3.10	74.83	0.10	0.10	0.05	0.15	1.00	6.00	1.000
29.11	3.16	100.70	0.10	0.10	0.05	0.15	1.00	6.00	1.000
38.11	3.75	100.70	0.10	0.10	0.05	0.15	1.00	6.00	1.000
39.09	3.82	100.70	0.10	0.10	0.05	0.15	1.00	6.00	1.000
39.11	8.00	10.70	0.10	0.10	0.20	0.15	1.49	6.00	168.000
44.09	8.00	10.70	0.10	0.10	0.20	0.15	1.49	6.00	168.000
44.11	4.19	109.62	0.10	0.10	0.05	0.15	1.00	6.00	1.000
53.11	4.83	109.62	0.10	0.10	0.05	0.15	1.00	6.00	1.000
54.49	4.93	109.62	0.10	0.10	0.05	0.15	1.00	6.00	1.000
54.51	4.85	100.70	0.10	0.10	0.05	0.15	1.00	6.00	1.000
62.00	5.34	100.70	0.10	0.10	0.05	0.15	1.00	6.00	1.000

Gain/Loss factors: shaft and toe

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimL	TSf0
0.60400	0.63700	0.67000	0.70300	0.73600					
1.00000	1.00000	1.00000	1.00000	1.00000					
Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR		
5.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000		
10.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000		
15.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000		
20.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000		
25.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000		
30.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000		
35.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000		
40.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000		
45.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000		
50.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000		
55.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000		
60.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000		
62.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000		
0.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000		

▲ GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS  
 Version 2010  
 English Units

FRA-70-1322L - Rear Abutment - HP14x73

Hammer Model: D 30-23		Made by: DELMAG	
No.	Weight kips	Stiffn k/inch	CoR
1	1.320		
2	1.320	262846.5	1.000
3	1.320	262846.5	1.000
4	1.320	262846.5	1.000
5	1.320	262846.5	1.000
Imp Block	1.200	127693.0	0.900
Helmet	1.900	60155.0	0.800
Combined Pile Top		15848.7	

HAMMER OPTIONS:  
 Hammer File ID No. 14 Hammer Type OE Diesel  
 Stroke Option FxdP-VarS Stroke Convergence Crit. 0.010  
 Fuel Pump Setting Maximum

HAMMER DATA:  
 Ram Weight (kips) 6.60 Ram Length (inch) 118.10  
 Maximum Stroke (ft) 13.44  
 Rated Stroke (ft) 11.18 Efficiency 0.800  
 Maximum Pressure (psi) 1550.00 Actual Pressure (psi) 1550.00  
 Compression Exponent 1.350 Expansion Exponent 1.250

1322L-RA-14X73

Ram Diameter	(inch)	16.51		
Combustion Delay	(s)	0.00100	Ignition Duration	(s) 0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION			PILE CUSHION		
Cross Sect. Area	(in2)	227.00	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	530.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	2.00	Thickness	(inch)	0.00
Coeff of Restitution		0.8	Coeff of Restitution		1.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	60155.0	Stiffness	(kips/in)	0.0

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Depth	(ft)	5.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	14.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	21.6
	kips	Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D	Quake	LbTop Perim Area
		k/in ft ft	kips	s/ft	inch	ft ft in2
1	0.239	15849 0.010 0.000 0.85	0.0	0.000	0.100	3.26 4.7 21.4
2	0.239	15849 0.000 0.000 1.00	0.0	0.000	0.100	6.53 4.7 21.4
18	0.239	15849 0.000 0.000 1.00	0.8	0.050	0.100	58.74 4.7 21.4
19	0.239	15849 0.000 0.000 1.00	5.9	0.050	0.100	62.00 4.7 21.4
Toe			14.9	0.150	0.100	

4.533 kips total unreduced pile weight (g= 32.17 ft/s2)  
 4.533 kips total reduced pile weight (g= 32.17 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile		Pile Segments: Automatic
No. of Slacks/Splices	0	Pile Damping (%) 1
		Pile Damping Fact.(k/ft/s) 0.751

Driveability Analysis	
Soil Damping Option	Smith
Max No Analysis Iterations	0 Time Increment/Critical 160
Output Time Interval	1 Analysis Time-Input (ms) 0
Output Level: Normal	
Gravity Mass, Pile, Hammer:	32.170 32.170 32.170
Output Segment Generation: Automatic	

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
5.00	11.18	1.00	0.800

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Rut	Bl Ct	Stroke (ft)	Ten Str	i t Comp Str	i t ENTHRU	Bl Rt
kips	b/ft	down up	ksi	ksi	kip-ft	b/min
21.6	Hammer did not run					
21.6	Hammer did not run					
21.6	Hammer did not run					
21.6	Hammer did not run					
21.6	Hammer did not run					

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Depth	(ft)	10.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
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Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model				Total Capacity Rut (kips)				37.0			
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.239	15849	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.7	21.4
2	0.239	15849	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.7	21.4
16	0.239	15849	0.000	0.000	1.00	0.0	0.050	0.100	52.21	4.7	21.4
17	0.239	15849	0.000	0.000	1.00	3.2	0.050	0.100	55.47	4.7	21.4
18	0.239	15849	0.000	0.000	1.00	9.0	0.050	0.100	58.74	4.7	21.4
19	0.239	15849	0.000	0.000	1.00	19.7	0.141	0.100	62.00	4.7	21.4
Toe						5.0	0.150	0.100			

4.533 kips total unreduced pile weight (g= 32.17 ft/s2)

4.533 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
10.00	11.18	1.00	0.800

▲

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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
37.0	1.6	3.97	3.95	-1.93	4	11	14.35	1	2	45.3
37.5	1.6	3.98	3.96	-1.91	4	11	14.49	1	2	45.2
38.0	1.7	4.00	3.98	-1.88	4	11	14.60	1	2	45.0
38.6	1.7	3.97	4.01	-1.89	4	11	14.58	1	2	44.7
39.1	1.7	3.99	4.02	-1.85	4	11	14.73	1	2	44.6

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Depth	(ft)	15.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor
			1.000

## PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	14.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model				Total Capacity Rut (kips)				136.9			
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.239	15849	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.7	21.4
2	0.239	15849	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.7	21.4
15	0.239	15849	0.000	0.000	1.00	1.0	0.050	0.100	48.95	4.7	21.4
16	0.239	15849	0.000	0.000	1.00	6.3	0.050	0.100	52.21	4.7	21.4
17	0.239	15849	0.000	0.000	1.00	12.1	0.050	0.100	55.47	4.7	21.4
18	0.239	15849	0.000	0.000	1.00	31.1	0.191	0.100	58.74	4.7	21.4
19	0.239	15849	0.000	0.000	1.00	32.3	0.178	0.100	62.00	4.7	21.4
Toe						54.2	0.150	0.100			

4.533 kips total unreduced pile weight (g= 32.17 ft/s2)

4.533 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
15.00	11.18	1.00	0.800

▲

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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min

1322L-RA-14X73													
136.9	8.6	6.13	6.15	-0.88	16	45	27.92	16	5	35.7	47.5		
139.8	8.8	6.18	6.20	-0.87	16	44	28.12	16	5	35.5	47.3		
142.7	9.1	6.23	6.24	-0.84	16	44	28.34	16	5	35.4	47.2		
145.6	9.3	6.28	6.28	-0.80	16	43	28.51	16	5	35.3	47.0		
148.5	9.5	6.32	6.33	-0.76	16	43	28.70	16	5	35.2	46.8		

FRA-70-1322L - Rear Abutment - HP14x73  
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Depth (ft) 20.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model										Total Capacity Rut (kips)	189.8
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
kips	k/in	ft	ft			kips	s/ft	inch	ft	ft	in2
1	0.239	15849	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.7	21.4
2	0.239	15849	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.7	21.4
13	0.239	15849	0.000	0.000	1.00	0.0	0.050	0.100	42.42	4.7	21.4
14	0.239	15849	0.000	0.000	1.00	3.6	0.050	0.100	45.68	4.7	21.4
15	0.239	15849	0.000	0.000	1.00	9.4	0.050	0.100	48.95	4.7	21.4
16	0.239	15849	0.000	0.000	1.00	21.2	0.151	0.100	52.21	4.7	21.4
17	0.239	15849	0.000	0.000	1.00	34.7	0.200	0.100	55.47	4.7	21.4
18	0.239	15849	0.000	0.000	1.00	28.7	0.100	0.100	58.74	4.7	21.4
19	0.239	15849	0.000	0.000	1.00	32.6	0.050	0.100	62.00	4.7	21.4
Toe						59.5	0.150	0.100			

4.533 kips total unredacted pile weight (g= 32.17 ft/s2)

4.533 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
20.00	11.18	1.00	0.800

FRA-70-1322L - Rear Abutment - HP14x73  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	b/min	
189.8	11.6	6.72	6.67	-0.70	15 36	31.25	16 5	34.7
192.7	11.9	6.76	6.71	-0.75	15 36	31.47	16 5	34.5
195.6	12.1	6.80	6.75	-0.80	15 36	31.67	16 5	34.5
198.5	12.4	6.83	6.79	-0.85	14 36	31.89	16 5	34.4
201.4	12.7	6.88	6.84	-0.89	14 36	32.20	16 5	34.3

FRA-70-1322L - Rear Abutment - HP14x73  
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Depth (ft) 25.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model										Total Capacity Rut (kips)	264.3
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
kips	k/in	ft	ft			kips	s/ft	inch	ft	ft	in2
1	0.239	15849	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.7	21.4
2	0.239	15849	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.7	21.4
12	0.239	15849	0.000	0.000	1.00	1.2	0.050	0.100	39.16	4.7	21.4
13	0.239	15849	0.000	0.000	1.00	6.7	0.050	0.100	42.42	4.7	21.4
14	0.239	15849	0.000	0.000	1.00	12.4	0.050	0.100	45.68	4.7	21.4



1322L-RA-14X73											
15	0.239	15849	0.000	0.000	1.00	32.3	0.194	0.100	48.95	4.7	21.4
16	0.239	15849	0.000	0.000	1.00	31.7	0.172	0.100	52.21	4.7	21.4
17	0.239	15849	0.000	0.000	1.00	29.9	0.050	0.100	55.47	4.7	21.4
18	0.239	15849	0.000	0.000	1.00	35.6	0.050	0.100	58.74	4.7	21.4
19	0.239	15849	0.000	0.000	1.00	41.2	0.050	0.100	62.00	4.7	21.4
Toe						73.1	0.150	0.100			

4.533 kips total unreduced pile weight (g= 32.17 ft/s2)  
4.533 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
25.00	11.18	1.00	0.800

↑  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
264.3	16.8	7.40	7.40	-0.98	13	32	34.42	15	5	34.0
267.2	17.1	7.45	7.43	-0.86	13	32	34.70	15	5	34.0
270.1	17.4	7.48	7.47	-0.74	13	32	34.98	15	5	33.9
273.0	17.7	7.51	7.51	-0.59	13	32	35.21	15	5	33.8
275.9	18.0	7.55	7.55	-0.44	13	32	35.42	15	5	33.7

↑  
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Depth	(ft)	30.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor
			1.000

#### PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	14.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity	Rut	(kips)			362.7
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.239	15849	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.7	21.4
2	0.239	15849	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.7	21.4
10	0.239	15849	0.000	0.000	1.00	0.1	0.050	0.100	32.63	4.7	21.4
11	0.239	15849	0.000	0.000	1.00	4.0	0.050	0.100	35.89	4.7	21.4
12	0.239	15849	0.000	0.000	1.00	9.7	0.050	0.100	39.16	4.7	21.4
13	0.239	15849	0.000	0.000	1.00	22.6	0.159	0.100	42.42	4.7	21.4
14	0.239	15849	0.000	0.000	1.00	34.7	0.200	0.100	45.68	4.7	21.4
15	0.239	15849	0.000	0.000	1.00	28.4	0.085	0.100	48.95	4.7	21.4
16	0.239	15849	0.000	0.000	1.00	33.0	0.050	0.100	52.21	4.7	21.4
17	0.239	15849	0.000	0.000	1.00	38.6	0.050	0.100	55.47	4.7	21.4
18	0.239	15849	0.000	0.000	1.00	43.7	0.050	0.100	58.74	4.7	21.4
19	0.239	15849	0.000	0.000	1.00	47.1	0.050	0.100	62.00	4.7	21.4
Toe						100.7	0.150	0.100			

4.533 kips total unreduced pile weight (g= 32.17 ft/s2)  
4.533 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
30.00	11.18	1.00	0.800

↑  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
362.7	23.9	8.20	8.16	-1.44	11	48	36.62	13	4	34.4
365.6	24.2	8.23	8.18	-1.46	11	47	36.82	13	4	34.5
368.5	24.4	8.25	8.20	-1.49	11	47	37.04	13	4	34.5
371.4	24.7	8.28	8.23	-1.52	11	47	37.24	13	4	34.6
374.3	25.0	8.31	8.25	-1.55	11	47	37.42	13	4	34.7

↑  
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Depth (ft) 35.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

## PILE PROFILE:

Toe Area (in<sup>2</sup>) 144.000 Pile Type Unknown  
 Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in <sup>2</sup>	ksi	lb/ft <sup>3</sup>	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)				442.2	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in <sup>2</sup>
1	0.239	15849	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.7	21.4
2	0.239	15849	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.7	21.4
9	0.239	15849	0.000	0.000	1.00	1.5	0.050	0.100	29.37	4.7	21.4
10	0.239	15849	0.000	0.000	1.00	7.1	0.050	0.100	32.63	4.7	21.4
11	0.239	15849	0.000	0.000	1.00	12.8	0.050	0.100	35.89	4.7	21.4
12	0.239	15849	0.000	0.000	1.00	33.6	0.197	0.100	39.16	4.7	21.4
13	0.239	15849	0.000	0.000	1.00	31.2	0.164	0.100	42.42	4.7	21.4
14	0.239	15849	0.000	0.000	1.00	30.3	0.050	0.100	45.68	4.7	21.4
15	0.239	15849	0.000	0.000	1.00	35.9	0.050	0.100	48.95	4.7	21.4
16	0.239	15849	0.000	0.000	1.00	41.6	0.050	0.100	52.21	4.7	21.4
17	0.239	15849	0.000	0.000	1.00	45.4	0.050	0.100	55.47	4.7	21.4
18	0.239	15849	0.000	0.000	1.00	49.3	0.050	0.100	58.74	4.7	21.4
19	0.239	15849	0.000	0.000	1.00	52.8	0.050	0.100	62.00	4.7	21.4
Toe						100.7	0.150	0.100			

4.533 kips total unreduced pile weight (g= 32.17 ft/s<sup>2</sup>)

4.533 kips total reduced pile weight (g= 32.17 ft/s<sup>2</sup>)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
35.00	11.18	1.00	0.800

⬆  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	b/min	
442.2	30.4	8.69	8.63	-1.99	10 43	38.71	12 4	35.3
445.1	30.7	8.72	8.65	-2.04	10 43	39.01	12 4	35.4
448.0	31.3	8.75	8.68	-2.06	10 42	39.21	12 4	35.3
450.9	31.6	8.77	8.70	-2.12	10 42	39.47	12 4	35.5
453.8	32.1	8.80	8.74	-2.17	10 42	39.68	12 4	35.4

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 FRA-70-1322L - Rear Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth (ft) 40.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

## PILE PROFILE:

Toe Area (in<sup>2</sup>) 144.000 Pile Type Unknown  
 Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in <sup>2</sup>	ksi	lb/ft <sup>3</sup>	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)				443.6	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in <sup>2</sup>
1	0.239	15849	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.7	21.4
2	0.239	15849	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.7	21.4
7	0.239	15849	0.000	0.000	1.00	0.2	0.050	0.100	22.84	4.7	21.4
8	0.239	15849	0.000	0.000	1.00	4.4	0.050	0.100	26.11	4.7	21.4
9	0.239	15849	0.000	0.000	1.00	10.1	0.050	0.100	29.37	4.7	21.4
10	0.239	15849	0.000	0.000	1.00	24.0	0.166	0.100	32.63	4.7	21.4
11	0.239	15849	0.000	0.000	1.00	34.7	0.200	0.100	35.89	4.7	21.4
12	0.239	15849	0.000	0.000	1.00	28.1	0.068	0.100	39.16	4.7	21.4
13	0.239	15849	0.000	0.000	1.00	33.4	0.050	0.100	42.42	4.7	21.4

1322L-RA-14X73											
14	0.239	15849	0.000	0.000	1.00	38.9	0.050	0.100	45.68	4.7	21.4
15	0.239	15849	0.000	0.000	1.00	43.9	0.050	0.100	48.95	4.7	21.4
16	0.239	15849	0.000	0.000	1.00	47.4	0.050	0.100	52.21	4.7	21.4
17	0.239	15849	0.000	0.000	1.00	51.2	0.050	0.100	55.47	4.7	21.4
18	0.239	15849	0.000	0.000	1.00	54.5	0.050	0.100	58.74	4.7	21.4
19	0.239	15849	0.000	0.000	1.00	62.0	0.117	0.100	62.00	4.7	21.4
Toe						10.7	0.150	0.100			

4.533 kips total unreduced pile weight (g= 32.17 ft/s2)

4.533 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
40.00	11.18	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke down	(ft) up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
443.6	29.3	8.54	8.51	-1.06	8	41	37.75	10	3	33.7	40.5
447.6	29.7	8.58	8.53	-1.19	8	41	38.02	10	3	33.9	40.4
451.6	30.2	8.61	8.57	-1.30	8	41	38.23	10	3	33.9	40.3
455.7	30.8	8.65	8.61	-1.39	8	41	38.42	10	3	34.0	40.2
459.7	31.5	8.69	8.65	-1.46	8	40	38.61	10	3	34.0	40.1

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Depth	(ft)	45.0	Standard Soil Setup
Shaft Gain/Loss Factor	0.604	Toe Gain/Loss Factor	1.000

#### PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	14.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips) 653.5					
No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.239	15849	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.7	21.4
2	0.239	15849	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.7	21.4
6	0.239	15849	0.000	0.000	1.00	1.8	0.050	0.100	19.58	4.7	21.4
7	0.239	15849	0.000	0.000	1.00	7.4	0.050	0.100	22.84	4.7	21.4
8	0.239	15849	0.000	0.000	1.00	13.2	0.051	0.100	26.11	4.7	21.4
9	0.239	15849	0.000	0.000	1.00	34.7	0.200	0.100	29.37	4.7	21.4
10	0.239	15849	0.000	0.000	1.00	30.8	0.157	0.100	32.63	4.7	21.4
11	0.239	15849	0.000	0.000	1.00	30.7	0.050	0.100	35.89	4.7	21.4
12	0.239	15849	0.000	0.000	1.00	36.3	0.050	0.100	39.16	4.7	21.4
13	0.239	15849	0.000	0.000	1.00	41.9	0.050	0.100	42.42	4.7	21.4
14	0.239	15849	0.000	0.000	1.00	45.6	0.050	0.100	45.68	4.7	21.4
15	0.239	15849	0.000	0.000	1.00	49.6	0.050	0.100	48.95	4.7	21.4
16	0.239	15849	0.000	0.000	1.00	53.0	0.050	0.100	52.21	4.7	21.4
17	0.239	15849	0.000	0.000	1.00	56.3	0.050	0.100	55.47	4.7	21.4
18	0.239	15849	0.000	0.000	1.00	71.1	0.185	0.100	58.74	4.7	21.4
19	0.239	15849	0.000	0.000	1.00	71.5	0.175	0.100	62.00	4.7	21.4
Toe						109.6	0.150	0.100			

4.533 kips total unreduced pile weight (g= 32.17 ft/s2)

4.533 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
45.00	11.18	1.00	0.800

FRA-70-1322L - Rear Abutment - HP14x73  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt	
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min	
653.5	89.5	9.98	9.97	-3.00	7	35	42.40	9	3	38.1	37.5
662.6	95.8	10.03	10.02	-3.02	7	34	42.74	9	3	38.1	37.4
671.7	101.0	10.08	10.06	-3.09	7	34	43.02	9	3	38.4	37.3

1322L-RA-14X73  
680.8 108.1 10.13 10.10 -3.12 7 34 43.33 9 3 38.6 37.2  
689.9 117.1 10.16 10.15 -3.14 7 34 43.63 9 3 38.5 37.1

▲  
FRA-70-1322L - Rear Abutment - HP14x73 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth (ft) 50.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:  
Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model		Total Capacity Rut (kips)		757.6							
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.239	15849	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.7	21.4
2	0.239	15849	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.7	21.4
4	0.239	15849	0.000	0.000	1.00	0.3	0.050	0.100	13.05	4.7	21.4
5	0.239	15849	0.000	0.000	1.00	4.7	0.050	0.100	16.32	4.7	21.4
6	0.239	15849	0.000	0.000	1.00	10.5	0.050	0.100	19.58	4.7	21.4
7	0.239	15849	0.000	0.000	1.00	25.4	0.172	0.100	22.84	4.7	21.4
8	0.239	15849	0.000	0.000	1.00	34.7	0.200	0.100	26.11	4.7	21.4
9	0.239	15849	0.000	0.000	1.00	27.9	0.050	0.100	29.37	4.7	21.4
10	0.239	15849	0.000	0.000	1.00	33.7	0.050	0.100	32.63	4.7	21.4
11	0.239	15849	0.000	0.000	1.00	39.3	0.050	0.100	35.89	4.7	21.4
12	0.239	15849	0.000	0.000	1.00	44.1	0.050	0.100	39.16	4.7	21.4
13	0.239	15849	0.000	0.000	1.00	47.6	0.050	0.100	42.42	4.7	21.4
14	0.239	15849	0.000	0.000	1.00	51.4	0.050	0.100	45.68	4.7	21.4
15	0.239	15849	0.000	0.000	1.00	54.7	0.050	0.100	48.95	4.7	21.4
16	0.239	15849	0.000	0.000	1.00	63.2	0.128	0.100	52.21	4.7	21.4
17	0.239	15849	0.000	0.000	1.00	74.1	0.200	0.100	55.47	4.7	21.4
18	0.239	15849	0.000	0.000	1.00	67.3	0.096	0.100	58.74	4.7	21.4
19	0.239	15849	0.000	0.000	1.00	68.9	0.050	0.100	62.00	4.7	21.4
Toe						109.6	0.150	0.100			

4.533 kips total unreduced pile weight (g= 32.17 ft/s2)  
4.533 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
50.00	11.18	1.00	0.800

▲  
FRA-70-1322L - Rear Abutment - HP14x73 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	b/min	
757.6	186.0	10.28	10.24	-1.56	6 32	42.56	7 3	38.2
766.7	194.9	10.47	10.37	-1.12	5 32	43.19	7 3	38.9
775.8	217.4	10.49	10.41	-1.07	5 32	43.31	7 3	39.0
784.9	247.1	10.52	10.44	-1.00	5 33	43.50	7 3	39.0
794.0	293.7	10.54	10.48	-0.85	5 33	43.68	7 3	38.8

▲  
FRA-70-1322L - Rear Abutment - HP14x73 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth (ft) 55.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:  
Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model		Total Capacity Rut (kips)		860.9							
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area

1322L-RA-14X73

	kips	k/in	ft	ft	kips	s/ft	inch	ft	ft	in2	
1	0.239	15849	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.7	21.4
2	0.239	15849	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.7	21.4
3	0.239	15849	0.000	0.000	1.00	2.1	0.050	0.100	9.79	4.7	21.4
4	0.239	15849	0.000	0.000	1.00	7.8	0.050	0.100	13.05	4.7	21.4
5	0.239	15849	0.000	0.000	1.00	14.8	0.084	0.100	16.32	4.7	21.4
6	0.239	15849	0.000	0.000	1.00	34.7	0.200	0.100	19.58	4.7	21.4
7	0.239	15849	0.000	0.000	1.00	30.3	0.148	0.100	22.84	4.7	21.4
8	0.239	15849	0.000	0.000	1.00	31.1	0.050	0.100	26.11	4.7	21.4
9	0.239	15849	0.000	0.000	1.00	36.6	0.050	0.100	29.37	4.7	21.4
10	0.239	15849	0.000	0.000	1.00	42.2	0.050	0.100	32.63	4.7	21.4
11	0.239	15849	0.000	0.000	1.00	45.8	0.050	0.100	35.89	4.7	21.4
12	0.239	15849	0.000	0.000	1.00	49.8	0.050	0.100	39.16	4.7	21.4
13	0.239	15849	0.000	0.000	1.00	53.2	0.050	0.100	42.42	4.7	21.4
14	0.239	15849	0.000	0.000	1.00	56.5	0.050	0.100	45.68	4.7	21.4
15	0.239	15849	0.000	0.000	1.00	72.1	0.190	0.100	48.95	4.7	21.4
16	0.239	15849	0.000	0.000	1.00	71.0	0.168	0.100	52.21	4.7	21.4
17	0.239	15849	0.000	0.000	1.00	67.2	0.050	0.100	55.47	4.7	21.4
18	0.239	15849	0.000	0.000	1.00	70.8	0.050	0.100	58.74	4.7	21.4
19	0.239	15849	0.000	0.000	1.00	74.1	0.050	0.100	62.00	4.7	21.4
Toe						100.7	0.150	0.100			

4.533 kips total unreduced pile weight (g= 32.17 ft/s2)

4.533 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
55.00	11.18	1.00	0.800

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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt	
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min	
860.9	905.2	10.56	10.49	-0.16	3	50	43.28	6	3	38.2	36.5
870.0	1536.4	10.57	10.52	-0.09	3	50	43.46	6	3	38.1	36.5
879.1	3540.7	10.58	10.53	0.00	1	0	43.71	6	3	37.9	36.5
888.2	7210.0	10.59	10.53	0.00	1	0	43.85	6	3	38.1	36.5
897.3	9999.0	10.60	10.53	0.00	1	0	44.10	6	3	37.9	36.5

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 Resource International Inc  
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Depth	(ft)	60.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	14.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)						979.6	
No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2		
1	0.239	15849	0.010	0.000	0.85	0.4	0.050	0.100	3.26	4.7	21.4		
2	0.239	15849	0.000	0.000	1.00	5.1	0.050	0.100	6.53	4.7	21.4		
3	0.239	15849	0.000	0.000	1.00	10.9	0.050	0.100	9.79	4.7	21.4		
4	0.239	15849	0.000	0.000	1.00	26.8	0.178	0.100	13.05	4.7	21.4		
5	0.239	15849	0.000	0.000	1.00	34.1	0.195	0.100	16.32	4.7	21.4		
6	0.239	15849	0.000	0.000	1.00	28.3	0.050	0.100	19.58	4.7	21.4		
7	0.239	15849	0.000	0.000	1.00	34.1	0.050	0.100	22.84	4.7	21.4		
8	0.239	15849	0.000	0.000	1.00	39.7	0.050	0.100	26.11	4.7	21.4		
9	0.239	15849	0.000	0.000	1.00	44.4	0.050	0.100	29.37	4.7	21.4		
10	0.239	15849	0.000	0.000	1.00	47.9	0.050	0.100	32.63	4.7	21.4		
11	0.239	15849	0.000	0.000	1.00	51.7	0.050	0.100	35.89	4.7	21.4		
12	0.239	15849	0.000	0.000	1.00	54.9	0.050	0.100	39.16	4.7	21.4		
13	0.239	15849	0.000	0.000	1.00	64.3	0.139	0.100	42.42	4.7	21.4		
14	0.239	15849	0.000	0.000	1.00	74.1	0.200	0.100	45.68	4.7	21.4		
15	0.239	15849	0.000	0.000	1.00	66.9	0.082	0.100	48.95	4.7	21.4		
16	0.239	15849	0.000	0.000	1.00	69.1	0.050	0.100	52.21	4.7	21.4		
17	0.239	15849	0.000	0.000	1.00	72.7	0.050	0.100	55.47	4.7	21.4		
18	0.239	15849	0.000	0.000	1.00	75.4	0.050	0.100	58.74	4.7	21.4		
19	0.239	15849	0.000	0.000	1.00	78.3	0.050	0.100	62.00	4.7	21.4		
Toe						100.7	0.150	0.100					

1322L-RA-14X73

4.533 kips total unreduced pile weight (g= 32.17 ft/s2)  
4.533 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
60.00	11.18	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i ksi	t Comp Str ksi	i ksi	t ENTHRU kip-ft	Bl Rt b/min
979.6	9999.0	10.53	10.45	0.00	1 0	42.86	4 2	36.8
988.7	9999.0	10.52	10.46	0.00	1 0	43.01	4 2	36.5
997.8	9999.0	10.52	10.45	0.00	1 0	43.14	4 2	36.6
1006.9	9999.0	10.52	10.45	0.00	1 0	43.25	4 2	36.3
1016.0	9999.0	10.52	10.45	0.00	1 0	43.37	4 2	36.2

▲  
FRA-70-1322L - Rear Abutment - HP14x73 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth ft	Stroke ft	Pressure Ratio	Efficy
62.0	11.18	1.00	0.800

PILE PROFILE:  
Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	Rut ft	1029.2 Perim ft	Area in2
1	0.239	15849	0.010	0.000	0.85	2.9	0.050	0.100	3.26	4.7	21.4
2	0.239	15849	0.000	0.000	1.00	8.6	0.050	0.100	6.53	4.7	21.4
3	0.239	15849	0.000	0.000	1.00	18.2	0.129	0.100	9.79	4.7	21.4
4	0.239	15849	0.000	0.000	1.00	34.7	0.200	0.100	13.05	4.7	21.4
5	0.239	15849	0.000	0.000	1.00	29.4	0.125	0.100	16.32	4.7	21.4
6	0.239	15849	0.000	0.000	1.00	31.9	0.050	0.100	19.58	4.7	21.4
7	0.239	15849	0.000	0.000	1.00	37.4	0.050	0.100	22.84	4.7	21.4
8	0.239	15849	0.000	0.000	1.00	42.9	0.050	0.100	26.11	4.7	21.4
9	0.239	15849	0.000	0.000	1.00	46.3	0.050	0.100	29.37	4.7	21.4
10	0.239	15849	0.000	0.000	1.00	50.4	0.050	0.100	32.63	4.7	21.4
11	0.239	15849	0.000	0.000	1.00	53.7	0.050	0.100	35.89	4.7	21.4
12	0.239	15849	0.000	0.000	1.00	57.3	0.055	0.100	39.16	4.7	21.4
13	0.239	15849	0.000	0.000	1.00	74.1	0.200	0.100	42.42	4.7	21.4
14	0.239	15849	0.000	0.000	1.00	69.8	0.150	0.100	45.68	4.7	21.4
15	0.239	15849	0.000	0.000	1.00	67.7	0.050	0.100	48.95	4.7	21.4
16	0.239	15849	0.000	0.000	1.00	71.3	0.050	0.100	52.21	4.7	21.4
17	0.239	15849	0.000	0.000	1.00	74.5	0.050	0.100	55.47	4.7	21.4
18	0.239	15849	0.000	0.000	1.00	77.0	0.050	0.100	58.74	4.7	21.4
19	0.239	15849	0.000	0.000	1.00	80.3	0.050	0.100	62.00	4.7	21.4
Toe						100.7	0.150	0.100			

4.533 kips total unreduced pile weight (g= 32.17 ft/s2)  
4.533 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
62.00	11.18	1.00	0.800

▲  
FRA-70-1322L - Rear Abutment - HP14x73 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i ksi	t Comp Str ksi	i ksi	t ENTHRU kip-ft	Bl Rt b/min
1029.2	9999.0	10.46	10.38	0.00	1 0	41.94	4 2	35.8
1038.3	9999.0	10.47	10.38	0.00	1 0	42.14	4 2	35.7
1047.4	9999.0	10.48	10.38	0.00	1 0	42.28	4 2	35.8
1056.5	9999.0	10.39	10.37	0.00	1 0	42.18	4 2	35.3
1065.6	9999.0	10.39	10.37	0.00	1 0	42.31	4 2	35.3

▲  
FRA-70-1322L - Rear Abutment - HP14x73 02/28/2021

## SUMMARY OVER DEPTHS

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: 0.604	1.000	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kip	kip	kip	bl/ft	ksi	ksi	ksi	ksi	ft	kip-ft
5.0	21.6	6.7	14.9	Hammer	did not	run				
10.0	37.0	32.0	5.0	1.6	14.352	-1.932	3.97	45.3		
15.0	136.9	82.7	54.2	8.6	27.916	-0.884	6.13	35.7		
20.0	189.8	130.3	59.5	11.6	31.252	-0.699	6.72	34.7		
25.0	264.3	191.2	73.1	16.8	34.424	-0.977	7.40	34.0		
30.0	362.7	262.0	100.7	23.9	36.616	-1.436	8.20	34.4		
35.0	442.2	341.5	100.7	30.4	38.707	-1.986	8.69	35.3		
40.0	443.6	432.9	10.7	29.3	37.750	-1.063	8.54	33.7		
45.0	653.5	543.9	109.6	89.5	42.401	-2.996	9.98	38.1		
50.0	757.6	648.0	109.6	186.0	42.557	-1.558	10.28	38.2		
55.0	860.9	760.2	100.7	905.2	43.285	-0.163	10.56	38.2		
60.0	979.6	878.9	100.7	9999.0	42.862	0.000	10.53	36.8		
62.0	1029.2	928.5	100.7	9999.0	41.943	0.000	10.46	35.8		

Refusal occurred; no driving time output possible

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: 0.637	1.000	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kip	kip	kip	bl/ft	ksi	ksi	ksi	ksi	ft	kip-ft
5.0	21.6	6.7	14.9	Hammer	did not	run				
10.0	37.5	32.5	5.0	1.6	14.490	-1.906	3.98	45.2		
15.0	139.8	85.6	54.2	8.8	28.116	-0.874	6.18	35.5		
20.0	192.7	133.2	59.5	11.9	31.470	-0.753	6.76	34.5		
25.0	267.2	194.1	73.1	17.1	34.695	-0.864	7.45	34.0		
30.0	365.6	264.9	100.7	24.2	36.821	-1.462	8.23	34.5		
35.0	445.1	344.4	100.7	30.7	39.011	-2.036	8.72	35.4		
40.0	447.6	436.9	10.7	29.7	38.023	-1.192	8.58	33.9		
45.0	662.6	553.0	109.6	95.8	42.741	-3.016	10.03	38.1		
50.0	766.7	657.1	109.6	194.9	43.186	-1.123	10.47	38.9		
55.0	870.0	769.3	100.7	1536.4	43.458	-0.087	10.57	38.1		
60.0	988.7	888.0	100.7	9999.0	43.007	0.000	10.52	36.5		
62.0	1038.3	937.6	100.7	9999.0	42.138	0.000	10.47	35.7		

Refusal occurred; no driving time output possible

▲

FRA-70-1322L - Rear Abutment - HP14x73

02/28/2021

Resource International Inc

GRLWEAP Version 2010

## SUMMARY OVER DEPTHS

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: 0.670	1.000	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kip	kip	kip	bl/ft	ksi	ksi	ksi	ksi	ft	kip-ft
5.0	21.6	6.7	14.9	Hammer	did not	run				
10.0	38.0	33.0	5.0	1.7	14.602	-1.882	4.00	45.0		
15.0	142.7	88.5	54.2	9.1	28.335	-0.838	6.23	35.4		
20.0	195.6	136.2	59.5	12.1	31.675	-0.803	6.80	34.5		
25.0	270.1	197.0	73.1	17.4	34.983	-0.737	7.48	33.9		
30.0	368.5	267.8	100.7	24.4	37.043	-1.490	8.25	34.5		
35.0	448.0	347.3	100.7	31.3	39.207	-2.062	8.75	35.3		
40.0	451.6	440.9	10.7	30.2	38.231	-1.295	8.61	33.9		
45.0	671.7	562.1	109.6	101.0	43.020	-3.091	10.08	38.4		
50.0	775.8	666.2	109.6	217.4	43.314	-1.070	10.49	39.0		
55.0	879.1	778.4	100.7	3540.7	43.712	0.000	10.58	37.9		
60.0	997.8	897.1	100.7	9999.0	43.138	0.000	10.52	36.6		
62.0	1047.4	946.7	100.7	9999.0	42.275	0.000	10.48	35.8		

Refusal occurred; no driving time output possible

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: 0.703	1.000	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kip	kip	kip	bl/ft	ksi	ksi	ksi	ksi	ft	kip-ft
5.0	21.6	6.7	14.9	Hammer	did not	run				
10.0	38.6	33.5	5.0	1.7	14.578	-1.889	3.97	44.7		
15.0	145.6	91.4	54.2	9.3	28.509	-0.797	6.28	35.3		
20.0	198.5	139.1	59.5	12.4	31.885	-0.850	6.83	34.4		
25.0	273.0	199.9	73.1	17.7	35.213	-0.595	7.51	33.8		
30.0	371.4	270.7	100.7	24.7	37.243	-1.516	8.28	34.6		
35.0	450.9	350.2	100.7	31.6	39.474	-2.125	8.77	35.5		
40.0	455.7	445.0	10.7	30.8	38.417	-1.385	8.65	34.0		
45.0	680.8	571.2	109.6	108.1	43.335	-3.125	10.13	38.6		
50.0	784.9	675.3	109.6	247.1	43.499	-0.998	10.52	39.0		
55.0	888.2	787.5	100.7	7210.0	43.854	0.000	10.59	38.1		
60.0	1006.9	906.2	100.7	9999.0	43.250	0.000	10.52	36.3		

1322L-RA-14X73  
62.0 1056.5 955.8 100.7 9999.0 42.179 0.000 10.39 35.3

Refusal occurred; no driving time output possible

↑  
FRA-70-1322L - Rear Abutment - HP14x73 02/28/2021  
Resource International Inc GRLWEAP Version 2010

#### SUMMARY OVER DEPTHS

Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	21.6	6.7	14.9	Hammer	did not	run		
10.0	39.1	34.1	5.0	1.7	14.730	-1.845	3.99	44.6
15.0	148.5	94.3	54.2	9.5	28.702	-0.757	6.32	35.2
20.0	201.4	142.0	59.5	12.7	32.195	-0.887	6.88	34.3
25.0	275.9	202.8	73.1	18.0	35.422	-0.441	7.55	33.7
30.0	374.3	273.6	100.7	25.0	37.422	-1.547	8.31	34.7
35.0	453.8	353.1	100.7	32.1	39.676	-2.168	8.80	35.4
40.0	459.7	449.0	10.7	31.5	38.614	-1.459	8.69	34.0
45.0	689.9	580.3	109.6	117.1	43.625	-3.144	10.16	38.5
50.0	794.0	684.4	109.6	293.7	43.680	-0.851	10.54	38.8
55.0	897.3	796.6	100.7	9999.0	44.098	0.000	10.60	37.9
60.0	1016.0	915.3	100.7	9999.0	43.374	0.000	10.52	36.2
62.0	1065.6	964.9	100.7	9999.0	42.306	0.000	10.39	35.3

Refusal occurred; no driving time output possible

↑  
FRA-70-1322L - Rear Abutment - HP14x73 02/28/2021  
Resource International Inc GRLWEAP Version 2010

#### Table of Depths Analyzed with Driving System Modifiers

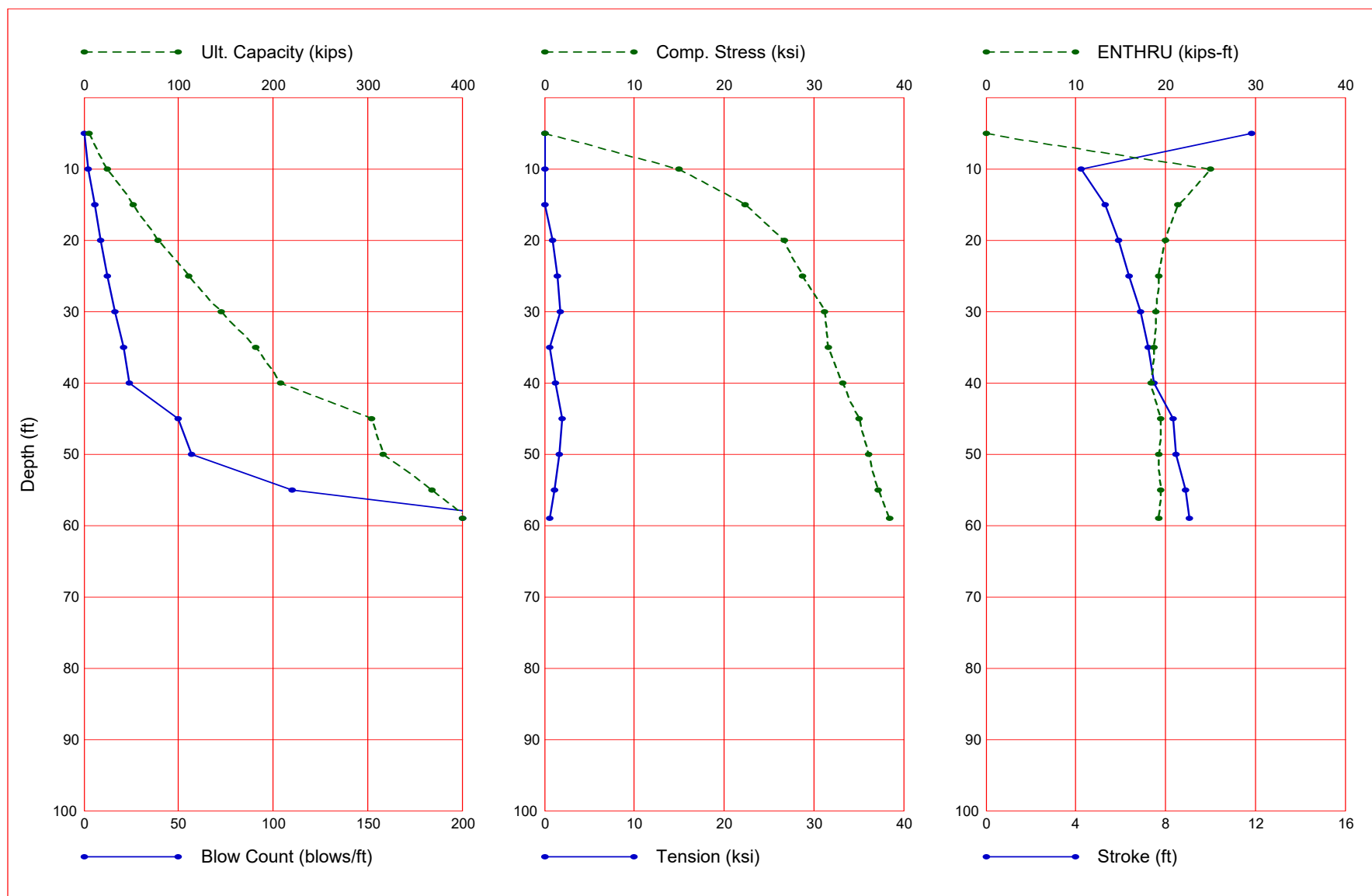
Depth	Temp. Length	Wait Time	Equivalent Stroke	Pressure Ratio	Efficy.	Stiffn. Factor	Cushion CoR
ft	ft	hr	ft				
5.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
10.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
15.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
20.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
25.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
30.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
35.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
40.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
45.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
50.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
55.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
60.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
62.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00

#### Soil Layer Resistance Values

Depth	Shaft Res.	End Bearing	Shaft Quake	Toe Quake	Shaft Damping	Toe Damping	Soil Setup	Limit Distance	Setup Time
ft	k/ft2	kips	inch	inch	s/ft	s/ft	Normlzd	ft	hrs
0.01	0.00	0.03	0.100	0.100	0.050	0.150	0.000	6.000	1.000
9.01	1.04	26.79	0.100	0.100	0.050	0.150	0.000	6.000	1.000
9.09	1.05	27.03	0.100	0.100	0.050	0.150	0.000	6.000	1.000
9.11	3.75	5.02	0.100	0.100	0.200	0.150	1.000	6.000	168.000
14.09	3.75	5.02	0.100	0.100	0.200	0.150	1.000	6.000	168.000
14.11	1.62	50.78	0.100	0.100	0.050	0.150	0.000	6.000	1.000
19.09	2.22	69.65	0.100	0.100	0.050	0.150	0.000	6.000	1.000
19.11	2.20	56.83	0.100	0.100	0.050	0.150	0.000	6.000	1.000
24.49	2.82	72.83	0.100	0.100	0.050	0.150	0.000	6.000	1.000
24.51	2.82	72.87	0.100	0.100	0.050	0.150	0.000	6.000	1.000
29.09	3.10	74.83	0.100	0.100	0.050	0.150	0.000	6.000	1.000
29.11	3.16	100.70	0.100	0.100	0.050	0.150	0.000	6.000	1.000
38.11	3.75	100.70	0.100	0.100	0.050	0.150	0.000	6.000	1.000
39.09	3.82	100.70	0.100	0.100	0.050	0.150	0.000	6.000	1.000
39.11	8.00	10.70	0.100	0.100	0.200	0.150	1.000	6.000	168.000
44.09	8.00	10.70	0.100	0.100	0.200	0.150	1.000	6.000	168.000
44.11	4.19	109.62	0.100	0.100	0.050	0.150	0.000	6.000	1.000
53.11	4.83	109.62	0.100	0.100	0.050	0.150	0.000	6.000	1.000
54.49	4.93	109.62	0.100	0.100	0.050	0.150	0.000	6.000	1.000
54.51	4.85	100.70	0.100	0.100	0.050	0.150	0.000	6.000	1.000
62.00	5.34	100.70	0.100	0.100	0.050	0.150	0.000	6.000	1.000



Gain/Loss 3 at Shaft and Toe 0.670 / 1.000



Gain/Loss 3 at Shaft and Toe 0.670 / 1.000

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
5.0	5.1	2.4	2.8	0.0	0.000	0.000	11.86	0.0
10.0	24.8	22.7	2.0	2.2	14.983	0.000	4.26	25.0
15.0	52.2	50.8	1.5	5.7	22.378	0.000	5.32	21.4
20.0	78.2	67.1	11.1	8.9	26.765	-0.947	5.89	20.0
25.0	110.9	90.4	20.5	12.4	28.698	-1.488	6.39	19.2
30.0	145.6	122.4	23.1	16.5	31.240	-1.749	6.90	18.9
35.0	181.6	158.5	23.1	20.9	31.602	-0.611	7.24	18.7
40.0	207.7	203.7	4.0	24.0	33.243	-1.180	7.49	18.4
45.0	303.9	260.5	43.4	50.0	35.088	-1.986	8.33	19.5
50.0	316.7	313.1	3.7	56.9	36.133	-1.608	8.45	19.2
55.0	368.6	364.9	3.7	110.1	37.220	-1.157	8.90	19.5
59.0	408.0	404.3	3.7	233.8	38.490	-0.637	9.06	19.3

Total Continuous Driving Time 47.00 minutes; Total Number of Blows 1948 (starting at penetration 5.0 ft)

GRLWEAP - Version 2010  
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.  
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ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

Input File: J:\GEOTECH\PROJECTS\2013\W-13-072 FRA-70-13.10 PROJECT 6A\ANALYSIS\FRA-70-1322L AND 1323C\DRIVEABILITY\FRA-70-1322L\FORWARD  
ABUTMENT\HP 10X42\1322L-FA-10X42.GMW  
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW  
Hammer File Version: 2003 (12/4/2018)

Input File Contents

FRA-70-1322L - For Abutment - HP10x42  
OUT OSG HAM STR FUL PEL N SPL N-U P-D %SK ISM 0 PHI RSA ITR H-D MXT DEX  
-100 0 41 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0.000  
Pile g Hammer g Toe Area Pile Size Pile Type  
32.170 32.170 144.000 10.000 Unknown  
W Cp A Cp E Cp T Cp CoR ROut StCp  
1.900 227.000 530.0 2.000 0.800 0.010 0.0  
A Cu E Cu T Cu CoR ROut StCu  
0.000 0.0 0.000 0.000 0.000 0.0  
LPle APle EPle WPle Peri CI CoR ROut  
59.000 12.40 29000.0 492.000 3.300 0 0.850 0.010  
FFatigue F0 0-Bottom  
0 0.000 0.000  
Manufac Hmr Name HmrType No Seg-s  
DELMAG D 19-42 1 5  
Ram Wt Ram L Ram Dia MaxStrk RtdStrk Efficy  
4.00 129.10 12.60 11.86 10.81 0.80  
IB. Wt IB. L IB. Dia IB CoR IB R0  
0.75 25.30 12.60 0.900 0.010  
CompStrk A Chamber V Chamber C Delay C Duratn Exp Coeff VolCStart Vol CEnd  
16.65 124.70 157.70 0.0020 0.0020 1.250 0.00 0.00  
P atm P1 P2 P3 P4 P5  
14.70 1600.00 1440.00 1295.00 1165.00 0.00  
Stroke Effic. Pressure R-Weight T-Delay Exp-Coeff Eps-Str Total-AW  
10.8100 0.8000 1600.0000 0.0000 0.0000 0.0000 0.0100 0.0000  
Qs Qt Js Jt Qx Jx Rati Dept  
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000  
Research Soil Model: Atoe, Plug, Gap, Q-fac

0.000 0.000 0.000 0.000  
 Research Soil Model: RD-skn: m, d, toe: m, d  
 0.000 0.000 0.000 0.000  
 Research Toe Plug: Res-int, Q-int, D-int, Res-plug, Q-plug, D-plug  
 0.000 0.000 0.000 0.000 0.000 0.000  
 Research Toe Plug: RD plug toe: m, d  
 0.000 0.000  
 Research Toe Plug: New Toe Plug Model is NOT applied  
 Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimL	TSf0
0.01	0.00	0.01	0.10	0.10	0.05	0.15	1.00	6.00	1.000
7.59	0.44	4.22	0.10	0.10	0.05	0.15	1.00	6.00	1.000
7.61	2.62	2.03	0.10	0.10	0.20	0.15	1.21	6.00	24.000
13.09	2.62	2.03	0.10	0.10	0.20	0.15	1.21	6.00	24.000
13.11	1.37	1.45	0.10	0.10	0.20	0.15	1.49	6.00	168.000
18.09	1.37	1.45	0.10	0.10	0.20	0.15	1.49	6.00	168.000
18.11	1.04	10.06	0.10	0.10	0.05	0.15	1.00	6.00	1.000
23.09	1.34	12.91	0.10	0.10	0.05	0.15	1.00	6.00	1.000
23.11	1.62	19.21	0.10	0.10	0.05	0.15	1.00	6.00	1.000
28.99	2.05	23.13	0.10	0.10	0.05	0.15	1.00	6.00	1.000
29.01	2.05	23.13	0.10	0.10	0.05	0.15	1.00	6.00	1.000
30.69	2.11	23.13	0.10	0.10	0.05	0.15	1.00	6.00	1.000
30.71	2.12	23.13	0.10	0.10	0.05	0.15	1.00	6.00	1.000
38.99	2.44	23.13	0.10	0.10	0.05	0.15	1.00	6.00	1.000
39.01	5.12	3.97	0.10	0.10	0.20	0.15	1.21	6.00	24.000
41.49	5.12	3.97	0.10	0.10	0.20	0.15	1.21	6.00	24.000
41.51	3.01	43.36	0.10	0.10	0.05	0.15	1.00	6.00	1.000
46.49	3.26	43.36	0.10	0.10	0.05	0.15	1.00	6.00	1.000
46.51	4.75	3.68	0.10	0.10	0.20	0.15	1.49	6.00	168.000
55.51	4.66	3.68	0.10	0.10	0.20	0.15	1.49	6.00	168.000
59.00	4.17	3.68	0.10	0.10	0.20	0.15	1.49	6.00	168.000

Gain/Loss factors: shaft and toe

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR
0.60400	0.63700	0.67000	0.70300	0.73600			
1.00000	1.00000	1.00000	1.00000	1.00000			
5.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
10.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
15.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
20.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
25.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
30.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
35.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
40.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
45.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
50.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
55.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
59.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
0.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000

▲ GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS  
 Version 2010  
 English Units

FRA-70-1322L - For Abutment - HP10x42

Hammer Model:	D 19-42	Made by:	DELMAG
No.	Weight kips	Stiffn k/inch	CoR
1	0.800		
2	0.800	140046.6	1.000
3	0.800	140046.6	1.000
4	0.800	140046.6	1.000
5	0.800	140046.6	1.000
Imp Block	0.753	70735.6	0.900
Helmet	1.900	60155.0	0.800
Combined Pile Top		9142.4	

HAMMER OPTIONS:  
 Hammer File ID No. 41 Hammer Type OE Diesel  
 Stroke Option FxdP-VarS Stroke Convergence Crit. 0.010  
 Fuel Pump Setting Maximum

HAMMER DATA:  
 Ram Weight (kips) 4.00 Ram Length (inch) 129.10  
 Maximum Stroke (ft) 11.86  
 Rated Stroke (ft) 10.81 Efficiency 0.800  
 Maximum Pressure (psi) 1600.00 Actual Pressure (psi) 1600.00  
 Compression Exponent 1.350 Expansion Exponent 1.250  
 Ram Diameter (inch) 12.60

Combustion Delay (s) 0.00200 Ignition Duration (s) 0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION			PILE CUSHION		
Cross Sect. Area	(in2)	227.00	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	530.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	2.00	Thickness	(inch)	0.00
Coeff of Restitution		0.8	Coeff of Restitution		1.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	60155.0	Stiffness	(kips/in)	0.0

FRA-70-1322L - For Abutment - HP10x42  
 Resource International Inc

02/28/2021  
 GRLWEAP Version 2010

Depth	(ft)	5.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	10.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
59.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.141

Pile and Soil Model						Total Capacity Rut (kips)				5.1	
No. Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area	
kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2	
1 0.139	9142	0.010	0.000	0.85	0.0	0.000	0.100	3.28	3.3	12.4	
2 0.139	9142	0.000	0.000	1.00	0.0	0.000	0.100	6.56	3.3	12.4	
17 0.139	9142	0.000	0.000	1.00	0.3	0.050	0.100	55.72	3.3	12.4	
18 0.139	9142	0.000	0.000	1.00	2.1	0.050	0.100	59.00	3.3	12.4	
Toe					2.8	0.150	0.100				

2.500 kips total unreduced pile weight (g= 32.17 ft/s2)  
 2.500 kips total reduced pile weight (g= 32.17 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile		Pile Segments: Automatic	
No. of Slacks/Splices	0	Pile Damping (%)	1
		Pile Damping Fact.(k/ft/s)	0.435

Driveability Analysis

Soil Damping Option	Smith	
Max No Analysis Iterations	0	Time Increment/Critical
Output Time Interval	1	Analysis Time-Input (ms)
Output Level: Normal		0
Gravity Mass, Pile, Hammer:	32.170	32.170
Output Segment Generation: Automatic		

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
5.00	10.81	1.00	0.800

INITIAL STATIC ANALYSIS: Total Wt, Sum(R) 5.2 5.1  
 Hammer+Pile Weight > Rult: Pile Runs

INITIAL STATIC ANALYSIS: Total Wt, Sum(R) 5.2 5.1  
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INITIAL STATIC ANALYSIS: Total Wt, Sum(R) 5.2 5.1  
 Hammer+Pile Weight > Rult: Pile Runs

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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
5.1	0.0	10.81	0.00	0.00	1	0	0.00	1	0	78.4
5.1	0.0	11.86	0.00	0.00	1	0	0.00	1	0	74.4
5.1	0.0	11.86	0.00	0.00	1	0	0.00	1	0	74.4
5.1	0.0	11.86	0.00	0.00	1	0	0.00	1	0	74.4
5.1	0.0	11.86	0.00	0.00	1	0	0.00	1	0	74.4

02/28/2021  
FRA-70-1322L - For Abutment - HP10x42  
Resource International Inc GRLWEAP Version 2010

Depth (ft) 10.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 10.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
59.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.141

No.	Weight kips	Pile and Soil Model Stiffn C-Slk T-Slk k/in ft ft	CoR	Total Capacity Soil-S kips	Soil-D s/ft	Quake inch	Rut LbTop ft	(kips) Perim ft	24.1 Area in2
1	0.139	9142 0.010 0.000 0.85	0.0	0.000	0.100	3.28	3.3	12.4	
2	0.139	9142 0.000 0.000 1.00	0.0	0.000	0.100	6.56	3.3	12.4	
15	0.139	9142 0.000 0.000 1.00	0.0	0.050	0.100	49.17	3.3	12.4	
16	0.139	9142 0.000 0.000 1.00	1.1	0.050	0.100	52.44	3.3	12.4	
17	0.139	9142 0.000 0.000 1.00	3.2	0.050	0.100	55.72	3.3	12.4	
18	0.139	9142 0.000 0.000 1.00	17.7	0.192	0.100	59.00	3.3	12.4	
Toe				2.0	0.150	0.100			

2.500 kips total unreduced pile weight (g= 32.17 ft/s2)

2.500 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
10.00	10.81	1.00	0.800

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FRA-70-1322L - For Abutment - HP10x42  
Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
24.1	2.1	4.21	4.19	0.00	1	0	14.60	1	2	57.8
24.4	2.1	4.24	4.21	0.00	1	0	14.80	1	2	57.6
24.8	2.2	4.26	4.22	0.00	1	0	14.98	1	2	57.5
25.1	2.2	4.24	4.26	0.00	1	0	14.95	1	2	57.5
25.5	2.3	4.26	4.28	0.00	1	0	15.08	1	2	57.4

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FRA-70-1322L - For Abutment - HP10x42  
Resource International Inc GRLWEAP Version 2010

Depth (ft) 15.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 10.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
59.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.141

No.	Weight kips	Pile and Soil Model Stiffn C-Slk T-Slk k/in ft ft	CoR	Total Capacity Soil-S kips	Soil-D s/ft	Quake inch	Rut LbTop ft	(kips) Perim ft	50.0 Area in2
1	0.139	9142 0.010 0.000 0.85	0.0	0.000	0.100	3.28	3.3	12.4	
2	0.139	9142 0.000 0.000 1.00	0.0	0.000	0.100	6.56	3.3	12.4	
14	0.139	9142 0.000 0.000 1.00	0.3	0.050	0.100	45.89	3.3	12.4	

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15	0.139	9142	0.000	0.000	1.00	2.2	0.050	0.100	49.17	3.3	12.4
16	0.139	9142	0.000	0.000	1.00	8.8	0.156	0.100	52.44	3.3	12.4
17	0.139	9142	0.000	0.000	1.00	22.6	0.200	0.100	55.72	3.3	12.4
18	0.139	9142	0.000	0.000	1.00	14.7	0.200	0.100	59.00	3.3	12.4
Toe						1.5	0.150	0.100			

2.500 kips total unreduced pile weight (g= 32.17 ft/s2)  
2.500 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
15.00	10.81	1.00	0.800

▲  
FRA-70-1322L - For Abutment - HP10x42 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down up	ksi			ksi			kip-ft	b/min
50.0	5.4	5.26 5.23	0.00	1	0	21.90	15	5	21.6	51.5
51.1	5.5	5.29 5.26	0.00	1	0	22.13	15	5	21.5	51.4
52.2	5.7	5.32 5.30	0.00	1	0	22.38	15	5	21.4	51.2
53.3	5.8	5.35 5.33	0.00	1	0	22.58	15	5	21.3	51.0
54.4	5.9	5.38 5.36	0.00	1	0	22.79	15	5	21.2	50.9

▲  
FRA-70-1322L - For Abutment - HP10x42 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth	(ft)	20.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	10.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
59.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.141

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	75.1
	kips	Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D Quake	LbTop	Perim
		k/in ft ft	kips	s/ft inch	ft	ft
1	0.139	9142 0.010 0.000 0.85	0.0	0.000 0.100	3.28	3.3
2	0.139	9142 0.000 0.000 1.00	0.0	0.000 0.100	6.56	3.3
12	0.139	9142 0.000 0.000 1.00	0.0	0.050 0.100	39.33	3.3
13	0.139	9142 0.000 0.000 1.00	1.2	0.050 0.100	42.61	3.3
14	0.139	9142 0.000 0.000 1.00	3.3	0.050 0.100	45.89	3.3
15	0.139	9142 0.000 0.000 1.00	18.7	0.193 0.100	49.17	3.3
16	0.139	9142 0.000 0.000 1.00	21.2	0.200 0.100	52.44	3.3
17	0.139	9142 0.000 0.000 1.00	9.0	0.200 0.100	55.72	3.3
18	0.139	9142 0.000 0.000 1.00	10.6	0.121 0.100	59.00	3.3
Toe			11.1	0.150 0.100		

2.500 kips total unreduced pile weight (g= 32.17 ft/s2)  
2.500 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
20.00	10.81	1.00	0.800

▲  
FRA-70-1322L - For Abutment - HP10x42 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down up	ksi			ksi			kip-ft	b/min
75.1	8.5	5.80 5.85	-1.02	13	48	26.25	15	5	20.0	48.8
76.6	8.7	5.84 5.88	-0.90	13	48	26.52	15	5	20.0	48.6
78.2	8.9	5.89 5.92	-0.95	14	45	26.77	15	5	20.0	48.4
79.8	9.1	5.92 5.96	-0.99	14	44	26.99	15	5	19.8	48.3
81.3	9.3	5.96 5.99	-1.02	14	45	27.20	15	5	19.8	48.2

▲  
FRA-70-1322L - For Abutment - HP10x42 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth	(ft)	25.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor 1.000

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## PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
59.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.141

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	107.8
	kips	Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D Quake	LbTop	Perim
		k/in ft ft	kips	s/ft inch	ft	ft
1	0.139	9142 0.010 0.000 0.85	0.0	0.000 0.100	3.28	3.3
2	0.139	9142 0.000 0.000 1.00	0.0	0.000 0.100	6.56	3.3
11	0.139	9142 0.000 0.000 1.00	0.4	0.050 0.100	36.06	3.3
12	0.139	9142 0.000 0.000 1.00	2.3	0.050 0.100	39.33	3.3
13	0.139	9142 0.000 0.000 1.00	9.8	0.163 0.100	42.61	3.3
14	0.139	9142 0.000 0.000 1.00	22.6	0.200 0.100	45.89	3.3
15	0.139	9142 0.000 0.000 1.00	14.0	0.200 0.100	49.17	3.3
16	0.139	9142 0.000 0.000 1.00	9.2	0.188 0.100	52.44	3.3
17	0.139	9142 0.000 0.000 1.00	12.5	0.050 0.100	55.72	3.3
18	0.139	9142 0.000 0.000 1.00	16.5	0.050 0.100	59.00	3.3
Toe			20.5	0.150 0.100		

2.500 kips total unredacted pile weight (g= 32.17 ft/s2)

2.500 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
25.00	10.81	1.00	0.800



FRA-70-1322L - For Abutment - HP10x42  
 Resource International Inc

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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down up	ksi		ksi		kip-ft	b/min
107.8	11.9	6.32 6.34	-1.48	12	38	28.36	13	4
109.3	12.1	6.35 6.37	-1.49	12	38	28.51	13	4
110.9	12.4	6.39 6.39	-1.49	12	38	28.70	13	5
112.5	12.7	6.41 6.44	-1.47	12	38	28.83	13	4
114.0	12.9	6.44 6.46	-1.44	12	38	29.01	13	4



FRA-70-1322L - For Abutment - HP10x42  
 Resource International Inc

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Depth	(ft)	30.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor
			1.000

## PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
59.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.141

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	142.5
	kips	Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D Quake	LbTop	Perim
		k/in ft ft	kips	s/ft inch	ft	ft
1	0.139	9142 0.010 0.000 0.85	0.0	0.000 0.100	3.28	3.3
2	0.139	9142 0.000 0.000 1.00	0.0	0.000 0.100	6.56	3.3
9	0.139	9142 0.000 0.000 1.00	0.0	0.050 0.100	29.50	3.3
10	0.139	9142 0.000 0.000 1.00	1.3	0.050 0.100	32.78	3.3
11	0.139	9142 0.000 0.000 1.00	3.4	0.050 0.100	36.06	3.3
12	0.139	9142 0.000 0.000 1.00	19.6	0.195 0.100	39.33	3.3
13	0.139	9142 0.000 0.000 1.00	20.5	0.200 0.100	42.61	3.3
14	0.139	9142 0.000 0.000 1.00	9.0	0.200 0.100	45.89	3.3
15	0.139	9142 0.000 0.000 1.00	10.8	0.113 0.100	49.17	3.3
16	0.139	9142 0.000 0.000 1.00	14.0	0.050 0.100	52.44	3.3
17	0.139	9142 0.000 0.000 1.00	19.1	0.050 0.100	55.72	3.3
18	0.139	9142 0.000 0.000 1.00	21.6	0.050 0.100	59.00	3.3
Toe			23.1	0.150 0.100		

2.500 kips total unredacted pile weight (g= 32.17 ft/s2)

2.500 kips total reduced pile weight (g= 32.17 ft/s2)



Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
30.00	10.81	1.00	0.800

FRA-70-1322L - For Abutment - HP10x42      02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
142.5	16.0	6.86	6.80	-1.78	10	32	30.93	12	4	18.9
144.0	16.2	6.88	6.81	-1.79	10	32	31.09	12	4	19.0
145.6	16.5	6.90	6.85	-1.75	10	32	31.24	12	4	18.9
147.1	16.7	6.92	6.87	-1.70	10	32	31.37	12	4	18.9
148.7	17.0	6.95	6.90	-1.65	9	32	31.56	12	4	18.9

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Depth	(ft)	35.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

## PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	10.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
59.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms)      7.141

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	178.5
	kips	Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D	Quake	LbTop Perim Area
		k/in ft ft	kips	s/ft	inch	ft ft in2
1	0.139	9142 0.010 0.000 0.85	0.0	0.000	0.100	3.28 3.3 12.4
2	0.139	9142 0.000 0.000 1.00	0.0	0.000	0.100	6.56 3.3 12.4
8	0.139	9142 0.000 0.000 1.00	0.5	0.050	0.100	26.22 3.3 12.4
9	0.139	9142 0.000 0.000 1.00	2.4	0.050	0.100	29.50 3.3 12.4
10	0.139	9142 0.000 0.000 1.00	10.7	0.169	0.100	32.78 3.3 12.4
11	0.139	9142 0.000 0.000 1.00	22.6	0.200	0.100	36.06 3.3 12.4
12	0.139	9142 0.000 0.000 1.00	13.3	0.200	0.100	39.33 3.3 12.4
13	0.139	9142 0.000 0.000 1.00	9.3	0.181	0.100	42.61 3.3 12.4
14	0.139	9142 0.000 0.000 1.00	12.6	0.050	0.100	45.89 3.3 12.4
15	0.139	9142 0.000 0.000 1.00	16.8	0.050	0.100	49.17 3.3 12.4
16	0.139	9142 0.000 0.000 1.00	20.5	0.050	0.100	52.44 3.3 12.4
17	0.139	9142 0.000 0.000 1.00	22.6	0.050	0.100	55.72 3.3 12.4
18	0.139	9142 0.000 0.000 1.00	24.0	0.050	0.100	59.00 3.3 12.4
Toe			23.1	0.150	0.100	

2.500 kips total unreduced pile weight (g= 32.17 ft/s2)  
 2.500 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
35.00	10.81	1.00	0.800

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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
178.5	20.3	7.21	7.18	-0.78	8	31	31.37	10	4	18.7
180.1	20.6	7.22	7.20	-0.70	8	31	31.47	10	4	18.6
181.6	20.9	7.24	7.22	-0.61	8	31	31.60	10	4	18.7
183.2	21.1	7.27	7.24	-0.53	8	31	31.75	10	4	18.7
184.7	21.4	7.29	7.26	-0.45	8	31	31.91	10	4	18.6

FRA-70-1322L - For Abutment - HP10x42      02/28/2021  
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Depth	(ft)	40.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

## PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	10.000		

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L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
59.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.141

Pile and Soil Model					Total Capacity Rut (kips)				204.0		
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.139	9142	0.010	0.000	0.85	0.0	0.000	0.100	3.28	3.3	12.4
2	0.139	9142	0.000	0.000	1.00	0.0	0.000	0.100	6.56	3.3	12.4
6	0.139	9142	0.000	0.000	1.00	0.0	0.050	0.100	19.67	3.3	12.4
7	0.139	9142	0.000	0.000	1.00	1.4	0.050	0.100	22.94	3.3	12.4
8	0.139	9142	0.000	0.000	1.00	3.5	0.050	0.100	26.22	3.3	12.4
9	0.139	9142	0.000	0.000	1.00	20.5	0.197	0.100	29.50	3.3	12.4
10	0.139	9142	0.000	0.000	1.00	19.8	0.200	0.100	32.78	3.3	12.4
11	0.139	9142	0.000	0.000	1.00	9.0	0.200	0.100	36.06	3.3	12.4
12	0.139	9142	0.000	0.000	1.00	11.0	0.105	0.100	39.33	3.3	12.4
13	0.139	9142	0.000	0.000	1.00	14.2	0.050	0.100	42.61	3.3	12.4
14	0.139	9142	0.000	0.000	1.00	19.3	0.050	0.100	45.89	3.3	12.4
15	0.139	9142	0.000	0.000	1.00	21.8	0.050	0.100	49.17	3.3	12.4
16	0.139	9142	0.000	0.000	1.00	23.3	0.050	0.100	52.44	3.3	12.4
17	0.139	9142	0.000	0.000	1.00	24.7	0.050	0.100	55.72	3.3	12.4
18	0.139	9142	0.000	0.000	1.00	31.5	0.122	0.100	59.00	3.3	12.4
Toe						4.0	0.150	0.100			

2.500 kips total unreduced pile weight (g= 32.17 ft/s2)

2.500 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
40.00	10.81	1.00	0.800

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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
204.0	23.4	7.45	7.43	-1.21	7	50	32.94	9	3	18.3
205.8	23.7	7.46	7.45	-1.22	8	50	33.07	9	4	18.3
207.7	24.0	7.49	7.47	-1.18	8	50	33.24	9	4	18.4
209.5	24.2	7.51	7.49	-1.10	8	50	33.41	9	4	18.4
211.4	24.6	7.53	7.52	-1.02	7	50	33.54	9	4	18.3

FRA-70-1322L - For Abutment - HP10x42 02/28/2021  
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Depth	(ft)	45.0	Standard Soil Setup
Shaft Gain/Loss Factor	0.604	Toe Gain/Loss Factor	1.000

## PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	10.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
59.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.141

Pile and Soil Model					Total Capacity Rut (kips)				299.3		
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.139	9142	0.010	0.000	0.85	0.0	0.000	0.100	3.28	3.3	12.4
2	0.139	9142	0.000	0.000	1.00	0.0	0.000	0.100	6.56	3.3	12.4
5	0.139	9142	0.000	0.000	1.00	0.5	0.050	0.100	16.39	3.3	12.4
6	0.139	9142	0.000	0.000	1.00	2.5	0.050	0.100	19.67	3.3	12.4
7	0.139	9142	0.000	0.000	1.00	11.7	0.174	0.100	22.94	3.3	12.4
8	0.139	9142	0.000	0.000	1.00	22.6	0.200	0.100	26.22	3.3	12.4
9	0.139	9142	0.000	0.000	1.00	12.6	0.200	0.100	29.50	3.3	12.4
10	0.139	9142	0.000	0.000	1.00	9.5	0.175	0.100	32.78	3.3	12.4
11	0.139	9142	0.000	0.000	1.00	12.7	0.050	0.100	36.06	3.3	12.4
12	0.139	9142	0.000	0.000	1.00	17.1	0.050	0.100	39.33	3.3	12.4
13	0.139	9142	0.000	0.000	1.00	20.6	0.050	0.100	42.61	3.3	12.4
14	0.139	9142	0.000	0.000	1.00	22.7	0.050	0.100	45.89	3.3	12.4
15	0.139	9142	0.000	0.000	1.00	24.1	0.050	0.100	49.17	3.3	12.4
16	0.139	9142	0.000	0.000	1.00	25.5	0.050	0.100	52.44	3.3	12.4
17	0.139	9142	0.000	0.000	1.00	40.3	0.179	0.100	55.72	3.3	12.4

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18 0.139 9142 0.000 0.000 1.00 33.5 0.050 0.100 59.00 3.3 12.4  
 Toe 43.4 0.150 0.100

2.500 kips total unreduced pile weight (g= 32.17 ft/s2)  
 2.500 kips total reduced pile weight (g= 32.17 ft/s2)

Depth Stroke Pressure Efficy  
 ft ft Ratio  
 45.00 10.81 1.00 0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min	
299.3	48.1	8.27	8.34	-1.90	7	20	34.73	7	3	19.4	41.0
301.6	49.0	8.30	8.36	-1.93	7	20	34.92	7	3	19.5	40.9
303.9	50.0	8.33	8.38	-1.99	7	20	35.09	7	3	19.5	40.9
306.1	51.4	8.36	8.42	-1.99	7	20	35.26	7	3	19.5	40.8
308.4	52.3	8.38	8.43	-2.06	7	19	35.41	7	3	19.6	40.7

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Depth (ft) 50.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

## PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 10.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
59.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.141

No.	Weight kips	Pile and Soil Model Stiffn C-Slk T-Slk k/in ft ft	CoR	Total Capacity Soil-S kips	Soil-D Quake s/ft	Rut (kips) LbTop Perim Area ft ft in2
1	0.139	9142 0.010 0.000 0.85	0.0	0.000 0.100	3.28 3.3 12.4	
2	0.139	9142 0.000 0.000 1.00	0.0	0.000 0.100	6.56 3.3 12.4	
3	0.139	9142 0.000 0.000 1.00	0.1	0.050 0.100	9.83 3.3 12.4	
4	0.139	9142 0.000 0.000 1.00	1.5	0.050 0.100	13.11 3.3 12.4	
5	0.139	9142 0.000 0.000 1.00	3.6	0.050 0.100	16.39 3.3 12.4	
6	0.139	9142 0.000 0.000 1.00	21.5	0.198 0.100	19.67 3.3 12.4	
7	0.139	9142 0.000 0.000 1.00	19.1	0.200 0.100	22.94 3.3 12.4	
8	0.139	9142 0.000 0.000 1.00	9.0	0.200 0.100	26.22 3.3 12.4	
9	0.139	9142 0.000 0.000 1.00	11.2	0.097 0.100	29.50 3.3 12.4	
10	0.139	9142 0.000 0.000 1.00	14.5	0.050 0.100	32.78 3.3 12.4	
11	0.139	9142 0.000 0.000 1.00	19.4	0.050 0.100	36.06 3.3 12.4	
12	0.139	9142 0.000 0.000 1.00	21.9	0.050 0.100	39.33 3.3 12.4	
13	0.139	9142 0.000 0.000 1.00	23.4	0.050 0.100	42.61 3.3 12.4	
14	0.139	9142 0.000 0.000 1.00	24.8	0.050 0.100	45.89 3.3 12.4	
15	0.139	9142 0.000 0.000 1.00	32.4	0.131 0.100	49.17 3.3 12.4	
16	0.139	9142 0.000 0.000 1.00	37.6	0.130 0.100	52.44 3.3 12.4	
17	0.139	9142 0.000 0.000 1.00	34.2	0.065 0.100	55.72 3.3 12.4	
18	0.139	9142 0.000 0.000 1.00	30.9	0.200 0.100	59.00 3.3 12.4	
Toe			3.7	0.150 0.100		

2.500 kips total unreduced pile weight (g= 32.17 ft/s2)  
 2.500 kips total reduced pile weight (g= 32.17 ft/s2)

Depth Stroke Pressure Efficy  
 ft ft Ratio  
 50.00 10.81 1.00 0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min	
308.6	52.7	8.36	8.42	-1.53	5	38	35.67	6	3	19.0	40.8
312.7	54.7	8.40	8.45	-1.58	5	38	35.89	6	3	19.1	40.7
316.7	56.9	8.45	8.49	-1.61	5	38	36.13	6	3	19.2	40.6
320.8	59.7	8.49	8.53	-1.62	5	38	36.35	6	3	19.2	40.5
324.9	62.1	8.54	8.57	-1.64	5	37	36.59	6	3	19.3	40.4

Depth (ft) 55.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
59.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.141

Pile and Soil Model						Total	Capacity	Rut	(kips)		355.4
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	PerIm	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.139	9142	0.010	0.000	0.85	0.0	0.000	0.100	3.28	3.3	12.4
2	0.139	9142	0.000	0.000	1.00	0.6	0.050	0.100	6.56	3.3	12.4
3	0.139	9142	0.000	0.000	1.00	2.6	0.050	0.100	9.83	3.3	12.4
4	0.139	9142	0.000	0.000	1.00	12.7	0.178	0.100	13.11	3.3	12.4
5	0.139	9142	0.000	0.000	1.00	22.6	0.200	0.100	16.39	3.3	12.4
6	0.139	9142	0.000	0.000	1.00	11.9	0.200	0.100	19.67	3.3	12.4
7	0.139	9142	0.000	0.000	1.00	9.6	0.168	0.100	22.94	3.3	12.4
8	0.139	9142	0.000	0.000	1.00	12.9	0.050	0.100	26.22	3.3	12.4
9	0.139	9142	0.000	0.000	1.00	17.4	0.050	0.100	29.50	3.3	12.4
10	0.139	9142	0.000	0.000	1.00	20.7	0.050	0.100	32.78	3.3	12.4
11	0.139	9142	0.000	0.000	1.00	22.8	0.050	0.100	36.06	3.3	12.4
12	0.139	9142	0.000	0.000	1.00	24.1	0.050	0.100	39.33	3.3	12.4
13	0.139	9142	0.000	0.000	1.00	25.5	0.050	0.100	42.61	3.3	12.4
14	0.139	9142	0.000	0.000	1.00	40.7	0.178	0.100	45.89	3.3	12.4
15	0.139	9142	0.000	0.000	1.00	33.6	0.050	0.100	49.17	3.3	12.4
16	0.139	9142	0.000	0.000	1.00	32.6	0.152	0.100	52.44	3.3	12.4
17	0.139	9142	0.000	0.000	1.00	30.8	0.200	0.100	55.72	3.3	12.4
18	0.139	9142	0.000	0.000	1.00	30.6	0.200	0.100	59.00	3.3	12.4
Toe						3.7	0.150	0.100			

2.500 kips total unreduced pile weight (g= 32.17 ft/s2)

2.500 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
55.00	10.81	1.00	0.800

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i ksi	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
355.4	92.1	8.79	8.77	-1.07	4	35	36.73	4	3	19.2
362.0	100.6	8.85	8.81	-1.11	4	35	36.98	4	3	19.3
368.6	110.1	8.90	8.85	-1.16	4	35	37.22	4	3	19.5
375.3	122.6	8.95	8.90	-1.18	4	35	37.44	4	3	19.5
381.9	134.5	8.99	8.93	-1.23	4	34	37.67	4	3	19.7

Depth (ft) 59.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
59.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.141

Pile and Soil Model						Total Capacity Rut (kips)			390.8		
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.139	9142	0.010	0.000	0.85	1.0	0.050	0.100	3.28	3.3	12.4
2	0.139	9142	0.000	0.000	1.00	3.1	0.050	0.100	6.56	3.3	12.4

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3	0.139	9142	0.000	0.000	1.00	16.8	0.190	0.100	9.83	3.3	12.4
4	0.139	9142	0.000	0.000	1.00	22.6	0.200	0.100	13.11	3.3	12.4
5	0.139	9142	0.000	0.000	1.00	9.0	0.200	0.100	16.39	3.3	12.4
6	0.139	9142	0.000	0.000	1.00	10.3	0.137	0.100	19.67	3.3	12.4
7	0.139	9142	0.000	0.000	1.00	13.3	0.050	0.100	22.94	3.3	12.4
8	0.139	9142	0.000	0.000	1.00	18.6	0.050	0.100	26.22	3.3	12.4
9	0.139	9142	0.000	0.000	1.00	21.3	0.050	0.100	29.50	3.3	12.4
10	0.139	9142	0.000	0.000	1.00	23.1	0.050	0.100	32.78	3.3	12.4
11	0.139	9142	0.000	0.000	1.00	24.5	0.050	0.100	36.06	3.3	12.4
12	0.139	9142	0.000	0.000	1.00	27.6	0.079	0.100	39.33	3.3	12.4
13	0.139	9142	0.000	0.000	1.00	40.3	0.165	0.100	42.61	3.3	12.4
14	0.139	9142	0.000	0.000	1.00	34.0	0.050	0.100	45.89	3.3	12.4
15	0.139	9142	0.000	0.000	1.00	31.7	0.180	0.100	49.17	3.3	12.4
16	0.139	9142	0.000	0.000	1.00	30.8	0.200	0.100	52.44	3.3	12.4
17	0.139	9142	0.000	0.000	1.00	30.5	0.200	0.100	55.72	3.3	12.4
18	0.139	9142	0.000	0.000	1.00	28.8	0.200	0.100	59.00	3.3	12.4
Toe						3.7	0.150	0.100			

2.500 kips total unredacted pile weight (g= 32.17 ft/s2)

2.500 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
59.00	10.81	1.00	0.800

FRA-70-1322L - For Abutment - HP10x42 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
390.8	163.2	8.98	8.92	-0.60	3	33	38.01	3	3	19.1
399.4	191.5	9.02	8.95	-0.63	3	33	38.24	3	3	19.3
408.0	233.8	9.06	8.99	-0.64	3	32	38.49	3	3	19.3
416.5	293.7	9.10	9.03	-0.65	3	32	38.68	3	3	19.4
425.1	385.4	9.14	9.06	-0.67	3	32	38.92	3	3	19.5

FRA-70-1322L - For Abutment - HP10x42 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

## SUMMARY OVER DEPTHS

Depth	Rut	G/L at Frictn	End Bg	Shaft and	Toe: 0.604	1.000	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	5.1	2.4	2.8	0.0	0.000	0.000	10.81	0.0
10.0	24.1	22.0	2.0	2.1	14.603	0.000	4.21	25.1
15.0	50.0	48.6	1.5	5.4	21.904	0.000	5.26	21.6
20.0	75.1	63.9	11.1	8.5	26.248	-1.017	5.80	20.0
25.0	107.8	87.3	20.5	11.9	28.356	-1.477	6.32	19.2
30.0	142.5	119.3	23.1	16.0	30.925	-1.780	6.86	18.9
35.0	178.5	155.4	23.1	20.3	31.370	-0.785	7.21	18.7
40.0	204.0	200.0	4.0	23.4	32.944	-1.209	7.45	18.3
45.0	299.3	256.0	43.4	48.1	34.728	-1.897	8.27	19.4
50.0	308.6	304.9	3.7	52.7	35.672	-1.529	8.36	19.0
55.0	355.4	351.7	3.7	92.1	36.732	-1.067	8.79	19.2
59.0	390.8	387.1	3.7	163.2	38.012	-0.603	8.98	19.1

Total Driving Time 41 minutes; Total No. of Blows 1684  
 Starting at penetration 5.0 ft

Depth	Rut	G/L at Frictn	End Bg	Shaft and	Toe: 0.637	1.000	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	5.1	2.4	2.8	0.0	0.000	0.000	11.86	0.0
10.0	24.4	22.4	2.0	2.1	14.804	0.000	4.24	25.1
15.0	51.1	49.7	1.5	5.5	22.134	0.000	5.29	21.5
20.0	76.6	65.5	11.1	8.7	26.519	-0.898	5.84	20.0
25.0	109.3	88.9	20.5	12.1	28.510	-1.490	6.35	19.2
30.0	144.0	120.9	23.1	16.2	31.086	-1.791	6.88	19.0
35.0	180.1	156.9	23.1	20.6	31.474	-0.698	7.22	18.6
40.0	205.8	201.9	4.0	23.7	33.069	-1.224	7.46	18.3
45.0	301.6	258.2	43.4	49.0	34.918	-1.935	8.30	19.5
50.0	312.7	309.0	3.7	54.7	35.891	-1.575	8.40	19.1
55.0	362.0	358.3	3.7	100.6	36.980	-1.112	8.85	19.3
59.0	399.4	395.7	3.7	191.5	38.240	-0.626	9.02	19.3

Total Driving Time 44 minutes; Total No. of Blows 1798  
 Starting at penetration 5.0 ft

FRA-70-1322L - For Abutment - HP10x42 02/28/2021

## SUMMARY OVER DEPTHS

Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	5.1	2.4	2.8	0.0	0.000	0.000	11.86	0.0
10.0	24.8	22.7	2.0	2.2	14.983	0.000	4.26	25.0
15.0	52.2	50.8	1.5	5.7	22.378	0.000	5.32	21.4
20.0	78.2	67.1	11.1	8.9	26.765	-0.947	5.89	20.0
25.0	110.9	90.4	20.5	12.4	28.698	-1.488	6.39	19.2
30.0	145.6	122.4	23.1	16.5	31.240	-1.749	6.90	18.9
35.0	181.6	158.5	23.1	20.9	31.602	-0.611	7.24	18.7
40.0	207.7	203.7	4.0	24.0	33.243	-1.180	7.49	18.4
45.0	303.9	260.5	43.4	50.0	35.088	-1.986	8.33	19.5
50.0	316.7	313.1	3.7	56.9	36.133	-1.608	8.45	19.2
55.0	368.6	364.9	3.7	110.1	37.220	-1.157	8.90	19.5
59.0	408.0	404.3	3.7	233.8	38.490	-0.637	9.06	19.3

Total Driving Time 47 minutes; Total No. of Blows 1948  
Starting at penetration 5.0 ft

Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	5.1	2.4	2.8	0.0	0.000	0.000	11.86	0.0
10.0	25.1	23.1	2.0	2.2	14.948	0.000	4.24	24.8
15.0	53.3	51.9	1.5	5.8	22.584	0.000	5.35	21.3
20.0	79.8	68.6	11.1	9.1	26.985	-0.989	5.92	19.8
25.0	112.5	92.0	20.5	12.7	28.830	-1.470	6.41	19.0
30.0	147.1	124.0	23.1	16.7	31.367	-1.700	6.92	18.9
35.0	183.2	160.1	23.1	21.1	31.750	-0.530	7.27	18.7
40.0	209.5	205.6	4.0	24.2	33.413	-1.102	7.51	18.4
45.0	306.1	262.8	43.4	51.4	35.259	-1.990	8.36	19.5
50.0	320.8	317.1	3.7	59.7	36.350	-1.623	8.49	19.2
55.0	375.3	371.6	3.7	122.6	37.436	-1.185	8.95	19.5
59.0	416.5	412.9	3.7	293.7	38.682	-0.654	9.10	19.4

Total Driving Time 53 minutes; Total No. of Blows 2153  
Starting at penetration 5.0 ft

↑  
FRA-70-1322L - For Abutment - HP10x42 02/28/2021  
Resource International Inc GRLWEAP Version 2010

## SUMMARY OVER DEPTHS

Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	5.1	2.4	2.8	0.0	0.000	0.000	11.86	0.0
10.0	25.5	23.4	2.0	2.3	15.079	0.000	4.26	24.7
15.0	54.4	53.0	1.5	5.9	22.788	0.000	5.38	21.2
20.0	81.3	70.2	11.1	9.3	27.203	-1.023	5.96	19.8
25.0	114.0	93.5	20.5	12.9	29.011	-1.440	6.44	19.1
30.0	148.7	125.6	23.1	17.0	31.561	-1.648	6.95	18.9
35.0	184.7	161.6	23.1	21.4	31.905	-0.445	7.29	18.6
40.0	211.4	207.4	4.0	24.6	33.545	-1.024	7.53	18.3
45.0	308.4	265.1	43.4	52.3	35.413	-2.057	8.38	19.6
50.0	324.9	321.2	3.7	62.1	36.594	-1.642	8.54	19.3
55.0	381.9	378.2	3.7	134.5	37.674	-1.226	8.99	19.7
59.0	425.1	421.4	3.7	385.4	38.923	-0.666	9.14	19.5

Total Driving Time 59 minutes; Total No. of Blows 2416  
Starting at penetration 5.0 ft

↑  
FRA-70-1322L - For Abutment - HP10x42 02/28/2021  
Resource International Inc GRLWEAP Version 2010

## Table of Depths Analyzed with Driving System Modifiers

Depth	Temp.	Wait	Equivalent	Pressure	Stiffn.	Cushion
ft	Length	Time	Stroke	Ratio	Factor	CoR
	ft	hr	ft			
5.00	59.00	0.00	10.81	1.00	0.80	1.00
10.00	59.00	0.00	10.81	1.00	0.80	1.00
15.00	59.00	0.00	10.81	1.00	0.80	1.00
20.00	59.00	0.00	10.81	1.00	0.80	1.00
25.00	59.00	0.00	10.81	1.00	0.80	1.00
30.00	59.00	0.00	10.81	1.00	0.80	1.00

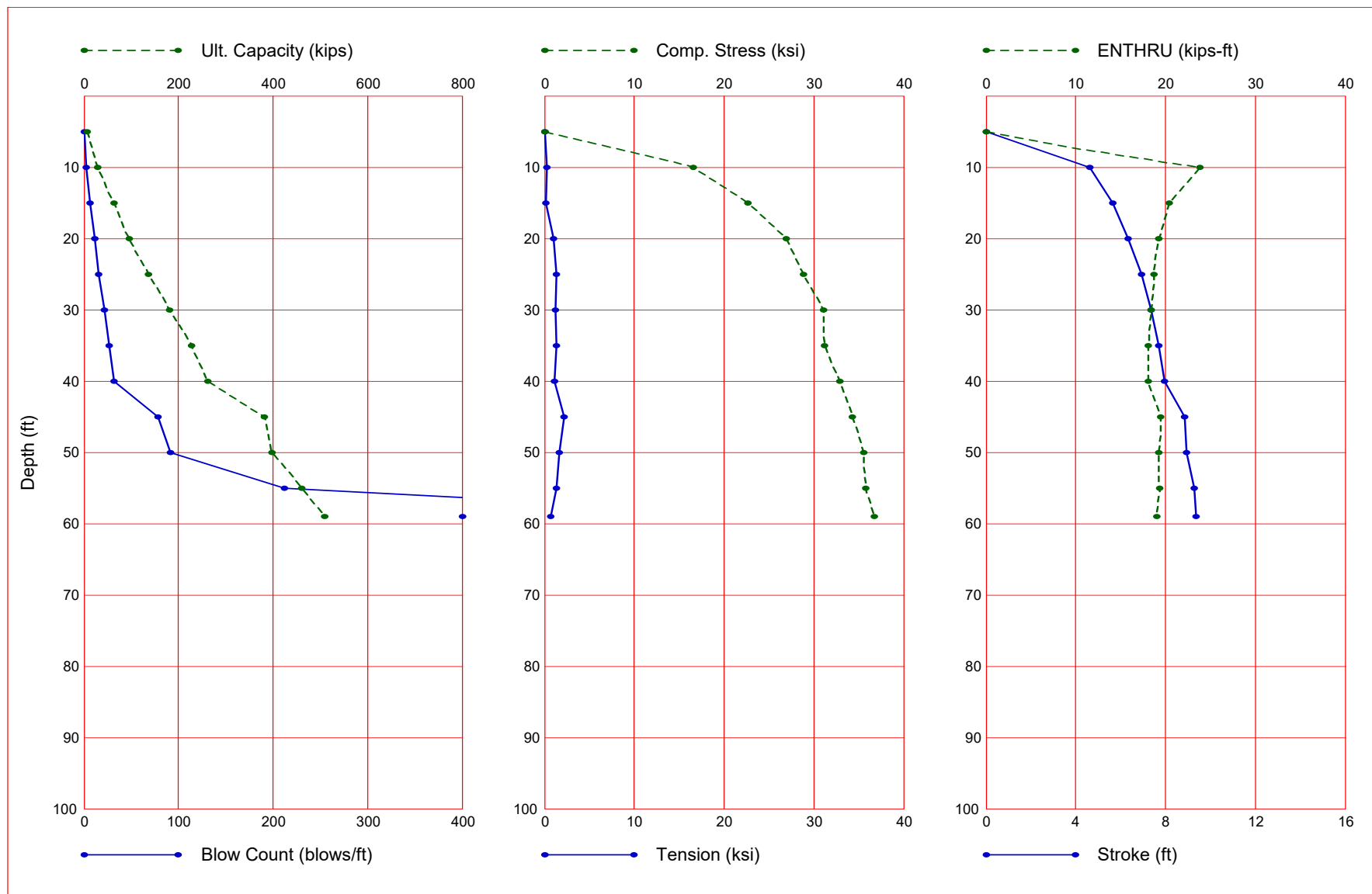
1322L-FA-10X42

35.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
40.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
45.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
50.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
55.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
59.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00

Soil Layer Resistance Values

Depth	Shaft Res.	End Bearing	Shaft Quake	Toe Quake	Shaft Damping	Toe Damping	Soil Setup	Limit Distance	Setup Time
ft	k/ft2	kips	inch	inch	s/ft	s/ft	Normlzd	ft	hrs
0.01	0.00	0.01	0.100	0.100	0.050	0.150	0.000	6.000	1.000
7.59	0.44	4.22	0.100	0.100	0.050	0.150	0.000	6.000	1.000
7.61	2.62	2.03	0.100	0.100	0.200	0.150	0.515	6.000	24.000
13.09	2.62	2.03	0.100	0.100	0.200	0.150	0.515	6.000	24.000
13.11	1.37	1.45	0.100	0.100	0.200	0.150	1.000	6.000	168.000
18.09	1.37	1.45	0.100	0.100	0.200	0.150	1.000	6.000	168.000
18.11	1.04	10.06	0.100	0.100	0.050	0.150	0.000	6.000	1.000
23.09	1.34	12.91	0.100	0.100	0.050	0.150	0.000	6.000	1.000
23.11	1.62	19.21	0.100	0.100	0.050	0.150	0.000	6.000	1.000
28.99	2.05	23.13	0.100	0.100	0.050	0.150	0.000	6.000	1.000
29.01	2.05	23.13	0.100	0.100	0.050	0.150	0.000	6.000	1.000
30.69	2.11	23.13	0.100	0.100	0.050	0.150	0.000	6.000	1.000
30.71	2.12	23.13	0.100	0.100	0.050	0.150	0.000	6.000	1.000
38.99	2.44	23.13	0.100	0.100	0.050	0.150	0.000	6.000	1.000
39.01	5.12	3.97	0.100	0.100	0.200	0.150	0.515	6.000	24.000
41.49	5.12	3.97	0.100	0.100	0.200	0.150	0.515	6.000	24.000
41.51	3.01	43.36	0.100	0.100	0.050	0.150	0.000	6.000	1.000
46.49	3.26	43.36	0.100	0.100	0.050	0.150	0.000	6.000	1.000
46.51	4.75	3.68	0.100	0.100	0.200	0.150	1.000	6.000	168.000
55.51	4.66	3.68	0.100	0.100	0.200	0.150	1.000	6.000	168.000
59.00	4.17	3.68	0.100	0.100	0.200	0.150	1.000	6.000	168.000

Gain/Loss 3 at Shaft and Toe 0.670 / 1.000





Gain/Loss 3 at Shaft and Toe 0.670 / 1.000

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
5.0	6.5	3.0	3.5	-1.0	0.000	0.000	0.00	0.0
10.0	30.3	27.8	2.5	2.7	16.536	-0.266	4.62	23.8
15.0	63.3	61.5	1.8	7.0	22.634	-0.175	5.64	20.4
20.0	95.6	81.6	13.9	11.2	26.961	-1.030	6.32	19.3
25.0	137.2	111.6	25.6	16.1	28.802	-1.385	6.92	18.7
30.0	181.8	152.8	28.9	21.9	31.115	-1.186	7.36	18.4
35.0	228.2	199.3	28.9	27.1	31.241	-1.334	7.70	18.1
40.0	261.3	256.3	5.0	32.3	32.899	-1.072	7.95	18.1
45.0	382.1	327.9	54.2	78.6	34.302	-2.199	8.87	19.5
50.0	397.3	392.7	4.6	91.7	35.603	-1.664	8.95	19.2
55.0	460.5	455.9	4.6	212.5	35.795	-1.299	9.27	19.4
59.0	509.6	505.0	4.6	786.3	36.757	-0.743	9.35	19.0

Total Continuous Driving Time 100.00 minutes; Total Number of Blows 3970 (starting at penetration 5.0 ft)

GRLWEAP - Version 2010  
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.  
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ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

Input File: J:\GEOTECH\PROJECTS\2013\W-13-072 FRA-70-13.10 PROJECT 6A\ANALYSIS\FRA-70-1322L AND 1323C\DRIVEABILITY\FRA-70-1322L\FORWARD  
ABUTMENT\HP 12X53\1322L-FA-12X53.GMW  
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW  
Hammer File Version: 2003 (12/4/2018)

Input File Contents

FRA-70-1322L - For Abutment - HP12x53  
OUT OSG HAM STR FUL PEL N SPL N-U P-D %SK ISM 0 PHI RSA ITR H-D MXT DEX  
-100 0 41 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0.000  
Pile g Hammer g Toe Area Pile Size Pile Type  
32.170 32.170 144.000 12.000 Unknown  
W Cp A Cp E Cp T Cp CoR ROut StCp  
1.900 227.000 530.0 2.000 0.800 0.010 0.0  
A Cu E Cu T Cu CoR ROut StCu  
0.000 0.0 0.000 0.000 0.000 0.0  
LPle APle EPle WPle Peri CI CoR ROut  
59.000 15.50 29000.0 492.000 3.970 0 0.850 0.010  
FFatigue F0 0-Bottom  
0 0.000 0.000  
Manufac Hmr Name HmrType No Seg-s  
DELMAG D 19-42 1 5  
Ram Wt Ram L Ram Dia MaxStrk RtdStrk Efficy  
4.00 129.10 12.60 11.86 10.81 0.80  
IB. Wt IB. L IB. Dia IB CoR IB R0  
0.75 25.30 12.60 0.900 0.010  
CompStrk A Chamber V Chamber C Delay C Duratn Exp Coeff VolCStart Vol CEnd  
16.65 124.70 157.70 0.0020 0.0020 1.250 0.00 0.00  
P atm P1 P2 P3 P4 P5  
14.70 1600.00 1440.00 1295.00 1165.00 0.00  
Stroke Effic. Pressure R-Weight T-Delay Exp-Coeff Eps-Str Total-AW  
10.8100 0.8000 1600.0000 0.0000 0.0000 0.0000 0.0100 0.0000  
Qs Qt Js Jt Qx Jx Rati Dept  
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000  
Research Soil Model: Atoe, Plug, Gap, Q-fac

0.000 0.000 0.000 0.000  
 Research Soil Model: RD-skn: m, d, toe: m, d  
 0.000 0.000 0.000 0.000  
 Research Toe Plug: Res-int, Q-int, D-int, Res-plug, Q-plug, D-plug  
 0.000 0.000 0.000 0.000 0.000 0.000  
 Research Toe Plug: RD plug toe: m, d  
 0.000 0.000  
 Research Toe Plug: New Toe Plug Model is NOT applied  
 Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimL	TSf0
0.01	0.00	0.01	0.10	0.10	0.05	0.15	1.00	6.00	1.000
7.59	0.46	5.27	0.10	0.10	0.05	0.15	1.00	6.00	1.000
7.61	2.62	2.54	0.10	0.10	0.20	0.15	1.21	6.00	24.000
13.09	2.62	2.54	0.10	0.10	0.20	0.15	1.21	6.00	24.000
13.11	1.37	1.82	0.10	0.10	0.20	0.15	1.49	6.00	168.000
18.09	1.37	1.82	0.10	0.10	0.20	0.15	1.49	6.00	168.000
18.11	1.11	12.59	0.10	0.10	0.05	0.15	1.00	6.00	1.000
23.09	1.42	16.17	0.10	0.10	0.05	0.15	1.00	6.00	1.000
23.11	1.74	24.01	0.10	0.10	0.05	0.15	1.00	6.00	1.000
28.99	2.20	28.91	0.10	0.10	0.05	0.15	1.00	6.00	1.000
29.01	2.20	28.91	0.10	0.10	0.05	0.15	1.00	6.00	1.000
30.69	2.26	28.91	0.10	0.10	0.05	0.15	1.00	6.00	1.000
30.71	2.26	28.91	0.10	0.10	0.05	0.15	1.00	6.00	1.000
38.99	2.61	28.91	0.10	0.10	0.05	0.15	1.00	6.00	1.000
39.01	5.12	4.96	0.10	0.10	0.20	0.15	1.21	6.00	24.000
41.49	5.12	4.96	0.10	0.10	0.20	0.15	1.21	6.00	24.000
41.51	3.23	54.20	0.10	0.10	0.05	0.15	1.00	6.00	1.000
46.49	3.50	54.20	0.10	0.10	0.05	0.15	1.00	6.00	1.000
46.51	4.75	4.60	0.10	0.10	0.20	0.15	1.49	6.00	168.000
55.51	4.75	4.60	0.10	0.10	0.20	0.15	1.49	6.00	168.000
59.00	4.45	4.60	0.10	0.10	0.20	0.15	1.49	6.00	168.000

Gain/Loss factors: shaft and toe

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR
0.60400	0.63700	0.67000	0.70300	0.73600			
1.00000	1.00000	1.00000	1.00000	1.00000			
5.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
10.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
15.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
20.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
25.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
30.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
35.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
40.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
45.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
50.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
55.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
59.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
0.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000

▲ GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS  
 Version 2010  
 English Units

FRA-70-1322L - For Abutment - HP12x53

Hammer Model:	D 19-42	Made by:	DELMAG
No.	Weight kips	Stiffn k/inch	CoR
1	0.800		
2	0.800	140046.6	1.000
3	0.800	140046.6	1.000
4	0.800	140046.6	1.000
5	0.800	140046.6	1.000
Imp Block	0.753	70735.6	0.900
Helmet	1.900	60155.0	0.800
Combined Pile Top		11428.0	

HAMMER OPTIONS:  
 Hammer File ID No. 41 Hammer Type OE Diesel  
 Stroke Option FxdP-VarS Stroke Convergence Crit. 0.010  
 Fuel Pump Setting Maximum

HAMMER DATA:  
 Ram Weight (kips) 4.00 Ram Length (inch) 129.10  
 Maximum Stroke (ft) 11.86  
 Rated Stroke (ft) 10.81 Efficiency 0.800  
 Maximum Pressure (psi) 1600.00 Actual Pressure (psi) 1600.00  
 Compression Exponent 1.350 Expansion Exponent 1.250  
 Ram Diameter (inch) 12.60

Combustion Delay (s) 0.00200 Ignition Duration (s) 0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION			PILE CUSHION		
Cross Sect. Area	(in2)	227.00	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	530.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	2.00	Thickness	(inch)	0.00
Coeff of Restitution		0.8	Coeff of Restitution		1.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	60155.0	Stiffness	(kips/in)	0.0

FRA-70-1322L - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	5.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	12.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
59.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.141

Pile and Soil Model						Total Capacity Rut (kips)				6.5	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.174	11428	0.010	0.000	0.85	0.0	0.000	0.100	3.28	4.0	15.5
2	0.174	11428	0.000	0.000	1.00	0.0	0.000	0.100	6.56	4.0	15.5
17	0.174	11428	0.000	0.000	1.00	0.4	0.050	0.100	55.72	4.0	15.5
18	0.174	11428	0.000	0.000	1.00	2.7	0.050	0.100	59.00	4.0	15.5
Toe						3.5	0.150	0.100			

3.125 kips total unreduced pile weight (g= 32.17 ft/s2)  
 3.125 kips total reduced pile weight (g= 32.17 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile		Pile Segments: Automatic	
No. of Slacks/Splices	0	Pile Damping (%)	1
		Pile Damping Fact.(k/ft/s)	0.544

Driveability Analysis

Soil Damping Option	Smith	
Max No Analysis Iterations	0	Time Increment/Critical
Output Time Interval	1	Analysis Time-Input (ms)
Output Level: Normal		
Gravity Mass, Pile, Hammer:	32.170	32.170 32.170
Output Segment Generation: Automatic		

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
5.00	10.81	1.00	0.800

FRA-70-1322L - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i t Comp Str	i t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	kip-ft	b/min
6.5	Hammer did not run					
6.5	Hammer did not run					
6.5	Hammer did not run					
6.5	Hammer did not run					
6.5	Hammer did not run					

FRA-70-1322L - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	10.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	12.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
59.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.141

Pile and Soil Model						Total Capacity Rut (kips)			29.5		
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.174	11428	0.010	0.000	0.85	0.0	0.000	0.100	3.28	4.0	15.5
2	0.174	11428	0.000	0.000	1.00	0.0	0.000	0.100	6.56	4.0	15.5
15	0.174	11428	0.000	0.000	1.00	0.0	0.050	0.100	49.17	4.0	15.5
16	0.174	11428	0.000	0.000	1.00	1.4	0.050	0.100	52.44	4.0	15.5
17	0.174	11428	0.000	0.000	1.00	4.0	0.050	0.100	55.72	4.0	15.5
18	0.174	11428	0.000	0.000	1.00	21.4	0.191	0.100	59.00	4.0	15.5
Toe						2.5	0.150	0.100			

3.125 kips total unreduced pile weight (g= 32.17 ft/s2)

3.125 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
10.00	10.81	1.00	0.800

FRA-70-1322L - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i ksi	t ksi	Comp Str ksi	i ksi	t ksi	ENTHRU kip-ft	Bl Rt b/min	
29.5	2.6	4.58	4.57	-0.26	2	9	16.28	1	2	24.0	55.4
29.9	2.6	4.60	4.58	-0.28	2	9	16.42	1	2	23.9	55.3
30.3	2.7	4.62	4.60	-0.27	2	9	16.54	1	2	23.8	55.2
30.7	2.7	4.64	4.62	-0.28	2	9	16.69	1	2	23.8	55.1
31.2	2.8	4.66	4.64	-0.27	2	9	16.81	1	2	23.7	54.9

FRA-70-1322L - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	15.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor
			1.000

## PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	12.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
59.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.141

Pile and Soil Model						Total Capacity Rut (kips)						60.7	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area		
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2		
1	0.174	11428	0.010	0.000	0.85	0.0	0.000	0.100	3.28	4.0	15.5		
2	0.174	11428	0.000	0.000	1.00	0.0	0.000	0.100	6.56	4.0	15.5		
14	0.174	11428	0.000	0.000	1.00	0.4	0.050	0.100	45.89	4.0	15.5		
15	0.174	11428	0.000	0.000	1.00	2.8	0.050	0.100	49.17	4.0	15.5		
16	0.174	11428	0.000	0.000	1.00	10.8	0.155	0.100	52.44	4.0	15.5		
17	0.174	11428	0.000	0.000	1.00	27.2	0.200	0.100	55.72	4.0	15.5		
18	0.174	11428	0.000	0.000	1.00	17.7	0.200	0.100	59.00	4.0	15.5		
Toe						1.8	0.150	0.100					

3.125 kips total unreduced pile weight (g= 32.17 ft/s2)

3.125 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
15.00	10.81	1.00	0.800

FRA-70-1322L - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i ksi	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min	
60.7	6.6	5.63	5.62	0.00	1	0	22.49	15	5	20.7	49.7

1322L-FA-12X53												
62.0	6.8	5.67	5.65	0.00	1	0	22.64	15	5	20.7	49.6	
63.3	7.0	5.64	5.70	-0.17	16	50	22.63	15	5	20.4	49.5	
64.6	7.2	5.68	5.73	-0.37	15	50	22.79	15	5	20.3	49.4	
66.0	7.4	5.71	5.76	-0.53	15	50	22.91	15	5	20.3	49.2	

FRA-70-1322L - For Abutment - HP12x53  
 Resource International Inc  
 02/28/2021  
 GRLWEAP Version 2010

Depth (ft) 20.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:  
 Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
59.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.141

Pile and Soil Model										Total Capacity Rut (kips)	91.8
No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.174	11428	0.010	0.000	0.85	0.0	0.000	0.100	3.28	4.0	15.5
2	0.174	11428	0.000	0.000	1.00	0.0	0.000	0.100	6.56	4.0	15.5
12	0.174	11428	0.000	0.000	1.00	0.0	0.050	0.100	39.33	4.0	15.5
13	0.174	11428	0.000	0.000	1.00	1.6	0.050	0.100	42.61	4.0	15.5
14	0.174	11428	0.000	0.000	1.00	4.2	0.050	0.100	45.89	4.0	15.5
15	0.174	11428	0.000	0.000	1.00	22.5	0.193	0.100	49.17	4.0	15.5
16	0.174	11428	0.000	0.000	1.00	25.5	0.200	0.100	52.44	4.0	15.5
17	0.174	11428	0.000	0.000	1.00	10.8	0.200	0.100	55.72	4.0	15.5
18	0.174	11428	0.000	0.000	1.00	13.3	0.119	0.100	59.00	4.0	15.5
Toe						13.9	0.150	0.100			

3.125 kips total unreduced pile weight (g= 32.17 ft/s2)  
 3.125 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft 20.00  
 Stroke ft 10.81  
 Pressure Ratio 1.00  
 Efficy 0.800

FRA-70-1322L - For Abutment - HP12x53  
 Resource International Inc  
 02/28/2021  
 GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i t Comp Str ksi	i t ENTHRU kip-ft	Bl Rt b/min
91.8	10.7	6.25	6.27	-1.07	14 45	26.54 15 5 19.4
93.7	11.0	6.29	6.31	-1.05	15 42	26.75 15 5 19.3
95.6	11.2	6.32	6.34	-1.03	15 42	26.96 15 5 19.3
97.5	11.5	6.36	6.37	-0.99	15 42	27.15 15 5 19.2
99.3	11.8	6.39	6.41	-0.93	15 42	27.35 15 5 19.1

FRA-70-1322L - For Abutment - HP12x53  
 Resource International Inc  
 02/28/2021  
 GRLWEAP Version 2010

Depth (ft) 25.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:  
 Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
59.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.141

Pile and Soil Model										Total Capacity Rut (kips)	133.5
No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.174	11428	0.010	0.000	0.85	0.0	0.000	0.100	3.28	4.0	15.5
2	0.174	11428	0.000	0.000	1.00	0.0	0.000	0.100	6.56	4.0	15.5
11	0.174	11428	0.000	0.000	1.00	0.5	0.050	0.100	36.06	4.0	15.5
12	0.174	11428	0.000	0.000	1.00	2.9	0.050	0.100	39.33	4.0	15.5
13	0.174	11428	0.000	0.000	1.00	12.0	0.162	0.100	42.61	4.0	15.5
14	0.174	11428	0.000	0.000	1.00	27.2	0.200	0.100	45.89	4.0	15.5

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15	0.174	11428	0.000	0.000	1.00	16.8	0.200	0.100	49.17	4.0	15.5
16	0.174	11428	0.000	0.000	1.00	11.2	0.187	0.100	52.44	4.0	15.5
17	0.174	11428	0.000	0.000	1.00	16.1	0.050	0.100	55.72	4.0	15.5
18	0.174	11428	0.000	0.000	1.00	21.2	0.050	0.100	59.00	4.0	15.5
Toe						25.6	0.150	0.100			

3.125 kips total unreduced pile weight (g= 32.17 ft/s2)  
3.125 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
25.00	10.81	1.00	0.800

▲  
FRA-70-1322L - For Abutment - HP12x53 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
133.5	15.5	6.78	6.80	-1.20	7	33	28.29	13	4	18.6
135.3	15.7	6.89	6.82	-1.30	8	33	28.67	13	4	18.8
137.2	16.1	6.92	6.87	-1.38	8	33	28.80	13	4	18.7
139.1	16.5	6.96	6.90	-1.46	8	33	28.98	13	4	18.7
141.0	16.9	6.99	6.94	-1.54	7	33	29.14	13	4	18.6

▲  
FRA-70-1322L - For Abutment - HP12x53 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth	(ft)	30.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor
			1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	12.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
59.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.141

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	178.0
	kips	Stiffn C-Slk T-Slk	CoR	Soil-S	Soil-D Quake	LbTop Perim
		k/in ft ft		kips	s/ft inch	ft ft
						in2
1	0.174	11428 0.010 0.000 0.85	0.0	0.000 0.100	3.28	4.0
2	0.174	11428 0.000 0.000 1.00	0.0	0.000 0.100	6.56	4.0
9	0.174	11428 0.000 0.000 1.00	0.0	0.050 0.100	29.50	4.0
10	0.174	11428 0.000 0.000 1.00	1.7	0.050 0.100	32.78	4.0
11	0.174	11428 0.000 0.000 1.00	4.3	0.050 0.100	36.06	4.0
12	0.174	11428 0.000 0.000 1.00	23.7	0.195 0.100	39.33	4.0
13	0.174	11428 0.000 0.000 1.00	24.6	0.200 0.100	42.61	4.0
14	0.174	11428 0.000 0.000 1.00	10.8	0.200 0.100	45.89	4.0
15	0.174	11428 0.000 0.000 1.00	13.6	0.111 0.100	49.17	4.0
16	0.174	11428 0.000 0.000 1.00	17.9	0.050 0.100	52.44	4.0
17	0.174	11428 0.000 0.000 1.00	24.6	0.050 0.100	55.72	4.0
18	0.174	11428 0.000 0.000 1.00	27.9	0.050 0.100	59.00	4.0
Toe			28.9	0.150 0.100		

3.125 kips total unreduced pile weight (g= 32.17 ft/s2)  
3.125 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
30.00	10.81	1.00	0.800

▲  
FRA-70-1322L - For Abutment - HP12x53 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
178.0	21.1	7.31	7.28	-1.24	11	31	30.85	12	4	18.5
179.9	21.5	7.34	7.31	-1.18	11	31	31.01	12	4	18.5
181.8	21.9	7.36	7.34	-1.19	12	27	31.11	12	4	18.4
183.6	22.2	7.39	7.36	-1.24	12	27	31.29	12	4	18.4
185.5	22.6	7.40	7.38	-1.28	11	27	31.40	12	4	18.3

▲  
FRA-70-1322L - For Abutment - HP12x53 02/28/2021  
Resource International Inc GRLWEAP Version 2010

1322L-FA-12X53

Depth (ft) 35.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

## PILE PROFILE:

Toe Area (in<sup>2</sup>) 144.000 Pile Type Unknown  
 Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in <sup>2</sup>	ksi	lb/ft <sup>3</sup>	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
59.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.141

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	224.4
	kips	Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D Quake	LbTop	Perim Area
		k/in ft ft	kips	s/ft inch	ft	ft in <sup>2</sup>
1	0.174	11428 0.010 0.000 0.85	0.0	0.000 0.100	3.28	4.0 15.5
2	0.174	11428 0.000 0.000 1.00	0.0	0.000 0.100	6.56	4.0 15.5
8	0.174	11428 0.000 0.000 1.00	0.6	0.050 0.100	26.22	4.0 15.5
9	0.174	11428 0.000 0.000 1.00	3.1	0.050 0.100	29.50	4.0 15.5
10	0.174	11428 0.000 0.000 1.00	13.1	0.168 0.100	32.78	4.0 15.5
11	0.174	11428 0.000 0.000 1.00	27.2	0.200 0.100	36.06	4.0 15.5
12	0.174	11428 0.000 0.000 1.00	16.0	0.200 0.100	39.33	4.0 15.5
13	0.174	11428 0.000 0.000 1.00	11.4	0.180 0.100	42.61	4.0 15.5
14	0.174	11428 0.000 0.000 1.00	16.2	0.050 0.100	45.89	4.0 15.5
15	0.174	11428 0.000 0.000 1.00	21.6	0.050 0.100	49.17	4.0 15.5
16	0.174	11428 0.000 0.000 1.00	26.4	0.050 0.100	52.44	4.0 15.5
17	0.174	11428 0.000 0.000 1.00	29.1	0.050 0.100	55.72	4.0 15.5
18	0.174	11428 0.000 0.000 1.00	30.9	0.050 0.100	59.00	4.0 15.5
Toe			28.9	0.150 0.100		

3.125 kips total unreduced pile weight (g= 32.17 ft/s<sup>2</sup>)3.125 kips total reduced pile weight (g= 32.17 ft/s<sup>2</sup>)

Depth Stroke Pressure Efficy  
 ft ft Ratio  
 35.00 10.81 1.00 0.800

▲ FRA-70-1322L - For Abutment - HP12x53 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down up	ksi		ksi		kip-ft	b/min
224.4	26.3	7.67 7.64	-1.41	9	26 31.03	10	4 18.2	42.7
226.3	26.7	7.68 7.67	-1.37	9	26 31.13	10	4 18.1	42.6
228.2	27.1	7.70 7.69	-1.33	9	26 31.24	10	4 18.1	42.5
230.0	27.4	7.73 7.72	-1.29	9	26 31.38	10	4 18.2	42.5
231.9	27.8	7.75 7.74	-1.24	9	26 31.48	10	4 18.2	42.4

▲ FRA-70-1322L - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth (ft) 40.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

## PILE PROFILE:

Toe Area (in<sup>2</sup>) 144.000 Pile Type Unknown  
 Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in <sup>2</sup>	ksi	lb/ft <sup>3</sup>	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
59.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.141

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	256.8
	kips	Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D Quake	LbTop	Perim Area
		k/in ft ft	kips	s/ft inch	ft	ft in <sup>2</sup>
1	0.174	11428 0.010 0.000 0.85	0.0	0.000 0.100	3.28	4.0 15.5
2	0.174	11428 0.000 0.000 1.00	0.0	0.000 0.100	6.56	4.0 15.5
6	0.174	11428 0.000 0.000 1.00	0.1	0.050 0.100	19.67	4.0 15.5
7	0.174	11428 0.000 0.000 1.00	1.8	0.050 0.100	22.94	4.0 15.5
8	0.174	11428 0.000 0.000 1.00	4.4	0.050 0.100	26.22	4.0 15.5
9	0.174	11428 0.000 0.000 1.00	24.7	0.196 0.100	29.50	4.0 15.5
10	0.174	11428 0.000 0.000 1.00	23.8	0.200 0.100	32.78	4.0 15.5
11	0.174	11428 0.000 0.000 1.00	10.8	0.200 0.100	36.06	4.0 15.5
12	0.174	11428 0.000 0.000 1.00	13.9	0.103 0.100	39.33	4.0 15.5
13	0.174	11428 0.000 0.000 1.00	18.3	0.050 0.100	42.61	4.0 15.5



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14	0.174	11428	0.000	0.000	1.00	24.8	0.050	0.100	45.89	4.0	15.5
15	0.174	11428	0.000	0.000	1.00	28.0	0.050	0.100	49.17	4.0	15.5
16	0.174	11428	0.000	0.000	1.00	30.0	0.050	0.100	52.44	4.0	15.5
17	0.174	11428	0.000	0.000	1.00	31.8	0.050	0.100	55.72	4.0	15.5
18	0.174	11428	0.000	0.000	1.00	39.4	0.120	0.100	59.00	4.0	15.5
Toe						5.0	0.150	0.100			

3.125 kips total unreduced pile weight (g= 32.17 ft/s2)  
3.125 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
40.00	10.81	1.00	0.800

▲  
FRA-70-1322L - For Abutment - HP12x53 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
256.8	31.2	7.91	7.90	-1.23	7	45	32.65	9	3	18.1
259.0	31.7	7.93	7.92	-1.15	7	45	32.77	9	3	18.1
261.3	32.3	7.95	7.95	-1.07	7	45	32.90	9	3	18.1
263.5	32.6	7.96	7.96	-0.96	7	45	33.02	9	3	18.2
265.7	33.1	8.00	7.99	-0.87	7	45	33.22	9	3	18.2

▲  
FRA-70-1322L - For Abutment - HP12x53 02/28/2021  
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Depth	(ft)	45.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor
			1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	12.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
59.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.141

Pile and Soil Model						Total Capacity Rut (kips)					376.6
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.174	11428	0.010	0.000	0.85	0.0	0.000	0.100	3.28	4.0	15.5
2	0.174	11428	0.000	0.000	1.00	0.0	0.000	0.100	6.56	4.0	15.5
5	0.174	11428	0.000	0.000	1.00	0.7	0.050	0.100	16.39	4.0	15.5
6	0.174	11428	0.000	0.000	1.00	3.2	0.050	0.100	19.67	4.0	15.5
7	0.174	11428	0.000	0.000	1.00	14.3	0.172	0.100	22.94	4.0	15.5
8	0.174	11428	0.000	0.000	1.00	27.2	0.200	0.100	26.22	4.0	15.5
9	0.174	11428	0.000	0.000	1.00	15.2	0.200	0.100	29.50	4.0	15.5
10	0.174	11428	0.000	0.000	1.00	11.6	0.173	0.100	32.78	4.0	15.5
11	0.174	11428	0.000	0.000	1.00	16.3	0.050	0.100	36.06	4.0	15.5
12	0.174	11428	0.000	0.000	1.00	22.0	0.050	0.100	39.33	4.0	15.5
13	0.174	11428	0.000	0.000	1.00	26.5	0.050	0.100	42.61	4.0	15.5
14	0.174	11428	0.000	0.000	1.00	29.2	0.050	0.100	45.89	4.0	15.5
15	0.174	11428	0.000	0.000	1.00	31.0	0.050	0.100	49.17	4.0	15.5
16	0.174	11428	0.000	0.000	1.00	32.8	0.050	0.100	52.44	4.0	15.5
17	0.174	11428	0.000	0.000	1.00	49.1	0.178	0.100	55.72	4.0	15.5
18	0.174	11428	0.000	0.000	1.00	43.4	0.050	0.100	59.00	4.0	15.5
Toe						54.2	0.150	0.100			

3.125 kips total unreduced pile weight (g= 32.17 ft/s2)  
3.125 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
45.00	10.81	1.00	0.800

▲  
FRA-70-1322L - For Abutment - HP12x53 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
376.6	74.3	8.82	8.82	-2.15	7	37	34.08	7	3	19.5
379.3	76.4	8.84	8.84	-2.17	7	37	34.19	7	3	19.5
382.1	78.6	8.87	8.87	-2.20	7	37	34.30	7	3	19.5
384.8	79.8	8.89	8.87	-2.21	7	37	34.41	7	3	19.6

1322L-FA-12X53  
387.5 82.2 8.91 8.90 -2.24 7 37 34.54 7 3 19.6 39.6

▲ FRA-70-1322L - For Abutment - HP12x53 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth (ft) 50.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
59.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.141

Pile and Soil Model						Total Capacity Rut (kips)				387.5	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.174	11428	0.010	0.000	0.85	0.0	0.000	0.100	3.28	4.0	15.5
2	0.174	11428	0.000	0.000	1.00	0.0	0.000	0.100	6.56	4.0	15.5
3	0.174	11428	0.000	0.000	1.00	0.1	0.050	0.100	9.83	4.0	15.5
4	0.174	11428	0.000	0.000	1.00	2.0	0.050	0.100	13.11	4.0	15.5
5	0.174	11428	0.000	0.000	1.00	4.6	0.050	0.100	16.39	4.0	15.5
6	0.174	11428	0.000	0.000	1.00	25.8	0.198	0.100	19.67	4.0	15.5
7	0.174	11428	0.000	0.000	1.00	23.0	0.200	0.100	22.94	4.0	15.5
8	0.174	11428	0.000	0.000	1.00	10.8	0.200	0.100	26.22	4.0	15.5
9	0.174	11428	0.000	0.000	1.00	14.2	0.095	0.100	29.50	4.0	15.5
10	0.174	11428	0.000	0.000	1.00	18.6	0.050	0.100	32.78	4.0	15.5
11	0.174	11428	0.000	0.000	1.00	25.0	0.050	0.100	36.06	4.0	15.5
12	0.174	11428	0.000	0.000	1.00	28.1	0.050	0.100	39.33	4.0	15.5
13	0.174	11428	0.000	0.000	1.00	30.1	0.050	0.100	42.61	4.0	15.5
14	0.174	11428	0.000	0.000	1.00	31.9	0.050	0.100	45.89	4.0	15.5
15	0.174	11428	0.000	0.000	1.00	40.4	0.129	0.100	49.17	4.0	15.5
16	0.174	11428	0.000	0.000	1.00	47.0	0.127	0.100	52.44	4.0	15.5
17	0.174	11428	0.000	0.000	1.00	44.0	0.064	0.100	55.72	4.0	15.5
18	0.174	11428	0.000	0.000	1.00	37.3	0.200	0.100	59.00	4.0	15.5
Toe						4.6	0.150	0.100			

3.125 kips total unreduced pile weight (g= 32.17 ft/s2)  
3.125 kips total reduced pile weight (g= 32.17 ft/s2)

Depth Stroke Pressure Efficy  
ft ft Ratio  
50.00 10.81 1.00 0.800

▲ FRA-70-1322L - For Abutment - HP12x53 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt	
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min	
387.5	82.9	8.87	8.86	-1.56	6	35	35.21	6	3	19.1	39.7
392.4	87.2	8.91	8.89	-1.61	5	17	35.41	6	3	19.1	39.6
397.3	91.7	8.95	8.92	-1.66	5	16	35.60	6	3	19.2	39.6
402.2	96.5	8.99	8.96	-1.72	5	16	35.78	6	3	19.3	39.5
407.1	101.6	9.02	8.99	-1.76	5	16	35.96	6	3	19.4	39.4

▲ FRA-70-1322L - For Abutment - HP12x53 02/28/2021  
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Depth (ft) 55.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
59.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.141

Pile and Soil Model						Total Capacity Rut (kips)				444.4	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2

1322L-FA-12X53											
1	0.174	11428	0.010	0.000	0.85	0.0	0.000	0.100	3.28	4.0	15.5
2	0.174	11428	0.000	0.000	1.00	0.8	0.050	0.100	6.56	4.0	15.5
3	0.174	11428	0.000	0.000	1.00	3.3	0.050	0.100	9.83	4.0	15.5
4	0.174	11428	0.000	0.000	1.00	15.4	0.176	0.100	13.11	4.0	15.5
5	0.174	11428	0.000	0.000	1.00	27.2	0.200	0.100	16.39	4.0	15.5
6	0.174	11428	0.000	0.000	1.00	14.3	0.200	0.100	19.67	4.0	15.5
7	0.174	11428	0.000	0.000	1.00	11.8	0.167	0.100	22.94	4.0	15.5
8	0.174	11428	0.000	0.000	1.00	16.5	0.050	0.100	26.22	4.0	15.5
9	0.174	11428	0.000	0.000	1.00	22.3	0.050	0.100	29.50	4.0	15.5
10	0.174	11428	0.000	0.000	1.00	26.7	0.050	0.100	32.78	4.0	15.5
11	0.174	11428	0.000	0.000	1.00	29.3	0.050	0.100	36.06	4.0	15.5
12	0.174	11428	0.000	0.000	1.00	31.1	0.050	0.100	39.33	4.0	15.5
13	0.174	11428	0.000	0.000	1.00	32.9	0.050	0.100	42.61	4.0	15.5
14	0.174	11428	0.000	0.000	1.00	49.5	0.177	0.100	45.89	4.0	15.5
15	0.174	11428	0.000	0.000	1.00	43.5	0.050	0.100	49.17	4.0	15.5
16	0.174	11428	0.000	0.000	1.00	40.5	0.150	0.100	52.44	4.0	15.5
17	0.174	11428	0.000	0.000	1.00	37.3	0.200	0.100	55.72	4.0	15.5
18	0.174	11428	0.000	0.000	1.00	37.3	0.200	0.100	59.00	4.0	15.5
Toe						4.6	0.150	0.100			

3.125 kips total unreduced pile weight (g= 32.17 ft/s2)  
3.125 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
55.00	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke down	(ft) up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
444.4	167.1	9.20	9.15	-1.26	4	32	35.45	4	3	19.3	39.1
452.5	187.6	9.24	9.18	-1.28	4	32	35.63	4	3	19.4	39.0
460.5	212.5	9.27	9.21	-1.30	4	32	35.79	4	3	19.4	38.9
468.5	247.2	9.31	9.24	-1.30	4	31	35.98	4	3	19.4	38.9
476.5	285.6	9.34	9.26	-1.32	4	31	36.16	4	3	19.5	38.8

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Depth	(ft)	59.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor
			1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	12.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
59.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms)      7.141

Pile and Soil Model						Total Capacity	Rut	(kips)		488.7	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.174	11428	0.010	0.000	0.85	1.3	0.050	0.100	3.28	4.0	15.5
2	0.174	11428	0.000	0.000	1.00	3.9	0.050	0.100	6.56	4.0	15.5
3	0.174	11428	0.000	0.000	1.00	20.3	0.189	0.100	9.83	4.0	15.5
4	0.174	11428	0.000	0.000	1.00	27.1	0.200	0.100	13.11	4.0	15.5
5	0.174	11428	0.000	0.000	1.00	10.8	0.200	0.100	16.39	4.0	15.5
6	0.174	11428	0.000	0.000	1.00	12.8	0.135	0.100	19.67	4.0	15.5
7	0.174	11428	0.000	0.000	1.00	17.1	0.050	0.100	22.94	4.0	15.5
8	0.174	11428	0.000	0.000	1.00	23.9	0.050	0.100	26.22	4.0	15.5
9	0.174	11428	0.000	0.000	1.00	27.4	0.050	0.100	29.50	4.0	15.5
10	0.174	11428	0.000	0.000	1.00	29.7	0.050	0.100	32.78	4.0	15.5
11	0.174	11428	0.000	0.000	1.00	31.5	0.050	0.100	36.06	4.0	15.5
12	0.174	11428	0.000	0.000	1.00	35.2	0.078	0.100	39.33	4.0	15.5
13	0.174	11428	0.000	0.000	1.00	49.5	0.163	0.100	42.61	4.0	15.5
14	0.174	11428	0.000	0.000	1.00	44.0	0.050	0.100	45.89	4.0	15.5
15	0.174	11428	0.000	0.000	1.00	38.8	0.178	0.100	49.17	4.0	15.5
16	0.174	11428	0.000	0.000	1.00	37.3	0.200	0.100	52.44	4.0	15.5
17	0.174	11428	0.000	0.000	1.00	37.3	0.200	0.100	55.72	4.0	15.5
18	0.174	11428	0.000	0.000	1.00	36.1	0.200	0.100	59.00	4.0	15.5
Toe						4.6	0.150	0.100			

3.125 kips total unreduced pile weight (g= 32.17 ft/s2)  
3.125 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
59.00	10.81	1.00	0.800

FRA-70-1322L - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
488.7	379.9	9.29	9.22	-0.72	3	30	36.45	3	3	19.0
499.2	518.1	9.32	9.25	-0.73	3	30	36.61	3	3	19.0
509.6	786.3	9.35	9.27	-0.74	3	29	36.76	3	3	19.0
520.1	1519.2	9.37	9.29	-0.75	3	29	36.90	3	3	19.0
530.5	9092.4	9.39	9.31	-0.76	3	29	37.06	3	3	19.0

FRA-70-1322L - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

## SUMMARY OVER DEPTHS

Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	b/ft	ksi	ksi	ft	kip-ft
5.0	6.5	3.0	3.5	Hammer	did not	run		
10.0	29.5	26.9	2.5	2.6	16.284	-0.263	4.58	24.0
15.0	60.7	58.9	1.8	6.6	22.490	0.000	5.63	20.7
20.0	91.8	77.9	13.9	10.7	26.540	-1.072	6.25	19.4
25.0	133.5	107.9	25.6	15.5	28.291	-1.199	6.78	18.6
30.0	178.0	149.1	28.9	21.1	30.853	-1.241	7.31	18.5
35.0	224.4	195.5	28.9	26.3	31.030	-1.413	7.67	18.2
40.0	256.8	251.9	5.0	31.2	32.646	-1.229	7.91	18.1
45.0	376.6	322.4	54.2	74.3	34.079	-2.150	8.82	19.5
50.0	387.5	382.9	4.6	82.9	35.210	-1.563	8.87	19.1
55.0	444.4	439.8	4.6	167.1	35.454	-1.259	9.20	19.3
59.0	488.7	484.1	4.6	379.9	36.445	-0.721	9.29	19.0

Total Driving Time 71 minutes; Total No. of Blows 2866  
 Starting at penetration 5.0 ft

Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	b/ft	ksi	ksi	ft	kip-ft
5.0	6.5	3.0	3.5	Hammer	did not	run		
10.0	29.9	27.3	2.5	2.6	16.415	-0.281	4.60	23.9
15.0	62.0	60.2	1.8	6.8	22.642	0.000	5.67	20.7
20.0	93.7	79.8	13.9	11.0	26.748	-1.048	6.29	19.3
25.0	135.3	109.8	25.6	15.7	28.675	-1.299	6.89	18.8
30.0	179.9	151.0	28.9	21.5	31.011	-1.181	7.34	18.5
35.0	226.3	197.4	28.9	26.7	31.134	-1.374	7.68	18.1
40.0	259.0	254.1	5.0	31.7	32.773	-1.154	7.93	18.1
45.0	379.3	325.1	54.2	76.4	34.190	-2.175	8.84	19.5
50.0	392.4	387.8	4.6	87.2	35.409	-1.612	8.91	19.1
55.0	452.5	447.9	4.6	187.6	35.635	-1.280	9.24	19.4
59.0	499.2	494.6	4.6	518.1	36.613	-0.732	9.32	19.0

Total Driving Time 82 minutes; Total No. of Blows 3276  
 Starting at penetration 5.0 ft

FRA-70-1322L - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

## SUMMARY OVER DEPTHS

Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	b/ft	ksi	ksi	ft	kip-ft
5.0	6.5	3.0	3.5	Hammer	did not	run		
10.0	30.3	27.8	2.5	2.7	16.536	-0.266	4.62	23.8
15.0	63.3	61.5	1.8	7.0	22.634	-0.175	5.64	20.4
20.0	95.6	81.6	13.9	11.2	26.961	-1.030	6.32	19.3
25.0	137.2	111.6	25.6	16.1	28.802	-1.385	6.92	18.7
30.0	181.8	152.8	28.9	21.9	31.115	-1.186	7.36	18.4
35.0	228.2	199.3	28.9	27.1	31.241	-1.334	7.70	18.1
40.0	261.3	256.3	5.0	32.3	32.899	-1.072	7.95	18.1
45.0	382.1	327.9	54.2	78.6	34.302	-2.199	8.87	19.5
50.0	397.3	392.7	4.6	91.7	35.603	-1.664	8.95	19.2
55.0	460.5	455.9	4.6	212.5	35.795	-1.299	9.27	19.4
59.0	509.6	505.0	4.6	786.3	36.757	-0.743	9.35	19.0

1322L-FA-12X53

Total Driving Time 100 minutes; Total No. of Blows 3970  
 Starting at penetration 5.0 ft

G/L at Shaft and Toe: 0.703 1.000									
Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU	
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft	
5.0	6.5	3.0	3.5	Hammer	did not run				
10.0	30.7	28.2	2.5	2.7	16.692	-0.281	4.64	23.8	
15.0	64.6	62.8	1.8	7.2	22.793	-0.365	5.68	20.3	
20.0	97.5	83.5	13.9	11.5	27.153	-0.987	6.36	19.2	
25.0	139.1	113.5	25.6	16.5	28.985	-1.460	6.96	18.7	
30.0	183.6	154.7	28.9	22.2	31.291	-1.242	7.39	18.4	
35.0	230.0	201.1	28.9	27.4	31.385	-1.290	7.73	18.2	
40.0	263.5	258.5	5.0	32.6	33.019	-0.963	7.96	18.2	
45.0	384.8	330.6	54.2	79.8	34.406	-2.213	8.89	19.6	
50.0	402.2	397.6	4.6	96.5	35.782	-1.720	8.99	19.3	
55.0	468.5	463.9	4.6	247.2	35.980	-1.300	9.31	19.4	
59.0	520.1	515.5	4.6	1519.2	36.905	-0.751	9.37	19.0	

Total Driving Time 143 minutes; Total No. of Blows 5631  
 Starting at penetration 5.0 ft

▲  
 FRA-70-1322L - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

#### SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.736 1.000									
Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU	
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft	
5.0	6.5	3.0	3.5	Hammer	did not run				
10.0	31.2	28.6	2.5	2.8	16.805	-0.268	4.66	23.7	
15.0	66.0	64.1	1.8	7.4	22.913	-0.531	5.71	20.3	
20.0	99.3	85.4	13.9	11.8	27.346	-0.934	6.39	19.1	
25.0	141.0	115.4	25.6	16.9	29.138	-1.537	6.99	18.6	
30.0	185.5	156.6	28.9	22.6	31.400	-1.283	7.40	18.3	
35.0	231.9	203.0	28.9	27.8	31.478	-1.236	7.75	18.2	
40.0	265.7	260.7	5.0	33.1	33.220	-0.870	8.00	18.2	
45.0	387.5	333.3	54.2	82.2	34.545	-2.239	8.91	19.6	
50.0	407.1	402.5	4.6	101.6	35.958	-1.758	9.02	19.4	
55.0	476.5	471.9	4.6	285.6	36.161	-1.323	9.34	19.5	
59.0	530.5	525.9	4.6	9092.4	37.056	-0.759	9.39	19.0	

Total Driving Time 540 minutes; Total No. of Blows 20998  
 Starting at penetration 5.0 ft

▲  
 FRA-70-1322L - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

#### Table of Depths Analyzed with Driving System Modifiers

Depth	Temp.	Wait	Equivalent	Pressure		Stiffn.	Cushion
ft	Length	Time	Stroke	Ratio	Efficy.	Factor	CoR
	ft	hr	ft				
5.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
10.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
15.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
20.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
25.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
30.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
35.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
40.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
45.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
50.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
55.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
59.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00

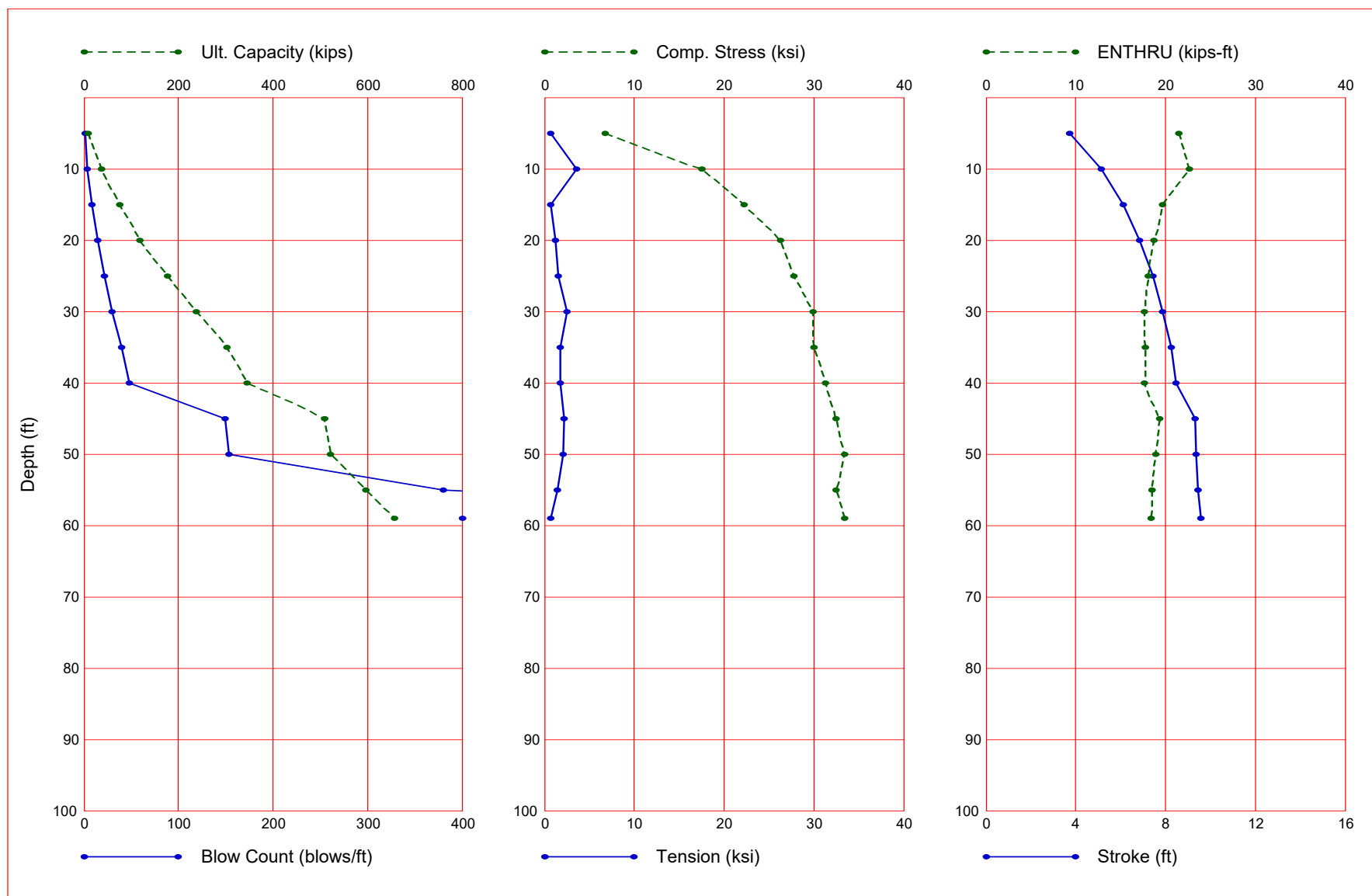
#### Soil Layer Resistance Values

Depth	Shaft	End	Shaft	Toe	Shaft	Toe	Soil	Limit	Setup
ft	Res.	Bearing	Quake	Quake	Damping	Damping	Setup	Distance	Time
	k/ft2	kips	inch	inch	s/ft	s/ft	Normlzd	ft	hrs
0.01	0.00	0.01	0.100	0.100	0.050	0.150	0.000	6.000	1.000
7.59	0.46	5.27	0.100	0.100	0.050	0.150	0.000	6.000	1.000
7.61	2.62	2.54	0.100	0.100	0.200	0.150	0.515	6.000	24.000
13.09	2.62	2.54	0.100	0.100	0.200	0.150	0.515	6.000	24.000
13.11	1.37	1.82	0.100	0.100	0.200	0.150	1.000	6.000	168.000
18.09	1.37	1.82	0.100	0.100	0.200	0.150	1.000	6.000	168.000
18.11	1.11	12.59	0.100	0.100	0.050	0.150	0.000	6.000	1.000
23.09	1.42	16.17	0.100	0.100	0.050	0.150	0.000	6.000	1.000

1322L-FA-12X53

23.11	1.74	24.01	0.100	0.100	0.050	0.150	0.000	6.000	1.000
28.99	2.20	28.91	0.100	0.100	0.050	0.150	0.000	6.000	1.000
29.01	2.20	28.91	0.100	0.100	0.050	0.150	0.000	6.000	1.000
30.69	2.26	28.91	0.100	0.100	0.050	0.150	0.000	6.000	1.000
30.71	2.26	28.91	0.100	0.100	0.050	0.150	0.000	6.000	1.000
38.99	2.61	28.91	0.100	0.100	0.050	0.150	0.000	6.000	1.000
39.01	5.12	4.96	0.100	0.100	0.200	0.150	0.515	6.000	24.000
41.49	5.12	4.96	0.100	0.100	0.200	0.150	0.515	6.000	24.000
41.51	3.23	54.20	0.100	0.100	0.050	0.150	0.000	6.000	1.000
46.49	3.50	54.20	0.100	0.100	0.050	0.150	0.000	6.000	1.000
46.51	4.75	4.60	0.100	0.100	0.200	0.150	1.000	6.000	168.000
55.51	4.75	4.60	0.100	0.100	0.200	0.150	1.000	6.000	168.000
59.00	4.45	4.60	0.100	0.100	0.200	0.150	1.000	6.000	168.000

Gain/Loss 3 at Shaft and Toe 0.670 / 1.000



Gain/Loss 3 at Shaft and Toe 0.670 / 1.000

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
5.0	8.9	4.2	4.8	1.2	6.761	-0.741	3.72	21.5
10.0	37.7	34.2	3.5	3.3	17.530	-3.582	5.12	22.7
15.0	76.7	74.1	2.5	8.6	22.291	-0.732	6.12	19.7
20.0	118.9	99.6	19.3	14.2	26.268	-1.201	6.85	18.7
25.0	176.4	141.1	35.3	22.1	27.784	-1.556	7.43	18.1
30.0	238.4	198.5	39.9	30.3	29.876	-2.541	7.88	17.7
35.0	303.1	263.2	39.9	40.3	30.013	-1.756	8.25	17.8
40.0	346.0	339.1	6.8	48.6	31.351	-1.732	8.46	17.7
45.0	509.3	434.4	74.8	149.3	32.494	-2.229	9.33	19.4
50.0	522.3	515.9	6.3	153.6	33.404	-2.079	9.36	18.9
55.0	597.1	590.7	6.3	380.4	32.493	-1.474	9.43	18.5
59.0	656.6	650.3	6.3	990.5	33.442	-0.707	9.58	18.4

Total Continuous Driving Time 155.00 minutes; Total Number of Blows 6048 (starting at penetration 5.0 ft)



GRLWEAP - Version 2010  
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins  
and Associates, Inc.) with cooperation from Pile Dynamics, Inc.  
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ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

▲

Input File: J:\GEOTECH\PROJECTS\2013\W-13-072 FRA-70-13.10 PROJECT 6A\ANALYSIS\FRA-70-1322L AND 1323C\DRIVEABILITY\FRA-70-1322L\FORWARD

ABUTMENT\HP 14X73\1322L-FA-14X73.GMW

Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW

Hammer File Version: 2003 (12/4/2018)

Input File Contents

```

FRA-70-1322L - For Abutment - HP14x73
OUT OSG HAM STR FUL PEL N SPL N-U P-D %SK ISM 0 PHI RSA ITR H-D MXT DEX
-100 0 41 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0.000

Pile g Hammer g Toe Area Pile Size Pile Type
32.170 32.170 144.000 14.000 Unknown
W Cp A Cp E Cp T Cp CoR ROut StCp
1.900 227.000 530.0 2.000 0.800 0.010 0.0
A Cu E Cu T Cu CoR ROut StCu
0.000 0.0 0.000 0.000 0.000 0.0
LPle APle EPle WPle Peri CI CoR ROut
59.000 21.40 29000.0 492.000 4.700 0 0.850 0.010
FFatigue F0 0-Bottom
0 0.000 0.000

Manufac Hmr Name HmrType No Seg-s
DELMAG D 19-42 1 5
Ram Wt Ram L Ram Dia MaxStrk RtdStrk Efficy
4.00 129.10 12.60 11.86 10.81 0.80
IB. Wt IB. L IB. Dia IB CoR IB R0
0.75 25.30 12.60 0.900 0.010
CompStrk A Chamber V Chamber C Delay C Duratn Exp Coeff VolCStart Vol CEnd
16.65 124.70 157.70 0.0020 0.0020 1.250 0.00 0.00
P atm P1 P2 P3 P4 P5
14.70 1600.00 1440.00 1295.00 1165.00 0.00
Stroke Effic. Pressure R-Weight T-Delay Exp-Coeff Eps-Str Total-AW
10.8100 0.8000 1600.0000 0.0000 0.0000 0.0000 0.0100 0.0000
Qs Qt Js Jt Qx Jx Rati Dept
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
Research Soil Model: Atoe, Plug, Gap, Q-fac

```

0.000 0.000 0.000 0.000  
 Research Soil Model: RD-skn: m, d, toe: m, d  
 0.000 0.000 0.000 0.000  
 Research Toe Plug: Res-int, Q-int, D-int, Res-plug, Q-plug, D-plug  
 0.000 0.000 0.000 0.000 0.000 0.000  
 Research Toe Plug: RD plug toe: m, d  
 0.000 0.000  
 Research Toe Plug: New Toe Plug Model is NOT applied  
 Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimL	TSf0
0.01	0.00	0.01	0.10	0.10	0.05	0.15	1.00	6.00	1.000
7.59	0.54	7.28	0.10	0.10	0.05	0.15	1.00	6.00	1.000
7.61	2.62	3.51	0.10	0.10	0.20	0.15	1.21	6.00	24.000
13.09	2.62	3.51	0.10	0.10	0.20	0.15	1.21	6.00	24.000
13.11	1.37	2.51	0.10	0.10	0.20	0.15	1.49	6.00	168.000
18.09	1.37	2.51	0.10	0.10	0.20	0.15	1.49	6.00	168.000
18.11	1.28	17.38	0.10	0.10	0.05	0.15	1.00	6.00	1.000
23.09	1.65	22.35	0.10	0.10	0.05	0.15	1.00	6.00	1.000
23.11	2.05	33.15	0.10	0.10	0.05	0.15	1.00	6.00	1.000
28.99	2.58	39.92	0.10	0.10	0.05	0.15	1.00	6.00	1.000
29.01	2.59	39.92	0.10	0.10	0.05	0.15	1.00	6.00	1.000
30.69	2.66	39.92	0.10	0.10	0.05	0.15	1.00	6.00	1.000
30.71	2.66	39.92	0.10	0.10	0.05	0.15	1.00	6.00	1.000
38.99	3.07	39.92	0.10	0.10	0.05	0.15	1.00	6.00	1.000
39.01	5.12	6.85	0.10	0.10	0.20	0.15	1.21	6.00	24.000
41.49	5.12	6.85	0.10	0.10	0.20	0.15	1.21	6.00	24.000
41.51	3.86	74.83	0.10	0.10	0.05	0.15	1.00	6.00	1.000
46.49	4.18	74.83	0.10	0.10	0.05	0.15	1.00	6.00	1.000
46.51	4.75	6.35	0.10	0.10	0.20	0.15	1.49	6.00	168.000
55.51	4.75	6.35	0.10	0.10	0.20	0.15	1.49	6.00	168.000
59.00	4.70	6.35	0.10	0.10	0.20	0.15	1.49	6.00	168.000

Gain/Loss factors: shaft and toe

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR
0.60400	0.63700	0.67000	0.70300	0.73600			
1.00000	1.00000	1.00000	1.00000	1.00000			
5.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
10.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
15.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
20.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
25.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
30.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
35.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
40.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
45.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
50.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
55.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
59.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
0.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000

▲ GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS  
 Version 2010  
 English Units

FRA-70-1322L - For Abutment - HP14x73

Hammer Model:	D 19-42	Made by:	DELMAG
No.	Weight kips	Stiffn k/inch	CoR
1	0.800		
2	0.800	140046.6	1.000
3	0.800	140046.6	1.000
4	0.800	140046.6	1.000
5	0.800	140046.6	1.000
Imp Block	0.753	70735.6	0.900
Helmet	1.900	60155.0	0.800
Combined Pile Top		15778.0	

HAMMER OPTIONS:  
 Hammer File ID No. 41 Hammer Type OE Diesel  
 Stroke Option FxdP-VarS Stroke Convergence Crit. 0.010  
 Fuel Pump Setting Maximum

HAMMER DATA:  
 Ram Weight (kips) 4.00 Ram Length (inch) 129.10  
 Maximum Stroke (ft) 11.86  
 Rated Stroke (ft) 10.81 Efficiency 0.800  
 Maximum Pressure (psi) 1600.00 Actual Pressure (psi) 1600.00  
 Compression Exponent 1.350 Expansion Exponent 1.250  
 Ram Diameter (inch) 12.60

Combustion Delay (s) 0.00200 Ignition Duration (s) 0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION			PILE CUSHION		
Cross Sect. Area	(in2)	227.00	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	530.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	2.00	Thickness	(inch)	0.00
Coeff of Restitution		0.8	Coeff of Restitution		1.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	60155.0	Stiffness	(kips/in)	0.0

FRA-70-1322L - For Abutment - HP14x73 02/28/2021  
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Depth	(ft)	5.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	14.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
59.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.141

Pile and Soil Model						Total Capacity Rut (kips)						8.9
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area	
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2	
1	0.240	15778	0.010	0.000	0.85	0.0	0.000	0.100	3.28	4.7	21.4	
2	0.240	15778	0.000	0.000	1.00	0.0	0.000	0.100	6.56	4.7	21.4	
17	0.240	15778	0.000	0.000	1.00	0.5	0.050	0.100	55.72	4.7	21.4	
18	0.240	15778	0.000	0.000	1.00	3.7	0.050	0.100	59.00	4.7	21.4	
Toe						4.8	0.150	0.100				

4.314 kips total unreduced pile weight (g= 32.17 ft/s2)  
 4.314 kips total reduced pile weight (g= 32.17 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile		Pile Segments: Automatic	
No. of Slacks/Splices	0	Pile Damping (%)	1
		Pile Damping Fact.(k/ft/s)	0.751

Driveability Analysis

Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	1	Analysis Time-Input (ms)	0
Output Level: Normal			
Gravity Mass, Pile, Hammer:	32.170	32.170	32.170
Output Segment Generation: Automatic			

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
5.00	10.81	1.00	0.800

FRA-70-1322L - For Abutment - HP14x73 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp	Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi		kip-ft	b/min
8.9	1.2	3.72	3.72	-0.74	6	42	6.76	1	7
8.9	1.2	3.72	3.72	-0.74	6	42	6.76	1	7
8.9	1.2	3.72	3.72	-0.74	6	42	6.76	1	7
8.9	1.2	3.72	3.72	-0.74	6	42	6.76	1	7
8.9	1.2	3.72	3.72	-0.74	6	42	6.76	1	7

FRA-70-1322L - For Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	10.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	14.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
59.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.141

Pile and Soil Model						Total Capacity Rut			(kips)			36.7
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area	
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2	
1	0.240	15778	0.010	0.000	0.85	0.0	0.000	0.100	3.28	4.7	21.4	
2	0.240	15778	0.000	0.000	1.00	0.0	0.000	0.100	6.56	4.7	21.4	
15	0.240	15778	0.000	0.000	1.00	0.0	0.050	0.100	49.17	4.7	21.4	
16	0.240	15778	0.000	0.000	1.00	2.0	0.050	0.100	52.44	4.7	21.4	
17	0.240	15778	0.000	0.000	1.00	5.5	0.050	0.100	55.72	4.7	21.4	
18	0.240	15778	0.000	0.000	1.00	25.7	0.190	0.100	59.00	4.7	21.4	
Toe						3.5	0.150	0.100				

4.314 kips total unreduced pile weight (g= 32.17 ft/s2)

4.314 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
10.00	10.81	1.00	0.800

FRA-70-1322L - For Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	b/min	
36.7	3.2	5.08	5.06	-3.61	5 8	17.34	7 3	22.8
37.2	3.3	5.10	5.07	-3.60	5 8	17.44	7 3	22.8
37.7	3.3	5.12	5.09	-3.58	5 8	17.53	8 3	22.7
38.2	3.4	5.13	5.11	-3.56	5 8	17.63	7 3	22.6
38.7	3.5	5.15	5.13	-3.52	5 8	17.69	7 3	22.6

FRA-70-1322L - For Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	15.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor
			1.000

## PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	14.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
59.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.141

Pile and Soil Model						Total Capacity	Rut	(kips)			73.5
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.240	15778	0.010	0.000	0.85	0.0	0.000	0.100	3.28	4.7	21.4
2	0.240	15778	0.000	0.000	1.00	0.0	0.000	0.100	6.56	4.7	21.4
14	0.240	15778	0.000	0.000	1.00	0.6	0.050	0.100	45.89	4.7	21.4
15	0.240	15778	0.000	0.000	1.00	3.8	0.050	0.100	49.17	4.7	21.4
16	0.240	15778	0.000	0.000	1.00	13.5	0.150	0.100	52.44	4.7	21.4
17	0.240	15778	0.000	0.000	1.00	32.2	0.200	0.100	55.72	4.7	21.4
18	0.240	15778	0.000	0.000	1.00	20.9	0.200	0.100	59.00	4.7	21.4
Toe						2.5	0.150	0.100			

4.314 kips total unreduced pile weight (g= 32.17 ft/s2)

4.314 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
15.00	10.81	1.00	0.800

FRA-70-1322L - For Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	b/min	
73.5	8.1	6.05	6.07	-0.77	5 8	22.03	15 5	19.8

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75.1	8.4	6.08	6.11	-0.65	15	50	22.17	15	5	19.7	47.8
76.7	8.6	6.12	6.14	-0.73	15	50	22.29	15	5	19.7	47.7
78.2	8.8	6.15	6.18	-0.80	15	50	22.43	15	5	19.6	47.5
79.8	9.1	6.19	6.21	-0.86	15	50	22.54	15	5	19.6	47.4

FRA-70-1322L - For Abutment - HP14x73 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth (ft) 20.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:  
Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
59.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.141

Pile and Soil Model										Total Capacity Rut (kips)	114.5
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.240	15778	0.010	0.000	0.85	0.0	0.000	0.100	3.28	4.7	21.4
2	0.240	15778	0.000	0.000	1.00	0.0	0.000	0.100	6.56	4.7	21.4
12	0.240	15778	0.000	0.000	1.00	0.0	0.050	0.100	39.33	4.7	21.4
13	0.240	15778	0.000	0.000	1.00	2.1	0.050	0.100	42.61	4.7	21.4
14	0.240	15778	0.000	0.000	1.00	5.7	0.050	0.100	45.89	4.7	21.4
15	0.240	15778	0.000	0.000	1.00	26.9	0.192	0.100	49.17	4.7	21.4
16	0.240	15778	0.000	0.000	1.00	30.1	0.200	0.100	52.44	4.7	21.4
17	0.240	15778	0.000	0.000	1.00	12.8	0.200	0.100	55.72	4.7	21.4
18	0.240	15778	0.000	0.000	1.00	17.5	0.114	0.100	59.00	4.7	21.4
Toe						19.3	0.150	0.100			

4.314 kips total unreduced pile weight (g= 32.17 ft/s2)  
4.314 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
20.00	10.81	1.00	0.800

FRA-70-1322L - For Abutment - HP14x73 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Rut	B1 Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	B1 Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	b/min	
114.5	13.5	6.78	6.73	-1.20	12 39	25.93	15 5	18.7 45.4
116.7	13.8	6.82	6.77	-1.21	12 39	26.10	15 5	18.6 45.3
118.9	14.2	6.85	6.79	-1.20	12 39	26.27	15 5	18.7 45.2
121.1	14.5	6.88	6.82	-1.19	12 39	26.46	15 5	18.6 45.1
123.3	14.9	6.91	6.86	-1.16	12 39	26.59	15 5	18.5 45.0

FRA-70-1322L - For Abutment - HP14x73 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth (ft) 25.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:  
Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
59.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.141

Pile and Soil Model										Total Capacity Rut (kips)	172.0
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.240	15778	0.010	0.000	0.85	0.0	0.000	0.100	3.28	4.7	21.4
2	0.240	15778	0.000	0.000	1.00	0.0	0.000	0.100	6.56	4.7	21.4
11	0.240	15778	0.000	0.000	1.00	0.7	0.050	0.100	36.06	4.7	21.4
12	0.240	15778	0.000	0.000	1.00	4.0	0.050	0.100	39.33	4.7	21.4
13	0.240	15778	0.000	0.000	1.00	14.8	0.157	0.100	42.61	4.7	21.4
14	0.240	15778	0.000	0.000	1.00	32.2	0.200	0.100	45.89	4.7	21.4

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15	0.240	15778	0.000	0.000	1.00	19.9	0.200	0.100	49.17	4.7	21.4
16	0.240	15778	0.000	0.000	1.00	13.5	0.185	0.100	52.44	4.7	21.4
17	0.240	15778	0.000	0.000	1.00	22.0	0.050	0.100	55.72	4.7	21.4
18	0.240	15778	0.000	0.000	1.00	29.4	0.050	0.100	59.00	4.7	21.4
Toe						35.3	0.150	0.100			

4.314 kips total unreduced pile weight (g= 32.17 ft/s2)  
4.314 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
25.00	10.81	1.00	0.800

▲  
FRA-70-1322L - For Abutment - HP14x73 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down up	ksi			ksi			kip-ft	b/min
172.0	21.2	7.38 7.35	-1.61	6	33	27.55	13	4	18.2	43.5
174.2	21.7	7.41 7.38	-1.58	6	33	27.66	13	4	18.1	43.4
176.4	22.1	7.43 7.41	-1.56	6	33	27.78	13	4	18.1	43.4
178.6	22.6	7.46 7.43	-1.53	13	28	27.89	13	4	18.1	43.3
180.8	23.1	7.48 7.47	-1.59	13	28	28.00	13	4	18.0	43.2

▲  
FRA-70-1322L - For Abutment - HP14x73 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth	(ft)	30.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor
			1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	14.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
59.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.141

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	234.0
	kips	Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D Quake	LbTop	Perim
		k/in ft ft	kips	s/ft inch	ft	ft
1	0.240	15778 0.010 0.000 0.85	0.0	0.000 0.100	3.28	4.7
2	0.240	15778 0.000 0.000 1.00	0.0	0.000 0.100	6.56	4.7
9	0.240	15778 0.000 0.000 1.00	0.0	0.050 0.100	29.50	4.7
10	0.240	15778 0.000 0.000 1.00	2.3	0.050 0.100	32.78	4.7
11	0.240	15778 0.000 0.000 1.00	5.9	0.050 0.100	36.06	4.7
12	0.240	15778 0.000 0.000 1.00	28.2	0.194 0.100	39.33	4.7
13	0.240	15778 0.000 0.000 1.00	29.2	0.200 0.100	42.61	4.7
14	0.240	15778 0.000 0.000 1.00	12.8	0.200 0.100	45.89	4.7
15	0.240	15778 0.000 0.000 1.00	17.9	0.106 0.100	49.17	4.7
16	0.240	15778 0.000 0.000 1.00	24.6	0.050 0.100	52.44	4.7
17	0.240	15778 0.000 0.000 1.00	34.3	0.050 0.100	55.72	4.7
18	0.240	15778 0.000 0.000 1.00	38.8	0.050 0.100	59.00	4.7
Toe			39.9	0.150 0.100		

4.314 kips total unreduced pile weight (g= 32.17 ft/s2)  
4.314 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
30.00	10.81	1.00	0.800

▲  
FRA-70-1322L - For Abutment - HP14x73 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down up	ksi			ksi			kip-ft	b/min
234.0	29.7	7.84 7.83	-2.65	8	27	29.62	12	4	17.7	42.2
236.2	30.1	7.85 7.85	-2.60	8	27	29.72	12	4	17.6	42.1
238.4	30.3	7.88 7.86	-2.54	8	27	29.88	12	4	17.7	42.1
240.6	30.8	7.89 7.89	-2.49	8	26	29.92	12	4	17.6	42.1
242.8	31.1	7.91 7.90	-2.42	8	27	30.07	12	4	17.6	42.0

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FRA-70-1322L - For Abutment - HP14x73 02/28/2021  
Resource International Inc GRLWEAP Version 2010

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Depth (ft) 35.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

## PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
59.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.141

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	298.7
	kips	Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D Quake	LbTop	Perim Area
		k/in ft ft	kips	s/ft inch	ft	ft in2
1	0.240	15778 0.010 0.000 0.85	0.0	0.000 0.100	3.28	4.7 21.4
2	0.240	15778 0.000 0.000 1.00	0.0	0.000 0.100	6.56	4.7 21.4
8	0.240	15778 0.000 0.000 1.00	0.8	0.050 0.100	26.22	4.7 21.4
9	0.240	15778 0.000 0.000 1.00	4.2	0.050 0.100	29.50	4.7 21.4
10	0.240	15778 0.000 0.000 1.00	16.2	0.164 0.100	32.78	4.7 21.4
11	0.240	15778 0.000 0.000 1.00	32.2	0.200 0.100	36.06	4.7 21.4
12	0.240	15778 0.000 0.000 1.00	18.9	0.200 0.100	39.33	4.7 21.4
13	0.240	15778 0.000 0.000 1.00	13.9	0.178 0.100	42.61	4.7 21.4
14	0.240	15778 0.000 0.000 1.00	22.2	0.050 0.100	45.89	4.7 21.4
15	0.240	15778 0.000 0.000 1.00	29.9	0.050 0.100	49.17	4.7 21.4
16	0.240	15778 0.000 0.000 1.00	36.7	0.050 0.100	52.44	4.7 21.4
17	0.240	15778 0.000 0.000 1.00	40.6	0.050 0.100	55.72	4.7 21.4
18	0.240	15778 0.000 0.000 1.00	43.1	0.050 0.100	59.00	4.7 21.4
Toe			39.9	0.150 0.100		

4.314 kips total unreduced pile weight (g= 32.17 ft/s2)

4.314 kips total reduced pile weight (g= 32.17 ft/s2)

Depth Stroke Pressure Efficy  
 ft ft Ratio  
 35.00 10.81 1.00 0.800

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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down up	ksi		ksi		kip-ft	b/min
298.7	39.2	8.21 8.20	-1.59	10	21 29.83	10	4 17.8	41.3
300.9	39.8	8.23 8.22	-1.68	10	21 29.93	10	4 17.8	41.2
303.1	40.3	8.25 8.24	-1.76	10	21 30.01	10	4 17.8	41.2
305.3	41.1	8.26 8.26	-1.83	10	21 30.05	10	4 17.8	41.1
307.5	41.4	8.28 8.27	-1.91	10	21 30.16	10	4 17.9	41.1

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Depth (ft) 40.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

## PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
59.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.141

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	340.7
	kips	Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D Quake	LbTop	Perim Area
		k/in ft ft	kips	s/ft inch	ft	ft in2
1	0.240	15778 0.010 0.000 0.85	0.0	0.000 0.100	3.28	4.7 21.4
2	0.240	15778 0.000 0.000 1.00	0.0	0.000 0.100	6.56	4.7 21.4
6	0.240	15778 0.000 0.000 1.00	0.1	0.050 0.100	19.67	4.7 21.4
7	0.240	15778 0.000 0.000 1.00	2.5	0.050 0.100	22.94	4.7 21.4
8	0.240	15778 0.000 0.000 1.00	6.1	0.050 0.100	26.22	4.7 21.4
9	0.240	15778 0.000 0.000 1.00	29.4	0.196 0.100	29.50	4.7 21.4
10	0.240	15778 0.000 0.000 1.00	28.2	0.200 0.100	32.78	4.7 21.4
11	0.240	15778 0.000 0.000 1.00	12.8	0.200 0.100	36.06	4.7 21.4
12	0.240	15778 0.000 0.000 1.00	18.4	0.098 0.100	39.33	4.7 21.4
13	0.240	15778 0.000 0.000 1.00	25.1	0.050 0.100	42.61	4.7 21.4

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14	0.240	15778	0.000	0.000	1.00	34.5	0.050	0.100	45.89	4.7	21.4
15	0.240	15778	0.000	0.000	1.00	39.0	0.050	0.100	49.17	4.7	21.4
16	0.240	15778	0.000	0.000	1.00	41.9	0.050	0.100	52.44	4.7	21.4
17	0.240	15778	0.000	0.000	1.00	44.4	0.050	0.100	55.72	4.7	21.4
18	0.240	15778	0.000	0.000	1.00	51.5	0.114	0.100	59.00	4.7	21.4
Toe						6.8	0.150	0.100			

4.314 kips total unredused pile weight (g= 32.17 ft/s2)  
4.314 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
40.00	10.81	1.00	0.800

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Rut	Bl Ct	Stroke	(ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi			ksi			kip-ft	b/min
340.7	47.1	8.43	8.42	-1.88	9	41	31.11	9	3	17.7	40.7
343.3	48.1	8.44	8.44	-1.80	9	41	31.21	9	3	17.6	40.7
346.0	48.6	8.46	8.46	-1.73	8	41	31.35	9	3	17.7	40.7
348.6	49.4	8.49	8.48	-1.67	8	21	31.44	9	3	17.7	40.6
351.2	50.4	8.51	8.50	-1.66	8	21	31.62	9	3	17.7	40.6

FRA-70-1322L - For Abutment - HP14x73      02/28/2021  
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Depth	(ft)	45.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	14.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
59.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms)      7.141

Pile and Soil Model						Total Capacity Rut (kips)					502.8	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area	
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2	
1	0.240	15778	0.010	0.000	0.85	0.0	0.000	0.100	3.28	4.7	21.4	
2	0.240	15778	0.000	0.000	1.00	0.0	0.000	0.100	6.56	4.7	21.4	
5	0.240	15778	0.000	0.000	1.00	0.9	0.050	0.100	16.39	4.7	21.4	
6	0.240	15778	0.000	0.000	1.00	4.4	0.050	0.100	19.67	4.7	21.4	
7	0.240	15778	0.000	0.000	1.00	17.5	0.169	0.100	22.94	4.7	21.4	
8	0.240	15778	0.000	0.000	1.00	32.2	0.200	0.100	26.22	4.7	21.4	
9	0.240	15778	0.000	0.000	1.00	18.0	0.200	0.100	29.50	4.7	21.4	
10	0.240	15778	0.000	0.000	1.00	14.3	0.170	0.100	32.78	4.7	21.4	
11	0.240	15778	0.000	0.000	1.00	22.4	0.050	0.100	36.06	4.7	21.4	
12	0.240	15778	0.000	0.000	1.00	30.5	0.050	0.100	39.33	4.7	21.4	
13	0.240	15778	0.000	0.000	1.00	37.0	0.050	0.100	42.61	4.7	21.4	
14	0.240	15778	0.000	0.000	1.00	40.7	0.050	0.100	45.89	4.7	21.4	
15	0.240	15778	0.000	0.000	1.00	43.2	0.050	0.100	49.17	4.7	21.4	
16	0.240	15778	0.000	0.000	1.00	45.7	0.050	0.100	52.44	4.7	21.4	
17	0.240	15778	0.000	0.000	1.00	60.0	0.175	0.100	55.72	4.7	21.4	
18	0.240	15778	0.000	0.000	1.00	61.3	0.050	0.100	59.00	4.7	21.4	
Toe						74.8	0.150	0.100				

4.314 kips total unredused pile weight (g= 32.17 ft/s2)  
4.314 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
45.00	10.81	1.00	0.800

FRA-70-1322L - For Abutment - HP14x73      02/28/2021  
 Resource International Inc      GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i ksi	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
502.8	139.8	9.29	9.26	-2.20	7	34	32.32	7	3	19.3
506.0	144.4	9.31	9.28	-2.21	7	34	32.41	7	3	19.4
509.3	149.3	9.33	9.30	-2.23	7	34	32.49	7	3	19.4
512.5	156.3	9.35	9.32	-2.25	7	33	32.56	7	3	19.3



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515.7 161.8 9.37 9.34 -2.29 7 16 32.64 7 3 19.4 38.7

▲  
FRA-70-1322L - For Abutment - HP14x73  
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Depth (ft) 50.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

## PILE PROFILE:

Toe Area (in<sup>2</sup>) 144.000 Pile Type Unknown  
Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in <sup>2</sup>	ksi	lb/ft <sup>3</sup>	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
59.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.141

Pile and Soil Model						Total Capacity Rut (kips)				510.6	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in <sup>2</sup>
1	0.240	15778	0.010	0.000	0.85	0.0	0.000	0.100	3.28	4.7	21.4
2	0.240	15778	0.000	0.000	1.00	0.0	0.000	0.100	6.56	4.7	21.4
3	0.240	15778	0.000	0.000	1.00	0.1	0.050	0.100	9.83	4.7	21.4
4	0.240	15778	0.000	0.000	1.00	2.7	0.050	0.100	13.11	4.7	21.4
5	0.240	15778	0.000	0.000	1.00	6.3	0.050	0.100	16.39	4.7	21.4
6	0.240	15778	0.000	0.000	1.00	30.7	0.198	0.100	19.67	4.7	21.4
7	0.240	15778	0.000	0.000	1.00	27.2	0.200	0.100	22.94	4.7	21.4
8	0.240	15778	0.000	0.000	1.00	12.8	0.200	0.100	26.22	4.7	21.4
9	0.240	15778	0.000	0.000	1.00	18.9	0.090	0.100	29.50	4.7	21.4
10	0.240	15778	0.000	0.000	1.00	25.6	0.050	0.100	32.78	4.7	21.4
11	0.240	15778	0.000	0.000	1.00	34.8	0.050	0.100	36.06	4.7	21.4
12	0.240	15778	0.000	0.000	1.00	39.2	0.050	0.100	39.33	4.7	21.4
13	0.240	15778	0.000	0.000	1.00	42.0	0.050	0.100	42.61	4.7	21.4
14	0.240	15778	0.000	0.000	1.00	44.5	0.050	0.100	45.89	4.7	21.4
15	0.240	15778	0.000	0.000	1.00	52.4	0.122	0.100	49.17	4.7	21.4
16	0.240	15778	0.000	0.000	1.00	61.4	0.121	0.100	52.44	4.7	21.4
17	0.240	15778	0.000	0.000	1.00	61.6	0.062	0.100	55.72	4.7	21.4
18	0.240	15778	0.000	0.000	1.00	44.2	0.200	0.100	59.00	4.7	21.4
Toe						6.3	0.150	0.100			

4.314 kips total unreduced pile weight (g= 32.17 ft/s<sup>2</sup>)4.314 kips total reduced pile weight (g= 32.17 ft/s<sup>2</sup>)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
50.00	10.81	1.00	0.800

▲  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	b/min	
510.6	137.3	9.30	9.24	-2.22	4 16	33.13	6 3	18.8 38.9
516.5	144.2	9.33	9.26	-2.16	4 17	33.22	6 3	18.9 38.9
522.3	153.6	9.36	9.29	-2.08	4 16	33.40	6 3	18.9 38.8
528.1	164.4	9.38	9.31	-1.98	4 16	33.53	6 3	18.9 38.8
533.9	176.3	9.41	9.34	-1.90	4 16	33.64	6 3	19.0 38.7

▲  
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Resource International Inc

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Depth (ft) 55.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

## PILE PROFILE:

Toe Area (in<sup>2</sup>) 144.000 Pile Type Unknown  
Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in <sup>2</sup>	ksi	lb/ft <sup>3</sup>	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
59.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.141

Pile and Soil Model						Total Capacity Rut (kips)				578.1	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in <sup>2</sup>
1	0.240	15778	0.010	0.000	0.85	0.0	0.000	0.100	3.28	4.7	21.4
2	0.240	15778	0.000	0.000	1.00	0.0	0.000	0.100	6.56	4.7	21.4
3	0.240	15778	0.000	0.000	1.00	0.1	0.050	0.100	9.83	4.7	21.4
4	0.240	15778	0.000	0.000	1.00	2.7	0.050	0.100	13.11	4.7	21.4
5	0.240	15778	0.000	0.000	1.00	6.3	0.050	0.100	16.39	4.7	21.4
6	0.240	15778	0.000	0.000	1.00	30.7	0.198	0.100	19.67	4.7	21.4
7	0.240	15778	0.000	0.000	1.00	27.2	0.200	0.100	22.94	4.7	21.4
8	0.240	15778	0.000	0.000	1.00	12.8	0.200	0.100	26.22	4.7	21.4
9	0.240	15778	0.000	0.000	1.00	18.9	0.090	0.100	29.50	4.7	21.4
10	0.240	15778	0.000	0.000	1.00	25.6	0.050	0.100	32.78	4.7	21.4
11	0.240	15778	0.000	0.000	1.00	34.8	0.050	0.100	36.06	4.7	21.4
12	0.240	15778	0.000	0.000	1.00	39.2	0.050	0.100	39.33	4.7	21.4
13	0.240	15778	0.000	0.000	1.00	42.0	0.050	0.100	42.61	4.7	21.4
14	0.240	15778	0.000	0.000	1.00	44.5	0.050	0.100	45.89	4.7	21.4
15	0.240	15778	0.000	0.000	1.00	52.4	0.122	0.100	49.17	4.7	21.4
16	0.240	15778	0.000	0.000	1.00	61.4	0.121	0.100	52.44	4.7	21.4
17	0.240	15778	0.000	0.000	1.00	61.6	0.062	0.100	55.72	4.7	21.4
18	0.240	15778	0.000	0.000	1.00	44.2	0.200	0.100	59.00	4.7	21.4
Toe						6.3	0.150	0.100			

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1	0.240	15778	0.010	0.000	0.85	0.0	0.000	0.100	3.28 4.7 21.4
2	0.240	15778	0.000	0.000	1.00	1.1	0.050	0.100	6.56 4.7 21.4
3	0.240	15778	0.000	0.000	1.00	4.6	0.050	0.100	9.83 4.7 21.4
4	0.240	15778	0.000	0.000	1.00	18.8	0.173	0.100	13.11 4.7 21.4
5	0.240	15778	0.000	0.000	1.00	32.2	0.200	0.100	16.39 4.7 21.4
6	0.240	15778	0.000	0.000	1.00	17.0	0.200	0.100	19.67 4.7 21.4
7	0.240	15778	0.000	0.000	1.00	14.7	0.163	0.100	22.94 4.7 21.4
8	0.240	15778	0.000	0.000	1.00	22.6	0.050	0.100	26.22 4.7 21.4
9	0.240	15778	0.000	0.000	1.00	31.0	0.050	0.100	29.50 4.7 21.4
10	0.240	15778	0.000	0.000	1.00	37.2	0.050	0.100	32.78 4.7 21.4
11	0.240	15778	0.000	0.000	1.00	40.8	0.050	0.100	36.06 4.7 21.4
12	0.240	15778	0.000	0.000	1.00	43.3	0.050	0.100	39.33 4.7 21.4
13	0.240	15778	0.000	0.000	1.00	45.8	0.050	0.100	42.61 4.7 21.4
14	0.240	15778	0.000	0.000	1.00	60.6	0.174	0.100	45.89 4.7 21.4
15	0.240	15778	0.000	0.000	1.00	61.5	0.050	0.100	49.17 4.7 21.4
16	0.240	15778	0.000	0.000	1.00	52.2	0.144	0.100	52.44 4.7 21.4
17	0.240	15778	0.000	0.000	1.00	44.2	0.200	0.100	55.72 4.7 21.4
18	0.240	15778	0.000	0.000	1.00	44.2	0.200	0.100	59.00 4.7 21.4
Toe						6.3	0.150	0.100	

4.314 kips total unreduced pile weight (g= 32.17 ft/s2)  
4.314 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
55.00	10.81	1.00	0.800

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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
578.1	285.6	9.49	9.41	-1.43	4	29	32.52	4	2	18.6
587.6	322.1	9.51	9.43	-1.45	4	28	32.62	4	2	18.6
597.1	380.4	9.43	9.42	-1.47	4	28	32.49	4	3	18.5
606.6	440.8	9.45	9.45	-1.48	4	28	32.58	4	2	18.4
616.1	516.7	9.47	9.47	-1.49	4	28	32.66	4	2	18.5

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Depth	(ft)	59.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor
			1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	14.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
59.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.141

Pile and Soil Model									
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	Rut
	kips	k/in	ft	ft		kips	s/ft	inch	(kips)
1	0.240	15778	0.010	0.000	0.85	1.8	0.050	0.100	3.28 4.7 21.4
2	0.240	15778	0.000	0.000	1.00	5.4	0.050	0.100	6.56 4.7 21.4
3	0.240	15778	0.000	0.000	1.00	24.4	0.187	0.100	9.83 4.7 21.4
4	0.240	15778	0.000	0.000	1.00	32.1	0.200	0.100	13.11 4.7 21.4
5	0.240	15778	0.000	0.000	1.00	12.8	0.200	0.100	16.39 4.7 21.4
6	0.240	15778	0.000	0.000	1.00	16.5	0.129	0.100	19.67 4.7 21.4
7	0.240	15778	0.000	0.000	1.00	23.4	0.050	0.100	22.94 4.7 21.4
8	0.240	15778	0.000	0.000	1.00	33.3	0.050	0.100	26.22 4.7 21.4
9	0.240	15778	0.000	0.000	1.00	38.2	0.050	0.100	29.50 4.7 21.4
10	0.240	15778	0.000	0.000	1.00	41.4	0.050	0.100	32.78 4.7 21.4
11	0.240	15778	0.000	0.000	1.00	43.9	0.050	0.100	36.06 4.7 21.4
12	0.240	15778	0.000	0.000	1.00	47.9	0.074	0.100	39.33 4.7 21.4
13	0.240	15778	0.000	0.000	1.00	61.9	0.158	0.100	42.61 4.7 21.4
14	0.240	15778	0.000	0.000	1.00	62.2	0.050	0.100	45.89 4.7 21.4
15	0.240	15778	0.000	0.000	1.00	47.9	0.175	0.100	49.17 4.7 21.4
16	0.240	15778	0.000	0.000	1.00	44.2	0.200	0.100	52.44 4.7 21.4
18	0.240	15778	0.000	0.000	1.00	44.0	0.200	0.100	59.00 4.7 21.4
Toe						6.3	0.150	0.100	

4.314 kips total unreduced pile weight (g= 32.17 ft/s2)  
4.314 kips total reduced pile weight (g= 32.17 ft/s2)

1322L-FA-14X73

Depth      Stroke      Pressure      Efficy  
ft          ft          Ratio          0.800  
59.00      10.81      1.00

▲  
FRA-70-1322L - For Abutment - HP14x73      02/28/2021  
Resource International Inc      GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i ksi	t ksi	Comp Str ksi	i ksi	t ksi	ENTHRU kip-ft	Bl Rt b/min
631.8	564.6	9.52	9.52	-0.67	3	27	33.20	3	2	18.3
644.2	731.8	9.55	9.54	-0.68	3	27	33.31	3	2	18.3
656.6	990.5	9.58	9.54	-0.71	3	26	33.44	3	2	18.4
669.1	1474.6	9.59	9.58	-0.68	3	26	33.56	3	2	18.4
681.5	2442.6	9.61	9.61	-0.64	3	26	33.68	3	2	18.4

▲  
FRA-70-1322L - For Abutment - HP14x73      02/28/2021  
Resource International Inc      GRLWEAP Version 2010

## SUMMARY OVER DEPTHS

Depth ft	Rut kips	G/L at Frictn kips	Shaft and End Bg kips	Toe: 0.604 1.000 Bl Ct bl/ft	Com Str ksi	Ten Str ksi	Stroke ft	ENTHRU kip-ft
5.0	8.9	4.2	4.8	1.2	6.761	-0.741	3.72	21.5
10.0	36.7	33.2	3.5	3.2	17.344	-3.614	5.08	22.8
15.0	73.5	71.0	2.5	8.1	22.025	-0.772	6.05	19.8
20.0	114.5	95.2	19.3	13.5	25.932	-1.203	6.78	18.7
25.0	172.0	136.6	35.3	21.2	27.548	-1.606	7.38	18.2
30.0	234.0	194.1	39.9	29.7	29.616	-2.650	7.84	17.7
35.0	298.7	258.7	39.9	39.2	29.831	-1.594	8.21	17.8
40.0	340.7	333.8	6.8	47.1	31.113	-1.884	8.43	17.7
45.0	502.8	428.0	74.8	139.8	32.317	-2.197	9.29	19.3
50.0	510.6	504.3	6.3	137.3	33.127	-2.221	9.30	18.8
55.0	578.1	571.7	6.3	285.6	32.518	-1.433	9.49	18.6
59.0	631.8	625.4	6.3	564.6	33.200	-0.672	9.52	18.3

Total Driving Time      118 minutes;  
Starting at penetration      5.0 ft      Total No. of Blows      4612

Depth ft	Rut kips	G/L at Frictn kips	Shaft and End Bg kips	Toe: 0.637 1.000 Bl Ct bl/ft	Com Str ksi	Ten Str ksi	Stroke ft	ENTHRU kip-ft
5.0	8.9	4.2	4.8	1.2	6.761	-0.741	3.72	21.5
10.0	37.2	33.7	3.5	3.3	17.438	-3.599	5.10	22.8
15.0	75.1	72.6	2.5	8.4	22.168	-0.648	6.08	19.7
20.0	116.7	97.4	19.3	13.8	26.100	-1.209	6.82	18.6
25.0	174.2	138.9	35.3	21.7	27.659	-1.582	7.41	18.1
30.0	236.2	196.3	39.9	30.1	29.717	-2.599	7.85	17.6
35.0	300.9	261.0	39.9	39.8	29.932	-1.676	8.23	17.8
40.0	343.3	336.5	6.8	48.1	31.211	-1.797	8.44	17.6
45.0	506.0	431.2	74.8	144.4	32.406	-2.209	9.31	19.4
50.0	516.5	510.1	6.3	144.2	33.219	-2.164	9.33	18.9
55.0	587.6	581.2	6.3	322.1	32.618	-1.449	9.51	18.6
59.0	644.2	637.8	6.3	731.8	33.314	-0.681	9.55	18.3

Total Driving Time      132 minutes;  
Starting at penetration      5.0 ft      Total No. of Blows      5185

▲  
FRA-70-1322L - For Abutment - HP14x73      02/28/2021  
Resource International Inc      GRLWEAP Version 2010

## SUMMARY OVER DEPTHS

Depth ft	Rut kips	G/L at Frictn kips	Shaft and End Bg kips	Toe: 0.670 1.000 Bl Ct bl/ft	Com Str ksi	Ten Str ksi	Stroke ft	ENTHRU kip-ft
5.0	8.9	4.2	4.8	1.2	6.761	-0.741	3.72	21.5
10.0	37.7	34.2	3.5	3.3	17.530	-3.582	5.12	22.7
15.0	76.7	74.1	2.5	8.6	22.291	-0.732	6.12	19.7
20.0	118.9	99.6	19.3	14.2	26.268	-1.201	6.85	18.7
25.0	176.4	141.1	35.3	22.1	27.784	-1.556	7.43	18.1
30.0	238.4	198.5	39.9	30.3	29.876	-2.541	7.88	17.7
35.0	303.1	263.2	39.9	40.3	30.013	-1.756	8.25	17.8
40.0	346.0	339.1	6.8	48.6	31.351	-1.732	8.46	17.7
45.0	509.3	434.4	74.8	149.3	32.494	-2.229	9.33	19.4
50.0	522.3	515.9	6.3	153.6	33.404	-2.079	9.36	18.9
55.0	597.1	590.7	6.3	380.4	32.493	-1.474	9.43	18.5
59.0	656.6	650.3	6.3	990.5	33.442	-0.707	9.58	18.4

Total Driving Time      155 minutes;      Total No. of Blows      6048

Starting at penetration 5.0 ft

G/L at Shaft and Toe: 0.703 1.000									
Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU	
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft	
5.0	8.9	4.2	4.8	1.2	6.761	-0.741	3.72	21.5	
10.0	38.2	34.7	3.5	3.4	17.634	-3.558	5.13	22.6	
15.0	78.2	75.7	2.5	8.8	22.430	-0.800	6.15	19.6	
20.0	121.1	101.8	19.3	14.5	26.458	-1.188	6.88	18.6	
25.0	178.6	143.3	35.3	22.6	27.890	-1.525	7.46	18.1	
30.0	240.6	200.7	39.9	30.8	29.922	-2.489	7.89	17.6	
35.0	305.3	265.4	39.9	41.1	30.050	-1.834	8.26	17.8	
40.0	348.6	341.7	6.8	49.4	31.444	-1.672	8.49	17.7	
45.0	512.5	437.7	74.8	156.3	32.561	-2.254	9.35	19.3	
50.0	528.1	521.7	6.3	164.4	33.527	-1.985	9.38	18.9	
55.0	606.6	600.2	6.3	440.8	32.584	-1.480	9.45	18.4	
59.0	669.1	662.7	6.3	1474.6	33.565	-0.680	9.59	18.4	

Total Driving Time 190 minutes; Total No. of Blows 7394  
 Starting at penetration 5.0 ft

↑  
 FRA-70-1322L - For Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

## SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.736 1.000									
Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU	
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft	
5.0	8.9	4.2	4.8	1.2	6.761	-0.741	3.72	21.5	
10.0	38.7	35.2	3.5	3.5	17.693	-3.516	5.15	22.6	
15.0	79.8	77.3	2.5	9.1	22.540	-0.857	6.19	19.6	
20.0	123.3	104.1	19.3	14.9	26.592	-1.157	6.91	18.5	
25.0	180.8	145.5	35.3	23.1	28.004	-1.586	7.48	18.0	
30.0	242.8	202.9	39.9	31.1	30.071	-2.419	7.91	17.6	
35.0	307.5	267.6	39.9	41.4	30.158	-1.906	8.28	17.9	
40.0	351.2	344.4	6.8	50.4	31.624	-1.655	8.51	17.7	
45.0	515.7	440.9	74.8	161.8	32.644	-2.292	9.37	19.4	
50.0	533.9	527.6	6.3	176.3	33.637	-1.904	9.41	19.0	
55.0	616.1	609.7	6.3	516.7	32.664	-1.494	9.47	18.5	
59.0	681.5	675.1	6.3	2442.6	33.682	-0.641	9.61	18.4	

Total Driving Time 252 minutes; Total No. of Blows 9770  
 Starting at penetration 5.0 ft

↑  
 FRA-70-1322L - For Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

## Table of Depths Analyzed with Driving System Modifiers

Depth	Temp. Length	Wait Time	Equivalent Stroke	Pressure Ratio	Efficy.	Stiffn. Factor	Cushion CoR
ft	ft	hr	ft				
5.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
10.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
15.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
20.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
25.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
30.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
35.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
40.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
45.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
50.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
55.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00
59.00	59.00	0.00	10.81	1.00	0.80	1.00	1.00

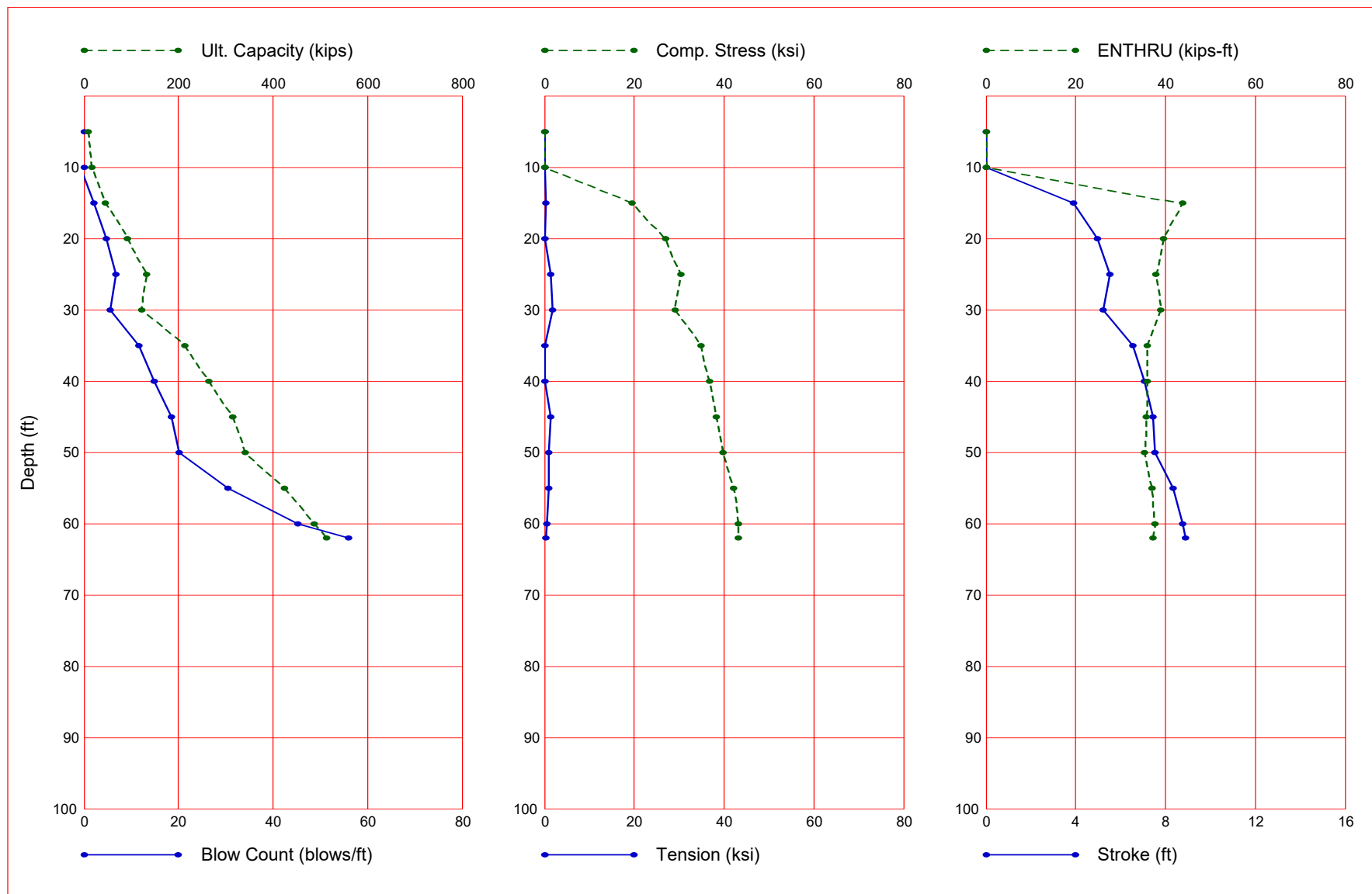
## Soil Layer Resistance Values

Depth	Shaft Res.	End Bearing	Shaft Quake	Toe Quake	Shaft Damping	Toe Damping	Soil Setup	Limit Distance	Setup Time
ft	k/ft2	kips	inch	inch	s/ft	s/ft	Normlzd	ft	hrs
0.01	0.00	0.01	0.100	0.100	0.050	0.150	0.000	6.000	1.000
7.59	0.54	7.28	0.100	0.100	0.050	0.150	0.000	6.000	1.000
7.61	2.62	3.51	0.100	0.100	0.200	0.150	0.515	6.000	24.000
13.09	2.62	3.51	0.100	0.100	0.200	0.150	0.515	6.000	24.000
13.11	1.37	2.51	0.100	0.100	0.200	0.150	1.000	6.000	168.000
18.09	1.37	2.51	0.100	0.100	0.200	0.150	1.000	6.000	168.000
18.11	1.28	17.38	0.100	0.100	0.050	0.150	0.000	6.000	1.000
23.09	1.65	22.35	0.100	0.100	0.050	0.150	0.000	6.000	1.000
23.11	2.05	33.15	0.100	0.100	0.050	0.150	0.000	6.000	1.000

1322L-FA-14X73

28.99	2.58	39.92	0.100	0.100	0.050	0.150	0.000	6.000	1.000
29.01	2.59	39.92	0.100	0.100	0.050	0.150	0.000	6.000	1.000
30.69	2.66	39.92	0.100	0.100	0.050	0.150	0.000	6.000	1.000
30.71	2.66	39.92	0.100	0.100	0.050	0.150	0.000	6.000	1.000
38.99	3.07	39.92	0.100	0.100	0.050	0.150	0.000	6.000	1.000
39.01	5.12	6.85	0.100	0.100	0.200	0.150	0.515	6.000	24.000
41.49	5.12	6.85	0.100	0.100	0.200	0.150	0.515	6.000	24.000
41.51	3.86	74.83	0.100	0.100	0.050	0.150	0.000	6.000	1.000
46.49	4.18	74.83	0.100	0.100	0.050	0.150	0.000	6.000	1.000
46.51	4.75	6.35	0.100	0.100	0.200	0.150	1.000	6.000	168.000
55.51	4.75	6.35	0.100	0.100	0.200	0.150	1.000	6.000	168.000
59.00	4.70	6.35	0.100	0.100	0.200	0.150	1.000	6.000	168.000

Gain/Loss 3 at Shaft and Toe 0.670 / 1.000



Gain/Loss 3 at Shaft and Toe 0.670 / 1.000

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
5.0	8.6	3.2	5.4	-1.0	0.000	0.000	0.00	0.0
10.0	17.6	15.5	2.1	-1.0	0.000	0.000	0.00	0.0
15.0	46.1	35.8	10.3	2.2	19.575	-0.308	3.92	43.9
20.0	92.1	58.7	33.4	4.8	26.959	-0.202	4.97	39.6
25.0	133.2	91.2	41.9	6.8	30.421	-1.290	5.54	37.8
30.0	121.9	115.5	6.3	5.5	29.024	-1.746	5.21	38.9
35.0	213.2	154.8	58.3	11.7	34.978	-0.196	6.57	36.0
40.0	264.6	201.1	63.5	14.9	36.809	0.000	7.07	35.9
45.0	315.8	252.2	63.5	18.5	38.340	-1.362	7.43	35.8
50.0	342.0	306.1	36.0	20.2	39.810	-0.924	7.55	35.2
55.0	423.3	365.0	58.3	30.4	42.210	-1.018	8.34	37.1
60.0	486.7	428.3	58.3	45.3	43.154	-0.594	8.76	37.6
62.0	513.2	454.9	58.3	56.1	43.226	-0.309	8.90	37.3

Total Continuous Driving Time 18.00 minutes; Total Number of Blows 787 (starting at penetration 5.0 ft)

GRLWEAP - Version 2010  
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.  
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ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

Input File: J:\GEOTECH\PROJECTS\2013\W-13-072 FRA-70-13.10 PROJECT 6A\ANALYSIS\FRA-70-1322L AND 1323C\DRIVEABILITY\FRA-70-1323C\REAR ABUTMENT\HP 10X42\1323C-RA-10X42.GW  
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW  
Hammer File Version: 2003 (12/4/2018)

Input File Contents

FRA-70-1323C - Rear Abutment - HP10x42  
OUT OSG HAM STR FUL PEL N SPL N-U P-D %SK ISM 0 PHI RSA ITR H-D MXT DEX  
-100 0 14 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0.000  
Pile g Hammer g Toe Area Pile Size Pile Type  
32.170 32.170 144.000 10.000 Unknown  
W Cp A Cp E Cp T Cp CoR ROut StCp  
1.900 227.000 530.0 2.000 0.800 0.010 0.0  
A Cu E Cu T Cu CoR ROut StCu  
0.000 0.0 0.000 0.000 0.000 0.0  
LPle APle EPle WPle Peri CI CoR ROut  
62.000 12.40 29000.0 492.000 3.300 0 0.850 0.010  
FFatigue F0 0-Bottom  
0 0.000 0.000  
Manufac Hmr Name HmrType No Seg-s  
DELMAG D 30-23 1 5  
Ram Wt Ram L Ram Dia MaxStrk RtdStrk Efficy  
6.60 118.10 16.51 13.44 11.18 0.80  
IB. Wt IB. L IB. Dia IB CoR IB RO  
1.20 25.00 16.51 0.900 0.010  
CompStrk A Chamber V Chamber C Delay C Duratn Exp Coeff VolCStart Vol CEnd  
16.30 214.03 280.90 0.0010 0.0020 1.250 0.00 0.00  
P atm P1 P2 P3 P4 P5  
14.70 1550.00 1395.00 1255.00 1130.00 0.00  
Stroke Effic. Pressure R-Weight T-Delay Exp-Coeff Eps-Str Total-AW  
11.1800 0.8000 1550.0000 0.0000 0.0000 0.0000 0.0100 0.0000  
Qs Qt Js Jt Qx Jx Rati Dept  
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000  
Research Soil Model: Atoe, Plug, Gap, Q-fac



0.000 0.000 0.000 0.000  
 Research Soil Model: RD-skn: m, d, toe: m, d  
 0.000 0.000 0.000 0.000  
 Research Toe Plug: Res-int, Q-int, D-int, Res-plug, Q-plug, D-plug  
 0.000 0.000 0.000 0.000 0.000 0.000  
 Research Toe Plug: RD plug toe: m, d  
 0.000 0.000

Research Toe Plug: New Toe Plug Model is NOT applied

Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimL	TSf0
0.01	0.00	0.01	0.10	0.10	0.05	0.15	1.00	6.00	1.000
9.01	0.71	9.65	0.10	0.10	0.05	0.15	1.00	6.00	1.000
9.29	0.73	9.95	0.10	0.10	0.05	0.15	1.00	6.00	1.000
9.31	2.75	2.13	0.10	0.10	0.20	0.15	1.49	6.00	168.000
11.79	2.75	2.13	0.10	0.10	0.20	0.15	1.49	6.00	168.000
11.81	0.77	8.13	0.10	0.10	0.05	0.15	1.00	6.00	1.000
16.79	1.10	11.59	0.10	0.10	0.05	0.15	1.00	6.00	1.000
16.81	1.44	27.69	0.10	0.10	0.05	0.15	1.00	6.00	1.000
24.49	2.15	41.43	0.10	0.10	0.05	0.15	1.00	6.00	1.000
24.51	2.16	41.46	0.10	0.10	0.05	0.15	1.00	6.00	1.000
25.79	2.22	42.69	0.10	0.10	0.05	0.15	1.00	6.00	1.000
25.81	1.29	6.33	0.10	0.10	0.05	0.15	1.00	6.00	1.000
30.79	1.40	6.33	0.10	0.10	0.05	0.15	1.00	6.00	1.000
30.81	2.46	58.35	0.10	0.10	0.05	0.15	1.00	6.00	1.000
39.79	2.92	58.35	0.10	0.10	0.05	0.15	1.00	6.00	1.000
39.81	2.95	63.52	0.10	0.10	0.05	0.15	1.00	6.00	1.000
45.79	3.28	63.52	0.10	0.10	0.05	0.15	1.00	6.00	1.000
45.81	3.16	35.96	0.10	0.10	0.05	0.15	1.00	6.00	1.000
50.79	3.41	35.96	0.10	0.10	0.05	0.15	1.00	6.00	1.000
50.81	3.50	58.35	0.10	0.10	0.05	0.15	1.00	6.00	1.000
59.81	3.96	58.35	0.10	0.10	0.05	0.15	1.00	6.00	1.000
62.00	4.07	58.35	0.10	0.10	0.05	0.15	1.00	6.00	1.000

Gain/Loss factors: shaft and toe

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR
0.60400	0.63700	0.67000	0.70300	0.73600			
1.00000	1.00000	1.00000	1.00000	1.00000			
5.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
10.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
15.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
20.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
25.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
30.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
35.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
40.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
45.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
50.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
55.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
60.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
62.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
0.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000

▲ GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS  
 Version 2010  
 English Units

FRA-70-1323C - Rear Abutment - HP10x42

Hammer Model: D 30-23 Made by: DELMAG

No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	1.320				
2	1.320	262846.5	1.000	0.0000	
3	1.320	262846.5	1.000	0.0000	
4	1.320	262846.5	1.000	0.0000	
5	1.320	262846.5	1.000	0.0000	
Imp Block	1.200	127693.0	0.900	0.0100	
Helmet	1.900	60155.0	0.800	0.0100	10.0
Combined Pile Top		9183.3			

HAMMER OPTIONS:

Hammer File ID No.	14	Hammer Type	OE Diesel
Stroke Option	FxdP-VarS	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Maximum		

HAMMER DATA:

Ram Weight	(kips)	6.60	Ram Length	(inch)	118.10
Maximum Stroke	(ft)	13.44			
Rated Stroke	(ft)	11.18	Efficiency		0.800
Maximum Pressure	(psi)	1550.00	Actual Pressure	(psi)	1550.00

1323C-RA-10X42  
 Compression Exponent 1.350 Expansion Exponent 1.250  
 Ram Diameter (inch) 16.51  
 Combustion Delay (s) 0.00100 Ignition Duration (s) 0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION			PILE CUSHION		
Cross Sect. Area	(in2)	227.00	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	530.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	2.00	Thickness	(inch)	0.00
Coeff of Restitution		0.8	Coeff of Restitution		1.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	60155.0	Stiffness	(kips/in)	0.0

↑  
 FRA-70-1323C - Rear Abutment - HP10x42 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth (ft) 5.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:  
 Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)				8.6	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.138	9183	0.010	0.000	0.85	0.0	0.000	0.100	3.26	3.3	12.4
2	0.138	9183	0.000	0.000	1.00	0.0	0.000	0.100	6.53	3.3	12.4
18	0.138	9183	0.000	0.000	1.00	0.4	0.050	0.100	58.74	3.3	12.4
19	0.138	9183	0.000	0.000	1.00	2.9	0.050	0.100	62.00	3.3	12.4
Toe						5.4	0.150	0.100			

2.627 kips total unredused pile weight (g= 32.17 ft/s2)  
 2.627 kips total reduced pile weight (g= 32.17 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile  
 No. of Slacks/Splices 0 Pile Segments: Automatic  
 Pile Damping (%) 1  
 Pile Damping Fact.(k/ft/s) 0.435

Driveability Analysis  
 Soil Damping Option Smith  
 Max No Analysis Iterations 0 Time Increment/Critical 160  
 Output Time Interval 1 Analysis Time-Input (ms) 0  
 Output Level: Normal  
 Gravity Mass, Pile, Hammer: 32.170 32.170 32.170  
 Output Segment Generation: Automatic

Depth	Stroke	Pressure	Efficcy
ft	ft	Ratio	
5.00	11.18	1.00	0.800

↑  
 FRA-70-1323C - Rear Abutment - HP10x42 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down up	ksi		ksi		kip-ft	b/min
8.6	Hammer did not run							
8.6	Hammer did not run							
8.6	Hammer did not run							
8.6	Hammer did not run							
8.6	Hammer did not run							

↑  
 FRA-70-1323C - Rear Abutment - HP10x42 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth (ft) 10.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

1323C-RA-10X42  
 Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)			17.2		
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.138	9183	0.010	0.000	0.85	0.0	0.000	0.100	3.26	3.3	12.4
2	0.138	9183	0.000	0.000	1.00	0.0	0.000	0.100	6.53	3.3	12.4
16	0.138	9183	0.000	0.000	1.00	0.0	0.050	0.100	52.21	3.3	12.4
17	0.138	9183	0.000	0.000	1.00	1.6	0.050	0.100	55.47	3.3	12.4
18	0.138	9183	0.000	0.000	1.00	4.3	0.050	0.100	58.74	3.3	12.4
19	0.138	9183	0.000	0.000	1.00	9.2	0.131	0.100	62.00	3.3	12.4
Toe						2.1	0.150	0.100			

2.627 kips total unreduced pile weight (g= 32.17 ft/s2)  
 2.627 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
10.00	11.18	1.00	0.800

▲ FRA-70-1323C - Rear Abutment - HP10x42 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i t Comp Str	i t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	kip-ft	b/min
17.2		Hammer did not run				
17.4		Hammer did not run				
17.6		Hammer did not run				
17.9		Hammer did not run				
18.1		Hammer did not run				

▲ FRA-70-1323C - Rear Abutment - HP10x42 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	15.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor 1.000

#### PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)			44.6		
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.138	9183	0.010	0.000	0.85	0.0	0.000	0.100	3.26	3.3	12.4
2	0.138	9183	0.000	0.000	1.00	0.0	0.000	0.100	6.53	3.3	12.4
15	0.138	9183	0.000	0.000	1.00	0.5	0.050	0.100	48.95	3.3	12.4
16	0.138	9183	0.000	0.000	1.00	3.0	0.050	0.100	52.21	3.3	12.4
17	0.138	9183	0.000	0.000	1.00	5.8	0.050	0.100	55.47	3.3	12.4
18	0.138	9183	0.000	0.000	1.00	15.3	0.188	0.100	58.74	3.3	12.4
19	0.138	9183	0.000	0.000	1.00	9.7	0.058	0.100	62.00	3.3	12.4
Toe						10.3	0.150	0.100			

2.627 kips total unreduced pile weight (g= 32.17 ft/s2)  
 2.627 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
15.00	11.18	1.00	0.800

▲ FRA-70-1323C - Rear Abutment - HP10x42 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i t Comp Str	i t ENTHRU	Bl Rt
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1323C-RA-10X42											
kips	b/ft	down	up	ksi			ksi		kip-ft	b/min	
44.6	2.1	3.86	3.89	-0.38	16	83	19.19	1	6	44.2	60.0
45.4	2.2	3.89	3.92	-0.37	16	82	19.31	1	4	44.0	59.8
46.1	2.2	3.92	3.94	-0.31	15	81	19.58	1	4	43.9	59.6
46.9	2.3	3.98	3.95	-0.27	16	79	19.80	1	4	44.0	59.3
47.6	2.3	4.00	3.98	-0.18	16	78	19.93	1	4	43.8	59.1

FRA-70-1323C - Rear Abutment - HP10x42 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth (ft) 20.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model										Total Capacity Rut (kips)	90.6
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
kips	k/in	ft	ft			kips	s/ft	inch	ft	ft	in2
1	0.138	9183	0.010	0.000	0.85	0.0	0.000	0.100	3.26	3.3	12.4
2	0.138	9183	0.000	0.000	1.00	0.0	0.000	0.100	6.53	3.3	12.4
13	0.138	9183	0.000	0.000	1.00	0.0	0.050	0.100	42.42	3.3	12.4
14	0.138	9183	0.000	0.000	1.00	1.7	0.050	0.100	45.68	3.3	12.4
15	0.138	9183	0.000	0.000	1.00	4.5	0.050	0.100	48.95	3.3	12.4
16	0.138	9183	0.000	0.000	1.00	10.0	0.143	0.100	52.21	3.3	12.4
17	0.138	9183	0.000	0.000	1.00	13.3	0.164	0.100	55.47	3.3	12.4
18	0.138	9183	0.000	0.000	1.00	10.7	0.050	0.100	58.74	3.3	12.4
19	0.138	9183	0.000	0.000	1.00	17.0	0.050	0.100	62.00	3.3	12.4
Toe						33.4	0.150	0.100			

2.627 kips total unreduced pile weight (g= 32.17 ft/s2)  
 2.627 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficcy
ft	ft	Ratio	
20.00	11.18	1.00	0.800

FRA-70-1323C - Rear Abutment - HP10x42 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	b/min	
90.6	4.7	4.93	4.89	0.00	1	0	26.70	53.1
91.4	4.7	4.95	4.91	-0.06	15	50	26.83	53.0
92.1	4.8	4.97	4.92	-0.20	15	50	26.96	52.9
92.9	4.8	4.99	4.94	-0.34	15	50	27.07	52.8
93.6	4.9	5.00	4.96	-0.46	15	50	27.18	52.7

FRA-70-1323C - Rear Abutment - HP10x42 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth (ft) 25.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model										Total Capacity Rut (kips)	131.7
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
kips	k/in	ft	ft			kips	s/ft	inch	ft	ft	in2
1	0.138	9183	0.010	0.000	0.85	0.0	0.000	0.100	3.26	3.3	12.4
2	0.138	9183	0.000	0.000	1.00	0.0	0.000	0.100	6.53	3.3	12.4
12	0.138	9183	0.000	0.000	1.00	0.6	0.050	0.100	39.16	3.3	12.4
13	0.138	9183	0.000	0.000	1.00	3.2	0.050	0.100	42.42	3.3	12.4

1323C-RA-10X42											
14	0.138	9183	0.000	0.000	1.00	6.0	0.050	0.100	45.68	3.3	12.4
15	0.138	9183	0.000	0.000	1.00	15.6	0.188	0.100	48.95	3.3	12.4
16	0.138	9183	0.000	0.000	1.00	9.6	0.050	0.100	52.21	3.3	12.4
17	0.138	9183	0.000	0.000	1.00	13.9	0.050	0.100	55.47	3.3	12.4
18	0.138	9183	0.000	0.000	1.00	18.8	0.050	0.100	58.74	3.3	12.4
19	0.138	9183	0.000	0.000	1.00	22.1	0.050	0.100	62.00	3.3	12.4
Toe						41.9	0.150	0.100			

2.627 kips total unredused pile weight (g= 32.17 ft/s2)

2.627 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
25.00	11.18	1.00	0.800

FRA-70-1323C - Rear Abutment - HP10x42 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down up	ksi		ksi		kip-ft	b/min
131.7	6.7	5.51 5.50	-1.31	13	44 30.09	15	5 37.8	50.1
132.4	6.8	5.52 5.51	-1.30	12	44 30.23	15	5 37.8	50.0
133.2	6.8	5.54 5.53	-1.29	12	44 30.42	15	5 37.8	49.9
133.9	6.9	5.50 5.55	-1.29	12	44 30.34	15	5 37.4	50.0
134.7	7.0	5.52 5.57	-1.28	12	44 30.47	15	5 37.3	49.9

FRA-70-1323C - Rear Abutment - HP10x42 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	30.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor 1.000

#### PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	10.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model										Total Capacity Rut (kips)	120.4
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.138	9183	0.010	0.000	0.85	0.0	0.000	0.100	3.26	3.3	12.4
2	0.138	9183	0.000	0.000	1.00	0.0	0.000	0.100	6.53	3.3	12.4
10	0.138	9183	0.000	0.000	1.00	0.1	0.050	0.100	32.63	3.3	12.4
11	0.138	9183	0.000	0.000	1.00	1.9	0.050	0.100	35.89	3.3	12.4
12	0.138	9183	0.000	0.000	1.00	4.7	0.050	0.100	39.16	3.3	12.4
13	0.138	9183	0.000	0.000	1.00	10.7	0.153	0.100	42.42	3.3	12.4
14	0.138	9183	0.000	0.000	1.00	12.8	0.156	0.100	45.68	3.3	12.4
15	0.138	9183	0.000	0.000	1.00	11.0	0.050	0.100	48.95	3.3	12.4
16	0.138	9183	0.000	0.000	1.00	17.3	0.050	0.100	52.21	3.3	12.4
17	0.138	9183	0.000	0.000	1.00	20.6	0.050	0.100	55.47	3.3	12.4
18	0.138	9183	0.000	0.000	1.00	20.5	0.050	0.100	58.74	3.3	12.4
19	0.138	9183	0.000	0.000	1.00	14.5	0.050	0.100	62.00	3.3	12.4
Toe						6.3	0.150	0.100			

2.627 kips total unredused pile weight (g= 32.17 ft/s2)

2.627 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
30.00	11.18	1.00	0.800

FRA-70-1323C - Rear Abutment - HP10x42 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down up	ksi		ksi		kip-ft	b/min
120.4	5.4	5.12 5.14	-1.60	11	45 28.69	10	6 38.7	51.9
121.1	5.5	5.14 5.15	-1.70	11	45 28.87	11	6 38.7	51.8
121.9	5.5	5.21 5.15	-1.75	11	45 29.02	10	6 38.9	51.7
122.6	5.6	5.22 5.17	-1.82	11	45 29.13	10	6 38.9	51.6
123.4	5.6	5.23 5.19	-1.87	11	45 29.24	10	6 38.8	51.5

FRA-70-1323C - Rear Abutment - HP10x42 02/28/2021

Resource International Inc

Depth (ft) 35.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)				211.7	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.138	9183	0.010	0.000	0.85	0.0	0.000	0.100	3.26	3.3	12.4
2	0.138	9183	0.000	0.000	1.00	0.0	0.000	0.100	6.53	3.3	12.4
9	0.138	9183	0.000	0.000	1.00	0.7	0.050	0.100	29.37	3.3	12.4
10	0.138	9183	0.000	0.000	1.00	3.4	0.050	0.100	32.63	3.3	12.4
11	0.138	9183	0.000	0.000	1.00	6.2	0.050	0.100	35.89	3.3	12.4
12	0.138	9183	0.000	0.000	1.00	15.6	0.188	0.100	39.16	3.3	12.4
13	0.138	9183	0.000	0.000	1.00	9.8	0.050	0.100	42.42	3.3	12.4
14	0.138	9183	0.000	0.000	1.00	14.3	0.050	0.100	45.68	3.3	12.4
15	0.138	9183	0.000	0.000	1.00	19.0	0.050	0.100	48.95	3.3	12.4
16	0.138	9183	0.000	0.000	1.00	22.3	0.050	0.100	52.21	3.3	12.4
17	0.138	9183	0.000	0.000	1.00	15.9	0.050	0.100	55.47	3.3	12.4
18	0.138	9183	0.000	0.000	1.00	18.2	0.050	0.100	58.74	3.3	12.4
19	0.138	9183	0.000	0.000	1.00	27.9	0.050	0.100	62.00	3.3	12.4
Toe						58.3	0.150	0.100			

2.627 kips total unredacted pile weight (g= 32.17 ft/s2)  
2.627 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
35.00	11.18	1.00	0.800

▲ FRA-70-1323C - Rear Abutment - HP10x42 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
211.7	11.5	6.55	6.50	-0.32	10	34	34.73	12	4	36.1
212.4	11.6	6.55	6.52	-0.26	10	34	34.79	12	4	36.0
213.2	11.7	6.57	6.53	-0.20	10	34	34.98	12	4	36.0
213.9	11.8	6.58	6.55	-0.13	10	34	35.11	12	4	36.0
214.6	11.9	6.60	6.57	-0.06	10	34	35.20	12	4	35.9

▲ FRA-70-1323C - Rear Abutment - HP10x42 02/28/2021  
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Depth (ft) 40.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)				263.1	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.138	9183	0.010	0.000	0.85	0.0	0.000	0.100	3.26	3.3	12.4
2	0.138	9183	0.000	0.000	1.00	0.0	0.000	0.100	6.53	3.3	12.4
7	0.138	9183	0.000	0.000	1.00	0.1	0.050	0.100	22.84	3.3	12.4
8	0.138	9183	0.000	0.000	1.00	2.1	0.050	0.100	26.11	3.3	12.4
9	0.138	9183	0.000	0.000	1.00	4.9	0.050	0.100	29.37	3.3	12.4
10	0.138	9183	0.000	0.000	1.00	11.5	0.161	0.100	32.63	3.3	12.4
11	0.138	9183	0.000	0.000	1.00	12.2	0.146	0.100	35.89	3.3	12.4
12	0.138	9183	0.000	0.000	1.00	11.4	0.050	0.100	39.16	3.3	12.4

1323C-RA-10X42												
13	0.138	9183	0.000	0.000	1.00	17.5	0.050	0.100	42.42	3.3	12.4	
14	0.138	9183	0.000	0.000	1.00	20.8	0.050	0.100	45.68	3.3	12.4	
15	0.138	9183	0.000	0.000	1.00	20.0	0.050	0.100	48.95	3.3	12.4	
16	0.138	9183	0.000	0.000	1.00	14.5	0.050	0.100	52.21	3.3	12.4	
17	0.138	9183	0.000	0.000	1.00	25.0	0.050	0.100	55.47	3.3	12.4	
18	0.138	9183	0.000	0.000	1.00	28.9	0.050	0.100	58.74	3.3	12.4	
19	0.138	9183	0.000	0.000	1.00	30.7	0.050	0.100	62.00	3.3	12.4	
Toe						63.5	0.150	0.100				

2.627 kips total unredacted pile weight (g= 32.17 ft/s2)  
2.627 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
40.00	11.18	1.00	0.800

▲  
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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i ksi	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min	
263.1	14.8	7.04	7.04	0.00	1	0	36.53	10	4	35.8	44.3
263.8	14.8	7.06	7.05	0.00	1	0	36.71	10	4	35.9	44.3
264.6	14.9	7.07	7.06	0.00	1	0	36.81	10	4	35.9	44.2
265.3	15.0	7.07	7.07	0.00	1	0	36.87	10	4	35.8	44.2
266.1	15.0	7.09	7.08	0.00	1	0	36.97	10	4	35.8	44.2

▲  
FRA-70-1323C - Rear Abutment - HP10x42 02/28/2021  
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Depth	(ft)	45.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor
			1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	10.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model										Total Capacity	Rut	(kips)	314.3
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area		
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2		
1	0.138	9183	0.010	0.000	0.85	0.0	0.000	0.100	3.26	3.3	12.4		
2	0.138	9183	0.000	0.000	1.00	0.0	0.000	0.100	6.53	3.3	12.4		
6	0.138	9183	0.000	0.000	1.00	0.9	0.050	0.100	19.58	3.3	12.4		
7	0.138	9183	0.000	0.000	1.00	3.6	0.050	0.100	22.84	3.3	12.4		
8	0.138	9183	0.000	0.000	1.00	6.3	0.050	0.100	26.11	3.3	12.4		
9	0.138	9183	0.000	0.000	1.00	15.7	0.188	0.100	29.37	3.3	12.4		
10	0.138	9183	0.000	0.000	1.00	9.9	0.050	0.100	32.63	3.3	12.4		
11	0.138	9183	0.000	0.000	1.00	14.7	0.050	0.100	35.89	3.3	12.4		
12	0.138	9183	0.000	0.000	1.00	19.2	0.050	0.100	39.16	3.3	12.4		
13	0.138	9183	0.000	0.000	1.00	22.4	0.050	0.100	42.42	3.3	12.4		
14	0.138	9183	0.000	0.000	1.00	15.3	0.050	0.100	45.68	3.3	12.4		
15	0.138	9183	0.000	0.000	1.00	19.0	0.050	0.100	48.95	3.3	12.4		
16	0.138	9183	0.000	0.000	1.00	28.0	0.050	0.100	52.21	3.3	12.4		
17	0.138	9183	0.000	0.000	1.00	29.8	0.050	0.100	55.47	3.3	12.4		
18	0.138	9183	0.000	0.000	1.00	31.8	0.050	0.100	58.74	3.3	12.4		
19	0.138	9183	0.000	0.000	1.00	33.9	0.050	0.100	62.00	3.3	12.4		
Toe						63.5	0.150	0.100					

2.627 kips total unredacted pile weight (g= 32.17 ft/s2)  
2.627 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
45.00	11.18	1.00	0.800

▲  
FRA-70-1323C - Rear Abutment - HP10x42 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt	
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min	
314.3	18.3	7.41	7.46	-1.38	7	48	38.17	7	7	35.9	43.2
315.0	18.4	7.42	7.47	-1.38	7	48	38.31	7	7	35.9	43.1

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315.8	18.5	7.43	7.49	-1.36	7	48	38.34	7	7	35.8	43.1
316.5	18.6	7.44	7.50	-1.35	7	48	38.47	7	7	35.8	43.1
317.3	18.7	7.46	7.51	-1.35	7	48	38.61	7	7	35.8	43.0

FRA-70-1323C - Rear Abutment - HP10x42  
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Depth	(ft)	50.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	10.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)				340.5	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.138	9183	0.010	0.000	0.85	0.0	0.000	0.100	3.26	3.3	12.4
2	0.138	9183	0.000	0.000	1.00	0.0	0.000	0.100	6.53	3.3	12.4
4	0.138	9183	0.000	0.000	1.00	0.1	0.050	0.100	13.05	3.3	12.4
5	0.138	9183	0.000	0.000	1.00	2.3	0.050	0.100	16.32	3.3	12.4
6	0.138	9183	0.000	0.000	1.00	5.1	0.050	0.100	19.58	3.3	12.4
7	0.138	9183	0.000	0.000	1.00	12.2	0.168	0.100	22.84	3.3	12.4
8	0.138	9183	0.000	0.000	1.00	11.7	0.136	0.100	26.11	3.3	12.4
9	0.138	9183	0.000	0.000	1.00	11.8	0.050	0.100	29.37	3.3	12.4
10	0.138	9183	0.000	0.000	1.00	17.7	0.050	0.100	32.63	3.3	12.4
11	0.138	9183	0.000	0.000	1.00	21.0	0.050	0.100	35.89	3.3	12.4
12	0.138	9183	0.000	0.000	1.00	19.5	0.050	0.100	39.16	3.3	12.4
13	0.138	9183	0.000	0.000	1.00	14.6	0.050	0.100	42.42	3.3	12.4
14	0.138	9183	0.000	0.000	1.00	25.9	0.050	0.100	45.68	3.3	12.4
15	0.138	9183	0.000	0.000	1.00	29.0	0.050	0.100	48.95	3.3	12.4
16	0.138	9183	0.000	0.000	1.00	30.8	0.050	0.100	52.21	3.3	12.4
17	0.138	9183	0.000	0.000	1.00	33.0	0.050	0.100	55.47	3.3	12.4
18	0.138	9183	0.000	0.000	1.00	34.6	0.050	0.100	58.74	3.3	12.4
19	0.138	9183	0.000	0.000	1.00	35.4	0.050	0.100	62.00	3.3	12.4
Toe						36.0	0.150	0.100			

2.627 kips total unredused pile weight (g= 32.17 ft/s2)  
 2.627 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
50.00	11.18	1.00	0.800

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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	b/min	
340.5	20.0	7.53	7.60	-0.96	6 46	39.65	6 7	35.2 42.8
341.3	20.1	7.54	7.61	-0.94	6 46	39.72	6 7	35.2 42.8
342.0	20.2	7.55	7.62	-0.92	6 46	39.81	6 7	35.2 42.8
342.8	20.3	7.56	7.63	-0.91	6 46	39.94	6 7	35.3 42.7
343.5	20.4	7.58	7.64	-0.89	6 46	40.01	6 7	35.3 42.7

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Depth	(ft)	55.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	10.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model	Total Capacity Rut (kips)	421.8
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1323C-RA-10X42											
No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.138	9183	0.010	0.000	0.85	0.0	0.000	0.100	3.26	3.3	12.4
2	0.138	9183	0.000	0.000	1.00	0.0	0.000	0.100	6.53	3.3	12.4
3	0.138	9183	0.000	0.000	1.00	1.0	0.050	0.100	9.79	3.3	12.4
4	0.138	9183	0.000	0.000	1.00	3.8	0.050	0.100	13.05	3.3	12.4
5	0.138	9183	0.000	0.000	1.00	6.6	0.052	0.100	16.32	3.3	12.4
6	0.138	9183	0.000	0.000	1.00	15.7	0.187	0.100	19.58	3.3	12.4
7	0.138	9183	0.000	0.000	1.00	10.1	0.050	0.100	22.84	3.3	12.4
8	0.138	9183	0.000	0.000	1.00	15.2	0.050	0.100	26.11	3.3	12.4
9	0.138	9183	0.000	0.000	1.00	19.4	0.050	0.100	29.37	3.3	12.4
10	0.138	9183	0.000	0.000	1.00	22.6	0.050	0.100	32.63	3.3	12.4
11	0.138	9183	0.000	0.000	1.00	14.7	0.050	0.100	35.89	3.3	12.4
12	0.138	9183	0.000	0.000	1.00	19.9	0.050	0.100	39.16	3.3	12.4
13	0.138	9183	0.000	0.000	1.00	28.1	0.050	0.100	42.42	3.3	12.4
14	0.138	9183	0.000	0.000	1.00	29.9	0.050	0.100	45.68	3.3	12.4
15	0.138	9183	0.000	0.000	1.00	32.0	0.050	0.100	48.95	3.3	12.4
16	0.138	9183	0.000	0.000	1.00	34.0	0.050	0.100	52.21	3.3	12.4
17	0.138	9183	0.000	0.000	1.00	34.8	0.050	0.100	55.47	3.3	12.4
18	0.138	9183	0.000	0.000	1.00	36.6	0.050	0.100	58.74	3.3	12.4
19	0.138	9183	0.000	0.000	1.00	39.1	0.050	0.100	62.00	3.3	12.4
Toe						58.3	0.150	0.100			

2.627 kips total unreduded pile weight (g= 32.17 ft/s2)  
2.627 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy Ratio
55.00	11.18	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	ksi	i	t	Comp	Str	ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
421.8	30.1	8.32	8.30	-1.02	4	40	41.99	6	7	36.9	40.9		
422.6	30.3	8.33	8.31	-1.02	4	40	42.10	6	7	37.0	40.9		
423.3	30.4	8.34	8.31	-1.02	4	40	42.21	6	7	37.1	40.8		
424.1	30.8	8.35	8.33	-1.00	4	40	42.19	6	7	37.0	40.8		
424.8	31.0	8.36	8.33	-1.00	4	40	42.31	6	7	37.0	40.8		

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 Resource International Inc
 

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Depth	(ft)	60.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor
			1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	10.000		

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model											
No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.138	9183	0.010	0.000	0.85	0.2	0.050	0.100	3.26	3.3	12.4
2	0.138	9183	0.000	0.000	1.00	2.5	0.050	0.100	6.53	3.3	12.4
3	0.138	9183	0.000	0.000	1.00	5.2	0.050	0.100	9.79	3.3	12.4
4	0.138	9183	0.000	0.000	1.00	13.0	0.174	0.100	13.05	3.3	12.4
5	0.138	9183	0.000	0.000	1.00	11.2	0.123	0.100	16.32	3.3	12.4
6	0.138	9183	0.000	0.000	1.00	12.2	0.050	0.100	19.58	3.3	12.4
7	0.138	9183	0.000	0.000	1.00	17.9	0.050	0.100	22.84	3.3	12.4
8	0.138	9183	0.000	0.000	1.00	21.2	0.050	0.100	26.11	3.3	12.4
9	0.138	9183	0.000	0.000	1.00	18.9	0.050	0.100	29.37	3.3	12.4
10	0.138	9183	0.000	0.000	1.00	14.7	0.050	0.100	32.63	3.3	12.4
11	0.138	9183	0.000	0.000	1.00	26.7	0.050	0.100	35.89	3.3	12.4
12	0.138	9183	0.000	0.000	1.00	29.1	0.050	0.100	39.16	3.3	12.4
13	0.138	9183	0.000	0.000	1.00	30.9	0.050	0.100	42.42	3.3	12.4
14	0.138	9183	0.000	0.000	1.00	33.1	0.050	0.100	45.68	3.3	12.4
15	0.138	9183	0.000	0.000	1.00	34.6	0.050	0.100	48.95	3.3	12.4
16	0.138	9183	0.000	0.000	1.00	35.5	0.050	0.100	52.21	3.3	12.4
17	0.138	9183	0.000	0.000	1.00	38.1	0.050	0.100	55.47	3.3	12.4
18	0.138	9183	0.000	0.000	1.00	40.0	0.050	0.100	58.74	3.3	12.4
19	0.138	9183	0.000	0.000	1.00	41.8	0.050	0.100	62.00	3.3	12.4

Toe 58.3 0.150 0.100

2.627 kips total unreduced pile weight (g= 32.17 ft/s2)  
2.627 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
60.00	11.18	1.00	0.800

↑  
FRA-70-1323C - Rear Abutment - HP10x42 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i t Comp Str ksi	i t ENTHRU kip-ft	Bl Rt b/min
485.2	44.7	8.75	8.70	-0.61	3 37 43.05	4 6 37.5 39.9
485.9	45.2	8.75	8.71	-0.59	3 37 43.06	4 6 37.4 39.9
486.7	45.3	8.76	8.71	-0.59	3 37 43.15	4 6 37.6 39.9
487.4	45.9	8.76	8.71	-0.58	3 37 43.17	4 6 37.5 39.9
488.2	46.6	8.77	8.73	-0.56	3 37 43.17	4 6 37.4 39.9

↑  
FRA-70-1323C - Rear Abutment - HP10x42 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth ft	Stroke ft	Pressure Ratio	Efficy
62.0	11.18	1.00	0.800

#### PILE PROFILE:

Toe Area in2	Pile Size inch	144.000 10.000	Pile Type	Unknown
-----------------	-------------------	-------------------	-----------	---------

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
62.0	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.504

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.138	9183	0.010	0.000	0.85	1.4	0.050	0.100	3.26	3.3	12.4
2	0.138	9183	0.000	0.000	1.00	4.2	0.050	0.100	6.53	3.3	12.4
3	0.138	9183	0.000	0.000	1.00	8.4	0.115	0.100	9.79	3.3	12.4
4	0.138	9183	0.000	0.000	1.00	14.4	0.176	0.100	13.05	3.3	12.4
5	0.138	9183	0.000	0.000	1.00	10.4	0.050	0.100	16.32	3.3	12.4
6	0.138	9183	0.000	0.000	1.00	16.1	0.050	0.100	19.58	3.3	12.4
7	0.138	9183	0.000	0.000	1.00	19.9	0.050	0.100	22.84	3.3	12.4
8	0.138	9183	0.000	0.000	1.00	22.1	0.050	0.100	26.11	3.3	12.4
9	0.138	9183	0.000	0.000	1.00	14.3	0.050	0.100	29.37	3.3	12.4
10	0.138	9183	0.000	0.000	1.00	21.7	0.050	0.100	32.63	3.3	12.4
11	0.138	9183	0.000	0.000	1.00	28.4	0.050	0.100	35.89	3.3	12.4
12	0.138	9183	0.000	0.000	1.00	30.2	0.050	0.100	39.16	3.3	12.4
13	0.138	9183	0.000	0.000	1.00	32.3	0.050	0.100	42.42	3.3	12.4
14	0.138	9183	0.000	0.000	1.00	34.3	0.050	0.100	45.68	3.3	12.4
15	0.138	9183	0.000	0.000	1.00	34.9	0.050	0.100	48.95	3.3	12.4
16	0.138	9183	0.000	0.000	1.00	37.0	0.050	0.100	52.21	3.3	12.4
17	0.138	9183	0.000	0.000	1.00	39.3	0.050	0.100	55.47	3.3	12.4
18	0.138	9183	0.000	0.000	1.00	41.1	0.050	0.100	58.74	3.3	12.4
19	0.138	9183	0.000	0.000	1.00	42.9	0.050	0.100	62.00	3.3	12.4
Toe						58.3	0.150	0.100			

2.627 kips total unreduced pile weight (g= 32.17 ft/s2)  
2.627 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
62.00	11.18	1.00	0.800

↑  
FRA-70-1323C - Rear Abutment - HP10x42 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i t Comp Str ksi	i t ENTHRU kip-ft	Bl Rt b/min
511.7	54.5	8.89	8.83	-0.33	2 36 43.19	3 6 37.5 39.7
512.5	55.2	8.89	8.84	-0.32	2 36 43.21	3 6 37.4 39.6
513.2	56.1	8.90	8.84	-0.31	2 36 43.23	3 6 37.3 39.7
514.0	56.2	8.90	8.84	-0.31	2 36 43.31	3 6 37.5 39.7
514.7	57.0	8.91	8.84	-0.30	2 36 43.34	3 6 37.4 39.6

SUMMARY OVER DEPTHS

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	8.6	3.2	5.4	Hammer	did not	run		
10.0	17.2	15.1	2.1	Hammer	did not	run		
15.0	44.6	34.3	10.3	2.1	19.186	-0.377	3.86	44.2
20.0	90.6	57.3	33.4	4.7	26.696	0.000	4.93	39.7
25.0	131.7	89.7	41.9	6.7	30.091	-1.308	5.51	37.8
30.0	120.4	114.1	6.3	5.4	28.691	-1.601	5.12	38.7
35.0	211.7	153.3	58.3	11.5	34.727	-0.324	6.55	36.1
40.0	263.1	199.6	63.5	14.8	36.530	0.000	7.04	35.8
45.0	314.3	250.7	63.5	18.3	38.169	-1.383	7.41	35.9
50.0	340.5	304.6	36.0	20.0	39.646	-0.957	7.53	35.2
55.0	421.8	363.5	58.3	30.1	41.986	-1.016	8.32	36.9
60.0	485.2	426.8	58.3	44.7	43.053	-0.611	8.75	37.5
62.0	511.7	453.4	58.3	54.5	43.187	-0.328	8.89	37.5

Total Driving Time 18 minutes; Total No. of Blows 776  
Starting at penetration 5.0 ft

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	8.6	3.2	5.4	Hammer	did not	run		
10.0	17.4	15.3	2.1	Hammer	did not	run		
15.0	45.4	35.0	10.3	2.2	19.307	-0.372	3.89	44.0
20.0	91.4	58.0	33.4	4.7	26.831	-0.063	4.95	39.6
25.0	132.4	90.5	41.9	6.8	30.227	-1.298	5.52	37.8
30.0	121.1	114.8	6.3	5.5	28.866	-1.698	5.14	38.7
35.0	212.4	154.1	58.3	11.6	34.787	-0.259	6.55	36.0
40.0	263.8	200.3	63.5	14.8	36.705	0.000	7.06	35.9
45.0	315.0	251.5	63.5	18.4	38.314	-1.377	7.42	35.9
50.0	341.3	305.3	36.0	20.1	39.724	-0.940	7.54	35.2
55.0	422.6	364.2	58.3	30.3	42.103	-1.017	8.33	37.0
60.0	485.9	427.6	58.3	45.2	43.061	-0.591	8.75	37.4
62.0	512.5	454.1	58.3	55.2	43.206	-0.318	8.89	37.4

Total Driving Time 18 minutes; Total No. of Blows 783  
Starting at penetration 5.0 ft

SUMMARY OVER DEPTHS

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	8.6	3.2	5.4	Hammer	did not	run		
10.0	17.6	15.5	2.1	Hammer	did not	run		
15.0	46.1	35.8	10.3	2.2	19.575	-0.308	3.92	43.9
20.0	92.1	58.7	33.4	4.8	26.959	-0.202	4.97	39.6
25.0	133.2	91.2	41.9	6.8	30.421	-1.290	5.54	37.8
30.0	121.9	115.5	6.3	5.5	29.024	-1.746	5.21	38.9
35.0	213.2	154.8	58.3	11.7	34.978	-0.196	6.57	36.0
40.0	264.6	201.1	63.5	14.9	36.809	0.000	7.07	35.9
45.0	315.8	252.2	63.5	18.5	38.340	-1.362	7.43	35.8
50.0	342.0	306.1	36.0	20.2	39.810	-0.924	7.55	35.2
55.0	423.3	365.0	58.3	30.4	42.210	-1.018	8.34	37.1
60.0	486.7	428.3	58.3	45.3	43.154	-0.594	8.76	37.6
62.0	513.2	454.9	58.3	56.1	43.226	-0.309	8.90	37.3

Total Driving Time 18 minutes; Total No. of Blows 787  
Starting at penetration 5.0 ft

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	8.6	3.2	5.4	Hammer	did not	run		
10.0	17.9	15.7	2.1	Hammer	did not	run		
15.0	46.9	36.5	10.3	2.3	19.802	-0.273	3.98	44.0
20.0	92.9	59.5	33.4	4.8	27.074	-0.336	4.99	39.5
25.0	133.9	92.0	41.9	6.9	30.340	-1.287	5.50	37.4
30.0	122.6	116.3	6.3	5.6	29.129	-1.815	5.22	38.9
35.0	213.9	155.6	58.3	11.8	35.108	-0.130	6.58	36.0
40.0	265.3	201.8	63.5	15.0	36.867	0.000	7.07	35.8

1323C-RA-10X42								
45.0	316.5	253.0	63.5	18.6	38.471	-1.355	7.44	35.8
50.0	342.8	306.8	36.0	20.3	39.937	-0.909	7.56	35.3
55.0	424.1	365.7	58.3	30.8	42.191	-0.997	8.35	37.0
60.0	487.4	429.1	58.3	45.9	43.168	-0.576	8.76	37.5
62.0	514.0	455.6	58.3	56.2	43.311	-0.309	8.90	37.5

Total Driving Time 19 minutes; Total No. of Blows 795  
Starting at penetration 5.0 ft

▲  
FRA-70-1323C - Rear Abutment - HP10x42 02/28/2021  
Resource International Inc GRLWEAP Version 2010

#### SUMMARY OVER DEPTHS

Depth ft	Rut kips	G/L at Frictn kips	Shaft and End Bg kips	Toe: Bl Ct bl/ft	0.736 Com Str ksi	1.000 Ten Str ksi	Stroke ft	ENTHRU kip-ft
5.0	8.6	3.2	5.4	Hammer	did not	run		
10.0	18.1	15.9	2.1	Hammer	did not	run		
15.0	47.6	37.3	10.3	2.3	19.930	-0.184	4.00	43.8
20.0	93.6	60.2	33.4	4.9	27.179	-0.465	5.00	39.4
25.0	134.7	92.7	41.9	7.0	30.473	-1.277	5.52	37.3
30.0	123.4	117.0	6.3	5.6	29.242	-1.875	5.23	38.8
35.0	214.6	156.3	58.3	11.9	35.199	-0.062	6.60	35.9
40.0	266.1	202.5	63.5	15.0	36.973	0.000	7.09	35.8
45.0	317.3	253.7	63.5	18.7	38.612	-1.349	7.46	35.8
50.0	343.5	307.6	36.0	20.4	40.013	-0.894	7.58	35.3
55.0	424.8	366.5	58.3	31.0	42.312	-0.999	8.36	37.0
60.0	488.2	429.8	58.3	46.6	43.172	-0.556	8.77	37.4
62.0	514.7	456.3	58.3	57.0	43.338	-0.302	8.91	37.4

Total Driving Time 19 minutes; Total No. of Blows 803  
Starting at penetration 5.0 ft

▲  
FRA-70-1323C - Rear Abutment - HP10x42 02/28/2021  
Resource International Inc GRLWEAP Version 2010

#### Table of Depths Analyzed with Driving System Modifiers

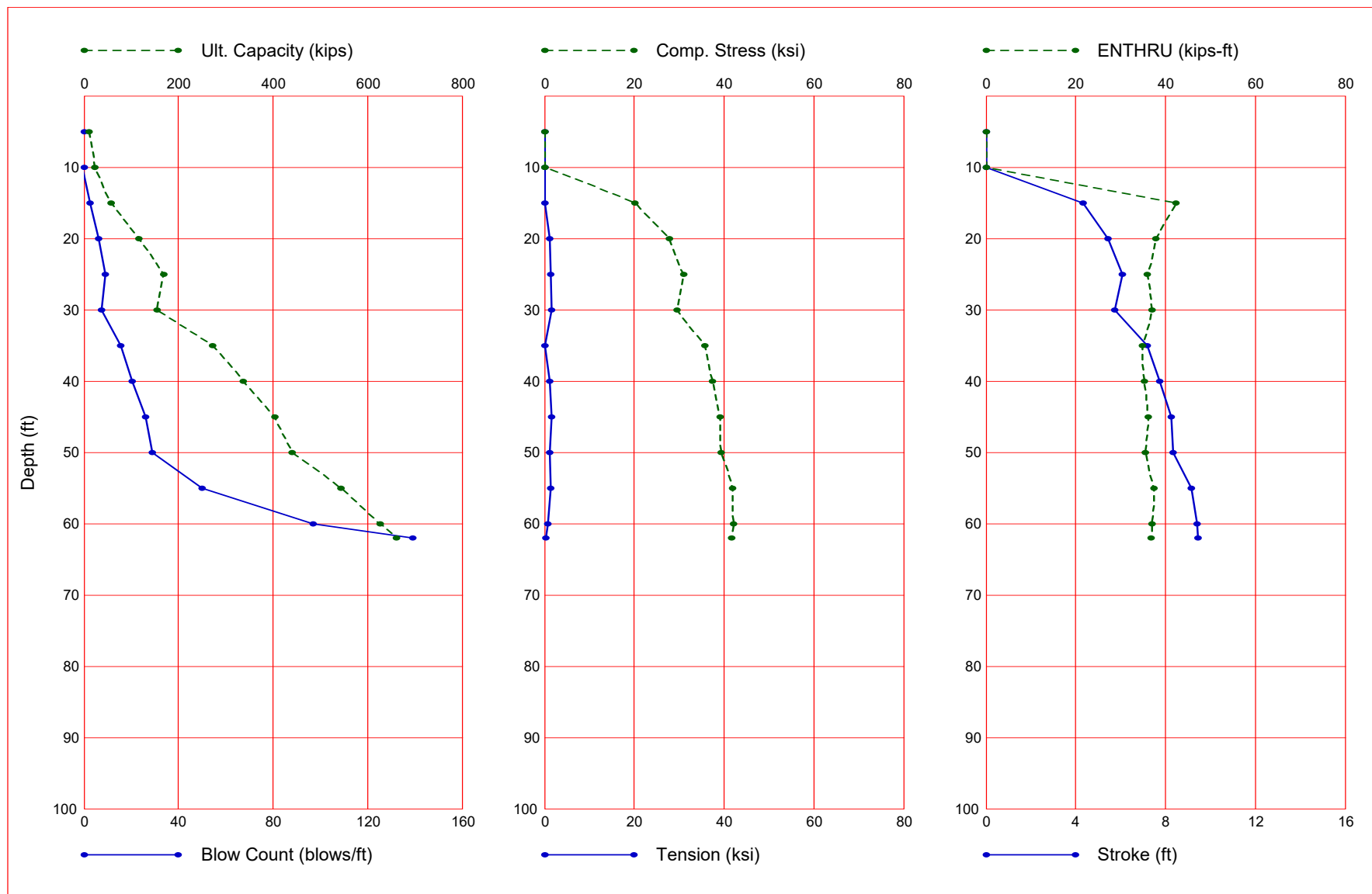
Depth ft	Temp. Length ft	Wait Time hr	Equivalent Stroke ft	Pressure Ratio	Efficy.	Stiffn. Factor	Cushion CoR
5.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
10.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
15.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
20.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
25.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
30.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
35.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
40.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
45.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
50.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
55.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
60.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
62.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00

#### Soil Layer Resistance Values

Depth ft	Shaft Res. k/ft2	End Bearing kips	Shaft Quake inch	Toe Quake inch	Shaft Damping s/ft	Toe Damping s/ft	Soil Setup Normlzd	Limit Distance ft	Setup Time hrs
0.01	0.00	0.01	0.100	0.100	0.050	0.150	0.000	6.000	1.000
9.01	0.71	9.65	0.100	0.100	0.050	0.150	0.000	6.000	1.000
9.29	0.73	9.95	0.100	0.100	0.050	0.150	0.000	6.000	1.000
9.31	2.75	2.13	0.100	0.100	0.200	0.150	1.000	6.000	168.000
11.79	2.75	2.13	0.100	0.100	0.200	0.150	1.000	6.000	168.000
11.81	0.77	8.13	0.100	0.100	0.050	0.150	0.000	6.000	1.000
16.79	1.10	11.59	0.100	0.100	0.050	0.150	0.000	6.000	1.000
16.81	1.44	27.69	0.100	0.100	0.050	0.150	0.000	6.000	1.000
24.49	2.15	41.43	0.100	0.100	0.050	0.150	0.000	6.000	1.000
24.51	2.16	41.46	0.100	0.100	0.050	0.150	0.000	6.000	1.000
25.79	2.22	42.69	0.100	0.100	0.050	0.150	0.000	6.000	1.000
25.81	1.29	6.33	0.100	0.100	0.050	0.150	0.000	6.000	1.000
30.79	1.40	6.33	0.100	0.100	0.050	0.150	0.000	6.000	1.000
30.81	2.46	58.35	0.100	0.100	0.050	0.150	0.000	6.000	1.000
39.79	2.92	58.35	0.100	0.100	0.050	0.150	0.000	6.000	1.000
39.81	2.95	63.52	0.100	0.100	0.050	0.150	0.000	6.000	1.000
45.79	3.28	63.52	0.100	0.100	0.050	0.150	0.000	6.000	1.000
45.81	3.16	35.96	0.100	0.100	0.050	0.150	0.000	6.000	1.000
50.79	3.41	35.96	0.100	0.100	0.050	0.150	0.000	6.000	1.000

								1323C-RA-10X42		
50.81	3.50	58.35	0.100	0.100	0.050	0.150	0.000	6.000	1.000	
59.81	3.96	58.35	0.100	0.100	0.050	0.150	0.000	6.000	1.000	
62.00	4.07	58.35	0.100	0.100	0.050	0.150	0.000	6.000	1.000	

Gain/Loss 3 at Shaft and Toe 0.670 / 1.000



Gain/Loss 3 at Shaft and Toe 0.670 / 1.000

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
5.0	10.9	4.2	6.7	-1.0	0.000	0.000	0.00	0.0
10.0	22.3	19.7	2.7	-1.0	0.000	0.000	0.00	0.0
15.0	57.7	44.8	12.9	2.8	20.205	0.000	4.35	42.3
20.0	116.2	74.5	41.7	6.1	27.805	-1.138	5.45	37.9
25.0	168.9	116.5	52.4	9.0	30.969	-1.383	6.06	36.0
30.0	155.5	147.6	7.9	7.3	29.612	-1.499	5.73	37.1
35.0	271.4	198.5	72.9	15.6	35.663	0.000	7.21	34.9
40.0	337.8	258.4	79.4	20.4	37.352	-1.252	7.75	35.4
45.0	404.3	324.9	79.4	26.3	39.208	-1.607	8.25	36.1
50.0	439.5	394.5	45.0	29.1	39.342	-1.200	8.35	35.6
55.0	543.8	470.9	72.9	50.2	41.823	-1.354	9.14	37.5
60.0	626.0	553.0	72.9	97.1	42.227	-0.714	9.39	37.0
62.0	660.4	587.4	72.9	139.0	41.694	-0.422	9.46	36.7

Total Continuous Driving Time 32.00 minutes; Total Number of Blows 1310 (starting at penetration 5.0 ft)

GRLWEAP - Version 2010  
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.  
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ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

Input File: J:\GEOTECH\PROJECTS\2013\W-13-072 FRA-70-13.10 PROJECT 6A\ANALYSIS\FRA-70-1322L AND 1323C\DRIVEABILITY\FRA-70-1323C\REAR ABUTMENT\HP 12X53\1323C-RA-12X53.GMW  
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW  
Hammer File Version: 2003 (12/4/2018)

Input File Contents

FRA-70-1323C - Rear Abutment - HP12x53  
OUT OSG HAM STR FUL PEL N SPL N-U P-D %SK ISM 0 PHI RSA ITR H-D MXT DEX  
-100 0 14 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0.000  
Pile g Hammer g Toe Area Pile Size Pile Type  
32.170 32.170 144.000 12.000 Unknown  
W Cp A Cp E Cp T Cp CoR ROut StCp  
1.900 227.000 530.0 2.000 0.800 0.010 0.0  
A Cu E Cu T Cu CoR ROut StCu  
0.000 0.0 0.000 0.000 0.000 0.0  
LPle APle EPle WPle Peri CI CoR ROut  
62.000 15.50 29000.0 492.000 3.970 0 0.850 0.010  
FFatigue F0 0-Bottom  
0 0.000 0.000  
Manufac Hmr Name HmrType No Seg-s  
DELMAG D 30-23 1 5  
Ram Wt Ram L Ram Dia MaxStrk RtdStrk Efficy  
6.60 118.10 16.51 13.44 11.18 0.80  
IB. Wt IB. L IB. Dia IB CoR IB R0  
1.20 25.00 16.51 0.900 0.010  
CompStrk A Chamber V Chamber C Delay C Duratn Exp Coeff VolCStart Vol CEnd  
16.30 214.03 280.90 0.0010 0.0020 1.250 0.00 0.00  
P atm P1 P2 P3 P4 P5  
14.70 1550.00 1395.00 1255.00 1130.00 0.00  
Stroke Effic. Pressure R-Weight T-Delay Exp-Coeff Eps-Str Total-AW  
11.1800 0.8000 1550.0000 0.0000 0.0000 0.0000 0.0100 0.0000  
Qs Qt Js Jt Qx Jx Rati Dept  
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000  
Research Soil Model: Atoe, Plug, Gap, Q-fac



0.000 0.000 0.000 0.000  
 Research Soil Model: RD-skn: m, d, toe: m, d  
 0.000 0.000 0.000 0.000  
 Research Toe Plug: Res-int, Q-int, D-int, Res-plug, Q-plug, D-plug  
 0.000 0.000 0.000 0.000 0.000 0.000  
 Research Toe Plug: RD plug toe: m, d  
 0.000 0.000

Research Toe Plug: New Toe Plug Model is NOT applied

Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimL	TSf0
0.01	0.00	0.01	0.10	0.10	0.05	0.15	1.00	6.00	1.000
9.01	0.76	12.06	0.10	0.10	0.05	0.15	1.00	6.00	1.000
9.29	0.79	12.44	0.10	0.10	0.05	0.15	1.00	6.00	1.000
9.31	2.75	2.66	0.10	0.10	0.20	0.15	1.49	6.00	168.000
11.79	2.75	2.66	0.10	0.10	0.20	0.15	1.49	6.00	168.000
11.81	0.83	10.17	0.10	0.10	0.05	0.15	1.00	6.00	1.000
16.79	1.18	14.49	0.10	0.10	0.05	0.15	1.00	6.00	1.000
16.81	1.55	34.61	0.10	0.10	0.05	0.15	1.00	6.00	1.000
24.49	2.32	51.79	0.10	0.10	0.05	0.15	1.00	6.00	1.000
24.51	2.32	51.82	0.10	0.10	0.05	0.15	1.00	6.00	1.000
25.79	2.39	53.36	0.10	0.10	0.05	0.15	1.00	6.00	1.000
25.81	1.36	7.91	0.10	0.10	0.05	0.15	1.00	6.00	1.000
30.79	1.49	7.91	0.10	0.10	0.05	0.15	1.00	6.00	1.000
30.81	2.65	72.94	0.10	0.10	0.05	0.15	1.00	6.00	1.000
39.79	3.14	72.94	0.10	0.10	0.05	0.15	1.00	6.00	1.000
39.81	3.19	79.39	0.10	0.10	0.05	0.15	1.00	6.00	1.000
45.79	3.54	79.39	0.10	0.10	0.05	0.15	1.00	6.00	1.000
45.81	3.40	44.95	0.10	0.10	0.05	0.15	1.00	6.00	1.000
50.79	3.66	44.95	0.10	0.10	0.05	0.15	1.00	6.00	1.000
50.81	3.77	72.94	0.10	0.10	0.05	0.15	1.00	6.00	1.000
59.81	4.26	72.94	0.10	0.10	0.05	0.15	1.00	6.00	1.000
62.00	4.39	72.94	0.10	0.10	0.05	0.15	1.00	6.00	1.000

Gain/Loss factors: shaft and toe

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR
0.60400	0.63700	0.67000	0.70300	0.73600			
1.00000	1.00000	1.00000	1.00000	1.00000			
5.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
10.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
15.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
20.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
25.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
30.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
35.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
40.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
45.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
50.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
55.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
60.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
62.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
0.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000

▲ GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS  
 Version 2010  
 English Units

FRA-70-1323C - Rear Abutment - HP12x53

Hammer Model: D 30-23 Made by: DELMAG

No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	1.320				
2	1.320	262846.5	1.000	0.0000	
3	1.320	262846.5	1.000	0.0000	
4	1.320	262846.5	1.000	0.0000	
5	1.320	262846.5	1.000	0.0000	
Imp Block	1.200	127693.0	0.900	0.0100	
Helmet	1.900	60155.0	0.800	0.0100	10.0
Combined Pile Top		11479.2			

HAMMER OPTIONS:

Hammer File ID No.	14	Hammer Type	OE Diesel
Stroke Option	FxdP-VarS	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Maximum		

HAMMER DATA:

Ram Weight	(kips)	6.60	Ram Length	(inch)	118.10
Maximum Stroke	(ft)	13.44			
Rated Stroke	(ft)	11.18	Efficiency		0.800
Maximum Pressure	(psi)	1550.00	Actual Pressure	(psi)	1550.00

1323C-RA-12X53  
 Compression Exponent 1.350 Expansion Exponent 1.250  
 Ram Diameter (inch) 16.51  
 Combustion Delay (s) 0.00100 Ignition Duration (s) 0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION				PILE CUSHION			
Cross Sect. Area	(in2)	227.00		Cross Sect. Area	(in2)	0.00	
Elastic-Modulus	(ksi)	530.0		Elastic-Modulus	(ksi)	0.0	
Thickness	(inch)	2.00		Thickness	(inch)	0.00	
Coeff of Restitution		0.8		Coeff of Restitution		1.0	
RoundOut	(ft)	0.0		RoundOut	(ft)	0.0	
Stiffness	(kips/in)	60155.0		Stiffness	(kips/in)	0.0	

↑  
 FRA-70-1323C - Rear Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	5.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:  
 Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)				10.9	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.173	11479	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.0	15.5
2	0.173	11479	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.0	15.5
18	0.173	11479	0.000	0.000	1.00	0.5	0.050	0.100	58.74	4.0	15.5
19	0.173	11479	0.000	0.000	1.00	3.7	0.050	0.100	62.00	4.0	15.5
Toe						6.7	0.150	0.100			

3.283 kips total unredused pile weight (g= 32.17 ft/s2)  
 3.283 kips total reduced pile weight (g= 32.17 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile		Pile Segments: Automatic	
No. of Slacks/Splices	0	Pile Damping (%)	1
		Pile Damping Fact.(k/ft/s)	0.544
Driveability Analysis			
Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	1	Analysis Time-Input (ms)	0
Output Level: Normal			
Gravity Mass, Pile, Hammer:	32.170	32.170	32.170
Output Segment Generation: Automatic			

Depth	Stroke	Pressure	Efficcy
ft	ft	Ratio	
5.00	11.18	1.00	0.800

↑  
 FRA-70-1323C - Rear Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down up	ksi		ksi		kip-ft	b/min
10.9	Hammer did not run							
10.9	Hammer did not run							
10.9	Hammer did not run							
10.9	Hammer did not run							
10.9	Hammer did not run							

↑  
 FRA-70-1323C - Rear Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	10.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

1323C-RA-12X53  
 Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)			21.8		
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.173	11479	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.0	15.5
2	0.173	11479	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.0	15.5
16	0.173	11479	0.000	0.000	1.00	0.0	0.050	0.100	52.21	4.0	15.5
17	0.173	11479	0.000	0.000	1.00	2.0	0.050	0.100	55.47	4.0	15.5
18	0.173	11479	0.000	0.000	1.00	5.6	0.050	0.100	58.74	4.0	15.5
19	0.173	11479	0.000	0.000	1.00	11.5	0.128	0.100	62.00	4.0	15.5
Toe						2.7	0.150	0.100			

3.283 kips total unreduced pile weight (g= 32.17 ft/s2)  
 3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficacy
ft	ft	Ratio	
10.00	11.18	1.00	0.800

▲ FRA-70-1323C - Rear Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i t Comp Str	i t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	kip-ft	b/min
21.8		Hammer did not run				
22.1		Hammer did not run				
22.3		Hammer did not run				
22.6		Hammer did not run				
22.8		Hammer did not run				

▲ FRA-70-1323C - Rear Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	15.0	Standard Soil Setup
Shaft Gain/Loss Factor	0.604	Toe Gain/Loss Factor	1.000

#### PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)			55.9		
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.173	11479	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.0	15.5
2	0.173	11479	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.0	15.5
15	0.173	11479	0.000	0.000	1.00	0.6	0.050	0.100	48.95	4.0	15.5
16	0.173	11479	0.000	0.000	1.00	3.9	0.050	0.100	52.21	4.0	15.5
17	0.173	11479	0.000	0.000	1.00	7.5	0.050	0.100	55.47	4.0	15.5
18	0.173	11479	0.000	0.000	1.00	18.6	0.187	0.100	58.74	4.0	15.5
19	0.173	11479	0.000	0.000	1.00	12.4	0.058	0.100	62.00	4.0	15.5
Toe						12.9	0.150	0.100			

3.283 kips total unreduced pile weight (g= 32.17 ft/s2)  
 3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficacy
ft	ft	Ratio	
15.00	11.18	1.00	0.800

▲ FRA-70-1323C - Rear Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i t Comp Str	i t ENTHRU	Bl Rt
-----	-------	-------------	---------	--------------	------------	-------

1323C-RA-12X53											
kips	b/ft	down	up	ksi			ksi		kip-ft	b/min	
55.9	2.7	4.29	4.27	0.00	1	0	19.82	2	2	42.6	57.2
56.8	2.8	4.32	4.30	0.00	1	0	20.00	3	2	42.5	56.9
57.7	2.8	4.35	4.33	0.00	1	0	20.21	3	2	42.3	56.8
58.6	2.9	4.38	4.35	0.00	1	0	20.44	4	2	42.2	56.6
59.5	2.9	4.41	4.38	0.00	1	0	20.64	4	2	42.1	56.4

FRA-70-1323C - Rear Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth (ft) 20.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model										Total Capacity Rut (kips)	114.4
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
kips	k/in	ft	ft			kips	s/ft	inch	ft	ft	in2
1	0.173	11479	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.0	15.5
2	0.173	11479	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.0	15.5
13	0.173	11479	0.000	0.000	1.00	0.0	0.050	0.100	42.42	4.0	15.5
14	0.173	11479	0.000	0.000	1.00	2.2	0.050	0.100	45.68	4.0	15.5
15	0.173	11479	0.000	0.000	1.00	5.8	0.050	0.100	48.95	4.0	15.5
16	0.173	11479	0.000	0.000	1.00	12.4	0.141	0.100	52.21	4.0	15.5
17	0.173	11479	0.000	0.000	1.00	16.4	0.162	0.100	55.47	4.0	15.5
18	0.173	11479	0.000	0.000	1.00	13.7	0.050	0.100	58.74	4.0	15.5
19	0.173	11479	0.000	0.000	1.00	22.0	0.050	0.100	62.00	4.0	15.5
Toe						41.7	0.150	0.100			

3.283 kips total unreduced pile weight (g= 32.17 ft/s2)  
 3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
20.00	11.18	1.00	0.800

FRA-70-1323C - Rear Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	b/min	
114.4	6.0	5.42	5.39	-1.15	15 50	27.63	15 5	38.1
115.3	6.1	5.43	5.41	-1.14	14 49	27.67	16 5	37.9
116.2	6.1	5.45	5.43	-1.14	14 49	27.81	15 5	37.9
117.1	6.2	5.47	5.45	-1.14	14 49	27.93	16 5	37.8
118.0	6.3	5.49	5.46	-1.15	14 47	28.05	16 5	37.8

FRA-70-1323C - Rear Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth (ft) 25.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model										Total Capacity Rut (kips)	167.1
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
kips	k/in	ft	ft			kips	s/ft	inch	ft	ft	in2
1	0.173	11479	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.0	15.5
2	0.173	11479	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.0	15.5
12	0.173	11479	0.000	0.000	1.00	0.8	0.050	0.100	39.16	4.0	15.5
13	0.173	11479	0.000	0.000	1.00	4.2	0.050	0.100	42.42	4.0	15.5

1323C-RA-12X53												
14	0.173	11479	0.000	0.000	1.00	7.7	0.050	0.100	45.68	4.0	15.5	
15	0.173	11479	0.000	0.000	1.00	18.9	0.188	0.100	48.95	4.0	15.5	
16	0.173	11479	0.000	0.000	1.00	12.3	0.050	0.100	52.21	4.0	15.5	
17	0.173	11479	0.000	0.000	1.00	17.9	0.050	0.100	55.47	4.0	15.5	
18	0.173	11479	0.000	0.000	1.00	24.4	0.050	0.100	58.74	4.0	15.5	
19	0.173	11479	0.000	0.000	1.00	28.6	0.050	0.100	62.00	4.0	15.5	
Toe						52.4	0.150	0.100				

3.283 kips total unredused pile weight (g= 32.17 ft/s2)

3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
25.00	11.18	1.00	0.800

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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	b/min	
167.1	8.8	6.02	6.04	-1.39	13 39	30.66	15 5	36.0
168.0	8.9	6.03	6.06	-1.39	13 39	30.81	15 5	36.0
168.9	9.0	6.06	6.07	-1.38	13 39	30.97	15 5	36.0
169.8	9.1	6.07	6.09	-1.38	13 39	31.11	15 5	36.0
170.7	9.2	6.08	6.11	-1.37	13 39	31.22	15 5	35.8

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Depth	(ft)	30.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

#### PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	12.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model										Total Capacity Rut (kips)	153.7
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
kips	k/in	ft	ft			kips	s/ft	inch	ft	ft	in2
1	0.173	11479	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.0	15.5
2	0.173	11479	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.0	15.5
10	0.173	11479	0.000	0.000	1.00	0.1	0.050	0.100	32.63	4.0	15.5
11	0.173	11479	0.000	0.000	1.00	2.5	0.050	0.100	35.89	4.0	15.5
12	0.173	11479	0.000	0.000	1.00	6.1	0.050	0.100	39.16	4.0	15.5
13	0.173	11479	0.000	0.000	1.00	13.3	0.151	0.100	42.42	4.0	15.5
14	0.173	11479	0.000	0.000	1.00	15.8	0.154	0.100	45.68	4.0	15.5
15	0.173	11479	0.000	0.000	1.00	14.1	0.050	0.100	48.95	4.0	15.5
16	0.173	11479	0.000	0.000	1.00	22.4	0.050	0.100	52.21	4.0	15.5
17	0.173	11479	0.000	0.000	1.00	26.6	0.050	0.100	55.47	4.0	15.5
18	0.173	11479	0.000	0.000	1.00	26.5	0.050	0.100	58.74	4.0	15.5
19	0.173	11479	0.000	0.000	1.00	18.5	0.050	0.100	62.00	4.0	15.5
Toe						7.9	0.150	0.100			

3.283 kips total unredused pile weight (g= 32.17 ft/s2)

3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
30.00	11.18	1.00	0.800

FRA-70-1323C - Rear Abutment - HP12x53 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	b/min	
153.7	7.1	5.70	5.69	-1.70	12 43	29.38	13 4	37.2
154.6	7.2	5.71	5.70	-1.60	12 43	29.50	13 4	37.1
155.5	7.3	5.73	5.71	-1.50	12 43	29.61	13 4	37.1
156.4	7.3	5.74	5.73	-1.42	12 39	29.70	13 4	37.0
157.3	7.4	5.70	5.75	-1.51	12 39	29.61	13 4	36.6

FRA-70-1323C - Rear Abutment - HP12x53 02/28/2021

Resource International Inc

Depth (ft) 35.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)				269.6	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.173	11479	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.0	15.5
2	0.173	11479	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.0	15.5
9	0.173	11479	0.000	0.000	1.00	0.9	0.050	0.100	29.37	4.0	15.5
10	0.173	11479	0.000	0.000	1.00	4.4	0.050	0.100	32.63	4.0	15.5
11	0.173	11479	0.000	0.000	1.00	8.0	0.050	0.100	35.89	4.0	15.5
12	0.173	11479	0.000	0.000	1.00	18.9	0.187	0.100	39.16	4.0	15.5
13	0.173	11479	0.000	0.000	1.00	12.5	0.050	0.100	42.42	4.0	15.5
14	0.173	11479	0.000	0.000	1.00	18.5	0.050	0.100	45.68	4.0	15.5
15	0.173	11479	0.000	0.000	1.00	24.6	0.050	0.100	48.95	4.0	15.5
16	0.173	11479	0.000	0.000	1.00	28.8	0.050	0.100	52.21	4.0	15.5
17	0.173	11479	0.000	0.000	1.00	20.4	0.050	0.100	55.47	4.0	15.5
18	0.173	11479	0.000	0.000	1.00	23.4	0.050	0.100	58.74	4.0	15.5
19	0.173	11479	0.000	0.000	1.00	36.2	0.050	0.100	62.00	4.0	15.5
Toe						72.9	0.150	0.100			

3.283 kips total unredueed pile weight (g= 32.17 ft/s2)  
3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
35.00	11.18	1.00	0.800

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FRA-70-1323C - Rear Abutment - HP12x53 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt	
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min	
269.6	15.4	7.19	7.18	0.00	1	0	35.40	12	4	35.0	43.9
270.5	15.5	7.19	7.19	0.00	1	0	35.49	12	4	35.0	43.9
271.4	15.6	7.21	7.21	0.00	1	0	35.66	12	4	34.9	43.8
272.3	15.7	7.22	7.21	0.00	1	0	35.75	12	4	35.0	43.8
273.2	15.8	7.24	7.23	0.00	1	0	35.94	12	4	34.9	43.7

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FRA-70-1323C - Rear Abutment - HP12x53 02/28/2021  
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Depth (ft) 40.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)				336.0	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.173	11479	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.0	15.5
2	0.173	11479	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.0	15.5
7	0.173	11479	0.000	0.000	1.00	0.1	0.050	0.100	22.84	4.0	15.5
8	0.173	11479	0.000	0.000	1.00	2.7	0.050	0.100	26.11	4.0	15.5
9	0.173	11479	0.000	0.000	1.00	6.3	0.050	0.100	29.37	4.0	15.5
10	0.173	11479	0.000	0.000	1.00	14.2	0.159	0.100	32.63	4.0	15.5
11	0.173	11479	0.000	0.000	1.00	15.2	0.144	0.100	35.89	4.0	15.5
12	0.173	11479	0.000	0.000	1.00	14.6	0.050	0.100	39.16	4.0	15.5

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13	0.173	11479	0.000	0.000	1.00	22.6	0.050	0.100	42.42	4.0	15.5
14	0.173	11479	0.000	0.000	1.00	26.9	0.050	0.100	45.68	4.0	15.5
15	0.173	11479	0.000	0.000	1.00	25.8	0.050	0.100	48.95	4.0	15.5
16	0.173	11479	0.000	0.000	1.00	18.5	0.050	0.100	52.21	4.0	15.5
17	0.173	11479	0.000	0.000	1.00	32.4	0.050	0.100	55.47	4.0	15.5
18	0.173	11479	0.000	0.000	1.00	37.4	0.050	0.100	58.74	4.0	15.5
19	0.173	11479	0.000	0.000	1.00	39.8	0.050	0.100	62.00	4.0	15.5
Toe						79.4	0.150	0.100			

3.283 kips total unredacted pile weight (g= 32.17 ft/s2)  
3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
40.00	11.18	1.00	0.800

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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
336.0	20.2	7.73	7.74	-1.25	8 48	37.16	10	3	35.3	42.4
336.9	20.3	7.74	7.74	-1.25	8 47	37.25	10	3	35.4	42.3
337.8	20.4	7.75	7.75	-1.25	8 47	37.35	10	3	35.4	42.3
338.7	20.6	7.76	7.77	-1.25	8 47	37.42	10	3	35.3	42.3
339.6	20.6	7.77	7.78	-1.24	8 47	37.54	10	3	35.3	42.2

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FRA-70-1323C - Rear Abutment - HP12x53 02/28/2021  
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Depth	(ft)	45.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor
			1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	12.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	402.5
	kips	Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D Quake	LbTop	Perim
		k/in ft ft	kips	s/ft inch	ft	ft
1	0.173	11479 0.010 0.000 0.85	0.0	0.000 0.100	3.26	4.0
2	0.173	11479 0.000 0.000 1.00	0.0	0.000 0.100	6.53	4.0
6	0.173	11479 0.000 0.000 1.00	1.1	0.050 0.100	19.58	4.0
7	0.173	11479 0.000 0.000 1.00	4.6	0.050 0.100	22.84	4.0
8	0.173	11479 0.000 0.000 1.00	8.2	0.050 0.100	26.11	4.0
9	0.173	11479 0.000 0.000 1.00	19.0	0.187 0.100	29.37	4.0
10	0.173	11479 0.000 0.000 1.00	12.7	0.050 0.100	32.63	4.0
11	0.173	11479 0.000 0.000 1.00	19.0	0.050 0.100	35.89	4.0
12	0.173	11479 0.000 0.000 1.00	24.9	0.050 0.100	39.16	4.0
13	0.173	11479 0.000 0.000 1.00	29.1	0.050 0.100	42.42	4.0
14	0.173	11479 0.000 0.000 1.00	19.6	0.050 0.100	45.68	4.0
15	0.173	11479 0.000 0.000 1.00	24.5	0.050 0.100	48.95	4.0
16	0.173	11479 0.000 0.000 1.00	36.3	0.050 0.100	52.21	4.0
17	0.173	11479 0.000 0.000 1.00	38.6	0.050 0.100	55.47	4.0
18	0.173	11479 0.000 0.000 1.00	41.3	0.050 0.100	58.74	4.0
19	0.173	11479 0.000 0.000 1.00	44.0	0.050 0.100	62.00	4.0
Toe			79.4	0.150 0.100		

3.283 kips total unredacted pile weight (g= 32.17 ft/s2)  
3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
45.00	11.18	1.00	0.800

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FRA-70-1323C - Rear Abutment - HP12x53 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
402.5	26.0	8.23	8.23	-1.59	7 42	38.86	9	3	36.0	41.1
403.4	26.1	8.24	8.23	-1.60	7 42	39.04	9	3	36.1	41.1

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404.3	26.3	8.25	8.24	-1.61	7	42	39.21	9	3	36.1	41.1
405.2	26.4	8.26	8.25	-1.62	7	42	39.36	9	3	36.2	41.0
406.1	26.5	8.27	8.25	-1.63	7	42	39.47	9	3	36.2	41.0

FRA-70-1323C - Rear Abutment - HP12x53  
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Depth (ft) 50.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:  
 Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)				437.7	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.173	11479	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.0	15.5
2	0.173	11479	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.0	15.5
4	0.173	11479	0.000	0.000	1.00	0.2	0.050	0.100	13.05	4.0	15.5
5	0.173	11479	0.000	0.000	1.00	2.9	0.050	0.100	16.32	4.0	15.5
6	0.173	11479	0.000	0.000	1.00	6.5	0.050	0.100	19.58	4.0	15.5
7	0.173	11479	0.000	0.000	1.00	15.1	0.166	0.100	22.84	4.0	15.5
8	0.173	11479	0.000	0.000	1.00	14.6	0.133	0.100	26.11	4.0	15.5
9	0.173	11479	0.000	0.000	1.00	15.2	0.050	0.100	29.37	4.0	15.5
10	0.173	11479	0.000	0.000	1.00	22.9	0.050	0.100	32.63	4.0	15.5
11	0.173	11479	0.000	0.000	1.00	27.2	0.050	0.100	35.89	4.0	15.5
12	0.173	11479	0.000	0.000	1.00	25.1	0.050	0.100	39.16	4.0	15.5
13	0.173	11479	0.000	0.000	1.00	18.6	0.050	0.100	42.42	4.0	15.5
14	0.173	11479	0.000	0.000	1.00	33.5	0.050	0.100	45.68	4.0	15.5
15	0.173	11479	0.000	0.000	1.00	37.6	0.050	0.100	48.95	4.0	15.5
16	0.173	11479	0.000	0.000	1.00	40.0	0.050	0.100	52.21	4.0	15.5
17	0.173	11479	0.000	0.000	1.00	42.9	0.050	0.100	55.47	4.0	15.5
18	0.173	11479	0.000	0.000	1.00	44.8	0.050	0.100	58.74	4.0	15.5
19	0.173	11479	0.000	0.000	1.00	45.8	0.050	0.100	62.00	4.0	15.5
Toe						45.0	0.150	0.100			

3.283 kips total unreduced pile weight (g= 32.17 ft/s2)  
 3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficacy
ft	ft	Ratio	
50.00	11.18	1.00	0.800

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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	kip-ft	b/min
437.7	28.9	8.33	8.36	-1.17	5 40	39.09	7 3	35.4
438.6	29.0	8.34	8.36	-1.19	5 40	39.22	7 3	35.5
439.5	29.1	8.35	8.37	-1.20	5 40	39.34	7 3	35.6
440.4	29.4	8.36	8.39	-1.20	5 40	39.38	7 3	35.5
441.3	29.5	8.37	8.39	-1.22	5 40	39.54	7 3	35.5

FRA-70-1323C - Rear Abutment - HP12x53  
 Resource International Inc  
 02/28/2021  
 GRLWEAP Version 2010

Depth (ft) 55.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:  
 Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model Total Capacity Rut (kips) 542.0



1323C-RA-12X53

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.173	11479	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.0	15.5
2	0.173	11479	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.0	15.5
3	0.173	11479	0.000	0.000	1.00	1.3	0.050	0.100	9.79	4.0	15.5
4	0.173	11479	0.000	0.000	1.00	4.8	0.050	0.100	13.05	4.0	15.5
5	0.173	11479	0.000	0.000	1.00	8.5	0.052	0.100	16.32	4.0	15.5
6	0.173	11479	0.000	0.000	1.00	19.0	0.187	0.100	19.58	4.0	15.5
7	0.173	11479	0.000	0.000	1.00	12.9	0.050	0.100	22.84	4.0	15.5
8	0.173	11479	0.000	0.000	1.00	19.6	0.050	0.100	26.11	4.0	15.5
9	0.173	11479	0.000	0.000	1.00	25.2	0.050	0.100	29.37	4.0	15.5
10	0.173	11479	0.000	0.000	1.00	29.3	0.050	0.100	32.63	4.0	15.5
11	0.173	11479	0.000	0.000	1.00	18.8	0.050	0.100	35.89	4.0	15.5
12	0.173	11479	0.000	0.000	1.00	25.6	0.050	0.100	39.16	4.0	15.5
13	0.173	11479	0.000	0.000	1.00	36.5	0.050	0.100	42.42	4.0	15.5
14	0.173	11479	0.000	0.000	1.00	38.8	0.050	0.100	45.68	4.0	15.5
15	0.173	11479	0.000	0.000	1.00	41.5	0.050	0.100	48.95	4.0	15.5
16	0.173	11479	0.000	0.000	1.00	44.2	0.050	0.100	52.21	4.0	15.5
17	0.173	11479	0.000	0.000	1.00	45.0	0.050	0.100	55.47	4.0	15.5
18	0.173	11479	0.000	0.000	1.00	47.4	0.050	0.100	58.74	4.0	15.5
19	0.173	11479	0.000	0.000	1.00	50.7	0.050	0.100	62.00	4.0	15.5
Toe						72.9	0.150	0.100			

3.283 kips total unredacted pile weight (g= 32.17 ft/s2)  
3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy Ratio
55.00	11.18	1.00	0.800

▲ FRA-70-1323C - Rear Abutment - HP12x53 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
542.0	49.4	9.13	9.07	-1.36	5	36	41.52	6	3	37.4	39.2
542.9	50.2	9.13	9.08	-1.34	5	36	41.67	6	3	37.3	39.1
543.8	50.2	9.14	9.07	-1.35	5	36	41.82	6	3	37.5	39.1
544.7	51.0	9.15	9.08	-1.32	5	36	41.89	6	3	37.4	39.1
545.6	51.8	9.15	9.10	-1.30	4	36	42.05	6	3	37.3	39.1

▲ FRA-70-1323C - Rear Abutment - HP12x53 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth Shaft Gain/Loss Factor	(ft)	60.0	Standard Soil Setup Toe Gain/Loss Factor	1.000
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PILE PROFILE:

Toe Area		(in2)	144.000	Pile Type		Unknown	
Pile Size		(inch)	12.000				
L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.173	11479	0.010	0.000	0.85	0.3	0.050	0.100	3.26	4.0	15.5
2	0.173	11479	0.000	0.000	1.00	3.2	0.050	0.100	6.53	4.0	15.5
3	0.173	11479	0.000	0.000	1.00	6.8	0.050	0.100	9.79	4.0	15.5
4	0.173	11479	0.000	0.000	1.00	15.9	0.172	0.100	13.05	4.0	15.5
5	0.173	11479	0.000	0.000	1.00	14.1	0.120	0.100	16.32	4.0	15.5
6	0.173	11479	0.000	0.000	1.00	15.7	0.050	0.100	19.58	4.0	15.5
7	0.173	11479	0.000	0.000	1.00	23.2	0.050	0.100	22.84	4.0	15.5
8	0.173	11479	0.000	0.000	1.00	27.4	0.050	0.100	26.11	4.0	15.5
9	0.173	11479	0.000	0.000	1.00	24.4	0.050	0.100	29.37	4.0	15.5
10	0.173	11479	0.000	0.000	1.00	18.7	0.050	0.100	32.63	4.0	15.5
11	0.173	11479	0.000	0.000	1.00	34.6	0.050	0.100	35.89	4.0	15.5
12	0.173	11479	0.000	0.000	1.00	37.7	0.050	0.100	39.16	4.0	15.5
13	0.173	11479	0.000	0.000	1.00	40.1	0.050	0.100	42.42	4.0	15.5
14	0.173	11479	0.000	0.000	1.00	43.0	0.050	0.100	45.68	4.0	15.5
15	0.173	11479	0.000	0.000	1.00	44.8	0.050	0.100	48.95	4.0	15.5
16	0.173	11479	0.000	0.000	1.00	45.9	0.050	0.100	52.21	4.0	15.5
17	0.173	11479	0.000	0.000	1.00	49.3	0.050	0.100	55.47	4.0	15.5
18	0.173	11479	0.000	0.000	1.00	51.9	0.050	0.100	58.74	4.0	15.5
19	0.173	11479	0.000	0.000	1.00	54.2	0.050	0.100	62.00	4.0	15.5

Toe 72.9 0.150 0.100

3.283 kips total unreduced pile weight (g= 32.17 ft/s2)  
3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
60.00	11.18	1.00	0.800

↑  
FRA-70-1323C - Rear Abutment - HP12x53 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i t Comp Str ksi	i t ENTHRU kip-ft	Bl Rt b/min
624.2	93.9	9.39	9.39	-0.75	3 33 42.11	4 2 37.1
625.1	95.6	9.39	9.39	-0.73	3 33 42.15	4 2 37.0
626.0	97.1	9.39	9.39	-0.71	3 33 42.23	4 2 37.0
626.9	99.0	9.39	9.40	-0.69	3 33 42.36	4 2 36.9
627.8	100.1	9.39	9.39	-0.69	3 33 42.41	4 2 36.9

↑  
FRA-70-1323C - Rear Abutment - HP12x53 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth ft	Stroke ft	Pressure Ratio	Efficy
62.0	11.18	1.00	0.800

PILE PROFILE:  
Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 12.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
62.0	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.504

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.173	11479	0.010	0.000	0.85	1.8	0.050	0.100	3.26	4.0	15.5
2	0.173	11479	0.000	0.000	1.00	5.4	0.050	0.100	6.53	4.0	15.5
3	0.173	11479	0.000	0.000	1.00	10.6	0.113	0.100	9.79	4.0	15.5
4	0.173	11479	0.000	0.000	1.00	17.6	0.175	0.100	13.05	4.0	15.5
5	0.173	11479	0.000	0.000	1.00	13.3	0.050	0.100	16.32	4.0	15.5
6	0.173	11479	0.000	0.000	1.00	20.9	0.050	0.100	19.58	4.0	15.5
7	0.173	11479	0.000	0.000	1.00	25.8	0.050	0.100	22.84	4.0	15.5
8	0.173	11479	0.000	0.000	1.00	28.5	0.050	0.100	26.11	4.0	15.5
9	0.173	11479	0.000	0.000	1.00	18.3	0.050	0.100	29.37	4.0	15.5
10	0.173	11479	0.000	0.000	1.00	28.0	0.050	0.100	32.63	4.0	15.5
11	0.173	11479	0.000	0.000	1.00	36.8	0.050	0.100	35.89	4.0	15.5
12	0.173	11479	0.000	0.000	1.00	39.1	0.050	0.100	39.16	4.0	15.5
13	0.173	11479	0.000	0.000	1.00	41.9	0.050	0.100	42.42	4.0	15.5
14	0.173	11479	0.000	0.000	1.00	44.6	0.050	0.100	45.68	4.0	15.5
15	0.173	11479	0.000	0.000	1.00	45.1	0.050	0.100	48.95	4.0	15.5
16	0.173	11479	0.000	0.000	1.00	47.9	0.050	0.100	52.21	4.0	15.5
17	0.173	11479	0.000	0.000	1.00	51.0	0.050	0.100	55.47	4.0	15.5
18	0.173	11479	0.000	0.000	1.00	53.3	0.050	0.100	58.74	4.0	15.5
19	0.173	11479	0.000	0.000	1.00	55.6	0.050	0.100	62.00	4.0	15.5
Toe						72.9	0.150	0.100			

3.283 kips total unreduced pile weight (g= 32.17 ft/s2)  
3.283 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
62.00	11.18	1.00	0.800

↑  
FRA-70-1323C - Rear Abutment - HP12x53 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i t Comp Str ksi	i t ENTHRU kip-ft	Bl Rt b/min
658.6	134.1	9.47	9.46	-0.44	3 32 41.60	3 2 36.8
659.5	138.9	9.48	9.47	-0.41	3 32 41.69	3 2 36.6
660.4	139.0	9.46	9.45	-0.42	3 32 41.69	3 2 36.7
661.3	144.9	9.48	9.47	-0.39	3 32 41.76	3 2 36.5
662.2	149.4	9.46	9.47	-0.37	3 32 41.75	3 2 36.4

SUMMARY OVER DEPTHS

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	10.9	4.2	6.7	Hammer	did not	run		
10.0	21.8	19.2	2.7	Hammer	did not	run		
15.0	55.9	43.0	12.9	2.7	19.818	0.000	4.29	42.6
20.0	114.4	72.7	41.7	6.0	27.628	-1.152	5.42	38.1
25.0	167.1	114.7	52.4	8.8	30.663	-1.385	6.02	36.0
30.0	153.7	145.8	7.9	7.1	29.376	-1.700	5.70	37.2
35.0	269.6	196.7	72.9	15.4	35.402	0.000	7.19	35.0
40.0	336.0	256.6	79.4	20.2	37.162	-1.254	7.73	35.3
45.0	402.5	323.1	79.4	26.0	38.856	-1.586	8.23	36.0
50.0	437.7	392.7	45.0	28.9	39.089	-1.173	8.33	35.4
55.0	542.0	469.1	72.9	49.4	41.516	-1.363	9.13	37.4
60.0	624.2	551.2	72.9	93.9	42.108	-0.754	9.39	37.1
62.0	658.6	585.6	72.9	134.1	41.599	-0.443	9.47	36.8

Total Driving Time 32 minutes; Total No. of Blows 1284  
Starting at penetration 5.0 ft

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	10.9	4.2	6.7	Hammer	did not	run		
10.0	22.1	19.4	2.7	Hammer	did not	run		
15.0	56.8	43.9	12.9	2.8	19.999	0.000	4.32	42.5
20.0	115.3	73.6	41.7	6.1	27.672	-1.142	5.43	37.9
25.0	168.0	115.6	52.4	8.9	30.812	-1.386	6.03	36.0
30.0	154.6	146.7	7.9	7.2	29.504	-1.596	5.71	37.1
35.0	270.5	197.6	72.9	15.5	35.492	0.000	7.19	35.0
40.0	336.9	257.5	79.4	20.3	37.245	-1.255	7.74	35.4
45.0	403.4	324.0	79.4	26.1	39.043	-1.596	8.24	36.1
50.0	438.6	393.6	45.0	29.0	39.223	-1.191	8.34	35.5
55.0	542.9	470.0	72.9	50.2	41.666	-1.341	9.13	37.3
60.0	625.1	552.1	72.9	95.6	42.153	-0.733	9.39	37.0
62.0	659.5	586.5	72.9	138.9	41.694	-0.412	9.48	36.6

Total Driving Time 32 minutes; Total No. of Blows 1302  
Starting at penetration 5.0 ft

SUMMARY OVER DEPTHS

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	10.9	4.2	6.7	Hammer	did not	run		
10.0	22.3	19.7	2.7	Hammer	did not	run		
15.0	57.7	44.8	12.9	2.8	20.205	0.000	4.35	42.3
20.0	116.2	74.5	41.7	6.1	27.805	-1.138	5.45	37.9
25.0	168.9	116.5	52.4	9.0	30.969	-1.383	6.06	36.0
30.0	155.5	147.6	7.9	7.3	29.612	-1.499	5.73	37.1
35.0	271.4	198.5	72.9	15.6	35.663	0.000	7.21	34.9
40.0	337.8	258.4	79.4	20.4	37.352	-1.252	7.75	35.4
45.0	404.3	324.9	79.4	26.3	39.208	-1.607	8.25	36.1
50.0	439.5	394.5	45.0	29.1	39.342	-1.200	8.35	35.6
55.0	543.8	470.9	72.9	50.2	41.823	-1.354	9.14	37.5
60.0	626.0	553.0	72.9	97.1	42.227	-0.714	9.39	37.0
62.0	660.4	587.4	72.9	139.0	41.694	-0.422	9.46	36.7

Total Driving Time 32 minutes; Total No. of Blows 1310  
Starting at penetration 5.0 ft

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	10.9	4.2	6.7	Hammer	did not	run		
10.0	22.6	19.9	2.7	Hammer	did not	run		
15.0	58.6	45.7	12.9	2.9	20.436	0.000	4.38	42.2
20.0	117.1	75.4	41.7	6.2	27.931	-1.142	5.47	37.8
25.0	169.8	117.4	52.4	9.1	31.114	-1.378	6.07	36.0
30.0	156.4	148.5	7.9	7.3	29.695	-1.425	5.74	37.0
35.0	272.3	199.3	72.9	15.7	35.755	0.000	7.22	35.0
40.0	338.7	259.3	79.4	20.6	37.425	-1.245	7.76	35.3

1323C-RA-12X53								
45.0	405.2	325.8	79.4	26.4	39.355	-1.618	8.26	36.2
50.0	440.4	395.4	45.0	29.4	39.383	-1.199	8.36	35.5
55.0	544.7	471.8	72.9	51.0	41.886	-1.322	9.15	37.4
60.0	626.9	553.9	72.9	99.0	42.360	-0.692	9.39	36.9
62.0	661.3	588.3	72.9	144.9	41.762	-0.385	9.48	36.5

Total Driving Time 33 minutes; Total No. of Blows 1333  
Starting at penetration 5.0 ft

▲  
FRA-70-1323C - Rear Abutment - HP12x53 02/28/2021  
Resource International Inc GRLWEAP Version 2010

#### SUMMARY OVER DEPTHS

Depth ft	Rut kips	G/L at Frictn kips	Shaft and End Bg kips	Toe: Bl Ct bl/ft	0.736 Com Str ksi	1.000 Ten Str ksi	Stroke ft	ENTHRU kip-ft
5.0	10.9	4.2	6.7	Hammer	did not	run		
10.0	22.8	20.2	2.7	Hammer	did not	run		
15.0	59.5	46.6	12.9	2.9	20.644	0.000	4.41	42.1
20.0	118.0	76.3	41.7	6.3	28.048	-1.148	5.49	37.8
25.0	170.7	118.3	52.4	9.2	31.222	-1.372	6.08	35.8
30.0	157.3	149.4	7.9	7.4	29.608	-1.513	5.70	36.6
35.0	273.2	200.2	72.9	15.8	35.937	0.000	7.24	34.9
40.0	339.6	260.2	79.4	20.6	37.537	-1.244	7.77	35.3
45.0	406.1	326.7	79.4	26.5	39.472	-1.628	8.27	36.2
50.0	441.3	396.3	45.0	29.5	39.535	-1.218	8.37	35.5
55.0	545.6	472.7	72.9	51.8	42.053	-1.304	9.15	37.3
60.0	627.8	554.8	72.9	100.1	42.407	-0.688	9.39	36.9
62.0	662.2	589.2	72.9	149.4	41.745	-0.373	9.46	36.4

Total Driving Time 33 minutes; Total No. of Blows 1349  
Starting at penetration 5.0 ft

▲  
FRA-70-1323C - Rear Abutment - HP12x53 02/28/2021  
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#### Table of Depths Analyzed with Driving System Modifiers

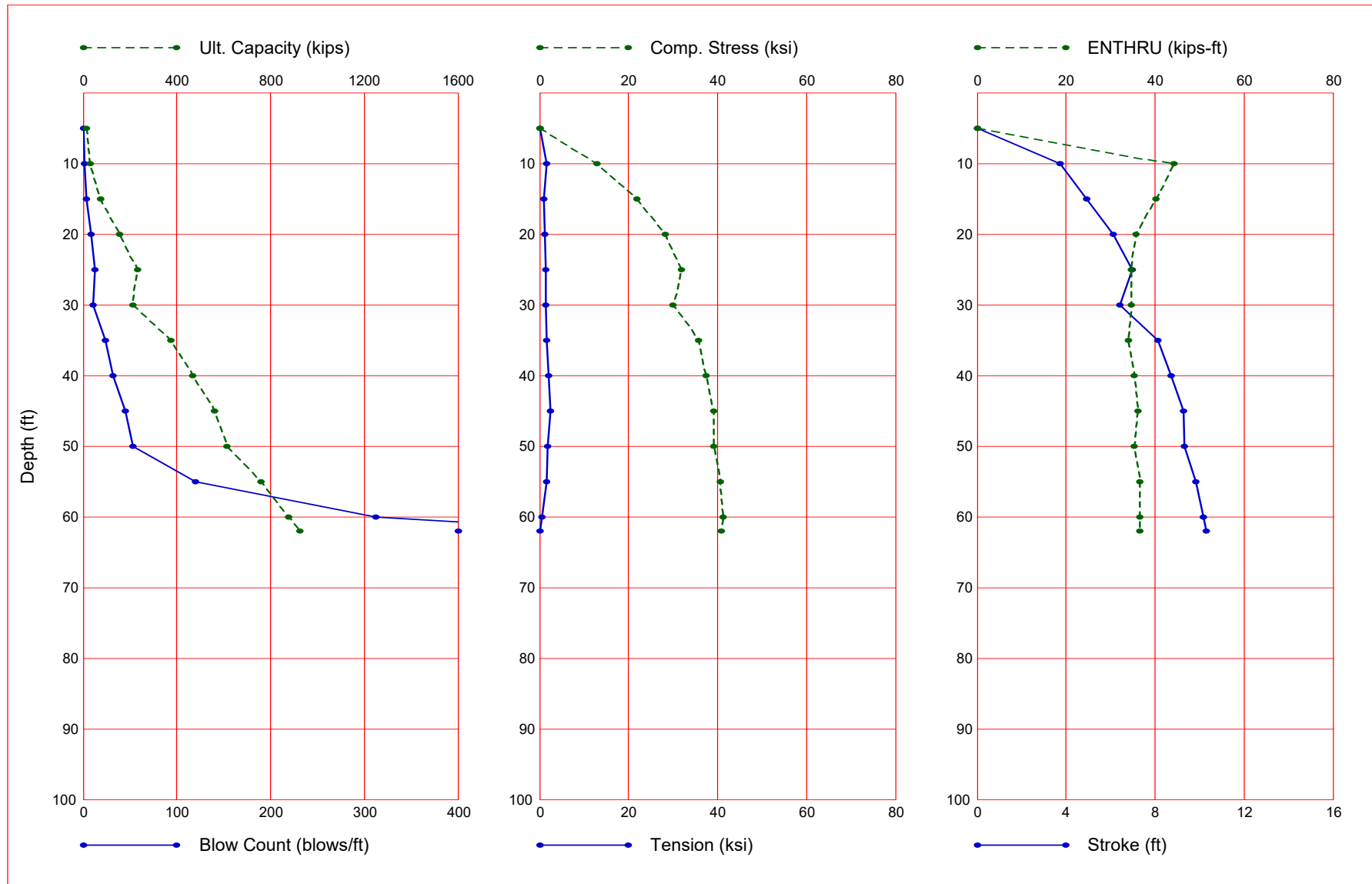
Depth ft	Temp. Length ft	Wait Time hr	Equivalent Stroke ft	Pressure Ratio	Efficy.	Stiffn. Factor	Cushion CoR
5.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
10.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
15.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
20.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
25.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
30.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
35.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
40.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
45.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
50.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
55.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
60.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
62.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00

#### Soil Layer Resistance Values

Depth ft	Shaft Res. k/ft2	End Bearing kips	Shaft Quake inch	Toe Quake inch	Shaft Damping s/ft	Toe Damping s/ft	Soil Setup Normlzd	Limit Distance ft	Setup Time hrs
0.01	0.00	0.01	0.100	0.100	0.050	0.150	0.000	6.000	1.000
9.01	0.76	12.06	0.100	0.100	0.050	0.150	0.000	6.000	1.000
9.29	0.79	12.44	0.100	0.100	0.050	0.150	0.000	6.000	1.000
9.31	2.75	2.66	0.100	0.100	0.200	0.150	1.000	6.000	168.000
11.79	2.75	2.66	0.100	0.100	0.200	0.150	1.000	6.000	168.000
11.81	0.83	10.17	0.100	0.100	0.050	0.150	0.000	6.000	1.000
16.79	1.18	14.49	0.100	0.100	0.050	0.150	0.000	6.000	1.000
16.81	1.55	34.61	0.100	0.100	0.050	0.150	0.000	6.000	1.000
24.49	2.32	51.79	0.100	0.100	0.050	0.150	0.000	6.000	1.000
24.51	2.32	51.82	0.100	0.100	0.050	0.150	0.000	6.000	1.000
25.79	2.39	53.36	0.100	0.100	0.050	0.150	0.000	6.000	1.000
25.81	1.36	7.91	0.100	0.100	0.050	0.150	0.000	6.000	1.000
30.79	1.49	7.91	0.100	0.100	0.050	0.150	0.000	6.000	1.000
30.81	2.65	72.94	0.100	0.100	0.050	0.150	0.000	6.000	1.000
39.79	3.14	72.94	0.100	0.100	0.050	0.150	0.000	6.000	1.000
39.81	3.19	79.39	0.100	0.100	0.050	0.150	0.000	6.000	1.000
45.79	3.54	79.39	0.100	0.100	0.050	0.150	0.000	6.000	1.000
45.81	3.40	44.95	0.100	0.100	0.050	0.150	0.000	6.000	1.000
50.79	3.66	44.95	0.100	0.100	0.050	0.150	0.000	6.000	1.000

1323C-RA-12X53									
50.81	3.77	72.94	0.100	0.100	0.050	0.150	0.000	6.000	1.000
59.81	4.26	72.94	0.100	0.100	0.050	0.150	0.000	6.000	1.000
62.00	4.39	72.94	0.100	0.100	0.050	0.150	0.000	6.000	1.000

Gain/Loss 3 at Shaft and Toe 0.670 / 1.000



Gain/Loss 3 at Shaft and Toe 0.670 / 1.000

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
5.0	15.1	5.9	9.2	-1.0	0.000	0.000	0.00	0.0
10.0	30.1	26.4	3.7	1.4	12.819	-1.558	3.74	44.3
15.0	76.4	58.5	17.9	3.7	21.927	-0.954	4.93	40.2
20.0	157.9	100.2	57.6	8.7	28.216	-1.268	6.13	35.7
25.0	232.0	159.6	72.4	13.1	31.809	-1.327	6.96	34.7
30.0	213.1	202.2	10.9	10.2	29.874	-1.374	6.44	34.6
35.0	374.5	273.8	100.7	23.5	35.768	-1.607	8.11	34.1
40.0	468.4	358.8	109.6	32.1	37.469	-1.954	8.74	35.4
45.0	562.7	453.1	109.6	45.2	39.191	-2.347	9.26	36.2
50.0	613.5	551.5	62.1	53.4	39.213	-1.900	9.33	35.3
55.0	760.3	659.6	100.7	120.3	40.595	-1.683	9.85	36.5
60.0	876.7	776.0	100.7	312.5	41.197	-0.509	10.16	36.5
62.0	925.4	824.7	100.7	565.7	40.893	0.000	10.30	36.5

Total Continuous Driving Time 84.00 minutes; Total Number of Blows 3213 (starting at penetration 5.0 ft)

GRLWEAP - Version 2010  
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins  
and Associates, Inc.) with cooperation from Pile Dynamics, Inc.  
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ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

Input File: J:\GEOTECH\PROJECTS\2013\W-13-072 FRA-70-13.10 PROJECT 6A\ANALYSIS\FRA-70-1322L AND 1323C\DRIVEABILITY\FRA-70-1323C\REAR  
ABUTMENT\HP 14X73\1323C-RA-14X73.GMW  
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW  
Hammer File Version: 2003 (12/4/2018)

Input File Contents

FRA-70-1323C - Rear Abutment - HP14x73  
OUT OSG HAM STR FUL PEL N SPL N-U P-D %SK ISM 0 PHI RSA ITR H-D MXT DEX  
-100 0 14 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0.000  
Pile g Hammer g Toe Area Pile Size Pile Type  
32.170 32.170 144.000 14.000 Unknown  
W Cp A Cp E Cp T Cp CoR ROut StCp  
1.900 227.000 530.0 2.000 0.800 0.010 0.0  
A Cu E Cu T Cu CoR ROut StCu  
0.000 0.0 0.000 0.000 0.000 0.0  
LPle APle EPle WPle Peri CI CoR ROut  
62.000 21.40 29000.0 492.000 4.700 0 0.850 0.010  
FFatigue F0 0-Bottom  
0 0.000 0.000  
Manufac Hmr Name HmrType No Seg-s  
DELMAG D 30-23 1 5  
Ram Wt Ram L Ram Dia MaxStrk RtdStrk Efficy  
6.60 118.10 16.51 13.44 11.18 0.80  
IB. Wt IB. L IB. Dia IB CoR IB R0  
1.20 25.00 16.51 0.900 0.010  
CompStrk A Chamber V Chamber C Delay C Duratn Exp Coeff VolCStart Vol CEnd  
16.30 214.03 280.90 0.0010 0.0020 1.250 0.00 0.00  
P atm P1 P2 P3 P4 P5  
14.70 1550.00 1395.00 1255.00 1130.00 0.00  
Stroke Effic. Pressure R-Weight T-Delay Exp-Coeff Eps-Str Total-AW  
11.1800 0.8000 1550.0000 0.0000 0.0000 0.0000 0.0100 0.0000  
Qs Qt Js Jt Qx Jx Rati Dept  
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000  
Research Soil Model: Atoe, Plug, Gap, Q-fac



0.000 0.000 0.000 0.000  
 Research Soil Model: RD-skn: m, d, toe: m, d  
 0.000 0.000 0.000 0.000  
 Research Toe Plug: Res-int, Q-int, D-int, Res-plug, Q-plug, D-plug  
 0.000 0.000 0.000 0.000 0.000 0.000  
 Research Toe Plug: RD plug toe: m, d  
 0.000 0.000  
 Research Toe Plug: New Toe Plug Model is NOT applied  
 Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimL	TSf0
0.01	0.00	0.02	0.10	0.10	0.05	0.15	1.00	6.00	1.000
9.01	0.90	16.65	0.10	0.10	0.05	0.15	1.00	6.00	1.000
9.29	0.93	17.17	0.10	0.10	0.05	0.15	1.00	6.00	1.000
9.31	2.75	3.68	0.10	0.10	0.20	0.15	1.49	6.00	168.000
11.79	2.75	3.68	0.10	0.10	0.20	0.15	1.49	6.00	168.000
11.81	0.97	14.04	0.10	0.10	0.05	0.15	1.00	6.00	1.000
16.79	1.38	20.01	0.10	0.10	0.05	0.15	1.00	6.00	1.000
16.81	1.85	47.78	0.10	0.10	0.05	0.15	1.00	6.00	1.000
24.49	2.77	71.50	0.10	0.10	0.05	0.15	1.00	6.00	1.000
24.51	2.77	71.55	0.10	0.10	0.05	0.15	1.00	6.00	1.000
25.79	2.85	73.67	0.10	0.10	0.05	0.15	1.00	6.00	1.000
25.81	1.56	10.93	0.10	0.10	0.05	0.15	1.00	6.00	1.000
30.79	1.70	10.93	0.10	0.10	0.05	0.15	1.00	6.00	1.000
30.81	3.17	100.70	0.10	0.10	0.05	0.15	1.00	6.00	1.000
39.79	3.76	100.70	0.10	0.10	0.05	0.15	1.00	6.00	1.000
39.81	3.82	109.62	0.10	0.10	0.05	0.15	1.00	6.00	1.000
45.79	4.25	109.62	0.10	0.10	0.05	0.15	1.00	6.00	1.000
45.81	4.05	62.06	0.10	0.10	0.05	0.15	1.00	6.00	1.000
50.79	4.36	62.06	0.10	0.10	0.05	0.15	1.00	6.00	1.000
50.81	4.51	100.70	0.10	0.10	0.05	0.15	1.00	6.00	1.000
59.81	5.10	100.70	0.10	0.10	0.05	0.15	1.00	6.00	1.000
62.00	5.25	100.70	0.10	0.10	0.05	0.15	1.00	6.00	1.000

Gain/Loss factors: shaft and toe

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR
0.60400	0.63700	0.67000	0.70300	0.73600			
1.00000	1.00000	1.00000	1.00000	1.00000			
5.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
10.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
15.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
20.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
25.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
30.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
35.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
40.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
45.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
50.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
55.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
60.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
62.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
0.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000

▲ GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS  
 Version 2010  
 English Units

FRA-70-1323C - Rear Abutment - HP14x73

Hammer Model: D 30-23 Made by: DELMAG

No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	1.320				
2	1.320	262846.5	1.000	0.0000	
3	1.320	262846.5	1.000	0.0000	
4	1.320	262846.5	1.000	0.0000	
5	1.320	262846.5	1.000	0.0000	
Imp Block	1.200	127693.0	0.900	0.0100	
Helmet	1.900	60155.0	0.800	0.0100	10.0
Combined Pile Top		15848.7			

HAMMER OPTIONS:  
 Hammer File ID No. 14 Hammer Type OE Diesel  
 Stroke Option FxdP-VarS Stroke Convergence Crit. 0.010  
 Fuel Pump Setting Maximum

HAMMER DATA:  
 Ram Weight (kips) 6.60 Ram Length (inch) 118.10  
 Maximum Stroke (ft) 13.44  
 Rated Stroke (ft) 11.18 Efficiency 0.800  
 Maximum Pressure (psi) 1550.00 Actual Pressure (psi) 1550.00

1323C-RA-14X73  
 Compression Exponent 1.350 Expansion Exponent 1.250  
 Ram Diameter (inch) 16.51  
 Combustion Delay (s) 0.00100 Ignition Duration (s) 0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION			PILE CUSHION		
Cross Sect. Area	(in2)	227.00	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	530.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	2.00	Thickness	(inch)	0.00
Coeff of Restitution		0.8	Coeff of Restitution		1.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	60155.0	Stiffness	(kips/in)	0.0

↑  
 FRA-70-1323C - Rear Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth (ft) 5.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:  
 Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)				15.1	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.239	15849	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.7	21.4
2	0.239	15849	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.7	21.4
18	0.239	15849	0.000	0.000	1.00	0.7	0.050	0.100	58.74	4.7	21.4
19	0.239	15849	0.000	0.000	1.00	5.2	0.050	0.100	62.00	4.7	21.4
Toe						9.2	0.150	0.100			

4.533 kips total unredused pile weight (g= 32.17 ft/s2)  
 4.533 kips total reduced pile weight (g= 32.17 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile  
 No. of Slacks/Splices 0 Pile Segments: Automatic  
 Pile Damping (%) 1  
 Pile Damping Fact.(k/ft/s) 0.751

Driveability Analysis  
 Soil Damping Option Smith  
 Max No Analysis Iterations 0 Time Increment/Critical 160  
 Output Time Interval 1 Analysis Time-Input (ms) 0  
 Output Level: Normal  
 Gravity Mass, Pile, Hammer: 32.170 32.170 32.170  
 Output Segment Generation: Automatic

Depth	Stroke	Pressure	Efficcy
ft	ft	Ratio	
5.00	11.18	1.00	0.800

↑  
 FRA-70-1323C - Rear Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	ksi		kip-ft	b/min
15.1	Hammer did not run							
15.1	Hammer did not run							
15.1	Hammer did not run							
15.1	Hammer did not run							
15.1	Hammer did not run							

↑  
 FRA-70-1323C - Rear Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth (ft) 10.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

1323C-RA-14X73  
 Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)				29.5	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.239	15849	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.7	21.4
2	0.239	15849	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.7	21.4
16	0.239	15849	0.000	0.000	1.00	0.0	0.050	0.100	52.21	4.7	21.4
17	0.239	15849	0.000	0.000	1.00	2.8	0.050	0.100	55.47	4.7	21.4
18	0.239	15849	0.000	0.000	1.00	7.8	0.050	0.100	58.74	4.7	21.4
19	0.239	15849	0.000	0.000	1.00	15.2	0.122	0.100	62.00	4.7	21.4
Toe						3.7	0.150	0.100			

4.533 kips total unreduced pile weight (g= 32.17 ft/s2)  
 4.533 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
10.00	11.18	1.00	0.800

▲ FRA-70-1323C - Rear Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	b/min	
29.5	1.4	3.68	3.71	-1.30	5 11	12.57	1 4	44.0 61.5
29.8	1.4	3.69	3.72	-1.30	5 11	12.60	1 4	44.0 61.4
30.1	1.4	3.74	3.71	-1.56	4 11	12.82	1 4	44.3 61.3
30.4	1.4	3.71	3.74	-1.39	4 11	12.72	1 4	44.0 61.3
30.7	1.4	3.72	3.75	-1.48	4 11	12.82	1 4	44.2 61.2

▲ FRA-70-1323C - Rear Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	15.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)				74.3	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.239	15849	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.7	21.4
2	0.239	15849	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.7	21.4
15	0.239	15849	0.000	0.000	1.00	0.9	0.050	0.100	48.95	4.7	21.4
16	0.239	15849	0.000	0.000	1.00	5.5	0.050	0.100	52.21	4.7	21.4
17	0.239	15849	0.000	0.000	1.00	10.5	0.050	0.100	55.47	4.7	21.4
18	0.239	15849	0.000	0.000	1.00	22.5	0.185	0.100	58.74	4.7	21.4
19	0.239	15849	0.000	0.000	1.00	17.0	0.057	0.100	62.00	4.7	21.4
Toe						17.9	0.150	0.100			

4.533 kips total unreduced pile weight (g= 32.17 ft/s2)  
 4.533 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
15.00	11.18	1.00	0.800

▲ FRA-70-1323C - Rear Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
-----	-------	-------------	---------	---	------------	---	----------	-------

1323C-RA-14X73											
kips	b/ft	down	up	ksi			ksi		kip-ft	b/min	
74.3	3.6	4.88	4.84	-1.01	3	11	21.64	10	4	40.4	53.6
75.3	3.6	4.90	4.86	-1.02	3	11	21.79	10	4	40.3	53.5
76.4	3.7	4.93	4.89	-0.95	3	11	21.93	10	4	40.2	53.4
77.5	3.8	4.96	4.91	-0.99	3	11	22.11	11	4	40.1	53.2
78.5	3.9	4.98	4.94	-0.91	3	11	22.21	11	4	39.9	53.1

FRA-70-1323C - Rear Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth (ft) 20.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model										Total Capacity Rut (kips)	155.7
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
kips	k/in	ft	ft			kips	s/ft	inch	ft	ft	in2
1	0.239	15849	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.7	21.4
2	0.239	15849	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.7	21.4
13	0.239	15849	0.000	0.000	1.00	0.0	0.050	0.100	42.42	4.7	21.4
14	0.239	15849	0.000	0.000	1.00	3.1	0.050	0.100	45.68	4.7	21.4
15	0.239	15849	0.000	0.000	1.00	8.2	0.050	0.100	48.95	4.7	21.4
16	0.239	15849	0.000	0.000	1.00	16.1	0.135	0.100	52.21	4.7	21.4
17	0.239	15849	0.000	0.000	1.00	20.6	0.157	0.100	55.47	4.7	21.4
18	0.239	15849	0.000	0.000	1.00	19.0	0.050	0.100	58.74	4.7	21.4
19	0.239	15849	0.000	0.000	1.00	31.1	0.050	0.100	62.00	4.7	21.4
Toe						57.6	0.150	0.100			

4.533 kips total unreduced pile weight (g= 32.17 ft/s2)  
 4.533 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
20.00	11.18	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min	
155.7	8.5	6.10	6.13	-1.38	14	43	28.04	15	5	35.8	47.6
156.8	8.6	6.12	6.14	-1.32	14	43	28.12	16	5	35.7	47.6
157.9	8.7	6.13	6.15	-1.27	14	43	28.22	16	5	35.7	47.5
158.9	8.8	6.14	6.17	-1.21	14	43	28.29	16	5	35.6	47.5
160.0	8.8	6.16	6.18	-1.17	14	43	28.44	16	5	35.6	47.4

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Depth (ft) 25.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model										Total Capacity Rut (kips)	229.9
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
kips	k/in	ft	ft			kips	s/ft	inch	ft	ft	in2
1	0.239	15849	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.7	21.4
2	0.239	15849	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.7	21.4
12	0.239	15849	0.000	0.000	1.00	1.1	0.050	0.100	39.16	4.7	21.4
13	0.239	15849	0.000	0.000	1.00	5.8	0.050	0.100	42.42	4.7	21.4

1323C-RA-14X73											
14	0.239	15849	0.000	0.000	1.00	10.8	0.050	0.100	45.68	4.7	21.4
15	0.239	15849	0.000	0.000	1.00	22.8	0.186	0.100	48.95	4.7	21.4
16	0.239	15849	0.000	0.000	1.00	17.1	0.050	0.100	52.21	4.7	21.4
17	0.239	15849	0.000	0.000	1.00	25.1	0.050	0.100	55.47	4.7	21.4
18	0.239	15849	0.000	0.000	1.00	34.4	0.050	0.100	58.74	4.7	21.4
19	0.239	15849	0.000	0.000	1.00	40.3	0.050	0.100	62.00	4.7	21.4
Toe						72.4	0.150	0.100			

4.533 kips total unredused pile weight (g= 32.17 ft/s2)

4.533 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
25.00	11.18	1.00	0.800

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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	b/min	
229.9	12.8	6.92	6.87	-1.28	13 34	31.55	15 5	34.7
230.9	13.0	6.94	6.89	-1.30	13 34	31.62	15 5	34.6
232.0	13.1	6.96	6.91	-1.33	13 34	31.81	15 5	34.7
233.1	13.2	6.97	6.92	-1.36	13 33	31.94	15 5	34.6
234.1	13.3	6.98	6.94	-1.40	13 33	32.06	15 5	34.6

FRA-70-1323C - Rear Abutment - HP14x73  
 Resource International Inc

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Depth	(ft)	30.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor
			1.000

#### PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	14.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)			211.0		
No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.239	15849	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.7	21.4
2	0.239	15849	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.7	21.4
10	0.239	15849	0.000	0.000	1.00	0.1	0.050	0.100	32.63	4.7	21.4
11	0.239	15849	0.000	0.000	1.00	3.5	0.050	0.100	35.89	4.7	21.4
12	0.239	15849	0.000	0.000	1.00	8.5	0.050	0.100	39.16	4.7	21.4
13	0.239	15849	0.000	0.000	1.00	17.1	0.145	0.100	42.42	4.7	21.4
14	0.239	15849	0.000	0.000	1.00	20.0	0.149	0.100	45.68	4.7	21.4
15	0.239	15849	0.000	0.000	1.00	19.6	0.050	0.100	48.95	4.7	21.4
16	0.239	15849	0.000	0.000	1.00	31.6	0.050	0.100	52.21	4.7	21.4
17	0.239	15849	0.000	0.000	1.00	37.6	0.050	0.100	55.47	4.7	21.4
18	0.239	15849	0.000	0.000	1.00	37.1	0.050	0.100	58.74	4.7	21.4
19	0.239	15849	0.000	0.000	1.00	25.0	0.050	0.100	62.00	4.7	21.4
Toe						10.9	0.150	0.100			

4.533 kips total unredused pile weight (g= 32.17 ft/s2)

4.533 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
30.00	11.18	1.00	0.800

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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	b/min	
211.0	10.1	6.40	6.43	-1.48	12 39	29.66	13 4	34.6
212.0	10.2	6.42	6.44	-1.43	12 39	29.75	13 4	34.6
213.1	10.2	6.44	6.46	-1.37	12 39	29.87	13 4	34.6
214.2	10.3	6.45	6.47	-1.30	12 39	30.01	13 4	34.6
215.2	10.4	6.47	6.49	-1.26	12 39	30.08	13 4	34.5

FRA-70-1323C - Rear Abutment - HP14x73  
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Resource International Inc

Depth (ft) 35.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)				372.4	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.239	15849	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.7	21.4
2	0.239	15849	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.7	21.4
9	0.239	15849	0.000	0.000	1.00	1.3	0.050	0.100	29.37	4.7	21.4
10	0.239	15849	0.000	0.000	1.00	6.1	0.050	0.100	32.63	4.7	21.4
11	0.239	15849	0.000	0.000	1.00	11.2	0.050	0.100	35.89	4.7	21.4
12	0.239	15849	0.000	0.000	1.00	22.9	0.185	0.100	39.16	4.7	21.4
13	0.239	15849	0.000	0.000	1.00	17.3	0.050	0.100	42.42	4.7	21.4
14	0.239	15849	0.000	0.000	1.00	25.9	0.050	0.100	45.68	4.7	21.4
15	0.239	15849	0.000	0.000	1.00	34.8	0.050	0.100	48.95	4.7	21.4
16	0.239	15849	0.000	0.000	1.00	40.7	0.050	0.100	52.21	4.7	21.4
17	0.239	15849	0.000	0.000	1.00	27.9	0.050	0.100	55.47	4.7	21.4
18	0.239	15849	0.000	0.000	1.00	32.3	0.050	0.100	58.74	4.7	21.4
19	0.239	15849	0.000	0.000	1.00	51.2	0.050	0.100	62.00	4.7	21.4
Toe						100.7	0.150	0.100			

4.533 kips total unredueed pile weight (g= 32.17 ft/s2)  
4.533 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
35.00	11.18	1.00	0.800

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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
372.4	23.3	8.09	8.08	-1.61	10	47	35.57	12	4	34.1
373.5	23.4	8.10	8.09	-1.61	10	47	35.68	12	4	34.1
374.5	23.5	8.11	8.10	-1.61	10	47	35.77	12	4	34.1
375.6	23.6	8.13	8.11	-1.60	10	47	35.91	12	4	34.2
376.7	23.7	8.14	8.11	-1.60	10	47	36.10	12	4	34.2

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Depth (ft) 40.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)				466.3	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.239	15849	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.7	21.4
2	0.239	15849	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.7	21.4
7	0.239	15849	0.000	0.000	1.00	0.2	0.050	0.100	22.84	4.7	21.4
8	0.239	15849	0.000	0.000	1.00	3.8	0.050	0.100	26.11	4.7	21.4
9	0.239	15849	0.000	0.000	1.00	8.8	0.050	0.100	29.37	4.7	21.4
10	0.239	15849	0.000	0.000	1.00	18.0	0.154	0.100	32.63	4.7	21.4
11	0.239	15849	0.000	0.000	1.00	19.5	0.139	0.100	35.89	4.7	21.4
12	0.239	15849	0.000	0.000	1.00	20.3	0.050	0.100	39.16	4.7	21.4

1323C-RA-14X73											
13	0.239	15849	0.000	0.000	1.00	32.0	0.050	0.100	42.42	4.7	21.4
14	0.239	15849	0.000	0.000	1.00	38.0	0.050	0.100	45.68	4.7	21.4
15	0.239	15849	0.000	0.000	1.00	36.1	0.050	0.100	48.95	4.7	21.4
16	0.239	15849	0.000	0.000	1.00	25.1	0.050	0.100	52.21	4.7	21.4
17	0.239	15849	0.000	0.000	1.00	45.6	0.050	0.100	55.47	4.7	21.4
18	0.239	15849	0.000	0.000	1.00	53.0	0.050	0.100	58.74	4.7	21.4
19	0.239	15849	0.000	0.000	1.00	56.3	0.050	0.100	62.00	4.7	21.4
Toe						109.6	0.150	0.100			

4.533 kips total unredacted pile weight (g= 32.17 ft/s2)  
4.533 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
40.00	11.18	1.00	0.800

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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt	
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min	
466.3	31.8	8.72	8.66	-1.94	8	41	37.32	10	3	35.4	40.1
467.4	32.1	8.73	8.68	-1.93	8	41	37.46	10	3	35.3	40.0
468.4	32.1	8.74	8.68	-1.95	8	41	37.47	10	3	35.4	40.0
469.5	32.4	8.75	8.70	-1.95	8	41	37.61	10	3	35.3	40.0
470.5	32.5	8.75	8.70	-1.97	8	41	37.65	10	3	35.4	40.0

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Depth	(ft)	45.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

#### PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	14.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total	Capacity	Rut	(kips)		560.6
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.239	15849	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.7	21.4
2	0.239	15849	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.7	21.4
6	0.239	15849	0.000	0.000	1.00	1.6	0.050	0.100	19.58	4.7	21.4
7	0.239	15849	0.000	0.000	1.00	6.5	0.050	0.100	22.84	4.7	21.4
8	0.239	15849	0.000	0.000	1.00	11.5	0.050	0.100	26.11	4.7	21.4
9	0.239	15849	0.000	0.000	1.00	23.0	0.185	0.100	29.37	4.7	21.4
10	0.239	15849	0.000	0.000	1.00	17.6	0.050	0.100	32.63	4.7	21.4
11	0.239	15849	0.000	0.000	1.00	26.7	0.050	0.100	35.89	4.7	21.4
12	0.239	15849	0.000	0.000	1.00	35.2	0.050	0.100	39.16	4.7	21.4
13	0.239	15849	0.000	0.000	1.00	41.0	0.050	0.100	42.42	4.7	21.4
14	0.239	15849	0.000	0.000	1.00	26.7	0.050	0.100	45.68	4.7	21.4
15	0.239	15849	0.000	0.000	1.00	33.9	0.050	0.100	48.95	4.7	21.4
16	0.239	15849	0.000	0.000	1.00	51.5	0.050	0.100	52.21	4.7	21.4
17	0.239	15849	0.000	0.000	1.00	54.7	0.050	0.100	55.47	4.7	21.4
18	0.239	15849	0.000	0.000	1.00	58.6	0.050	0.100	58.74	4.7	21.4
19	0.239	15849	0.000	0.000	1.00	62.5	0.050	0.100	62.00	4.7	21.4
Toe						109.6	0.150	0.100			

4.533 kips total unredacted pile weight (g= 32.17 ft/s2)  
4.533 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
45.00	11.18	1.00	0.800

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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt	
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min	
560.6	44.6	9.24	9.17	-2.37	7	38	38.97	9	3	36.3	38.9
561.7	44.6	9.25	9.16	-2.38	7	38	39.04	9	3	36.4	38.9

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562.7	45.2	9.26	9.19	-2.35	7	38	39.19	9	3	36.2	38.9
563.8	45.2	9.27	9.18	-2.36	7	37	39.28	9	3	36.4	38.9
564.9	45.8	9.28	9.20	-2.33	7	37	39.43	9	3	36.3	38.9

FRA-70-1323C - Rear Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	50.0	Standard Soil Setup
Shaft Gain/Loss Factor	0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	14.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)				611.4	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.239	15849	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.7	21.4
2	0.239	15849	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.7	21.4
4	0.239	15849	0.000	0.000	1.00	0.3	0.050	0.100	13.05	4.7	21.4
5	0.239	15849	0.000	0.000	1.00	4.1	0.050	0.100	16.32	4.7	21.4
6	0.239	15849	0.000	0.000	1.00	9.1	0.050	0.100	19.58	4.7	21.4
7	0.239	15849	0.000	0.000	1.00	18.9	0.161	0.100	22.84	4.7	21.4
8	0.239	15849	0.000	0.000	1.00	19.0	0.128	0.100	26.11	4.7	21.4
9	0.239	15849	0.000	0.000	1.00	21.1	0.050	0.100	29.37	4.7	21.4
10	0.239	15849	0.000	0.000	1.00	32.4	0.050	0.100	32.63	4.7	21.4
11	0.239	15849	0.000	0.000	1.00	38.4	0.050	0.100	35.89	4.7	21.4
12	0.239	15849	0.000	0.000	1.00	35.0	0.050	0.100	39.16	4.7	21.4
13	0.239	15849	0.000	0.000	1.00	25.2	0.050	0.100	42.42	4.7	21.4
14	0.239	15849	0.000	0.000	1.00	47.3	0.050	0.100	45.68	4.7	21.4
15	0.239	15849	0.000	0.000	1.00	53.2	0.050	0.100	48.95	4.7	21.4
16	0.239	15849	0.000	0.000	1.00	56.6	0.050	0.100	52.21	4.7	21.4
17	0.239	15849	0.000	0.000	1.00	60.8	0.050	0.100	55.47	4.7	21.4
18	0.239	15849	0.000	0.000	1.00	63.5	0.050	0.100	58.74	4.7	21.4
19	0.239	15849	0.000	0.000	1.00	64.5	0.050	0.100	62.00	4.7	21.4
Toe						62.1	0.150	0.100			

4.533 kips total unredused pile weight (g= 32.17 ft/s2)  
 4.533 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficcy
ft	ft	Ratio	
50.00	11.18	1.00	0.800

FRA-70-1323C - Rear Abutment - HP14x73 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	b/min	
611.4	52.2	9.32	9.27	-1.94	6 35	39.02	7 3	35.4 38.8
612.5	52.8	9.33	9.28	-1.92	6 35	39.16	7 3	35.4 38.8
613.5	53.4	9.33	9.29	-1.90	6 35	39.21	7 3	35.3 38.8
614.6	53.2	9.34	9.28	-1.91	6 35	39.26	7 3	35.4 38.8
615.7	53.8	9.35	9.29	-1.88	6 35	39.38	7 3	35.4 38.8

FRA-70-1323C - Rear Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	55.0	Standard Soil Setup
Shaft Gain/Loss Factor	0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	14.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model	Total Capacity Rut (kips)	758.1
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1323C-RA-14X73

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.239	15849	0.010	0.000	0.85	0.0	0.000	0.100	3.26	4.7	21.4
2	0.239	15849	0.000	0.000	1.00	0.0	0.000	0.100	6.53	4.7	21.4
3	0.239	15849	0.000	0.000	1.00	1.8	0.050	0.100	9.79	4.7	21.4
4	0.239	15849	0.000	0.000	1.00	6.8	0.050	0.100	13.05	4.7	21.4
5	0.239	15849	0.000	0.000	1.00	11.9	0.052	0.100	16.32	4.7	21.4
6	0.239	15849	0.000	0.000	1.00	23.1	0.185	0.100	19.58	4.7	21.4
7	0.239	15849	0.000	0.000	1.00	17.9	0.050	0.100	22.84	4.7	21.4
8	0.239	15849	0.000	0.000	1.00	27.5	0.050	0.100	26.11	4.7	21.4
9	0.239	15849	0.000	0.000	1.00	35.6	0.050	0.100	29.37	4.7	21.4
10	0.239	15849	0.000	0.000	1.00	41.4	0.050	0.100	32.63	4.7	21.4
11	0.239	15849	0.000	0.000	1.00	25.5	0.050	0.100	35.89	4.7	21.4
12	0.239	15849	0.000	0.000	1.00	35.5	0.050	0.100	39.16	4.7	21.4
13	0.239	15849	0.000	0.000	1.00	51.7	0.050	0.100	42.42	4.7	21.4
14	0.239	15849	0.000	0.000	1.00	55.0	0.050	0.100	45.68	4.7	21.4
15	0.239	15849	0.000	0.000	1.00	58.9	0.050	0.100	48.95	4.7	21.4
16	0.239	15849	0.000	0.000	1.00	62.7	0.050	0.100	52.21	4.7	21.4
17	0.239	15849	0.000	0.000	1.00	63.6	0.050	0.100	55.47	4.7	21.4
18	0.239	15849	0.000	0.000	1.00	66.9	0.050	0.100	58.74	4.7	21.4
19	0.239	15849	0.000	0.000	1.00	71.8	0.050	0.100	62.00	4.7	21.4
Toe						100.7	0.150	0.100			

4.533 kips total unredacted pile weight (g= 32.17 ft/s2)  
4.533 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy Ratio
55.00	11.18	1.00	0.800

▲ FRA-70-1323C - Rear Abutment - HP14x73 02/28/2021  
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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
758.1	113.6	9.96	9.87	-1.70	5	32	40.77	6	3	37.0	37.6
759.2	119.3	9.86	9.85	-1.69	5	32	40.60	6	3	36.5	37.7
760.3	120.3	9.85	9.84	-1.68	5	32	40.59	6	3	36.5	37.7
761.3	123.1	9.87	9.86	-1.63	5	32	40.76	6	3	36.3	37.7
762.4	123.3	9.86	9.84	-1.64	5	32	40.76	6	3	36.4	37.7

▲ FRA-70-1323C - Rear Abutment - HP14x73 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth ft	(ft)	60.0	Standard Soil Setup
Shaft Gain/Loss Factor	0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area in2	144.000	Pile Type	Unknown
Pile Size inch	14.000		

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.239	15849	0.010	0.000	0.85	0.4	0.050	0.100	3.26	4.7	21.4
2	0.239	15849	0.000	0.000	1.00	4.4	0.050	0.100	6.53	4.7	21.4
3	0.239	15849	0.000	0.000	1.00	9.5	0.050	0.100	9.79	4.7	21.4
4	0.239	15849	0.000	0.000	1.00	19.8	0.168	0.100	13.05	4.7	21.4
5	0.239	15849	0.000	0.000	1.00	18.5	0.115	0.100	16.32	4.7	21.4
6	0.239	15849	0.000	0.000	1.00	21.8	0.050	0.100	19.58	4.7	21.4
7	0.239	15849	0.000	0.000	1.00	32.8	0.050	0.100	22.84	4.7	21.4
8	0.239	15849	0.000	0.000	1.00	38.7	0.050	0.100	26.11	4.7	21.4
9	0.239	15849	0.000	0.000	1.00	33.9	0.050	0.100	29.37	4.7	21.4
10	0.239	15849	0.000	0.000	1.00	25.3	0.050	0.100	32.63	4.7	21.4
11	0.239	15849	0.000	0.000	1.00	49.0	0.050	0.100	35.89	4.7	21.4
12	0.239	15849	0.000	0.000	1.00	53.4	0.050	0.100	39.16	4.7	21.4
13	0.239	15849	0.000	0.000	1.00	56.9	0.050	0.100	42.42	4.7	21.4
14	0.239	15849	0.000	0.000	1.00	61.1	0.050	0.100	45.68	4.7	21.4
15	0.239	15849	0.000	0.000	1.00	63.5	0.050	0.100	48.95	4.7	21.4
16	0.239	15849	0.000	0.000	1.00	64.7	0.050	0.100	52.21	4.7	21.4
17	0.239	15849	0.000	0.000	1.00	69.8	0.050	0.100	55.47	4.7	21.4
18	0.239	15849	0.000	0.000	1.00	73.5	0.050	0.100	58.74	4.7	21.4
19	0.239	15849	0.000	0.000	1.00	76.8	0.050	0.100	62.00	4.7	21.4

Toe 100.7 0.150 0.100

4.533 kips total unreduced pile weight (g= 32.17 ft/s<sup>2</sup>)  
 4.533 kips total reduced pile weight (g= 32.17 ft/s<sup>2</sup>)

Depth ft	Stroke ft	Pressure Ratio	Efficy
60.00	11.18	1.00	0.800

↑  
 FRA-70-1323C - Rear Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
874.5	301.9	10.16	10.15	-0.52	3	30	41.12	4	2	36.6	37.2
875.6	308.1	10.16	10.15	-0.51	3	30	41.18	4	2	36.5	37.2
876.7	312.5	10.16	10.14	-0.51	3	30	41.20	4	2	36.5	37.2
877.7	319.1	10.16	10.14	-0.50	3	30	41.27	4	2	36.5	37.2
878.8	325.5	10.16	10.14	-0.50	3	30	41.29	4	2	36.5	37.2

↑  
 FRA-70-1323C - Rear Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth (ft)	62.0	Standard Soil Setup
Shaft Gain/Loss Factor	0.604	Toe Gain/Loss Factor 1.000

# PILE PROFILE:

Toe Area Pile Size	(in <sup>2</sup> ) (inch)	144.000 14.000	Pile Type	Unknown
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L b Top ft	Area in <sup>2</sup>	E-Mod ksi	Spec Wt lb/ft <sup>3</sup>	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
62.0	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.504

Pile and Soil Model						Total Capacity Rut (kips)					923.2	
No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in <sup>2</sup>	
1	0.239	15849	0.010	0.000	0.85	2.5	0.050	0.100	3.26	4.7	21.4	
2	0.239	15849	0.000	0.000	1.00	7.5	0.050	0.100	6.53	4.7	21.4	
3	0.239	15849	0.000	0.000	1.00	14.2	0.107	0.100	9.79	4.7	21.4	
4	0.239	15849	0.000	0.000	1.00	21.7	0.172	0.100	13.05	4.7	21.4	
5	0.239	15849	0.000	0.000	1.00	18.5	0.050	0.100	16.32	4.7	21.4	
6	0.239	15849	0.000	0.000	1.00	29.4	0.050	0.100	19.58	4.7	21.4	
7	0.239	15849	0.000	0.000	1.00	36.4	0.050	0.100	22.84	4.7	21.4	
8	0.239	15849	0.000	0.000	1.00	40.2	0.050	0.100	26.11	4.7	21.4	
9	0.239	15849	0.000	0.000	1.00	24.7	0.050	0.100	29.37	4.7	21.4	
10	0.239	15849	0.000	0.000	1.00	39.1	0.050	0.100	32.63	4.7	21.4	
11	0.239	15849	0.000	0.000	1.00	52.1	0.050	0.100	35.89	4.7	21.4	
12	0.239	15849	0.000	0.000	1.00	55.4	0.050	0.100	39.16	4.7	21.4	
13	0.239	15849	0.000	0.000	1.00	59.5	0.050	0.100	42.42	4.7	21.4	
14	0.239	15849	0.000	0.000	1.00	63.3	0.050	0.100	45.68	4.7	21.4	
15	0.239	15849	0.000	0.000	1.00	63.6	0.050	0.100	48.95	4.7	21.4	
16	0.239	15849	0.000	0.000	1.00	67.7	0.050	0.100	52.21	4.7	21.4	
17	0.239	15849	0.000	0.000	1.00	72.3	0.050	0.100	55.47	4.7	21.4	
18	0.239	15849	0.000	0.000	1.00	75.6	0.050	0.100	58.74	4.7	21.4	
19	0.239	15849	0.000	0.000	1.00	78.8	0.050	0.100	62.00	4.7	21.4	
Toe						100.7	0.150	0.100				

4.533 kips total unreduced pile weight (g= 32.17 ft/s<sup>2</sup>)  
 4.533 kips total reduced pile weight (g= 32.17 ft/s<sup>2</sup>)

Depth ft	Stroke ft	Pressure Ratio	Efficy
62.00	11.18	1.00	0.800

↑  
 FRA-70-1323C - Rear Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
923.2	536.1	10.31	10.23	0.00	1	0	40.81	3	2	36.5	37.0
924.3	550.7	10.30	10.22	0.00	1	0	40.84	3	2	36.5	37.0
925.4	565.7	10.30	10.22	0.00	1	0	40.89	3	2	36.5	37.0
926.4	579.2	10.30	10.21	0.00	1	0	40.95	3	2	36.5	37.0
927.5	597.5	10.29	10.20	0.00	2	46	40.96	3	2	36.5	37.0

SUMMARY OVER DEPTHS

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	15.1	5.9	9.2	Hammer	did not	run		
10.0	29.5	25.8	3.7	1.4	12.573	-1.301	3.68	44.0
15.0	74.3	56.4	17.9	3.6	21.636	-1.007	4.88	40.4
20.0	155.7	98.1	57.6	8.5	28.037	-1.382	6.10	35.8
25.0	229.9	157.5	72.4	12.8	31.552	-1.281	6.92	34.7
30.0	211.0	200.0	10.9	10.1	29.660	-1.484	6.40	34.6
35.0	372.4	271.7	100.7	23.3	35.569	-1.610	8.09	34.1
40.0	466.3	356.7	109.6	31.8	37.324	-1.942	8.72	35.4
45.0	560.6	451.0	109.6	44.6	38.968	-2.370	9.24	36.3
50.0	611.4	549.3	62.1	52.2	39.022	-1.943	9.32	35.4
55.0	758.1	657.4	100.7	113.6	40.769	-1.700	9.96	37.0
60.0	874.5	773.8	100.7	301.9	41.123	-0.522	10.16	36.6
62.0	923.2	822.5	100.7	536.1	40.807	0.000	10.31	36.5

Total Driving Time 81 minutes;  
Starting at penetration 5.0 ft Total No. of Blows 3099

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	15.1	5.9	9.2	Hammer	did not	run		
10.0	29.8	26.1	3.7	1.4	12.597	-1.303	3.69	44.0
15.0	75.3	57.5	17.9	3.6	21.786	-1.022	4.90	40.3
20.0	156.8	99.2	57.6	8.6	28.123	-1.322	6.12	35.7
25.0	230.9	158.6	72.4	13.0	31.623	-1.300	6.94	34.6
30.0	212.0	201.1	10.9	10.2	29.753	-1.426	6.42	34.6
35.0	373.5	272.8	100.7	23.4	35.684	-1.608	8.10	34.1
40.0	467.4	357.7	109.6	32.1	37.460	-1.934	8.73	35.3
45.0	561.7	452.1	109.6	44.6	39.035	-2.379	9.25	36.4
50.0	612.5	550.4	62.1	52.8	39.156	-1.924	9.33	35.4
55.0	759.2	658.5	100.7	119.3	40.597	-1.691	9.86	36.5
60.0	875.6	774.9	100.7	308.1	41.184	-0.514	10.16	36.5
62.0	924.3	823.6	100.7	550.7	40.839	0.000	10.30	36.5

Total Driving Time 83 minutes;  
Starting at penetration 5.0 ft Total No. of Blows 3172

SUMMARY OVER DEPTHS

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	15.1	5.9	9.2	Hammer	did not	run		
10.0	30.1	26.4	3.7	1.4	12.819	-1.558	3.74	44.3
15.0	76.4	58.5	17.9	3.7	21.927	-0.954	4.93	40.2
20.0	157.9	100.2	57.6	8.7	28.216	-1.268	6.13	35.7
25.0	232.0	159.6	72.4	13.1	31.809	-1.327	6.96	34.7
30.0	213.1	202.2	10.9	10.2	29.874	-1.374	6.44	34.6
35.0	374.5	273.8	100.7	23.5	35.768	-1.607	8.11	34.1
40.0	468.4	358.8	109.6	32.1	37.469	-1.954	8.74	35.4
45.0	562.7	453.1	109.6	45.2	39.191	-2.347	9.26	36.2
50.0	613.5	551.5	62.1	53.4	39.213	-1.900	9.33	35.3
55.0	760.3	659.6	100.7	120.3	40.595	-1.683	9.85	36.5
60.0	876.7	776.0	100.7	312.5	41.197	-0.509	10.16	36.5
62.0	925.4	824.7	100.7	565.7	40.893	0.000	10.30	36.5

Total Driving Time 84 minutes;  
Starting at penetration 5.0 ft Total No. of Blows 3213

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	15.1	5.9	9.2	Hammer	did not	run		
10.0	30.4	26.7	3.7	1.4	12.719	-1.388	3.71	44.0
15.0	77.5	59.6	17.9	3.8	22.110	-0.994	4.96	40.1
20.0	158.9	101.3	57.6	8.8	28.290	-1.214	6.14	35.6
25.0	233.1	160.7	72.4	13.2	31.941	-1.363	6.97	34.6
30.0	214.2	203.2	10.9	10.3	30.012	-1.298	6.45	34.6
35.0	375.6	274.9	100.7	23.6	35.913	-1.604	8.13	34.2
40.0	469.5	359.9	109.6	32.4	37.608	-1.950	8.75	35.3

1323C-RA-14X73								
45.0	563.8	454.2	109.6	45.2	39.282	-2.363	9.27	36.4
50.0	614.6	552.5	62.1	53.2	39.264	-1.905	9.34	35.4
55.0	761.3	660.6	100.7	123.1	40.763	-1.632	9.87	36.3
60.0	877.7	777.0	100.7	319.1	41.266	-0.501	10.16	36.5
62.0	926.4	825.7	100.7	579.2	40.953	0.000	10.30	36.5

Total Driving Time 86 minutes; Total No. of Blows 3268  
Starting at penetration 5.0 ft

▲  
FRA-70-1323C - Rear Abutment - HP14x73 02/28/2021  
Resource International Inc GRLWEAP Version 2010

#### SUMMARY OVER DEPTHS

Depth ft	Rut kips	G/L at Frictn kips	Shaft and End Bg kips	Toe: Bl Ct bl/ft	0.736 Com Str ksi	1.000 Ten Str ksi	Stroke ft	ENTHRU kip-ft
5.0	15.1	5.9	9.2	Hammer	did not	run		
10.0	30.7	27.0	3.7	1.4	12.815	-1.480	3.72	44.2
15.0	78.5	60.7	17.9	3.9	22.210	-0.909	4.98	39.9
20.0	160.0	102.4	57.6	8.8	28.438	-1.169	6.16	35.6
25.0	234.1	161.8	72.4	13.3	32.058	-1.398	6.98	34.6
30.0	215.2	204.3	10.9	10.4	30.076	-1.258	6.47	34.5
35.0	376.7	276.0	100.7	23.7	36.099	-1.604	8.14	34.2
40.0	470.5	360.9	109.6	32.5	37.646	-1.968	8.75	35.4
45.0	564.9	455.2	109.6	45.8	39.429	-2.332	9.28	36.3
50.0	615.7	553.6	62.1	53.8	39.376	-1.880	9.35	35.4
55.0	762.4	661.7	100.7	123.3	40.763	-1.645	9.86	36.4
60.0	878.8	778.1	100.7	325.5	41.289	-0.495	10.16	36.5
62.0	927.5	826.8	100.7	597.5	40.962	-0.001	10.29	36.5

Total Driving Time 87 minutes; Total No. of Blows 3318  
Starting at penetration 5.0 ft

▲  
FRA-70-1323C - Rear Abutment - HP14x73 02/28/2021  
Resource International Inc GRLWEAP Version 2010

#### Table of Depths Analyzed with Driving System Modifiers

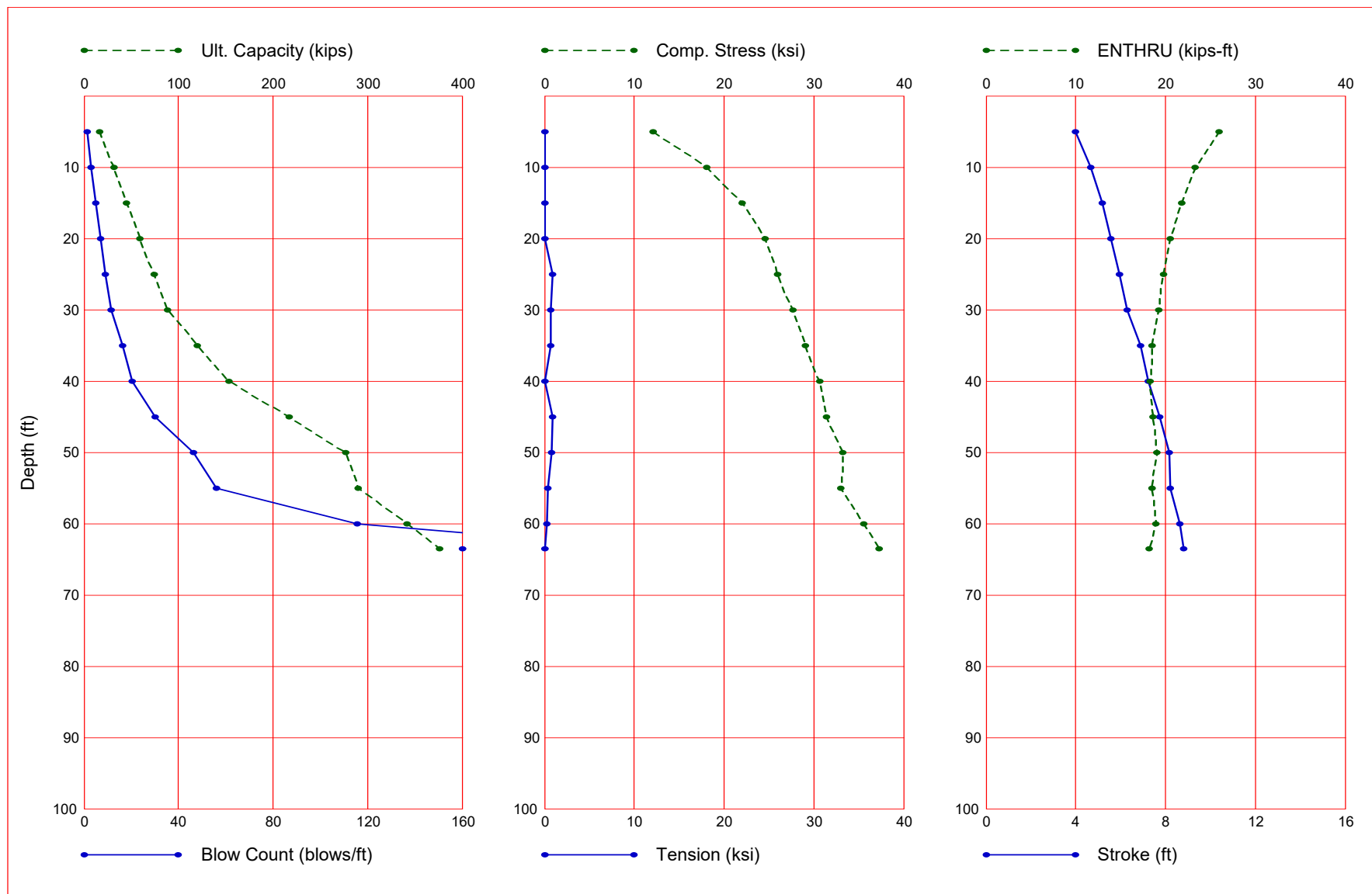
Depth ft	Temp. Length ft	Wait Time hr	Equivalent Stroke ft	Pressure Ratio	Efficy.	Stiffn. Factor	Cushion CoR
5.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
10.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
15.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
20.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
25.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
30.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
35.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
40.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
45.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
50.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
55.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
60.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00
62.00	62.00	0.00	11.18	1.00	0.80	1.00	1.00

#### Soil Layer Resistance Values

Depth ft	Shaft Res. k/ft2	End Bearing kips	Shaft Quake inch	Toe Quake inch	Shaft Damping s/ft	Toe Damping s/ft	Soil Setup Normlzd	Limit Distance ft	Setup Time hrs
0.01	0.00	0.02	0.100	0.100	0.050	0.150	0.000	6.000	1.000
9.01	0.90	16.65	0.100	0.100	0.050	0.150	0.000	6.000	1.000
9.29	0.93	17.17	0.100	0.100	0.050	0.150	0.000	6.000	1.000
9.31	2.75	3.68	0.100	0.100	0.200	0.150	1.000	6.000	168.000
11.79	2.75	3.68	0.100	0.100	0.200	0.150	1.000	6.000	168.000
11.81	0.97	14.04	0.100	0.100	0.050	0.150	0.000	6.000	1.000
16.79	1.38	20.01	0.100	0.100	0.050	0.150	0.000	6.000	1.000
16.81	1.85	47.78	0.100	0.100	0.050	0.150	0.000	6.000	1.000
24.49	2.77	71.50	0.100	0.100	0.050	0.150	0.000	6.000	1.000
24.51	2.77	71.55	0.100	0.100	0.050	0.150	0.000	6.000	1.000
25.79	2.85	73.67	0.100	0.100	0.050	0.150	0.000	6.000	1.000
25.81	1.56	10.93	0.100	0.100	0.050	0.150	0.000	6.000	1.000
30.79	1.70	10.93	0.100	0.100	0.050	0.150	0.000	6.000	1.000
30.81	3.17	100.70	0.100	0.100	0.050	0.150	0.000	6.000	1.000
39.79	3.76	100.70	0.100	0.100	0.050	0.150	0.000	6.000	1.000
39.81	3.82	109.62	0.100	0.100	0.050	0.150	0.000	6.000	1.000
45.79	4.25	109.62	0.100	0.100	0.050	0.150	0.000	6.000	1.000
45.81	4.05	62.06	0.100	0.100	0.050	0.150	0.000	6.000	1.000
50.79	4.36	62.06	0.100	0.100	0.050	0.150	0.000	6.000	1.000

								1323C-RA-14X73		
50.81	4.51	100.70	0.100	0.100	0.050	0.150	0.000	6.000	1.000	
59.81	5.10	100.70	0.100	0.100	0.050	0.150	0.000	6.000	1.000	
62.00	5.25	100.70	0.100	0.100	0.050	0.150	0.000	6.000	1.000	

Gain/Loss 3 at Shaft and Toe 0.670 / 1.000



Gain/Loss 3 at Shaft and Toe 0.670 / 1.000

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
5.0	16.8	15.2	1.5	1.6	12.056	0.000	3.99	26.0
10.0	31.4	30.3	1.2	3.2	18.076	0.000	4.69	23.3
15.0	45.2	44.0	1.2	5.0	21.978	0.000	5.20	21.8
20.0	59.4	57.9	1.5	6.9	24.606	0.000	5.55	20.5
25.0	74.6	73.1	1.5	9.1	25.971	-0.940	5.97	19.8
30.0	88.9	88.1	0.8	11.4	27.699	-0.731	6.31	19.2
35.0	119.6	101.9	17.7	16.5	29.041	-0.648	6.87	18.5
40.0	153.8	136.0	17.7	20.6	30.682	0.000	7.22	18.3
45.0	217.2	181.2	36.0	30.3	31.425	-0.855	7.74	18.6
50.0	276.5	233.1	43.4	46.5	33.231	-0.848	8.15	19.0
55.0	289.7	286.0	3.7	55.9	33.034	-0.387	8.21	18.5
60.0	341.5	337.8	3.7	115.5	35.558	-0.231	8.64	18.9
63.5	375.9	372.2	3.7	241.5	37.265	0.000	8.79	18.2

Total Continuous Driving Time 47.00 minutes; Total Number of Blows 1945 (starting at penetration 5.0 ft)

## ABOUT THE WAVE EQUATION ANALYSIS RESULTS

Input File: J:\GEOTECH\PROJECTS\2013\W-13-072 FRA-70-13.10 PROJECT 6A\ANALYSIS\FRA-70-1322L AND 1323C\DRIVEABILITY\FRA-70-1323C\FORWARD  
ABUTMENT\HP 10X42\1323C-FA-10X42.GWW  
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW  
Hammer File Version: 2003 (12/4/2018)

Page 1



0.000 0.000 0.000 0.000  
 Research Soil Model: RD-skn: m, d, toe: m, d  
 0.000 0.000 0.000 0.000  
 Research Toe Plug: Res-int, Q-int, D-int, Res-plug, Q-plug, D-plug  
 0.000 0.000 0.000 0.000 0.000 0.000  
 Research Toe Plug: RD plug toe: m, d  
 0.000 0.000  
 Research Toe Plug: New Toe Plug Model is NOT applied  
 Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimL	TSf0
0.01	1.38	1.55	0.10	0.10	0.20	0.15	1.49	6.00	168.000
9.01	1.39	1.55	0.10	0.10	0.20	0.15	1.49	6.00	168.000
9.19	1.39	1.55	0.10	0.10	0.20	0.15	1.49	6.00	168.000
9.21	1.24	1.16	0.10	0.10	0.20	0.15	1.49	6.00	168.000
18.21	1.25	1.16	0.10	0.10	0.20	0.15	1.49	6.00	168.000
19.69	1.26	1.16	0.10	0.10	0.20	0.15	1.49	6.00	168.000
19.71	1.37	1.45	0.10	0.10	0.20	0.15	1.49	6.00	168.000
28.71	1.38	1.45	0.10	0.10	0.20	0.15	1.49	6.00	168.000
29.69	1.40	1.45	0.10	0.10	0.20	0.15	1.49	6.00	168.000
29.71	0.92	0.77	0.10	0.10	0.20	0.15	1.49	6.00	168.000
34.19	0.92	0.77	0.10	0.10	0.20	0.15	1.49	6.00	168.000
34.21	1.96	17.74	0.10	0.10	0.05	0.15	1.00	6.00	1.000
41.19	2.19	17.74	0.10	0.10	0.05	0.15	1.00	6.00	1.000
41.21	2.83	35.96	0.10	0.10	0.05	0.15	1.00	6.00	1.000
46.19	3.06	35.96	0.10	0.10	0.05	0.15	1.00	6.00	1.000
46.21	3.09	43.36	0.10	0.10	0.05	0.15	1.00	6.00	1.000
51.19	3.34	43.36	0.10	0.10	0.05	0.15	1.00	6.00	1.000
51.21	4.75	3.68	0.10	0.10	0.20	0.15	1.49	6.00	168.000
60.21	4.66	3.68	0.10	0.10	0.20	0.15	1.49	6.00	168.000
63.50	4.20	3.68	0.10	0.10	0.20	0.15	1.49	6.00	168.000

Gain/Loss factors: shaft and toe

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR
5.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
10.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
15.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
20.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
25.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
30.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
35.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
40.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
45.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
50.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
55.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
60.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
63.50	0.00	0.00	0.000	0.0	0.000	0.000	0.000
0.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000

▲ GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS  
 Version 2010  
 English Units

FRA-70-1323C - For Abutment - HP10x42

Hammer Model:	D 19-42	Made by:	DELMAG
No.	Weight kips	Stiffn k/inch	CoR
1	0.800		
2	0.800	140046.6	1.000
3	0.800	140046.6	1.000
4	0.800	140046.6	1.000
5	0.800	140046.6	1.000
Imp Block	0.753	70735.6	0.900
Helmet	1.900	60155.0	0.800
Combined Pile Top		8966.4	

HAMMER OPTIONS:  
 Hammer File ID No. 41 Hammer Type OE Diesel  
 Stroke Option FxdP-VarS Stroke Convergence Crit. 0.010  
 Fuel Pump Setting Maximum

HAMMER DATA:  
 Ram Weight (kips) 4.00 Ram Length (inch) 129.10  
 Maximum Stroke (ft) 11.86  
 Rated Stroke (ft) 10.81 Efficiency 0.800  
 Maximum Pressure (psi) 1600.00 Actual Pressure (psi) 1600.00  
 Compression Exponent 1.350 Expansion Exponent 1.250  
 Ram Diameter (inch) 12.60

Combustion Delay (s) 0.00200 Ignition Duration (s) 0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION			PILE CUSHION		
Cross Sect. Area	(in2)	227.00	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	530.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	2.00	Thickness	(inch)	0.00
Coeff of Restitution		0.8	Coeff of Restitution		1.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	60155.0	Stiffness	(kips/in)	0.0

FRA-70-1323C - For Abutment - HP10x42 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	5.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	10.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
63.5	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.686

Pile and Soil Model						Total Capacity Rut (kips) 15.3					
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.142	8966	0.010	0.000	0.85	0.0	0.000	0.100	3.34	3.3	12.4
2	0.142	8966	0.000	0.000	1.00	0.0	0.000	0.100	6.68	3.3	12.4
18	0.142	8966	0.000	0.000	1.00	4.5	0.200	0.100	60.16	3.3	12.4
19	0.142	8966	0.000	0.000	1.00	9.2	0.200	0.100	63.50	3.3	12.4
Toe						1.5	0.150	0.100			

2.690 kips total unreduced pile weight (g= 32.17 ft/s2)  
 2.690 kips total reduced pile weight (g= 32.17 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile		Pile Segments: Automatic	
No. of Slacks/Splices	0	Pile Damping (%)	1
		Pile Damping Fact.(k/ft/s)	0.435

Driveability Analysis

Soil Damping Option	Smith	
Max No Analysis Iterations	0	Time Increment/Critical 160
Output Time Interval	1	Analysis Time-Input (ms) 0
Output Level: Normal		
Gravity Mass, Pile, Hammer:	32.170	32.170 32.170
Output Segment Generation: Automatic		

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
5.00	10.81	1.00	0.800

FRA-70-1323C - For Abutment - HP10x42 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	B1 Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	B1 Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	b/min	
15.3	1.6	3.87	3.89	0.00	1 0	11.21	1 7	25.9 60.1
16.0	1.6	3.95	3.92	0.00	1 0	11.61	1 2	26.0 59.7
16.8	1.6	3.99	3.96	0.00	1 0	12.06	1 2	26.0 59.4
17.5	1.7	4.03	4.00	0.00	1 0	12.50	1 2	25.9 59.1
18.3	1.8	4.07	4.04	0.00	1 0	12.88	1 2	25.8 58.8

FRA-70-1323C - For Abutment - HP10x42 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	10.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	10.000		

1323C-FA-10X42

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
63.5	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.686

Pile and Soil Model										Total Capacity Rut (kips)	28.4
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.142	8966	0.010	0.000	0.85	0.0	0.000	0.100	3.34	3.3	12.4
2	0.142	8966	0.000	0.000	1.00	0.0	0.000	0.100	6.68	3.3	12.4
17	0.142	8966	0.000	0.000	1.00	9.1	0.200	0.100	56.82	3.3	12.4
18	0.142	8966	0.000	0.000	1.00	9.2	0.200	0.100	60.16	3.3	12.4
19	0.142	8966	0.000	0.000	1.00	9.0	0.200	0.100	63.50	3.3	12.4
Toe						1.2	0.150	0.100			

2.690 kips total unreduced pile weight (g= 32.17 ft/s2)

2.690 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
10.00	10.81	1.00	0.800

▲ FRA-70-1323C - For Abutment - HP10x42 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	b/min	
28.4	2.9	4.56	4.54	0.00	1 0	17.16	1 2	23.8
29.9	3.0	4.63	4.61	0.00	1 0	17.68	1 2	23.6
31.4	3.2	4.69	4.67	0.00	1 0	18.08	2 2	23.3
32.9	3.4	4.75	4.73	0.00	1 0	18.48	4 3	23.2
34.4	3.6	4.81	4.79	0.00	1 0	18.84	5 3	23.0

▲ FRA-70-1323C - For Abutment - HP10x42 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth	(ft)	15.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	10.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
63.5	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.686

Pile and Soil Model										Total Capacity Rut (kips)	40.9
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.142	8966	0.010	0.000	0.85	0.0	0.000	0.100	3.34	3.3	12.4
2	0.142	8966	0.000	0.000	1.00	0.0	0.000	0.100	6.68	3.3	12.4
15	0.142	8966	0.000	0.000	1.00	4.5	0.200	0.100	50.13	3.3	12.4
16	0.142	8966	0.000	0.000	1.00	9.2	0.200	0.100	53.47	3.3	12.4
17	0.142	8966	0.000	0.000	1.00	9.2	0.200	0.100	56.82	3.3	12.4
18	0.142	8966	0.000	0.000	1.00	8.5	0.200	0.100	60.16	3.3	12.4
19	0.142	8966	0.000	0.000	1.00	8.3	0.200	0.100	63.50	3.3	12.4
Toe						1.2	0.150	0.100			

2.690 kips total unreduced pile weight (g= 32.17 ft/s2)

2.690 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
15.00	10.81	1.00	0.800

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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	b/min	
40.9	4.4	5.05	5.02	0.00	1 0	20.93	15 5	22.2
43.0	4.7	5.13	5.10	0.00	1 0	21.47	15 5	22.0

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45.2	5.0	5.20	5.17	0.00	1	0	21.98	15	5	21.8	51.9
47.4	5.3	5.26	5.23	0.00	1	0	22.50	15	5	21.6	51.5
49.5	5.6	5.33	5.30	0.00	1	0	22.97	15	5	21.4	51.2

FRA-70-1323C - For Abutment - HP10x42  
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Depth (ft) 20.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:  
 Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
63.5	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.686

Pile and Soil Model						Total Capacity Rut (kips)				53.7	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.142	8966	0.010	0.000	0.85	0.0	0.000	0.100	3.34	3.3	12.4
2	0.142	8966	0.000	0.000	1.00	0.0	0.000	0.100	6.68	3.3	12.4
14	0.142	8966	0.000	0.000	1.00	9.0	0.200	0.100	46.79	3.3	12.4
15	0.142	8966	0.000	0.000	1.00	9.2	0.200	0.100	50.13	3.3	12.4
16	0.142	8966	0.000	0.000	1.00	9.0	0.200	0.100	53.47	3.3	12.4
17	0.142	8966	0.000	0.000	1.00	8.3	0.200	0.100	56.82	3.3	12.4
18	0.142	8966	0.000	0.000	1.00	8.3	0.200	0.100	60.16	3.3	12.4
19	0.142	8966	0.000	0.000	1.00	8.4	0.200	0.100	63.50	3.3	12.4
Toe						1.5	0.150	0.100			

2.690 kips total unreduced pile weight (g= 32.17 ft/s2)  
 2.690 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
20.00	10.81	1.00	0.800

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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
53.7	6.1	5.45	5.43	0.00	1	0	23.90	14	5	21.1
56.5	6.5	5.53	5.52	0.00	1	0	24.34	14	5	20.8
59.4	6.9	5.55	5.60	0.00	1	0	24.61	14	5	20.5
62.2	7.4	5.63	5.69	-0.16	14	50	25.06	14	5	20.3
65.1	7.8	5.72	5.75	-0.54	14	48	25.53	14	5	20.2

FRA-70-1323C - For Abutment - HP10x42  
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Depth (ft) 25.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:  
 Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
63.5	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.686

Pile and Soil Model						Total Capacity Rut (kips)				67.4	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.142	8966	0.010	0.000	0.85	0.0	0.000	0.100	3.34	3.3	12.4
2	0.142	8966	0.000	0.000	1.00	0.0	0.000	0.100	6.68	3.3	12.4
12	0.142	8966	0.000	0.000	1.00	4.4	0.200	0.100	40.11	3.3	12.4
13	0.142	8966	0.000	0.000	1.00	9.2	0.200	0.100	43.45	3.3	12.4
14	0.142	8966	0.000	0.000	1.00	9.2	0.200	0.100	46.79	3.3	12.4
15	0.142	8966	0.000	0.000	1.00	8.5	0.200	0.100	50.13	3.3	12.4
16	0.142	8966	0.000	0.000	1.00	8.3	0.200	0.100	53.47	3.3	12.4
17	0.142	8966	0.000	0.000	1.00	8.3	0.200	0.100	56.82	3.3	12.4

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18	0.142	8966	0.000	0.000	1.00	8.8	0.200	0.100	60.16	3.3	12.4
19	0.142	8966	0.000	0.000	1.00	9.2	0.200	0.100	63.50	3.3	12.4
Toe						1.5	0.150	0.100			

2.690 kips total unreduced pile weight (g= 32.17 ft/s2)  
2.690 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
25.00	10.81	1.00	0.800

▲  
FRA-70-1323C - For Abutment - HP10x42 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
67.4	8.1	5.79	5.83	-0.72	12	47	25.09	12	4	20.0
71.0	8.6	5.88	5.91	-0.91	12	47	25.54	12	4	19.9
74.6	9.1	5.97	6.00	-0.94	12	47	25.97	12	4	19.8
78.2	9.7	6.06	6.08	-0.86	12	47	26.37	12	4	19.6
81.8	10.3	6.14	6.16	-0.68	11	47	26.76	12	4	19.5

▲  
FRA-70-1323C - For Abutment - HP10x42 02/28/2021  
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Depth	(ft)	30.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor
			1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	10.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
63.5	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.686

Pile and Soil Model						Total Capacity Rut (kips)						80.2
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area	
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2	
1	0.142	8966	0.010	0.000	0.85	0.0	0.000	0.100	3.34	3.3	12.4	
2	0.142	8966	0.000	0.000	1.00	0.0	0.000	0.100	6.68	3.3	12.4	
11	0.142	8966	0.000	0.000	1.00	8.9	0.200	0.100	36.76	3.3	12.4	
12	0.142	8966	0.000	0.000	1.00	9.2	0.200	0.100	40.11	3.3	12.4	
13	0.142	8966	0.000	0.000	1.00	9.0	0.200	0.100	43.45	3.3	12.4	
14	0.142	8966	0.000	0.000	1.00	8.3	0.200	0.100	46.79	3.3	12.4	
15	0.142	8966	0.000	0.000	1.00	8.3	0.200	0.100	50.13	3.3	12.4	
16	0.142	8966	0.000	0.000	1.00	8.4	0.200	0.100	53.47	3.3	12.4	
17	0.142	8966	0.000	0.000	1.00	9.2	0.200	0.100	56.82	3.3	12.4	
18	0.142	8966	0.000	0.000	1.00	9.2	0.200	0.100	60.16	3.3	12.4	
19	0.142	8966	0.000	0.000	1.00	8.9	0.200	0.100	63.50	3.3	12.4	
Toe						0.8	0.150	0.100				

2.690 kips total unreduced pile weight (g= 32.17 ft/s2)  
2.690 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
30.00	10.81	1.00	0.800

▲  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
80.2	10.0	6.12	6.14	-0.85	11	46	26.83	11	4	19.5
84.5	10.7	6.22	6.23	-0.55	10	46	27.26	11	4	19.3
88.9	11.4	6.31	6.32	-0.73	11	41	27.70	11	4	19.2
93.2	12.1	6.40	6.41	-0.86	11	41	28.14	11	4	19.0
97.6	12.9	6.48	6.50	-0.87	11	41	28.53	11	4	18.9

▲  
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Depth	(ft)	35.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor
			1.000

## PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
63.5	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.686

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	110.1
	kips	Stiffn C-Slk T-Slk CoR	Soil-S Soil-D Quake	LbTop	Perim	Area
		k/in ft ft	kips s/ft inch	ft	ft	in2
1	0.142	8966 0.010 0.000 0.85	0.0 0.000 0.100	3.34	3.3	12.4
2	0.142	8966 0.000 0.000 1.00	0.0 0.000 0.100	6.68	3.3	12.4
9	0.142	8966 0.000 0.000 1.00	4.3 0.200 0.100	30.08	3.3	12.4
10	0.142	8966 0.000 0.000 1.00	9.2 0.200 0.100	33.42	3.3	12.4
11	0.142	8966 0.000 0.000 1.00	9.2 0.200 0.100	36.76	3.3	12.4
12	0.142	8966 0.000 0.000 1.00	8.6 0.200 0.100	40.11	3.3	12.4
13	0.142	8966 0.000 0.000 1.00	8.3 0.200 0.100	43.45	3.3	12.4
14	0.142	8966 0.000 0.000 1.00	8.3 0.200 0.100	46.79	3.3	12.4
15	0.142	8966 0.000 0.000 1.00	8.8 0.200 0.100	50.13	3.3	12.4
16	0.142	8966 0.000 0.000 1.00	9.2 0.200 0.100	53.47	3.3	12.4
17	0.142	8966 0.000 0.000 1.00	9.2 0.200 0.100	56.82	3.3	12.4
18	0.142	8966 0.000 0.000 1.00	7.4 0.200 0.100	60.16	3.3	12.4
19	0.142	8966 0.000 0.000 1.00	9.9 0.140 0.100	63.50	3.3	12.4
Toe			17.7 0.150 0.100			

2.690 kips total unreduced pile weight (g= 32.17 ft/s2)

2.690 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
35.00	10.81	1.00	0.800



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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down up	ksi		ksi		kip-ft	b/min
110.1	14.6	6.72 6.66	-0.40	9	35 28.36	9	4 18.8	45.6
114.9	15.6	6.80 6.75	-0.61	9	35 28.69	9	4 18.7	45.3
119.6	16.5	6.87 6.84	-0.65	9	35 29.04	9	4 18.5	45.0
124.4	17.3	6.95 6.92	-0.48	9	35 29.35	9	4 18.5	44.8
129.1	18.1	7.03 6.99	-0.19	9	34 29.66	9	4 18.4	44.5



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Depth	(ft)	40.0	Standard Soil Setup
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor
			1.000

## PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
63.5	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.686

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	144.2
	kips	Stiffn C-Slk T-Slk CoR	Soil-S Soil-D Quake	LbTop	Perim	Area
		k/in ft ft	kips s/ft inch	ft	ft	in2
1	0.142	8966 0.010 0.000 0.85	0.0 0.000 0.100	3.34	3.3	12.4
2	0.142	8966 0.000 0.000 1.00	0.0 0.000 0.100	6.68	3.3	12.4
8	0.142	8966 0.000 0.000 1.00	8.9 0.200 0.100	26.74	3.3	12.4
9	0.142	8966 0.000 0.000 1.00	9.2 0.200 0.100	30.08	3.3	12.4
10	0.142	8966 0.000 0.000 1.00	9.0 0.200 0.100	33.42	3.3	12.4
11	0.142	8966 0.000 0.000 1.00	8.3 0.200 0.100	36.76	3.3	12.4
12	0.142	8966 0.000 0.000 1.00	8.3 0.200 0.100	40.11	3.3	12.4
13	0.142	8966 0.000 0.000 1.00	8.4 0.200 0.100	43.45	3.3	12.4
14	0.142	8966 0.000 0.000 1.00	9.2 0.200 0.100	46.79	3.3	12.4
15	0.142	8966 0.000 0.000 1.00	9.2 0.200 0.100	50.13	3.3	12.4
16	0.142	8966 0.000 0.000 1.00	9.0 0.200 0.100	53.47	3.3	12.4
17	0.142	8966 0.000 0.000 1.00	6.1 0.200 0.100	56.82	3.3	12.4
18	0.142	8966 0.000 0.000 1.00	17.9 0.071 0.100	60.16	3.3	12.4

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19 0.142 8966 0.000 0.000 1.00 23.1 0.050 0.100 63.50 3.3 12.4  
 Toe 17.7 0.150 0.100

2.690 kips total unreduced pile weight (g= 32.17 ft/s2)  
 2.690 kips total reduced pile weight (g= 32.17 ft/s2)

Depth Stroke Pressure Efficy  
 ft ft Ratio  
 40.00 10.81 1.00 0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min	
144.2	19.0	7.08	7.05	-0.60	8	33	30.01	8	3	18.4	44.3
149.0	19.8	7.14	7.12	-0.22	8	33	30.33	8	3	18.3	44.1
153.8	20.6	7.22	7.19	0.00	1	0	30.68	8	3	18.3	43.9
158.5	21.4	7.27	7.26	0.00	1	0	30.95	8	3	18.2	43.7
163.3	22.1	7.34	7.32	0.00	1	0	31.25	8	3	18.2	43.5

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Depth (ft) 45.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

## PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 10.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
63.5	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.686

No.	Weight kips	Pile and Soil Model Stiffn C-Slk T-Slk k/in ft ft	CoR	Total Capacity Soil-S kips	Soil-D Quake s/ft	Rut (kips) LbTop Perim Area ft ft in2
1	0.142	8966 0.010 0.000 0.85	0.0	0.000 0.100	3.34 3.3 12.4	
2	0.142	8966 0.000 0.000 1.00	0.0	0.000 0.100	6.68 3.3 12.4	
6	0.142	8966 0.000 0.000 1.00	4.2	0.200 0.100	20.05 3.3 12.4	
7	0.142	8966 0.000 0.000 1.00	9.2	0.200 0.100	23.39 3.3 12.4	
8	0.142	8966 0.000 0.000 1.00	9.2	0.200 0.100	26.74 3.3 12.4	
9	0.142	8966 0.000 0.000 1.00	8.6	0.200 0.100	30.08 3.3 12.4	
10	0.142	8966 0.000 0.000 1.00	8.3	0.200 0.100	33.42 3.3 12.4	
11	0.142	8966 0.000 0.000 1.00	8.3	0.200 0.100	36.76 3.3 12.4	
12	0.142	8966 0.000 0.000 1.00	8.8	0.200 0.100	40.11 3.3 12.4	
13	0.142	8966 0.000 0.000 1.00	9.2	0.200 0.100	43.45 3.3 12.4	
14	0.142	8966 0.000 0.000 1.00	9.2	0.200 0.100	46.79 3.3 12.4	
15	0.142	8966 0.000 0.000 1.00	7.5	0.200 0.100	50.13 3.3 12.4	
16	0.142	8966 0.000 0.000 1.00	9.8	0.141 0.100	53.47 3.3 12.4	
17	0.142	8966 0.000 0.000 1.00	22.5	0.050 0.100	56.82 3.3 12.4	
18	0.142	8966 0.000 0.000 1.00	24.7	0.050 0.100	60.16 3.3 12.4	
19	0.142	8966 0.000 0.000 1.00	32.3	0.050 0.100	63.50 3.3 12.4	
Toe			36.0	0.150 0.100		

2.690 kips total unreduced pile weight (g= 32.17 ft/s2)  
 2.690 kips total reduced pile weight (g= 32.17 ft/s2)

Depth Stroke Pressure Efficy  
 ft ft Ratio  
 45.00 10.81 1.00 0.800

▲  
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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min	
207.6	27.9	7.63	7.61	-0.75	6	48	30.96	6	3	18.6	42.7
212.4	29.1	7.69	7.67	-0.82	6	47	31.21	6	3	18.6	42.6
217.2	30.3	7.74	7.73	-0.85	6	47	31.43	6	3	18.6	42.4
221.9	31.5	7.80	7.79	-0.87	6	46	31.70	6	3	18.6	42.3
226.7	32.8	7.84	7.84	-0.88	6	45	31.90	6	3	18.7	42.1

▲  
 FRA-70-1323C - For Abutment - HP10x42 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth (ft) 50.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

## PILE PROFILE:

Toe Area (in<sup>2</sup>) 144.000 Pile Type Unknown  
 Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in <sup>2</sup>	ksi	lb/ft <sup>3</sup>	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
63.5	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.686

Pile and Soil Model					Total Capacity Rut (kips)					267.0	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in <sup>2</sup>
1	0.142	8966	0.010	0.000	0.85	0.0	0.000	0.100	3.34	3.3	12.4
2	0.142	8966	0.000	0.000	1.00	0.0	0.000	0.100	6.68	3.3	12.4
5	0.142	8966	0.000	0.000	1.00	8.8	0.200	0.100	16.71	3.3	12.4
6	0.142	8966	0.000	0.000	1.00	9.2	0.200	0.100	20.05	3.3	12.4
7	0.142	8966	0.000	0.000	1.00	9.0	0.200	0.100	23.39	3.3	12.4
8	0.142	8966	0.000	0.000	1.00	8.3	0.200	0.100	26.74	3.3	12.4
9	0.142	8966	0.000	0.000	1.00	8.3	0.200	0.100	30.08	3.3	12.4
10	0.142	8966	0.000	0.000	1.00	8.4	0.200	0.100	33.42	3.3	12.4
11	0.142	8966	0.000	0.000	1.00	9.2	0.200	0.100	36.76	3.3	12.4
12	0.142	8966	0.000	0.000	1.00	9.2	0.200	0.100	40.11	3.3	12.4
13	0.142	8966	0.000	0.000	1.00	9.0	0.200	0.100	43.45	3.3	12.4
14	0.142	8966	0.000	0.000	1.00	6.1	0.200	0.100	46.79	3.3	12.4
15	0.142	8966	0.000	0.000	1.00	17.7	0.072	0.100	50.13	3.3	12.4
16	0.142	8966	0.000	0.000	1.00	23.1	0.050	0.100	53.47	3.3	12.4
17	0.142	8966	0.000	0.000	1.00	28.9	0.050	0.100	56.82	3.3	12.4
18	0.142	8966	0.000	0.000	1.00	33.2	0.050	0.100	60.16	3.3	12.4
19	0.142	8966	0.000	0.000	1.00	35.2	0.050	0.100	63.50	3.3	12.4
Toe						43.4	0.150	0.100			

2.690 kips total unredacted pile weight (g= 32.17 ft/s<sup>2</sup>)

2.690 kips total reduced pile weight (g= 32.17 ft/s<sup>2</sup>)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
50.00	10.81	1.00	0.800



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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up			ksi			kip-ft	b/min
267.0	42.2	8.06	8.06	-0.78	5	43	32.74	5	3	19.0
271.7	44.2	8.10	8.10	-0.80	5	42	32.97	5	3	19.0
276.5	46.5	8.15	8.15	-0.85	5	42	33.23	5	3	19.0
281.3	49.0	8.21	8.20	-0.92	5	41	33.51	5	3	19.0
286.0	52.2	8.18	8.25	-1.03	5	41	33.59	5	3	18.9



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Depth (ft) 55.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

## PILE PROFILE:

Toe Area (in<sup>2</sup>) 144.000 Pile Type Unknown  
 Pile Size (inch) 10.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in <sup>2</sup>	ksi	lb/ft <sup>3</sup>	ft		ft/s	k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
63.5	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.686

Pile and Soil Model					Total Capacity Rut (kips)					276.2	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in <sup>2</sup>
1	0.142	8966	0.010	0.000	0.85	0.0	0.000	0.100	3.34	3.3	12.4
2	0.142	8966	0.000	0.000	1.00	0.0	0.000	0.100	6.68	3.3	12.4
3	0.142	8966	0.000	0.000	1.00	4.2	0.200	0.100	10.03	3.3	12.4
4	0.142	8966	0.000	0.000	1.00	9.2	0.200	0.100	13.37	3.3	12.4
5	0.142	8966	0.000	0.000	1.00	9.2	0.200	0.100	16.71	3.3	12.4



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6	0.142	8966	0.000	0.000	1.00	8.6	0.200	0.100	20.05	3.3	12.4
7	0.142	8966	0.000	0.000	1.00	8.3	0.200	0.100	23.39	3.3	12.4
8	0.142	8966	0.000	0.000	1.00	8.3	0.200	0.100	26.74	3.3	12.4
9	0.142	8966	0.000	0.000	1.00	8.8	0.200	0.100	30.08	3.3	12.4
10	0.142	8966	0.000	0.000	1.00	9.2	0.200	0.100	33.42	3.3	12.4
11	0.142	8966	0.000	0.000	1.00	9.2	0.200	0.100	36.76	3.3	12.4
12	0.142	8966	0.000	0.000	1.00	7.5	0.200	0.100	40.11	3.3	12.4
13	0.142	8966	0.000	0.000	1.00	9.6	0.143	0.100	43.45	3.3	12.4
14	0.142	8966	0.000	0.000	1.00	22.5	0.050	0.100	46.79	3.3	12.4
15	0.142	8966	0.000	0.000	1.00	24.6	0.050	0.100	50.13	3.3	12.4
16	0.142	8966	0.000	0.000	1.00	32.3	0.050	0.100	53.47	3.3	12.4
17	0.142	8966	0.000	0.000	1.00	34.2	0.050	0.100	56.82	3.3	12.4
18	0.142	8966	0.000	0.000	1.00	35.4	0.078	0.100	60.16	3.3	12.4
19	0.142	8966	0.000	0.000	1.00	31.5	0.200	0.100	63.50	3.3	12.4
Toe						3.7	0.150	0.100			

2.690 kips total unreduced pile weight (g= 32.17 ft/s2)  
2.690 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficacy
55.00	10.81	1.00	0.800

↑  
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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
276.2	47.5	8.15	8.15	-0.42	3	41	32.64	3	3	18.6
283.0	52.0	8.13	8.21	-0.40	3	40	32.73	3	3	18.4
289.7	55.9	8.21	8.27	-0.39	3	39	33.03	3	3	18.5
296.4	60.6	8.28	8.33	-0.37	3	39	33.36	3	3	18.5
303.1	65.7	8.35	8.38	-0.39	3	38	33.63	3	3	18.6

↑  
FRA-70-1323C - For Abutment - HP10x42 02/28/2021  
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Depth (ft)	60.0	Standard Soil Setup	
Shaft Gain/Loss Factor	0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:			
Toe Area	(in2)	144.000	Pile Type
Pile Size	(inch)	10.000	Unknown

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
63.5	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.686

No.	Weight kips	Pile and Soil Model Stiffn C-Slk T-Slk CoR	Total Capacity Soil-S Quake	Rut (kips)	323.0
1	0.142	8966 0.010 0.000 0.85	0.0 0.000 0.100	3.34	3.3
2	0.142	8966 0.000 0.000 1.00	8.7 0.200 0.100	6.68	3.3
3	0.142	8966 0.000 0.000 1.00	9.2 0.200 0.100	10.03	3.3
4	0.142	8966 0.000 0.000 1.00	9.0 0.200 0.100	13.37	3.3
5	0.142	8966 0.000 0.000 1.00	8.3 0.200 0.100	16.71	3.3
6	0.142	8966 0.000 0.000 1.00	8.3 0.200 0.100	20.05	3.3
7	0.142	8966 0.000 0.000 1.00	8.4 0.200 0.100	23.39	3.3
8	0.142	8966 0.000 0.000 1.00	9.2 0.200 0.100	26.74	3.3
9	0.142	8966 0.000 0.000 1.00	9.2 0.200 0.100	30.08	3.3
10	0.142	8966 0.000 0.000 1.00	9.0 0.200 0.100	33.42	3.3
11	0.142	8966 0.000 0.000 1.00	6.1 0.200 0.100	36.76	3.3
12	0.142	8966 0.000 0.000 1.00	17.6 0.073 0.100	40.11	3.3
13	0.142	8966 0.000 0.000 1.00	23.1 0.050 0.100	43.45	3.3
14	0.142	8966 0.000 0.000 1.00	28.8 0.050 0.100	46.79	3.3
15	0.142	8966 0.000 0.000 1.00	33.1 0.050 0.100	50.13	3.3
16	0.142	8966 0.000 0.000 1.00	35.2 0.050 0.100	53.47	3.3
17	0.142	8966 0.000 0.000 1.00	33.4 0.157 0.100	56.82	3.3
18	0.142	8966 0.000 0.000 1.00	31.4 0.200 0.100	60.16	3.3
19	0.142	8966 0.000 0.000 1.00	31.2 0.200 0.100	63.50	3.3
Toe			3.7 0.150 0.100		

2.690 kips total unreduced pile weight (g= 32.17 ft/s2)  
2.690 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficacy
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ft ft Ratio  
60.00 10.81 1.00 0.800

▲ FRA-70-1323C - For Abutment - HP10x42 02/28/2021  
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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min	
323.0	87.2	8.51	8.51	-0.21	2	37	34.83	2	2	18.8	40.5
332.2	99.5	8.58	8.56	-0.22	2	36	35.20	2	2	18.9	40.4
341.5	115.5	8.64	8.61	-0.23	2	36	35.56	2	2	18.9	40.3
350.8	135.6	8.69	8.65	-0.24	2	36	35.88	2	2	18.9	40.2
360.1	165.2	8.74	8.70	-0.23	2	35	36.18	2	2	18.9	40.1

▲ FRA-70-1323C - For Abutment - HP10x42 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth (ft) 63.5 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 10.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	12.40	29000.	492.0	3.3	0	16524.	21.8
63.5	12.40	29000.	492.0	3.3	0	16524.	21.8

Wave Travel Time 2L/c (ms) 7.686

No.	Weight kips	Pile and Soil Model Stiffn C-Slk T-Slk k/in ft ft	CoR	Total Capacity Soil-S Soil-D Quake kips s/ft inch	Rut LbTop	(kips) Perim	354.0 Area in2
1	0.142	8966 0.010 0.000 0.85	0.85	9.2 0.200 0.100	3.34	3.3	12.4
2	0.142	8966 0.000 0.000 1.00	1.00	9.2 0.200 0.100	6.68	3.3	12.4
3	0.142	8966 0.000 0.000 1.00	1.00	9.0 0.200 0.100	10.03	3.3	12.4
4	0.142	8966 0.000 0.000 1.00	1.00	8.3 0.200 0.100	13.37	3.3	12.4
5	0.142	8966 0.000 0.000 1.00	1.00	8.3 0.200 0.100	16.71	3.3	12.4
6	0.142	8966 0.000 0.000 1.00	1.00	8.4 0.200 0.100	20.05	3.3	12.4
7	0.142	8966 0.000 0.000 1.00	1.00	9.2 0.200 0.100	23.39	3.3	12.4
8	0.142	8966 0.000 0.000 1.00	1.00	9.2 0.200 0.100	26.74	3.3	12.4
9	0.142	8966 0.000 0.000 1.00	1.00	8.9 0.200 0.100	30.08	3.3	12.4
10	0.142	8966 0.000 0.000 1.00	1.00	6.1 0.200 0.100	33.42	3.3	12.4
11	0.142	8966 0.000 0.000 1.00	1.00	18.4 0.069 0.100	36.76	3.3	12.4
12	0.142	8966 0.000 0.000 1.00	1.00	23.2 0.050 0.100	40.11	3.3	12.4
13	0.142	8966 0.000 0.000 1.00	1.00	29.2 0.050 0.100	43.45	3.3	12.4
14	0.142	8966 0.000 0.000 1.00	1.00	33.2 0.050 0.100	46.79	3.3	12.4
15	0.142	8966 0.000 0.000 1.00	1.00	35.3 0.050 0.100	50.13	3.3	12.4
16	0.142	8966 0.000 0.000 1.00	1.00	33.2 0.163 0.100	53.47	3.3	12.4
17	0.142	8966 0.000 0.000 1.00	1.00	31.4 0.200 0.100	56.82	3.3	12.4
18	0.142	8966 0.000 0.000 1.00	1.00	31.2 0.200 0.100	60.16	3.3	12.4
19	0.142	8966 0.000 0.000 1.00	1.00	29.5 0.200 0.100	63.50	3.3	12.4
Toe				3.7 0.150 0.100			

2.690 kips total unreduced pile weight (g= 32.17 ft/s2)  
2.690 kips total reduced pile weight (g= 32.17 ft/s2)

Depth Stroke Pressure Efficcy  
ft ft Ratio  
63.50 10.81 1.00 0.800

▲ FRA-70-1323C - For Abutment - HP10x42 02/28/2021  
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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min	
354.0	144.3	8.70	8.65	0.00	1	0	36.51	1	2	18.2	40.2
364.9	185.9	8.75	8.70	0.00	1	0	36.91	1	2	18.1	40.0
375.9	241.5	8.79	8.73	0.00	1	0	37.27	1	2	18.2	40.0
386.9	344.3	8.84	8.77	0.00	1	0	37.63	1	2	18.1	39.9
397.8	532.9	8.87	8.80	0.00	1	0	38.00	1	2	18.1	39.8

▲ FRA-70-1323C - For Abutment - HP10x42 02/28/2021  
Resource International Inc GRLWEAP Version 2010

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.604 1.000  
Depth Rut Frictn End Bg Bl Ct Com Str Ten Str Stroke ENTHRU

## 1323C-FA-10X42

ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	15.3	13.7	1.5	1.6	11.208	0.000	3.87	25.9
10.0	28.4	27.3	1.2	2.9	17.164	0.000	4.56	23.8
15.0	40.9	39.7	1.2	4.4	20.933	0.000	5.05	22.2
20.0	53.7	52.2	1.5	6.1	23.903	0.000	5.45	21.1
25.0	67.4	65.9	1.5	8.1	25.095	-0.718	5.79	20.0
30.0	80.2	79.4	0.8	10.0	26.830	-0.850	6.12	19.5
35.0	110.1	92.4	17.7	14.6	28.359	-0.401	6.72	18.8
40.0	144.2	126.5	17.7	19.0	30.006	-0.603	7.08	18.4
45.0	207.6	171.7	36.0	27.9	30.956	-0.748	7.63	18.6
50.0	267.0	223.6	43.4	42.2	32.738	-0.779	8.06	19.0
55.0	276.2	272.6	3.7	47.5	32.643	-0.419	8.15	18.6
60.0	323.0	319.3	3.7	87.2	34.827	-0.215	8.51	18.8
63.5	354.0	350.3	3.7	144.3	36.509	0.000	8.70	18.2

Total Driving Time 36 minutes; Total No. of Blows 1540  
Starting at penetration 5.0 ft

G/L at Shaft and Toe: 0.637 1.000								
Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	16.0	14.5	1.5	1.6	11.610	0.000	3.95	26.0
10.0	29.9	28.8	1.2	3.0	17.676	0.000	4.63	23.6
15.0	43.0	41.9	1.2	4.7	21.471	0.000	5.13	22.0
20.0	56.5	55.1	1.5	6.5	24.344	0.000	5.53	20.8
25.0	71.0	69.5	1.5	8.6	25.539	-0.913	5.88	19.9
30.0	84.5	83.8	0.8	10.7	27.256	-0.553	6.22	19.3
35.0	114.9	97.1	17.7	15.6	28.690	-0.615	6.80	18.7
40.0	149.0	131.3	17.7	19.8	30.327	-0.224	7.14	18.3
45.0	212.4	176.4	36.0	29.1	31.211	-0.819	7.69	18.6
50.0	271.7	228.4	43.4	44.2	32.969	-0.800	8.10	19.0
55.0	283.0	279.3	3.7	52.0	32.731	-0.403	8.13	18.4
60.0	332.2	328.6	3.7	99.5	35.196	-0.218	8.58	18.9
63.5	364.9	361.3	3.7	185.9	36.910	0.000	8.75	18.1

Total Driving Time 41 minutes; Total No. of Blows 1724  
Starting at penetration 5.0 ft

↑

FRA-70-1323C - For Abutment - HP10x42  
Resource International Inc

02/28/2021  
GRLWEAP Version 2010

## SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.670 1.000								
Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	16.8	15.2	1.5	1.6	12.056	0.000	3.99	26.0
10.0	31.4	30.3	1.2	3.2	18.076	0.000	4.69	23.3
15.0	45.2	44.0	1.2	5.0	21.978	0.000	5.20	21.8
20.0	59.4	57.9	1.5	6.9	24.606	0.000	5.55	20.5
25.0	74.6	73.1	1.5	9.1	25.971	-0.940	5.97	19.8
30.0	88.9	88.1	0.8	11.4	27.699	-0.731	6.31	19.2
35.0	119.6	101.9	17.7	16.5	29.041	-0.648	6.87	18.5
40.0	153.8	136.0	17.7	20.6	30.682	0.000	7.22	18.3
45.0	217.2	181.2	36.0	30.3	31.425	-0.855	7.74	18.6
50.0	276.5	233.1	43.4	46.5	33.231	-0.848	8.15	19.0
55.0	289.7	286.0	3.7	55.9	33.034	-0.387	8.21	18.5
60.0	341.5	337.8	3.7	115.5	35.558	-0.231	8.64	18.9
63.5	375.9	372.2	3.7	241.5	37.265	0.000	8.79	18.2

Total Driving Time 47 minutes; Total No. of Blows 1945  
Starting at penetration 5.0 ft

G/L at Shaft and Toe: 0.703 1.000								
Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	17.5	16.0	1.5	1.7	12.502	0.000	4.03	25.9
10.0	32.9	31.8	1.2	3.4	18.478	0.000	4.75	23.2
15.0	47.4	46.2	1.2	5.3	22.501	0.000	5.26	21.6
20.0	62.2	60.8	1.5	7.4	25.055	-0.162	5.63	20.3
25.0	78.2	76.7	1.5	9.7	26.372	-0.857	6.06	19.6
30.0	93.2	92.4	0.8	12.1	28.142	-0.863	6.40	19.0
35.0	124.4	106.6	17.7	17.3	29.350	-0.482	6.95	18.5
40.0	158.5	140.8	17.7	21.4	30.954	0.000	7.27	18.2
45.0	221.9	186.0	36.0	31.5	31.697	-0.870	7.80	18.6
50.0	281.3	237.9	43.4	49.0	33.514	-0.922	8.21	19.0
55.0	296.4	292.7	3.7	60.6	33.355	-0.370	8.28	18.5
60.0	350.8	347.1	3.7	135.6	35.876	-0.240	8.69	18.9
63.5	386.9	383.2	3.7	344.3	37.629	0.000	8.84	18.1

Total Driving Time 55 minutes; Total No. of Blows 2272

Starting at penetration 5.0 ft

FRA-70-1323C - For Abutment - HP10x42  
Resource International Inc02/28/2021  
GRLWEAP Version 2010

## SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.736 1.000									
Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU	
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft	
5.0	18.3	16.7	1.5	1.8	12.876	0.000	4.07	25.8	
10.0	34.4	33.2	1.2	3.6	18.836	0.000	4.81	23.0	
15.0	49.5	48.4	1.2	5.6	22.966	0.000	5.33	21.4	
20.0	65.1	63.6	1.5	7.8	25.527	-0.536	5.72	20.2	
25.0	81.8	80.3	1.5	10.3	26.761	-0.679	6.14	19.5	
30.0	97.6	96.8	0.8	12.9	28.533	-0.866	6.48	18.9	
35.0	129.1	111.4	17.7	18.1	29.659	-0.191	7.03	18.4	
40.0	163.3	145.6	17.7	22.1	31.255	0.000	7.34	18.2	
45.0	226.7	190.7	36.0	32.8	31.903	-0.884	7.84	18.7	
50.0	286.0	242.7	43.4	52.2	33.588	-1.026	8.18	18.9	
55.0	303.1	299.4	3.7	65.7	33.630	-0.386	8.35	18.6	
60.0	360.1	356.4	3.7	165.2	36.183	-0.228	8.74	18.9	
63.5	397.8	394.2	3.7	532.9	37.995	0.000	8.87	18.1	

Total Driving Time 68 minutes; Total No. of Blows 2792

Starting at penetration 5.0 ft

FRA-70-1323C - For Abutment - HP10x42  
Resource International Inc02/28/2021  
GRLWEAP Version 2010

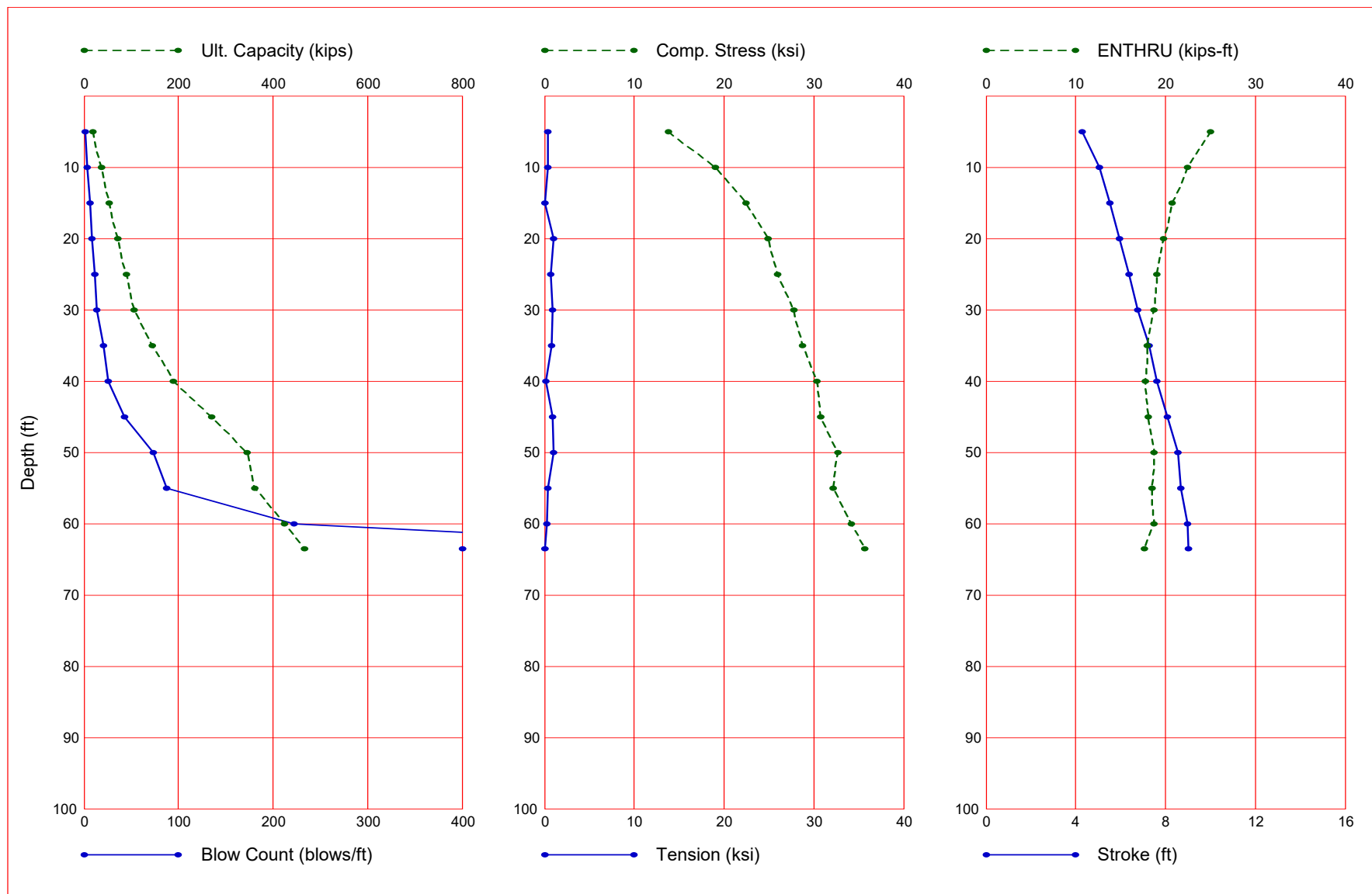
## Table of Depths Analyzed with Driving System Modifiers

Depth	Temp.	Wait	Equivalent	Pressure		Stiffn.	Cushion
ft	Length	Time	Stroke	Ratio	Efficy.	Factor	CoR
	ft	hr	ft				
5.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
10.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
15.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
20.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
25.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
30.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
35.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
40.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
45.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
50.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
55.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
60.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
63.50	63.50	0.00	10.81	1.00	0.80	1.00	1.00

## Soil Layer Resistance Values

Depth	Shaft	End	Shaft	Toe	Shaft	Toe	Soil	Limit	Setup
ft	Res.	Bearing	Quake	Quake	Damping	Damping	Setup	Distance	Time
	k/ft2	kips	inch	inch	s/ft	s/ft	Normlzd	ft	hrs
0.01	1.38	1.55	0.100	0.100	0.200	0.150	1.000	6.000	168.000
9.01	1.39	1.55	0.100	0.100	0.200	0.150	1.000	6.000	168.000
9.19	1.39	1.55	0.100	0.100	0.200	0.150	1.000	6.000	168.000
9.21	1.24	1.16	0.100	0.100	0.200	0.150	1.000	6.000	168.000
18.21	1.25	1.16	0.100	0.100	0.200	0.150	1.000	6.000	168.000
19.69	1.26	1.16	0.100	0.100	0.200	0.150	1.000	6.000	168.000
19.71	1.37	1.45	0.100	0.100	0.200	0.150	1.000	6.000	168.000
28.71	1.38	1.45	0.100	0.100	0.200	0.150	1.000	6.000	168.000
29.69	1.40	1.45	0.100	0.100	0.200	0.150	1.000	6.000	168.000
29.71	0.92	0.77	0.100	0.100	0.200	0.150	1.000	6.000	168.000
34.19	0.92	0.77	0.100	0.100	0.200	0.150	1.000	6.000	168.000
34.21	1.96	17.74	0.100	0.100	0.050	0.150	0.000	6.000	1.000
41.19	2.19	17.74	0.100	0.100	0.050	0.150	0.000	6.000	1.000
41.21	2.83	35.96	0.100	0.100	0.050	0.150	0.000	6.000	1.000
46.19	3.06	35.96	0.100	0.100	0.050	0.150	0.000	6.000	1.000
46.21	3.09	43.36	0.100	0.100	0.050	0.150	0.000	6.000	1.000
51.19	3.34	43.36	0.100	0.100	0.050	0.150	0.000	6.000	1.000
51.21	4.75	3.68	0.100	0.100	0.200	0.150	1.000	6.000	168.000
60.21	4.66	3.68	0.100	0.100	0.200	0.150	1.000	6.000	168.000
63.50	4.20	3.68	0.100	0.100	0.200	0.150	1.000	6.000	168.000

Gain/Loss 3 at Shaft and Toe 0.670 / 1.000



Gain/Loss 3 at Shaft and Toe 0.670 / 1.000

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
5.0	20.2	18.3	1.9	1.9	13.847	-0.357	4.29	25.0
10.0	37.7	36.3	1.5	3.9	19.021	-0.337	5.07	22.4
15.0	54.3	52.8	1.5	6.1	22.438	0.000	5.51	20.7
20.0	71.3	69.4	1.8	8.5	24.888	-0.994	5.96	19.8
25.0	89.5	87.7	1.8	11.3	25.966	-0.741	6.37	19.0
30.0	106.6	105.6	1.0	14.0	27.771	-0.874	6.76	18.7
35.0	144.8	122.6	22.2	21.2	28.781	-0.776	7.29	18.0
40.0	188.6	166.4	22.2	25.9	30.347	-0.202	7.62	17.8
45.0	269.7	224.8	45.0	42.6	30.804	-0.927	8.08	18.1
50.0	346.2	292.0	54.2	73.3	32.670	-0.992	8.57	18.7
55.0	361.5	356.9	4.6	87.5	32.204	-0.414	8.67	18.5
60.0	424.7	420.1	4.6	222.0	34.189	-0.236	8.99	18.7
63.5	467.7	463.1	4.6	750.1	35.631	0.000	9.04	17.7

Total Continuous Driving Time 92.00 minutes; Total Number of Blows 3734 (starting at penetration 5.0 ft)

GRLWEAP - Version 2010  
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.  
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ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

▲

Input File: J:\GEOTECH\PROJECTS\2013\W-13-072 FRA-70-13.10 PROJECT 6A\ANALYSIS\FRA-70-1322L AND 1323C\DRIVEABILITY\FRA-70-1323C\FORWARD  
ABUTMENT\HP 12X53\1323C-FA-12X53.GMW

Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW

Hammer File Version: 2003 (12/4/2018)

Input File Contents

FRA-70-1323C - For Abutment - HP12x53  
OUT OSG HAM STR FUL PEL N SPL N-U P-D %SK ISM 0 PHI RSA ITR H-D MXT DEX  
-100 0 41 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0.000  
Pile g Hammer g Toe Area Pile Size Pile Type  
32.170 32.170 144.000 12.000 Unknown  
W Cp A Cp E Cp T Cp CoR ROut StCp  
1.900 227.000 530.0 2.000 0.800 0.010 0.0  
A Cu E Cu T Cu CoR ROut StCu  
0.000 0.0 0.000 0.000 0.000 0.0  
LPle APle EPle WPLE Peri CI CoR ROut  
63.500 15.50 29000.0 492.000 3.970 0 0.850 0.010  
FFatigue F0 0-Bottom  
0 0.000 0.000  
Manufac Hmr Name HmrType No Seg-s  
DELMAG D 19-42 1 5  
Ram Wt Ram L Ram Dia MaxStrk RtdStrk Efficy  
4.00 129.10 12.60 11.86 10.81 0.80  
IB. Wt IB. L IB. Dia IB CoR IB R0  
0.75 25.30 12.60 0.900 0.010  
CompStrk A Chamber V Chamber C Delay C Duratn Exp Coeff VolCStart Vol CEnd  
16.65 124.70 157.70 0.0020 0.0020 1.250 0.00 0.00  
P atm P1 P2 P3 P4 P5  
14.70 1600.00 1440.00 1295.00 1165.00 0.00  
Stroke Effic. Pressure R-Weight T-Delay Exp-Coeff Eps-Str Total-AW  
10.8100 0.8000 1600.0000 0.0000 0.0000 0.0000 0.0100 0.0000  
Qs Qt Js Jt Qx Jx Rati Dept  
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000  
Research Soil Model: Atoe, Plug, Gap, Q-fac

0.000 0.000 0.000 0.000  
 Research Soil Model: RD-skn: m, d, toe: m, d  
 0.000 0.000 0.000 0.000  
 Research Toe Plug: Res-int, Q-int, D-int, Res-plug, Q-plug, D-plug  
 0.000 0.000 0.000 0.000 0.000 0.000  
 Research Toe Plug: RD plug toe: m, d  
 0.000 0.000

Research Toe Plug: New Toe Plug Model is NOT applied

Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimL	TSf0
0.01	1.38	1.94	0.10	0.10	0.20	0.15	1.49	6.00	168.000
9.01	1.38	1.94	0.10	0.10	0.20	0.15	1.49	6.00	168.000
9.19	1.38	1.94	0.10	0.10	0.20	0.15	1.49	6.00	168.000
9.21	1.24	1.45	0.10	0.10	0.20	0.15	1.49	6.00	168.000
18.21	1.24	1.45	0.10	0.10	0.20	0.15	1.49	6.00	168.000
19.69	1.25	1.45	0.10	0.10	0.20	0.15	1.49	6.00	168.000
19.71	1.37	1.82	0.10	0.10	0.20	0.15	1.49	6.00	168.000
28.71	1.37	1.82	0.10	0.10	0.20	0.15	1.49	6.00	168.000
29.69	1.37	1.82	0.10	0.10	0.20	0.15	1.49	6.00	168.000
29.71	0.92	0.97	0.10	0.10	0.20	0.15	1.49	6.00	168.000
34.19	0.92	0.97	0.10	0.10	0.20	0.15	1.49	6.00	168.000
34.21	2.09	22.18	0.10	0.10	0.05	0.15	1.00	6.00	1.000
41.19	2.34	22.18	0.10	0.10	0.05	0.15	1.00	6.00	1.000
41.21	3.04	44.95	0.10	0.10	0.05	0.15	1.00	6.00	1.000
46.19	3.29	44.95	0.10	0.10	0.05	0.15	1.00	6.00	1.000
46.21	3.33	54.20	0.10	0.10	0.05	0.15	1.00	6.00	1.000
51.19	3.59	54.20	0.10	0.10	0.05	0.15	1.00	6.00	1.000
51.21	4.75	4.60	0.10	0.10	0.20	0.15	1.49	6.00	168.000
60.21	4.75	4.60	0.10	0.10	0.20	0.15	1.49	6.00	168.000
63.50	4.48	4.60	0.10	0.10	0.20	0.15	1.49	6.00	168.000

Gain/Loss factors: shaft and toe

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR
5.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
10.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
15.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
20.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
25.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
30.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
35.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
40.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
45.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
50.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
55.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
60.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
63.50	0.00	0.00	0.000	0.0	0.000	0.000	0.000
0.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000

▲ GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS  
 Version 2010  
 English Units

FRA-70-1323C - For Abutment - HP12x53

Hammer Model: D 19-42 Made by: DELMAG

No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	0.800				
2	0.800	140046.6	1.000	0.0000	
3	0.800	140046.6	1.000	0.0000	
4	0.800	140046.6	1.000	0.0000	
5	0.800	140046.6	1.000	0.0000	
Imp Block	0.753	70735.6	0.900	0.0100	
Helmet	1.900	60155.0	0.800	0.0100	5.8
Combined Pile Top		11208.0			

HAMMER OPTIONS:

Hammer File ID No.	41	Hammer Type	OE Diesel
Stroke Option	FxdP-VarS	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Maximum		

HAMMER DATA:

Ram Weight	(kips)	4.00	Ram Length	(inch)	129.10
Maximum Stroke	(ft)	11.86			
Rated Stroke	(ft)	10.81	Efficiency		0.800
Maximum Pressure	(psi)	1600.00	Actual Pressure	(psi)	1600.00
Compression Exponent		1.350	Expansion Exponent		1.250
Ram Diameter	(inch)	12.60			



Combustion Delay (s) 0.00200 Ignition Duration (s) 0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION				PILE CUSHION			
Cross Sect. Area	(in2)	227.00		Cross Sect. Area	(in2)	0.00	
Elastic-Modulus	(ksi)	530.0		Elastic-Modulus	(ksi)	0.0	
Thickness	(inch)	2.00		Thickness	(inch)	0.00	
Coeff of Restitution		0.8		Coeff of Restitution		1.0	
RoundOut	(ft)	0.0		RoundOut	(ft)	0.0	
Stiffness	(kips/in)	60155.0		Stiffness	(kips/in)	0.0	

FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	5.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	12.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
63.5	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.686

Pile and Soil Model						Total Capacity Rut (kips) 18.4					
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.177	11208	0.010	0.000	0.85	0.0	0.000	0.100	3.34	4.0	15.5
2	0.177	11208	0.000	0.000	1.00	0.0	0.000	0.100	6.68	4.0	15.5
18	0.177	11208	0.000	0.000	1.00	5.4	0.200	0.100	60.16	4.0	15.5
19	0.177	11208	0.000	0.000	1.00	11.0	0.200	0.100	63.50	4.0	15.5
Toe						1.9	0.150	0.100			

3.363 kips total unreduced pile weight (g= 32.17 ft/s2)  
 3.363 kips total reduced pile weight (g= 32.17 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile		Pile Segments: Automatic	
No. of Slacks/Splices	0	Pile Damping (%)	1
		Pile Damping Fact.(k/ft/s)	0.544

Driveability Analysis

Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	1	Analysis Time-Input (ms)	0
Output Level: Normal			
Gravity Mass, Pile, Hammer:	32.170	32.170	32.170
Output Segment Generation: Automatic			

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
5.00	10.81	1.00	0.800

FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	B1 Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	B1 Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	b/min	
18.4	1.8	4.23	4.21	-0.38	3 12	13.23	1 2	25.4
19.3	1.8	4.29	4.25	-0.36	3 12	13.67	1 2	25.3
20.2	1.9	4.29	4.31	-0.36	3 12	13.85	1 2	25.0
21.1	2.0	4.33	4.35	-0.34	3 12	14.18	1 2	24.8
22.0	2.1	4.37	4.40	-0.32	3 12	14.50	1 2	24.7

FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	10.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	12.000		

1323C-FA-12X53

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
63.5	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.686

Pile and Soil Model										Total Capacity Rut (kips)	34.2
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.177	11208	0.010	0.000	0.85	0.0	0.000	0.100	3.34	4.0	15.5
2	0.177	11208	0.000	0.000	1.00	0.0	0.000	0.100	6.68	4.0	15.5
17	0.177	11208	0.000	0.000	1.00	10.9	0.200	0.100	56.82	4.0	15.5
18	0.177	11208	0.000	0.000	1.00	11.0	0.200	0.100	60.16	4.0	15.5
19	0.177	11208	0.000	0.000	1.00	10.8	0.200	0.100	63.50	4.0	15.5
Toe						1.5	0.150	0.100			

3.363 kips total unreduced pile weight (g= 32.17 ft/s2)

3.363 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
10.00	10.81	1.00	0.800

▲  
FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min	
34.2	3.5	4.94	4.91	-0.44	2	10	18.25	6	3	22.9	53.4
35.9	3.7	5.00	4.97	-0.36	2	10	18.64	8	3	22.6	53.0
37.7	3.9	5.07	5.04	-0.34	3	12	19.02	8	3	22.4	52.7
39.5	4.1	5.13	5.10	-0.31	3	12	19.37	10	4	22.2	52.4
41.3	4.4	5.19	5.16	-0.24	3	12	19.70	10	4	22.0	52.1

▲  
FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
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Depth	(ft)	15.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	12.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
63.5	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.686

Pile and Soil Model										Total Capacity Rut (kips)	49.1
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.177	11208	0.010	0.000	0.85	0.0	0.000	0.100	3.34	4.0	15.5
2	0.177	11208	0.000	0.000	1.00	0.0	0.000	0.100	6.68	4.0	15.5
15	0.177	11208	0.000	0.000	1.00	5.4	0.200	0.100	50.13	4.0	15.5
16	0.177	11208	0.000	0.000	1.00	11.0	0.200	0.100	53.47	4.0	15.5
18	0.177	11208	0.000	0.000	1.00	10.2	0.200	0.100	60.16	4.0	15.5
19	0.177	11208	0.000	0.000	1.00	10.0	0.200	0.100	63.50	4.0	15.5
Toe						1.5	0.150	0.100			

3.363 kips total unreduced pile weight (g= 32.17 ft/s2)

3.363 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
15.00	10.81	1.00	0.800

▲  
FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt	
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min	
49.1	5.4	5.42	5.40	-0.22	3	12	21.75	15	5	21.3	50.8
51.7	5.8	5.50	5.48	-0.12	19	14	22.21	15	5	21.1	50.4
54.3	6.1	5.51	5.56	0.00	1	0	22.44	15	5	20.7	50.2

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 56.9 6.5 5.58 5.63 0.00 1 0 22.82 15 5 20.6 49.9  
 59.5 6.8 5.65 5.70 0.00 1 0 23.22 15 5 20.4 49.6

▲  
 FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth (ft) 20.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:  
 Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
63.5	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.686

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	64.4
	kips	Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D Quake	LbTop Perim	Area
		k/in ft ft	kips	s/ft inch	ft ft	in2
1	0.177	11208 0.010 0.000 0.85	0.0	0.000 0.100	3.34 4.0	15.5
2	0.177	11208 0.000 0.000 1.00	0.0	0.000 0.100	6.68 4.0	15.5
14	0.177	11208 0.000 0.000 1.00	10.8	0.200 0.100	46.79 4.0	15.5
15	0.177	11208 0.000 0.000 1.00	11.0	0.200 0.100	50.13 4.0	15.5
16	0.177	11208 0.000 0.000 1.00	10.8	0.200 0.100	53.47 4.0	15.5
17	0.177	11208 0.000 0.000 1.00	10.0	0.200 0.100	56.82 4.0	15.5
19	0.177	11208 0.000 0.000 1.00	10.1	0.200 0.100	63.50 4.0	15.5
Toe			1.8	0.150 0.100		

3.363 kips total unreduced pile weight (g= 32.17 ft/s2)  
 3.363 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
20.00	10.81	1.00	0.800

▲  
 FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i t Comp Str	i t ENTHRU	Bl Rt
kips	b/ft	down up	ksi	ksi	kip-ft	b/min
64.4	7.5	5.79 5.83	-0.17	16 48 24.03	14 5 20.1	48.9
67.8	8.0	5.87 5.90	-0.60	14 48 24.45	14 5 20.0	48.6
71.3	8.5	5.96 5.99	-0.99	14 48 24.89	14 5 19.8	48.2
74.7	9.1	6.05 6.07	-1.21	14 48 25.32	14 5 19.6	47.9
78.1	9.6	6.12 6.14	-1.18	14 48 25.69	14 5 19.6	47.6

▲  
 FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth (ft) 25.0 Standard Soil Setup  
 Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:  
 Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
63.5	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.686

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	80.9
	kips	Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D Quake	LbTop Perim	Area
		k/in ft ft	kips	s/ft inch	ft ft	in2
1	0.177	11208 0.010 0.000 0.85	0.0	0.000 0.100	3.34 4.0	15.5
2	0.177	11208 0.000 0.000 1.00	0.0	0.000 0.100	6.68 4.0	15.5
12	0.177	11208 0.000 0.000 1.00	5.3	0.200 0.100	40.11 4.0	15.5
13	0.177	11208 0.000 0.000 1.00	11.0	0.200 0.100	43.45 4.0	15.5
15	0.177	11208 0.000 0.000 1.00	10.2	0.200 0.100	50.13 4.0	15.5
16	0.177	11208 0.000 0.000 1.00	10.0	0.200 0.100	53.47 4.0	15.5
18	0.177	11208 0.000 0.000 1.00	10.6	0.200 0.100	60.16 4.0	15.5
19	0.177	11208 0.000 0.000 1.00	11.0	0.200 0.100	63.50 4.0	15.5
Toe			1.8	0.150 0.100		

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3.363 kips total unreduced pile weight (g= 32.17 ft/s2)  
3.363 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
25.00	10.81	1.00	0.800

↑  
FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
80.9	10.0	6.20	6.22	-1.17	10	47	25.22	12	4	19.4
85.2	10.6	6.29	6.31	-0.93	9	47	25.61	12	4	19.2
89.5	11.3	6.37	6.39	-0.74	12	41	25.97	12	4	19.0
93.8	11.9	6.45	6.47	-0.91	12	41	26.29	12	4	18.9
98.2	12.6	6.53	6.54	-1.00	12	41	26.66	12	4	18.8

↑  
FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth (ft)	30.0	Standard Soil Setup
Shaft Gain/Loss Factor	0.604	Toe Gain/Loss Factor
		1.000

PILE PROFILE:  
Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 12.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
63.5	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.686

No.	Weight kips	Pile and Soil Model Stiffn C-Slk T-Slk k/in ft ft	CoR	Soil-S kips	Soil-D Quake s/ft	Rut (kips) inch	96.2 LbTop Perim Area ft ft in2
1	0.177	11208 0.010 0.000 0.85	0.0	0.000 0.100	3.34	4.0	15.5
2	0.177	11208 0.000 0.000 1.00	0.0	0.000 0.100	6.68	4.0	15.5
11	0.177	11208 0.000 0.000 1.00	10.7	0.200 0.100	36.76	4.0	15.5
12	0.177	11208 0.000 0.000 1.00	11.0	0.200 0.100	40.11	4.0	15.5
13	0.177	11208 0.000 0.000 1.00	10.8	0.200 0.100	43.45	4.0	15.5
14	0.177	11208 0.000 0.000 1.00	10.0	0.200 0.100	46.79	4.0	15.5
16	0.177	11208 0.000 0.000 1.00	10.1	0.200 0.100	53.47	4.0	15.5
17	0.177	11208 0.000 0.000 1.00	11.0	0.200 0.100	56.82	4.0	15.5
19	0.177	11208 0.000 0.000 1.00	10.7	0.200 0.100	63.50	4.0	15.5
Toe			1.0	0.150 0.100			

3.363 kips total unreduced pile weight (g= 32.17 ft/s2)  
3.363 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
30.00	10.81	1.00	0.800

↑  
FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
96.2	12.3	6.51	6.53	-0.94	11	41	26.73	11	4	18.8
101.4	13.0	6.68	6.62	-0.97	11	41	27.37	11	4	18.8
106.6	14.0	6.76	6.71	-0.87	11	41	27.77	11	4	18.7
111.8	15.0	6.85	6.80	-0.70	10	35	28.15	11	4	18.5
117.0	16.1	6.93	6.89	-0.95	10	35	28.51	11	4	18.4

↑  
FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth (ft)	35.0	Standard Soil Setup
Shaft Gain/Loss Factor	0.604	Toe Gain/Loss Factor
		1.000

PILE PROFILE:  
Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 12.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s

1323C-FA-12X53

0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
63.5	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.686

Pile and Soil Model										Total Capacity Rut (kips)	133.3
No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.177	11208	0.010	0.000	0.85	0.0	0.000	0.100	3.34	4.0	15.5
2	0.177	11208	0.000	0.000	1.00	0.0	0.000	0.100	6.68	4.0	15.5
9	0.177	11208	0.000	0.000	1.00	5.2	0.200	0.100	30.08	4.0	15.5
10	0.177	11208	0.000	0.000	1.00	11.0	0.200	0.100	33.42	4.0	15.5
12	0.177	11208	0.000	0.000	1.00	10.3	0.200	0.100	40.11	4.0	15.5
13	0.177	11208	0.000	0.000	1.00	10.0	0.200	0.100	43.45	4.0	15.5
15	0.177	11208	0.000	0.000	1.00	10.6	0.200	0.100	50.13	4.0	15.5
16	0.177	11208	0.000	0.000	1.00	11.0	0.200	0.100	53.47	4.0	15.5
18	0.177	11208	0.000	0.000	1.00	8.9	0.200	0.100	60.16	4.0	15.5
19	0.177	11208	0.000	0.000	1.00	12.3	0.138	0.100	63.50	4.0	15.5
Toe						22.2	0.150	0.100			

3.363 kips total unreduced pile weight (g= 32.17 ft/s2)  
3.363 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy Ratio
35.00	10.81	1.00	0.800

FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
133.3	19.0	7.14	7.11	-1.11	9	35	28.16	9	4	18.2	44.2
139.0	20.0	7.22	7.19	-1.02	9	34	28.52	9	4	18.1	43.9
144.8	21.2	7.29	7.28	-0.78	9	34	28.78	9	3	18.0	43.7
150.5	22.0	7.37	7.35	-0.47	9	34	29.09	9	3	17.9	43.5
156.2	22.8	7.43	7.41	-0.09	9	34	29.33	9	4	17.8	43.3

FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth (ft)	40.0	Standard Soil Setup
Shaft Gain/Loss Factor	0.604	Toe Gain/Loss Factor
		1.000

PILE PROFILE:

Toe Area (in2)	144.000	Pile Type	Unknown
Pile Size (inch)	12.000		

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
63.5	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.686

Pile and Soil Model										Total Capacity Rut (kips)	177.2
No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.177	11208	0.010	0.000	0.85	0.0	0.000	0.100	3.34	4.0	15.5
2	0.177	11208	0.000	0.000	1.00	0.0	0.000	0.100	6.68	4.0	15.5
8	0.177	11208	0.000	0.000	1.00	10.7	0.200	0.100	26.74	4.0	15.5
9	0.177	11208	0.000	0.000	1.00	11.0	0.200	0.100	30.08	4.0	15.5
10	0.177	11208	0.000	0.000	1.00	10.8	0.200	0.100	33.42	4.0	15.5
11	0.177	11208	0.000	0.000	1.00	10.0	0.200	0.100	36.76	4.0	15.5
13	0.177	11208	0.000	0.000	1.00	10.0	0.200	0.100	43.45	4.0	15.5
14	0.177	11208	0.000	0.000	1.00	11.0	0.200	0.100	46.79	4.0	15.5
16	0.177	11208	0.000	0.000	1.00	10.7	0.200	0.100	53.47	4.0	15.5
17	0.177	11208	0.000	0.000	1.00	7.4	0.200	0.100	56.82	4.0	15.5
18	0.177	11208	0.000	0.000	1.00	22.8	0.070	0.100	60.16	4.0	15.5
19	0.177	11208	0.000	0.000	1.00	29.7	0.050	0.100	63.50	4.0	15.5
Toe						22.2	0.150	0.100			

3.363 kips total unreduced pile weight (g= 32.17 ft/s2)  
3.363 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy Ratio
40.00	10.81	1.00	0.800

FRA-70-1323C - For Abutment - HP12x53  
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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
177.2	24.0	7.50	7.48	-0.03	8 28	29.76	8 3	17.8	43.1	
182.9	24.9	7.56	7.54	0.00	1 0	30.08	8 3	17.8	42.9	
188.6	25.9	7.62	7.61	-0.20	8 50	30.35	8 3	17.8	42.8	
194.3	27.0	7.68	7.68	-0.38	8 50	30.61	8 3	17.7	42.6	
200.0	28.0	7.74	7.73	-0.46	8 50	30.89	8 3	17.8	42.4	

FRA-70-1323C - For Abutment - HP12x53  
Resource International Inc

02/28/2021  
GRLWEAP Version 2010

Depth (ft) 45.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 12.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
63.5	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.686

No.	Weight kips	Pile and Soil Model Stiffn C-Slk T-Slk k/in ft ft	CoR	Total Capacity Soil-S kips	Rut Soil-D Quake s/ft inch	(kips) LbTop Perim ft ft	258.3 Area in2
1	0.177	11208 0.010 0.000 0.85	0.0	0.000 0.100	3.34	4.0	15.5
2	0.177	11208 0.000 0.000 1.00	0.0	0.000 0.100	6.68	4.0	15.5
6	0.177	11208 0.000 0.000 1.00	5.1	0.200 0.100	20.05	4.0	15.5
7	0.177	11208 0.000 0.000 1.00	11.0	0.200 0.100	23.39	4.0	15.5
9	0.177	11208 0.000 0.000 1.00	10.3	0.200 0.100	30.08	4.0	15.5
10	0.177	11208 0.000 0.000 1.00	10.0	0.200 0.100	33.42	4.0	15.5
12	0.177	11208 0.000 0.000 1.00	10.6	0.200 0.100	40.11	4.0	15.5
13	0.177	11208 0.000 0.000 1.00	11.0	0.200 0.100	43.45	4.0	15.5
15	0.177	11208 0.000 0.000 1.00	8.9	0.200 0.100	50.13	4.0	15.5
16	0.177	11208 0.000 0.000 1.00	12.1	0.139 0.100	53.47	4.0	15.5
17	0.177	11208 0.000 0.000 1.00	28.9	0.050 0.100	56.82	4.0	15.5
18	0.177	11208 0.000 0.000 1.00	31.8	0.050 0.100	60.16	4.0	15.5
19	0.177	11208 0.000 0.000 1.00	41.7	0.050 0.100	63.50	4.0	15.5
Toe				45.0	0.150 0.100		

3.363 kips total unreduced pile weight (g= 32.17 ft/s2)  
3.363 kips total reduced pile weight (g= 32.17 ft/s2)

Depth (ft) 45.00  
Stroke (ft) 10.81  
Pressure Ratio 1.00  
Efficy 0.800

FRA-70-1323C - For Abutment - HP12x53  
Resource International Inc

02/28/2021  
GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
258.3	38.4	8.05	8.06	-0.72	6 44	30.63	7 3	18.3	41.6	
264.0	40.0	8.11	8.10	-0.82	6 43	30.83	7 3	18.4	41.5	
269.7	42.6	8.08	8.16	-0.93	6 43	30.80	7 3	18.1	41.5	
275.4	44.5	8.14	8.21	-1.03	6 42	31.05	7 3	18.2	41.3	
281.1	46.5	8.20	8.26	-1.12	6 41	31.29	7 3	18.3	41.2	

FRA-70-1323C - For Abutment - HP12x53  
Resource International Inc

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Depth (ft) 50.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 12.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
63.5	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.686

1323C-FA-12X53

Pile and Soil Model						Total Capacity			Rut (kips)		334.7	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area	
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2	
1	0.177	11208	0.010	0.000	0.85	0.0	0.000	0.100	3.34	4.0	15.5	
2	0.177	11208	0.000	0.000	1.00	0.0	0.000	0.100	6.68	4.0	15.5	
5	0.177	11208	0.000	0.000	1.00	10.6	0.200	0.100	16.71	4.0	15.5	
6	0.177	11208	0.000	0.000	1.00	11.0	0.200	0.100	20.05	4.0	15.5	
7	0.177	11208	0.000	0.000	1.00	10.8	0.200	0.100	23.39	4.0	15.5	
8	0.177	11208	0.000	0.000	1.00	10.0	0.200	0.100	26.74	4.0	15.5	
10	0.177	11208	0.000	0.000	1.00	10.0	0.200	0.100	33.42	4.0	15.5	
11	0.177	11208	0.000	0.000	1.00	11.0	0.200	0.100	36.76	4.0	15.5	
13	0.177	11208	0.000	0.000	1.00	10.7	0.200	0.100	43.45	4.0	15.5	
14	0.177	11208	0.000	0.000	1.00	7.4	0.200	0.100	46.79	4.0	15.5	
15	0.177	11208	0.000	0.000	1.00	22.6	0.071	0.100	50.13	4.0	15.5	
16	0.177	11208	0.000	0.000	1.00	29.7	0.050	0.100	53.47	4.0	15.5	
17	0.177	11208	0.000	0.000	1.00	37.3	0.050	0.100	56.82	4.0	15.5	
18	0.177	11208	0.000	0.000	1.00	42.9	0.050	0.100	60.16	4.0	15.5	
19	0.177	11208	0.000	0.000	1.00	45.6	0.050	0.100	63.50	4.0	15.5	
Toe						54.2	0.150	0.100				

3.363 kips total unreduced pile weight (g= 32.17 ft/s2)  
3.363 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficcy
ft	ft	Ratio	
50.00	10.81	1.00	0.800

▲ FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
334.7	65.5	8.47	8.51	-1.07	5	39	32.19	5	3	18.6
340.5	69.3	8.52	8.55	-1.02	5	39	32.43	5	3	18.7
346.2	73.3	8.57	8.59	-0.99	5	38	32.67	5	3	18.7
351.9	77.7	8.62	8.62	-1.01	5	38	32.90	5	3	18.8
357.6	83.3	8.66	8.67	-1.03	5	37	33.12	5	3	18.8

▲ FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth	(ft)	55.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	12.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
63.5	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.686

Pile and Soil Model						Total Capacity	Rut	(kips)			345.4
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.177	11208	0.010	0.000	0.85	0.0	0.000	0.100	3.34	4.0	15.5
2	0.177	11208	0.000	0.000	1.00	0.0	0.000	0.100	6.68	4.0	15.5
3	0.177	11208	0.000	0.000	1.00	5.0	0.200	0.100	10.03	4.0	15.5
4	0.177	11208	0.000	0.000	1.00	11.0	0.200	0.100	13.37	4.0	15.5
6	0.177	11208	0.000	0.000	1.00	10.3	0.200	0.100	20.05	4.0	15.5
7	0.177	11208	0.000	0.000	1.00	10.0	0.200	0.100	23.39	4.0	15.5
9	0.177	11208	0.000	0.000	1.00	10.5	0.200	0.100	30.08	4.0	15.5
10	0.177	11208	0.000	0.000	1.00	11.0	0.200	0.100	33.42	4.0	15.5
12	0.177	11208	0.000	0.000	1.00	8.9	0.200	0.100	40.11	4.0	15.5
13	0.177	11208	0.000	0.000	1.00	12.0	0.141	0.100	43.45	4.0	15.5
14	0.177	11208	0.000	0.000	1.00	28.9	0.050	0.100	46.79	4.0	15.5
15	0.177	11208	0.000	0.000	1.00	31.7	0.050	0.100	50.13	4.0	15.5
16	0.177	11208	0.000	0.000	1.00	41.7	0.050	0.100	53.47	4.0	15.5
17	0.177	11208	0.000	0.000	1.00	44.3	0.050	0.100	56.82	4.0	15.5
18	0.177	11208	0.000	0.000	1.00	45.5	0.076	0.100	60.16	4.0	15.5
19	0.177	11208	0.000	0.000	1.00	38.1	0.200	0.100	63.50	4.0	15.5
Toe						4.6	0.150	0.100			

3.363 kips total unreduced pile weight (g= 32.17 ft/s2)  
3.363 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
55.00	10.81	1.00	0.800

FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
345.4	73.4	8.55	8.57	-0.38	3	36	31.71	3	2	18.3
353.5	79.7	8.61	8.61	-0.42	3	36	31.97	3	2	18.4
361.5	87.5	8.67	8.66	-0.41	3	36	32.20	3	2	18.5
369.6	96.5	8.72	8.71	-0.41	3	35	32.44	3	2	18.5
377.7	106.7	8.77	8.75	-0.46	3	35	32.66	3	3	18.6

FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	60.0	Standard Soil Setup
Shaft Gain/Loss Factor	0.604	Toe Gain/Loss Factor	1.000

## PILE PROFILE:

Toe Area	(in <sup>2</sup> )	144.000	Pile Type	Unknown
Pile Size	(inch)	12.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in <sup>2</sup>	ksi	lb/ft <sup>3</sup>	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
63.5	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.686

Pile and Soil Model						Total Capacity Rut (kips)				402.4	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in <sup>2</sup>
1	0.177	11208	0.010	0.000	0.85	0.0	0.000	0.100	3.34	4.0	15.5
2	0.177	11208	0.000	0.000	1.00	10.5	0.200	0.100	6.68	4.0	15.5
3	0.177	11208	0.000	0.000	1.00	11.0	0.200	0.100	10.03	4.0	15.5
4	0.177	11208	0.000	0.000	1.00	10.8	0.200	0.100	13.37	4.0	15.5
5	0.177	11208	0.000	0.000	1.00	10.0	0.200	0.100	16.71	4.0	15.5
7	0.177	11208	0.000	0.000	1.00	10.0	0.200	0.100	23.39	4.0	15.5
8	0.177	11208	0.000	0.000	1.00	11.0	0.200	0.100	26.74	4.0	15.5
10	0.177	11208	0.000	0.000	1.00	10.8	0.200	0.100	33.42	4.0	15.5
11	0.177	11208	0.000	0.000	1.00	7.4	0.200	0.100	36.76	4.0	15.5
12	0.177	11208	0.000	0.000	1.00	22.5	0.072	0.100	40.11	4.0	15.5
13	0.177	11208	0.000	0.000	1.00	29.7	0.050	0.100	43.45	4.0	15.5
14	0.177	11208	0.000	0.000	1.00	37.2	0.050	0.100	46.79	4.0	15.5
15	0.177	11208	0.000	0.000	1.00	42.9	0.050	0.100	50.13	4.0	15.5
16	0.177	11208	0.000	0.000	1.00	45.6	0.050	0.100	53.47	4.0	15.5
17	0.177	11208	0.000	0.000	1.00	41.4	0.155	0.100	56.82	4.0	15.5
18	0.177	11208	0.000	0.000	1.00	38.1	0.200	0.100	60.16	4.0	15.5
19	0.177	11208	0.000	0.000	1.00	38.1	0.200	0.100	63.50	4.0	15.5
Toe						4.6	0.150	0.100			

3.363 kips total unreduced pile weight (g= 32.17 ft/s<sup>2</sup>)  
 3.363 kips total reduced pile weight (g= 32.17 ft/s<sup>2</sup>)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
60.00	10.81	1.00	0.800

FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min
402.4	154.5	8.90	8.85	-0.24	2	34	33.65	2	2	18.6
413.5	181.8	8.94	8.88	-0.24	2	33	33.92	2	2	18.7
424.7	222.0	8.99	8.92	-0.24	2	33	34.19	2	2	18.7
435.9	283.1	9.01	8.95	-0.24	2	32	34.39	2	2	18.7
447.1	372.4	9.04	8.98	-0.25	2	32	34.65	2	2	18.7

FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	63.5	Standard Soil Setup
Shaft Gain/Loss Factor	0.604	Toe Gain/Loss Factor	1.000

## PILE PROFILE:



1323C-FA-12X53  
 Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 12.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	15.50	29000.	492.0	4.0	0	16524.	27.2
63.5	15.50	29000.	492.0	4.0	0	16524.	27.2

Wave Travel Time 2L/c (ms) 7.686

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	441.1
	kips	Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D Quake	LbTop	Perim
		k/in ft ft	kips	s/ft inch	ft	ft
1	0.177	11208 0.010 0.000 0.85	11.0	0.200 0.100	3.34	4.0
2	0.177	11208 0.000 0.000 1.00	11.0	0.200 0.100	6.68	4.0
3	0.177	11208 0.000 0.000 1.00	10.8	0.200 0.100	10.03	4.0
4	0.177	11208 0.000 0.000 1.00	10.0	0.200 0.100	13.37	4.0
6	0.177	11208 0.000 0.000 1.00	10.1	0.200 0.100	20.05	4.0
7	0.177	11208 0.000 0.000 1.00	11.0	0.200 0.100	23.39	4.0
9	0.177	11208 0.000 0.000 1.00	10.6	0.200 0.100	30.08	4.0
10	0.177	11208 0.000 0.000 1.00	7.4	0.200 0.100	33.42	4.0
11	0.177	11208 0.000 0.000 1.00	23.5	0.068 0.100	36.76	4.0
12	0.177	11208 0.000 0.000 1.00	29.8	0.050 0.100	40.11	4.0
13	0.177	11208 0.000 0.000 1.00	37.7	0.050 0.100	43.45	4.0
14	0.177	11208 0.000 0.000 1.00	43.0	0.050 0.100	46.79	4.0
15	0.177	11208 0.000 0.000 1.00	45.7	0.050 0.100	50.13	4.0
16	0.177	11208 0.000 0.000 1.00	41.0	0.161 0.100	53.47	4.0
17	0.177	11208 0.000 0.000 1.00	38.1	0.200 0.100	56.82	4.0
19	0.177	11208 0.000 0.000 1.00	37.0	0.200 0.100	63.50	4.0
Toe			4.6	0.150 0.100		

3.363 kips total unreduced pile weight (g= 32.17 ft/s2)  
 3.363 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
63.50	10.81	1.00	0.800

↑  
 FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down up	ksi			ksi			kip-ft	b/min
441.1	297.9	9.04 8.96	0.00	1	0	35.20	1	2	18.0	39.5
454.4	415.1	9.10 9.01	0.00	1	0	35.56	1	2	18.0	39.3
467.7	750.1	9.04 9.05	0.00	1	0	35.63	1	2	17.7	39.4
481.0	1598.9	9.17 9.08	0.00	1	0	36.15	1	2	17.9	39.2
494.4	9999.0	9.10 9.10	0.00	1	0	36.21	1	2	17.7	39.2

↑  
 FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

#### SUMMARY OVER DEPTHS

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: 0.604 1.000	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips		bl/ft	ksi	ksi	ft	kip-ft
5.0	18.4	16.5	1.9	1.8	13.234	-0.377	4.23	25.4	
10.0	34.2	32.7	1.5	3.5	18.253	-0.441	4.94	22.9	
15.0	49.1	47.6	1.5	5.4	21.747	-0.222	5.42	21.3	
20.0	64.4	62.6	1.8	7.5	24.027	-0.165	5.79	20.1	
25.0	80.9	79.1	1.8	10.0	25.222	-1.174	6.20	19.4	
30.0	96.2	95.2	1.0	12.3	26.730	-0.942	6.51	18.8	
35.0	133.3	111.2	22.2	19.0	28.164	-1.109	7.14	18.2	
40.0	177.2	155.0	22.2	24.0	29.761	-0.027	7.50	17.8	
45.0	258.3	213.3	45.0	38.4	30.631	-0.719	8.05	18.3	
50.0	334.7	280.5	54.2	65.5	32.186	-1.066	8.47	18.6	
55.0	345.4	340.8	4.6	73.4	31.709	-0.384	8.55	18.3	
60.0	402.4	397.8	4.6	154.5	33.649	-0.243	8.90	18.6	
63.5	441.1	436.5	4.6	297.9	35.199	0.000	9.04	18.0	

Total Driving Time 61 minutes; Total No. of Blows 2477  
 Starting at penetration 5.0 ft

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: 0.637 1.000	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips		bl/ft	ksi	ksi	ft	kip-ft
5.0	19.3	17.4	1.9	1.8	13.670	-0.364	4.29	25.3	
10.0	35.9	34.5	1.5	3.7	18.635	-0.364	5.00	22.6	
15.0	51.7	50.2	1.5	5.8	22.214	-0.118	5.50	21.1	

1323C-FA-12X53								
20.0	67.8	66.0	1.8	8.0	24.450	-0.605	5.87	20.0
25.0	85.2	83.4	1.8	10.6	25.606	-0.932	6.29	19.2
30.0	101.4	100.4	1.0	13.0	27.372	-0.973	6.68	18.8
35.0	139.0	116.9	22.2	20.0	28.520	-1.023	7.22	18.1
40.0	182.9	160.7	22.2	24.9	30.079	0.000	7.56	17.8
45.0	264.0	219.0	45.0	40.0	30.826	-0.821	8.11	18.4
50.0	340.5	286.3	54.2	69.3	32.425	-1.016	8.52	18.7
55.0	353.5	348.9	4.6	79.7	31.966	-0.419	8.61	18.4
60.0	413.5	408.9	4.6	181.8	33.918	-0.244	8.94	18.7
63.5	454.4	449.8	4.6	415.1	35.555	0.000	9.10	18.0

Total Driving Time 71 minutes; Total No. of Blows 2879  
Starting at penetration 5.0 ft

↑  
FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
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#### SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.670 1.000								
Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	20.2	18.3	1.9	1.9	13.847	-0.357	4.29	25.0
10.0	37.7	36.3	1.5	3.9	19.021	-0.337	5.07	22.4
15.0	54.3	52.8	1.5	6.1	22.438	0.000	5.51	20.7
20.0	71.3	69.4	1.8	8.5	24.888	-0.994	5.96	19.8
25.0	89.5	87.7	1.8	11.3	25.966	-0.741	6.37	19.0
30.0	106.6	105.6	1.0	14.0	27.771	-0.874	6.76	18.7
35.0	144.8	122.6	22.2	21.2	28.781	-0.776	7.29	18.0
40.0	188.6	166.4	22.2	25.9	30.347	-0.202	7.62	17.8
45.0	269.7	224.8	45.0	42.6	30.804	-0.927	8.08	18.1
50.0	346.2	292.0	54.2	73.3	32.670	-0.992	8.57	18.7
55.0	361.5	356.9	4.6	87.5	32.204	-0.414	8.67	18.5
60.0	424.7	420.1	4.6	222.0	34.189	-0.236	8.99	18.7
63.5	467.7	463.1	4.6	750.1	35.631	0.000	9.04	17.7

Total Driving Time 92 minutes; Total No. of Blows 3734  
Starting at penetration 5.0 ft

G/L at Shaft and Toe: 0.703 1.000								
Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	21.1	19.2	1.9	2.0	14.177	-0.339	4.33	24.8
10.0	39.5	38.1	1.5	4.1	19.373	-0.309	5.13	22.2
15.0	56.9	55.4	1.5	6.5	22.821	0.000	5.58	20.6
20.0	74.7	72.9	1.8	9.1	25.315	-1.209	6.05	19.6
25.0	93.8	92.0	1.8	11.9	26.293	-0.911	6.45	18.9
30.0	111.8	110.8	1.0	15.0	28.147	-0.697	6.85	18.5
35.0	150.5	128.3	22.2	22.0	29.091	-0.467	7.37	17.9
40.0	194.3	172.1	22.2	27.0	30.612	-0.375	7.68	17.7
45.0	275.4	230.5	45.0	44.5	31.052	-1.032	8.14	18.2
50.0	351.9	297.7	54.2	77.7	32.904	-1.009	8.62	18.8
55.0	369.6	365.0	4.6	96.5	32.445	-0.411	8.72	18.5
60.0	435.9	431.3	4.6	283.1	34.391	-0.236	9.01	18.7
63.5	481.0	476.4	4.6	1598.9	36.151	0.000	9.17	17.9

Total Driving Time 140 minutes; Total No. of Blows 5578  
Starting at penetration 5.0 ft

↑  
FRA-70-1323C - For Abutment - HP12x53 02/28/2021  
Resource International Inc GRLWEAP Version 2010

#### SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.736 1.000								
Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
5.0	22.0	20.1	1.9	2.1	14.499	-0.318	4.37	24.7
10.0	41.3	39.8	1.5	4.4	19.699	-0.240	5.19	22.0
15.0	59.5	58.0	1.5	6.8	23.216	0.000	5.65	20.4
20.0	78.1	76.3	1.8	9.6	25.695	-1.178	6.12	19.6
25.0	98.2	96.3	1.8	12.6	26.657	-0.996	6.53	18.8
30.0	117.0	116.0	1.0	16.1	28.508	-0.953	6.93	18.4
35.0	156.2	134.0	22.2	22.8	29.326	-0.091	7.43	17.8
40.0	200.0	177.9	22.2	28.0	30.891	-0.460	7.74	17.8
45.0	281.1	236.2	45.0	46.5	31.292	-1.119	8.20	18.3
50.0	357.6	303.4	54.2	83.3	33.122	-1.029	8.66	18.8
55.0	377.7	373.1	4.6	106.7	32.658	-0.462	8.77	18.6
60.0	447.1	442.5	4.6	372.4	34.648	-0.246	9.04	18.7
63.5	494.4	489.8	4.6	9999.0	36.208	0.000	9.10	17.7

Refusal occurred; no driving time output possible



FRA-70-1323C - For Abutment - HP12x53  
Resource International Inc

02/28/2021  
GRLWEAP Version 2010

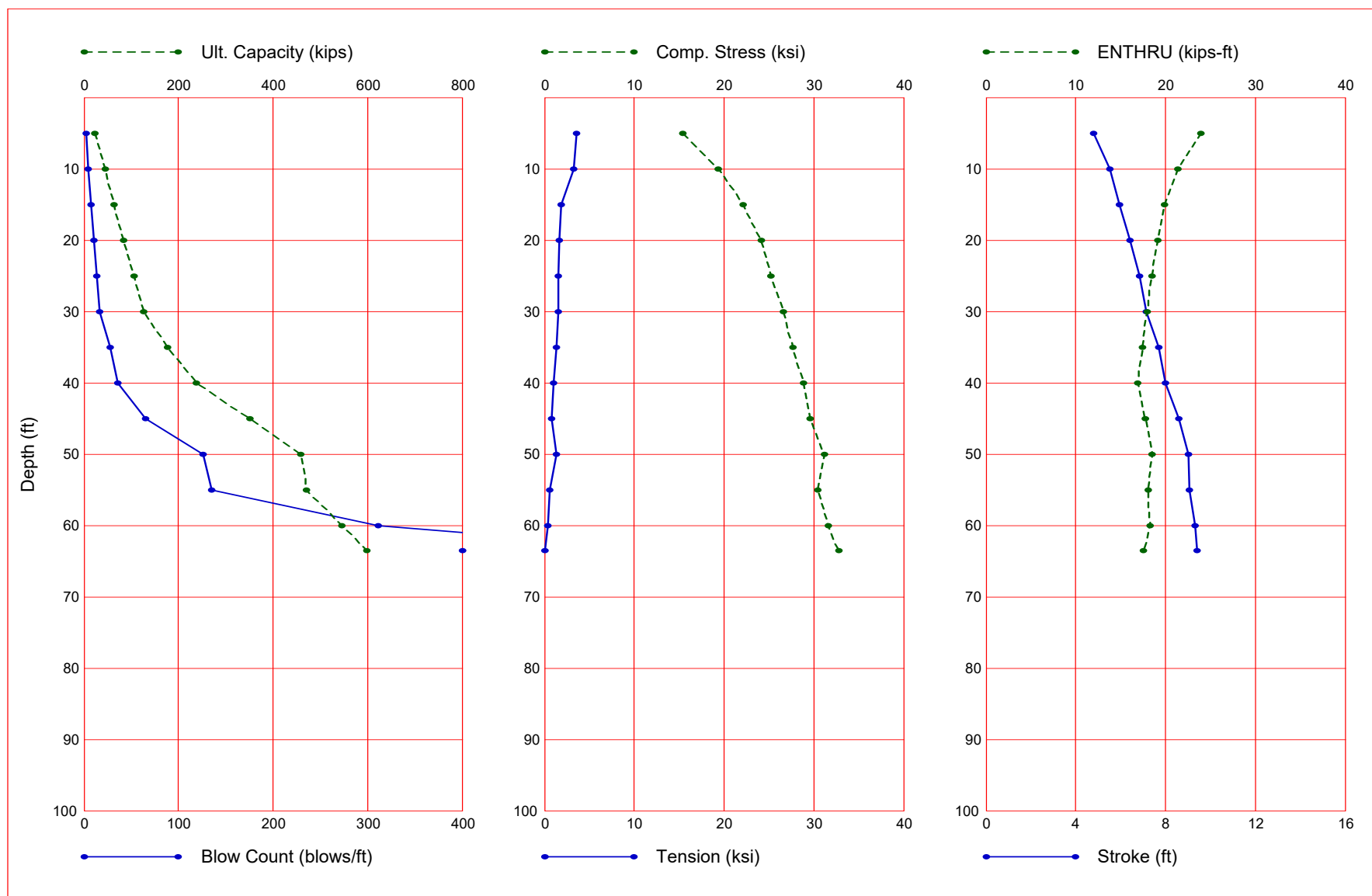
Table of Depths Analyzed with Driving System Modifiers

Depth	Temp.	Wait	Equivalent	Pressure		Stiffn.	Cushion
ft	Length	Time	Stroke	Ratio	Efficy.	Factor	CoR
	ft	hr	ft				
5.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
10.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
15.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
20.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
25.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
30.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
35.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
40.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
45.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
50.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
55.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
60.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
63.50	63.50	0.00	10.81	1.00	0.80	1.00	1.00

Soil Layer Resistance Values

Depth	Shaft	End	Shaft	Toe	Shaft	Toe	Soil	Limit	Setup
ft	Res.	Bearing	Quake	Quake	Damping	Damping	Setup	Distance	Time
	k/ft2	klps	inch	inch	s/ft	s/ft	Normlzd	ft	hrs
0.01	1.38	1.94	0.100	0.100	0.200	0.150	1.000	6.000	168.000
9.01	1.38	1.94	0.100	0.100	0.200	0.150	1.000	6.000	168.000
9.19	1.38	1.94	0.100	0.100	0.200	0.150	1.000	6.000	168.000
9.21	1.24	1.45	0.100	0.100	0.200	0.150	1.000	6.000	168.000
18.21	1.24	1.45	0.100	0.100	0.200	0.150	1.000	6.000	168.000
19.69	1.25	1.45	0.100	0.100	0.200	0.150	1.000	6.000	168.000
19.71	1.37	1.82	0.100	0.100	0.200	0.150	1.000	6.000	168.000
28.71	1.37	1.82	0.100	0.100	0.200	0.150	1.000	6.000	168.000
29.69	1.37	1.82	0.100	0.100	0.200	0.150	1.000	6.000	168.000
29.71	0.92	0.97	0.100	0.100	0.200	0.150	1.000	6.000	168.000
34.19	0.92	0.97	0.100	0.100	0.200	0.150	1.000	6.000	168.000
34.21	2.09	22.18	0.100	0.100	0.050	0.150	0.000	6.000	1.000
41.19	2.34	22.18	0.100	0.100	0.050	0.150	0.000	6.000	1.000
41.21	3.04	44.95	0.100	0.100	0.050	0.150	0.000	6.000	1.000
46.19	3.29	44.95	0.100	0.100	0.050	0.150	0.000	6.000	1.000
46.21	3.33	54.20	0.100	0.100	0.050	0.150	0.000	6.000	1.000
51.19	3.59	54.20	0.100	0.100	0.050	0.150	0.000	6.000	1.000
51.21	4.75	4.60	0.100	0.100	0.200	0.150	1.000	6.000	168.000
60.21	4.75	4.60	0.100	0.100	0.200	0.150	1.000	6.000	168.000
63.50	4.48	4.60	0.100	0.100	0.200	0.150	1.000	6.000	168.000

Gain/Loss 3 at Shaft and Toe 0.670 / 1.000



Gain/Loss 3 at Shaft and Toe 0.670 / 1.000

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft
5.0	24.3	21.6	2.7	2.2	15.431	-3.538	4.78	23.9
10.0	45.0	42.9	2.0	4.7	19.349	-3.220	5.51	21.4
15.0	64.5	62.5	2.0	7.3	22.174	-1.856	5.96	19.9
20.0	84.7	82.2	2.5	10.3	24.208	-1.675	6.41	19.1
25.0	106.3	103.8	2.5	13.5	25.220	-1.573	6.85	18.5
30.0	126.3	125.0	1.3	17.2	26.616	-1.500	7.15	18.0
35.0	177.1	146.4	30.6	27.4	27.629	-1.311	7.71	17.4
40.0	237.7	207.1	30.6	36.2	28.851	-1.041	7.98	16.9
45.0	351.1	289.1	62.1	65.4	29.644	-0.787	8.58	17.8
50.0	458.8	384.0	74.8	126.4	31.160	-1.300	9.02	18.5
55.0	471.2	464.8	6.3	135.0	30.424	-0.610	9.06	18.1
60.0	546.0	539.6	6.3	311.8	31.655	-0.361	9.33	18.3
63.5	598.1	591.8	6.3	636.6	32.843	0.000	9.42	17.5

Total Continuous Driving Time 118.00 minutes; Total Number of Blows 4662 (starting at penetration 5.0 ft)

GRLWEAP - Version 2010  
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.  
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ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

Input File: J:\GEOTECH\PROJECTS\2013\W-13-072 FRA-70-13.10 PROJECT 6A\ANALYSIS\FRA-70-1322L AND 1323C\DRIVEABILITY\FRA-70-1323C\FORWARD  
ABUTMENT\HP 14X73\1323C-FA-14X73.GMW  
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW  
Hammer File Version: 2003 (12/4/2018)

Input File Contents  
FRA-70-1323C - For Abutment - HP14x73

OUT	OSG	HAM	STR	FUL	PEL	N	SPL	N-U	P-D	%SK	ISM	0	PHI	RSA	ITR	H-D	MXT	Dex
-100	0	41	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0.000
Pile g	Hammer g	Toe Area	Pile Size	Pile Type														
32.170	32.170	144.000	14.000	Unknown														
W Cp	A Cp	E Cp	T Cp	CoR	ROut	StCp												
1.900	227.000	530.0	2.000	0.800	0.010	0.0												
A Cu	E Cu	T Cu	CoR	ROut	StCu													
0.000	0.0	0.000	0.000	0.000	0.0													
LPle	APle	EPle	WPle	Peri	CI	CoR	ROut											
63.500	21.40	29000.0	492.000	4.700	0	0.850	0.010											
FFatigue	F0	0-Bottom																
0	0.000	0.000																
Manufac	Hmr Name	HmrType	No	Seg-s														
DELMAG	D 19-42	1	5															
Ram Wt	Ram L	Ram Dia	MaxStrk	RtdStrk	Efficy													
4.00	129.10	12.60	11.86	10.81	0.80													
IB. Wt	IB. L	IB. Dia	IB CoR	IB RO														
0.75	25.30	12.60	0.900	0.010														
CompStrk	A Chamber	V Chamber	C Delay	C Duratn	Exp Coeff	VolCStart	Vol CEnd											
16.65	124.70	157.70	0.0020	0.0020	1.250	0.00	0.00											
P atm	P1	P2	P3	P4	P5													
14.70	1600.00	1440.00	1295.00	1165.00	0.00													
Stroke	Effic.	Pressure	R-Weight	T-Delay	Exp-Coeff	Eps-Str	Total-AW											
10.8100	0.8000	1600.0000	0.0000	0.0000	0.0000	0.0100	0.0000											
Qs	Qt	Js	Jt	Qx	Jx	Rati	Dept											
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000											

Research Soil Model: Atoe, Plug, Gap, Q-fac

0.000 0.000 0.000 0.000  
 Research Soil Model: RD-skn: m, d, toe: m, d  
 0.000 0.000 0.000 0.000  
 Research Toe Plug: Res-int, Q-int, D-int, Res-plug, Q-plug, D-plug  
 0.000 0.000 0.000 0.000 0.000 0.000  
 Research Toe Plug: RD plug toe: m, d  
 0.000 0.000

Research Toe Plug: New Toe Plug Model is NOT applied

Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimL	TSf0
0.01	1.38	2.67	0.10	0.10	0.20	0.15	1.49	6.00	168.000
9.01	1.38	2.67	0.10	0.10	0.20	0.15	1.49	6.00	168.000
9.19	1.38	2.67	0.10	0.10	0.20	0.15	1.49	6.00	168.000
9.21	1.24	2.01	0.10	0.10	0.20	0.15	1.49	6.00	168.000
18.21	1.24	2.01	0.10	0.10	0.20	0.15	1.49	6.00	168.000
19.69	1.24	2.01	0.10	0.10	0.20	0.15	1.49	6.00	168.000
19.71	1.37	2.51	0.10	0.10	0.20	0.15	1.49	6.00	168.000
28.71	1.37	2.51	0.10	0.10	0.20	0.15	1.49	6.00	168.000
29.69	1.37	2.51	0.10	0.10	0.20	0.15	1.49	6.00	168.000
29.71	0.92	1.34	0.10	0.10	0.20	0.15	1.49	6.00	168.000
34.19	0.92	1.34	0.10	0.10	0.20	0.15	1.49	6.00	168.000
34.21	2.45	30.62	0.10	0.10	0.05	0.15	1.00	6.00	1.000
41.19	2.73	30.62	0.10	0.10	0.05	0.15	1.00	6.00	1.000
41.21	3.62	62.06	0.10	0.10	0.05	0.15	1.00	6.00	1.000
46.19	3.92	62.06	0.10	0.10	0.05	0.15	1.00	6.00	1.000
46.21	3.97	74.83	0.10	0.10	0.05	0.15	1.00	6.00	1.000
51.19	4.29	74.83	0.10	0.10	0.05	0.15	1.00	6.00	1.000
51.21	4.75	6.35	0.10	0.10	0.20	0.15	1.49	6.00	168.000
60.21	4.75	6.35	0.10	0.10	0.20	0.15	1.49	6.00	168.000
63.50	4.72	6.35	0.10	0.10	0.20	0.15	1.49	6.00	168.000

Gain/Loss factors: shaft and toe

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR
5.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
10.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
15.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
20.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
25.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
30.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
35.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
40.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
45.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
50.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
55.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
60.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000
63.50	0.00	0.00	0.000	0.0	0.000	0.000	0.000
0.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000

▲ GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS  
 Version 2010  
 English Units

FRA-70-1323C - For Abutment - HP14x73

Hammer Model: D 19-42 Made by: DELMAG

No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	0.800				
2	0.800	140046.6	1.000	0.0000	
3	0.800	140046.6	1.000	0.0000	
4	0.800	140046.6	1.000	0.0000	
5	0.800	140046.6	1.000	0.0000	
Imp Block	0.753	70735.6	0.900	0.0100	
Helmet	1.900	60155.0	0.800	0.0100	5.8
Combined Pile Top		15474.3			

HAMMER OPTIONS:

Hammer File ID No.	41	Hammer Type	OE Diesel
Stroke Option	FxdP-VarS	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Maximum		

HAMMER DATA:

Ram Weight	(kips)	4.00	Ram Length	(inch)	129.10
Maximum Stroke	(ft)	11.86			
Rated Stroke	(ft)	10.81	Efficiency		0.800
Maximum Pressure	(psi)	1600.00	Actual Pressure	(psi)	1600.00
Compression Exponent		1.350	Expansion Exponent		1.250
Ram Diameter	(inch)	12.60			

Combustion Delay (s) 0.00200 Ignition Duration (s) 0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION			PILE CUSHION		
Cross Sect. Area	(in2)	227.00	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	530.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	2.00	Thickness	(inch)	0.00
Coeff of Restitution		0.8	Coeff of Restitution		1.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	60155.0	Stiffness	(kips/in)	0.0

FRA-70-1323C - For Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	5.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	14.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
63.5	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.686

Pile and Soil Model						Total Capacity Rut (kips)				22.2	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.244	15474	0.010	0.000	0.85	0.0	0.000	0.100	3.34	4.7	21.4
2	0.244	15474	0.000	0.000	1.00	0.0	0.000	0.100	6.68	4.7	21.4
18	0.244	15474	0.000	0.000	1.00	6.5	0.200	0.100	60.16	4.7	21.4
19	0.244	15474	0.000	0.000	1.00	13.0	0.200	0.100	63.50	4.7	21.4
Toe						2.7	0.150	0.100			

4.643 kips total unreduced pile weight (g= 32.17 ft/s2)  
 4.643 kips total reduced pile weight (g= 32.17 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile		Pile Segments: Automatic	
No. of Slacks/Splices	0	Pile Damping (%)	1
		Pile Damping Fact.(k/ft/s)	0.751

Driveability Analysis

Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	1	Analysis Time-Input (ms)	0
Output Level: Normal			
Gravity Mass, Pile, Hammer:	32.170	32.170	32.170
Output Segment Generation: Automatic			

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
5.00	10.81	1.00	0.800

FRA-70-1323C - For Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	B1 Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	B1 Rt
kips	b/ft	down	up	ksi	ksi	kip-ft	b/min	
22.2	2.1	4.65	4.69	-3.25	6 9	14.69	1 2	24.0
23.2	2.2	4.69	4.73	-3.33	6 9	14.96	1 2	23.9
24.3	2.2	4.78	4.77	-3.54	6 9	15.43	1 2	23.9
25.4	2.3	4.83	4.81	-3.58	6 9	15.70	1 2	23.8
26.4	2.5	4.87	4.86	-3.60	6 9	15.96	4 3	23.7

FRA-70-1323C - For Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	10.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	14.000		



L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
63.5	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.686

Pile and Soil Model						Total Capacity	Rut	(kips)			40.7
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.244	15474	0.010	0.000	0.85	0.0	0.000	0.100	3.34	4.7	21.4
2	0.244	15474	0.000	0.000	1.00	0.0	0.000	0.100	6.68	4.7	21.4
17	0.244	15474	0.000	0.000	1.00	12.9	0.200	0.100	56.82	4.7	21.4
18	0.244	15474	0.000	0.000	1.00	13.0	0.200	0.100	60.16	4.7	21.4
19	0.244	15474	0.000	0.000	1.00	12.7	0.200	0.100	63.50	4.7	21.4
Toe						2.0	0.150	0.100			

4.643 kips total unreduced pile weight (g= 32.17 ft/s2)

4.643 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
10.00	10.81	1.00	0.800

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FRA-70-1323C - For Abutment - HP14x73 02/28/2021  
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Rut kips	Bl Ct b/ft	Stroke (ft) down	(ft) up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
40.7	4.2	5.38	5.37	-3.57	6	9	18.76	10	4	21.8	51.1
42.8	4.4	5.44	5.43	-3.42	6	9	19.05	12	4	21.6	50.8
45.0	4.7	5.51	5.49	-3.22	6	9	19.35	12	4	21.4	50.6
47.1	5.0	5.56	5.55	-3.02	6	9	19.67	16	5	21.3	50.2
49.2	5.3	5.56	5.62	-2.71	6	9	19.80	16	5	20.9	50.1

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Depth	(ft)	15.0	Standard Soil Setup	
Shaft Gain/Loss Factor		0.604	Toe Gain/Loss Factor	1.000

## PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	Unknown
Pile Size	(inch)	14.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
63.5	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.686

Pile and Soil Model						Total Capacity		Rut (kips)		58.4	
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.244	15474	0.010	0.000	0.85	0.0	0.000	0.100	3.34	4.7	21.4
2	0.244	15474	0.000	0.000	1.00	0.0	0.000	0.100	6.68	4.7	21.4
15	0.244	15474	0.000	0.000	1.00	6.3	0.200	0.100	50.13	4.7	21.4
16	0.244	15474	0.000	0.000	1.00	13.0	0.200	0.100	53.47	4.7	21.4
18	0.244	15474	0.000	0.000	1.00	12.1	0.200	0.100	60.16	4.7	21.4
19	0.244	15474	0.000	0.000	1.00	11.8	0.200	0.100	63.50	4.7	21.4
Toe						2.0	0.150	0.100			

4.643 kips total unreduced pile weight (g= 32.17 ft/s2)

4.643 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
15.00	10.81	1.00	0.800

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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt	
kips	b/ft	down	up	ksi		ksi		kip-ft	b/min		
58.4	6.5	5.82	5.85	-2.38	6	9	21.46	15	5	20.3	49.0
61.4	6.9	5.89	5.92	-2.11	6	9	21.80	15	5	20.1	48.6
64.5	7.3	5.96	5.99	-1.86	6	9	22.17	15	5	19.9	48.3

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67.6 7.7 6.03 6.06 -1.60 2 10 22.49 15 5 19.8 48.0  
70.7 8.2 6.10 6.13 -1.42 2 10 22.81 15 5 19.7 47.8

▲  
FRA-70-1323C - For Abutment - HP14x73 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth (ft) 20.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:  
Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
63.5	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.686

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	76.6
	kips	Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D Quake	LbTop	Perim Area
		k/in ft ft	kips	s/ft inch	ft	ft in2
1	0.244	15474 0.010 0.000 0.85	0.0	0.000 0.100	3.34	4.7 21.4
2	0.244	15474 0.000 0.000 1.00	0.0	0.000 0.100	6.68	4.7 21.4
14	0.244	15474 0.000 0.000 1.00	12.8	0.200 0.100	46.79	4.7 21.4
15	0.244	15474 0.000 0.000 1.00	13.0	0.200 0.100	50.13	4.7 21.4
16	0.244	15474 0.000 0.000 1.00	12.8	0.200 0.100	53.47	4.7 21.4
17	0.244	15474 0.000 0.000 1.00	11.8	0.200 0.100	56.82	4.7 21.4
19	0.244	15474 0.000 0.000 1.00	11.9	0.200 0.100	63.50	4.7 21.4
Toe			2.5	0.150 0.100		

4.643 kips total unreduced pile weight (g= 32.17 ft/s2)  
4.643 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
20.00	10.81	1.00	0.800

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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down up	ksi		ksi		kip-ft	b/min
76.6	9.1	6.25 6.27	-2.12	17	7 23.50	14	5 19.4	47.2
80.7	9.7	6.33 6.35	-1.94	17	7 23.88	14	5 19.2	46.9
84.7	10.3	6.41 6.43	-1.67	17	7 24.21	14	5 19.1	46.6
88.8	11.0	6.49 6.50	-1.45	18	14 24.58	14	5 19.1	46.3
92.8	11.6	6.56 6.58	-1.33	18	14 24.89	14	5 18.9	46.1

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FRA-70-1323C - For Abutment - HP14x73 02/28/2021  
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Depth (ft) 25.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:  
Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
63.5	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.686

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	96.1
	kips	Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D Quake	LbTop	Perim Area
		k/in ft ft	kips	s/ft inch	ft	ft in2
1	0.244	15474 0.010 0.000 0.85	0.0	0.000 0.100	3.34	4.7 21.4
2	0.244	15474 0.000 0.000 1.00	0.0	0.000 0.100	6.68	4.7 21.4
12	0.244	15474 0.000 0.000 1.00	6.2	0.200 0.100	40.11	4.7 21.4
13	0.244	15474 0.000 0.000 1.00	13.0	0.200 0.100	43.45	4.7 21.4
15	0.244	15474 0.000 0.000 1.00	12.1	0.200 0.100	50.13	4.7 21.4
16	0.244	15474 0.000 0.000 1.00	11.8	0.200 0.100	53.47	4.7 21.4
18	0.244	15474 0.000 0.000 1.00	12.5	0.200 0.100	60.16	4.7 21.4
19	0.244	15474 0.000 0.000 1.00	13.0	0.200 0.100	63.50	4.7 21.4
Toe			2.5	0.150 0.100		

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4.643 kips total unreduced pile weight (g= 32.17 ft/s2)  
4.643 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
25.00	10.81	1.00	0.800

↑  
FRA-70-1323C - For Abutment - HP14x73 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min	
96.1	12.0	6.63	6.64	-1.97	17	7	24.46	12	4	18.7	45.8
101.2	12.7	6.78	6.72	-1.82	17	7	24.92	12	4	18.7	45.4
106.3	13.5	6.85	6.80	-1.57	17	7	25.22	12	4	18.5	45.2
111.4	14.4	6.93	6.87	-1.25	17	7	25.53	12	4	18.4	44.9
116.5	15.3	6.99	6.95	-1.04	12	42	25.76	12	4	18.3	44.7

↑  
FRA-70-1323C - For Abutment - HP14x73 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth (ft)	30.0	Standard Soil Setup
Shaft Gain/Loss Factor	0.604	Toe Gain/Loss Factor 1.000

PILE PROFILE:  
Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
63.5	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.686

No.	Weight kips	Pile and Soil Model Stiffn C-Slk T-Slk k/in ft ft	CoR	Soil-S kips	Soil-D Quake s/ft	Rut (kips) inch	LbTop ft	Perim ft	Area in2
1	0.244	15474 0.010 0.000 0.85	0.0	0.000 0.100	3.34	4.7	21.4		
2	0.244	15474 0.000 0.000 1.00	0.0	0.000 0.100	6.68	4.7	21.4		
11	0.244	15474 0.000 0.000 1.00	12.7	0.200 0.100	36.76	4.7	21.4		
12	0.244	15474 0.000 0.000 1.00	13.0	0.200 0.100	40.11	4.7	21.4		
13	0.244	15474 0.000 0.000 1.00	12.8	0.200 0.100	43.45	4.7	21.4		
14	0.244	15474 0.000 0.000 1.00	11.8	0.200 0.100	46.79	4.7	21.4		
16	0.244	15474 0.000 0.000 1.00	11.9	0.200 0.100	53.47	4.7	21.4		
17	0.244	15474 0.000 0.000 1.00	13.0	0.200 0.100	56.82	4.7	21.4		
19	0.244	15474 0.000 0.000 1.00	12.6	0.200 0.100	63.50	4.7	21.4		
Toe			1.3	0.150 0.100					

4.643 kips total unreduced pile weight (g= 32.17 ft/s2)  
4.643 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
30.00	10.81	1.00	0.800

↑  
FRA-70-1323C - For Abutment - HP14x73 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min	
114.0	14.8	6.98	6.94	-2.11	17	7	25.91	11	4	18.2	44.8
120.2	16.0	7.06	7.03	-1.82	17	7	26.26	11	4	18.1	44.5
126.3	17.2	7.15	7.12	-1.50	17	7	26.62	11	4	18.0	44.2
132.5	18.6	7.23	7.21	-1.23	17	7	26.93	11	4	17.9	44.0
138.6	20.0	7.32	7.30	-1.19	8	35	27.26	11	4	17.8	43.7

↑  
FRA-70-1323C - For Abutment - HP14x73 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth (ft)	35.0	Standard Soil Setup
Shaft Gain/Loss Factor	0.604	Toe Gain/Loss Factor 1.000

PILE PROFILE:  
Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s

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0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
63.5	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.686

Pile and Soil Model										Total Capacity Rut (kips)	163.5
No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.244	15474	0.010	0.000	0.85	0.0	0.000	0.100	3.34	4.7	21.4
2	0.244	15474	0.000	0.000	1.00	0.0	0.000	0.100	6.68	4.7	21.4
9	0.244	15474	0.000	0.000	1.00	6.1	0.200	0.100	30.08	4.7	21.4
10	0.244	15474	0.000	0.000	1.00	13.0	0.200	0.100	33.42	4.7	21.4
12	0.244	15474	0.000	0.000	1.00	12.1	0.200	0.100	40.11	4.7	21.4
13	0.244	15474	0.000	0.000	1.00	11.8	0.200	0.100	43.45	4.7	21.4
15	0.244	15474	0.000	0.000	1.00	12.5	0.200	0.100	50.13	4.7	21.4
16	0.244	15474	0.000	0.000	1.00	13.0	0.200	0.100	53.47	4.7	21.4
18	0.244	15474	0.000	0.000	1.00	10.5	0.200	0.100	60.16	4.7	21.4
19	0.244	15474	0.000	0.000	1.00	15.9	0.132	0.100	63.50	4.7	21.4
Toe						30.6	0.150	0.100			

4.643 kips total unreduced pile weight (g= 32.17 ft/s2)  
4.643 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
35.00	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i t	Comp Str ksi	i t	ENTHRU kip-ft	Bl Rt b/min
163.5	24.3	7.57	7.55	-1.07	9 29	27.16	9 3	17.7
170.3	25.9	7.64	7.63	-1.21	9 29	27.40	9 3	17.6
177.1	27.4	7.71	7.71	-1.31	9 29	27.63	9 3	17.4
183.8	28.5	7.78	7.78	-1.27	9 29	27.91	9 3	17.4
190.6	29.6	7.83	7.84	-1.15	9 29	28.09	9 3	17.2

FRA-70-1323C - For Abutment - HP14x73 02/28/2021  
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Depth (ft)	40.0	Standard Soil Setup
Shaft Gain/Loss Factor	0.604	Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2)	144.000	Pile Type	Unknown
Pile Size (inch)	14.000		

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
63.5	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.686

Pile and Soil Model										Total Capacity Rut (kips)	224.2
No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.244	15474	0.010	0.000	0.85	0.0	0.000	0.100	3.34	4.7	21.4
2	0.244	15474	0.000	0.000	1.00	0.0	0.000	0.100	6.68	4.7	21.4
8	0.244	15474	0.000	0.000	1.00	12.6	0.200	0.100	26.74	4.7	21.4
9	0.244	15474	0.000	0.000	1.00	13.0	0.200	0.100	30.08	4.7	21.4
10	0.244	15474	0.000	0.000	1.00	12.8	0.200	0.100	33.42	4.7	21.4
11	0.244	15474	0.000	0.000	1.00	11.8	0.200	0.100	36.76	4.7	21.4
13	0.244	15474	0.000	0.000	1.00	11.9	0.200	0.100	43.45	4.7	21.4
14	0.244	15474	0.000	0.000	1.00	13.0	0.200	0.100	46.79	4.7	21.4
16	0.244	15474	0.000	0.000	1.00	12.7	0.200	0.100	53.47	4.7	21.4
17	0.244	15474	0.000	0.000	1.00	8.8	0.200	0.100	56.82	4.7	21.4
18	0.244	15474	0.000	0.000	1.00	31.1	0.068	0.100	60.16	4.7	21.4
19	0.244	15474	0.000	0.000	1.00	41.1	0.050	0.100	63.50	4.7	21.4
Toe						30.6	0.150	0.100			

4.643 kips total unreduced pile weight (g= 32.17 ft/s2)  
4.643 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficy
40.00	10.81	1.00	0.800

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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min	
224.2	32.8	7.94	7.94	-1.66	8	28	28.61	8	3	17.2	41.9
231.0	34.4	8.00	8.00	-1.39	8	28	28.85	8	3	17.1	41.8
237.7	36.2	7.98	8.06	-1.04	8	28	28.85	8	3	16.9	41.7
244.5	37.7	8.04	8.11	-0.68	8	28	29.09	8	3	17.0	41.6
251.3	39.2	8.10	8.15	-0.58	5	46	29.35	8	3	17.1	41.5

FRA-70-1323C - For Abutment - HP14x73  
Resource International Inc

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Depth (ft) 45.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
63.5	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.686

No.	Weight kips	Pile and Soil Model Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Total Capacity Soil-S kips	Soil-D s/ft	Quake inch	Rut LbTop ft	Perim ft	Area in2
1	0.244	15474	0.010	0.000	0.85	0.0	0.000	0.100	3.34	4.7	21.4
2	0.244	15474	0.000	0.000	1.00	0.0	0.000	0.100	6.68	4.7	21.4
6	0.244	15474	0.000	0.000	1.00	6.0	0.200	0.100	20.05	4.7	21.4
7	0.244	15474	0.000	0.000	1.00	13.0	0.200	0.100	23.39	4.7	21.4
9	0.244	15474	0.000	0.000	1.00	12.2	0.200	0.100	30.08	4.7	21.4
10	0.244	15474	0.000	0.000	1.00	11.8	0.200	0.100	33.42	4.7	21.4
12	0.244	15474	0.000	0.000	1.00	12.5	0.200	0.100	40.11	4.7	21.4
13	0.244	15474	0.000	0.000	1.00	13.0	0.200	0.100	43.45	4.7	21.4
15	0.244	15474	0.000	0.000	1.00	10.6	0.200	0.100	50.13	4.7	21.4
16	0.244	15474	0.000	0.000	1.00	15.7	0.133	0.100	53.47	4.7	21.4
17	0.244	15474	0.000	0.000	1.00	40.0	0.050	0.100	56.82	4.7	21.4
18	0.244	15474	0.000	0.000	1.00	44.1	0.050	0.100	60.16	4.7	21.4
19	0.244	15474	0.000	0.000	1.00	58.9	0.050	0.100	63.50	4.7	21.4
Toe						62.1	0.150	0.100			

4.643 kips total unreduced pile weight (g= 32.17 ft/s2)  
4.643 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft 45.00  
Stroke ft 10.81  
Pressure Ratio 1.00  
Efficy 0.800

FRA-70-1323C - For Abutment - HP14x73  
Resource International Inc

02/28/2021  
GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min	
337.6	59.0	8.50	8.53	-0.90	6	42	29.38	7	3	17.7	40.5
344.4	61.9	8.53	8.56	-0.81	6	41	29.51	7	3	17.8	40.5
351.1	65.4	8.58	8.61	-0.79	6	38	29.64	7	3	17.8	40.4
357.9	68.6	8.63	8.65	-0.96	6	38	29.82	7	3	17.9	40.3
364.7	72.6	8.67	8.70	-1.05	6	38	29.98	6	3	17.9	40.1

FRA-70-1323C - For Abutment - HP14x73  
Resource International Inc

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Depth (ft) 50.0 Standard Soil Setup  
Shaft Gain/Loss Factor 0.604 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2) 144.000 Pile Type Unknown  
Pile Size (inch) 14.000

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
63.5	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.686

1323C-FA-14X73

Pile and Soil Model						Total Capacity			Rut (kips)		445.3	
No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2	
1	0.244	15474	0.010	0.000	0.85	0.0	0.000	0.100	3.34	4.7	21.4	
2	0.244	15474	0.000	0.000	1.00	0.0	0.000	0.100	6.68	4.7	21.4	
5	0.244	15474	0.000	0.000	1.00	12.5	0.200	0.100	16.71	4.7	21.4	
6	0.244	15474	0.000	0.000	1.00	13.0	0.200	0.100	20.05	4.7	21.4	
7	0.244	15474	0.000	0.000	1.00	12.8	0.200	0.100	23.39	4.7	21.4	
8	0.244	15474	0.000	0.000	1.00	11.8	0.200	0.100	26.74	4.7	21.4	
10	0.244	15474	0.000	0.000	1.00	11.9	0.200	0.100	33.42	4.7	21.4	
11	0.244	15474	0.000	0.000	1.00	13.0	0.200	0.100	36.76	4.7	21.4	
13	0.244	15474	0.000	0.000	1.00	12.7	0.200	0.100	43.45	4.7	21.4	
14	0.244	15474	0.000	0.000	1.00	8.8	0.200	0.100	46.79	4.7	21.4	
15	0.244	15474	0.000	0.000	1.00	30.9	0.068	0.100	50.13	4.7	21.4	
16	0.244	15474	0.000	0.000	1.00	41.1	0.050	0.100	53.47	4.7	21.4	
17	0.244	15474	0.000	0.000	1.00	52.2	0.050	0.100	56.82	4.7	21.4	
18	0.244	15474	0.000	0.000	1.00	60.5	0.050	0.100	60.16	4.7	21.4	
19	0.244	15474	0.000	0.000	1.00	64.5	0.050	0.100	63.50	4.7	21.4	
Toe						74.8	0.150	0.100				

4.643 kips total unreduced pile weight (g= 32.17 ft/s2)  
4.643 kips total reduced pile weight (g= 32.17 ft/s2)

Depth ft	Stroke ft	Pressure Ratio	Efficacy
50.00	10.81	1.00	0.800

▲ FRA-70-1323C - For Abutment - HP14x73 02/28/2021  
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Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min	
445.3	111.0	8.95	8.94	-1.17	5	17	30.81	5	3	18.4	39.6
452.1	118.2	8.98	8.96	-1.24	5	17	30.99	5	3	18.5	39.5
458.8	126.4	9.02	8.99	-1.30	5	17	31.16	5	3	18.5	39.4
465.6	135.4	9.05	9.02	-1.35	5	17	31.29	5	3	18.5	39.4
472.4	145.7	9.09	9.05	-1.38	5	17	31.44	5	3	18.6	39.3

▲ FRA-70-1323C - For Abutment - HP14x73 02/28/2021  
Resource International Inc GRLWEAP Version 2010

Depth (ft)	55.0	Standard Soil Setup	
Shaft Gain/Loss Factor	0.604	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area (in2)	144.000	Pile Type	Unknown
Pile Size (inch)	14.000		

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
63.5	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.686

Pile and Soil Model						Total Capacity	Rut	(kips)		452.1	
No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.244	15474	0.010	0.000	0.85	0.0	0.000	0.100	3.34	4.7	21.4
2	0.244	15474	0.000	0.000	1.00	0.0	0.000	0.100	6.68	4.7	21.4
3	0.244	15474	0.000	0.000	1.00	5.9	0.200	0.100	10.03	4.7	21.4
4	0.244	15474	0.000	0.000	1.00	13.0	0.200	0.100	13.37	4.7	21.4
6	0.244	15474	0.000	0.000	1.00	12.2	0.200	0.100	20.05	4.7	21.4
7	0.244	15474	0.000	0.000	1.00	11.8	0.200	0.100	23.39	4.7	21.4
9	0.244	15474	0.000	0.000	1.00	12.5	0.200	0.100	30.08	4.7	21.4
10	0.244	15474	0.000	0.000	1.00	13.0	0.200	0.100	33.42	4.7	21.4
12	0.244	15474	0.000	0.000	1.00	10.6	0.200	0.100	40.11	4.7	21.4
13	0.244	15474	0.000	0.000	1.00	15.4	0.135	0.100	43.45	4.7	21.4
14	0.244	15474	0.000	0.000	1.00	40.0	0.050	0.100	46.79	4.7	21.4
15	0.244	15474	0.000	0.000	1.00	44.0	0.050	0.100	50.13	4.7	21.4
16	0.244	15474	0.000	0.000	1.00	58.8	0.050	0.100	53.47	4.7	21.4
17	0.244	15474	0.000	0.000	1.00	62.5	0.050	0.100	56.82	4.7	21.4
18	0.244	15474	0.000	0.000	1.00	63.1	0.073	0.100	60.16	4.7	21.4
19	0.244	15474	0.000	0.000	1.00	45.1	0.200	0.100	63.50	4.7	21.4
Toe						6.3	0.150	0.100			

4.643 kips total unreduced pile weight (g= 32.17 ft/s2)  
4.643 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
55.00	10.81	1.00	0.800

FRA-70-1323C - For Abutment - HP14x73 02/28/2021  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt	
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min	
452.1	113.0	8.97	8.95	-0.42	4	18	30.14	4	2	18.0	39.6
461.6	122.5	9.02	8.98	-0.51	3	32	30.26	4	2	18.1	39.5
471.2	135.0	9.06	9.01	-0.61	3	32	30.42	4	2	18.1	39.4
480.7	149.7	9.10	9.05	-0.66	3	32	30.57	4	2	18.1	39.3
490.3	167.2	9.14	9.08	-0.67	3	31	30.71	4	2	18.2	39.2

FRA-70-1323C - For Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	60.0	Standard Soil Setup
Shaft Gain/Loss Factor	0.604	Toe Gain/Loss Factor	1.000

## PILE PROFILE:

Toe Area	(in <sup>2</sup> )	144.000	Pile Type	Unknown
Pile Size	(inch)	14.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in <sup>2</sup>	ksi	lb/ft <sup>3</sup>	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
63.5	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.686

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	Rut	(kips)	519.5
	kips	k/in	ft	ft		kips	s/ft	inch	LbTop	Perim	Area
1	0.244	15474	0.010	0.000	0.85	0.0	0.000	0.100	3.34	4.7	21.4
2	0.244	15474	0.000	0.000	1.00	12.4	0.200	0.100	6.68	4.7	21.4
3	0.244	15474	0.000	0.000	1.00	13.0	0.200	0.100	10.03	4.7	21.4
4	0.244	15474	0.000	0.000	1.00	12.8	0.200	0.100	13.37	4.7	21.4
5	0.244	15474	0.000	0.000	1.00	11.8	0.200	0.100	16.71	4.7	21.4
7	0.244	15474	0.000	0.000	1.00	11.9	0.200	0.100	23.39	4.7	21.4
8	0.244	15474	0.000	0.000	1.00	13.0	0.200	0.100	26.74	4.7	21.4
10	0.244	15474	0.000	0.000	1.00	12.7	0.200	0.100	33.42	4.7	21.4
11	0.244	15474	0.000	0.000	1.00	8.8	0.200	0.100	36.76	4.7	21.4
12	0.244	15474	0.000	0.000	1.00	30.6	0.069	0.100	40.11	4.7	21.4
13	0.244	15474	0.000	0.000	1.00	41.1	0.050	0.100	43.45	4.7	21.4
14	0.244	15474	0.000	0.000	1.00	52.1	0.050	0.100	46.79	4.7	21.4
15	0.244	15474	0.000	0.000	1.00	60.5	0.050	0.100	50.13	4.7	21.4
16	0.244	15474	0.000	0.000	1.00	64.4	0.050	0.100	53.47	4.7	21.4
17	0.244	15474	0.000	0.000	1.00	53.0	0.149	0.100	56.82	4.7	21.4
18	0.244	15474	0.000	0.000	1.00	45.1	0.200	0.100	60.16	4.7	21.4
19	0.244	15474	0.000	0.000	1.00	45.1	0.200	0.100	63.50	4.7	21.4
Toe						6.3	0.150	0.100			

4.643 kips total unreduced pile weight (g= 32.17 ft/s<sup>2</sup>)  
 4.643 kips total reduced pile weight (g= 32.17 ft/s<sup>2</sup>)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
60.00	10.81	1.00	0.800

FRA-70-1323C - For Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt	
kips	b/ft	down	up	ksi		ksi			kip-ft	b/min	
519.5	227.0	9.26	9.18	-0.30	2	30	31.27	2	2	18.3	39.0
532.7	264.3	9.30	9.21	-0.34	2	30	31.46	2	2	18.3	38.9
546.0	311.8	9.33	9.24	-0.36	2	30	31.65	2	2	18.3	38.9
559.2	375.8	9.37	9.28	-0.34	2	29	31.84	2	2	18.4	38.8
572.4	467.5	9.39	9.31	-0.28	2	29	32.01	2	2	18.3	38.7

FRA-70-1323C - For Abutment - HP14x73 02/28/2021  
 Resource International Inc GRLWEAP Version 2010

Depth	(ft)	63.5	Standard Soil Setup
Shaft Gain/Loss Factor	0.604	Toe Gain/Loss Factor	1.000

## PILE PROFILE:

1323C-FA-14X73  
 Toe Area (in2) 144.000 Pile Type Unknown  
 Pile Size (inch) 14.000

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	21.40	29000.	492.0	4.7	0	16524.	37.6
63.5	21.40	29000.	492.0	4.7	0	16524.	37.6

Wave Travel Time 2L/c (ms) 7.686

No.	Weight	Pile and Soil Model	Total Capacity	Rut	(kips)	566.5
	kips	Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D Quake	LbTop	Perim
		k/in ft ft	kips	s/ft inch	ft	ft
1	0.244	15474 0.010 0.000 0.85	13.0	0.200 0.100	3.34	4.7
2	0.244	15474 0.000 0.000 1.00	13.0	0.200 0.100	6.68	4.7
3	0.244	15474 0.000 0.000 1.00	12.7	0.200 0.100	10.03	4.7
4	0.244	15474 0.000 0.000 1.00	11.8	0.200 0.100	13.37	4.7
6	0.244	15474 0.000 0.000 1.00	11.9	0.200 0.100	20.05	4.7
7	0.244	15474 0.000 0.000 1.00	13.0	0.200 0.100	23.39	4.7
9	0.244	15474 0.000 0.000 1.00	12.5	0.200 0.100	30.08	4.7
10	0.244	15474 0.000 0.000 1.00	8.8	0.200 0.100	33.42	4.7
11	0.244	15474 0.000 0.000 1.00	32.1	0.065 0.100	36.76	4.7
12	0.244	15474 0.000 0.000 1.00	41.2	0.050 0.100	40.11	4.7
13	0.244	15474 0.000 0.000 1.00	52.9	0.050 0.100	43.45	4.7
14	0.244	15474 0.000 0.000 1.00	60.7	0.050 0.100	46.79	4.7
15	0.244	15474 0.000 0.000 1.00	64.6	0.050 0.100	50.13	4.7
16	0.244	15474 0.000 0.000 1.00	52.0	0.156 0.100	53.47	4.7
17	0.244	15474 0.000 0.000 1.00	45.1	0.200 0.100	56.82	4.7
19	0.244	15474 0.000 0.000 1.00	44.9	0.200 0.100	63.50	4.7
Toe			6.3	0.150 0.100		

4.643 kips total unreduced pile weight (g= 32.17 ft/s2)  
 4.643 kips total reduced pile weight (g= 32.17 ft/s2)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
63.50	10.81	1.00	0.800

↑  
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Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down up	ksi			ksi			kip-ft	b/min
566.5	369.5	9.37 9.29	0.00	1	0	32.41	1	2	17.6	38.8
582.3	470.4	9.40 9.31	0.00	1	0	32.64	1	2	17.6	38.7
598.1	636.6	9.42 9.34	0.00	1	0	32.84	1	2	17.5	38.7
614.0	930.6	9.44 9.36	0.00	1	0	33.05	1	2	17.4	38.6
629.8	1560.7	9.46 9.38	0.00	1	0	33.26	1	2	17.4	38.6

↑  
 FRA-70-1323C - For Abutment - HP14x73 02/28/2021  
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#### SUMMARY OVER DEPTHS

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: 0.604 1.000	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips		bl/ft	ksi	ksi	ft	kip-ft
5.0	22.2	19.5	2.7	2.1	14.694	-3.247	4.65	24.0	
10.0	40.7	38.7	2.0	4.2	18.762	-3.567	5.38	21.8	
15.0	58.4	56.4	2.0	6.5	21.460	-2.383	5.82	20.3	
20.0	76.6	74.1	2.5	9.1	23.503	-2.119	6.25	19.4	
25.0	96.1	93.6	2.5	12.0	24.461	-1.974	6.63	18.7	
30.0	114.0	112.7	1.3	14.8	25.909	-2.106	6.98	18.2	
35.0	163.5	132.9	30.6	24.3	27.157	-1.071	7.57	17.7	
40.0	224.2	193.6	30.6	32.8	28.610	-1.658	7.94	17.2	
45.0	337.6	275.6	62.1	59.0	29.382	-0.904	8.50	17.7	
50.0	445.3	370.5	74.8	111.0	30.809	-1.175	8.95	18.4	
55.0	452.1	445.7	6.3	113.0	30.135	-0.420	8.97	18.0	
60.0	519.5	513.1	6.3	227.0	31.266	-0.300	9.26	18.3	
63.5	566.5	560.2	6.3	369.5	32.407	0.000	9.37	17.6	

Total Driving Time 89 minutes; Total No. of Blows 3551  
 Starting at penetration 5.0 ft

Depth	Rut	G/L at Frictn	Shaft and End Bg	Toe: 0.637 1.000	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips		bl/ft	ksi	ksi	ft	kip-ft
5.0	23.2	20.6	2.7	2.2	14.958	-3.326	4.69	23.9	
10.0	42.8	40.8	2.0	4.4	19.054	-3.416	5.44	21.6	
15.0	61.4	59.4	2.0	6.9	21.799	-2.109	5.89	20.1	



1323C-FA-14X73									
20.0	80.7	78.2	2.5	9.7	23.882	-1.943	6.33	19.2	
25.0	101.2	98.7	2.5	12.7	24.921	-1.817	6.78	18.7	
30.0	120.2	118.8	1.3	16.0	26.260	-1.823	7.06	18.1	
35.0	170.3	139.7	30.6	25.9	27.404	-1.211	7.64	17.6	
40.0	231.0	200.4	30.6	34.4	28.845	-1.392	8.00	17.1	
45.0	344.4	282.3	62.1	61.9	29.514	-0.809	8.53	17.8	
50.0	452.1	377.2	74.8	118.2	30.993	-1.245	8.98	18.5	
55.0	461.6	455.3	6.3	122.5	30.265	-0.508	9.02	18.1	
60.0	532.7	526.4	6.3	264.3	31.461	-0.337	9.30	18.3	
63.5	582.3	576.0	6.3	470.4	32.638	0.000	9.40	17.6	

Total Driving Time 101 minutes; Total No. of Blows 4016  
Starting at penetration 5.0 ft

▲  
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#### SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.670 1.000									
Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU	
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft	
5.0	24.3	21.6	2.7	2.2	15.431	-3.538	4.78	23.9	
10.0	45.0	42.9	2.0	4.7	19.349	-3.220	5.51	21.4	
15.0	64.5	62.5	2.0	7.3	22.174	-1.856	5.96	19.9	
20.0	84.7	82.2	2.5	10.3	24.208	-1.675	6.41	19.1	
25.0	106.3	103.8	2.5	13.5	25.220	-1.573	6.85	18.5	
30.0	126.3	125.0	1.3	17.2	26.616	-1.500	7.15	18.0	
35.0	177.1	146.4	30.6	27.4	27.629	-1.311	7.71	17.4	
40.0	237.7	207.1	30.6	36.2	28.851	-1.041	7.98	16.9	
45.0	351.1	289.1	62.1	65.4	29.644	-0.787	8.58	17.8	
50.0	458.8	384.0	74.8	126.4	31.160	-1.300	9.02	18.5	
55.0	471.2	464.8	6.3	135.0	30.424	-0.610	9.06	18.1	
60.0	546.0	539.6	6.3	311.8	31.655	-0.361	9.33	18.3	
63.5	598.1	591.8	6.3	636.6	32.843	0.000	9.42	17.5	

Total Driving Time 118 minutes; Total No. of Blows 4662  
Starting at penetration 5.0 ft

G/L at Shaft and Toe: 0.703 1.000									
Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU	
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft	
5.0	25.4	22.7	2.7	2.3	15.704	-3.575	4.83	23.8	
10.0	47.1	45.1	2.0	5.0	19.666	-3.022	5.56	21.3	
15.0	67.6	65.6	2.0	7.7	22.488	-1.601	6.03	19.8	
20.0	88.8	86.3	2.5	11.0	24.581	-1.450	6.49	19.1	
25.0	111.4	108.9	2.5	14.4	25.529	-1.254	6.93	18.4	
30.0	132.5	131.1	1.3	18.6	26.933	-1.226	7.23	17.9	
35.0	183.8	153.2	30.6	28.5	27.914	-1.266	7.78	17.4	
40.0	244.5	213.9	30.6	37.7	29.090	-0.678	8.04	17.0	
45.0	357.9	295.8	62.1	68.6	29.825	-0.956	8.63	17.9	
50.0	465.6	390.8	74.8	135.4	31.293	-1.351	9.05	18.5	
55.0	480.7	474.4	6.3	149.7	30.572	-0.663	9.10	18.1	
60.0	559.2	552.8	6.3	375.8	31.840	-0.342	9.37	18.4	
63.5	614.0	607.6	6.3	930.6	33.046	0.000	9.44	17.4	

Total Driving Time 142 minutes; Total No. of Blows 5614  
Starting at penetration 5.0 ft

▲  
FRA-70-1323C - For Abutment - HP14x73 02/28/2021  
Resource International Inc GRLWEAP Version 2010

#### SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.736 1.000									
Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU	
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft	
5.0	26.4	23.8	2.7	2.5	15.961	-3.603	4.87	23.7	
10.0	49.2	47.2	2.0	5.3	19.798	-2.709	5.56	20.9	
15.0	70.7	68.7	2.0	8.2	22.807	-1.422	6.10	19.7	
20.0	92.8	90.3	2.5	11.6	24.886	-1.328	6.56	18.9	
25.0	116.5	114.0	2.5	15.3	25.760	-1.035	6.99	18.3	
30.0	138.6	137.3	1.3	20.0	27.261	-1.194	7.32	17.8	
35.0	190.6	160.0	30.6	29.6	28.085	-1.148	7.83	17.2	
40.0	251.3	220.6	30.6	39.2	29.348	-0.579	8.10	17.1	
45.0	364.7	302.6	62.1	72.6	29.979	-1.045	8.67	17.9	
50.0	472.4	397.5	74.8	145.7	31.444	-1.383	9.09	18.6	
55.0	490.3	483.9	6.3	167.2	30.714	-0.669	9.14	18.2	
60.0	572.4	566.1	6.3	467.5	32.007	-0.284	9.39	18.3	
63.5	629.8	623.4	6.3	1560.7	33.263	0.000	9.46	17.4	

1323C-FA-14X73

Total Driving Time      186 minutes;  
Starting at penetration      5.0 ft  
Total No. of Blows      7297

▲  
 FRA-70-1323C - For Abutment - HP14x73  
 Resource International Inc

02/28/2021  
 GRLWEAP Version 2010

Table of Depths Analyzed with Driving System Modifiers

Depth	Temp. Length	Wait Time	Equivalent Stroke	Pressure Ratio	Efficy.	Stiffn. Factor	Cushion CoR
ft	ft	hr	ft				
5.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
10.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
15.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
20.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
25.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
30.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
35.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
40.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
45.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
50.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
55.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
60.00	63.50	0.00	10.81	1.00	0.80	1.00	1.00
63.50	63.50	0.00	10.81	1.00	0.80	1.00	1.00

Soil Layer Resistance Values

Depth	Shaft Res.	End Bearing	Shaft Quake	Toe Quake	Shaft Damping	Toe Damping	Soil Setup	Limit Distance	Setup Time
ft	k/ft2	kips	inch	inch	s/ft	s/ft	Normlzd	ft	hrs
0.01	1.38	2.67	0.100	0.100	0.200	0.150	1.000	6.000	168.000
9.01	1.38	2.67	0.100	0.100	0.200	0.150	1.000	6.000	168.000
9.19	1.38	2.67	0.100	0.100	0.200	0.150	1.000	6.000	168.000
9.21	1.24	2.01	0.100	0.100	0.200	0.150	1.000	6.000	168.000
18.21	1.24	2.01	0.100	0.100	0.200	0.150	1.000	6.000	168.000
19.69	1.24	2.01	0.100	0.100	0.200	0.150	1.000	6.000	168.000
19.71	1.37	2.51	0.100	0.100	0.200	0.150	1.000	6.000	168.000
28.71	1.37	2.51	0.100	0.100	0.200	0.150	1.000	6.000	168.000
29.69	1.37	2.51	0.100	0.100	0.200	0.150	1.000	6.000	168.000
29.71	0.92	1.34	0.100	0.100	0.200	0.150	1.000	6.000	168.000
34.19	0.92	1.34	0.100	0.100	0.200	0.150	1.000	6.000	168.000
34.21	2.45	30.62	0.100	0.100	0.050	0.150	0.000	6.000	1.000
41.19	2.73	30.62	0.100	0.100	0.050	0.150	0.000	6.000	1.000
41.21	3.62	62.06	0.100	0.100	0.050	0.150	0.000	6.000	1.000
46.19	3.92	62.06	0.100	0.100	0.050	0.150	0.000	6.000	1.000
46.21	3.97	74.83	0.100	0.100	0.050	0.150	0.000	6.000	1.000
51.19	4.29	74.83	0.100	0.100	0.050	0.150	0.000	6.000	1.000
51.21	4.75	6.35	0.100	0.100	0.200	0.150	1.000	6.000	168.000
60.21	4.75	6.35	0.100	0.100	0.200	0.150	1.000	6.000	168.000
63.50	4.72	6.35	0.100	0.100	0.200	0.150	1.000	6.000	168.000

## **APPENDIX VIII**

### **SETTLEMENT CALCULATIONS**

W-13-072 FRA-70-13.10 (FRA-70-1322L and 1323C Bridge Structure)  
Embankment Settlement

Calculated By: BRT Date: 1/21/2015  
Checked By: JPS Date: 1/22/2015

Borings B-113-4-13 (Rear Abutments)

5.5' net embankment height considered - Existing grade is at 725.0 and proposed profile grade is at 730.5 for a net embankment height of 5.5'

H= 5.5 ft  
B= 50.0 ft  
 $\gamma_{BF}$  = 120 pcf  
D<sub>w</sub> = 27.5 ft Below Ground Surface  
 $\Delta\sigma$  = 660 psf At Ground Surface

																				Total Embankment Settlement				
Layer	Soil Class.	Soil Type	Layer Depth (ft)		Layer Thickness H (ft)	Depth to Midpoint (ft)	$\gamma$ (pcf)	$\sigma_{vo}$ Bottom (psf)	$\sigma_{vo}$ Midpoint (psf)	$\sigma_{vo}'$ Midpoint (psf)	$\sigma_p^{(1)}$ (psf)	LL	$C_c^{(2)}$	$C_r^{(3)}$	$e_o^{(4)}$	$N_{60}$	$(N1)_{60}^{(5)}$	$C_u^{(6)}$	$Z_r/B$	$I^{(7)}$	$\Delta\sigma_v^{(8)}$ (psf)	$\sigma_{v'}'$ Midpoint (psf)	$S_c^{(9,10)}$ (ft)	$S_c$ (in)
1	A-6a	C	0.0	2.5	2.5	1.3	120	300	156	156	3,156	35	0.225	0.011	0.546				0.03	1.000	660	816	0.013	0.157
	A-6a	C	2.5	5.5	3.0	4.0	120	660	480	480	3,480	35	0.225	0.011	0.546				0.08	0.998	659	1,139	0.008	0.098
2	A-1-b	G	5.5	8.0	2.5	6.8	125	973	816	816	3,816					17	22	79	0.14	0.992	655	1,471	0.008	0.097
	A-1-b	G	8.0	10.5	2.5	9.3	125	1,285	1,129	1,129	4,129					17	20	75	0.19	0.982	648	1,777	0.007	0.079
3	A-6a	C	10.5	13.0	2.5	11.8	115	1,573	1,429	1,429	4,429	28	0.162	0.016	0.491				0.24	0.965	637	2,066	0.004	0.052
4	A-2-6	G	13.0	17.0	4.0	15.0	120	2,053	1,813	1,813	4,813					9	9	56	0.30	0.937	618	2,431	0.009	0.110
5	A-4a	C	17.0	20.5	3.5	18.8	115	2,455	2,254	2,254	5,254	32	0.198	0.020	0.522				0.38	0.896	591	2,845	0.005	0.055
6	A-1-b	G	20.5	23.0	2.5	21.8	135	2,793	2,624	2,624	5,624					63	57	202	0.44	0.859	567	3,191	0.001	0.013
	A-1-b	G	23.0	25.5	2.5	24.3	135	3,130	2,961	2,961	5,961					63	55	191	0.49	0.828	546	3,508	0.001	0.012
7	A-1-a	G	25.5	31.0	5.5	28.3	135	3,873	3,501	3,454	6,454					87	71	275	0.57	0.777	513	3,967	0.001	0.014
	A-1-a	G	31.0	37.0	6.0	34.0	135	4,683	4,278	3,872	6,872					87	68	256	0.68	0.707	467	4,339	0.001	0.014
8	A-1-b	G	37.0	43.0	6.0	40.0	135	5,493	5,088	4,308	7,308					52	39	126	0.80	0.642	424	4,731	0.002	0.023
	A-1-b	G	43.0	50.0	7.0	46.5	135	6,438	5,965	4,779	7,779					52	37	120	0.93	0.580	383	5,162	0.002	0.023
	A-1-b	G	50.0	57.0	7.0	53.5	135	7,383	6,910	5,288	8,288					52	35	114	1.07	0.522	345	5,632	0.002	0.020
9	A-1-a	G	57.0	64.0	7.0	60.5	135	8,328	7,855	5,796	8,796					100	65	238	1.21	0.474	313	6,109	0.001	0.008
	A-1-a	G	64.0	72.0	8.0	68.0	135	9,408	8,868	6,340	9,340					100	62	223	1.36	0.430	284	6,624	0.001	0.008
																				Total Settlement:		0.784 in		

- $\sigma_p' = \sigma_{vo}' + \sigma_m$ . Estimate  $\sigma_m$  of 3,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003
- $C_c = 0.009(LL-10)$ ; Ref. Table 26, FHWA GEC 5
- $C_r = 0.05(C_c)$  for embankment fill and  $0.10(C_c)$  for natural cohesive soils; Ref. Section 5.4.2.5 of FHWA GEC 5
- $e_o = (C_u/1.15) + 0.35$ ; Ref. Table 8-2, Holtz and Kovacs 1981
- $(N1)_{60} = C_u N_{60}$ , where  $C_u = [0.77 \log(40/\sigma_{vo}')] \leq 2.0$  ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
- Bearing capacity index; Ref. Figure 10.6.2.4-1, AASHTO LRFD BDS
- Influence factor for strip loaded footing
- $\Delta\sigma_v = q_e(I)$
- $S_c = [C_u/(1+e_o)](H) \log(\sigma_p'/\sigma_{vo}')$  for  $\sigma_p' < \sigma_{vo}' < \sigma_{v'}'$ ;  $[C_r/(1+e_o)](H) \log(\sigma_p'/\sigma_{vo}')$  for  $\sigma_{vo}' < \sigma_{v'}' < \sigma_p'$ ;  $[C_r/(1+e_o)](H) \log(\sigma_p'/\sigma_{vo}') + [C_u/(1+e_o)](H) \log(\sigma_{v'}'/\sigma_p')$  for  $\sigma_{vo}' < \sigma_p' < \sigma_{v'}'$ ; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesive soil layers)
- $S_c = H(1/C') \log(\sigma_{v'}'/\sigma_{vo}')$ ; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)

W-13-072 FRA-70-13.10 (FRA-70-1322L and 1323C Bridge Structure)  
Embankment Settlement

Calculated By: BRT  
Checked By: JPS  
Date: 1/21/2015  
Date: 1/22/2015

Borings B-113-4-13 (Rear Abutments)

5.5' net embankment height considered - Existing grade is at 725.0 and proposed profile grade is at 730.5 for a net embankment height of 5.5'

H= 5.5 ft  
B= 50.0 ft  
 $\gamma_{bf}$  = 120 pcf  
 $D_w$  = 27.5 ft Below Ground Surface  
 $\Delta\sigma$  = 660 psf At Ground Surface

Settlement Below Abutment Footing for Downdrag Analysis																										
Layer	Soil Type	Soil Type	Layer Depth (ft)		Layer Thickness (ft)	Depth to Midpoint (ft)	$\gamma$ (pcf)	$\sigma_{vo}$ Bottom (psf)	$\sigma_{vo}$ Midpoint (psf)	$\sigma_{vo}'$ Midpoint (psf)	$\sigma_p^{*(1)}$ (psf)	LL	$C_c^{(2)}$	$C_r^{(3)}$	$e_o^{(4)}$	$N_{60}$	$(N1)_{60}^{(5)}$	$C_u^{(6)}$	$Z_r/B$	$I^{(7)}$	$\Delta\sigma_v^{(8)}$ (psf)	$\sigma_{v'}'$ Midpoint (psf)	$S_c^{(9,10)}$ (ft)	$S_c$ (in)	Relative Movement (in)	
3	A-6a	C	0.0	2.5	2.5	1.3	115	288	150	150	3,150	28	0.162	0.008	0.491				0.03	0.002	1	151	0.000	0.001	0.110	
4	A-2-6	G	2.5	6.5	4.0	4.5	120	768	528	528	3,528					9	13	61	0.09	0.048	31	559	0.002	0.020	0.091	
5	A-4a	C	6.5	10.0	3.5	8.3	115	1,170	969	969	3,969	32	0.198	0.010	0.522				0.17	0.140	92	1,061	0.001	0.011	0.080	
6	A-1-b	G	10.0	12.5	2.5	11.3	135	1,508	1,339	1,339	4,339					63	72	277	0.23	0.202	133	1,472	0.000	0.004	0.075	
	A-1-b	G	12.5	15.0	2.5	13.8	135	1,845	1,676	1,676	4,676					63	67	250	0.28	0.241	159	1,836	0.000	0.005	0.071	
7	A-1-a	G	15.0	20.5	5.5	17.8	135	2,588	2,216	2,216	5,216					87	84	355	0.36	0.287	189	2,405	0.001	0.007	0.064	
	A-1-a	G	20.5	26.5	6.0	23.5	135	3,398	2,993	2,993	5,993					87	75	300	0.47	0.325	215	3,207	0.001	0.007	0.057	
8	A-1-b	G	26.5	32.5	6.0	29.5	135	4,208	3,803	3,678	6,678					52	42	136	0.59	0.346	228	3,906	0.001	0.014	0.043	
	A-1-b	G	32.5	39.5	7.0	36.0	135	5,153	4,680	4,150	7,150					52	39	128	0.72	0.355	234	4,384	0.001	0.016	0.027	
	A-1-b	G	39.5	46.5	7.0	43.0	135	6,098	5,625	4,658	7,658					52	37	122	0.86	0.355	234	4,892	0.001	0.015	0.013	
9	A-1-a	G	46.5	53.5	7.0	50.0	135	7,043	6,570	5,166	8,166					100	68	259	1.00	0.348	230	5,396	0.001	0.006	0.007	
	A-1-a	G	53.5	61.5	8.0	57.5	135	8,123	7,583	5,711	8,711					100	65	241	1.15	0.337	222	5,933	0.001	0.007	0.000	
1. $\sigma_p^* = \sigma_{vo} + \sigma_m$ ; Estimate $\sigma_m$ of 3,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003																					Total Settlement:				0.111 in	

1.  $\sigma_p' = \sigma_{vo}' + \sigma_m$ ; Estimate  $\sigma_m$  of 3,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003  
2.  $C_c = 0.009(LL-10)$ ; Ref. Table 26, FHWA GEC 5  
3.  $C_r = 0.05(C_c)$  for embankment fill and  $0.10(C_c)$  for natural cohesive soils; Ref. Section 5.4.2.5 of FHWA GEC 5  
4.  $e_o = (C_r/1.15)+0.35$ ; Ref. Table 8-2, Holtz and Kovacs 1981  
5.  $(N1)_{60} = C_u N_{60}$ , where  $C_u = [0.77 \log(40/\sigma_{vo}')] \leq 2.0$  ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS  
6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS  
7. Influence factor for strip loaded footing  
8.  $\Delta\sigma_v = q_e(l)$   
9.  $S_c = [C_r/(1+e_o)](H) \log(\sigma_{v'}/\sigma_{vo}')$  for  $\sigma_{v'}' \leq \sigma_{vo}' < \sigma_{v'}$ ;  $[C_r/(1+e_o)](H) \log(\sigma_p'/\sigma_{vo}')$  for  $\sigma_{v'}' < \sigma_{v'}$ ;  $[C_r/(1+e_o)](H) \log(\sigma_p'/\sigma_{vo}')$  for  $\sigma_{v'}' < \sigma_p' < \sigma_{v'}$ ; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesiv soil layers)  
10.  $S_c = H(1/C') \log(\sigma_{v'}/\sigma_{vo}')$ ; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)  
11.  $(S_c)_t = S_c(U/100)$ ;  $U = 100$  for all granular soils at time  $t = 0$

Depth of Downdrag: 0.0 ft.

W-13-072 FRA-70-13.10 (FRA-70-1322L and 1323C Bridge Structure)  
Embankment Settlement

Calculated By: BRT Date: 1/21/2015  
Checked By: JPS Date: 1/22/2015

Borings B-016-0-08 and B-016-7-13 (Forward Abutments)

10.0' net embankment height considered - Existing grade is at 727.0 and proposed profile grade is at 737.0 for a net embankment height of 10.0'

H= 10.0 ft  
B= 50.0 ft  
 $\gamma_{BF}$  = 120 pcf  
 $D_w$  = 29.0 ft Below Ground Surface  
 $\Delta\sigma$  = 1,200 psf At Ground Surface

																				Total Embankment Settlement				
Layer	Soil Class.	Soil Type	Layer Depth (ft)		Layer Thickness H (ft)	Depth to Midpoint (ft)	$\gamma$ (pcf)	$\sigma_{vo}$ Bottom (psf)	$\sigma_{vo}$ Midpoint (psf)	$\sigma_{vo}'$ Midpoint (psf)	$\sigma_p^{(1)}$ (psf)	LL	$C_c^{(2)}$	$C_r^{(3)}$	$e_o^{(4)}$	$N_{60}$	$(N1)_{60}^{(5)}$	$C_u^{(6)}$	$Z_r/B$	$I^{(7)}$	$\Delta\sigma_v^{(8)}$ (psf)	$\sigma_{v'}'$ Midpoint (psf)	$S_c^{(9,10)}$ (ft)	$S_c$ (in)
1	A-2-4	G	0.0	6.0	6.0	3.0	130	780	390	390	3,390					43	67	249	0.06	0.999	1,199	1,589	0.015	0.176
2	A-6a	C	6.0	8.5	2.5	7.3	115	1,068	924	924	3,924	35	0.225	0.011	0.546				0.15	0.991	1,189	2,112	0.007	0.078
	A-6a	C	8.5	11.0	2.5	9.8	115	1,355	1,211	1,211	4,211	35	0.225	0.011	0.546				0.20	0.979	1,175	2,386	0.005	0.064
	A-6a	C	11.0	13.5	2.5	12.3	115	1,643	1,499	1,499	4,499	35	0.225	0.023	0.546				0.25	0.961	1,154	2,653	0.009	0.108
3	A-3a	G	13.5	15.5	2.0	14.5	120	1,883	1,763	1,763	4,763					7	7	49	0.29	0.942	1,130	2,893	0.009	0.106
	A-3a	G	15.5	18.0	2.5	16.8	120	2,183	2,033	2,033	5,033					7	7	48	0.34	0.919	1,102	3,135	0.010	0.117
4	A-6a	C	18.0	20.0	2.0	19.0	115	2,413	2,298	2,298	5,298	31	0.189	0.019	0.514				0.38	0.893	1,072	3,369	0.004	0.050
	A-6a	C	20.0	22.5	2.5	21.3	115	2,700	2,556	2,556	5,556	31	0.189	0.019	0.514				0.43	0.866	1,039	3,595	0.005	0.055
	A-6a	C	22.5	25.0	2.5	23.8	115	2,988	2,844	2,844	5,844	31	0.189	0.019	0.514				0.48	0.834	1,001	3,845	0.004	0.049
5	A-6b	C	25.0	28.0	3.0	26.5	120	3,348	3,168	3,168	6,168	40	0.270	0.027	0.585				0.53	0.799	959	4,127	0.006	0.070
	A-6b	C	28.0	31.0	3.0	29.5	120	3,708	3,528	3,496	6,496	40	0.270	0.027	0.585				0.59	0.762	914	4,410	0.005	0.062
6	A-2-4	G	31.0	36.0	5.0	33.5	120	4,308	4,008	3,727	6,727					4	3	49	0.67	0.713	856	4,583	0.009	0.111
7	A-1-b	G	36.0	41.0	5.0	38.5	135	4,983	4,645	4,052	7,052					80	61	221	0.77	0.657	789	4,841	0.002	0.021
8	A-6a	C	41.0	46.0	5.0	43.5	130	5,633	5,308	4,403	7,403	30	0.180	0.018	0.507				0.87	0.607	729	5,131	0.004	0.048
9	A-1-b	G	46.0	51.0	5.0	48.5	135	6,308	5,970	4,753	7,753					54	38	125	0.97	0.562	675	5,428	0.002	0.028
10	A-6a	C	51.0	56.0	5.0	53.5	130	6,958	6,633	5,104	8,104	30	0.180	0.018	0.507				1.07	0.522	627	5,731	0.003	0.036
																				Total Settlement:		1.181 in		

- $\sigma_p' = \sigma_{vo}' + \sigma_m$ ; Estimate  $\sigma_m$  of 3,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003
- $C_c = 0.009(LL-10)$ ; Ref. Table 26, FHWA GEC 5
- $C_r = 0.05(C_c)$  for embankment fill and  $0.10(C_c)$  for natural cohesive soils; Ref. Section 5.4.2.5 of FHWA GEC 5
- $e_o = (C_u/1.15) + 0.35$ ; Ref. Table 8-2, Holtz and Kovacs 1981
- $(N1)_{60} = C_u N_{60}$ , where  $C_u = [0.77 \log(40/\sigma_{vo}')] \leq 2.0$  ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
- Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
- Influence factor for strip loaded footing
- $\Delta\sigma_v = q_e(I)$
- $S_c = [C_u/(1+e_o)](H) \log(\sigma_p'/\sigma_{vo}')$  for  $\sigma_p' < \sigma_{vo}' < \sigma_{v'}'$ ;  $[C_r/(1+e_o)](H) \log(\sigma_p'/\sigma_{vo}')$  for  $\sigma_{vo}' < \sigma_{v'}' \leq \sigma_p'$ ;  $[C_r/(1+e_o)](H) \log(\sigma_p'/\sigma_{vo}') + [C_u/(1+e_o)](H) \log(\sigma_{v'}'/\sigma_p')$  for  $\sigma_{vo}' < \sigma_p' < \sigma_{v'}'$ ; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesive soil layers)
- $S_c = H(1/C') \log(\sigma_{v'}'/\sigma_{vo}')$ ; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)

W-13-072 FRA-70-13.10 (FRA-70-1322L and 1323C Bridge Structure)  
Embankment Settlement

Calculated By: BRT Date: 1/21/2015  
Checked By: JPS Date: 1/22/2015

Borings B-016-0-08 and B-016-7-13 (Forward Abutments)

10.0' net embankment height considered - Existing grade is at 727.0 and proposed profile grade is at 737.0 for a net embankment height of 10.0'

H= 10.0 ft  
B= 50.0 ft  
 $\gamma_{ef}$  = 120 pcf  
 $D_u$  = 29.0 ft Below Ground Surface  
 $\Delta\sigma$  = 1,200 psf At Ground Surface

Settlement Below Abutment Footing for Downdrag Analysis																									
Layer	Soil Type	Soil Type	Layer Depth (ft)		Layer Thickness (ft)	Depth to Midpoint (ft)	γ (pcf)	σ <sub>vo</sub> Bottom (psf)	σ <sub>vo</sub> Midpoint (psf)	σ <sub>vo</sub> ' Midpoint (psf)	σ <sub>p</sub> ' (1) (psf)	LL	C <sub>c</sub> (2)	C <sub>r</sub> (3)	e <sub>o</sub> (4)	N <sub>60</sub>	(N1) <sub>60</sub> (5)	C <sub>u</sub> (6)	Z <sub>r</sub> /B	I (7)	Δσ <sub>v</sub> ' (8) (psf)	σ <sub>v</sub> ' ' Midpoint (psf)	S <sub>c</sub> (9,10) (ft)	S <sub>c</sub> (in)	Relative Movement (in)
1	A-2-4	G	4.0	6.0	2.0	5.0	130	780	650	650	3,650					43	59	211	0.10	0.059	71	721	0.000	0.005	0.398
2	A-6a	C	6.0	8.5	2.5	7.3	115	1,068	924	924	3,924	35	0.225	0.011	0.546				0.15	0.116	139	1,063	0.001	0.013	0.384
	A-6a	C	8.5	11.0	2.5	9.8	115	1,355	1,211	1,211	4,211	35	0.225	0.011	0.546				0.20	0.173	207	1,419	0.001	0.015	0.369
	A-6a	C	11.0	13.5	2.5	12.3	115	1,643	1,499	1,499	4,499	35	0.225	0.023	0.546				0.25	0.219	263	1,761	0.003	0.031	0.339
3	A-3a	G	13.5	15.5	2.0	14.5	120	1,883	1,763	1,763	4,763					7	7	49	0.29	0.251	302	2,064	0.003	0.034	0.305
	A-3a	G	15.5	18.0	2.5	16.8	120	2,183	2,033	2,033	5,033					7	7	48	0.34	0.277	332	2,365	0.003	0.041	0.264
4	A-6a	C	18.0	20.0	2.0	19.0	115	2,413	2,298	2,298	5,298	31	0.189	0.019	0.514				0.38	0.297	357	2,654	0.002	0.019	0.245
	A-6a	C	20.0	22.5	2.5	21.3	115	2,700	2,556	2,556	5,556	31	0.189	0.019	0.514				0.43	0.313	376	2,932	0.002	0.022	0.223
	A-6a	C	22.5	25.0	2.5	23.8	115	2,988	2,844	2,844	5,844	31	0.189	0.019	0.514				0.48	0.327	392	3,236	0.002	0.021	0.202
5	A-6b	C	25.0	28.0	3.0	26.5	120	3,348	3,168	3,168	6,168	40	0.270	0.027	0.585				0.53	0.338	405	3,573	0.003	0.032	0.170
	A-6b	C	28.0	31.0	3.0	29.5	120	3,708	3,528	3,496	6,496	40	0.270	0.027	0.585				0.59	0.346	415	3,912	0.002	0.030	0.140
6	A-2-4	G	31.0	36.0	5.0	33.5	120	4,308	4,008	3,727	6,727					4	3	49	0.67	0.353	423	4,150	0.005	0.058	0.082
7	A-1-b	G	36.0	41.0	5.0	38.5	135	4,983	4,645	4,052	7,052					80	61	221	0.77	0.356	427	4,479	0.001	0.012	0.070
8	A-6a	C	41.0	46.0	5.0	43.5	130	5,633	5,308	4,403	7,403	30	0.180	0.018	0.507				0.87	0.354	425	4,828	0.002	0.029	0.042
9	A-1-b	G	46.0	51.0	5.0	48.5	135	6,308	5,970	4,753	7,753					54	38	125	0.97	0.350	420	5,173	0.001	0.018	0.024
10	A-6a	C	51.0	56.0	5.0	53.5	130	6,958	6,633	5,104	8,104	30	0.180	0.018	0.507				1.07	0.343	412	5,516	0.002	0.024	0.000
1. σ <sub>p</sub> ' = σ <sub>vo</sub> ' + σ <sub>m</sub> ; Estimate σ <sub>m</sub> of 3,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003																				Total Settlement:			0.403 in		

1.  $\sigma_p' = \sigma_{vo}' + \sigma_m$ ; Estimate  $\sigma_m$  of 3,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003

2.  $C_c = 0.009(LL-10)$ ; Ref. Table 26, FHWA GEC 5

3.  $C_r = 0.05(C_c)$  for embankment fill and  $0.10(C_c)$  for natural cohesive soils; Ref. Section 5.4.2.5 of FHWA GEC 5

4.  $e_o = (C_u/1.15) + 0.35$ ; Ref. Table 8-2, Holtz and Kovacs 1981

5.  $(N1)_{60} = C_u N_{60}$ , where  $C_u = [0.77 \log(40/\sigma_{vo}')] \leq 2.0$  ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS

6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS

7. Influence factor for strip loaded footing

8.  $\Delta\sigma_v = q_e(I)$

9.  $S_c = [C_u/(1+e_o)](H) \log(\sigma_p'/\sigma_{vo}')$  for  $\sigma_p' \leq \sigma_{vo}' < \sigma_{v'}'$ ;  $[C_u/(1+e_o)](H) \log(\sigma_p'/\sigma_{vo}')$  for  $\sigma_{vo}' < \sigma_{v'}' \leq \sigma_p'$ ;  $[C_r/(1+e_o)](H) \log(\sigma_p'/\sigma_{vo}') + [C_u/(1+e_o)](H) \log(\sigma_{v'}'/\sigma_p')$  for  $\sigma_{vo}' < \sigma_p' < \sigma_{v'}'$ ; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesiv soil layers)

10.  $S_c = H(1/C) \log(\sigma_p'/\sigma_{vo}')$ ; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)

11.  $(S_c)_t = S_c(U/100)$ ; U = 100 for all granular soils at time t = 0

Depth of Downdrag: **0.0 ft.**

## **APPENDIX IX**

### **LATERAL DESIGN PARAMETERS**



FRA-70-1322L I-70 WB over the Scioto River Lateral Design Parameters												
Boring No.	Elevation (feet msl)	Soil Class.	Soil Type	Strata	N <sub>60</sub>	N1 <sub>60</sub>	γ (pcf)	γ' (pcf)	Strength Parameter	k (soil) k <sub>rm</sub> (rock)	ε <sub>50</sub> (soil) E <sub>r</sub> (rock)	RQD (rock)
Rear Abutment (B-001-S-57 / B-113-5-13)	723.4 to 705.4	A-1-a	G	4	32	38	130	130	φ = 41°	315 pci	-	-
	705.4 to 700.4	A-6a	C	3	30	30	125	125	Su = 3,750 psf	1,250 pci	0.0048	-
	700.4 to 695.4	A-1-b	G	4	70	58	135	135	φ = 42°	355 pci	-	-
	695.4 to 685.4	A-1-a	G	4	45	34	130	130	φ = 41°	315 pci	-	-
	685.4 to 675.4	A-1-a	G	4	82	57	135	72.6	φ = 43°	215 pci	-	-
	675.4 to 670.4	A-6a	C	2	100	100	130	67.6	Su = 8,000 psf	2,665 pci	0.0033	-
	670.4 to 660.0	Boulders	G	4	100	63	140	77.6	φ = 45°	255 pci	-	-
	660.0 to 652.2	A-1-a	G	4	100	59	135	72.6	φ = 43°	215 pci	-	-
	652.2 to 650.8	Mudstone	R	9	-	-	150	87.6	Qu = 200 psi	0.0005	20,000 psi	15
	650.8 to 637.0	Limestone	R	9	-	-	165	102.6	Qu = 10,000 psi	0.00005	1,000,000 psi	77
Pier 1 (B-005-S-57)	681.1 to 673.1	A-1-a	G	4	24	41	125	62.6	φ = 42°	195 pci	-	-
	673.1 to 668.1	A-3a	G	4	73	99	135	72.6	φ = 40°	155 pci	-	-
	668.1 to 658.1	A-1-a	G	4	100	117	135	72.6	φ = 43°	215 pci	-	-
	658.1 to 654.1	A-2-4	G	4	20	21	125	62.6	φ = 37°	110 pci	-	-
	654.1 to 652.1	A-1-a	G	4	100	102	135	72.6	φ = 43°	215 pci	-	-
	652.1 to 651.5	Shale	R	9	-	-	150	87.6	Qu = 200 psi	0.0005	20,000 psi	15
	651.5 to 645.1	Limestone	R	9	-	-	165	102.6	Qu = 10,000 psi	0.00005	1,000,000 psi	85
Pier 2 (B-009-S-57)	685.5 to 673.5	A-1-b	G	4	24	37	125	62.6	φ = 40°	155 pci	-	-
	673.5 to 669.5	A-1-b	G	4	73	93	135	72.6	φ = 42°	195 pci	-	-
	669.5 to 659.5	A-1-a	G	4	100	112	135	72.6	φ = 43°	215 pci	-	-
	659.5 to 655.5	A-1-a	G	4	20	20	125	62.6	φ = 38°	125 pci	-	-
	655.5 to 650.8	A-1-a	G	4	100	97	135	72.6	φ = 43°	215 pci	-	-
	650.8 to 648.1	Shale	R	9	-	-	150	87.6	Qu = 200 psi	0.0005	20,000 psi	15
	648.1 to 645.4	Limestone	R	9	-	-	165	102.6	Qu = 10,000 psi	0.00005	1,000,000 psi	85
Pier 3 (B-013-S-57 / B-113-8-13)	690.8 to 683.8	A-1-a	G	4	15	26	125	62.6	φ = 39°	140 pci	-	-
	683.8 to 678.8	A-1-a	G	4	90	125	135	72.6	φ = 43°	215 pci	-	-
	678.8 to 673.8	A-3a	G	4	27	34	125	62.6	φ = 38°	125 pci	-	-
	673.8 to 668.8	A-1-a	G	4	30	35	130	67.6	φ = 41°	175 pci	-	-
	668.8 to 660.8	A-1-a	G	4	100	105	135	72.6	φ = 43°	215 pci	-	-
	660.8 to 644.0	Shale	R	9	-	-	150	87.6	Qu = 200 psi	0.0005	20,000 psi	15
	644.0 to 634.4	Dolomite	R	9	-	-	165	102.6	Qu = 10,000 psi	0.00005	1,000,000 psi	40
	634.4 to 625.0	Limestone	R	9	-	-	165	102.6	Qu = 10,000 psi	0.00005	1,000,000 psi	90
Pier 4 (B-020-S-57 / B-113-9-13)	725.4 to 711.4	A-1-b	G	4	10	13	120	120	φ = 36°	160 pci	-	-
	711.4 to 701.4	A-4a	C	3	21	21	120	120	Su = 2,625 psf	875 pci	0.0055	-
	701.4 to 696.4	A-6a	C	3	15	15	120	120	Su = 1,875 psf	625 pci	0.0065	-
	696.4 to 691.4	A-2-4	G	4	23	18	125	125	φ = 36°	160 pci	-	-
	691.4 to 683.8	A-1-a	G	4	25	18	125	62.6	φ = 38°	125 pci	-	-
	683.8 to 674.3	A-4a	G	4	58	40	130	67.6	φ = 36°	95 pci	-	-
	674.3 to 669.3	A-2-4	G	4	45	30	135	72.6	φ = 38°	125 pci	-	-
	669.3 to 656.3	A-2-4	G	4	75	47	135	72.6	φ = 40°	155 pci	-	-
	656.3 to 650.8	Shale	R	9	-	-	150	87.6	Qu = 200 psi	0.0005	20,000 psi	15
	650.8 to 645.6	Mudstone	R	9	-	-	150	87.6	Qu = 200 psi	0.0005	20,000 psi	15
	645.6 to 633.3	Limestone	R	9	-	-	165	102.6	Qu = 10,000 psi	0.00005	1,000,000 psi	95
Forward Abutment (B-020-S-57 / B-114-1-13)	725.4 to 711.4	A-1-b	G	4	10	13	120	120	φ = 36°	160 pci	-	-
	711.4 to 701.4	A-4a	C	3	21	21	120	120	Su = 2,625 psf	875 pci	0.0055	-
	701.4 to 696.4	A-6a	C	3	15	15	120	120	Su = 1,875 psf	625 pci	0.0065	-
	696.4 to 691.4	A-2-4	G	4	23	18	125	125	φ = 36°	160 pci	-	-
	691.4 to 684.4	A-1-a	G	4	25	18	125	62.6	φ = 38°	125 pci	-	-
	684.4 to 682.1	A-1-a	G	4	29	21	130	67.6	φ = 39°	140 pci	-	-
	682.1 to 679.6	A-4a	C	2	41	41	125	62.6	Su = 5,125 psf	1,710 pci	0.0043	-
	679.6 to 674.6	A-2-4	G	4	100	69	135	72.6	φ = 41°	175 pci	-	-
	674.6 to 662.1	A-6b	C	2	38	38	125	62.6	Su = 4,750 psf	1,585 pci	0.0044	-
	662.1 to 655.6	Shale	R	9	-	-	150	87.6	Qu = 200 psi	0.0005	20,000 psi	15
	655.6 to 641.6	Shale	R	9	-	-	150	87.6	Qu = 360 psi	0.0005	32,000 psi	37
	641.6 to 635.6	Limestone	R	9	-	-	165	102.6	Qu = 10,000 psi	0.00005	1,000,000 psi	95

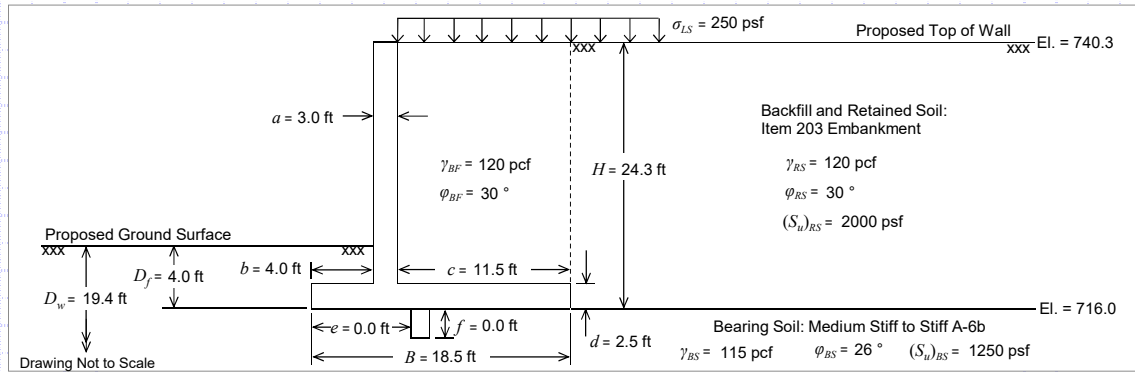
<div>FRA-70-1323C</div> <div>Ramp D3 over the Scioto River</div> <div>Lateral Design Parameters</div>												
Boring No.	Elevation (feet msl)	Soil Class.	Soil Type	Strata	N <sub>60</sub>	N1 <sub>60</sub>	γ (pcf)	γ' (pcf)	Strength Parameter	k (soil) k <sub>rm</sub> (rock)	ε <sub>50</sub> (soil) E <sub>r</sub> (rock)	RQD (rock)
Rear Abutment (B-113-5-13)	725.7 to 720.2	A-6a	C	3	21	21	120	120	Su = 2,625 psf	875 pci	0.0055	-
	720.2 to 715.2	A-1-b	G	4	11	14	120	120	φ = 36°	160 pci	-	-
	715.2 to 705.2	A-1-a	G	4	22	22	125	125	φ = 39°	250 pci	-	-
	705.2 to 702.7	A-6a	C	3	22	22	120	120	Su = 2,750 psf	915 pci	0.0053	-
	702.7 to 697.7	A-1-a	G	4	19	16	125	125	φ = 37°	190 pci	-	-
	697.7 to 688.7	A-1-a	G	4	52	40	135	135	φ = 41°	315 pci	-	-
	688.7 to 683.7	A-1-b	G	4	13	9	120	57.6	φ = 34°	70 pci	-	-
	683.7 to 674.7	A-1-a	G	4	100	67	135	72.6	φ = 43°	215 pci	-	-
	674.7 to 668.7	Boulders	G	4	100	64	140	77.6	φ = 45°	255 pci	-	-
	668.7 to 663.7	A-3a	G	4	85	52	135	72.6	φ = 40°	155 pci	-	-
	663.7 to 652.2	A-1-a	G	4	100	59	135	72.6	φ = 43°	215 pci	-	-
	652.2 to 650.8	Mudstone	R	9	-	-	150	87.6	Qu = 200 psi	0.0005	20,000 psi	15
	650.8 to 640.0	Limestone	R	9	-	-	165	102.6	Qu = 10,000 psi	0.00005	1,000,000 psi	77
Pier 1 (B-113-6-13)	691.5 to 681.7	A-2-6	G	4	5	8	120	57.6	φ = 33°	60 pci	-	-
	681.7 to 678.7	A-1-a	G	4	14	19	125	62.6	φ = 38°	125 pci	-	-
	678.7 to 661.2	A-1-a	G	4	89	100	135	72.6	φ = 43°	215 pci	-	-
	661.2 to 652.2	A-1-b	G	4	94	89	135	72.6	φ = 42°	195 pci	-	-
	652.2 to 647.6	Shale	R	9	-	-	150	87.6	Qu = 200 psi	0.0005	20,000 psi	15
	647.6 to 627.8	Limestone	R	9	-	-	165	102.6	Qu = 10,000 psi	0.00005	1,000,000 psi	88
Pier 2 (B-113-7-13)	690.3 to 684.3	A-1-b	G	4	4	7	120	57.6	φ = 33°	60 pci	-	-
	684.3 to 680.2	A-4a	G	4	4	6	120	57.6	φ = 29°	25 pci	-	-
	680.2 to 675.2	A-1-a	G	4	35	47	130	67.6	φ = 42°	195 pci	-	-
	675.2 to 670.6	A-1-b	G	4	100	121	135	72.6	φ = 42°	195 pci	-	-
	670.6 to 669.6	Boulders	G	4	100	115	140	77.6	φ = 45°	255 pci	-	-
	669.6 to 664.7	A-1-b	G	4	100	110	135	72.6	φ = 42°	195 pci	-	-
	664.7 to 662.7	A-2-4	G	4	94	98	135	72.6	φ = 41°	175 pci	-	-
	662.7 to 660.5	A-6b	C	2	100	100	130	67.6	Su = 8,000 psf	2,665 pci	0.0033	-
	660.5 to 659.4	Boulders	G	4	100	100	140	77.6	φ = 45°	255 pci	-	-
	659.4 to 648.8	Shale	R	9	-	-	150	87.6	Qu = 750 psi	0.00025	68,000 psi	21
	648.8 to 634.6	Limestone	R	9	-	-	165	102.6	Qu = 10,000 psi	0.00005	1,000,000 psi	81
Pier 3 (B-113-8-13)	691.0 to 676.8	A-1-a	G	4	18	27	125	62.6	φ = 40°	155 pci	-	-
	676.8 to 671.8	A-1-a	G	4	42	51	130	67.6	φ = 43°	215 pci	-	-
	671.8 to 663.6	A-4a	G	4	86	94	135	72.6	φ = 38°	125 pci	-	-
	663.6 to 659.5	Boulders	G	4	100	100	140	77.6	φ = 45°	255 pci	-	-
	659.5 to 646.8	A-1-a	G	4	87	80	135	72.6	φ = 43°	215 pci	-	-
	646.8 to 644.0	A-6b	C	2	100	100	130	67.6	Su = 8,000 psf	2,665 pci	0.0033	-
	644.0 to 634.4	Dolomite	R	9	-	-	165	102.6	Qu = 10,000 psi	0.00005	1,000,000 psi	40
	634.4 to 624.8	Limestone	R	9	-	-	165	102.6	Qu = 10,000 psi	0.00005	1,000,000 psi	90
Pier 4 (B-113-9-13)	706.3 to 700.8	A-6a	C	3	10	10	115	115	Su = 1,250 psf	365 pci	0.0080	-
	700.8 to 698.3	A-1-b	G	4	54	71	135	135	φ = 42°	355 pci	-	-
	698.3 to 693.3	A-6b	C	3	19	19	120	120	Su = 2,375 psf	790 pci	0.0058	-
	693.3 to 691.3	A-6b	C	3	8	8	115	115	Su = 1,000 psf	235 pci	0.0090	-
	691.3 to 685.8	A-6a	C	1	5	5	110	110	Su = 625 psf	85 pci	0.0125	-
	685.8 to 683.3	A-4a	C	2	10	10	115	52.6	Su = 1,250 psf	365 pci	0.0080	-
	683.3 to 680.8	A-4a	G	4	23	21	125	62.6	φ = 34°	70 pci	-	-
	680.8 to 674.3	A-4a	G	4	58	51	135	72.6	φ = 38°	125 pci	-	-
	674.3 to 669.3	A-2-4	G	4	45	37	135	72.6	φ = 39°	140 pci	-	-
	669.3 to 656.3	A-2-4	G	4	75	58	135	72.6	φ = 41°	175 pci	-	-
	656.3 to 650.8	Shale	R	9	-	-	150	87.6	Qu = 200 psi	0.0005	20,000 psi	15
	650.8 to 645.6	Mudstone	R	9	-	-	150	87.6	Qu = 200 psi	0.0005	20,000 psi	15
	645.6 to 633.3	Limestone	R	9	-	-	165	102.6	Qu = 10,000 psi	0.00005	1,000,000 psi	95
Forward Abutment (B-114-1-13)	716.6 to 706.1	A-6b	C	3	12	12	115	115	Su = 1,500 psf	500 pci	0.0070	-
	706.1 to 696.1	A-6a	C	3	15	15	120	120	Su = 1,875 psf	625 pci	0.0065	-
	696.1 to 691.6	A-6b	C	3	8	8	115	115	Su = 1,000 psf	235 pci	0.0090	-
	691.6 to 684.6	A-1-a	G	4	17	14	125	62.6	φ = 37°	110 pci	-	-
	684.6 to 679.6	A-1-a	G	4	41	32	130	67.6	φ = 40°	155 pci	-	-
	679.6 to 674.6	A-2-4	G	4	100	76	135	72.6	φ = 41°	175 pci	-	-
	674.6 to 662.1	A-6b	C	2	38	38	125	62.6	Su = 4,750 psf	1,585 pci	0.0044	-
	662.1 to 655.6	Shale	R	9	-	-	150	87.6	Qu = 200 psi	0.0005	20,000 psi	15
	655.6 to 641.6	Shale	R	9	-	-	150	87.6	Qu = 360 psi	0.0005	32,000 psi	37
	641.6 to 635.6	Limestone	R	9	-	-	165	102.6	Qu = 10,000 psi	0.00005	1,000,000 psi	95

## **APPENDIX X**

### **CIP WALL CALCULATIONS (FORWARD ABUTMENT WINGWALL)**



**FRA-70-1323C - Forward Abutment Wingwall - Panel 3 - CIP Wall Without Shear Key - Borings B-019-5-19 and B-114-1-13**



**CIP Wall Dimensions and Surcharge Loading**

Wall Height, (H) =	24.3 ft
Foundation Width (Entire Base Width), (B) =	18.5 ft
Stem Width, (a) =	3.0 ft
Toe Width, (b) =	4.0 ft
Heel Width, (c) =	11.5 ft
Footing Thickness, (d) =	2.5 ft
Location of Shear Key, (e) =	0.0 ft
Depth of Shear Key, (f) =	0.0 ft
Embedment Depth, (D <sub>f</sub> ) =	4.0 ft
Wall Length, (L) =	124 ft
Live Surcharge Load, (σ <sub>LS</sub> ) =	250 psf
Depth to Groundwater, (D <sub>w</sub> ) =	19.4 ft

**Bearing and Retained/Backfill Soil Properties:**

Bearing Soil Unit Weight, (γ <sub>BS</sub> ) =	115 pcf
Bearing Soil Friction Angle, (φ <sub>BS</sub> ) =	26°
Bearing Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>BS</sub> ] =	1250 psf
Backfill and Retained Soil Unit Weight, (γ <sub>BF</sub> , γ <sub>RS</sub> ) =	120 pcf
Retained Soil Friction Angle, (φ <sub>RS</sub> ) =	30°
Retained Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>RS</sub> ] =	2000 psf
Active Earth Pressure Coefficient, (K <sub>a</sub> ) =	0.297
Passive Earth Pressure Coefficient, (K <sub>p</sub> ) =	7.410

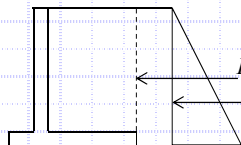
**LRFD Load Factors**

	DC	EV	EH	LS	EP
Strength Ia	0.90	1.00	1.50	1.75	0.90
Strength Ib	1.25	1.35	1.50	1.75	0.90
Service I	1.00	1.00	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

**Check Sliding (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 10.6.3.4**

Sliding Force:



$$P_H = P_{EH} + P_{LS}$$

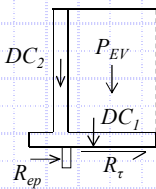
$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf}) (24.3 \text{ ft})^2 (0.297) (1.50) = 15.78 \text{ kip/ft}$$

$$P_{LS} = \sigma_{LS} H K_a \gamma_{LS} = (250 \text{ psf}) (24.3 \text{ ft}) (0.297) (1.75) = 3.16 \text{ kip/ft}$$

$$P_H = 15.78 \text{ kip/ft} + 3.16 \text{ kip/ft} = 18.94 \text{ kip/ft}$$

**Check Sliding Resistance**

$$\text{Nominal Sliding Resisting: } R_n = R_\tau + R_{ep}$$



$$R_{ep} = \gamma_{BS} D_f j K_p \gamma_{ep} + \frac{1}{2} \gamma_{BS} f^2 K_p \gamma_{ep}$$

$$R_{ep} = (115 \text{ pcf}) (4.0 \text{ ft}) (0.0 \text{ ft}) (7.41) (0.90) + \frac{1}{2} (115 \text{ pcf}) (0.0 \text{ ft})^2 (7.41) (0.90) = 0.00 \text{ kip/ft}$$

$$\text{Check Drained Condition: } R_\tau = P_v \tan \delta$$

$$P_v = DC_1 + DC_2 + P_{EV} = \gamma_c \cdot [B \cdot d + (H - d) \cdot a] \cdot \gamma_{DC} + \gamma_{BF} \cdot (H - d) \cdot c \cdot \gamma_{EV}$$

$$P_v = (150 \text{ pcf}) [(18.5 \text{ ft}) (2.5 \text{ ft}) + (24.3 \text{ ft} - 2.5 \text{ ft}) (3.0 \text{ ft})] (0.90) + (120 \text{ pcf}) (24.3 \text{ ft} - 2.5 \text{ ft}) (11.5 \text{ ft}) (1.00) = 45.16 \text{ kip/ft}$$

$$\tan \delta = \tan \phi_{BS} = \tan(26^\circ) = 0.49$$

$$R_\tau = (45.16 \text{ kip/ft}) (0.49) = 22.13 \text{ kip/ft}$$

**Verify Sliding Force Less Than Factored Sliding Resistance - Drained Condition**

$$P_H \leq \phi_n \cdot R_n \rightarrow P_H \leq \phi_\tau \cdot R_\tau + \phi_{ep} \cdot R_{ep} \rightarrow 18.94 \text{ kip/ft} \leq (22.13 \text{ kip/ft}) (1.00) + (0.00 \text{ kip/ft}) (0.50) = 22.13 \text{ kip/ft}$$

$$= 18.94 \text{ kip/ft} \leq 22.13 \text{ kip/ft}$$

**OK**

$$\text{Use } \phi_\tau = 1.00 \quad \text{Use } \phi_{ep} = 0.50 \quad (\text{Per AASHTO LRFD BDM Tables 10.5.5.2.2-1 and 11.5.7-1})$$



### CIP Wall Dimensions and Surcharge Loading

Wall Height, (H) =	24.3 ft
Foundation Width (Entire Base Width), (B) =	18.5 ft
Stem Width, (a) =	3.0 ft
Toe Width, (b) =	4.0 ft
Heel Width, (c) =	11.5 ft
Footing Thickness, (d) =	2.5 ft
Location of Shear Key, (e) =	0.0 ft
Depth of Shear Key, (f) =	0.0 ft
Embedment Depth, (D <sub>f</sub> ) =	4.0 ft
Wall Length, (L) =	124 ft
Live Surcharge Load, (σ <sub>LS</sub> ) =	250 psf
Depth to Groundwater, (D <sub>w</sub> ) =	19.4 ft

### Bearing and Retained/Backfill Soil Properties:

Bearing Soil Unit Weight, (γ <sub>BS</sub> ) =	115 pcf
Bearing Soil Friction Angle, (φ <sub>BS</sub> ) =	26 °
Bearing Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>BS</sub> ] =	1250 psf
Backfill and Retained Soil Unit Weight, (γ <sub>BF</sub> , γ <sub>RS</sub> ) =	120 pcf
Retained Soil Friction Angle, (φ <sub>RS</sub> ) =	30 °
Retained Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>RS</sub> ] =	2000 psf
Active Earth Pressure Coefficient, (K <sub>a</sub> ) =	0.297
Passive Earth Pressure Coefficient, (K <sub>p</sub> ) =	7.410

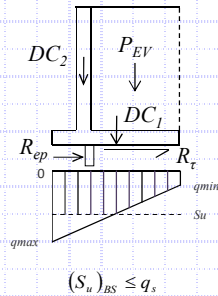
### LRFD Load Factors

	DC	EV	EH	LS	EP
Strength Ia	0.90	1.00	1.50	1.75	0.90
Strength Ib	1.25	1.35	1.50	1.75	0.90
Service I	1.00	1.00	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

### Check Sliding (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 10.6.3.4 (Continued)

Check Undrained Condition:  $R_{\tau} = ((S_u)_{BS} \leq q_s) \cdot B$



$$(S_u)_{BS} = 1.25 \text{ ksf}$$

$$q_{max} = \frac{1}{2} \sigma_{max} = (4.09 \text{ ksf}) / 2 = 2.05 \text{ ksf}$$

$$q_{min} = \frac{1}{2} \sigma_{min} = (0.79 \text{ ksf}) / 2 = 0.40 \text{ ksf}$$

$$\sigma_{max} = \frac{P_v}{B} \left( 1 + 6 \frac{e}{B} \right) = (45.16 \text{ kip/ft} / 18.5 \text{ ft}) [1 + 6(2.08 \text{ ft} / 18.5 \text{ ft})] = 4.09 \text{ ksf}$$

$$\sigma_{min} = \frac{P_v}{B} \left( 1 - 6 \frac{e}{B} \right) = (45.16 \text{ kip/ft} / 18.5 \text{ ft}) [1 - 6(2.08 \text{ ft} / 18.5 \text{ ft})] = 0.79 \text{ ksf}$$

$$R_{\tau} = 0.5(1.25 \text{ ksf} - 0.4 \text{ ksf})[(18.5 \text{ ft}(1.25 \text{ ksf} - 0.4 \text{ ksf})) / (2.05 \text{ ksf} - 0.4 \text{ ksf})] + (1.25 \text{ ksf} - 0.4 \text{ ksf})[(18.5 \text{ ft}(2.05 \text{ ksf} - 1.25 \text{ ksf})) / (2.05 \text{ ksf} - 0.4 \text{ ksf})] + (0.4 \text{ ksf})(18.5 \text{ ft}) = 19.07 \text{ kip/ft}$$

### Verify Sliding Force Less Than Factored Sliding Resistance - Undrained Condition

$$P_H \leq \phi_n \cdot R_n \rightarrow P_H \leq \phi_{\tau} \cdot R_{\tau} + \phi_{ep} \cdot R_{ep} \rightarrow 18.94 \text{ kip/ft} \leq (19.07 \text{ kip/ft})(1.00) + (0.00 \text{ kip/ft})(0.50) = 19.07$$

$$= 18.94 \text{ kip/ft} \leq 19.07 \text{ kip/ft} \quad \text{OK}$$

$$\text{Use } \phi_{\tau} = 1.00 \quad \text{Use } \phi_{ep} = 0.50 \quad (\text{Per AASHTO LRFD BDM Tables 10.5.5.2.2-1 and 11.5.7-1})$$



### CIP Wall Dimensions and Surcharge Loading

Wall Height, (H) =	24.3 ft
Foundation Width (Entire Base Width), (B) =	18.5 ft
Stem Width, (a) =	3.0 ft
Toe Width, (b) =	4.0 ft
Heel Width, (c) =	11.5 ft
Footing Thickness, (d) =	2.5 ft
Location of Shear Key, (e) =	0.0 ft
Depth of Shear Key, (f) =	0.0 ft
Embedment Depth, (D <sub>f</sub> ) =	4.0 ft
Wall Length, (L) =	124 ft
Live Surcharge Load, (σ <sub>LS</sub> ) =	250 psf
Depth to Groundwater, (D <sub>w</sub> ) =	19.4 ft

### Bearing and Retained/Backfill Soil Properties:

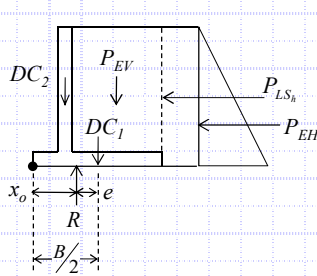
Bearing Soil Unit Weight, (γ <sub>BS</sub> ) =	115 pcf
Bearing Soil Friction Angle, (φ <sub>BS</sub> ) =	26 °
Bearing Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>BS</sub> ] =	1250 psf
Backfill and Retained Soil Unit Weight, (γ <sub>BF</sub> , γ <sub>RS</sub> ) =	120 pcf
Retained Soil Friction Angle, (φ <sub>RS</sub> ) =	30 °
Retained Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>RS</sub> ] =	2000 psf
Active Earth Pressure Coefficient, (K <sub>a</sub> ) =	0.297
Passive Earth Pressure Coefficient, (K <sub>p</sub> ) =	7.410

### LRFD Load Factors

	DC	EV	EH	LS	EP
Strength Ia	0.90	1.00	1.50	1.75	0.90
Strength Ib	1.25	1.35	1.50	1.75	0.90
Service I	1.00	1.00	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

### Check Eccentricity (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.6.3.3



$$e = \frac{B}{2} - x_0$$

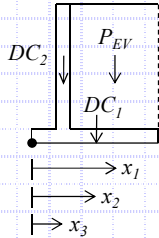
$$x_0 = \frac{M_V - M_H}{P_V} = (489.89 \text{ kip-ft/ft} - 166.21 \text{ kip-ft/ft}) / (45.16 \text{ kip/ft}) = 7.17 \text{ ft}$$

$$\left. \begin{aligned} M_V &= 489.89 \text{ kip-ft/ft} \\ M_H &= 166.21 \text{ kip-ft/ft} \end{aligned} \right\} \text{Defined below}$$

$$P_V = P_{EV} + DC_1 + DC_2 = 30.08 \text{ kip/ft} + 6.24 \text{ kip/ft} + 8.83 \text{ kip/ft} = 45.16 \text{ kip/ft}$$

$$e = (18.5 \text{ ft} / 2) - 7.17 \text{ ft} = 2.08 \text{ ft}$$

Resisting Moment,  $M_V$ :



$$M_V = P_{EV}(x_1) + DC_1(x_2) + DC_2(x_3)$$

$$P_{EV} = \gamma_{BF} \cdot (H - d) \cdot c \cdot \gamma_{EV} = (120 \text{ pcf})(24.3 \text{ ft} - 2.5 \text{ ft})(11.5 \text{ ft})(1.00) = 30.08 \text{ kip/ft}$$

$$DC_1 = \gamma_c \cdot B \cdot d \cdot \gamma_{DC} = (150 \text{ pcf})(18.5 \text{ ft})(2.5 \text{ ft})(0.90) = 6.24 \text{ kip/ft}$$

$$DC_2 = \gamma_c \cdot (H - d) \cdot a \cdot \gamma_{DC} = (150 \text{ pcf})(24.3 \text{ ft} - 2.5 \text{ ft})(3.0 \text{ ft})(0.90) = 8.83 \text{ kip/ft}$$

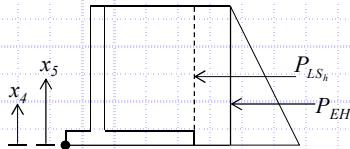
$$x_1 = a + b + \frac{c}{2} = 3.0 \text{ ft} + 4.0 \text{ ft} + (11.5 \text{ ft} / 2) = 12.8 \text{ ft}$$

$$x_2 = \frac{B}{2} = 18.5 \text{ ft} / 2 = 9.3 \text{ ft}$$

$$x_3 = b + \frac{a}{2} = 4.0 \text{ ft} + (3.0 \text{ ft} / 2) = 5.5 \text{ ft}$$

$$M_V = (30.08 \text{ kip/ft})(12.8 \text{ ft}) + (6.24 \text{ kip/ft})(9.3 \text{ ft}) + (8.83 \text{ kip/ft})(5.5 \text{ ft}) = 489.89 \text{ kip-ft/ft}$$

Overturning Moment,  $M_H$ :



$$M_H = P_{EH}(x_2) + P_{LS_h}(x_3)$$

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(24.3 \text{ ft})^2 (0.297)(1.50) = 15.78 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (250 \text{ psf})(24.3 \text{ ft})(0.297)(1.75) = 3.16 \text{ kip/ft}$$

$$x_2 = \frac{H}{3} = (24.3 \text{ ft}) / 3 = 8.10 \text{ ft}$$

$$x_3 = \frac{H}{2} = (24.3 \text{ ft}) / 2 = 12.15 \text{ ft}$$

$$M_H = (15.78 \text{ kip/ft})(8.1 \text{ ft}) + (3.16 \text{ kip/ft})(12.15 \text{ ft}) = 166.21 \text{ kip-ft/ft}$$

Limiting Eccentricity:

$$e_{\max} = \frac{B}{3} \rightarrow e_{\max} = (18.5 \text{ ft}) / 3 = 6.17 \text{ ft}$$

### Check Eccentricity

$$e < e_{\max} \rightarrow 2.08 \text{ ft} < 6.17 \text{ ft} \quad \text{OK}$$



### CIP Wall Dimensions and Surcharge Loading

Wall Height, (H) =	24.3 ft
Foundation Width (Entire Base Width), (B) =	18.5 ft
Stem Width, (a) =	3.0 ft
Toe Width, (b) =	4.0 ft
Heel Width, (c) =	11.5 ft
Footing Thickness, (d) =	2.5 ft
Location of Shear Key, (e) =	0.0 ft
Depth of Shear Key, (f) =	0.0 ft
Embedment Depth, (D <sub>f</sub> ) =	4.0 ft
Wall Length, (L) =	124 ft
Live Surcharge Load, (σ <sub>LS</sub> ) =	250 psf
Depth to Groundwater, (D <sub>w</sub> ) =	19.4 ft

### Bearing and Retained/Backfill Soil Properties:

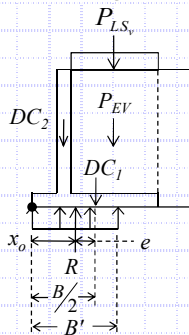
Bearing Soil Unit Weight, (γ <sub>BS</sub> ) =	115 pcf
Bearing Soil Friction Angle, (φ <sub>BS</sub> ) =	26 °
Bearing Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>BS</sub> ] =	1250 psf
Backfill and Retained Soil Unit Weight, (γ <sub>BF</sub> , γ <sub>RS</sub> ) =	120 pcf
Retained Soil Friction Angle, (φ <sub>RS</sub> ) =	30 °
Retained Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>RS</sub> ] =	2000 psf
Active Earth Pressure Coefficient, (K <sub>a</sub> ) =	0.297
Passive Earth Pressure Coefficient, (K <sub>p</sub> ) =	7.410

### LRFD Load Factors

	DC	EV	EH	LS	EP
Strength Ia	0.90	1.00	1.50	1.75	0.90
Strength Ib	1.25	1.35	1.50	1.75	0.90
Service I	1.00	1.00	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

### Check Bearing Capacity (Loading Case - Strength Ib) - AASHTO LRFD BDM Section 11.6.3.2



$$q_{eq} = \frac{P_V}{B'}$$

$$B' = B - 2e = 18.5 \text{ ft} - 2(0.60 \text{ ft}) = 17.30 \text{ ft}$$

$$e = \frac{B}{2} - x_0 = (18.5 \text{ ft} / 2) - 8.65 \text{ ft} = 0.60 \text{ ft}$$

$$x_0 = \frac{M_V - M_H}{P_V} = (768.67 \text{ kip-ft/ft} - 166.21 \text{ kip-ft/ft}) / (69.64 \text{ kip/ft}) = 8.65 \text{ ft}$$

$$q_{eq} = (69.64 \text{ kip/ft}) / (17.30 \text{ ft}) = 4.03 \text{ ksf}$$

Resisting Moment,  $M_V$ :

$$M_V = P_{EV}(x_1) + P_{LS_v}(x_1) + DC_1(x_2) + DC_2(x_3)$$

$$P_{EV} = \gamma_{BF} \cdot (H - d) \cdot c \cdot \gamma_{EV} = (120 \text{ pcf})(24.3 \text{ ft} - 2.5 \text{ ft})(11.5 \text{ ft})(1.35) = 40.61 \text{ kip/ft}$$

$$P_{LS_v} = \sigma_{LS} \cdot B \cdot \gamma_{LS} = (250 \text{ psf})(18.5 \text{ ft})(1.75) = 8.094 \text{ kip/ft}$$

$$DC_1 = \gamma_c \cdot B \cdot d \cdot \gamma_{DC} = (150 \text{ pcf})(18.5 \text{ ft})(2.5 \text{ ft})(1.25) = 8.67 \text{ kip/ft}$$

$$DC_2 = \gamma_c \cdot (H - d) \cdot a \cdot \gamma_{DC} = (150 \text{ pcf})(24.3 \text{ ft} - 2.5 \text{ ft})(3.0 \text{ ft})(1.25) = 12.26 \text{ kip/ft}$$

$$x_1 = a + b + c/2 = 3.0 \text{ ft} + 4.0 \text{ ft} + (11.5 \text{ ft} / 2) = 12.8 \text{ ft}$$

$$x_2 = B/2 = 18.5 \text{ ft} / 2 = 9.3 \text{ ft}$$

$$x_3 = b + a/2 = 4.0 \text{ ft} + (3.0 \text{ ft} / 2) = 5.5 \text{ ft}$$

$$M_V = (40.61 \text{ kip/ft})(12.8 \text{ ft}) + (8.09 \text{ kip/ft})(12.8 \text{ ft}) + (8.67 \text{ kip/ft})(9.3 \text{ ft}) + (12.26 \text{ kip/ft})(5.5 \text{ ft}) = 768.67 \text{ kip-ft/ft}$$

Overturning Moment,  $M_H$ :

$$M_H = P_{EH}(x_4) + P_{LS_h}(x_5)$$

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(24.3 \text{ ft})^2(0.297)(1.50) = 15.78 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (250 \text{ psf})(24.3 \text{ ft})(0.297)(1.75) = 3.16 \text{ kip/ft}$$

$$x_4 = H/3 = (24.3 \text{ ft}) / 3 = 8.10 \text{ ft}$$

$$x_5 = H/2 = (24.3 \text{ ft}) / 2 = 12.15 \text{ ft}$$

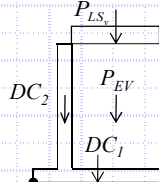
$$M_H = (15.78 \text{ kip/ft})(8.1 \text{ ft}) + (3.16 \text{ kip/ft})(12.15 \text{ ft}) = 166.21 \text{ kip-ft/ft}$$

Vertical Force,  $P_V$ :

$$P_V = P_{EV} + P_{LS_v} + DC_1 + DC_2$$

$$P_V = 40.61 \text{ kip/ft} + 8.09 \text{ kip/ft} + 8.67 \text{ kip/ft} + 12.26 \text{ kip/ft}$$

$$P_V = 69.64 \text{ kip/ft}$$





### CIP Wall Dimensions and Surcharge Loading

Wall Height, (H) =	24.3 ft
Foundation Width (Entire Base Width), (B) =	18.5 ft
Stem Width, (a) =	3.0 ft
Toe Width, (b) =	4.0 ft
Heel Width, (c) =	11.5 ft
Footings Thickness, (d) =	2.5 ft
Location of Shear Key, (e) =	0.0 ft
Depth of Shear Key, (f) =	0.0 ft
Embedment Depth, (D <sub>f</sub> ) =	4.0 ft
Wall Length, (L) =	124 ft
Live Surcharge Load, (σ <sub>LS</sub> ) =	250 psf
Depth to Groundwater, (D <sub>w</sub> ) =	19.4 ft

### Bearing and Retained/Backfill Soil Properties:

Bearing Soil Unit Weight, (γ <sub>BS</sub> ) =	115 pcf
Bearing Soil Friction Angle, (φ <sub>BS</sub> ) =	26 °
Bearing Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>BS</sub> ] =	1250 psf
Backfill and Retained Soil Unit Weight, (γ <sub>BF</sub> , γ <sub>RS</sub> ) =	120 pcf
Retained Soil Friction Angle, (φ <sub>RS</sub> ) =	30 °
Retained Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>RS</sub> ] =	2000 psf
Active Earth Pressure Coefficient, (K <sub>a</sub> ) =	0.297
Passive Earth Pressure Coefficient, (K <sub>p</sub> ) =	7.410

### LRFD Load Factors

	DC	EV	EH	LS	EP
Strength Ia	0.90	1.00	1.50	1.75	0.90
Strength Ib	1.25	1.35	1.50	1.75	0.90
Service I	1.00	1.00	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

### Check Bearing Capacity (Loading Case - Strength Ib) - AASHTO LRFD BDM Section 11.6.3.2 (Continued)

#### Check Bearing Resistance - Drained Condition

$$\text{Nominal Bearing Resistance: } q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + \frac{1}{2} \gamma B' N_{\gamma m} C_{w\gamma}$$

$$N_{cm} = N_c s_c i_c = 23.901$$

$$N_{qm} = N_q s_q d_q i_q = 13.546$$

$$N_{\gamma m} = N_{\gamma} s_{\gamma} i_{\gamma} = 11.837$$

$$N_c = 22.254$$

$$s_c = 1 + (17.3 \text{ ft} / 124 \text{ ft}) (11.854 / 22.254) = 1.074$$

$$i_c = 1.000 \text{ (Assumed)}$$

$$N_q = 11.854$$

$$s_q = 1 + (17.3 \text{ ft} / 124 \text{ ft}) \tan(26^\circ) = 1.068$$

$$d_q = 1 + 2 \tan(26^\circ) [1 - \sin(26^\circ)]^2 \tan^{-1}(4.0 \text{ ft} / 17.3 \text{ ft}) = 1.070$$

$$i_q = 1.000 \text{ (Assumed)}$$

$$C_{wq} = 19.4 \text{ ft} > 4.0 \text{ ft} = 1.000$$

$$N_{\gamma} = 12.539$$

$$s_{\gamma} = 1 - 0.4 (17.3 \text{ ft} / 124 \text{ ft}) = 0.944$$

$$i_{\gamma} = 1.000 \text{ (Assumed)}$$

$$C_{w\gamma} = 19.4 \text{ ft} < 1.5 (17.3 \text{ ft}) + 4.0 \text{ ft} = 0.874$$

$$q_n = (0 \text{ psf})(23.901) + (115 \text{ pcf})(4.0 \text{ ft})(13.546)(1.000) + \frac{1}{2}(115 \text{ pcf})(17.3 \text{ ft})(11.837)(0.874) = 16.52 \text{ ksf}$$

#### Verify Equivalent Pressure Less Than Factored Bearing Resistance

$$q_{eq} \leq q_n \cdot \phi_b \rightarrow 4.03 \text{ ksf} \leq (16.52 \text{ ksf})(0.55) = 9.09 \text{ ksf} \rightarrow 4.03 \text{ ksf} \leq 9.09 \text{ ksf} \quad \text{OK}$$

$$\text{Use } \phi_b = 0.55 \text{ (Per AASHTO LRFD BDM Table 11.5.7-1)}$$

#### Check Bearing Resistance - Undrained Condition

$$\text{Nominal Bearing Resistance: } q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + \frac{1}{2} \gamma B' N_{\gamma m} C_{w\gamma}$$

$$N_{cm} = N_c s_c i_c = 5.520$$

$$N_{qm} = N_q s_q d_q i_q = 1.000$$

$$N_{\gamma m} = N_{\gamma} s_{\gamma} i_{\gamma} = 0.000$$

$$N_c = 5.140$$

$$s_c = 1 + (17.3 \text{ ft} / [(5)(124 \text{ ft})]) = 1.074$$

$$i_c = 1.000 \text{ (Assumed)}$$

$$N_q = 1.000$$

$$s_q = 1.000$$

$$d_q = 1 + 2 \tan(0^\circ) [1 - \sin(0^\circ)]^2 \tan^{-1}(4.0 \text{ ft} / 17.3 \text{ ft}) = 1.000$$

$$i_q = 1.000 \text{ (Assumed)}$$

$$C_{wq} = 19.4 \text{ ft} > 4.0 \text{ ft} = 1.000$$

$$N_{\gamma} = 0.000$$

$$s_{\gamma} = 1.000$$

$$i_{\gamma} = 1.000 \text{ (Assumed)}$$

$$C_{w\gamma} = 19.4 \text{ ft} < 1.5 (17.3 \text{ ft}) + 4.0 \text{ ft} = 0.874$$

$$q_n = (1250 \text{ psf})(5.520) + (115 \text{ pcf})(4.0 \text{ ft})(1.000)(1.000) + \frac{1}{2}(115 \text{ pcf})(17.3 \text{ ft})(0.000)(0.874) = 7.36 \text{ ksf}$$

#### Verify Equivalent Pressure Less Than Factored Bearing Resistance

$$q_{eq} \leq q_n \cdot \phi_b \rightarrow 4.03 \text{ ksf} \leq (7.36 \text{ ksf})(0.55) = 4.05 \text{ ksf} \rightarrow 4.03 \text{ ksf} \leq 4.05 \text{ ksf} \quad \text{OK}$$

$$\text{Use } \phi_b = 0.55 \text{ (Per AASHTO LRFD BDM Table 11.5.7-1)}$$





### CIP Wall Dimensions and Surcharge Loading

Wall Height, (H) =	24.3 ft
Foundation Width (Entire Base Width), (B) =	18.5 ft
Stem Width, (a) =	3.0 ft
Toe Width, (b) =	4.0 ft
Heel Width, (c) =	11.5 ft
Footing Thickness, (d) =	2.5 ft
Location of Shear Key, (e) =	0.0 ft
Depth of Shear Key, (f) =	0.0 ft
Embedment Depth, (D <sub>f</sub> ) =	4.0 ft
Wall Length, (L) =	124 ft
Live Surcharge Load, (σ <sub>LS</sub> ) =	250 psf
Depth to Groundwater, (D <sub>w</sub> ) =	19.4 ft

### Bearing and Retained/Backfill Soil Properties:

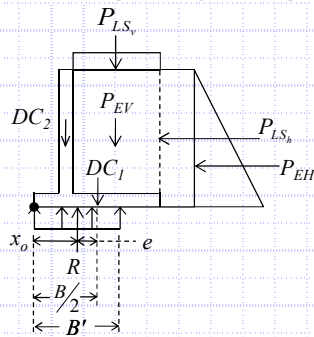
Bearing Soil Unit Weight, (γ <sub>BS</sub> ) =	115 pcf
Bearing Soil Friction Angle, (φ <sub>BS</sub> ) =	26 °
Bearing Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>BS</sub> ] =	1250 psf
Backfill and Retained Soil Unit Weight, (γ <sub>BF</sub> , γ <sub>RS</sub> ) =	120 pcf
Retained Soil Friction Angle, (φ <sub>RS</sub> ) =	30 °
Retained Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>RS</sub> ] =	2000 psf
Active Earth Pressure Coefficient, (K <sub>a</sub> ) =	0.297
Passive Earth Pressure Coefficient, (K <sub>p</sub> ) =	7.410

### LRFD Load Factors

	DC	EV	EH	LS	EP
Strength Ia	0.90	1.00	1.50	1.75	0.90
Strength Ib	1.25	1.35	1.50	1.75	0.90
Service I	1.00	1.00	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

### Check Bearing Capacity (Loading Case - Strength Ib) - AASHTO LRFD BDM Section 11.6.3.2



$$q_{eq} = P_V / B'$$

$$B' = B - 2e = 18.5 \text{ ft} - 2(0.44 \text{ ft}) = 17.62 \text{ ft}$$

$$e = B/2 - x_o = (18.5 \text{ ft} / 2) - 8.81 \text{ ft} = 0.44 \text{ ft}$$

$$x_o = \frac{M_V - M_H}{P_V} = (560.67 \text{ kip-ft/ft} - 107.15 \text{ kip-ft/ft}) / (51.46 \text{ kip/ft}) = 8.81 \text{ ft}$$

$$q_{eq} = (51.46 \text{ kip/ft}) / (17.62 \text{ ft}) = 2.92 \text{ ksf}$$

$$M_V = [(\gamma_{BF} \cdot (H - d) \cdot c \cdot \gamma_{EV}) + (\sigma_{LS} \cdot B \cdot \gamma_{LS})] \left( a + b + \frac{c}{2} \right) + (\gamma_c \cdot B \cdot d \cdot \gamma_{DC}) \left( \frac{B}{2} \right) + (\gamma_c \cdot (H - d) \cdot a \cdot \gamma_{DC}) \left( b + \frac{a}{2} \right)$$

$$M_V = [(120 \text{ pcf})(24.3 \text{ ft} - 2.5 \text{ ft})(11.5 \text{ ft})(1.00) + (250 \text{ psf})(18.5 \text{ ft})(1.00)](3.0 \text{ ft} + 4.0 \text{ ft} + (11.5 \text{ ft} / 2)) + [(150 \text{ pcf})(18.5 \text{ ft})(2.5 \text{ ft})(1.00)](18.5 \text{ ft} / 2) + [(150 \text{ pcf})(24.3 \text{ ft} - 2.5 \text{ ft})(3.0 \text{ ft})(1.00)](4.0 \text{ ft} + (3.0 \text{ ft} / 2)) = 560.67 \text{ kip-ft/ft}$$

$$M_H = \left( \frac{1}{2} \gamma_{RS} \cdot H^2 \cdot K_a \cdot \gamma_{EH} \right) \left( \frac{H}{3} \right) + (\sigma_{LS} \cdot H \cdot K_a \cdot \gamma_{LS}) \left( \frac{H}{2} \right)$$

$$M_H = \left[ \frac{1}{2} (120 \text{ pcf})(24.3 \text{ ft})^2 (0.297)(1.00) \right] (24.3 \text{ ft} / 3) + [(250 \text{ psf})(24.3 \text{ ft})(0.297)(1.00)] (24.3 \text{ ft} / 2) = 107.15 \text{ kip-ft/ft}$$

$$P_V = (\gamma_{BF} \cdot (H - d) \cdot c \cdot \gamma_{EV}) + (\sigma_{LS} \cdot B \cdot \gamma_{LS}) + (\gamma_c \cdot B \cdot d \cdot \gamma_{DC}) + (\gamma_c \cdot (H - d) \cdot a \cdot \gamma_{DC})$$

$$P_V = (120 \text{ pcf})(24.3 \text{ ft} - 2.5 \text{ ft})(11.5 \text{ ft})(1.00) + (250 \text{ psf})(18.5 \text{ ft})(1.00) + (150 \text{ pcf})(18.5 \text{ ft})(2.5 \text{ ft})(1.00) + (150 \text{ pcf})(24.3 \text{ ft} - 2.5 \text{ ft})(3.0 \text{ ft})(1.00) = 51.46 \text{ kip/ft}$$

### Settlement (See Attached Spreadsheet Calculations):

Total Settlement at Maximum Wall Height: (S<sub>t</sub>)<sub>max</sub> = N/A in

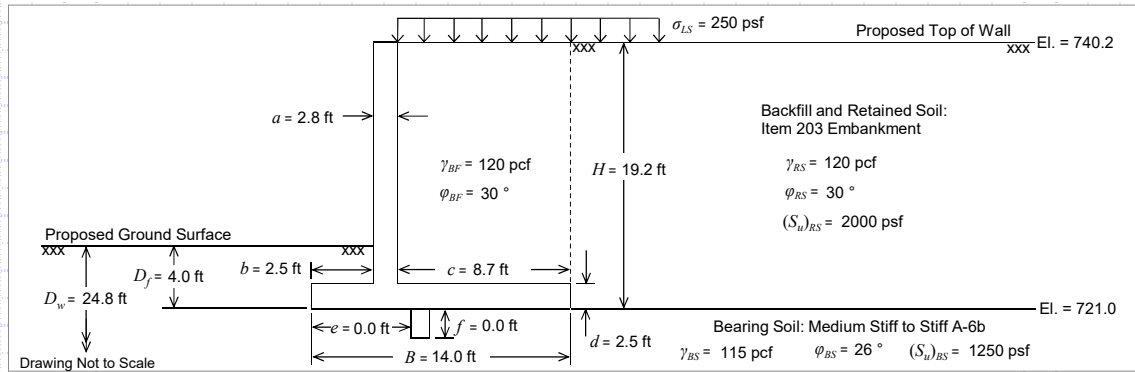
Total Settlement at Minimum Wall Height: (S<sub>t</sub>)<sub>min</sub> = N/A in

Differential Settlement Along Wall Alignment: δ<sub>s</sub> = N/A

δ<sub>s</sub> < 1/500 → N/A < 1/500



**FRA-70-1323C - Forward Abutment Wingwall - Panel 4 - CIP Wall Without Shear Key - Borings B-019-5-19 and B-114-1-13**



**CIP Wall Dimensions and Surcharge Loading**

Wall Height, (H) =	19.2 ft
Foundation Width (Entire Base Width), (B) =	14.0 ft
Stem Width, (a) =	2.8 ft
Toe Width, (b) =	2.5 ft
Heel Width, (c) =	8.7 ft
Footing Thickness, (d) =	2.5 ft
Location of Shear Key, (e) =	0.0 ft
Depth of Shear Key, (f) =	0.0 ft
Embedment Depth, (D <sub>f</sub> ) =	4.0 ft
Wall Length, (L) =	124 ft
Live Surcharge Load, (σ <sub>LS</sub> ) =	250 psf
Depth to Groundwater, (D <sub>w</sub> ) =	24.8 ft

**Bearing and Retained/Backfill Soil Properties:**

Bearing Soil Unit Weight, (γ <sub>BS</sub> ) =	115 pcf
Bearing Soil Friction Angle, (φ <sub>BS</sub> ) =	26°
Bearing Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>BS</sub> ] =	1250 psf
Backfill and Retained Soil Unit Weight, (γ <sub>BF</sub> , γ <sub>RS</sub> ) =	120 pcf
Retained Soil Friction Angle, (φ <sub>RS</sub> ) =	30°
Retained Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>RS</sub> ] =	2000 psf
Active Earth Pressure Coefficient, (K <sub>a</sub> ) =	0.297
Passive Earth Pressure Coefficient, (K <sub>p</sub> ) =	7.410

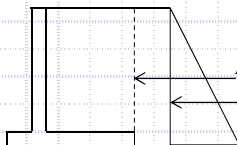
**LRFD Load Factors**

	DC	EV	EH	LS	EP
Strength Ia	0.90	1.00	1.50	1.75	0.90
Strength Ib	1.25	1.35	1.50	1.75	0.90
Service I	1.00	1.00	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

**Check Sliding (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 10.6.3.4**

Sliding Force:



$$P_H = P_{EH} + P_{LS_h}$$

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf}) (19.2 \text{ ft})^2 (0.297) (1.50) = 9.85 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (250 \text{ psf}) (19.2 \text{ ft}) (0.297) (1.75) = 2.49 \text{ kip/ft}$$

$$P_H = 9.85 \text{ kip/ft} + 2.49 \text{ kip/ft} = 12.34 \text{ kip/ft}$$

**Check Sliding Resistance**

Nominal Sliding Resisting:  $R_n = R_\tau + R_{ep}$

$$R_{ep} = \gamma_{BS} D_f j K_p \gamma_{ep} + \frac{1}{2} \gamma_{BS} f^2 K_p \gamma_{ep}$$

$$R_{ep} = (115 \text{ pcf}) (4.0 \text{ ft}) (0.0 \text{ ft}) (7.41) (0.90) + \frac{1}{2} (115 \text{ pcf}) (0.0 \text{ ft})^2 (7.41) (0.90) = 0.00 \text{ kip/ft}$$

Check Drained Condition:  $R_\tau = P_v \tan \delta$

$$P_v = DC_1 + DC_2 + P_{EV} = \gamma_c \cdot [B \cdot d + (H - d) \cdot a] \cdot \gamma_{DC} + \gamma_{BF} \cdot (H - d) \cdot c \cdot \gamma_{EV}$$

$$P_v = (150 \text{ pcf}) [(14.0 \text{ ft}) (2.5 \text{ ft}) + (19.2 \text{ ft} - 2.5 \text{ ft}) (2.8 \text{ ft})] (0.90) + (120 \text{ pcf}) (19.2 \text{ ft} - 2.5 \text{ ft}) (8.7 \text{ ft}) (1.00) = 28.47 \text{ kip/ft}$$

$$\tan \delta = \tan \phi_{BS} = \tan(26) = 0.49$$

$$R_\tau = (28.47 \text{ kip/ft}) (0.49) = 13.95 \text{ kip/ft}$$

**Verify Sliding Force Less Than Factored Sliding Resistance - Drained Condition**

$$P_H \leq \phi_n \cdot R_n \rightarrow P_H \leq \phi_\tau \cdot R_\tau + \phi_{ep} \cdot R_{ep} \rightarrow 12.34 \text{ kip/ft} \leq (13.95 \text{ kip/ft}) (1.00) + (0.00 \text{ kip/ft}) (0.50) = 13.95 \text{ kip/ft}$$

$$= 12.34 \text{ kip/ft} \leq 13.95 \text{ kip/ft}$$

OK

Use  $\phi_\tau = 1.00$  Use  $\phi_{ep} = 0.50$  (Per AASHTO LRFD BDM Tables 10.5.5.2.2-1 and 11.5.7-1)



### CIP Wall Dimensions and Surcharge Loading

Wall Height, (H) =	19.2 ft
Foundation Width (Entire Base Width), (B) =	14.0 ft
Stem Width, (a) =	2.8 ft
Toe Width, (b) =	2.5 ft
Heel Width, (c) =	8.7 ft
Footing Thickness, (d) =	2.5 ft
Location of Shear Key, (e) =	0.0 ft
Depth of Shear Key, (f) =	0.0 ft
Embedment Depth, (D <sub>f</sub> ) =	4.0 ft
Wall Length, (L) =	124 ft
Live Surcharge Load, (σ <sub>LS</sub> ) =	250 psf
Depth to Groundwater, (D <sub>w</sub> ) =	24.8 ft

### Bearing and Retained/Backfill Soil Properties:

Bearing Soil Unit Weight, (γ <sub>BS</sub> ) =	115 pcf
Bearing Soil Friction Angle, (φ <sub>BS</sub> ) =	26 °
Bearing Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>BS</sub> ] =	1250 psf
Backfill and Retained Soil Unit Weight, (γ <sub>BF</sub> , γ <sub>RS</sub> ) =	120 pcf
Retained Soil Friction Angle, (φ <sub>RS</sub> ) =	30 °
Retained Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>RS</sub> ] =	2000 psf
Active Earth Pressure Coefficient, (K <sub>a</sub> ) =	0.297
Passive Earth Pressure Coefficient, (K <sub>p</sub> ) =	7.410

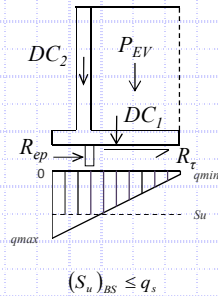
### LRFD Load Factors

	DC	EV	EH	LS	EP
Strength Ia	0.90	1.00	1.50	1.75	0.90
Strength Ib	1.25	1.35	1.50	1.75	0.90
Service I	1.00	1.00	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

### Check Sliding (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 10.6.3.4 (Continued)

Check Undrained Condition:  $R_{\tau} = ((S_u)_{BS} \leq q_s) \cdot B$



$$(S_u)_{BS} = 1.25 \text{ ksf}$$

$$q_{max} = \frac{1}{2} \sigma_{max} = (3.88 \text{ ksf}) / 2 = 1.94 \text{ ksf}$$

$$q_{min} = \frac{1}{2} \sigma_{min} = (0.19 \text{ ksf}) / 2 = 0.10 \text{ ksf}$$

$$\sigma_{max} = \frac{P_v}{B} \left( 1 + 6 \frac{e}{B} \right) = (28.47 \text{ kip/ft} / 14.0 \text{ ft}) [1 + 6(2.12 \text{ ft} / 14.0 \text{ ft})] = 3.88 \text{ ksf}$$

$$\sigma_{min} = \frac{P_v}{B} \left( 1 - 6 \frac{e}{B} \right) = (28.47 \text{ kip/ft} / 14.0 \text{ ft}) [1 - 6(2.12 \text{ ft} / 14.0 \text{ ft})] = 0.19 \text{ ksf}$$

$$R_{\tau} = 0.5(1.25 \text{ ksf} - 0.1 \text{ ksf})[(14.0 \text{ ft}(1.25 \text{ ksf} - 0.1 \text{ ksf})) / (1.94 \text{ ksf} - 0.1 \text{ ksf})] + (1.25 \text{ ksf} - 0.1 \text{ ksf})[(14.0 \text{ ft}(1.94 \text{ ksf} - 1.25 \text{ ksf})) / (1.94 \text{ ksf} - 0.1 \text{ ksf})] + (0.1 \text{ ksf})(14.0 \text{ ft}) = 12.47 \text{ kip/ft}$$

### Verify Sliding Force Less Than Factored Sliding Resistance - Undrained Condition

$$P_H \leq \phi_n \cdot R_n \rightarrow P_H \leq \phi_{\tau} \cdot R_{\tau} + \phi_{ep} \cdot R_{ep} \rightarrow 12.34 \text{ kip/ft} \leq (12.47 \text{ kip/ft})(1.00) + (0.00 \text{ kip/ft})(0.50) = 12.47$$

$$= 12.34 \text{ kip/ft} \leq 12.47 \text{ kip/ft} \quad \text{OK}$$

$$\text{Use } \phi_{\tau} = 1.00 \quad \text{Use } \phi_{ep} = 0.50 \quad (\text{Per AASHTO LRFD BDM Tables 10.5.5.2.2-1 and 11.5.7-1})$$

### CIP Wall Dimensions and Surcharge Loading

Wall Height, ( $H$ ) =	19.2 ft
Foundation Width (Entire Base Width), ( $B$ ) =	14.0 ft
Stem Width, ( $a$ ) =	2.8 ft
Toe Width, ( $b$ ) =	2.5 ft
Heel Width, ( $c$ ) =	8.7 ft
Footing Thickness, ( $d$ ) =	2.5 ft
Location of Shear Key, ( $e$ ) =	0.0 ft
Depth of Shear Key, ( $f$ ) =	0.0 ft
Embedment Depth, ( $D_f$ ) =	4.0 ft
Wall Length, ( $L$ ) =	124 ft
Live Surcharge Load, ( $a_{LS}$ ) =	250 psf
Depth to Groundwater, ( $D_w$ ) =	24.8 ft

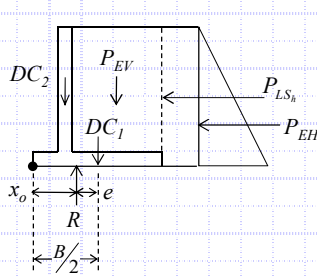
**Bearing and Retained/Backfill Soil Properties:**

Bearing Soil Unit Weight, ( $\gamma_{BS}$ ) =	115 pcf
Bearing Soil Friction Angle, ( $\phi_{BS}$ ) =	26°
Bearing Soil Undrained Shear Strength, [ $(s_u)_{BS}$ ] =	1250 psf
Backfill and Retained Soil Unit Weight, ( $\gamma_{BF}$ , $\gamma_{RS}$ ) =	120 pcf
Retained Soil Friction Angle, ( $\phi_{RS}$ ) =	30°
Retained Soil Undrained Shear Strength, [ $(s_u)_{RS}$ ] =	2000 psf
Active Earth Pressure Coefficient, ( $K_a$ ) =	0.297
Passive Earth Pressure Coefficient, ( $K_p$ ) =	7.410

## LRFD Load Factors

	DC	EV	EH	LS	EP	
Strength Ia	0.90	1.00	1.50	1.75	0.90	} (AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)
Strength Ib	1.25	1.35	1.50	1.75	0.90	
Service I	1.00	1.00	1.00	1.00	1.00	

**Check Eccentricity (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.6.3.3**



$$e = B/2 - x_o$$

$$x_o = \frac{M_V - M_H}{P_V} = (225.94 \text{ kip-ft/ft} - 86.94 \text{ kip-ft/ft}) / (28.47 \text{ kip/ft}) = 4.88 \text{ ft}$$

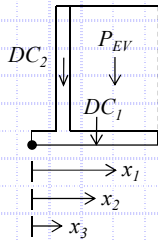
$$\left. \begin{array}{l} M_V = 225.94 \text{ kip}\cdot\text{ft}/\text{ft} \\ M_H = 86.94 \text{ kip}\cdot\text{ft}/\text{ft} \end{array} \right\} \text{Defined below}$$

$$P_V = P_{EV} + DC_1 + DC_2 = 17.43 \text{ kip/ft} + 4.73 \text{ kip/ft} + 6.31 \text{ kip/ft} = 28.47 \text{ kip/ft}$$

$$e = (14.0 \text{ ft} / 2) - 4.88 \text{ ft} = 2.12 \text{ ft}$$

Resisting Moment,  $M_v$ :

$$M_V = P_{EV}(x_1) + DC_1(x_2) + DC_2(x_3)$$



$$P_{EV} = \gamma_{BF} \cdot (H - d) \cdot c \cdot \gamma_{EV} = (120 \text{ pcf})(19.2 \text{ ft} - 2.5 \text{ ft})(8.7 \text{ ft})(1.00) = 17.43 \text{ kip/ft}$$

$$DC_1 = \gamma_c \cdot B \cdot d \cdot \gamma_{DC} = (150 \text{ pcf})(14.0 \text{ ft})(2.5 \text{ ft})(0.90) = 4.73 \text{ kip/ft}$$

$$DC_2 = \gamma_c \cdot (H - d) \cdot a \cdot \gamma_{DC} = (150 \text{ pcf})(19.2 \text{ ft} - 2.5 \text{ ft})(2.8 \text{ ft})(0.90) = 6.31 \text{ kip/ft}$$

$$x_1 = a + b + \frac{c}{2} = 2.8 \text{ ft} + 2.5 \text{ ft} + (8.7 \text{ ft} / 2) = 9.7 \text{ ft}$$

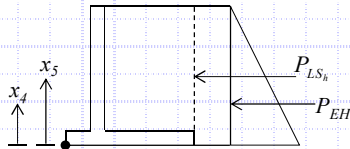
$$x_2 = B/2 = 14.0 \text{ ft} / 2 = 7.0 \text{ ft}$$

$$x_3 = b + a/2 = 2.5 \text{ ft} + (2.8 \text{ ft} / 2) = 3.9 \text{ ft}$$

$$M_V = (17.43 \text{ kip/ft})(9.7 \text{ ft}) + (4.73 \text{ kip/ft})(7.0 \text{ ft}) + (6.31 \text{ kip/ft})(3.9 \text{ ft}) = 225.94 \text{ kip-ft/ft}$$

Overturning Moment,  $M_H$ :

$$M_H = P_{EH}(x_2) + P_{LS}(x_3)$$



$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(19.2 \text{ ft})^2(0.297)(1.50) = 9.85 \text{ kip/ft}$$

$$P_{LS} = \sigma_{LS} HK_a \gamma_{LS} = (250 \text{ psf})(19.2 \text{ ft})(0.297)(1.75) = 2.49 \text{ kip/ft}$$

$$x_2 = H/3 = (19.2 \text{ ft}) / 3 = 6.40 \text{ ft}$$

$$x_3 = H/2 = (19.2 \text{ ft}) / 2 = 9.60 \text{ ft}$$

$$M_H = (9.85 \text{ kip/ft})(6.4 \text{ ft}) + (2.49 \text{ kip/ft})(9.60 \text{ ft}) = 86.94 \text{ kip-ft/ft}$$

### Limiting Eccentricity:

$$e_{\max} = B/3 \rightarrow e_{\max} = (14.0 \text{ ft})/3 = 4.67 \text{ ft}$$

## Check Eccentricity

$$e < e_{\max} \rightarrow 2.12 \text{ ft} < 4.67 \text{ ft} \quad \text{OK}$$



### CIP Wall Dimensions and Surcharge Loading

Wall Height, (H) =	19.2 ft
Foundation Width (Entire Base Width), (B) =	14.0 ft
Stem Width, (a) =	2.8 ft
Toe Width, (b) =	2.5 ft
Heel Width, (c) =	8.7 ft
Footing Thickness, (d) =	2.5 ft
Location of Shear Key, (e) =	0.0 ft
Depth of Shear Key, (f) =	0.0 ft
Embedment Depth, (D <sub>f</sub> ) =	4.0 ft
Wall Length, (L) =	124 ft
Live Surcharge Load, (σ <sub>LS</sub> ) =	250 psf
Depth to Groundwater, (D <sub>w</sub> ) =	24.8 ft

### Bearing and Retained/Backfill Soil Properties:

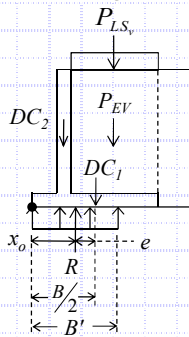
Bearing Soil Unit Weight, (γ <sub>BS</sub> ) =	115 pcf
Bearing Soil Friction Angle, (φ <sub>BS</sub> ) =	26 °
Bearing Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>BS</sub> ] =	1250 psf
Backfill and Retained Soil Unit Weight, (γ <sub>BF</sub> , γ <sub>RS</sub> ) =	120 pcf
Retained Soil Friction Angle, (φ <sub>RS</sub> ) =	30 °
Retained Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>RS</sub> ] =	2000 psf
Active Earth Pressure Coefficient, (K <sub>a</sub> ) =	0.297
Passive Earth Pressure Coefficient, (K <sub>p</sub> ) =	7.410

### LRFD Load Factors

	DC	EV	EH	LS	EP
Strength Ia	0.90	1.00	1.50	1.75	0.90
Strength Ib	1.25	1.35	1.50	1.75	0.90
Service I	1.00	1.00	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

### Check Bearing Capacity (Loading Case - Strength Ib) - AASHTO LRFD BDM Section 11.6.3.2



$$q_{eq} = \frac{P_V}{B'}$$

$$B' = B - 2e = 14.0 \text{ ft} - 2(0.79 \text{ ft}) = 12.42 \text{ ft}$$

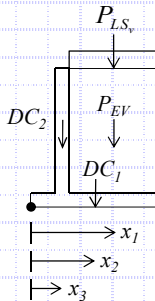
$$e = \frac{B}{2} - x_o = (14.0 \text{ ft} / 2) - 6.21 \text{ ft} = 0.79 \text{ ft}$$

$$x_o = \frac{M_V - M_H}{P_V} = (366.37 \text{ kip-ft} - 86.94 \text{ kip-ft}) / (44.99 \text{ kip/ft}) = 6.21 \text{ ft}$$

$$q_{eq} = (44.99 \text{ kip/ft}) / (12.42 \text{ ft}) = 3.62 \text{ ksf}$$

Resisting Moment, M<sub>V</sub>:

$$M_V = P_{EV}(x_1) + P_{LS_v}(x_1) + DC_1(x_2) + DC_2(x_3)$$



$$P_{EV} = \gamma_{BF} \cdot (H - d) \cdot c \cdot \gamma_{EV} = (120 \text{ pcf})(19.2 \text{ ft} - 2.5 \text{ ft})(8.7 \text{ ft})(1.35) = 23.54 \text{ kip/ft}$$

$$P_{LS_v} = \sigma_{LS} \cdot B \cdot \gamma_{LS} = (250 \text{ psf})(14.0 \text{ ft})(1.75) = 6.125 \text{ kip/ft}$$

$$DC_1 = \gamma_c \cdot B \cdot d \cdot \gamma_{DC} = (150 \text{ pcf})(14.0 \text{ ft})(2.5 \text{ ft})(1.25) = 6.56 \text{ kip/ft}$$

$$DC_2 = \gamma_c \cdot (H - d) \cdot a \cdot \gamma_{DC} = (150 \text{ pcf})(19.2 \text{ ft} - 2.5 \text{ ft})(2.8 \text{ ft})(1.25) = 8.77 \text{ kip/ft}$$

$$x_1 = a + b + c/2 = 2.8 \text{ ft} + 2.5 \text{ ft} + (8.7 \text{ ft} / 2) = 9.7 \text{ ft}$$

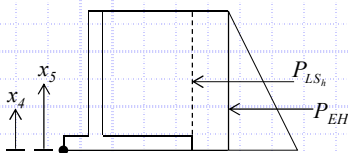
$$x_2 = B/2 = 14.0 \text{ ft} / 2 = 7.0 \text{ ft}$$

$$x_3 = b + a/2 = 2.5 \text{ ft} + (2.8 \text{ ft} / 2) = 3.9 \text{ ft}$$

$$M_V = (23.54 \text{ kip/ft})(9.7 \text{ ft}) + (6.13 \text{ kip/ft})(9.7 \text{ ft}) + (6.56 \text{ kip/ft})(7.0 \text{ ft}) + (8.77 \text{ kip/ft})(3.9 \text{ ft}) = 366.37 \text{ kip-ft/ft}$$

Overturning Moment, M<sub>H</sub>:

$$M_H = P_{EH}(x_4) + P_{LS_h}(x_5)$$



$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(19.2 \text{ ft})^2(0.297)(1.50) = 9.85 \text{ kip/ft}$$

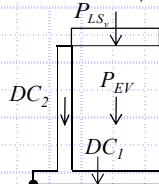
$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (250 \text{ psf})(19.2 \text{ ft})(0.297)(1.75) = 2.49 \text{ kip/ft}$$

$$x_4 = H/3 = (19.2 \text{ ft}) / 3 = 6.40 \text{ ft}$$

$$x_5 = H/2 = (19.2 \text{ ft}) / 2 = 9.60 \text{ ft}$$

$$M_H = (9.85 \text{ kip/ft})(6.4 \text{ ft}) + (2.49 \text{ kip/ft})(9.60 \text{ ft}) = 86.94 \text{ kip-ft/ft}$$

Vertical Force, P<sub>V</sub>:



$$P_V = P_{EV} + P_{LS_v} + DC_1 + DC_2$$

$$P_V = 23.54 \text{ kip/ft} + 6.13 \text{ kip/ft} + 6.56 \text{ kip/ft} + 8.77 \text{ kip/ft}$$

$$P_V = 44.99 \text{ kip/ft}$$



### CIP Wall Dimensions and Surcharge Loading

Wall Height, (H) =	19.2 ft
Foundation Width (Entire Base Width), (B) =	14.0 ft
Stem Width, (a) =	2.8 ft
Toe Width, (b) =	2.5 ft
Heel Width, (c) =	8.7 ft
Footings Thickness, (d) =	2.5 ft
Location of Shear Key, (e) =	0.0 ft
Depth of Shear Key, (f) =	0.0 ft
Embedment Depth, (D <sub>f</sub> ) =	4.0 ft
Wall Length, (L) =	124 ft
Live Surcharge Load, (σ <sub>LS</sub> ) =	250 psf
Depth to Groundwater, (D <sub>w</sub> ) =	24.8 ft

### Bearing and Retained/Backfill Soil Properties:

Bearing Soil Unit Weight, (γ <sub>BS</sub> ) =	115 pcf
Bearing Soil Friction Angle, (φ <sub>BS</sub> ) =	26 °
Bearing Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>BS</sub> ] =	1250 psf
Backfill and Retained Soil Unit Weight, (γ <sub>BF</sub> , γ <sub>RS</sub> ) =	120 pcf
Retained Soil Friction Angle, (φ <sub>RS</sub> ) =	30 °
Retained Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>RS</sub> ] =	2000 psf
Active Earth Pressure Coefficient, (K <sub>a</sub> ) =	0.297
Passive Earth Pressure Coefficient, (K <sub>p</sub> ) =	7.410

### LRFD Load Factors

	DC	EV	EH	LS	EP
Strength Ia	0.90	1.00	1.50	1.75	0.90
Strength Ib	1.25	1.35	1.50	1.75	0.90
Service I	1.00	1.00	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

### Check Bearing Capacity (Loading Case - Strength Ib) - AASHTO LRFD BDM Section 11.6.3.2 (Continued)

#### Check Bearing Resistance - Drained Condition

$$\text{Nominal Bearing Resistance: } q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + \frac{1}{2} \gamma B' N_{\gamma m} C_{w\gamma}$$

$$N_{cm} = N_c s_c i_c = 23.433$$

$$N_{qm} = N_q s_q d_q i_q = 13.629$$

$$N_{\gamma m} = N_{\gamma} s_{\gamma} i_{\gamma} = 12.037$$

$$N_c = 22.254$$

$$s_c = 1 + (12.42 \text{ ft} / 124 \text{ ft}) (11.854 / 22.254)$$

$$= 1.053$$

$$i_c = 1.000 \text{ (Assumed)}$$

$$N_q = 11.854$$

$$s_q = 1 + (12.42 \text{ ft} / 124 \text{ ft}) \tan(26^\circ) = 1.049$$

$$d_q = 1 + 2 \tan(26^\circ) [1 - \sin(26^\circ)]^2 \tan^{-1}(4.0 \text{ ft} / 12.42 \text{ ft})$$

$$= 1.096$$

$$i_q = 1.000 \text{ (Assumed)}$$

$$C_{wq} = 24.8 \text{ ft} > 4.0 \text{ ft} = 1.000$$

$$N_{\gamma} = 12.539$$

$$s_{\gamma} = 1 - 0.4 (12.42 \text{ ft} / 124 \text{ ft}) = 0.960$$

$$i_{\gamma} = 1.000 \text{ (Assumed)}$$

$$C_{w\gamma} = 24.8 \text{ ft} > 1.5 (12.42 \text{ ft}) + 4.0 \text{ ft} = 1.000$$

$$q_n = (0 \text{ psf})(23.433) + (115 \text{ pcf})(4.0 \text{ ft})(13.629)(1.000) + \frac{1}{2}(115 \text{ pcf})(12.4 \text{ ft})(12.037)(1.000) = 14.87 \text{ ksf}$$

#### Verify Equivalent Pressure Less Than Factored Bearing Resistance

$$q_{eq} \leq q_n \cdot \phi_b \rightarrow 3.62 \text{ ksf} \leq (14.87 \text{ ksf})(0.55) = 8.18 \text{ ksf} \rightarrow 3.62 \text{ ksf} \leq 8.18 \text{ ksf} \quad \text{OK}$$

$$\text{Use } \phi_b = 0.55 \text{ (Per AASHTO LRFD BDM Table 11.5.7-1)}$$

#### Check Bearing Resistance - Undrained Condition

$$\text{Nominal Bearing Resistance: } q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + \frac{1}{2} \gamma B' N_{\gamma m} C_{w\gamma}$$

$$N_{cm} = N_c s_c i_c = 5.412$$

$$N_{qm} = N_q s_q d_q i_q = 1.000$$

$$N_{\gamma m} = N_{\gamma} s_{\gamma} i_{\gamma} = 0.000$$

$$N_c = 5.140$$

$$s_c = 1 + (12.42 \text{ ft} / [(5)(124 \text{ ft})]) = 1.053$$

$$i_c = 1.000 \text{ (Assumed)}$$

$$N_q = 1.000$$

$$s_q = 1.000$$

$$d_q = 1 + 2 \tan(0^\circ) [1 - \sin(0^\circ)]^2 \tan^{-1}(4.0 \text{ ft} / 12.42 \text{ ft})$$

$$= 1.000$$

$$i_q = 1.000 \text{ (Assumed)}$$

$$C_{wq} = 24.8 \text{ ft} > 4.0 \text{ ft} = 1.000$$

$$N_{\gamma} = 0.000$$

$$s_{\gamma} = 1.000$$

$$i_{\gamma} = 1.000 \text{ (Assumed)}$$

$$C_{w\gamma} = 24.8 \text{ ft} > 1.5 (12.42 \text{ ft}) + 4.0 \text{ ft} = 1.000$$

$$q_n = (1250 \text{ psf})(5.412) + (115 \text{ pcf})(4.0 \text{ ft})(1.000)(1.000) + \frac{1}{2}(115 \text{ pcf})(12.4 \text{ ft})(0.000)(1.000) = 7.23 \text{ ksf}$$

#### Verify Equivalent Pressure Less Than Factored Bearing Resistance

$$q_{eq} \leq q_n \cdot \phi_b \rightarrow 3.62 \text{ ksf} \leq (7.23 \text{ ksf})(0.55) = 3.98 \text{ ksf} \rightarrow 3.62 \text{ ksf} \leq 3.98 \text{ ksf} \quad \text{OK}$$

$$\text{Use } \phi_b = 0.55 \text{ (Per AASHTO LRFD BDM Table 11.5.7-1)}$$



### CIP Wall Dimensions and Surcharge Loading

Wall Height, (H) =	19.2 ft
Foundation Width (Entire Base Width), (B) =	14.0 ft
Stem Width, (a) =	2.8 ft
Toe Width, (b) =	2.5 ft
Heel Width, (c) =	8.7 ft
Footing Thickness, (d) =	2.5 ft
Location of Shear Key, (e) =	0.0 ft
Depth of Shear Key, (f) =	0.0 ft
Embedment Depth, (D <sub>f</sub> ) =	4.0 ft
Wall Length, (L) =	124 ft
Live Surcharge Load, (σ <sub>LS</sub> ) =	250 psf
Depth to Groundwater, (D <sub>w</sub> ) =	24.8 ft

### Bearing and Retained/Backfill Soil Properties:

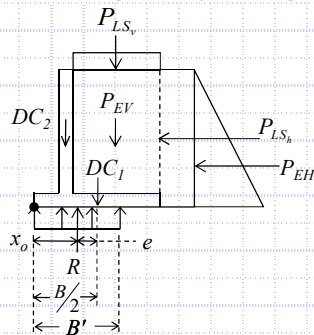
Bearing Soil Unit Weight, (γ <sub>BS</sub> ) =	115 pcf
Bearing Soil Friction Angle, (φ <sub>BS</sub> ) =	26 °
Bearing Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>BS</sub> ] =	1250 psf
Backfill and Retained Soil Unit Weight, (γ <sub>BF</sub> , γ <sub>RS</sub> ) =	120 pcf
Retained Soil Friction Angle, (φ <sub>RS</sub> ) =	30 °
Retained Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>RS</sub> ] =	2000 psf
Active Earth Pressure Coefficient, (K <sub>a</sub> ) =	0.297
Passive Earth Pressure Coefficient, (K <sub>p</sub> ) =	7.410

### LRFD Load Factors

	DC	EV	EH	LS	EP
Strength Ia	0.90	1.00	1.50	1.75	0.90
Strength Ib	1.25	1.35	1.50	1.75	0.90
Service I	1.00	1.00	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

### Check Bearing Capacity (Loading Case - Strength Ib) - AASHTO LRFD BDM Section 11.6.3.2



$$q_{eq} = P_V / B'$$

$$B' = B - 2e = 14.0 \text{ ft} - 2(0.66 \text{ ft}) = 12.68 \text{ ft}$$

$$e = B/2 - x_o = (14.0 \text{ ft} / 2) - 6.34 \text{ ft} = 0.66 \text{ ft}$$

$$x_o = \frac{M_V - M_H}{P_V} = (266.13 \text{ kip-ft/ft} - 55.73 \text{ kip-ft/ft}) / (33.20 \text{ kip/ft}) = 6.34 \text{ ft}$$

$$q_{eq} = (33.20 \text{ kip/ft}) / (12.68 \text{ ft}) = 2.62 \text{ ksf}$$

$$M_V = [(\gamma_{BF} \cdot (H - d) \cdot c \cdot \gamma_{EV}) + (\sigma_{LS} \cdot B \cdot \gamma_{LS})] \left( a + b + \frac{c}{2} \right) + (\gamma_c \cdot B \cdot d \cdot \gamma_{DC}) \left( \frac{B}{2} \right) + (\gamma_c \cdot (H - d) \cdot a \cdot \gamma_{DC}) \left( b + \frac{a}{2} \right)$$

$$M_V = [(120 \text{ pcf})(19.2 \text{ ft} - 2.5 \text{ ft})(8.7 \text{ ft})(1.00) + (250 \text{ psf})(14.0 \text{ ft})(1.00)](2.8 \text{ ft} + 2.5 \text{ ft} + (8.7 \text{ ft} / 2)) + [(150 \text{ pcf})(14.0 \text{ ft})(2.5 \text{ ft})(1.00)](14.0 \text{ ft} / 2) + [(150 \text{ pcf})(19.2 \text{ ft} - 2.5 \text{ ft})(2.8 \text{ ft})(1.00)](2.5 \text{ ft} + (2.8 \text{ ft} / 2)) = 266.13 \text{ kip-ft/ft}$$

$$M_H = \left( \frac{1}{2} \gamma_{RS} \cdot H^2 \cdot K_a \cdot \gamma_{EH} \right) \left( \frac{H}{3} \right) + (\sigma_{LS} \cdot H \cdot K_a \cdot \gamma_{LS}) \left( \frac{H}{2} \right)$$

$$M_H = \left[ \frac{1}{2} (120 \text{ pcf})(19.2 \text{ ft})^2 (0.297)(1.00) \right] (19.2 \text{ ft} / 3) + [(250 \text{ psf})(19.2 \text{ ft})(0.297)(1.00)] (19.2 \text{ ft} / 2) = 55.73 \text{ kip-ft/ft}$$

$$P_V = (\gamma_{BF} \cdot (H - d) \cdot c \cdot \gamma_{EV}) + (\sigma_{LS} \cdot B \cdot \gamma_{LS}) + (\gamma_c \cdot B \cdot d \cdot \gamma_{DC}) + (\gamma_c \cdot (H - d) \cdot a \cdot \gamma_{DC})$$

$$P_V = (120 \text{ pcf})(19.2 \text{ ft} - 2.5 \text{ ft})(8.7 \text{ ft})(1.00) + (250 \text{ psf})(14.0 \text{ ft})(1.00) + (150 \text{ pcf})(14.0 \text{ ft})(2.5 \text{ ft})(1.00) + (150 \text{ pcf})(19.2 \text{ ft} - 2.5 \text{ ft})(2.8 \text{ ft})(1.00) = 33.2 \text{ kip/ft}$$

### Settlement (See Attached Spreadsheet Calculations):

Total Settlement at Maximum Wall Height: (S<sub>t</sub>)<sub>max</sub> = N/A in

Total Settlement at Minimum Wall Height: (S<sub>t</sub>)<sub>min</sub> = N/A in

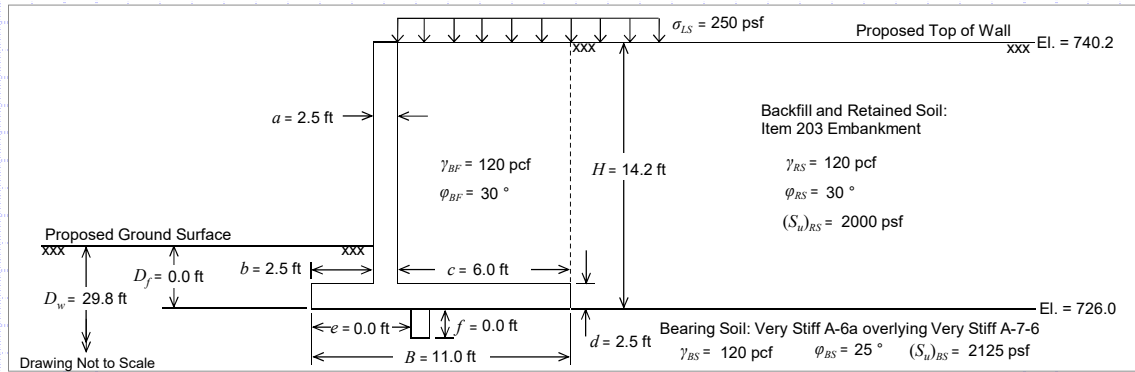
Differential Settlement Along Wall Alignment: δ<sub>s</sub> = N/A

δ<sub>s</sub> < 1/500 → N/A < 1/500





**FRA-70-1323C - Forward Abutment Wingwall - Panel 5 - CIP Wall Without Shear Key - Borings B-019-5-19 and B-114-1-13**



**CIP Wall Dimensions and Surcharge Loading**

Wall Height, (H) =	14.2 ft
Foundation Width (Entire Base Width), (B) =	11.0 ft
Stem Width, (a) =	2.5 ft
Toe Width, (b) =	2.5 ft
Heel Width, (c) =	6.0 ft
Footing Thickness, (d) =	2.5 ft
Location of Shear Key, (e) =	0.0 ft
Depth of Shear Key, (f) =	0.0 ft
Embedment Depth, (D_f) =	0.0 ft
Wall Length, (L) =	124 ft
Live Surcharge Load, (σ_LS) =	250 psf
Depth to Groundwater, (D_w) =	29.8 ft

**Bearing and Retained/Backfill Soil Properties:**

Bearing Soil Unit Weight, (γ_BS) =	120 pcf
Bearing Soil Friction Angle, (φ_BS) =	25°
Bearing Soil Undrained Shear Strength, [(s_u)_BS] =	2125 psf
Backfill and Retained Soil Unit Weight, (γ_BF, γ_RS) =	120 pcf
Retained Soil Friction Angle, (φ_RS) =	30°
Retained Soil Undrained Shear Strength, [(s_u)_RS] =	2000 psf
Active Earth Pressure Coefficient, (K_a) =	0.297
Passive Earth Pressure Coefficient, (K_p) =	7.410

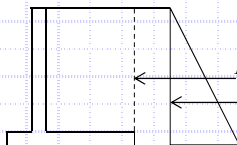
**LRFD Load Factors**

	DC	EV	EH	LS	EP
Strength Ia	0.90	1.00	1.50	1.75	0.90
Strength Ib	1.25	1.35	1.50	1.75	0.90
Service I	1.00	1.00	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

**Check Sliding (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 10.6.3.4**

Sliding Force:



$$P_H = P_{EH} + P_{LS}$$

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf}) (14.2 \text{ ft})^2 (0.297) (1.50) = 5.39 \text{ kip/ft}$$

$$P_{LS} = \sigma_{LS} H K_a \gamma_{LS} = (250 \text{ psf}) (14.2 \text{ ft}) (0.297) (1.75) = 1.85 \text{ kip/ft}$$

$$P_H = 5.39 \text{ kip/ft} + 1.85 \text{ kip/ft} = 7.24 \text{ kip/ft}$$

**Check Sliding Resistance**

$$\text{Nominal Sliding Resisting: } R_n = R_\tau + R_{ep}$$

$$R_{ep} = \gamma_{BS} D_f J K_p \gamma_{ep} + \frac{1}{2} \gamma_{BS} f^2 K_p \gamma_{ep}$$

$$R_{ep} = (120 \text{ pcf}) (0.0 \text{ ft}) (0.0 \text{ ft}) (7.41) (0.90) + \frac{1}{2} (120 \text{ pcf}) (0.0 \text{ ft})^2 (7.41) (0.90) = 0.00 \text{ kip/ft}$$

$$\text{Check Drained Condition: } R_\tau = P_V \tan \delta$$

$$P_V = DC_1 + DC_2 + P_{EV} = \gamma_c \cdot [B \cdot d + (H - d) \cdot a] \cdot \gamma_{DC} + \gamma_{BF} \cdot (H - d) \cdot c \cdot \gamma_{EV}$$

$$P_V = (150 \text{ pcf}) [(11.0 \text{ ft}) (2.5 \text{ ft}) + (14.2 \text{ ft} - 2.5 \text{ ft}) (2.5 \text{ ft})] (0.90) + (120 \text{ pcf}) (14.2 \text{ ft} - 2.5 \text{ ft}) (6.0 \text{ ft}) (1.00) = 16.09 \text{ kip/ft}$$

$$\tan \delta = \tan \phi_{BS} = \tan(25) = 0.47$$

$$R_\tau = (16.09 \text{ kip/ft}) (0.47) = 7.56 \text{ kip/ft}$$

**Verify Sliding Force Less Than Factored Sliding Resistance - Drained Condition**

$$P_H \leq \phi_n \cdot R_n \rightarrow P_H \leq \phi_\tau \cdot R_\tau + \phi_{ep} \cdot R_{ep} \rightarrow 7.24 \text{ kip/ft} \leq (7.56 \text{ kip/ft}) (1.00) + (0.00 \text{ kip/ft}) (0.50) = 7.56 \text{ kip/ft}$$

$$= 7.24 \text{ kip/ft} \leq 7.56 \text{ kip/ft}$$

OK

$$\text{Use } \phi_\tau = 1.00 \quad \text{Use } \phi_{ep} = 0.50 \quad (\text{Per AASHTO LRFD BDM Tables 10.5.5.2.2-1 and 11.5.7-1})$$





### CIP Wall Dimensions and Surcharge Loading

Wall Height, (H) =	14.2 ft
Foundation Width (Entire Base Width), (B) =	11.0 ft
Stem Width, (a) =	2.5 ft
Toe Width, (b) =	2.5 ft
Heel Width, (c) =	6.0 ft
Footing Thickness, (d) =	2.5 ft
Location of Shear Key, (e) =	0.0 ft
Depth of Shear Key, (f) =	0.0 ft
Embedment Depth, (D <sub>f</sub> ) =	0.0 ft
Wall Length, (L) =	124 ft
Live Surcharge Load, (σ <sub>LS</sub> ) =	250 psf
Depth to Groundwater, (D <sub>w</sub> ) =	29.8 ft

### Bearing and Retained/Backfill Soil Properties:

Bearing Soil Unit Weight, (γ <sub>BS</sub> ) =	120 pcf
Bearing Soil Friction Angle, (φ <sub>BS</sub> ) =	25 °
Bearing Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>BS</sub> ] =	2125 psf
Backfill and Retained Soil Unit Weight, (γ <sub>BF</sub> , γ <sub>RS</sub> ) =	120 pcf
Retained Soil Friction Angle, (φ <sub>RS</sub> ) =	30 °
Retained Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>RS</sub> ] =	2000 psf
Active Earth Pressure Coefficient, (K <sub>a</sub> ) =	0.297
Passive Earth Pressure Coefficient, (K <sub>p</sub> ) =	7.410

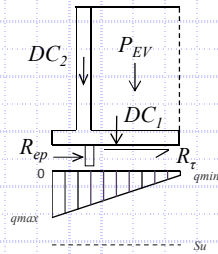
### LRFD Load Factors

	DC	EV	EH	LS	EP
Strength Ia	0.90	1.00	1.50	1.75	0.90
Strength Ib	1.25	1.35	1.50	1.75	0.90
Service I	1.00	1.00	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

### Check Sliding (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 10.6.3.4 (Continued)

Check Undrained Condition:  $R_{\tau} = ((s_u)_{BS} \leq q_s) \cdot B$



$$(s_u)_{BS} = 2.13 \text{ ksf}$$

$$q_{max} = \frac{1}{2} \sigma_{max} = (2.68 \text{ ksf}) / 2 = 1.34 \text{ ksf}$$

$$q_{min} = \frac{1}{2} \sigma_{min} = (0.25 \text{ ksf}) / 2 = 0.13 \text{ ksf}$$

$$\sigma_{max} = \frac{P_v}{B} \left( 1 + 6 \frac{e}{B} \right) = (16.09 \text{ kip/ft} / 11.0 \text{ ft}) [1 + 6(1.52 \text{ ft} / 11.0 \text{ ft})] = 2.68 \text{ ksf}$$

$$\sigma_{min} = \frac{P_v}{B} \left( 1 - 6 \frac{e}{B} \right) = (16.09 \text{ kip/ft} / 11.0 \text{ ft}) [1 - 6(1.52 \text{ ft} / 11.0 \text{ ft})] = 0.25 \text{ ksf}$$

$$R_{\tau} = 0.5(1.34 \text{ ksf} - 0.13 \text{ ksf})(11.0 \text{ ft}) + (0.13 \text{ ksf})(11.0 \text{ ft}) = 8.09 \text{ kip/ft}$$

### Verify Sliding Force Less Than Factored Sliding Resistance - Undrained Condition

$$P_H \leq \phi_n \cdot R_n \rightarrow P_H \leq \phi_{\tau} \cdot R_{\tau} + \phi_{ep} \cdot R_{ep} \rightarrow 7.24 \text{ kip/ft} \leq (8.09 \text{ kip/ft})(1.00) + (0.00 \text{ kip/ft})(0.50) = 8.09$$

$$= 7.24 \text{ kip/ft} \leq 8.09 \text{ kip/ft} \quad \text{OK}$$

$$\text{Use } \phi_{\tau} = 1.00 \quad \text{Use } \phi_{ep} = 0.50 \quad (\text{Per AASHTO LRFD BDM Tables 10.5.5.2.2-1 and 11.5.7-1})$$



### CIP Wall Dimensions and Surcharge Loading

Wall Height, (H) =	14.2 ft
Foundation Width (Entire Base Width), (B) =	11.0 ft
Stem Width, (a) =	2.5 ft
Toe Width, (b) =	2.5 ft
Heel Width, (c) =	6.0 ft
Footing Thickness, (d) =	2.5 ft
Location of Shear Key, (e) =	0.0 ft
Depth of Shear Key, (f) =	0.0 ft
Embedment Depth, (D <sub>f</sub> ) =	0.0 ft
Wall Length, (L) =	124 ft
Live Surcharge Load, (σ <sub>LS</sub> ) =	250 psf
Depth to Groundwater, (D <sub>w</sub> ) =	29.8 ft

### Bearing and Retained/Backfill Soil Properties:

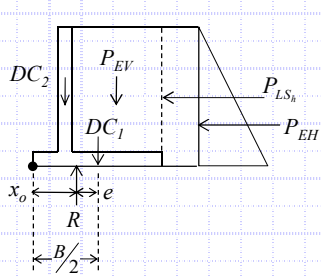
Bearing Soil Unit Weight, (γ <sub>BS</sub> ) =	120 pcf
Bearing Soil Friction Angle, (φ <sub>BS</sub> ) =	25 °
Bearing Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>BS</sub> ] =	2125 psf
Backfill and Retained Soil Unit Weight, (γ <sub>BF</sub> , γ <sub>RS</sub> ) =	120 pcf
Retained Soil Friction Angle, (φ <sub>RS</sub> ) =	30 °
Retained Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>RS</sub> ] =	2000 psf
Active Earth Pressure Coefficient, (K <sub>a</sub> ) =	0.297
Passive Earth Pressure Coefficient, (K <sub>p</sub> ) =	7.410

### LRFD Load Factors

	DC	EV	EH	LS	EP
Strength Ia	0.90	1.00	1.50	1.75	0.90
Strength Ib	1.25	1.35	1.50	1.75	0.90
Service I	1.00	1.00	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

### Check Eccentricity (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.6.3.3



$$e = \frac{B}{2} - x_o$$

$$x_o = \frac{M_V - M_H}{P_V} = \frac{(102.62 \text{ kip-ft/ft} - 38.63 \text{ kip-ft/ft})}{(16.09 \text{ kip/ft})} = 3.98 \text{ ft}$$

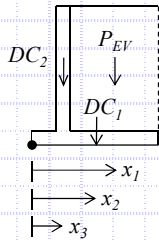
$$M_V = 102.62 \text{ kip-ft/ft}$$

$$M_H = 38.63 \text{ kip-ft/ft}$$

$$P_V = P_{EV} + DC_1 + DC_2 = 8.42 \text{ kip/ft} + 3.71 \text{ kip/ft} + 3.95 \text{ kip/ft} = 16.09 \text{ kip/ft}$$

$$e = \left(\frac{11.0 \text{ ft}}{2}\right) - 3.98 \text{ ft} = 1.52 \text{ ft}$$

Resisting Moment,  $M_V$ :



$$M_V = P_{EV}(x_1) + DC_1(x_2) + DC_2(x_3)$$

$$P_{EV} = \gamma_{BF} \cdot (H - d) \cdot c \cdot \gamma_{EV} = (120 \text{ pcf})(14.2 \text{ ft} - 2.5 \text{ ft})(6.0 \text{ ft})(1.00) = 8.42 \text{ kip/ft}$$

$$DC_1 = \gamma_c \cdot B \cdot d \cdot \gamma_{DC} = (150 \text{ pcf})(11.0 \text{ ft})(2.5 \text{ ft})(0.90) = 3.71 \text{ kip/ft}$$

$$DC_2 = \gamma_c \cdot (H - d) \cdot a \cdot \gamma_{DC} = (150 \text{ pcf})(14.2 \text{ ft} - 2.5 \text{ ft})(2.5 \text{ ft})(0.90) = 3.95 \text{ kip/ft}$$

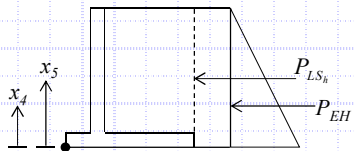
$$x_1 = a + b + \frac{c}{2} = 2.5 \text{ ft} + 2.5 \text{ ft} + (6.0 \text{ ft} / 2) = 8.0 \text{ ft}$$

$$x_2 = \frac{B}{2} = 11.0 \text{ ft} / 2 = 5.5 \text{ ft}$$

$$x_3 = b + \frac{a}{2} = 2.5 \text{ ft} + (2.5 \text{ ft} / 2) = 3.8 \text{ ft}$$

$$M_V = (8.42 \text{ kip/ft})(8.0 \text{ ft}) + (3.71 \text{ kip/ft})(5.5 \text{ ft}) + (3.95 \text{ kip/ft})(3.8 \text{ ft}) = 102.62 \text{ kip-ft/ft}$$

Overturning Moment,  $M_H$ :



$$M_H = P_{EH}(x_2) + P_{LS_h}(x_3)$$

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(14.2 \text{ ft})^2 (0.297)(1.50) = 5.39 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (250 \text{ psf})(14.2 \text{ ft})(0.297)(1.75) = 1.85 \text{ kip/ft}$$

$$x_2 = \frac{H}{3} = (14.2 \text{ ft}) / 3 = 4.73 \text{ ft}$$

$$x_3 = \frac{H}{2} = (14.2 \text{ ft}) / 2 = 7.10 \text{ ft}$$

$$M_H = (5.39 \text{ kip/ft})(4.73 \text{ ft}) + (1.85 \text{ kip/ft})(7.10 \text{ ft}) = 38.63 \text{ kip-ft/ft}$$

Limiting Eccentricity:

$$e_{\max} = \frac{B}{3} \rightarrow e_{\max} = (11.0 \text{ ft}) / 3 = 3.67 \text{ ft}$$

### Check Eccentricity

$$e < e_{\max} \rightarrow 1.52 \text{ ft} < 3.67 \text{ ft} \quad \text{OK}$$



### CIP Wall Dimensions and Surcharge Loading

Wall Height, (H) =	14.2 ft
Foundation Width (Entire Base Width), (B) =	11.0 ft
Stem Width, (a) =	2.5 ft
Toe Width, (b) =	2.5 ft
Heel Width, (c) =	6.0 ft
Footing Thickness, (d) =	2.5 ft
Location of Shear Key, (e) =	0.0 ft
Depth of Shear Key, (f) =	0.0 ft
Embedment Depth, (D <sub>f</sub> ) =	0.0 ft
Wall Length, (L) =	124 ft
Live Surcharge Load, (σ <sub>LS</sub> ) =	250 psf
Depth to Groundwater, (D <sub>w</sub> ) =	29.8 ft

### Bearing and Retained/Backfill Soil Properties:

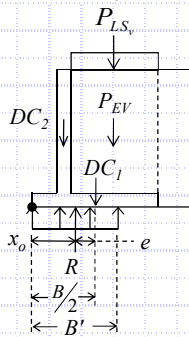
Bearing Soil Unit Weight, (γ <sub>BS</sub> ) =	120 pcf
Bearing Soil Friction Angle, (φ <sub>BS</sub> ) =	25°
Bearing Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>BS</sub> ] =	2125 psf
Backfill and Retained Soil Unit Weight, (γ <sub>BF</sub> , γ <sub>RS</sub> ) =	120 pcf
Retained Soil Friction Angle, (φ <sub>RS</sub> ) =	30°
Retained Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>RS</sub> ] =	2000 psf
Active Earth Pressure Coefficient, (K <sub>a</sub> ) =	0.297
Passive Earth Pressure Coefficient, (K <sub>p</sub> ) =	7.410

### LRFD Load Factors

	DC	EV	EH	LS	EP
Strength Ia	0.90	1.00	1.50	1.75	0.90
Strength Ib	1.25	1.35	1.50	1.75	0.90
Service I	1.00	1.00	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

### Check Bearing Capacity (Loading Case - Strength Ib) - AASHTO LRFD BDM Section 11.6.3.2



$$q_{eq} = \frac{P_V}{B'}$$

$$B' = B - 2e = 11.0 \text{ ft} - 2(0.29 \text{ ft}) = 10.42 \text{ ft}$$

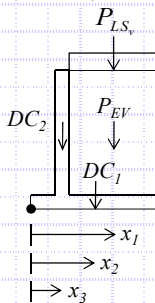
$$e = \frac{B}{2} - x_o = (11.0 \text{ ft} / 2) - 5.21 \text{ ft} = 0.29 \text{ ft}$$

$$x_o = \frac{M_V - M_H}{P_V} = (178.40 \text{ kip-ft} - 38.63 \text{ kip-ft}) / (26.83 \text{ kip/ft}) = 5.21 \text{ ft}$$

$$q_{eq} = (26.83 \text{ kip/ft}) / (10.42 \text{ ft}) = 2.57 \text{ ksf}$$

Resisting Moment, M<sub>V</sub>:

$$M_V = P_{EV}(x_1) + P_{LS}(x_1) + DC_1(x_2) + DC_2(x_3)$$



$$P_{EV} = \gamma_{BF} \cdot (H - d) \cdot c \cdot \gamma_{EV} = (120 \text{ pcf})(14.2 \text{ ft} - 2.5 \text{ ft})(6.0 \text{ ft})(1.35) = 11.37 \text{ kip/ft}$$

$$P_{LS} = \sigma_{LS} \cdot B \cdot \gamma_{LS} = (250 \text{ psf})(11.0 \text{ ft})(1.75) = 4.813 \text{ kip/ft}$$

$$DC_1 = \gamma_c \cdot B \cdot d \cdot \gamma_{DC} = (150 \text{ pcf})(11.0 \text{ ft})(2.5 \text{ ft})(1.25) = 5.16 \text{ kip/ft}$$

$$DC_2 = \gamma_c \cdot (H - d) \cdot a \cdot \gamma_{DC} = (150 \text{ pcf})(14.2 \text{ ft} - 2.5 \text{ ft})(2.5 \text{ ft})(1.25) = 5.48 \text{ kip/ft}$$

$$x_1 = a + b + c/2 = 2.5 \text{ ft} + 2.5 \text{ ft} + (6.0 \text{ ft} / 2) = 8.0 \text{ ft}$$

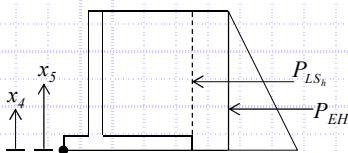
$$x_2 = B/2 = 11.0 \text{ ft} / 2 = 5.5 \text{ ft}$$

$$x_3 = b + a/2 = 2.5 \text{ ft} + (2.5 \text{ ft} / 2) = 3.8 \text{ ft}$$

$$M_V = (11.37 \text{ kip/ft})(8.0 \text{ ft}) + (4.81 \text{ kip/ft})(8.0 \text{ ft}) + (5.16 \text{ kip/ft})(5.5 \text{ ft}) + (5.48 \text{ kip/ft})(3.8 \text{ ft}) = 178.40 \text{ kip-ft/ft}$$

Overturning Moment, M<sub>H</sub>:

$$M_H = P_{EH}(x_4) + P_{LS}(x_5)$$



$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(14.2 \text{ ft})^2(0.297)(1.50) = 5.39 \text{ kip/ft}$$

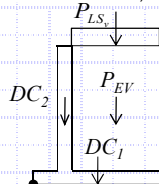
$$P_{LS} = \sigma_{LS} H K_a \gamma_{LS} = (250 \text{ psf})(14.2 \text{ ft})(0.297)(1.75) = 1.85 \text{ kip/ft}$$

$$x_4 = H/3 = (14.2 \text{ ft}) / 3 = 4.73 \text{ ft}$$

$$x_5 = H/2 = (14.2 \text{ ft}) / 2 = 7.10 \text{ ft}$$

$$M_H = (5.39 \text{ kip/ft})(4.73 \text{ ft}) + (1.85 \text{ kip/ft})(7.10 \text{ ft}) = 38.63 \text{ kip-ft/ft}$$

Vertical Force, P<sub>V</sub>:



$$P_V = P_{EV} + P_{LS} + DC_1 + DC_2$$

$$P_V = 11.37 \text{ kip/ft} + 4.81 \text{ kip/ft} + 5.16 \text{ kip/ft} + 5.48 \text{ kip/ft}$$

$$P_V = 26.83 \text{ kip/ft}$$



### CIP Wall Dimensions and Surcharge Loading

Wall Height, (H) =	14.2 ft
Foundation Width (Entire Base Width), (B) =	11.0 ft
Stem Width, (a) =	2.5 ft
Toe Width, (b) =	2.5 ft
Heel Width, (c) =	6.0 ft
Footing Thickness, (d) =	2.5 ft
Location of Shear Key, (e) =	0.0 ft
Depth of Shear Key, (f) =	0.0 ft
Embedment Depth, (D <sub>f</sub> ) =	0.0 ft
Wall Length, (L) =	124 ft
Live Surcharge Load, (σ <sub>LS</sub> ) =	250 psf
Depth to Groundwater, (D <sub>w</sub> ) =	29.8 ft

### Bearing and Retained/Backfill Soil Properties:

Bearing Soil Unit Weight, (γ <sub>BS</sub> ) =	120 pcf
Bearing Soil Friction Angle, (φ <sub>BS</sub> ) =	25 °
Bearing Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>BS</sub> ] =	2125 psf
Backfill and Retained Soil Unit Weight, (γ <sub>BF</sub> , γ <sub>RS</sub> ) =	120 pcf
Retained Soil Friction Angle, (φ <sub>RS</sub> ) =	30 °
Retained Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>RS</sub> ] =	2000 psf
Active Earth Pressure Coefficient, (K <sub>a</sub> ) =	0.297
Passive Earth Pressure Coefficient, (K <sub>p</sub> ) =	7.410

### LRFD Load Factors

	DC	EV	EH	LS	EP
Strength Ia	0.90	1.00	1.50	1.75	0.90
Strength Ib	1.25	1.35	1.50	1.75	0.90
Service I	1.00	1.00	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

### Check Bearing Capacity (Loading Case - Strength Ib) - AASHTO LRFD BDM Section 11.6.3.2 (Continued)

#### Check Bearing Resistance - Drained Condition

$$\text{Nominal Bearing Resistance: } q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + \frac{1}{2} \gamma B' N_{\gamma m} C_{w\gamma}$$

$$N_{cm} = N_c s_c i_c = 21.612$$

$$N_{qm} = N_q s_q d_q i_q = 11.078$$

$$N_{\gamma m} = N_{\gamma} s_{\gamma} i_{\gamma} = 10.506$$

$$N_c = 20.721$$

$$s_c = 1 + (10.42 \text{ ft} / 124 \text{ ft}) (10.662 / 20.721)$$

$$= 1.043$$

$$i_c = 1.000 \text{ (Assumed)}$$

$$N_q = 10.662$$

$$s_q = 1 + (10.42 \text{ ft} / 124 \text{ ft}) \tan(25^\circ) = 1.039$$

$$d_q = 1 + 2 \tan(25^\circ) [1 - \sin(25^\circ)]^2 \tan^{-1} (0.0 \text{ ft} / 10.42 \text{ ft})$$

$$= 1.000$$

$$i_q = 1.000 \text{ (Assumed)}$$

$$C_{wq} = 29.8 \text{ ft} > 0.0 \text{ ft} = 1.000$$

$$N_{\gamma} = 10.876$$

$$s_{\gamma} = 1 - 0.4 (10.42 \text{ ft} / 124 \text{ ft}) = 0.966$$

$$i_{\gamma} = 1.000 \text{ (Assumed)}$$

$$C_{w\gamma} = 29.8 \text{ ft} > 1.5 (10.42 \text{ ft}) + 0.0 \text{ ft} = 1.000$$

$$q_n = (0 \text{ psf})(21.612) + (120 \text{ pcf})(0.0 \text{ ft})(11.078)(1.000) + \frac{1}{2} (120 \text{ pcf})(10.4 \text{ ft})(10.506)(1.000) = 6.57 \text{ ksf}$$

#### Verify Equivalent Pressure Less Than Factored Bearing Resistance

$$q_{eq} \leq q_n \cdot \phi_b \rightarrow 2.57 \text{ ksf} \leq (6.57 \text{ ksf})(0.55) = 3.61 \text{ ksf} \rightarrow 2.57 \text{ ksf} \leq 3.61 \text{ ksf} \quad \text{OK}$$

$$\text{Use } \phi_b = 0.55 \text{ (Per AASHTO LRFD BDM Table 11.5.7-1)}$$

#### Check Bearing Resistance - Undrained Condition

$$\text{Nominal Bearing Resistance: } q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + \frac{1}{2} \gamma B' N_{\gamma m} C_{w\gamma}$$

$$N_{cm} = N_c s_c i_c = 5.361$$

$$N_{qm} = N_q s_q d_q i_q = 1.000$$

$$N_{\gamma m} = N_{\gamma} s_{\gamma} i_{\gamma} = 0.000$$

$$N_c = 5.140$$

$$s_c = 1 + (10.42 \text{ ft} / [(5)(124 \text{ ft})]) = 1.043$$

$$i_c = 1.000 \text{ (Assumed)}$$

$$N_q = 1.000$$

$$s_q = 1.000$$

$$d_q = 1 + 2 \tan(0^\circ) [1 - \sin(0^\circ)]^2 \tan^{-1} (0.0 \text{ ft} / 10.42 \text{ ft})$$

$$= 1.000$$

$$i_q = 1.000 \text{ (Assumed)}$$

$$C_{wq} = 29.8 \text{ ft} > 0.0 \text{ ft} = 1.000$$

$$N_{\gamma} = 0.000$$

$$s_{\gamma} = 1.000$$

$$i_{\gamma} = 1.000 \text{ (Assumed)}$$

$$C_{w\gamma} = 29.8 \text{ ft} > 1.5 (10.42 \text{ ft}) + 0.0 \text{ ft} = 1.000$$

$$q_n = (2125 \text{ psf})(5.361) + (120 \text{ pcf})(0.0 \text{ ft})(1.000)(1.000) + \frac{1}{2} (120 \text{ pcf})(10.4 \text{ ft})(0.000)(1.000) = 11.39 \text{ ksf}$$

#### Verify Equivalent Pressure Less Than Factored Bearing Resistance

$$q_{eq} \leq q_n \cdot \phi_b \rightarrow 2.57 \text{ ksf} \leq (11.39 \text{ ksf})(0.55) = 6.26 \text{ ksf} \rightarrow 2.57 \text{ ksf} \leq 6.26 \text{ ksf} \quad \text{OK}$$

$$\text{Use } \phi_b = 0.55 \text{ (Per AASHTO LRFD BDM Table 11.5.7-1)}$$



### CIP Wall Dimensions and Surcharge Loading

Wall Height, (H) =	14.2 ft
Foundation Width (Entire Base Width), (B) =	11.0 ft
Stem Width, (a) =	2.5 ft
Toe Width, (b) =	2.5 ft
Heel Width, (c) =	6.0 ft
Footing Thickness, (d) =	2.5 ft
Location of Shear Key, (e) =	0.0 ft
Depth of Shear Key, (f) =	0.0 ft
Embedment Depth, (D <sub>f</sub> ) =	0.0 ft
Wall Length, (L) =	124 ft
Live Surcharge Load, (σ <sub>LS</sub> ) =	250 psf
Depth to Groundwater, (D <sub>w</sub> ) =	29.8 ft

### Bearing and Retained/Backfill Soil Properties:

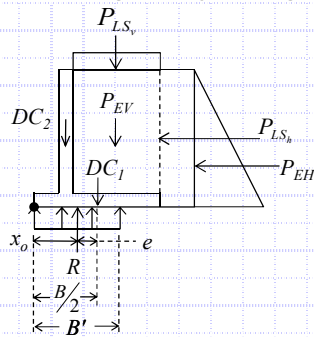
Bearing Soil Unit Weight, (γ <sub>BS</sub> ) =	120 pcf
Bearing Soil Friction Angle, (φ <sub>BS</sub> ) =	25 °
Bearing Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>BS</sub> ] =	2125 psf
Backfill and Retained Soil Unit Weight, (γ <sub>BF</sub> , γ <sub>RS</sub> ) =	120 pcf
Retained Soil Friction Angle, (φ <sub>RS</sub> ) =	30 °
Retained Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>RS</sub> ] =	2000 psf
Active Earth Pressure Coefficient, (K <sub>a</sub> ) =	0.297
Passive Earth Pressure Coefficient, (K <sub>p</sub> ) =	7.410

### LRFD Load Factors

	DC	EV	EH	LS	EP
Strength Ia	0.90	1.00	1.50	1.75	0.90
Strength Ib	1.25	1.35	1.50	1.75	0.90
Service I	1.00	1.00	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

### Check Bearing Capacity (Loading Case - Strength Ib) - AASHTO LRFD BDM Section 11.6.3.2



$$q_{eq} = \frac{P_V}{B'}$$

$$B' = B - 2e = 11.0 \text{ ft} - 2(0.22 \text{ ft}) = 10.56 \text{ ft}$$

$$e = \frac{B}{2} - x_o = (11.0 \text{ ft} / 2) - 5.28 \text{ ft} = 0.22 \text{ ft}$$

$$x_o = \frac{M_V - M_H}{P_V} = (128.53 \text{ kip-ft/ft} - 24.49 \text{ kip-ft/ft}) / (19.69 \text{ kip/ft}) = 5.28 \text{ ft}$$

$$q_{eq} = (19.69 \text{ kip/ft}) / (10.56 \text{ ft}) = 1.86 \text{ ksf}$$

$$M_V = [(\gamma_{BF} \cdot (H - d) \cdot c \cdot \gamma_{EV}) + (\sigma_{LS} \cdot B \cdot \gamma_{LS})] \left( a + b + \frac{c}{2} \right) + (\gamma_c \cdot B \cdot d \cdot \gamma_{DC}) \left( \frac{B}{2} \right) + (\gamma_c \cdot (H - d) \cdot a \cdot \gamma_{DC}) \left( b + \frac{a}{2} \right)$$

$$M_V = [(120 \text{ pcf})(14.2 \text{ ft} - 2.5 \text{ ft})(6.0 \text{ ft})(1.00) + (250 \text{ psf})(11.0 \text{ ft})(1.00)](2.5 \text{ ft} + 2.5 \text{ ft} + (6.0 \text{ ft} / 2)) + [(150 \text{ pcf})(11.0 \text{ ft})(2.5 \text{ ft})(1.00)](11.0 \text{ ft} / 2) + [(150 \text{ pcf})(14.2 \text{ ft} - 2.5 \text{ ft})(2.5 \text{ ft})(1.00)](2.5 \text{ ft} + (2.5 \text{ ft} / 2)) = 128.53 \text{ kip-ft/ft}$$

$$M_H = \left( \frac{1}{2} \gamma_{RS} \cdot H^2 \cdot K_a \cdot \gamma_{EH} \right) \left( \frac{H}{3} \right) + (\sigma_{LS} \cdot H \cdot K_a \cdot \gamma_{LS}) \left( \frac{H}{2} \right)$$

$$M_H = \left[ \frac{1}{2} (120 \text{ pcf})(14.2 \text{ ft})^2 (0.297)(1.00) \right] (14.2 \text{ ft} / 3) + [(250 \text{ psf})(14.2 \text{ ft})(0.297)(1.00)] (14.2 \text{ ft} / 2) = 24.49 \text{ kip-ft/ft}$$

$$P_V = (\gamma_{BF} \cdot (H - d) \cdot c \cdot \gamma_{EV}) + (\sigma_{LS} \cdot B \cdot \gamma_{LS}) + (\gamma_c \cdot B \cdot d \cdot \gamma_{DC}) + (\gamma_c \cdot (H - d) \cdot a \cdot \gamma_{DC})$$

$$P_V = (120 \text{ pcf})(14.2 \text{ ft} - 2.5 \text{ ft})(6.0 \text{ ft})(1.00) + (250 \text{ psf})(11.0 \text{ ft})(1.00) + (150 \text{ pcf})(11.0 \text{ ft})(2.5 \text{ ft})(1.00) + (150 \text{ pcf})(14.2 \text{ ft} - 2.5 \text{ ft})(2.5 \text{ ft})(1.00) = 19.69 \text{ kip/ft}$$

### Settlement (See Attached Spreadsheet Calculations):

Total Settlement at Maximum Wall Height: (S<sub>t</sub>)<sub>max</sub> = N/A in

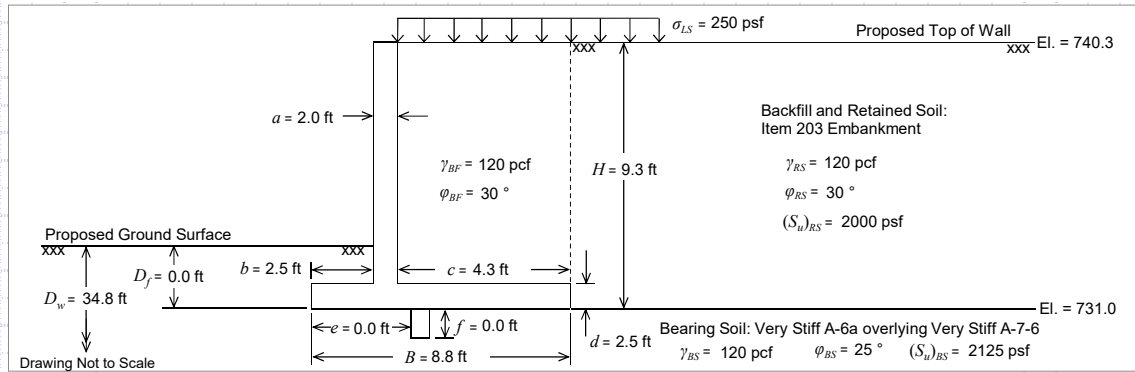
Total Settlement at Minimum Wall Height: (S<sub>t</sub>)<sub>min</sub> = N/A in

Differential Settlement Along Wall Alignment: δ<sub>s</sub> = N/A

δ<sub>s</sub> < 1/500 → N/A < 1/500



**FRA-70-1323C - Forward Abutment Wingwall - Panel 6 - CIP Wall Without Shear Key - Borings B-019-5-19 and B-114-1-13**



**CIP Wall Dimensions and Surcharge Loading**

Wall Height, (H) =	9.3 ft
Foundation Width (Entire Base Width), (B) =	8.8 ft
Stem Width, (a) =	2.0 ft
Toe Width, (b) =	2.5 ft
Heel Width, (c) =	4.3 ft
Footing Thickness, (d) =	2.5 ft
Location of Shear Key, (e) =	0.0 ft
Depth of Shear Key, (f) =	0.0 ft
Embedment Depth, (D <sub>f</sub> ) =	0.0 ft
Wall Length, (L) =	124 ft
Live Surcharge Load, (σ <sub>LS</sub> ) =	250 psf
Depth to Groundwater, (D <sub>w</sub> ) =	34.8 ft

**Bearing and Retained/Backfill Soil Properties:**

Bearing Soil Unit Weight, (γ <sub>BS</sub> ) =	120 pcf
Bearing Soil Friction Angle, (φ <sub>BS</sub> ) =	25°
Bearing Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>BS</sub> ] =	2125 psf
Backfill and Retained Soil Unit Weight, (γ <sub>BF</sub> , γ <sub>RS</sub> ) =	120 pcf
Retained Soil Friction Angle, (φ <sub>RS</sub> ) =	30°
Retained Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>RS</sub> ] =	2000 psf
Active Earth Pressure Coefficient, (K <sub>a</sub> ) =	0.297
Passive Earth Pressure Coefficient, (K <sub>p</sub> ) =	7.410

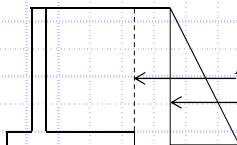
**LRFD Load Factors**

	DC	EV	EH	LS	EP
Strength Ia	0.90	1.00	1.50	1.75	0.90
Strength Ib	1.25	1.35	1.50	1.75	0.90
Service I	1.00	1.00	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

**Check Sliding (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 10.6.3.4**

Sliding Force:



$$P_H = P_{EH} + P_{LS_h}$$

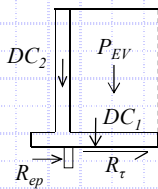
$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf}) (9.3 \text{ ft})^2 (0.297) (1.50) = 2.31 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (250 \text{ psf}) (9.3 \text{ ft}) (0.297) (1.75) = 1.21 \text{ kip/ft}$$

$$P_H = 2.31 \text{ kip/ft} + 1.21 \text{ kip/ft} = 3.52 \text{ kip/ft}$$

**Check Sliding Resistance**

$$\text{Nominal Sliding Resisting: } R_n = R_\tau + R_{ep}$$



$$R_{ep} = \gamma_{BS} D_f J K_p \gamma_{ep} + \frac{1}{2} \gamma_{BS} f^2 K_p \gamma_{ep}$$

$$R_{ep} = (120 \text{ pcf}) (0.0 \text{ ft}) (0.0 \text{ ft}) (7.41) (0.90) + \frac{1}{2} (120 \text{ pcf}) (0.0 \text{ ft})^2 (7.41) (0.90) = 0.00 \text{ kip/ft}$$

$$\text{Check Drained Condition: } R_\tau = P_V \tan \delta$$

$$P_V = DC_1 + DC_2 + P_{EV} = \gamma_c \cdot [B \cdot d + (H - d) \cdot a] \cdot \gamma_{DC} + \gamma_{BF} \cdot (H - d) \cdot c \cdot \gamma_{EV}$$

$$P_V = (150 \text{ pcf}) [(8.8 \text{ ft}) (2.5 \text{ ft}) + (9.3 \text{ ft} - 2.5 \text{ ft}) (2.0 \text{ ft})] (0.90) + (120 \text{ pcf}) (9.3 \text{ ft} - 2.5 \text{ ft}) (4.3 \text{ ft}) (1.00) = 8.31 \text{ kip/ft}$$

$$\tan \delta = \tan \phi_{BS} = \tan(25) = 0.47$$

$$R_\tau = (8.31 \text{ kip/ft}) (0.47) = 3.91 \text{ kip/ft}$$

**Verify Sliding Force Less Than Factored Sliding Resistance - Drained Condition**

$$P_H \leq \phi_n \cdot R_n \rightarrow P_H \leq \phi_\tau \cdot R_\tau + \phi_{ep} \cdot R_{ep} \rightarrow 3.52 \text{ kip/ft} \leq (3.91 \text{ kip/ft}) (1.00) + (0.00 \text{ kip/ft}) (0.50) = 3.91 \text{ kip/ft}$$

$$= 3.52 \text{ kip/ft} \leq 3.91 \text{ kip/ft}$$

OK

$$\text{Use } \phi_\tau = 1.00 \quad \text{Use } \phi_{ep} = 0.50 \quad (\text{Per AASHTO LRFD BDM Tables 10.5.5.2.2-1 and 11.5.7-1})$$



### CIP Wall Dimensions and Surcharge Loading

Wall Height, (H) =	9.3 ft
Foundation Width (Entire Base Width), (B) =	8.8 ft
Stem Width, (a) =	2.0 ft
Toe Width, (b) =	2.5 ft
Heel Width, (c) =	4.3 ft
Footing Thickness, (d) =	2.5 ft
Location of Shear Key, (e) =	0.0 ft
Depth of Shear Key, (f) =	0.0 ft
Embedment Depth, (D <sub>f</sub> ) =	0.0 ft
Wall Length, (L) =	124 ft
Live Surcharge Load, (σ <sub>LS</sub> ) =	250 psf
Depth to Groundwater, (D <sub>w</sub> ) =	34.8 ft

### Bearing and Retained/Backfill Soil Properties:

Bearing Soil Unit Weight, (γ <sub>BS</sub> ) =	120 pcf
Bearing Soil Friction Angle, (φ <sub>BS</sub> ) =	25 °
Bearing Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>BS</sub> ] =	2125 psf
Backfill and Retained Soil Unit Weight, (γ <sub>BF</sub> , γ <sub>RS</sub> ) =	120 pcf
Retained Soil Friction Angle, (φ <sub>RS</sub> ) =	30 °
Retained Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>RS</sub> ] =	2000 psf
Active Earth Pressure Coefficient, (K <sub>a</sub> ) =	0.297
Passive Earth Pressure Coefficient, (K <sub>p</sub> ) =	7.410

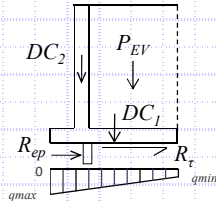
### LRFD Load Factors

	DC	EV	EH	LS	EP
Strength Ia	0.90	1.00	1.50	1.75	0.90
Strength Ib	1.25	1.35	1.50	1.75	0.90
Service I	1.00	1.00	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

### Check Sliding (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 10.6.3.4 (Continued)

Check Undrained Condition:  $R_{\tau} = ((s_u)_{BS} \leq q_s) \cdot B$



$$(s_u)_{BS} = 2.13 \text{ ksf}$$

$$q_{max} = \frac{1}{2} \sigma_{max} = (1.45 \text{ ksf}) / 2 = 0.73 \text{ ksf}$$

$$q_{min} = \frac{1}{2} \sigma_{min} = (0.44 \text{ ksf}) / 2 = 0.22 \text{ ksf}$$

$$\sigma_{max} = \frac{P_v}{B} \left( 1 + 6 \frac{e}{B} \right) = (8.31 \text{ kip/ft} / 8.8 \text{ ft}) [1 + 6(0.79 \text{ ft} / 8.8 \text{ ft})] = 1.45 \text{ ksf}$$

$$\sigma_{min} = \frac{P_v}{B} \left( 1 - 6 \frac{e}{B} \right) = (8.31 \text{ kip/ft} / 8.8 \text{ ft}) [1 - 6(0.79 \text{ ft} / 8.8 \text{ ft})] = 0.44 \text{ ksf}$$

$$R_{\tau} = 0.5(0.73 \text{ ksf} - 0.22 \text{ ksf})(8.8 \text{ ft}) + (0.22 \text{ ksf})(8.8 \text{ ft}) = 4.18 \text{ kip/ft}$$

### Verify Sliding Force Less Than Factored Sliding Resistance - Undrained Condition

$$P_H \leq \phi_n \cdot R_n \rightarrow P_H \leq \phi_{\tau} \cdot R_{\tau} + \phi_{ep} \cdot R_{ep} \rightarrow 3.52 \text{ kip/ft} \leq (4.18 \text{ kip/ft})(1.00) + (0.00 \text{ kip/ft})(0.50) = 4.18$$

$$= 3.52 \text{ kip/ft} \leq 4.18 \text{ kip/ft} \quad \text{OK}$$

$$\text{Use } \phi_{\tau} = 1.00 \quad \text{Use } \phi_{ep} = 0.50 \quad (\text{Per AASHTO LRFD BDM Tables 10.5.5.2.2-1 and 11.5.7-1})$$





### CIP Wall Dimensions and Surcharge Loading

Wall Height, (H) =	9.3 ft
Foundation Width (Entire Base Width), (B) =	8.8 ft
Stem Width, (a) =	2.0 ft
Toe Width, (b) =	2.5 ft
Heel Width, (c) =	4.3 ft
Footing Thickness, (d) =	2.5 ft
Location of Shear Key, (e) =	0.0 ft
Depth of Shear Key, (f) =	0.0 ft
Embedment Depth, (D <sub>f</sub> ) =	0.0 ft
Wall Length, (L) =	124 ft
Live Surcharge Load, (σ <sub>LS</sub> ) =	250 psf
Depth to Groundwater, (D <sub>w</sub> ) =	34.8 ft

### Bearing and Retained/Backfill Soil Properties:

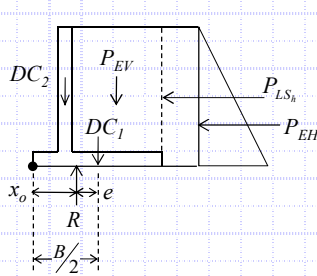
Bearing Soil Unit Weight, (γ <sub>BS</sub> ) =	120 pcf
Bearing Soil Friction Angle, (φ <sub>BS</sub> ) =	25 °
Bearing Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>BS</sub> ] =	2125 psf
Backfill and Retained Soil Unit Weight, (γ <sub>BF</sub> , γ <sub>RS</sub> ) =	120 pcf
Retained Soil Friction Angle, (φ <sub>RS</sub> ) =	30 °
Retained Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>RS</sub> ] =	2000 psf
Active Earth Pressure Coefficient, (K <sub>a</sub> ) =	0.297
Passive Earth Pressure Coefficient, (K <sub>p</sub> ) =	7.410

### LRFD Load Factors

	DC	EV	EH	LS	EP
Strength Ia	0.90	1.00	1.50	1.75	0.90
Strength Ib	1.25	1.35	1.50	1.75	0.90
Service I	1.00	1.00	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

### Check Eccentricity (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.6.3.3



$$e = \frac{B}{2} - x_o$$

$$x_o = \frac{M_V - M_H}{P_V} = \frac{(42.83 \text{ kip-ft/ft} - 12.79 \text{ kip-ft/ft})}{(8.31 \text{ kip/ft})} = 3.61 \text{ ft}$$

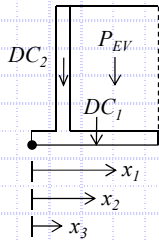
$$M_V = 42.83 \text{ kip-ft/ft}$$

$$M_H = 12.79 \text{ kip-ft/ft}$$

$$P_V = P_{EV} + DC_1 + DC_2 = 3.51 \text{ kip/ft} + 2.97 \text{ kip/ft} + 1.84 \text{ kip/ft} = 8.31 \text{ kip/ft}$$

$$e = (8.8 \text{ ft} / 2) - 3.61 \text{ ft} = 0.79 \text{ ft}$$

Resisting Moment, M<sub>V</sub>:



$$M_V = P_{EV}(x_1) + DC_1(x_2) + DC_2(x_3)$$

$$P_{EV} = \gamma_{BF} \cdot (H - d) \cdot c \cdot \gamma_{EV} = (120 \text{ pcf})(9.3 \text{ ft} - 2.5 \text{ ft})(4.3 \text{ ft})(1.00) = 3.51 \text{ kip/ft}$$

$$DC_1 = \gamma_c \cdot B \cdot d \cdot \gamma_{DC} = (150 \text{ pcf})(8.8 \text{ ft})(2.5 \text{ ft})(0.90) = 2.97 \text{ kip/ft}$$

$$DC_2 = \gamma_c \cdot (H - d) \cdot a \cdot \gamma_{DC} = (150 \text{ pcf})(9.3 \text{ ft} - 2.5 \text{ ft})(2.0 \text{ ft})(0.90) = 1.84 \text{ kip/ft}$$

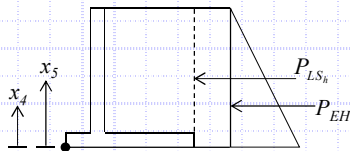
$$x_1 = a + b + \frac{c}{2} = 2.0 \text{ ft} + 2.5 \text{ ft} + (4.3 \text{ ft} / 2) = 6.7 \text{ ft}$$

$$x_2 = \frac{B}{2} = 8.8 \text{ ft} / 2 = 4.4 \text{ ft}$$

$$x_3 = b + \frac{a}{2} = 2.5 \text{ ft} + (2.0 \text{ ft} / 2) = 3.5 \text{ ft}$$

$$M_V = (3.51 \text{ kip/ft})(6.7 \text{ ft}) + (2.97 \text{ kip/ft})(4.4 \text{ ft}) + (1.84 \text{ kip/ft})(3.5 \text{ ft}) = 42.83 \text{ kip-ft/ft}$$

Overturning Moment, M<sub>H</sub>:



$$M_H = P_{EH}(x_2) + P_{LS}(x_3)$$

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(9.3 \text{ ft})^2 (0.297)(1.50) = 2.31 \text{ kip/ft}$$

$$P_{LS} = \sigma_{LS} H K_a \gamma_{LS} = (250 \text{ psf})(9.3 \text{ ft})(0.297)(1.75) = 1.21 \text{ kip/ft}$$

$$x_2 = \frac{H}{3} = (9.3 \text{ ft}) / 3 = 3.10 \text{ ft}$$

$$x_3 = \frac{H}{2} = (9.3 \text{ ft}) / 2 = 4.65 \text{ ft}$$

$$M_H = (2.31 \text{ kip/ft})(3.1 \text{ ft}) + (1.21 \text{ kip/ft})(4.65 \text{ ft}) = 12.79 \text{ kip-ft/ft}$$

Limiting Eccentricity:

$$e_{\max} = \frac{B}{3} \rightarrow e_{\max} = (8.8 \text{ ft}) / 3 = 2.93 \text{ ft}$$

### Check Eccentricity

$$e < e_{\max} \rightarrow 0.79 \text{ ft} < 2.93 \text{ ft} \quad \text{OK}$$





### CIP Wall Dimensions and Surcharge Loading

Wall Height, (H) =	9.3 ft
Foundation Width (Entire Base Width), (B) =	8.8 ft
Stem Width, (a) =	2.0 ft
Toe Width, (b) =	2.5 ft
Heel Width, (c) =	4.3 ft
Footing Thickness, (d) =	2.5 ft
Location of Shear Key, (e) =	0.0 ft
Depth of Shear Key, (f) =	0.0 ft
Embedment Depth, (D <sub>f</sub> ) =	0.0 ft
Wall Length, (L) =	124 ft
Live Surcharge Load, (σ <sub>LS</sub> ) =	250 psf
Depth to Groundwater, (D <sub>w</sub> ) =	34.8 ft

### Bearing and Retained/Backfill Soil Properties:

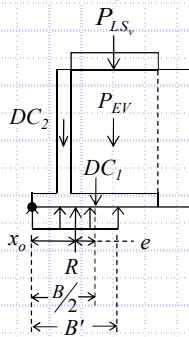
Bearing Soil Unit Weight, (γ <sub>BS</sub> ) =	120 pcf
Bearing Soil Friction Angle, (φ <sub>BS</sub> ) =	25 °
Bearing Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>BS</sub> ] =	2125 psf
Backfill and Retained Soil Unit Weight, (γ <sub>BF</sub> , γ <sub>RS</sub> ) =	120 pcf
Retained Soil Friction Angle, (φ <sub>RS</sub> ) =	30 °
Retained Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>RS</sub> ] =	2000 psf
Active Earth Pressure Coefficient, (K <sub>a</sub> ) =	0.297
Passive Earth Pressure Coefficient, (K <sub>p</sub> ) =	7.410

### LRFD Load Factors

	DC	EV	EH	LS	EP
Strength Ia	0.90	1.00	1.50	1.75	0.90
Strength Ib	1.25	1.35	1.50	1.75	0.90
Service I	1.00	1.00	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

### Check Bearing Capacity (Loading Case - Strength Ib) - AASHTO LRFD BDM Section 11.6.3.2



$$q_{eq} = \frac{P_V}{B'}$$

$$B' = B - 2e = 8.8 \text{ ft} - 2(-0.28 \text{ ft}) = 9.36 \text{ ft}$$

$$e = \frac{B}{2} - x_o = (8.8 \text{ ft} / 2) - 4.68 \text{ ft} = -0.28 \text{ ft}$$

$$x_o = \frac{M_V - M_H}{P_V} = (84.18 \text{ kip-ft/ft} - 12.79 \text{ kip-ft/ft}) / (15.26 \text{ kip/ft}) = 4.68 \text{ ft}$$

$$q_{eq} = (15.26 \text{ kip/ft}) / (9.36 \text{ ft}) = 1.63 \text{ ksf}$$

Resisting Moment,  $M_V$ :

$$M_V = P_{EV}(x_1) + P_{LS_v}(x_1) + DC_1(x_2) + DC_2(x_3)$$

$$P_{EV} = \gamma_{BF} \cdot (H - d) \cdot c \cdot \gamma_{EV} = (120 \text{ pcf})(9.3 \text{ ft} - 2.5 \text{ ft})(4.3 \text{ ft})(1.35) = 4.74 \text{ kip/ft}$$

$$P_{LS_v} = \sigma_{LS} \cdot B \cdot \gamma_{LS} = (250 \text{ psf})(8.8 \text{ ft})(1.75) = 3.85 \text{ kip/ft}$$

$$DC_1 = \gamma_c \cdot B \cdot d \cdot \gamma_{DC} = (150 \text{ pcf})(8.8 \text{ ft})(2.5 \text{ ft})(1.25) = 4.13 \text{ kip/ft}$$

$$DC_2 = \gamma_c \cdot (H - d) \cdot a \cdot \gamma_{DC} = (150 \text{ pcf})(9.3 \text{ ft} - 2.5 \text{ ft})(2.0 \text{ ft})(1.25) = 2.55 \text{ kip/ft}$$

$$x_1 = a + b + c/2 = 2.0 \text{ ft} + 2.5 \text{ ft} + (4.3 \text{ ft} / 2) = 6.7 \text{ ft}$$

$$x_2 = B/2 = 8.8 \text{ ft} / 2 = 4.4 \text{ ft}$$

$$x_3 = b + a/2 = 2.5 \text{ ft} + (2.0 \text{ ft} / 2) = 3.5 \text{ ft}$$

$$M_V = (4.74 \text{ kip/ft})(6.7 \text{ ft}) + (3.85 \text{ kip/ft})(6.7 \text{ ft}) + (4.13 \text{ kip/ft})(4.4 \text{ ft}) + (2.55 \text{ kip/ft})(3.5 \text{ ft}) = 84.18 \text{ kip-ft/ft}$$

Overturning Moment,  $M_H$ :

$$M_H = P_{EH}(x_4) + P_{LS_h}(x_5)$$

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(9.3 \text{ ft})^2(0.297)(1.50) = 2.31 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (250 \text{ psf})(9.3 \text{ ft})(0.297)(1.75) = 1.21 \text{ kip/ft}$$

$$x_4 = H/3 = (9.3 \text{ ft}) / 3 = 3.10 \text{ ft}$$

$$x_5 = H/2 = (9.3 \text{ ft}) / 2 = 4.65 \text{ ft}$$

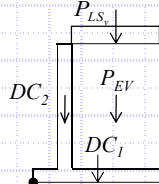
$$M_H = (2.31 \text{ kip/ft})(3.1 \text{ ft}) + (1.21 \text{ kip/ft})(4.65 \text{ ft}) = 12.79 \text{ kip-ft/ft}$$

Vertical Force,  $P_V$ :

$$P_V = P_{EV} + P_{LS_v} + DC_1 + DC_2$$

$$P_V = 4.74 \text{ kip/ft} + 3.85 \text{ kip/ft} + 4.13 \text{ kip/ft} + 2.55 \text{ kip/ft}$$

$$P_V = 15.26 \text{ kip/ft}$$





### CIP Wall Dimensions and Surcharge Loading

Wall Height, (H) =	9.3 ft
Foundation Width (Entire Base Width), (B) =	8.8 ft
Stem Width, (a) =	2.0 ft
Toe Width, (b) =	2.5 ft
Heel Width, (c) =	4.3 ft
Footing Thickness, (d) =	2.5 ft
Location of Shear Key, (e) =	0.0 ft
Depth of Shear Key, (f) =	0.0 ft
Embedment Depth, (D <sub>f</sub> ) =	0.0 ft
Wall Length, (L) =	124 ft
Live Surcharge Load, (σ <sub>LS</sub> ) =	250 psf
Depth to Groundwater, (D <sub>w</sub> ) =	34.8 ft

### Bearing and Retained/Backfill Soil Properties:

Bearing Soil Unit Weight, (γ <sub>BS</sub> ) =	120 pcf
Bearing Soil Friction Angle, (φ <sub>BS</sub> ) =	25 °
Bearing Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>BS</sub> ] =	2125 psf
Backfill and Retained Soil Unit Weight, (γ <sub>BF</sub> , γ <sub>RS</sub> ) =	120 pcf
Retained Soil Friction Angle, (φ <sub>RS</sub> ) =	30 °
Retained Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>RS</sub> ] =	2000 psf
Active Earth Pressure Coefficient, (K <sub>a</sub> ) =	0.297
Passive Earth Pressure Coefficient, (K <sub>p</sub> ) =	7.410

### LRFD Load Factors

	DC	EV	EH	LS	EP
Strength Ia	0.90	1.00	1.50	1.75	0.90
Strength Ib	1.25	1.35	1.50	1.75	0.90
Service I	1.00	1.00	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

### Check Bearing Capacity (Loading Case - Strength Ib) - AASHTO LRFD BDM Section 11.6.3.2 (Continued)

#### Check Bearing Resistance - Drained Condition

$$\text{Nominal Bearing Resistance: } q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + \frac{1}{2} \gamma B' N_{\gamma m} C_{w\gamma}$$

$$N_{cm} = N_c s_c i_c = 21.529$$

$$N_{qm} = N_q s_q d_q i_q = 11.035$$

$$N_{\gamma m} = N_{\gamma} s_{\gamma} i_{\gamma} = 10.550$$

$$N_c = 20.721$$

$$s_c = 1 + (9.36 \text{ ft} / 124 \text{ ft}) (10.662 / 20.721)$$

$$= 1.039$$

$$i_c = 1.000 \text{ (Assumed)}$$

$$N_q = 10.662$$

$$s_q = 1 + (9.36 \text{ ft} / 124 \text{ ft}) \tan(25^\circ) = 1.035$$

$$d_q = 1 + 2 \tan(25^\circ) [1 - \sin(25^\circ)]^2 \tan^{-1} (0.0 \text{ ft} / 9.36 \text{ ft})$$

$$= 1.000$$

$$i_q = 1.000 \text{ (Assumed)}$$

$$C_{wq} = 34.8 \text{ ft} > 0.0 \text{ ft} = 1.000$$

$$N_{\gamma} = 10.876$$

$$s_{\gamma} = 1 - 0.4 (9.36 \text{ ft} / 124 \text{ ft}) = 0.970$$

$$i_{\gamma} = 1.000 \text{ (Assumed)}$$

$$C_{w\gamma} = 34.8 \text{ ft} > 1.5 (9.36 \text{ ft}) + 0.0 \text{ ft} = 1.000$$

$$q_n = (0 \text{ psf})(21.529) + (120 \text{ pcf})(0.0 \text{ ft})(11.035)(1.000) + \frac{1}{2} (120 \text{ pcf})(9.4 \text{ ft})(10.550)(1.000) = 5.92 \text{ ksf}$$

#### Verify Equivalent Pressure Less Than Factored Bearing Resistance

$$q_{eq} \leq q_n \cdot \phi_b \rightarrow 1.63 \text{ ksf} \leq (5.92 \text{ ksf})(0.55) = 3.26 \text{ ksf} \rightarrow 1.63 \text{ ksf} \leq 3.26 \text{ ksf} \quad \text{OK}$$

$$\text{Use } \phi_b = 0.55 \text{ (Per AASHTO LRFD BDM Table 11.5.7-1)}$$

#### Check Bearing Resistance - Undrained Condition

$$\text{Nominal Bearing Resistance: } q_n = cN_{cm} + \gamma D_f N_{qm} C_{wq} + \frac{1}{2} \gamma B' N_{\gamma m} C_{w\gamma}$$

$$N_{cm} = N_c s_c i_c = 5.340$$

$$N_{qm} = N_q s_q d_q i_q = 1.000$$

$$N_{\gamma m} = N_{\gamma} s_{\gamma} i_{\gamma} = 0.000$$

$$N_c = 5.140$$

$$s_c = 1 + (9.36 \text{ ft} / [(5)(124 \text{ ft})]) = 1.039$$

$$i_c = 1.000 \text{ (Assumed)}$$

$$N_q = 1.000$$

$$s_q = 1.000$$

$$d_q = 1 + 2 \tan(0^\circ) [1 - \sin(0^\circ)]^2 \tan^{-1} (0.0 \text{ ft} / 9.36 \text{ ft})$$

$$= 1.000$$

$$i_q = 1.000 \text{ (Assumed)}$$

$$C_{wq} = 34.8 \text{ ft} > 0.0 \text{ ft} = 1.000$$

$$N_{\gamma} = 0.000$$

$$s_{\gamma} = 1.000$$

$$i_{\gamma} = 1.000 \text{ (Assumed)}$$

$$C_{w\gamma} = 34.8 \text{ ft} > 1.5 (9.36 \text{ ft}) + 0.0 \text{ ft} = 1.000$$

$$q_n = (2125 \text{ psf})(5.340) + (120 \text{ pcf})(0.0 \text{ ft})(1.000)(1.000) + \frac{1}{2} (120 \text{ pcf})(9.4 \text{ ft})(0.000)(1.000) = 11.35 \text{ ksf}$$

#### Verify Equivalent Pressure Less Than Factored Bearing Resistance

$$q_{eq} \leq q_n \cdot \phi_b \rightarrow 1.63 \text{ ksf} \leq (11.35 \text{ ksf})(0.55) = 6.24 \text{ ksf} \rightarrow 1.63 \text{ ksf} \leq 6.24 \text{ ksf} \quad \text{OK}$$

$$\text{Use } \phi_b = 0.55 \text{ (Per AASHTO LRFD BDM Table 11.5.7-1)}$$



### CIP Wall Dimensions and Surcharge Loading

Wall Height, (H) =	9.3 ft
Foundation Width (Entire Base Width), (B) =	8.8 ft
Stem Width, (a) =	2.0 ft
Toe Width, (b) =	2.5 ft
Heel Width, (c) =	4.3 ft
Footing Thickness, (d) =	2.5 ft
Location of Shear Key, (e) =	0.0 ft
Depth of Shear Key, (f) =	0.0 ft
Embedment Depth, (D <sub>f</sub> ) =	0.0 ft
Wall Length, (L) =	124 ft
Live Surcharge Load, (σ <sub>LS</sub> ) =	250 psf
Depth to Groundwater, (D <sub>w</sub> ) =	34.8 ft

### Bearing and Retained/Backfill Soil Properties:

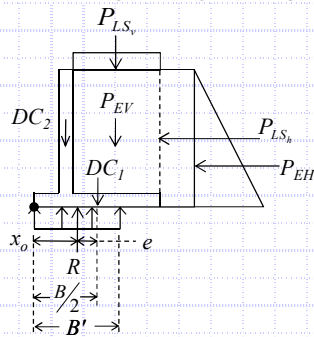
Bearing Soil Unit Weight, (γ <sub>BS</sub> ) =	120 pcf
Bearing Soil Friction Angle, (φ <sub>BS</sub> ) =	25 °
Bearing Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>BS</sub> ] =	2125 psf
Backfill and Retained Soil Unit Weight, (γ <sub>BF</sub> , γ <sub>RS</sub> ) =	120 pcf
Retained Soil Friction Angle, (φ <sub>RS</sub> ) =	30 °
Retained Soil Undrained Shear Strength, [(s <sub>u</sub> ) <sub>RS</sub> ] =	2000 psf
Active Earth Pressure Coefficient, (K <sub>a</sub> ) =	0.297
Passive Earth Pressure Coefficient, (K <sub>p</sub> ) =	7.410

### LRFD Load Factors

	DC	EV	EH	LS	EP
Strength Ia	0.90	1.00	1.50	1.75	0.90
Strength Ib	1.25	1.35	1.50	1.75	0.90
Service I	1.00	1.00	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

### Check Bearing Capacity (Loading Case - Strength Ib) - AASHTO LRFD BDM Section 11.6.3.2



$$q_{eq} = P_V / B'$$

$$B' = B - 2e = 8.8 \text{ ft} - 2(-0.27 \text{ ft}) = 9.34 \text{ ft}$$

$$e = B/2 - x_o = (8.8 \text{ ft} / 2) - 4.67 \text{ ft} = -0.27 \text{ ft}$$

$$x_o = \frac{M_V - M_H}{P_V} = (59.62 \text{ kip-ft/ft} - 7.99 \text{ kip-ft/ft}) / (11.05 \text{ kip/ft}) = 4.67 \text{ ft}$$

$$q_{eq} = (11.05 \text{ kip/ft}) / (9.34 \text{ ft}) = 1.18 \text{ ksf}$$

$$M_V = [(\gamma_{BF} \cdot (H - d) \cdot c \cdot \gamma_{EV}) + (\sigma_{LS} \cdot B \cdot \gamma_{LS})] \left( a + b + \frac{c}{2} \right) + (\gamma_c \cdot B \cdot d \cdot \gamma_{DC}) \left( \frac{B}{2} \right) + (\gamma_c \cdot (H - d) \cdot a \cdot \gamma_{DC}) \left( b + \frac{a}{2} \right)$$

$$M_V = [(120 \text{ pcf})(9.3 \text{ ft} - 2.5 \text{ ft})(4.3 \text{ ft})(1.00) + (250 \text{ psf})(8.8 \text{ ft})(1.00)](2.0 \text{ ft} + 2.5 \text{ ft} + (4.3 \text{ ft} / 2)) + [(150 \text{ pcf})(8.8 \text{ ft})(2.5 \text{ ft})(1.00)](8.8 \text{ ft} / 2) + [(150 \text{ pcf})(9.3 \text{ ft} - 2.5 \text{ ft})(2.0 \text{ ft})(1.00)](2.5 \text{ ft} + (2.0 \text{ ft} / 2)) = 59.62 \text{ kip-ft/ft}$$

$$M_H = \left( \frac{1}{2} \gamma_{RS} \cdot H^2 \cdot K_a \cdot \gamma_{EH} \right) \left( \frac{H}{3} \right) + (\sigma_{LS} \cdot H \cdot K_a \cdot \gamma_{LS}) \left( \frac{H}{2} \right)$$

$$M_H = \left[ \frac{1}{2} (120 \text{ pcf})(9.3 \text{ ft})^2 (0.297)(1.00) \right] (9.3 \text{ ft} / 3) + [(250 \text{ psf})(9.3 \text{ ft})(0.297)(1.00)] (9.3 \text{ ft} / 2) = 7.99 \text{ kip-ft/ft}$$

$$P_V = (\gamma_{BF} \cdot (H - d) \cdot c \cdot \gamma_{EV}) + (\sigma_{LS} \cdot B \cdot \gamma_{LS}) + (\gamma_c \cdot B \cdot d \cdot \gamma_{DC}) + (\gamma_c \cdot (H - d) \cdot a \cdot \gamma_{DC})$$

$$P_V = (120 \text{ pcf})(9.3 \text{ ft} - 2.5 \text{ ft})(4.3 \text{ ft})(1.00) + (250 \text{ psf})(8.8 \text{ ft})(1.00) + (150 \text{ pcf})(8.8 \text{ ft})(2.5 \text{ ft})(1.00) + (150 \text{ pcf})(9.3 \text{ ft} - 2.5 \text{ ft})(2.0 \text{ ft})(1.00) = 11.05 \text{ kip/ft}$$

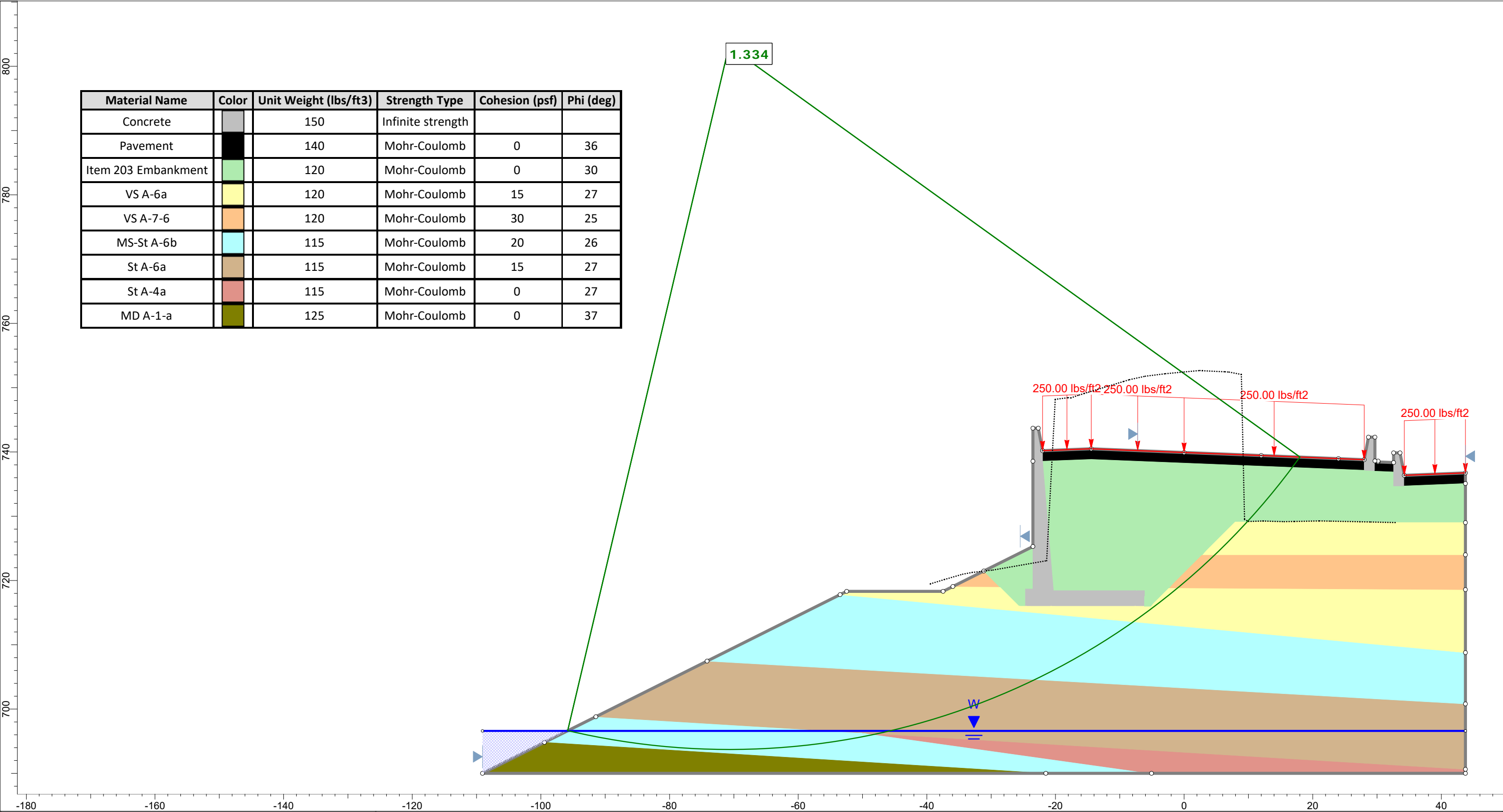
### Settlement (See Attached Spreadsheet Calculations):

$$\text{Total Settlement at Maximum Wall Height: } (S_t)_{\max} = \text{N/A in}$$

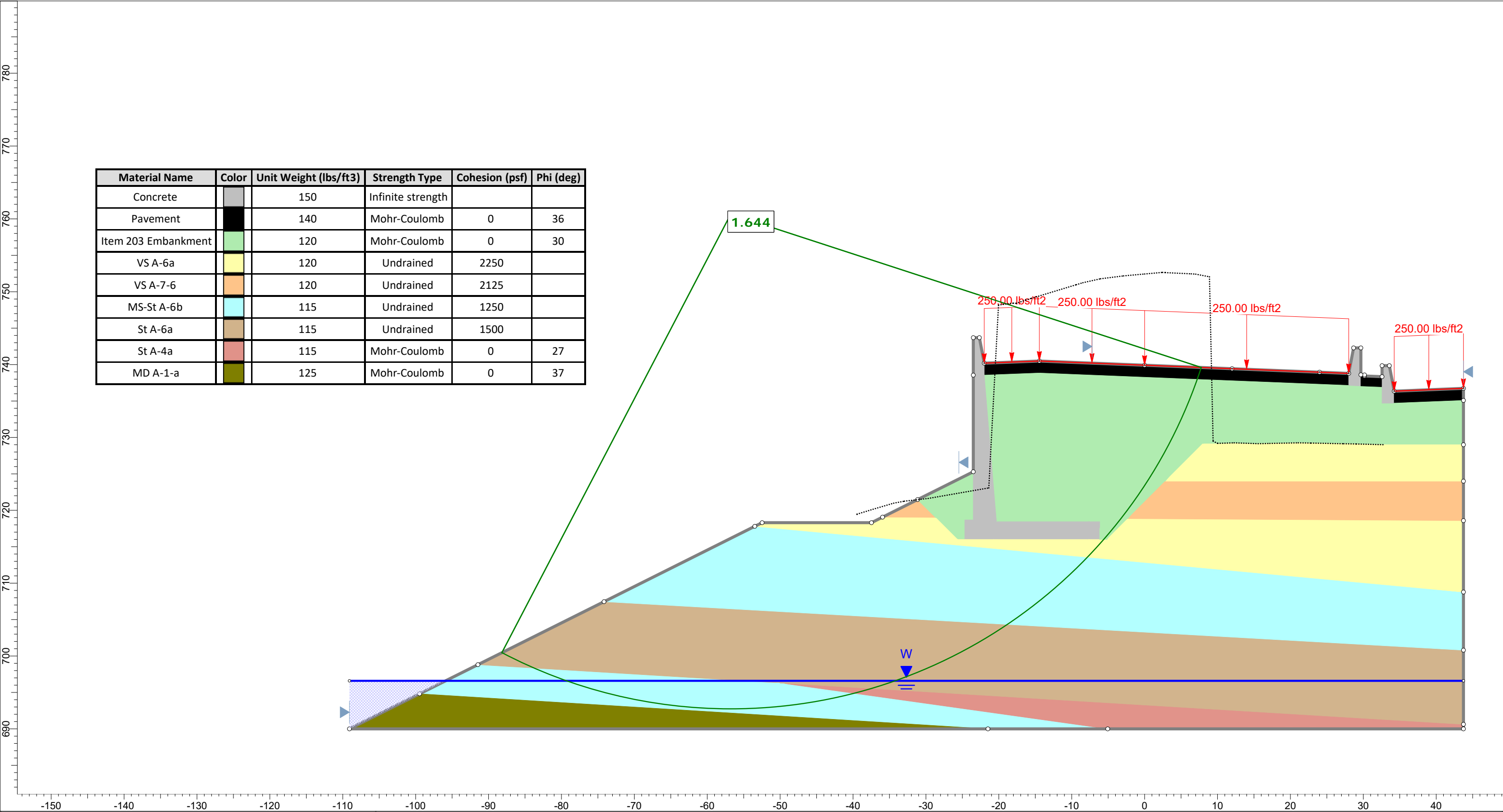
$$\text{Total Settlement at Minimum Wall Height: } (S_t)_{\min} = \text{N/A in}$$

$$\text{Differential Settlement Along Wall Alignment: } \delta_s = \text{N/A}$$

$$\delta_s < 1/500 \rightarrow \text{N/A} < 1/500$$



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Concrete		150	Infinite strength		
Pavement		140	Mohr-Coulomb	0	36
Item 203 Embankment		120	Mohr-Coulomb	0	30
VS A-6a		120	Mohr-Coulomb	15	27
VS A-7-6		120	Mohr-Coulomb	30	25
MS-St A-6b		115	Mohr-Coulomb	20	26
St A-6a		115	Mohr-Coulomb	15	27
St A-4a		115	Mohr-Coulomb	0	27
MD A-1-a		125	Mohr-Coulomb	0	37



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Concrete		150	Infinite strength		
Pavement		140	Mohr-Coulomb	0	36
Item 203 Embankment		120	Mohr-Coulomb	0	30
VS A-6a		120	Undrained	2250	
VS A-7-6		120	Undrained	2125	
MS-St A-6b		115	Undrained	1250	
St A-6a		115	Undrained	1500	
St A-4a		115	Mohr-Coulomb	0	27
MD A-1-a		125	Mohr-Coulomb	0	37

