CTL Engineering, Inc.
1310 S. Franklin Road
Indianapolis, Indiana 46239
Phone: (317) 295-8650 • Fax: (317) 295-8395
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Consulting Engineers – Testing – Inspection Services – Analytical Laboratories

July 25, 2019

Indiana Department of Transportation
Geotechnical Services Division
120 South Shortridge Road
Indianapolis, Indiana 46219

Attention: Mr. Athar Khan, PE

Reference: Geotechnical Investigation
Bridge Replacement
Des No. 1006266
US 52 over Mud Creek
Rush County, IN
CTL Project No.: 19050015IND

Dear Mr. Khan:

CTL Engineering, Inc. has completed the geotechnical investigation and on the above referenced site. Enclosed is an electronic copy of the report.

Thank you for the opportunity to be of service to you on this project. If you have any questions or need further information, please contact us at (317) 295-8650.

Sincerely,

CTL ENGINEERING, INC.

Ali Karaki

Ali Karaki, PE
Principal

cc: Ms. Haiyan Yang, PE, INDOT Geotechnical Services Division
Mr. Mir Zaheer, PE, INDOT Geotechnical Services Division

GEOTECHNICAL INVESTIGATION

BRIDGE REPLACEMENT
DES NO. 1006266
US 52 OVER MUD CREEK
RUSH COUNTY, IN
CTL PROJECT NO.: 19050015IND

PREPARED FOR:

INDIANA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL SERVICES DIVISION
120 SOUTH SHORTRIDGE ROAD
INDIANAPOLIS, INDIANA 46219

PREPARED BY:

CTL ENGINEERING, INC.
1310 S. FRANKLIN ROAD
INDIANAPOLIS, INDIANA 46239

JULY 25, 2019

CTL Engineering, Inc.
1310 S. Franklin Road
Indianapolis, Indiana 46239
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Indiana Department of Transportation
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120 South Shortridge Road
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Attention: Mr. Athar Khan, PE

Reference: Geotechnical Investigation
Bridge Replacement
Des No. 1006266
US 52 over Mud Creek
Rush County, IN
CTL Project No.: 19050015IND

Dear Mr. Khan:

In accordance with your authorization to proceed, CTL Engineering, Inc. has completed the geotechnical investigation on the above referenced site. The report includes the results of the field and laboratory testing and foundation recommendations for the proposed bridge replacement.

Thank you for the opportunity to be of service to you on this project. If you have any questions or need further information, please contact us at (317) 295-8650.

Sincerely,

CTL ENGINEERING, INC.

Ali Karaki

Ali Karaki, PE
Principal

Ms. Haiyan Yang, PE, INDOT Geotechnical Services Division
Mr. Mir Zaheer, PE, INDT Geotechnical Services Division

EXECUTIVE SUMMARY

Des No.: 1006266
US 52 over Mud Creek
Rush County, IN

Project Description: The project involves replacement of the existing three span reinforced concrete slab bridge with a new three-spans continuous reinforced concrete slab bridge with span lengths of 27'-0", 36'-0" and 27-0". The projected AADT for the year 2040 is 3,739 VPD with 11.57% truck traffic.

Subsurface Conditions: Pavement cores obtained from the roadway indicated that the existing pavement consists of hot mix asphalt (HMA) over Portland Cement Concrete (PCC). Below the surface cover, the test borings encountered soft to stiff clay (A-6) to depths ranging from 8 to 14 feet. Below the upper clay layer, stiff to hard glacial tills described as clay or sandy clay loam of A-6 and A-4 soil categories were encountered. Intermittent sand and gravel layers were encountered with the tills to the terminus depth of borings. Groundwater was recorded during the drilling operation at depths below 3 feet from the surface.

Bridge: Available bridge plan indicates that the bottom of the pile caps of Bents 1 and 4 are at about Elevation 927.0 feet while Piers 2 and 3 are at about Elevation 910.0 feet. The anticipated Q_{100} and Q_{500} scour elevations are at 894.70 and 889.09 feet, respectively. Bents 1 and 4 will be protected with 24" revetment riprap over geotextiles. The interior piers will be constructed as wall piers.

The proposed bridge may be supported on a deep foundation system consisting of HP 12x53 or HP 12x74 steel piles seated into the glacial deposits. The piles may be designed for a factored design soil resistance (R_R) provided in Table 5 of the geotechnical report. Note that hard driving is expected through the underlying glacial deposits. Also, cobbles or boulders are known to be present within these deposits. The pile tip elevations presented in Table 4 of the geotechnical report could vary depending upon the consistency of encountered soils; therefore the provided pile tip elevations should be considered an estimate. Pile driving should be performed in accordance with INDOT Standard Specifications (ISS), Section 701.05(b). All piles should be protected with pile attachments.

Pavement Considerations: The roadway improvement involves full depth pavement replacement and mill/overlay. Full depth pavement is planned for approximately 71 feet of roadway length. Milling and overlay of 1.5 inches HMA would be performed for approximately 93 feet of roadway length. The proposed grade of the bridge approaches will constructed at or near the existing grade for about 132 feet in length.

The proposed pavement may be designed using the soil parameters provided below in Table A. The recommended subgrade treatment should be performed in accordance with INDOT Standard Specifications 207. Subsequent to removal of existing pavement and site grading, the exposed foundation soils should be proofrolled in accordance with 203.26, if applicable. A modified subgrade treatment Type ID shall be used for full depth patches in accordance with the attached

special provisions in Appendix F of the geotechnical report. A Geotextile in accordance with 918.02(c), Type 2A shall be placed over the excavated area. Foundation improvement will be at the discretion of the Engineer.

Table A – Soil Parameters for Pavement Design

Resilient Modulus (M_R) of Prepared Subgrade	10,000
Resilient Modulus (M_R) of Natural Subgrade	3,500
Predominant Soil Type	Clay (A-6)
Percent Passing #200	54
% Silt	15
LL	31
PL	13
PI	18
Depth to Water Table	> 3 feet below existing grade
Average Density (pcf) of Natural Subgrade	125
Average Moisture (%) of Natural Subgrade	18
Organic Content	N/A
Marl Content	N/A
Sulfate Content (ppm)	< 20
Rock Depth	> 90 feet below existing grade
Geotextile for Underdrains	918.02(b) Type 1A (NW) [(1)]
Subgrade Treatment	Type ID

[(1)] For underdrain trench < 3 ft deep.

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MODIFIED SUBGRADE TREATMENT

I. PROJECT LOCATION AND DESCRIPTION

The project is located on US 52 over Mud Creek, approximately 5.46 miles west of SR 44 in Rush County, Indiana. The project involves replacement of existing three span reinforced concrete slab bridge with a new bridge as summarized below.

A. **Bridge**: Bridge plans prepared by HNTB Indiana, Inc. dated 02/01/2019 indicate that the existing three span bridge will be replaced with three-spans continuous reinforced concrete slab bridge with span lengths of 27'-0", 36'-0" and 27-0". The end bents will be constructed over a pile foundation system and will be protected with 24" Class 1 revetment riprap over geotextiles. The interior piers will be constructed as wall piers. The plans indicate that the anticipated Q_{100} and Q_{500} low scour elevations are at 894.70 and 889.09 feet, respectively.

B. **Roadway**: The roadway improvement involves full depth pavement replacement and mill/overlay. Full depth pavement is planned from Stations 457+01.96 to 457+51.00 and 458+83 to 459+04.97 Line "A", approximately 71 feet of roadway length. Milling and overlay of 1.5 inches HMA would be performed from Stations 456+53.91 to 457+01.96 and 459+04.97 to 460+50.00 Line "A", approximately 93 feet of roadway length. The projected AADT for the year 2040 is 3,739 VPD with 11.57% truck traffic.

II. SUBSURFACE INVESTIGATION

Three (3) structure test borings, designated as TB-1, TB-2 and TB-3 were drilled in the vicinity of the proposed bridge bents and piers to depths of 70.0 feet, 93.5 feet and 70.0 feet below existing grade, respectively. Test Boring TB-3 encountered bouldery zone at a depth of 14 feet which required us to offset the boring to TB-3A where another bouldery zone was encountered. Then, the boring was relocated to TB-3B where concrete rubbles were encountered at a depth of 14 feet. Then, the test boring was relocated to TB-3C on the left side of the roadway. Additionally, two (2) roadway borings, designated as RB-1 and RB-2, were drilled to a depth of 10.0 feet each below existing grade, and two (2) pavement cores PC-1 and PC-2 were obtained from the existing pavement at the same location of the roadway test borings. Stations and offsets of the test borings and pavement cores are shown on the attached Test Boring Records and Pavement Core Reports in Appendix B.

The test borings were advanced with an ATV mounted drilling rigs utilizing solid flight Auger (SFA) and hollow stem augers (HSA) between the time period of May 6th, 2019 and May 10th, 2019. Standard Penetration tests were conducted using 140-pound automatic hammers falling 30 inches to drive 2-inch O.D. split barrel samplers for 18 inches.

Soil samples obtained from the drilling operation were preserved in glass jars and visually classified in the field by the drilling crew and in the laboratory by an engineer. The recovered soil samples were tested for Natural Moisture Content. Representative soil samples were also tested for pH, Water Soluble Sulfate, Atterberg Limits, Grain Size Distribution and Unconfined Compressive Strength.

Drilling, soil sampling and laboratory testing were performed following standard geotechnical engineering practices, INDOT and current AASHTO/ASTM procedures. Results from field tests are shown on the enclosed Test Boring Records in Appendix B and laboratory test sheets in Appendix C.

Stations, offsets and elevations of the test borings were interpolated from the plans prepared by HNTB Indiana, Inc. dated 02/01/2019. Test boring and pavement core locations shown on the Test Boring Records and Pavement Core Report should be considered approximate.

III. FINDINGS

The pavement cores obtained from the roadway indicated that the existing pavement consists of hot mix asphalt (HMA) over Portland Cement Concrete (PCC). Thickness and details of the pavement cores are shown on the attached Pavement Core Report in Appendix B and summarized below in Table 1.

Table 1 – Summary of Pavement Thickness in Pavement Cores

Pavement Core No.	Location	Station	Offset	Line	Pavement Thickness (inches)	
					HMA	PCC
PC-1	WB/Driving	456+50	6’ Lt	A	9-0”	9-0”
PC-2	EB/Driving	460+50	6’ Rt	A	8-1/2”	9-1/2”

The test borings encountered full depth HMA or cement concrete pavement as summarized below in Table 2. Thickness of the pavement encountered in the test borings should be considered an estimate and pavement type was visually observed in the hole. No actual pavement cores were obtained in TB-1, TB-3 and TB-3C.

Table 2 – Summary of Pavement Thickness in Test Borings

Test Boring No.	Location	Station	Offset	Line	Pavement Thickness (inches)	
					HMA	PCC
TB-1	Shoulder	457+60	13' Rt	A	12-0"	---
TB-2	Bridge Deck	458+10	15' Lt	A	---	17-1/2"
TB-3	Shoulder	458+70	14' Rt	A	12-0"	---
TB-3C	Shoulder	458+83	15' Lt	A	8-0"	---

Samples collected from the upper 1 to 3 inches of the existing surficial soils (topsoil) exhibited the results summarized below in Table 3. Laboratory test results are included in Appendix C.

Table 3 – Topsoil Test Results*

Designation	Station	Offset	Tested Depth (inch)	pH	Gravel	Sand	Silt	Clay	Organic Content (% by Weight)	Phosphorus (ppm)	Potassium (ppm)
					(% by Weight)						
TS-1	457+00	25' Rt	1-6	6.9	21	66	3	10	9.7	63	122
TS-2	459+50	30' Lt	1-6	7.0	23	58	13	7	9.3	62	182
TS-3	460+50	20' Rt	1-6	7.1	21	66	8	6	6.5	69	100

* All existing topsoil test results presented herein are for information only.

Below the surface cover, the test borings encountered soft to stiff clay (A-6) to depths ranging from 8 to 14 feet below the existing surface. Below the upper clay layer, stiff to hard glacial tills described as clay or sandy clay loam of A-6 and A-4 soil categories. Intermittent sand and gravel layers were encountered with the tills to the terminus depth of borings.

Detailed information of soil type and standard penetration values are shown in the Test Boring Records in Appendix B.

The cohesive soil below the pavement exhibited Liquid Limit (LL) value of 31.5 percent and Plasticity Index (PI) value of 18.2 percent. Natural moisture content values of the soils ranged from 13.3 to 22.3 percent. The pH values of the subgrade soils ranged from 7.6 to 7.8. The sulfate content of the tested sample was determined to be less than 20 ppm. Test results are shown on the laboratory testing sheets in Appendix C.

Groundwater was recorded during the drilling operation as shown on the attached Test Boring Records in Appendix B and summarized below in Table 3. It should be noted that fluctuations in groundwater levels should be expected over time due to variations in precipitation and water levels of Mud Creek.

Table 4 – Groundwater Readings

Boring No.	Groundwater Depth (feet)			Cave-in Depth (feet)
	During Drilling	At Completion	Delayed Reading	
RB-1	Dry	Dry	Dry @ 24 Hrs.	8.5
RB-2	3.6	8.0	2.7 @ 24 Hrs.	8.3
TB-1	12	16.8	11.5 @ 24 Hrs.	44.0
TB-2*	---	---	---	---
TB-3A	13.0	16.0	---	33.0

* Drilled through the bridge deck over the creek.

IV. DISCUSSION AND RECOMMENDATIONS

A. Bridge

1. Seismic Coefficients

Based on the soil type, Standard Penetration Test (SPT) and/or estimated average Undrained Shear Strength (S_u), the Site Class for the specific bridge meets the requirements of Class D in accordance with AASHTO LRFD Bridge Design Specifications 8th Edition (2017) Table 3.10.3.1-1. Using a Site Class D and a Peak Ground Acceleration Coefficient A_s = 0.066 results in an Acceleration Coefficient (S_{D1}) of 0.13. From Table 3.10.6-1, Seismic Zones, an Acceleration Coefficient (S_{D1}) of 0.13 indicates the site is in Seismic Zone 1. In accordance with INDOT Geotechnical Design Memorandum No. 2010-02, liquefaction assessment is not required because the site is determined to be in Seismic Zone 1.

2. Bridge Support

The available bridge plan indicates that the bottom of the pile caps of Bents 1 and 4 are at about Elevation 927.0 while Piers 2 and 3 are at about Elevation 910 feet. The anticipated Q_{100} and Q_{500} scour elevations are at 894.70 and 889.09 feet, respectively. Bents 1 and 4 will be protected from scour with spill through slopes with 24" rip rap over geotextiles.

Based upon the above considerations, the proposed bridge may be supported on a deep foundation system consisting of HP 12x53 or HP 12x74 steel piles seated into the glacial deposits. The piles may be designed for a factored design soil resistance (R_R) provided in Table 5.

Note that hard driving is expected through the sand and gravel and glacial till deposits. Also, cobbles or boulders are known to be present within the glacial deposits. The pile tip elevations presented in Table 5 could vary depending upon the consistency of encountered soils; therefore the provided pile tip elevations should be considered an estimate.

The pile recommendations are presented in accordance with INDOT Office of Geotechnical Engineering Load and Resistance Factor Design policy for Foundations and the AASHTO LRFD Bridge Design Specifications 8th Edition (2017). General recommendations for the bridge are provided below

a. Pile driving should follow INDOT Standard Specifications (ISS) Section 701.05 (b). A minimum of one pile at one end bent and one interior pier shall be tested using Pile Driving Analyzer (PDA). An indicator test pile shall be driven first at each bent and re-struck after 3 days in accordance with ISS 701.05(b). All piles shall be driven to the required nominal driving resistance and the piles should be maintained within location and alignment tolerance in accordance with ISS Section 701.09 (b).

b. As shown in Appendix E, the Wave Equation analyses indicate that a hammer with a rated energy of about 75 ft-kips may be required for driving the piles to the nominal driving resistances provided in Tables 3 and 4. Additional drivability analyses will be required when the contractor submits a pile driving hammer for approval.

c. All piles shall be protected with pile tip attachments due to driving into the underlying hard sandy clay loam and/or clay layers and possible cobbles and boulders. Pile tip attachments should be in accordance with ISS Sections 915.01.

d. The spacing between piles should not be less than three (3) times the pile diameter measured from center-to-center of piles.

e. No corrosion protection is needed for the piles as determined by the pH values of the soils.

f. The proposed revetment rip rap at Bents 1 and 4 shall be placed over geotextiles 918.02(a) Type 1A (NW).

Table 5 – Resistance for Design and Driving of Piles

Summary of Static and Driving Resistances				
Bent/Pier	Bents 1 & 4	Piers 2 & 3	Bents 1 & 4	Piers 2 & 3
Pile Size and Type Pile Wall Thickness (inch) Grade of Steel (ksi)	HP 12x53 --- 50 ksi	HP12x53 --- 50 ksi	HP 12x74 --- 50 ksi	HP 12x74 --- 50 ksi
Factored Design Soil Resistance per Pile, R_R (kips)	298	248	347	295
Resistance Factor, Φ_{dyn}	0.70	0.70	0.70	0.70
Downdrag Load, DD (kips)	0	0	0	0
Nominal Soil Resistance, R_n (kips)	426	354	495	422
Downdrag Friction, R_{sdd} (kips)	0	0	0	0
Scour Zone Friction, $R_{s\ scour}$ (kips)	0	72	0	73
Maximum Relaxation in Shale (kips)	0	0	0	0
Nominal Driving Resistance, R_{ndr} (kips)*	426	426	495*	495*
Estimated Pile Tip Elevation	±868	±844	±855	±838
Method of Testing – Dynamic Pile Load (PDA) in accordance with ISS 701.05(b)				

* *Based on WEAP analyses using D 30-32 pile hammer with a rated energy of about 75 ft-kips, HP 12x74 designed for Ultimate Capacity of 600 kips will require blowcounts greater than 120 bpf. Nominal Driving Resistance of 495 kips meets the allowable criteria for compression stress and number of blows per foot. Therefore, design of HP12x74 for an ultimate capacity of 600 kips is not adequate if D 30-32 or equivalent hammer rated energy should be used.*

B. Pavement Considerations

The proposed pavement may be designed using the soil parameters provided below in Table 6. The recommended subgrade treatment should be performed in accordance with INDOT Standard Specifications 207.

In areas of full depth pavement replacement and where full depth patching will be needed, the exposed foundation soils should be proofrolled in accordance with 203.26, where applicable. A subgrade treatment Type ID shall be used in accordance with the attached USP in Appendix F. Geotextiles in accordance with 918.02(c), Type 2 B shall be placed over the excavated area. Foundation improvement will be at the discretion of the Engineer.

Table 6 – Soil Parameters for Pavement Design

Resilient Modulus (M_R) of Prepared Subgrade	10,000
Resilient Modulus (M_R) of Natural Subgrade	3,500
Predominant Soil Type	Clay (A-6)
Percent Passing #200	54
% Silt	15
LL	31
PL	13
PI	18
Depth to Water Table	> 3 feet below existing grade
Average Density (pcf) of Natural Subgrade	125
Average Moisture (%) of Natural Subgrade	18
Organic Content	N/A
Marl Content	N/A
Sulfate Content (ppm)	< 20
Rock Depth	> 90 feet below existing grade
Geotextile for Underdrains	918.02(b) Type 1A (NW) [(1)]
Subgrade Treatment	Type ID

[(1)] For underdrain trench < 3 ft deep.

C. Embankments

General site preparation and recommendations for embankment construction and fill placement are provided in the following paragraphs.

1. All surface objects including trees, tree stumps, grass, vegetation, surficial soils and roots, located within the construction limits, shall be cleared and grubbed in accordance with ISS Section 201. Soft/wet soils or loose/wet soils if encountered shall be removed and replaced with B borrow to a maximum depth of 24 inches. Foundation improvement will be at the discretion of the Engineer.

2. Ponding water and perched water may be encountered particularly after heavy rains. During earthwork operations, care should be taken to provide adequate drainage on the exposed soils. Ditches must be kept open at all times, and the subgrade shall be graded at the end of each day, to facilitate good drainage.

3. Embankment may be constructed at a slope rate no steeper than 3:1 (Horizontal to Vertical) or as shown on the plans. All slopes should be seeded and growth of vegetation permitted to limit soil erosion and sloughing.

4. Proposed embankment fills placed on existing embankments shall be benched and compacted in accordance with Section 203.21.

5. Borrow material needed in fill areas should be in accordance with ISS Section 211. Topsoil and/or organically contaminated materials are not acceptable for use as backfill.

6. The backfill should be placed and compacted in accordance with ISS Section 203. The fill should not be placed in a frozen condition or over a frozen subgrade.

7. Roadside ditches sloping at a rate of 3 percent or steeper should be seeded and/or protected with riprap or other erosion protection.

8. Temporary excavation more than 5.0 feet in depth should be sloped and/or shored according to OSHA requirements.

D. General Site Preparation and Earthwork

The following general site preparation and earthwork recommendations are provided.

1. All surface objects, pavement, grass, vegetation, topsoil and roots, located within the construction limits, shall be cleared and grubbed in accordance with ISS Section 201.

2. Subsequent to removal of existing pavement and site grading, the exposed foundation soils shall be proofrolled and modified as recommended above in section B. Foundation improvement will be at the discretion of the Engineer.

3. During earthwork operations, care should be taken to provide adequate drainage on the exposed soils. The subgrade should be graded at the end of each day to facilitate good drainage.

4. Borrow material needed in fill areas should be in accordance with ISS Section 211. Topsoil and/or organically contaminated materials are not acceptable for use as backfill.

5. The backfill should be placed and compacted in accordance with ISS Section 203. The engineered fill should not be placed in a frozen condition or over a frozen subgrade.

6. All subgrade soils and pavement materials should conform to the latest issue of INDOT Construction and Material Specifications.

V. CONCLUDING REMARKS

The evaluations, conclusions, and recommendations in this report are based on our interpretation of the field and laboratory data obtained during the exploration, information available at the time of this report, our understanding of the project scope at the time of the report and our experience with similar sites and subsurface conditions using generally accepted geotechnical engineering practices. Although individual test borings are representative of the subsurface conditions at the boring locations on the dates drilled, they are not necessarily representative of the subsurface conditions between boring locations or subsurface conditions during other seasons of the year. If the scope of the project changes the recommendations may change and may require additional investigation.

During the design process, it is recommended that CTL work with the project designers to confirm that the geotechnical recommendations are properly incorporated into the final plans and specifications, and to assist with establishing criteria for the construction observation and testing. CTL is not responsible for independent conclusions, opinions and recommendations made by others based on the data and the recommendations provided in this report.

The report was prepared by CTL Engineering, Inc. (Consultant) solely for the use of the Client in accordance with an executed contract. The Client's use of or reliance on this report is limited by the terms and conditions of the contract and by the qualifications and limitations stated in the report. It is also acknowledged that the Client's use of and reliance of this report is limited for reasons which include: actual site conditions that may change with time; hidden conditions, not discoverable within the scope of the assessment, may exist at the site; and the scope of the investigation may have been limited by time, budget and other constraints imposed by the Client.

Neither the report, nor its contents, conclusions nor recommendations are intended for the use of any party other than the Client. Consultant and the Client assume no liability for any reliance placed on this report by such party. The rights of the Client under contract may not be assigned to any person or entity, without the consent of the Consultant which consent shall not be unreasonably withheld.

This geotechnical report does not address the environmental conditions of the site. The Consultant is not responsible for consequences or conditions arising from facts that were concealed, withheld, or not fully disclosed at the time the assessment was conducted.

To the fullest extent permitted by law, the Consultant and Client agree to indemnify and hold each other, and their officers and employees harmless from and against claims, damages, losses and expenses arising out of unknown or concealed conditions. Furthermore, neither the Consultant nor its employees shall be liable to the Owner in an amount in excess of the available professional liability insurance coverage of the Consultant. In addition, Client and Consultant agree neither shall be liable for any special, indirect or consequential damages of any kind or nature.

The Consultant's services have been provided consistent with its professional standard of care. No other warranties are made, either expressed or implied.

Sincerely,

CTL ENGINEERING, INC.

Ali Karaki, P.E.
Principal Engineer

Kiran Ramesh, EIT
Staff Geotechnical Engineer

APPENDIX A

GENERAL SITE PLAN
BORING LOCATION PLAN

PROJECT	DESIGNATION
1006266	1006266
CONTRACT	BRIDGE FILE
B-35450	052-70-10277

STRUCTURE INFORMATION

STRUCTURE	TYPE	SPAN AND SKEW	OVER	STATION
052-70-10277	CONTINUOUS REINF. CONCRETE SLAB BRIDGE	3 SPANS: 27'-0", 36'-0", 27'-0" SKEW: 00°00'00"	MUD CREEK	458+17, Line "A"

INDIANA DEPARTMENT OF TRANSPORTATION

BRIDGE PLANS

FOR SPANS OVER 20 FEET

ROUTE: US 52 AT: RP 119+92

PROJECT NO. 1006266 (P.E., CONST.)

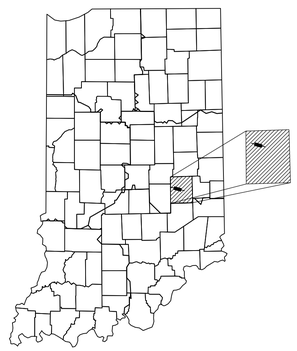
NO ADDITIONAL RIGHT-OF-WAY REQUIRED FOR THIS PROJECT

TRAFFIC DATA

A.A.D.T.	2020	3371	V.P.D.
A.A.D.T.	2040	3739	V.P.D.
D.H.V.	2040	366	V.P.H.
DIRECTIONAL DISTRIBUTION		50.26	%
TRUCKS		11.57	% A.A.D.T.
		10.43	% D.H.V.

DESIGN DATA

DESIGN SPEED	55	MPH
PROJECT DESIGN CRITERIA	3R (NON-FREEWAY)	
FUNCTIONAL CLASSIFICATION	MINOR ARTERIAL	
RURAL/URBAN	RURAL	
TERRAIN	LEVEL	
ACCESS CONTROL	N/A	



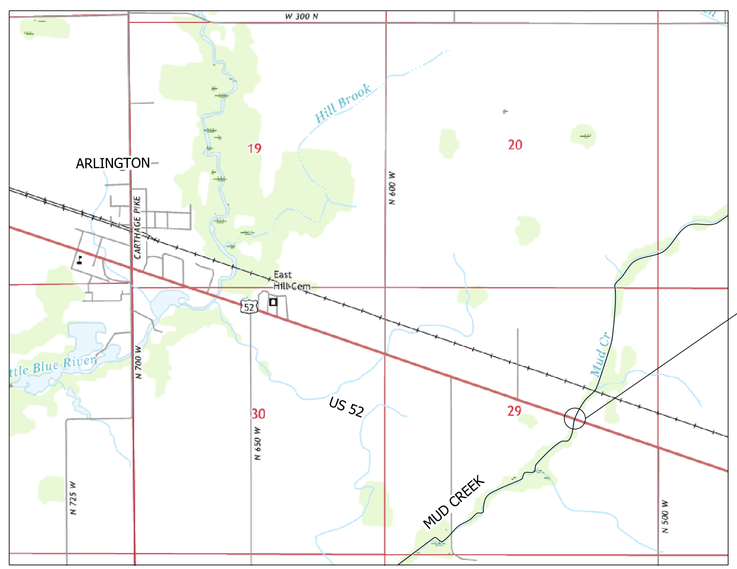
PROJECT LOCATION SHOWN BY

LATITUDE: 39° 37' 59" LONGITUDE: 85° 32' 41"

BRIDGE LENGTH:	0.017	MI.
ROADWAY LENGTH:	0.058	MI.
TOTAL LENGTH:	0.075	MI.
MAX. GRADE:	± 0.50	%

HYDROLOGIC UNIT CODE: 05120205040040

NEW BRIDGE CONSTRUCTION ON US 52 OVER MUD CREEK, LOCATED APPROXIMATELY 5.46 MILES WEST OF SR 44, IN SECTION 29, T-14-N, R-9-E, POSEY TOWNSHIP, RUSH COUNTY, INDIANA.



BRIDGE FILE NO 052-70-10277
US 52 OVER MUD CREEK

NOT TO SCALE

LOCATION MAP
(RUSH COUNTY)

NOTE TO REVIEWER

PLEASE SEE CORRESPONDENCE FILE FOR DOCUMENTATION OF DESIGN DECISIONS

STAGE 1 PLANS
APRIL 16, 2019

INDIANA DEPARTMENT OF TRANSPORTATION
STANDARD SPECIFICATIONS DATED 2018
TO BE USED WITH THESE PLANS.

HNTB Indiana, Inc.
The HNTB Companies
Infrastructure Solutions
111 Monument Circle
Suite 1200
Indianapolis, IN 46204

DRAFT
NOT FOR CONSTRUCTION

PLANS PREPARED BY: HNTB Indiana, Inc. (317) 636-4682 PHONE NUMBER

CERTIFIED BY: DATE

APPROVED FOR LETTING: INDIANA DEPARTMENT OF TRANSPORTATION DATE

BRIDGE FILE	
052-70-10277	
DESIGNATION	
1006266	

SURVEY BOOK	SHEETS		
ELECTRONIC	1	of	10
CONTRACT	PROJECT		
B-35450	1006266		

cvhayden
2/1/2019 1:11:32 pm
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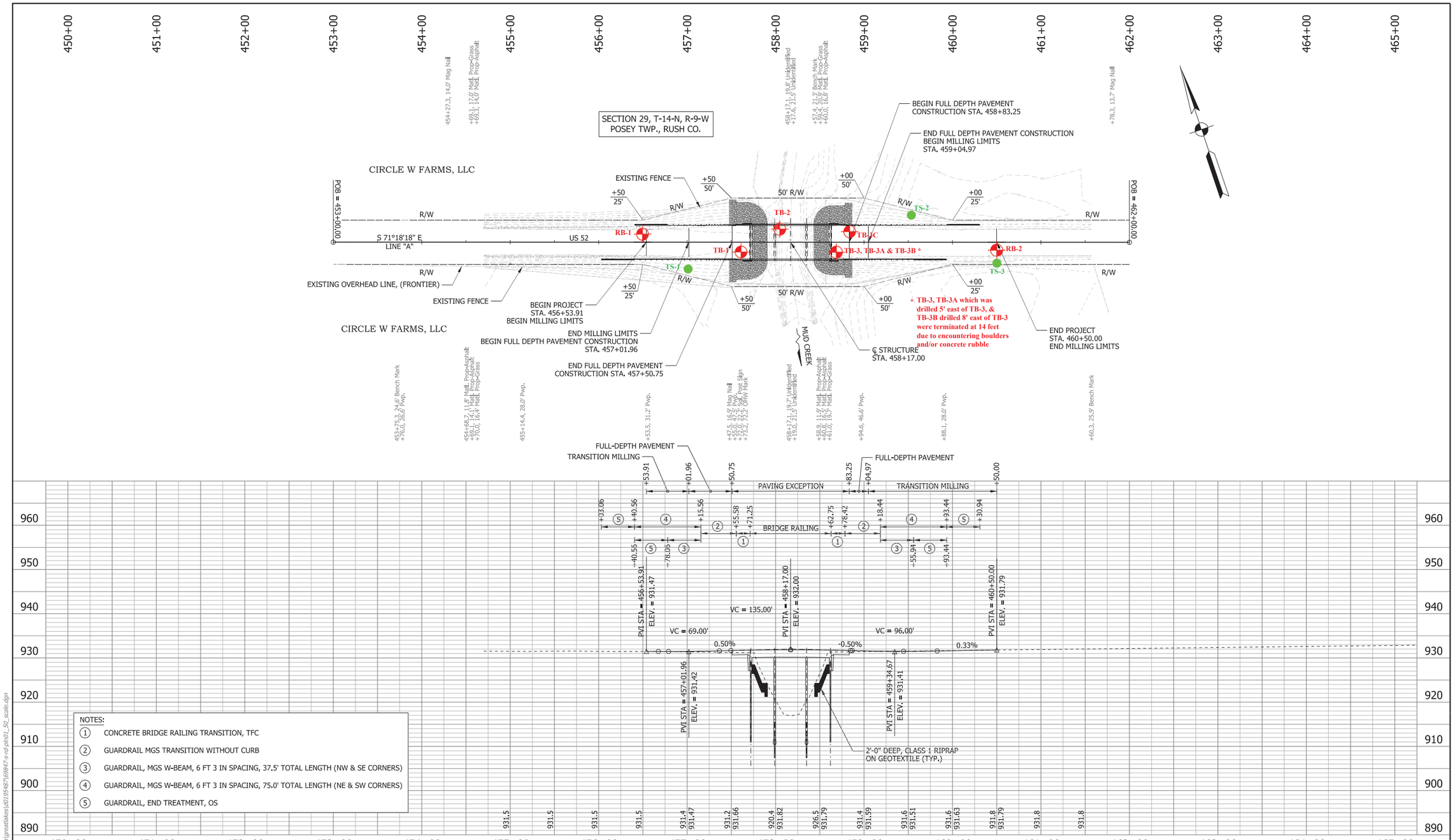

DRAFT
NOT FOR CONSTRUCTION

RECOMMENDED FOR APPROVAL _____ DESIGN ENGINEER DATE

DESIGNED: JWC DRAWN: CVH
CHECKED: MSS CHECKED: JWC

INDIANA
DEPARTMENT OF TRANSPORTATION

PLAN AND PROFILE
LINE "A"

HORIZONTAL SCALE	BRIDGE FILE
1" = 50'	052-70-10277
VERTICAL SCALE	DESIGNATION
1" = 10'	1006266
SURVEY BOOK	SHEETS
ELECTRONIC	5 of 10
CONTRACT	PROJECT
B-35450	1006266

cvhayden
2/1/2019 2:21:05 pm
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APPENDIX B

TEST BORING RECORDS
PAVEMENT CORE REPORT

CTL ENGINEERING INC.

SOIL DESCRIPTION

NON-COHESIVE SOIL DESCRIPTION	STANDARD PENETRATION BLOWCOUNTS PER FOOT (BPF)
Very Loose	0 - 5
Loose	6 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	Over 50

COHESIVE SOIL DESCRIPTION	STANDARD PENETRATION BLOWCOUNTS PER FOOT (BPF)
Very Soft	0 - 3
Soft	4 - 5
Medium Stiff	6 - 10
Stiff	11 - 15
Very Stiff	16 - 30
Hard	Over 30

GRADATION COMPONENT	SIZE
Boulders	Retained on 8"
Cobbles	Passing 8" Retained on 3"
Gravel	Passing 3" Retained on #10
Sand	Passing #10 Retained on #200
Silt	0.075 mm to 0.002 mm
Clay	Smaller than 0.002 mm

MOISTURE TERMS	DESCRIPTION
Dry	Powdery
Slightly Moist	Below Plastic Limit
Moist	Above Plastic, Below Liquid
Very Moist	At Liquid
Wet	Above Liquid

CTL ENGINEERING INC

TEST BORING RECORD

CLIENT	Indiana Department of Transportation	BORING NO.	RB- 1
PROJECT	Bridge Replacement	SHEET	1 OF 1
ROUTE NO.	US 52	COUNTY	Rush
DATE STARTED	05-08-19		
LOCATION	US 52 over Mud Creek	DATE COMPLETED	05-09-19
DES NO.	1006266	PROJECT NO:	19050015
CTL PROJECT NO	19050015IND		

Boring Elevation	931.0 Feet	Boring Depth	10.0 feet	Boring Method	SFA
Latitude	39.63323931	Station	456+50	Rig Type	CME-550 ATV
Longitude	-85.545371	Offset	6.0 feet Lt	Casing Diameter	4" O.D.
		Line	"A"	Core Size	---

Hammer	Automatic
Hammer Efficiency	87.4
Driller/Inspector	ED/DW
Temperature	72° F
Weather	Sunny

GROUNDWATER: Encountered at Dry; At completion Dry; Dry After 24 hours; Caved in at 8.5 feet

Stratum Elevation	Sample Depth	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12"	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	Atterberg Limits LL	PL	PI
930.2		**ASPHALT CONCRETE** (9") (Visual)	0.8										
929.5		**CEMENT CONCRETE** (9") (Visual)	1.5										
	2.5	Brown and Gray, Moist, Medium Stiff to Very Stiff, **CLAY** A-6 (7), Lab 1		SS-1	3 3 3	6	83	22.3					
				SS-2	3 3 4	7	100	23.1					
	5.0			SS-3	5 6 8	14	83	15.3					
	7.5			SS-4	6 7 9	16	100	21.8					
				SS-5	4 4 5	9	100	23.1					
921.0	10.0	**Bottom of Boring at 10.0 feet**	10.0										
		Boring backfilled in accordance with INDOT requirements and pavement restored with concrete patch.											
	12.5												
	15.0												

BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling	AC - Auger Cuttings	DCP - Dynamic Cone Penetrometer Test
HA - Hand Auger	SBS - Subbase Sample	

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TEST BORING RECORD

CLIENT : Indiana Department of Transportation
BORING NO. : **RB- 1A**
PROJECT : Bridge Replacement
SHEET : 1 OF 1
ROUTE NO. : US 52
COUNTY : Rush
DATE STARTED : 05-08-19
LOCATION : US 52 over Mud Creek
DATE COMPLETED : 05-09-19
DES NO. : 1006266
PROJECT NO: 19050015
CTL PROJECT NO : 19050015IND

Boring Elevation: 931.0 Feet
Latitude : 39.63323931
Longitude -85.545371
Boring Depth : 3.5 feet
Station : 456+55
Offset : 6.0 feet Lt
Line : "A"
Boring Method : SFA
Rig Type : CME-550 ATV
Casing Diameter : 4" O.D.
Core Size : ---
Hammer : Automatic
Hammer Efficiency 87.4
Driller/Inspector : ED/DW
Temperature : 72° F
Weather : Sunny

GROUNDWATER: Encountered at Dry At completion Dry

Stratum Elevation	Sample Depth	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12"	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	Atterberg Limits LL	PL	PI
		Refer to RB-1 for Soil Descriptions.											
	2.5			ST-1			50	23.4	129.3	2.501 @ 7.7%	32	13	18
927.5		**Bottom of Boring at 3.5 feet**	3.5										
	5.0	Boring backfilled in accordance with INDOT requirements and pavement restored with concrete patch.											
	7.5												
	10.0												
	12.5												
	15.0												

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
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MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling	AC - Auger Cuttings	DCP - Dynamic Cone Penetrometer Test
HA - Hand Auger	SBS - Subbase Sample	

TEST BORING RECORD

CLIENT	: Indiana Department of Transportation	BORING NO. :	**RB- 2**
PROJECT	: Bridge Replacement	SHEET :	1 OF 1
ROUTE NO.	: US 52 COUNTY : Rush	DATE STARTED :	05-08-19
LOCATION	: US 52 over Mud Creek	DATE COMPLETED :	05-08-19
DES NO.	: 1006266 PROJECT NO: 19050015	CTL PROJECT NO :	19050015IND

Boring Elevation: 931.0 Feet	Boring Depth : 10.0 feet	Boring Method : SFA	Hammer : Automatic
Latitude : 39.6328444	Station : 460+50	Rig Type : CME-550 ATV	Hammer Efficiency : 87.4
Longitude : -85.54404061	Offset : 6.0 feet Rt	Casing Diameter : 4" O.D.	Driller/Inspector : ED/DW
	Line : "A"	Core Size : ---	Temperature : 78° F
			Weather : Sunny

GROUNDWATER: Encountered at 3.6 feet At completion 8.0 feet 2.7 feet After 24 hours Caved in at 8.3 feet

Stratum Elevation	Sample Depth	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12"	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	Atterberg Limits LL	PL	PI
930.3		**ASPHALT CONCRETE** (8.5") (Visual)	0.7										
929.5		**CEMENT CONCRETE** (9.5") (Visual)	1.5										
	2.5	Brown and Gray, Moist to Wet, Medium Stiff to Stiff, **CLAY** Sand Seam at 3.5 feet A-6, As Lab 1		SS-1	3 3 4	7	100	14.8					
				SS-2	3 2 3	5	83	13.2					
	5.0			SS-3	3 4 5	9	100	14.6					
	7.5			SS-4	4 5 7	12	100	10.2					
923.0			8.0										
		Brown, Moist, Stiff to Very Stiff, **CLAY (TILL)** A-6, As Lab 2		SS-5	5 7 10	17	100	8.2					
921.0	10.0	**Bottom of Boring at 10.0 feet**	10.0										
		Boring backfilled in accordance with INDOT requirements and pavement restored with concrete patch.											
	12.5												
	15.0												

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling	AC - Auger Cuttings	DCP - Dynamic Cone Penetrometer Test
HA - Hand Auger	SBS - Subbase Sample	

TEST BORING RECORD

CLIENT	Indiana Department of Transportation	BORING NO.	RB- 2A
PROJECT	Bridge Replacement	SHEET	1 OF 1
ROUTE NO.	US 52 COUNTY: Rush	DATE STARTED	05-08-19
LOCATION	US 52 over Mud Creek	DATE COMPLETED	05-08-19
DES NO.	1006266 PROJECT NO: 19050015	CTL PROJECT NO	19050015IND

Boring Elevation: 931.0 Feet	Boring Depth: 3.5 feet	Boring Method: SFA	Hammer: Automatic
Latitude: 39.6328444	Station: 460+55	Rig Type: CME-550 ATV	Hammer Efficiency: 87.4
Longitude: -85.54404061	Offset: 6.0 feet Rt	Casing Diameter: 4" O.D.	Driller/Inspector: ED/DW
	Line: "A"	Core Size: ---	Temperature: 78° F
			Weather: Sunny

GROUNDWATER: Encountered at Dry At completion Dry

Stratum Elevation	Sample Depth	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12"	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	Atterberg Limits LL	PL	PI
	2.5	**Refer to RB-2 for Soil Descriptions.**		ST-1			40	15.3	123.8	2.109 @ 15.0%			
927.5		**Bottom of Boring at 3.5 feet**	3.5										
	5.0	Boring backfilled in accordance with INDOT requirements and pavement restored with concrete patch.											
	7.5												
	10.0												
	12.5												
	15.0												

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling	AC - Auger Cuttings	DCP - Dynamic Cone Penetrometer Test
HA - Hand Auger	SBS - Subbase Sample	

TEST BORING RECORD

CLIENT	Indiana Department of Transportation	BORING NO.	TB- 1
PROJECT	Bridge Replacement	SHEET	1 OF 4
ROUTE NO.	US 52 — COUNTY: Rush	DATE STARTED	05-06-19
LOCATION	US 52 over Mud Creek	DATE COMPLETED	05-07-19
DES NO.	1006266 — PROJECT NO: 19050015	CTL PROJECT NO	19050015IND

Boring Elevation: 931.0 Feet	Boring Depth: 70.0 feet	Boring Method: HSA	Hammer: Automatic
Latitude: 39.63308192	Station: 457+60	Rig Type: CME-550 ATV	Hammer Efficiency: 87.4
Longitude: -85.54502478	Offset: 13.0 feet Rt	Casing Diameter: 3.25" I.D.	Driller/Inspector: ED/DW
	Line: "A"	Core Size: ---	Temperature: 70° F
			Weather: Sunny

GROUNDWATER: Encountered at 12.0 feet; At completion 16.8 feet; 11.5 feet After 24 hours; Caved in at 44.0 feet

Stratum Elevation	Sample Depth	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12"	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	Atterberg Limits LL	PL	PI
930.0		**ASPHALT CONCRETE** (12") (Visual)	1.0										
929.5		**SAND AND GRAVEL** (6") (Visual)	1.5										
	2.5	Brown, Moist, Loose to Very Loose, **SANDY LOAM** (Visual)		SS-1	4 3 3	6	100	15.9					
927.0			4.0	SS-2	2 2 3	5	83	19.6					
	5.0												
	7.5	Brown, Moist, Soft to Medium Stiff, **CLAY** (Sand Seam encountered at 12.0 feet) A-6, As Lab 1		SS-3	3 3 3	6	83	15.8					
	10.0			SS-4	3 2 3	5	100	24.6					
919.0			12.0										
	12.5	Brown and Gray, Moist, Stiff to Very Stiff, **CLAY (TILL)** A-6 (9), Lab 2		SS-5	4 5 7	12	100	9.7					
	15.0												

Continued on next page

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling	AC - Auger Cuttings	DCP - Dynamic Cone Penetrometer Test
HA - Hand Auger	SBS - Subbase Sample	

TEST BORING RECORD

CLIENT : Indiana Department of Transportation
BORING NO. : **TB- 1**
PROJECT : Bridge Replacement
SHEET : 2 OF 4

Stratum Elevation	Sample Depth	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12"	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	Atterberg Limits LL	PL	PI
	17.5												
	20.0			SS-6	6 8 12	20	100	9.4					
	22.5												
	25.0	Brown and Gray, Moist, Stiff to Very Stiff, **CLAY (TILL)** A-6 (9), Lab 2		SS-7	9 11 14	25	100	10.3	134.9	5.112 @ 14.2%	33	10	23
	27.5												
	30.0			SS-8	10 12 15	27	100	10.1					
	32.5												

Continued on next page

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling	AC - Auger Cuttings	DCP - Dynamic Cone Penetrometer Test
HA - Hand Auger	SBS - Subbase Sample	

TEST BORING RECORD

CLIENT : Indiana Department of Transportation
BORING NO. : **TB- 1**
PROJECT : Bridge Replacement
SHEET : 3 OF 4

Stratum Elevation	Sample Depth	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12"	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	Atterberg Limits LL	PL	PI
	35.0			SS-9	7 6 5	11	100	9.6	135.8	5.360 @ 8.9%			
	37.5	Brown and Gray, Moist, Stiff to Very Stiff, **CLAY (TILL)** A-6 (9), Lab 2											
892.0			39.0										
	40.0			SS-10	6 10 12	22	100	14.3					
	42.5	Brown, Wet, Medium Dense to Dense, **SAND AND GRAVEL** (Visual)											
	45.0			SS-11	11 14 17	31	100	9.6					
885.0			46.0										
	47.5												
	50.0	Gray, Moist, Hard, **SANDY CLAY LOAM (TILL)** A-4 (0), Lab 3		SS-12	9 13 19	32	100	16.2	129.7	9.123 @ 13.0%	18	12	7
	52.5												

Continued on next page

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling	AC - Auger Cuttings	DCP - Dynamic Cone Penetrometer Test
HA - Hand Auger	SBS - Subbase Sample	

TEST BORING RECORD

CLIENT : Indiana Department of Transportation

BORING NO. : **TB- 1**

PROJECT : Bridge Replacement

SHEET : 4 OF 4

Stratum Elevation	Sample Depth	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12"	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	Atterberg Limits LL	PL	PI
				SS-13	15 27 39	66	100	11.7					
	55.0	Gray, Moist, Hard, **SANDY CLAY LOAM (TILL)** A-4 (0), Lab 3											
	57.5												
871.5			59.5	SS-14	26 39 41	80	100	8.2					
	60.0	Brown and Gray, Wet, Very Dense, **SAND AND GRAVEL** with Traces of Clay (Visual)											
869.0			62.0										
	62.5												
	65.0	Brown and Gray, Moist, Hard, **SANDY CLAY LOAM (TILL)** with Traces of Large Gravel A-4, As Lab 3		SS-15	22 15 18	33	100	18.2					
	67.5												
				SS-16	19 23 26	49	100	19.2					
861.0	70.0	**Bottom of Boring at 70.0 feet**	70.0										

Boring backfilled in accordance with INDOT requirements and pavement restored with concrete patch.

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling	AC - Auger Cuttings	DCP - Dynamic Cone Penetrometer Test
HA - Hand Auger	SBS - Subbase Sample	

TEST BORING RECORD

CLIENT	Indiana Department of Transportation	BORING NO.	TB- 2
PROJECT	Bridge Replacement	SHEET	1 OF 4
ROUTE NO.	US 52	COUNTY	Rush
DATE STARTED	05-07-19		
LOCATION	US 52 over Mud Creek	DATE COMPLETED	05-07-19
DES NO.	1006266	PROJECT NO:	19050015
CTL PROJECT NO	19050015IND		

Boring Elevation	931.0 Feet	Boring Depth	93.5 feet	Boring Method	HSA
Latitude	39.63312255	Station	458+10	Rig Type	CME-550 ATV
Longitude	-85.54484363	Offset	15.0 feet Lt	Casing Diameter	3.25" I.D.
		Line	"A"	Core Size	---

Hammer	Automatic
Hammer Efficiency	87.4
Driller/Inspector	ED/DW
Temperature	75° F
Weather	Sunny

GROUNDWATER: Encountered at Dry At completion Dry

Stratum Elevation	Sample Depth	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12"	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	Atterberg Limits LL	PL	PI
929.5		**CEMENT CONCRETE** (17.5") (Visual)	1.5										
	2.5												
	5.0												
	7.5	**Space Between Bridge Deck and Water Surface**											
	10.0												
	12.5												
918.0			13.0										
917.0		**WATER** (12") (Visual)	14.0										
	15.0	Brown, Wet, Medium Dense, **SAND AND GRAVEL** with Traces of Cobbles (Visual)		SS-1	6 11 17	28	50	6.7					
914.0			17.0										
	17.5	Brown and Gray, Moist, Stiff to Hard, **CLAY (TILL)** with Traces of Gravel and Cobbles A-6, As Lab 2		SS-2	4 6 7	13	100	10.5					
	20.0												

Continued on next page

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling	AC - Auger Cuttings	DCP - Dynamic Cone Penetrometer Test
HA - Hand Auger	SBS - Subbase Sample	

TEST BORING RECORD

CLIENT : Indiana Department of Transportation

BORING NO. : **TB- 2**

PROJECT : Bridge Replacement

SHEET : 2 OF 4

Stratum Elevation	Sample Depth	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12"	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	Atterberg Limits LL	PL	PI
				SS-3	6 6 7	13	33	8.7					
	22.5			SS-4	4 6 6	12	83	11.3					
	25.0												
	27.5	Brown and Gray, Moist, Stiff to Hard, **CLAY (TILL)** with Traces of Gravel and Cobbles A-6, As Lab 2 (3 feet Heaving sand encountered and cleaned out at 28 feet)		SS-5	4 5 8	13	67	8.9					
	30.0												
	32.5			SS-6	17 22 26	48	100	10.2					
	35.0												
895.0			36.0										
	37.5			SS-7	8 13 15	28	100	11.7					
	40.0	Brown and Gray, Wet, Medium Dense to Dense, **GRAVELLY SAND** (Visual)											
	42.5			SS-8	9 15 18	33	100	23.8					
	45.0												

Continued on next page

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling	AC - Auger Cuttings	DCP - Dynamic Cone Penetrometer Test
HA - Hand Auger	SBS - Subbase Sample	

TEST BORING RECORD

CLIENT : Indiana Department of Transportation
BORING NO. : **TB- 2**
PROJECT : Bridge Replacement
SHEET : 3 OF 4

Stratum Elevation	Sample Depth	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12"	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	Atterberg Limits LL	PL	PI
885.0		Brown and Gray, Wet, Medium Dense to Dense, **GRAVELLY SAND** (Visual)	46.0										
	47.5			SS-9	12 16 19	35	83	7.5					
	50.0												
	52.5			SS-10	18 26 34	60	100	7.8					
	55.0												
	57.5	Gray, Moist, Hard, **CLAY (TILL)** with Traces of Gravel and Cobbles A-6, As Lab 2		SS-11	17 28 33	61	100	7.8					
	60.0												
	62.5			SS-12	36 47 50/4"		88	9.8					
	65.0												
	67.5			SS-13	15 19 23	42	100	15.2					
	70.0												

Continued on next page

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
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HA - Hand Auger	SBS - Subbase Sample	

TEST BORING RECORD

CLIENT : Indiana Department of Transportation

BORING NO. : **TB- 2**

PROJECT : Bridge Replacement

SHEET : 4 OF 4

Stratum Elevation	Sample Depth	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12"	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	Atterberg Limits LL	PL	PI
859.0		Gray, Moist, Hard, **CLAY (TILL)** with Traces of Gravel and Cobbles A-6, As Lab 2	72.0										
	72.5			SS-14	13 21 27	48	100	17.9					
	75.0												
	77.5			SS-15	22 31 36	67	83	15.9					
	80.0	Gray, Moist, Hard, **SANDY CLAY LOAM (TILL)** with Traces of Gravel A-4, As Lab 3											
	82.5			SS-16	11 14 18	32	100	18.1					
	85.0												
	87.5			SS-17	50/5"		100	17.1					
842.0			89.0										
	90.0	Brown and Gray, Wet, Very Dense, **SAND AND GRAVEL** with Traces of Cobbles Boulder encountered Auger Refusal at 79.5 feet (Visual)											
	92.5			SS-18	36 50/4"		100	9.8					
837.5		**Bottom of Boring at 93.5 feet**	93.5										
	95.0	Boring backfilled in accordance with INDOT requirements and pavement restored with concrete patch.											

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling	AC - Auger Cuttings	DCP - Dynamic Cone Penetrometer Test
HA - Hand Auger	SBS - Subbase Sample	

TEST BORING RECORD

CLIENT	Indiana Department of Transportation	BORING NO.	TB- 3
PROJECT	Bridge Replacement	SHEET	1 OF 1
ROUTE NO.	US 52 — COUNTY: Rush	DATE STARTED	05-10-19
LOCATION	US 52 over Mud Creek	DATE COMPLETED	05-10-19
DES NO.	1006266 — PROJECT NO: 19050015	CTL PROJECT NO	19050015IND

Boring Elevation: 931.0 Feet	Boring Depth: 14.0 feet	Boring Method: HSA	Hammer: Automatic
Latitude: 39.63298607	Station: 458+70	Rig Type: CME-550 ATV	Hammer Efficiency: 87.4
Longitude: -85.54465784	Offset: 14.0 feet Rt	Casing Diameter: 3.25" I.D.	Driller/Inspector: ED/DW
	Line: "A"	Core Size: ---	Temperature: 60° F
			Weather: Cloudy

GROUNDWATER: Encountered at Dry At completion Dry

Stratum Elevation	Sample Depth	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12"	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	Atterberg Limits LL	PL	PI
930.0		**ASPHALT CONCRETE** (12") (Visual)	1.0										
	2.5	Brown, Slightly Moist, Very Loose to Loose, **SAND AND GRAVEL (FILL)**		SS-1	2 2 3	5	50	6.4					
	5.0			SS-2	3 2 3	5	33	7.8					
	7.5			SS-3	3 4 4	8	44	5.3					
923.0			8.0										
	10.0	Brown and Gray, Moist, Medium Stiff to Hard, **CLAY** with Traces of Cobbles		SS-4	4 3 4	7	83	13.1					
	12.5	**Boring was terminated at 14 feet upon encountering auger refusal on boulders. Test boring was moved to TB-3A, 5 feet east of TB-3.** A-6, As Lab 2											
917.0			14.0	SS-5	50/3"		66	7.0					
		Bottom of Boring at 14.0 feet											
	15.0	Boring backfilled in accordance with INDOT requirements and pavement restored with concrete patch.											
	17.5												
	20.0												

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling	AC - Auger Cuttings	DCP - Dynamic Cone Penetrometer Test
HA - Hand Auger	SBS - Subbase Sample	

TEST BORING RECORD

CLIENT	Indiana Department of Transportation	BORING NO.	TB- 3A
PROJECT	Bridge Replacement	SHEET	1 OF 1
ROUTE NO.	US 52	COUNTY	Rush
DATE STARTED	05-10-19		
LOCATION	US 52 over Mud Creek	DATE COMPLETED	05-10-19
DES NO.	1006266	PROJECT NO:	19050015
CTL PROJECT NO	19050015IND		

Boring Elevation	931.0 Feet	Boring Depth	14.0 feet	Boring Method	HSA
Latitude		Station	458+75	Rig Type	CME-550 ATV
Longitude		Offset	14.0 feet Rt	Casing Diameter	3.25" I.D.
		Line	"A"	Core Size	---

Hammer	Automatic
Hammer Efficiency	87.4
Driller/Inspector	ED/DW
Temperature	60° F
Weather	Cloudy

GROUNDWATER: Encountered at Dry At completion Dry

Stratum Elevation	Sample Depth	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12"	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	Atterberg Limits LL	PL	PI
	2.5												
	5.0												
	7.5	**Boring was terminated at 14 feet upon encountering auger refusal on cobbles and boulders. Test boring was moved to TB-3B, 8 feet east of TB-3.**											
	10.0												
	12.5												
917.0			14.0										
		Bottom of Boring at 14.0 feet											
	15.0	Boring backfilled in accordance with INDOT requirements and pavement restored with concrete patch.											
	17.5												
	20.0												

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling	AC - Auger Cuttings	DCP - Dynamic Cone Penetrometer Test
HA - Hand Auger	SBS - Subbase Sample	

TEST BORING RECORD

CLIENT	: Indiana Department of Transportation	BORING NO.	: TB- 3B
PROJECT	: Bridge Replacement	SHEET	: 1 OF 1
ROUTE NO.	: US 52 COUNTY : Rush	DATE STARTED	: 05-10-19
LOCATION	: US 52 over Mud Creek	DATE COMPLETED	: 05-10-19
DES NO.	: 1006266 PROJECT NO: 19050015	CTL PROJECT NO	: 19050015IND

Boring Elevation: 931.0 Feet	Boring Depth : 14.0 feet	Boring Method : HSA	Hammer : Automatic
Latitude :	Station : 458+78	Rig Type : CME-550 ATV	Hammer Efficiency : 87.4
Longitude	Offset : 14.0 feet Rt	Casing Diameter : 3.25" I.D.	Driller/Inspector : ED/DW
	Line : "A"	Core Size : ---	Temperature : 60° F
			Weather : Cloudy

GROUNDWATER: Encountered at Dry At completion Dry

Stratum Elevation	Sample Depth	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12"	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	Atterberg Limits LL	PL	PI
	2.5												
	5.0												
	7.5	**Boring was terminated at 14 feet upon encountering auger refusal on concrete rubble. Test boring was moved to TB-3C.**											
	10.0												
	12.5												
917.0			14.0										
		Bottom of Boring at 14.0 feet											
	15.0	Boring backfilled in accordance with INDOT requirements and pavement restored with concrete patch.											
	17.5												
	20.0												

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling	AC - Auger Cuttings	DCP - Dynamic Cone Penetrometer Test
HA - Hand Auger	SBS - Subbase Sample	

TEST BORING RECORD

CLIENT	Indiana Department of Transportation	BORING NO.	TB- 3C
PROJECT	Bridge Replacement	SHEET	1 OF 4
ROUTE NO.	US 52	COUNTY	Rush
DATE STARTED	05-10-19		
LOCATION	US 52 over Mud Creek	DATE COMPLETED	05-10-19
DES NO.	1006266	PROJECT NO:	19050015
CTL PROJECT NO	19050015IND		

Boring Elevation	931.0 Feet	Boring Depth	70.0 feet	Boring Method	HSA
Latitude	39.63305742	Station	458+83	Rig Type	CME-550 ATV
Longitude	-85.54459308	Offset	15.0 feet Lt	Casing Diameter	3.25" I.D.
		Line	"A"	Core Size	---

Hammer	Automatic
Hammer Efficiency	87.4
Driller/Inspector	ED/DW
Temperature	60° F
Weather	Cloudy

GROUNDWATER: Encountered at 13.0 feet At completion 16.0 feet Caved in at 33.0 feet

Stratum Elevation	Sample Depth	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12"	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	Atterberg Limits LL	PL	PI
930.3		**ASPHALT CONCRETE** (8") (Visual)	0.7										
929.5		**SAND AND GRAVEL** (10") (Visual)	1.5										
	2.5			SS-1	4 4 5	9	100	13.3					
	5.0			SS-2	2 2 2	4	83	17.4					
	7.5	Brown and Gray, Moist, Medium Stiff to Soft, **CLAY** A-6, As Lab 1		SS-3	2 2 3	5	100	17.9					
	10.0			SS-4	2 2 3	5	83	15.8					
919.0			12.0										
	12.5	Brown and Gray, Wet to Moist, Stiff to Hard, **CLAY (TILL)** with Traces of Gravel and Cobbles A-6, As Lab 2											
	15.0			SS-5	5 5 6	11	100	9.9					

Continued on next page

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling	AC - Auger Cuttings	DCP - Dynamic Cone Penetrometer Test
HA - Hand Auger	SBS - Subbase Sample	

TEST BORING RECORD

CLIENT : Indiana Department of Transportation
BORING NO. : **TB- 3C**
PROJECT : Bridge Replacement
SHEET : 2 OF 4

Stratum Elevation	Sample Depth	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12"	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	Atterberg Limits LL	PL	PI
	17.5												
	20.0			SS-6	8 16 12	28	100	9.9					
	22.5												
	25.0	Brown and Gray, Wet to Moist, Stiff to Hard, **CLAY (TILL)** with Traces of Gravel and Cobbles A-6, As Lab 2		SS-7	8 7 6	13	100	18.2					
	27.5												
	30.0	Encountered Cobbles in SS-8 and SS-9		SS-8	5 6 7	13	11	11.5					
	32.5												

Continued on next page

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling	AC - Auger Cuttings	DCP - Dynamic Cone Penetrometer Test
HA - Hand Auger	SBS - Subbase Sample	

TEST BORING RECORD

CLIENT : Indiana Department of Transportation

BORING NO. : **TB- 3C**

PROJECT : Bridge Replacement

SHEET : 3 OF 4

Stratum Elevation	Sample Depth	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12"	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	Atterberg Limits LL	PL	PI
				SS-9	16 25 31	56	11	10.7					
	35.0	Brown and Gray, Wet to Moist, Stiff to Hard, **CLAY (TILL)** with Traces of Gravel and Cobbles A-6, As Lab 2											
894.0			37.0										
	37.5												
				SS-10	8 8 10	18	67	8.6					
	40.0	3 feet heaving sand encountered and cleaned at 41 feet.											
	42.5												
		Brown and Gray, Wet, Medium Dense, **GRAVELLY SAND** (Visual)		SS-11	8 11 13	24	100	21.6					
	45.0												
	47.5												
				SS-12	9 12 16	28	100	14.2					
	50.0												
880.0			51.0										
		Brown and Gray, Moist, Hard, **CLAY (TILL)** with Traces of Gravel and Cobbles A-6, As Lab 2											
	52.5												

Continued on next page

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling	AC - Auger Cuttings	DCP - Dynamic Cone Penetrometer Test
HA - Hand Auger	SBS - Subbase Sample	

TEST BORING RECORD

CLIENT : Indiana Department of Transportation

BORING NO. : **TB- 3C**

PROJECT : Bridge Replacement

SHEET : 4 OF 4

Stratum Elevation	Sample Depth	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12"	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	Atterberg Limits LL	PL	PI
				SS-13	50/2"		0						
	55.0												
	57.5												
				SS-14	28 50/3"		50	7.5					
	60.0	Brown and Gray, Moist, Hard, **CLAY (TILL)** with Traces of Gravel and Cobbles A-6, As Lab 2											
	62.5												
				SS-15	50/4"		11						
	65.0												
864.0			67.0										
	67.5	Brown, Wet, Very Dense, **GRAVELLY SAND** with Traces of Cobbles (Visual)											
				SS-16	39 47 28	75	100	7.9					
861.0	70.0		70.0										

Bottom of Boring at 70.0 feet

Boring backfilled in accordance with INDOT requirements and pavement restored with concrete patch.

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling	AC - Auger Cuttings	DCP - Dynamic Cone Penetrometer Test
HA - Hand Auger	SBS - Subbase Sample	

TEST BORING RECORD

CLIENT : Indiana Department of Transportation
BORING NO. : **TS- 1**
PROJECT : Bridge Replacement
SHEET : 1 OF 1
ROUTE NO. : US 52 COUNTY : Rush
DATE STARTED : 05-06-19
LOCATION : US 52 over Mud Creek
DATE COMPLETED : 05-06-19
DES NO. : 1006266 PROJECT NO: 19050015
CTL PROJECT NO : 19050015IND

Boring Elevation: 929.0 Feet
Latitude : 39.63309449
Longitude -85.54524465

Boring Depth : 0.5 feet
Station : 457+00
Offset : 25.0 feet Rt
Line : "A"

Boring Method : HSA
Rig Type : CME-550 ATV
Casing Diameter : 3.25" I.D.
Core Size : ---

Hammer : Automatic
Hammer Efficiency 87.4
Driller/Inspector : ED/DW
Temperature : 72° F
Weather : Sunny

GROUNDWATER: Encountered at Dry At completion Dry

Stratum Elevation	Sample Depth	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12"	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	Atterberg Limits LL	PL	PI
928.5		**TOPSOIL**	0.5	BS-1				16.6			NP	NP	NP
		Bottom of Boring at 0.5 feet											
		Boring backfilled in accordance with INDOT requirements.											
	2.5												
	5.0												
	7.5												
	10.0												

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling	AC - Auger Cuttings	DCP - Dynamic Cone Penetrometer Test
HA - Hand Auger	SBS - Subbase Sample	

TEST BORING RECORD

CLIENT : Indiana Department of Transportation
BORING NO. : **TS- 2**
PROJECT : Bridge Replacement
SHEET : 1 OF 1
ROUTE NO. : US 52
COUNTY : Rush
DATE STARTED : 05-08-19
LOCATION : US 52 over Mud Creek
DATE COMPLETED : 05-08-19
DES NO. : 1006266
PROJECT NO: 19050015
CTL PROJECT NO : 19050015IND

Boring Elevation: 927.0 Feet
Latitude : 39.6330349
Longitude -85.54433795
Boring Depth : 0.5 feet
Station : 459+50
Offset : 30.0 feet Lt
Line : "A"
Boring Method : HSA
Rig Type : CME-550 ATV
Casing Diameter : 3.25" I.D.
Core Size : ---
Hammer : Automatic
Hammer Efficiency 87.4
Driller/Inspector : ED/DW
Temperature : 72° F
Weather : Sunny

GROUNDWATER: Encountered at Dry At completion Dry

Stratum Elevation	Sample Depth	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12"	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	Atterberg Limits LL	PL	PI
926.5		**TOPSOIL**	0.5	BS-1				27.2			NP	NP	NP
		Bottom of Boring at 0.5 feet											
		Boring backfilled in accordance with INDOT requirements.											
	2.5												
	5.0												
	7.5												
	10.0												

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling	AC - Auger Cuttings	DCP - Dynamic Cone Penetrometer Test
HA - Hand Auger	SBS - Subbase Sample	

TEST BORING RECORD

CLIENT : Indiana Department of Transportation
BORING NO. : **TS- 3**
PROJECT : Bridge Replacement
SHEET : 1 OF 1
ROUTE NO. : US 52 COUNTY : Rush
DATE STARTED : 05-08-19
LOCATION : US 52 over Mud Creek
DATE COMPLETED : 05-08-19
DES NO. : 1006266 PROJECT NO: 19050015
CTL PROJECT NO : 19050015IND

Boring Elevation: 930.0 Feet
Latitude : 39.63281022
Longitude -85.54405826

Boring Depth : 0.5 feet
Station : 460+50
Offset : 20.0 feet Rt
Line : "A"

Boring Method : HSA
Rig Type : CME-550 ATV
Casing Diameter : 3.25" I.D.
Core Size : ---

Hammer : Automatic
Hammer Efficiency 87.4
Driller/Inspector : ED/DW
Temperature : 78° F
Weather : Sunny

GROUNDWATER: Encountered at Dry At completion Dry

Stratum Elevation	Sample Depth	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12"	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	Atterberg Limits LL	PL	PI
929.5		**TOPSOIL**	0.5	BS-1				17.6			NP	NP	NP
		Bottom of Boring at 0.5 feet											
		Boring backfilled in accordance with INDOT requirements.											
	2.5												
	5.0												
	7.5												
	10.0												

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BORING METHOD	SAMPLING METHOD	ABBREVIATIONS
HSA - Hollow Stem Auger	SS - Split Spoon Sample	* - Hand Penetrometer
SFA - Solid Flight Auger	ST - Shelby Tube Sample	LL - Liquid Limit
RC - Rock Coring	CR - Rock Core Sample	PL - Plastic Limit
MD - Mud Drilling	BS - Bag Sample	PI - Plasticity Index
WD - Wash Drilling	AC - Auger Cuttings	DCP - Dynamic Cone Penetrometer Test
HA - Hand Auger	SBS - Subbase Sample	

PAVEMENT CORE REPORT

Des. No.: 1006266
US 52 over Mud Creek, Rush County, IN
CTL Project No.: 19050015IND

Location	Core No.	Date Cored	Core Dia.	Station	Offset	Line	Lane
US 52	PC-1	05/08/2019	4”	456+50	6’ Lt	“A”	WB/Driving

Depth (inches)	Pavement Type	Notes
0” – 2-0”	Asphalt Concrete	Surface Course
2-0” – 3-1/2”		Intermediate Course
3-1/2” – 5-1/4”		Intermediate Course
5-1/4” – 7-0”		Intermediate Course; Break
7-0” – 9-0”		Intermediate Course; Break
9-0” – 18-0”	Cement Concrete	PCC; Break at 11-1/2”

Recovered Core Length (inches)	In-hole Depth (inches)	Recovery (%)
18-0”	18-0”	100

PAVEMENT CORE REPORT

Des. No.: 1006266
US 52 over Mud Creek, Rush County, IN
CTL Project No.: 19050015IND

Location	Core No.	Date Cored	Core Dia.	Station	Offset	Line	Lane
US 52	PC-2	05/08/2019	4”	460+50	6’ Rt	“A”	EB/Driving

Depth (inches)	Pavement Type	Notes
0” – 1-1/2”	Asphalt Concrete	Surface Course
1-1/2” – 4-0”		Intermediate Course
4-0” – 6-1/2”		Intermediate Course
6-1/2” – 8-1/2”		Intermediate Course; Break
8-1/2” – 18-0”	Cement Concrete	PCC; Break at 11-0” and crumbled after 15-0”

Recovered Core Length (inches)	In-hole Depth (inches)	Recovery (%)
---*	18-0”	---*

* Portion of the core crumbled

APPENDIX C

LABORATORY TESTING

Summary of Classification Test Results
Grain Size Distribution Curves
Unconfined Compressive Strength Test Results
Topsoil Analysis Results
Summary of Special Laboratory Test Results

Lab No.	Boring No.	Sample No.	Depth (feet)	Textural Classification	AASHTO Classification	Gravel %	Sand %	Silt %	Clay %	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Moisture %
Lab 1	RB- 1A	ST-1	1.5-3.5	CLAY	A-6 (7)	4.8	41.2	14.6	39.4	31.5	13.3	18.2	23.4
Lab 2	TB- 1	SS-7	23.5-25.0	CLAY	A-6 (9)	0.5	42.6	12.9	44.0	33.1	10.0	23.1	10.3
Lab 3	TB- 1	SS-12	48.5-50.0	SANDY CLAY LOAM	A-4 (0)	8.6	48.5	19.9	23.0	18.2	11.7	6.5	16.2
Lab 4	TS- 1	TS-1	0.0-0.5	SAND	A-2-4 (0)	21.1	66.4	2.8	9.7	NP	NP	NP	16.6
Lab 5	TS- 2	TS-2	0.0-0.5	SAND	A-2-4 (0)	23.1	57.7	12.7	6.5	NP	NP	NP	27.2
Lab 6	TS- 3	TS-3	0.0-0.5	SAND	A-2-4 (0)	21.1	65.7	7.6	5.5	NP	NP	NP	17.6

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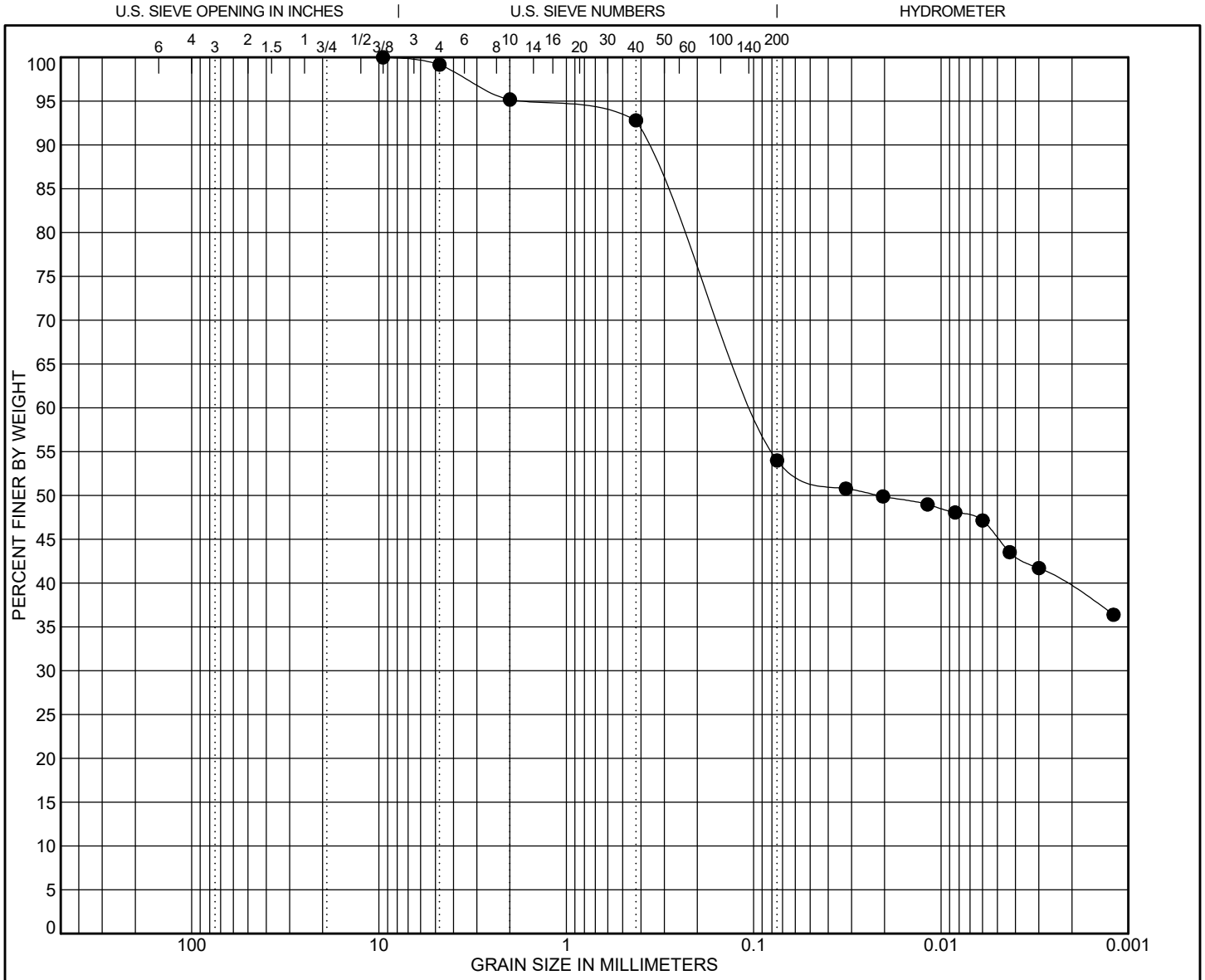
SUMMARY OF CLASSIFICATION TEST RESULTS

Des. No. : 1006266
Project Type : Bridge Replacement
Route : US 52
Location : US 52 over Mud Creek

Project No. : 19050015
County : Rush
CTL Proj. No. : 19050015IND

INDOT_SUMMARY_CLASSIFICATION TESTING 19050015IND.GPJ INDOT_4.GDT 7/17/19



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

Boring No.	RB- 1A	Classification	MC	LL	PL	PI	Cc	Cu
Sample	ST-1	CLAY	23.4	31.5	13.3	18.2		
Depth	1.5-3.5	A-6 (7)						
Station	456+55	Lab 1						
Offset	6.0 feet Lt							
Line	'A'							

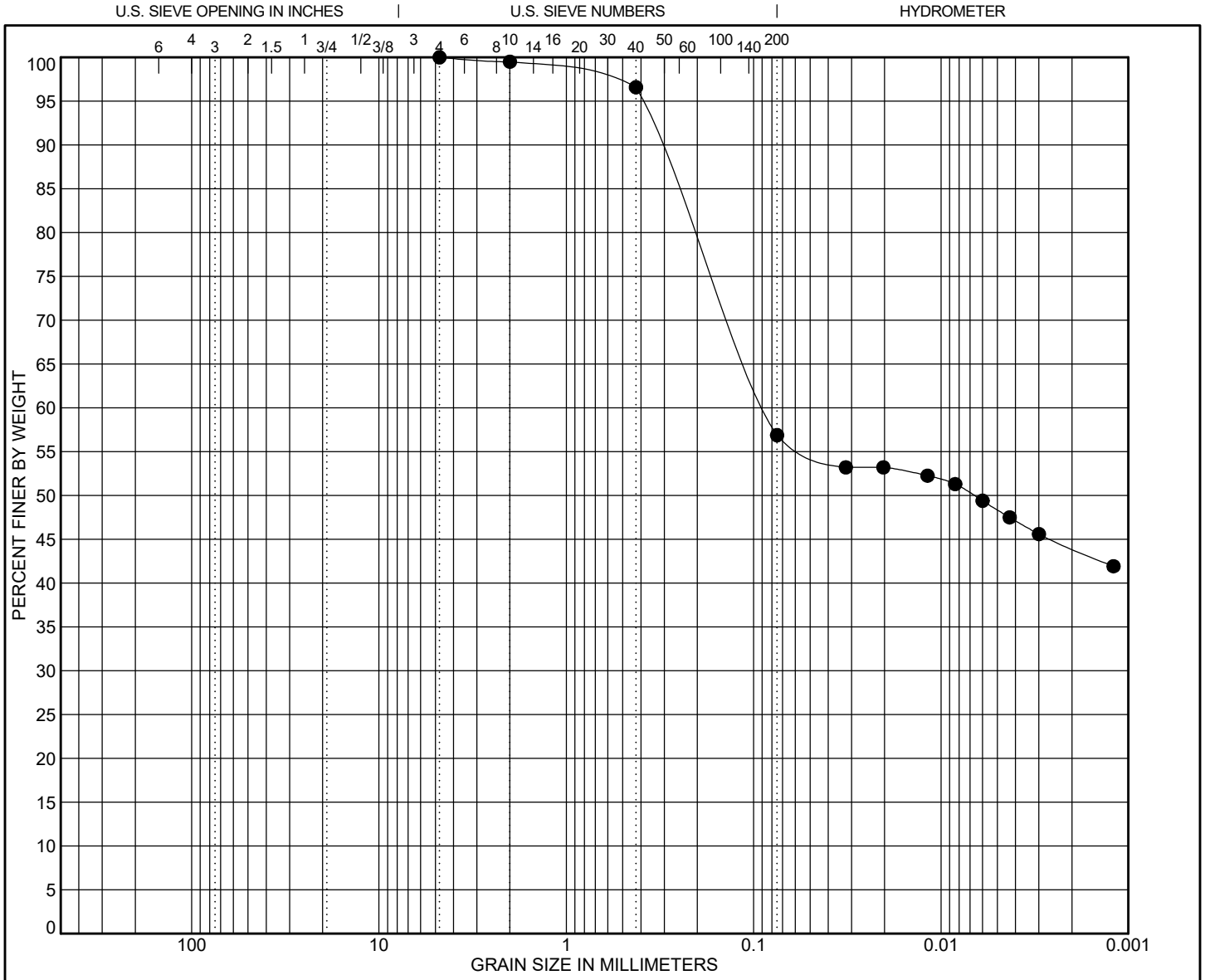
Remarks	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
	9.525	0.098	0.022			4.8	41.2	14.6	39.4

CTL ENGINEERING

CTL Engineering, Inc.
Phone: 317-295-8650

GRAIN SIZE DISTRIBUTION

Client : Indiana Department of Transportation
Des No. : 1006266
Route : US 52
County : Rush
Location : US 52 over Mud Creek



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

Boring No.	TB- 1	Classification	MC	LL	PL	PI	Cc	Cu
Sample	SS-7	CLAY	10.3	33.1	10.0	23.1		
Depth	23.5-25.0	A-6 (9)						
Station	457+60	Lab 2						
Offset	13.0 feet Rt							
Line	'A'							

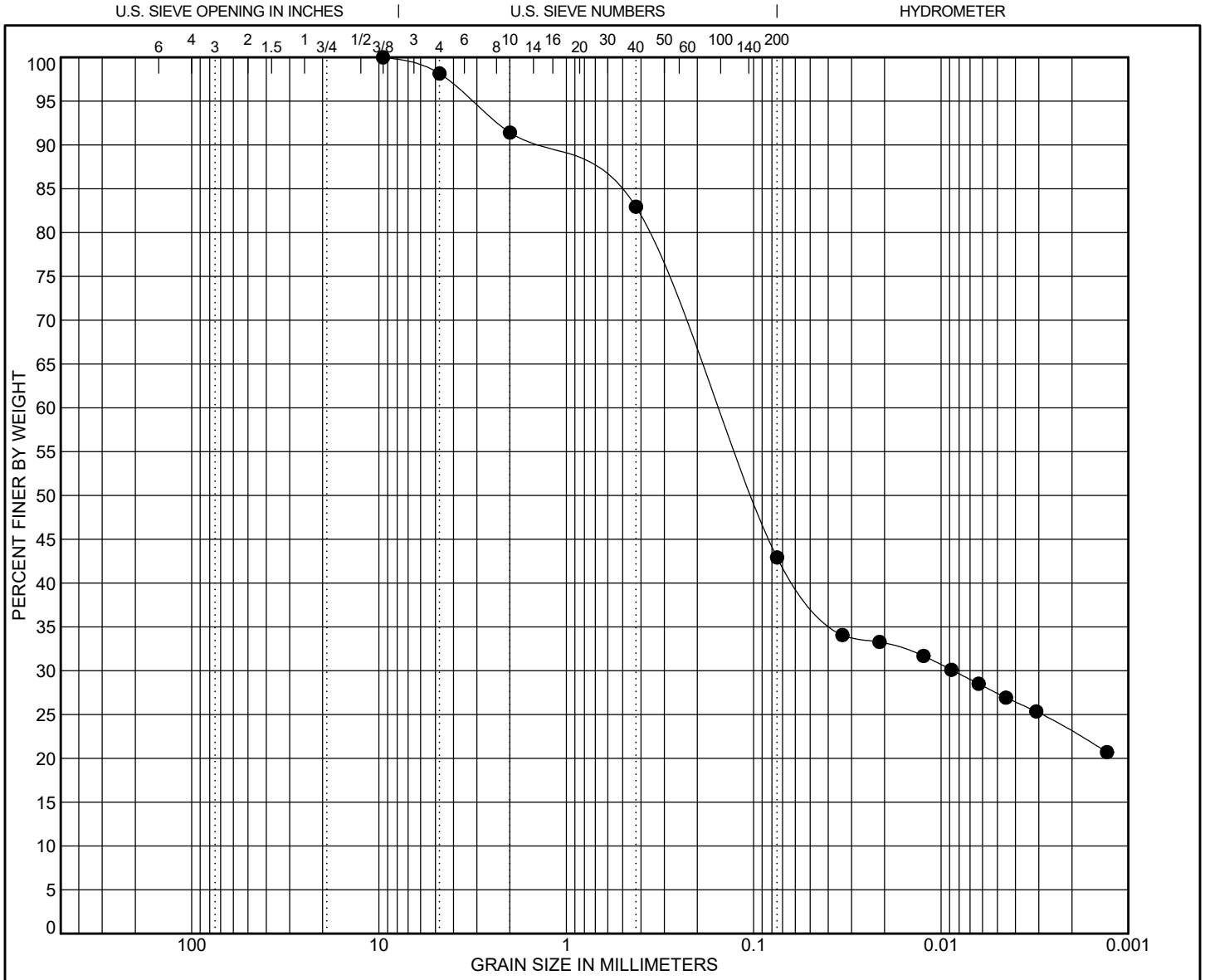
Remarks	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
	4.75	0.086	0.007			0.5	42.6	12.9	44.0

CTL ENGINEERING

CTL Engineering, Inc.
Phone: 317-295-8650

GRAIN SIZE DISTRIBUTION

Client : Indiana Department of Transportation
Des No. : 1006266
Route : US 52
County : Rush
Location : US 52 over Mud Creek



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

Boring No.	TB- 1	Classification	MC	LL	PL	PI	Cc	Cu
Sample	SS-12	SANDY CLAY LOAM	16.2	18.2	11.7	6.5		
Depth	48.5-50.0	A-4 (0)						
Station	457+60	Lab 3						
Offset	13.0 feet Rt							
Line	'A'							

Remarks	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
	9.525	0.157	0.102	0.009		8.6	48.5	19.9	23.0

CTL ENGINEERING

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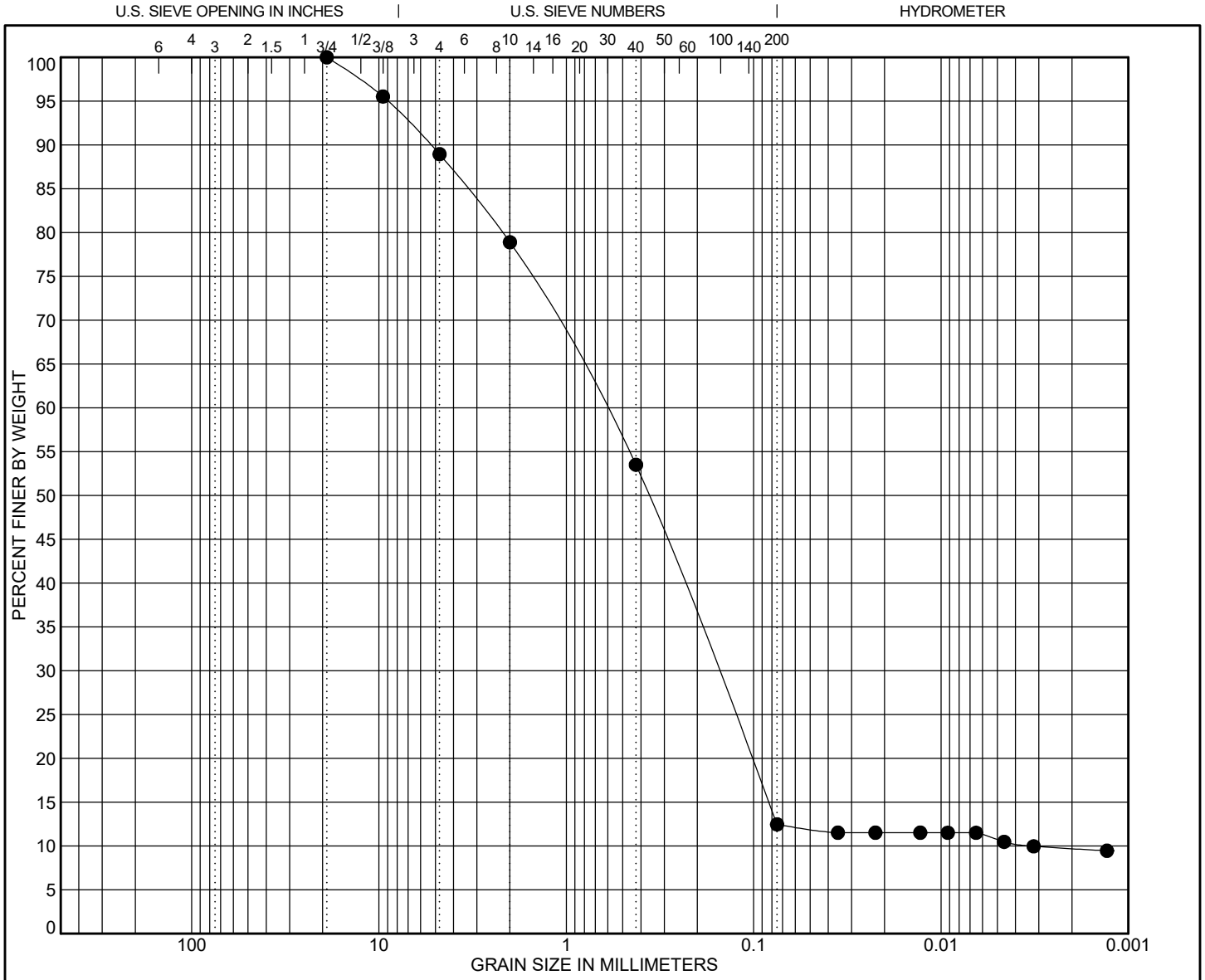
Phone: 317-295-8650

GRAIN SIZE DISTRIBUTION

Client : Indiana Department of Transportation
Des No. : 1006266
Route : US 52
County : Rush
Location : US 52 over Mud Creek



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

Boring No.	TS- 1	Classification	MC	LL	PL	PI	Cc	Cu
Sample	TS-1	SAND	16.6	NP	NP	NP	11.91	191.87
Depth	0.0-0.5	A-2-4 (0)						
Station	457+00	Lab 4						
Offset	25.0 feet Rt							
Line	'A'							

Remarks	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
	19	0.632	0.367	0.157	0.003	21.1	66.4	2.8	9.7

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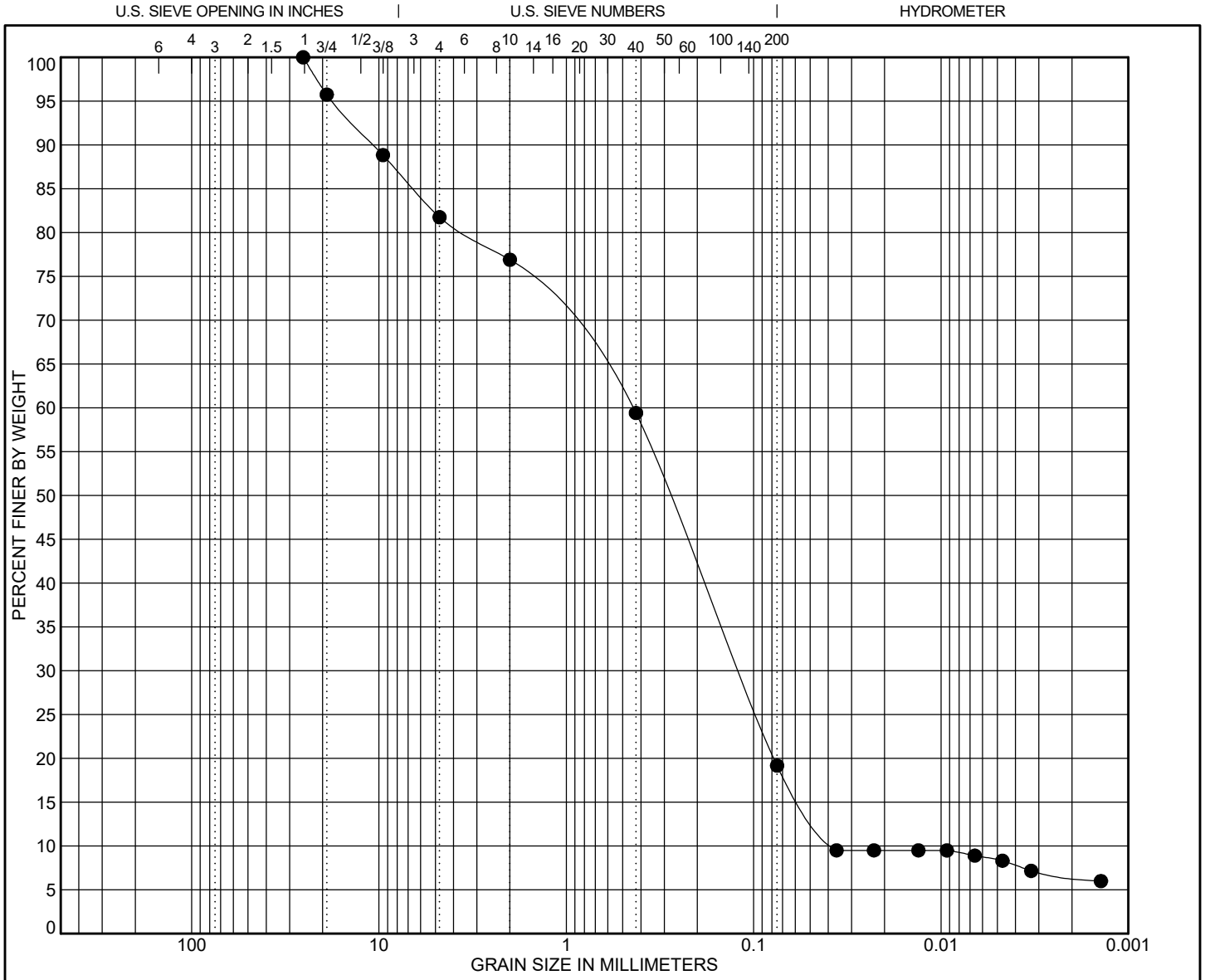
Phone: 317-295-8650

GRAIN SIZE DISTRIBUTION

Client : Indiana Department of Transportation
Des No. : 1006266
Route : US 52
County : Rush
Location : US 52 over Mud Creek



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

Boring No.	TS- 2	Classification	MC	LL	PL	PI	Cc	Cu
Sample	TS-2	SAND	27.2	NP	NP	NP	0.85	11.94
Depth	0.0-0.5	A-2-4 (0)						
Station	459+50	Lab 5						
Offset	30.0 feet Lt							
Line	'A'							

Remarks	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
	25.4	0.448	0.283	0.12	0.038	23.1	57.7	12.7	6.5

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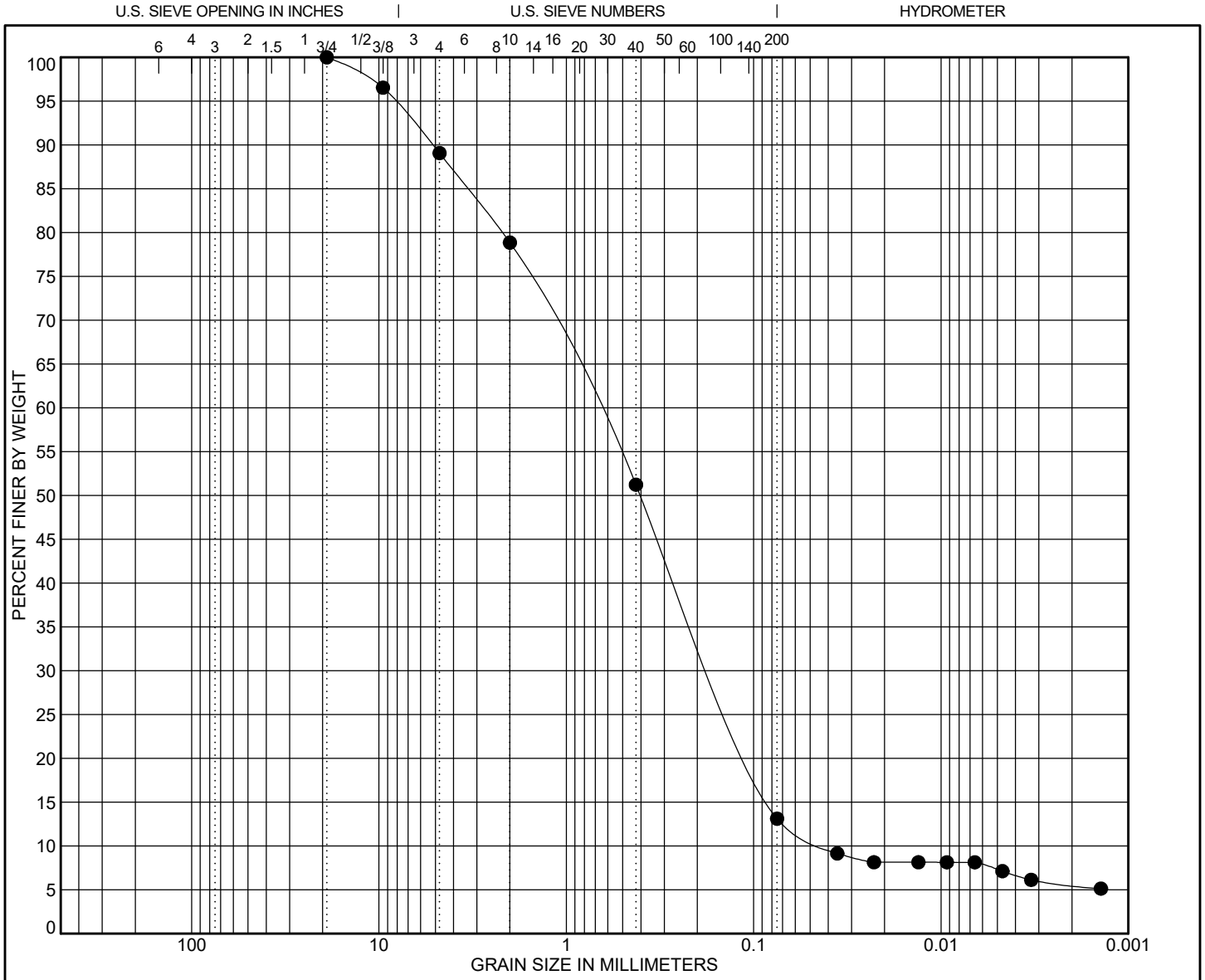
GRAIN SIZE DISTRIBUTION

Client : Indiana Department of Transportation
Des No. : 1006266
Route : US 52
County : Rush
Location : US 52 over Mud Creek



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

Boring No.	TS- 3	Classification	MC	LL	PL	PI	Cc	Cu
Sample	TS-3	SAND	17.6	NP	NP	NP	0.90	16.58
Depth	0.0-0.5	A-2-4 (0)						
Station	460+50	Lab 6						
Offset	20.0 feet Rt							
Line	'A'							

Remarks	D100	D60	D50	D30	D10	%Gravel	%Sand	%Silt	%Clay
	19	0.695	0.402	0.162	0.042	21.1	65.7	7.7	5.5

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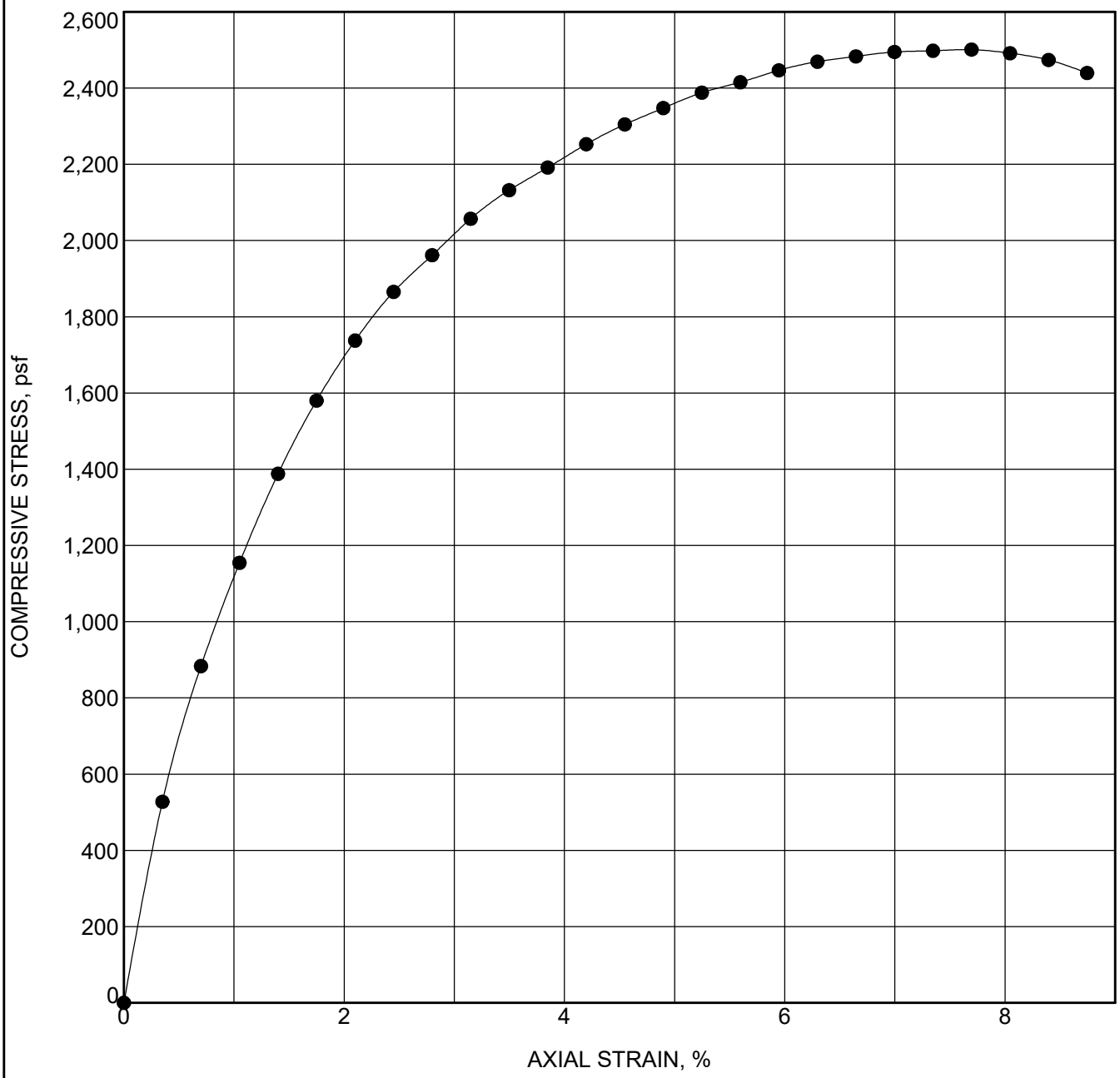
GRAIN SIZE DISTRIBUTION

Client : Indiana Department of Transportation
Des No. : 1006266
Route : US 52
County : Rush
Location : US 52 over Mud Creek



Boring No.	Sample No.	Depth	Classification
RB- 1A	**ST-1**	**1.5 - 3.5**	**Clay**

Moisture Content (%)	Wet Density (pcf)	Dry Density (pcf)	Unconfined Strength (psf)	Strain Rate (%)	Failure Strain (%)
23.4	**129.3**	**104.8**	**2501**	**0.4**	**7.7**
Shear Strength (psf)	Saturation (%)	Void Ratio	Specimen Diameter (mm)	Specimen Height (mm)	Height/Diameter Ratio
1250	**98**	**0.667**	**72.5**	**181.5**	**2.5**

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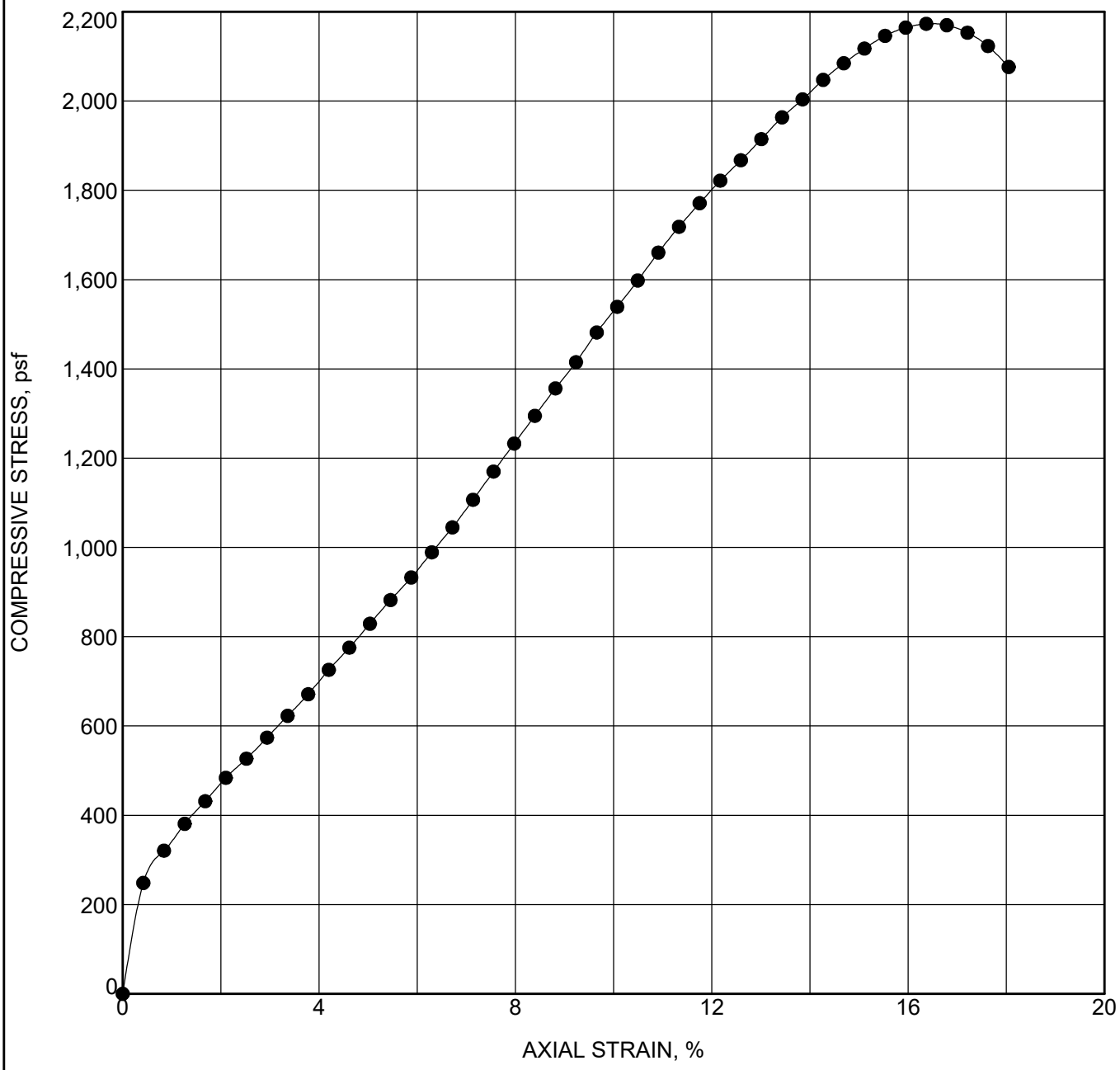
UNCONFINED COMPRESSIVE STRENGTH TEST

Des. No. : 1006266 Project No. : 19050015
Route : US 52 County : Rush
Location : US 52 over Mud Creek

INDOT_UNCONFINED_SO_NE_RP 19050015IND.GPJ US_LAB.GDT 7/17/19



Boring No.	Sample No.	Depth	Classification
RB- 2A	**ST-1**	**1.5 - 3.5**	**Clay**

Moisture Content (%)	Wet Density (pcf)	Dry Density (pcf)	Unconfined Strength (psf)	Strain Rate (%)	Failure Strain (%)
15.3	**123.8**	**107.4**	**2109**	**0.5**	**15.0**
Shear Strength (psf)	Saturation (%)	Void Ratio	Specimen Diameter (mm)	Specimen Height (mm)	Height/Diameter Ratio
1054	**72**	**0.569**	**71.6**	**151.3**	**2.1**

CTL Engineering, Inc.
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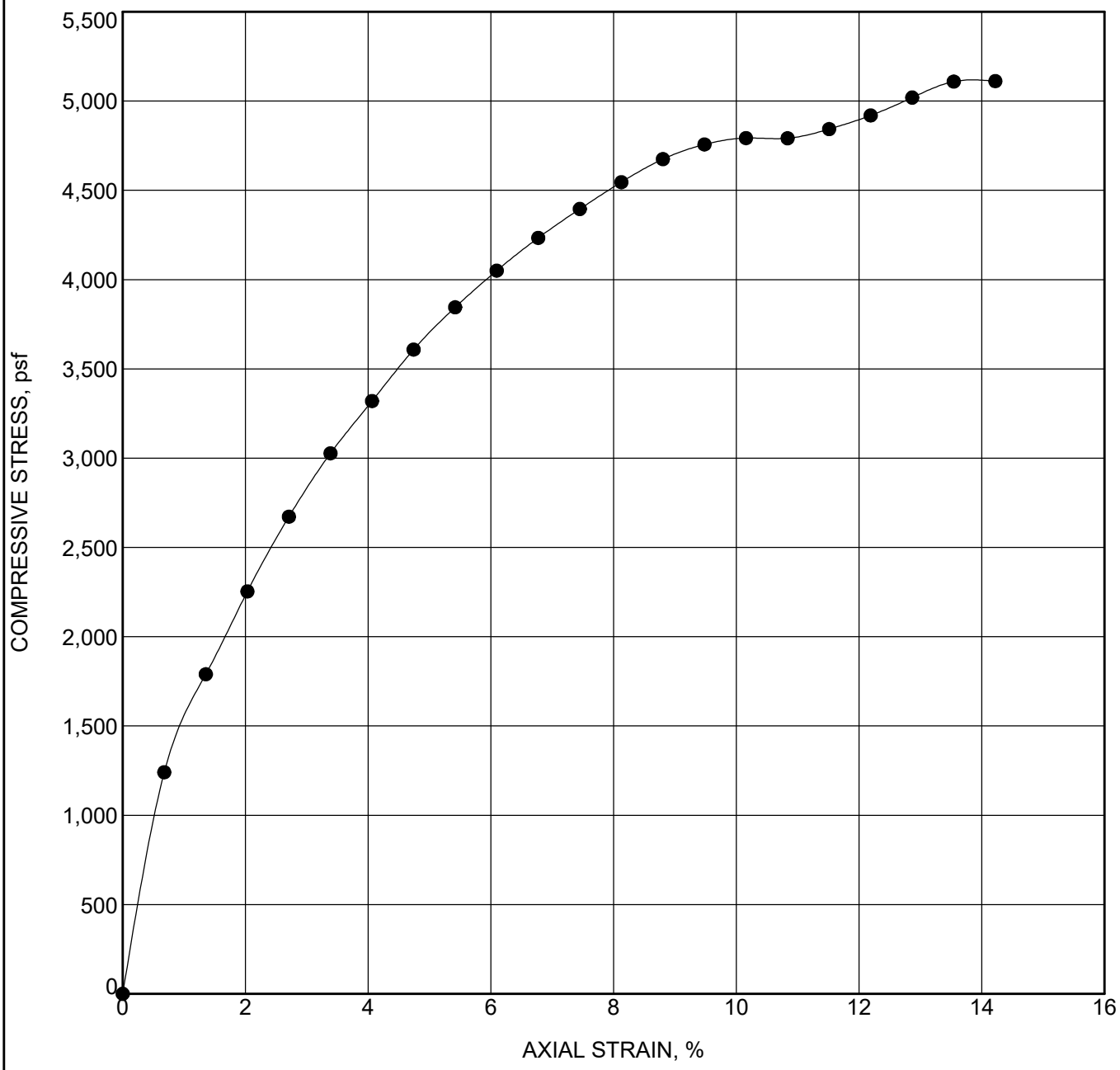
UNCONFINED COMPRESSIVE STRENGTH TEST

Des. No. : 1006266 Project No. : 19050015
Route : US 52 County : Rush
Location : US 52 over Mud Creek

INDOT_UNCONFINED_SO_NE_RP 19050015IND.GPJ US_LAB.GDT 7/17/19



Boring No.	Sample No.	Depth	Classification
TB- 1	**SS-7**	**23.5 - 25.0**	**Clay**

Moisture Content (%)	Wet Density (pcf)	Dry Density (pcf)	Unconfined Strength (psf)	Strain Rate (%)	Failure Strain (%)
10.3	**134.9**	**122.3**	**5112**	**0.8**	**14.2**
Shear Strength (psf)	Saturation (%)	Void Ratio	Specimen Diameter (mm)	Specimen Height (mm)	Height/Diameter Ratio
2556	**73**	**0.377**	**34.5**	**93.8**	**2.7**

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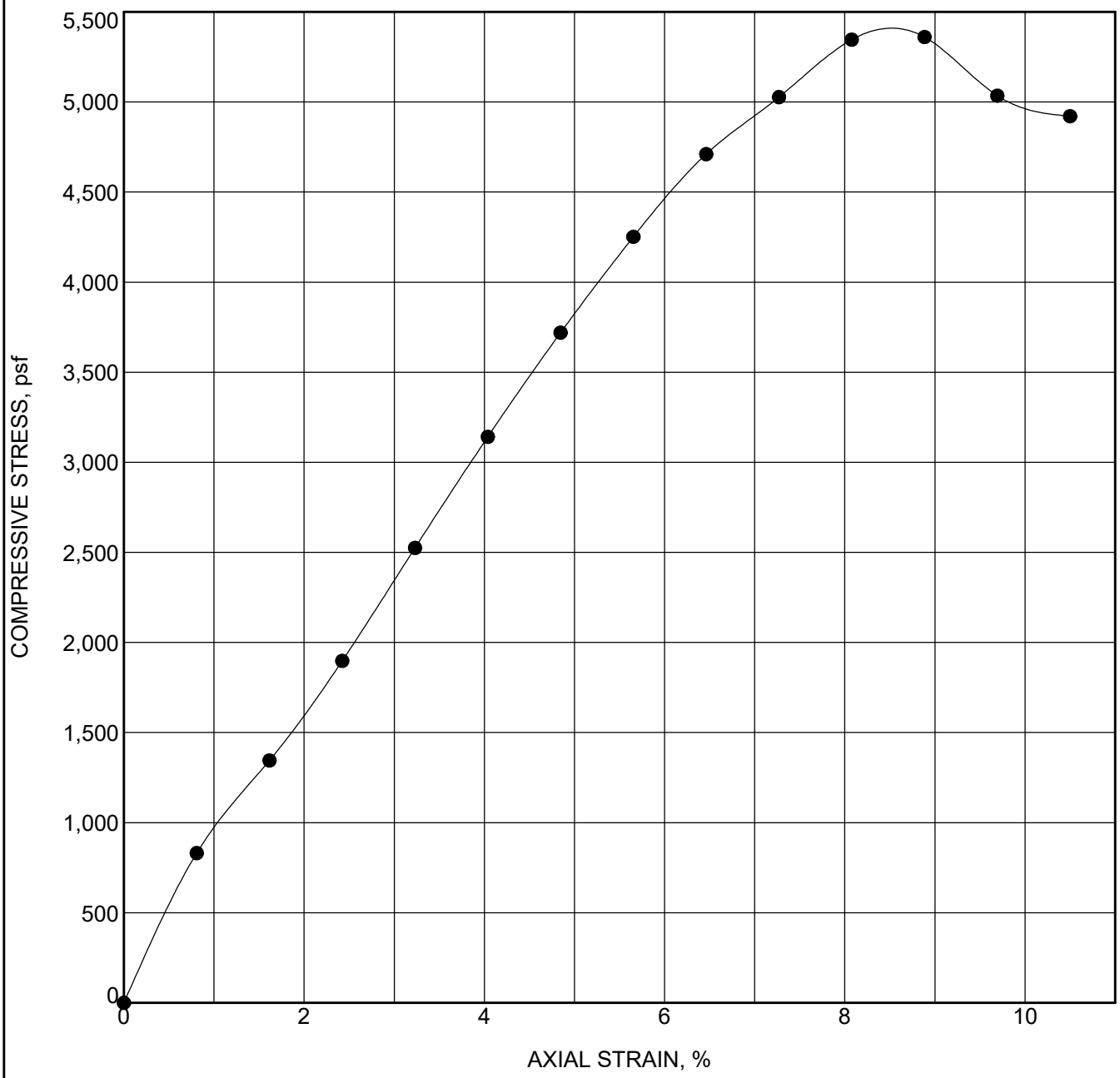
UNCONFINED COMPRESSIVE STRENGTH TEST

Des. No. : 1006266 Project No. : 19050015
Route : US 52 County : Rush
Location : US 52 over Mud Creek



Boring No.	Sample No.	Depth	Classification
TB- 1	**SS-9**	**33.5 - 35.0**	**Clay**

Moisture Content (%)	Wet Density (pcf)	Dry Density (pcf)	Unconfined Strength (psf)	Strain Rate (%)	Failure Strain (%)
9.6	**135.8**	**124.0**	**5360**	**1.0**	**8.9**
Shear Strength (psf)	Saturation (%)	Void Ratio	Specimen Diameter (mm)	Specimen Height (mm)	Height/Diameter Ratio
2680	**72**	**0.359**	**35.1**	**78.6**	**2.2**

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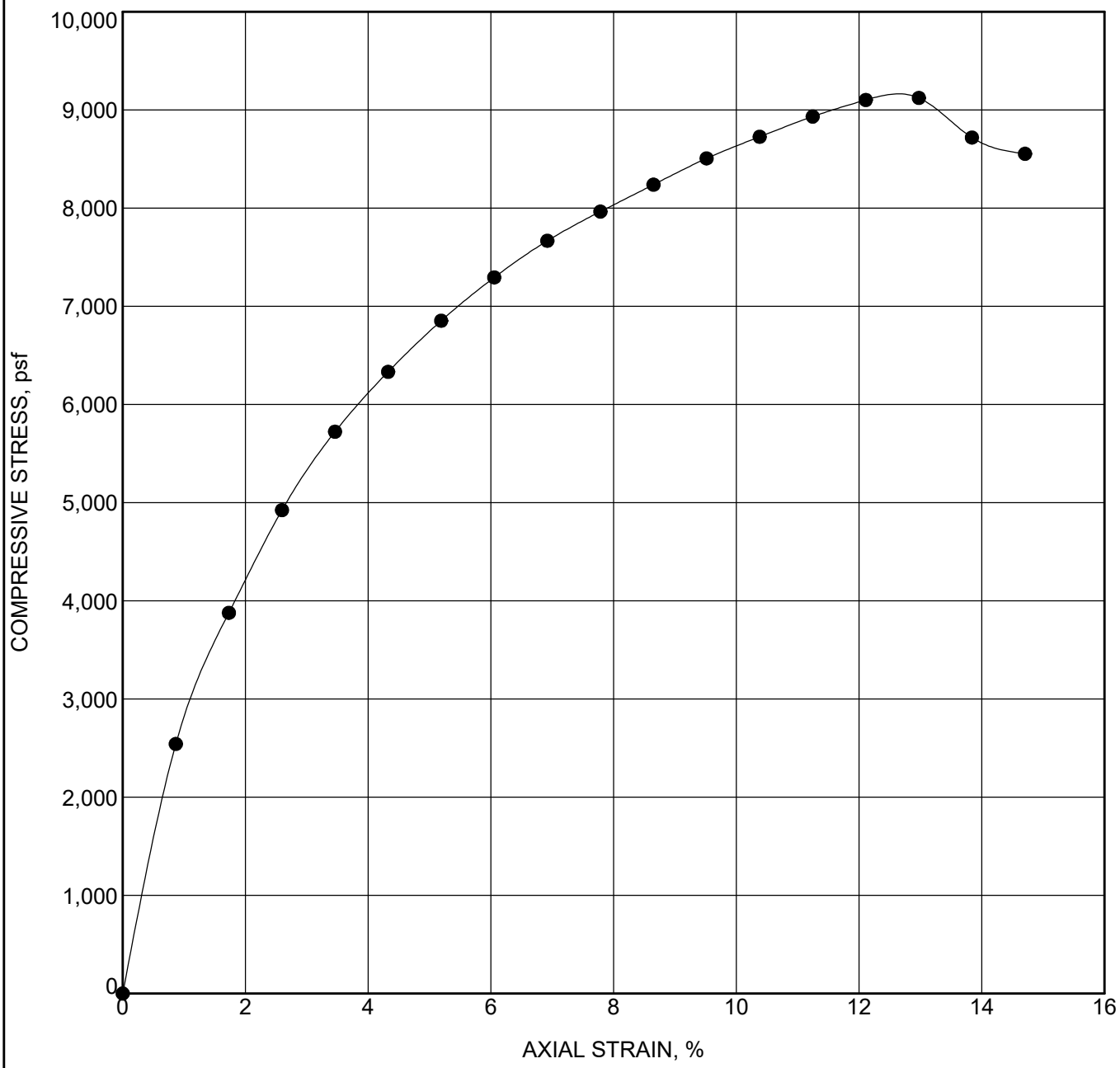
UNCONFINED COMPRESSIVE STRENGTH TEST

Des. No. : 1006266 Project No. : 19050015
Route : US 52 County : Rush
Location : US 52 over Mud Creek

INDOT_UNCONFINED_SO_NE_RP 19050015IND.GPJ US_LAB.GDT 7/17/19



Boring No.	Sample No.	Depth	Classification
TB- 1	**SS-12**	**48.5 - 50.0**	**Sandy Clay Loam**

Moisture Content (%)	Wet Density (pcf)	Dry Density (pcf)	Unconfined Strength (psf)	Strain Rate (%)	Failure Strain (%)
16.2	**129.7**	**111.6**	**9123**	**1.0**	**13.0**
Shear Strength (psf)	Saturation (%)	Void Ratio	Specimen Diameter (mm)	Specimen Height (mm)	Height/Diameter Ratio
4561	**86**	**0.509**	**36.1**	**73.4**	**2.0**

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UNCONFINED COMPRESSIVE STRENGTH TEST

Des. No. : 1006266 Project No. : 19050015
Route : US 52 County : Rush
Location : US 52 over Mud Creek

INDOT_UNCONFINED_SO_NE_RP 19050015IND.GPJ US_LAB.GDT 7/17/19

INDIANA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL SERVICES DIVISION
Summary of Existing Topsoil Test Results for use with Plant Growth Layer

Rev 11/17

Date: 5/17/2019
Des. No.: 1006266
Project: Bridge Replacement
Location: US 52 over Mud Creek, Rush County, IN

					ANALYSIS							
REF.	LOCATION				AASHTO T 289	AASHTO T 88 and T 89	AASHTO T 88 and T 89	AASHTO T 88 and T 89	AASHTO T 88 and T 89	AASHTO T 267 and T 21**	Bray P-1 Equivalent	NCRRP 221, Chapt 7***
Boring Log	Station	Offset (feet)	Lt/Rt	Tested Depth (inch)	pH	Gravel*	Sand	Silt	Clay	Organic Content (% by Wt)	Phosphorus (ppm)	Potassium (ppm)
						(% by Weight)						
TS-1	457+00	25' Rt	Rt	N/A	6.9	21	66	3	10	9.7	63	122
TS-2	459+50	30' Lt	Lt	N/A	7.0	23	58	13	7	9.3	62	182
TS-3	460+50	20' Rt	Rt	N/A	7.1	21	66	8	6	6.5	69	100
	Acceptable Ranges per 914.01 =				6.0 - 7.3	N/A	5 - 50%	30 - 80%	5 - 30%	3 - 10%**	20 - 80	105 - 250

* For informational purposes only

** In Davies, Gibson, Knox, Pike Posey, and Vanderburgh Counties, AASHTO T 21 shall also be performed. Acceptable range is 4 - 10%

*** North Central Regional Research Publication 221, Chapter 7

Note: All existing topsoil test results presented herein are for information only.

BROOKSIDE LABORATORIES, INC.

** SOIL ANALYSIS REPORT **

CTL Engineering, Inc.
1310 S. Franklin
Indianapolis, IN 46239

File Number: 75795
Date Received: 05/14/2019
Date Reported: 05/15/2019

Submitted By: Home Office

SAMPLE LOCATION: TS-1

NBR	FIELD	DESCRIPTION	Phos - M3 (ppm)	K - M3 (ppm)
959	TS-1		63	122

BROOKSIDE LABORATORIES, INC.

** SOIL ANALYSIS REPORT **

CTL Engineering, Inc.
1310 S. Franklin
Indianapolis, IN 46239

File Number: 75795
Date Received: 05/14/2019
Date Reported: 05/15/2019

Submitted By: Home Office

SAMPLE LOCATION: TS-2

NBR	FIELD	DESCRIPTION	Phos - M3 (ppm)	K - M3 (ppm)
960	TS-2		62	182

BROOKSIDE LABORATORIES, INC.

** SOIL ANALYSIS REPORT **

CTL Engineering, Inc.
1310 S. Franklin
Indianapolis, IN 46239

File Number: 75795
Date Received: 05/14/2019
Date Reported: 05/15/2019

Submitted By: Home Office

SAMPLE LOCATION: TS-3

NBR	FIELD	DESCRIPTION	Phos - M3 (ppm)	K - M3 (ppm)
961	TS-3		69	100

Boring	Sample	Depth	Wet Density (pcf)	Dry Density (pcf)	Qu (ksf)	c (ksf)	Moisture %	Max Dry Density (pcf)	Optimum Moisture %	Resilient Modulus @ Opt.	Resilient Modulus +2% of Opt.	Resilient Modulus In-situ	Sulfate (ppm)	Phosphorus (ppm)	Potassium (ppm)	LOI (%)	Calcium Carbonate (%)	pH
RB- 1	SS-1	1.5-3.0					22.3											
RB- 1	SS-2	3.0-4.5					23.1											
RB- 1	SS-3	4.5-6.0					15.3											
RB- 1	SS-4	6.0-7.5					21.8											
RB- 1	SS-5	8.5-10.0					23.1											
RB- 1A	ST-1	1.5-3.5	129.3	104.8	2.501	1.250	23.4						<20					7.8
RB- 2	SS-1	1.5-3.0					14.8											
RB- 2	SS-2	3.0-4.5					13.2											
RB- 2	SS-3	4.5-6.0					14.6											
RB- 2	SS-4	6.0-7.5					10.2											
RB- 2	SS-5	8.5-10.0					8.2											
RB- 2A	ST-1	1.5-3.5	123.8	107.4	2.109	1.054	15.3											
TB- 1	SS-1	1.0-2.5					15.9											
TB- 1	SS-2	3.5-5.0					19.6											
TB- 1	SS-3	6.0-7.5					15.8											
TB- 1	SS-4	8.5-10.0					24.6											
TB- 1	SS-5	13.5-15.0					9.7											
TB- 1	SS-6	18.5-20.0					9.4											
TB- 1	SS-7	23.5-25.0	134.9	122.3	5.112	2.556	10.3											7.6
TB- 1	SS-8	28.5-30.0					10.1											
TB- 1	SS-9	33.5-35.0	135.8	124.0	5.360	2.680	9.6											
TB- 1	SS-10	38.5-40.0					14.3											
TB- 1	SS-11	43.5-45.0					9.6											
TB- 1	SS-12	48.5-50.0	129.7	111.6	9.123	4.561	16.2											
TB- 1	SS-13	53.5-55.0					11.7											
TB- 1	SS-14	58.5-60.0					8.2											

CTL ENGINEERING INC
CTL Engineering, Inc.
Phone: 317-295-8650

SUMMARY OF SPECIAL LABORATORY TEST RESULTS

Des. No. : 1006266
Project Type : Bridge Replacement
Route : US 52
Location : US 52 over Mud Creek

Project No. : 19050015
County : Rush
CTL Proj. No. : 19050015IND

Boring	Sample	Depth	Wet Density (pcf)	Dry Density (pcf)	Qu (ksf)	c (ksf)	Moisture %	Max Dry Density (pcf)	Optimum Moisture %	Resilient Modulus @ Opt.	Resilient Modulus +2% of Opt.	Resilient Modulus In-situ	Sulfate (ppm)	Phosphorus (ppm)	Potassium (ppm)	LOI (%)	Calcium Carbonate (%)	pH
TB- 1	SS-15	65.5-67.0					18.2											
TB- 1	SS-16	68.5-70.0					19.2											
TB- 2	SS-1	15.0-16.5					6.7											
TB- 2	SS-2	17.5-19.0					10.5											
TB- 2	SS-3	20.0-21.5					8.7											
TB- 2	SS-4	22.5-24.0					11.3											
TB- 2	SS-5	27.5-29.0					8.9											
TB- 2	SS-6	32.5-34.0					10.2											
TB- 2	SS-7	37.5-39.0					11.7											
TB- 2	SS-8	42.5-44.0					23.8											
TB- 2	SS-9	47.5-49.0					7.5											
TB- 2	SS-10	52.5-54.0					7.8											
TB- 2	SS-11	57.5-59.0					7.8											
TB- 2	SS-12	62.5-63.7					9.8											
TB- 2	SS-13	67.5-69.0					15.2											
TB- 2	SS-14	72.5-74.0					17.9											
TB- 2	SS-15	77.5-79.0					15.9											
TB- 2	SS-16	82.5-84.0					18.1											
TB- 2	SS-17	87.5-87.9					17.1											
TB- 2	SS-18	92.5-93.3					9.8											
TB- 3	SS-1	1.0-2.5					6.4											
TB- 3	SS-2	3.5-5.0					7.8											
TB- 3	SS-3	6.0-7.5					5.3											
TB- 3	SS-4	8.5-10.0					13.1											
TB- 3	SS-5	13.5-13.8					7.0											
TB- 3C	SS-1	1.0-2.5					13.3											

CTL Engineering, Inc.
Phone: 317-295-8650

SUMMARY OF SPECIAL LABORATORY TEST RESULTS

Des. No. : 1006266
Project Type : Bridge Replacement
Route : US 52
Location : US 52 over Mud Creek

Project No. : 19050015
County : Rush
CTL Proj. No. : 19050015IND

Boring	Sample	Depth	Wet Density (pcf)	Dry Density (pcf)	Qu (ksf)	c (ksf)	Moisture %	Max Dry Density (pcf)	Optimum Moisture %	Resilient Modulus @ Opt.	Resilient Modulus +2% of Opt.	Resilient Modulus In-situ	Sulfate (ppm)	Phosphorus (ppm)	Potassium (ppm)	LOI (%)	Calcium Carbonate (%)	pH
TB- 3C	SS-2	3.5-5.0					17.4											
TB- 3C	SS-3	6.0-7.5					17.9											
TB- 3C	SS-4	8.5-10.0					15.8											
TB- 3C	SS-5	13.5-15.0					9.9											
TB- 3C	SS-6	18.5-20.0					9.9											
TB- 3C	SS-7	23.5-25.0					18.2											
TB- 3C	SS-8	28.5-30.0					11.5											
TB- 3C	SS-9	33.5-35.0					10.7											
TB- 3C	SS-10	38.5-40.0					8.6											
TB- 3C	SS-11	43.5-45.0					21.6											
TB- 3C	SS-12	48.5-50.0					14.2											
TB- 3C	SS-14	58.5-59.3					7.5											
TB- 3C	SS-15	65.5-					8.4											
TB- 3C	SS-16	68.5-70.0					7.9											
TS- 1	TS-1	0.0-0.5					16.6									9.7		6.9
TS- 2	TS-2	0.0-0.5					27.2									9.3		7.0
TS- 3	TS-3	0.0-0.5					17.6									6.5		7.1

CTL Engineering, Inc.
Phone: 317-295-8650

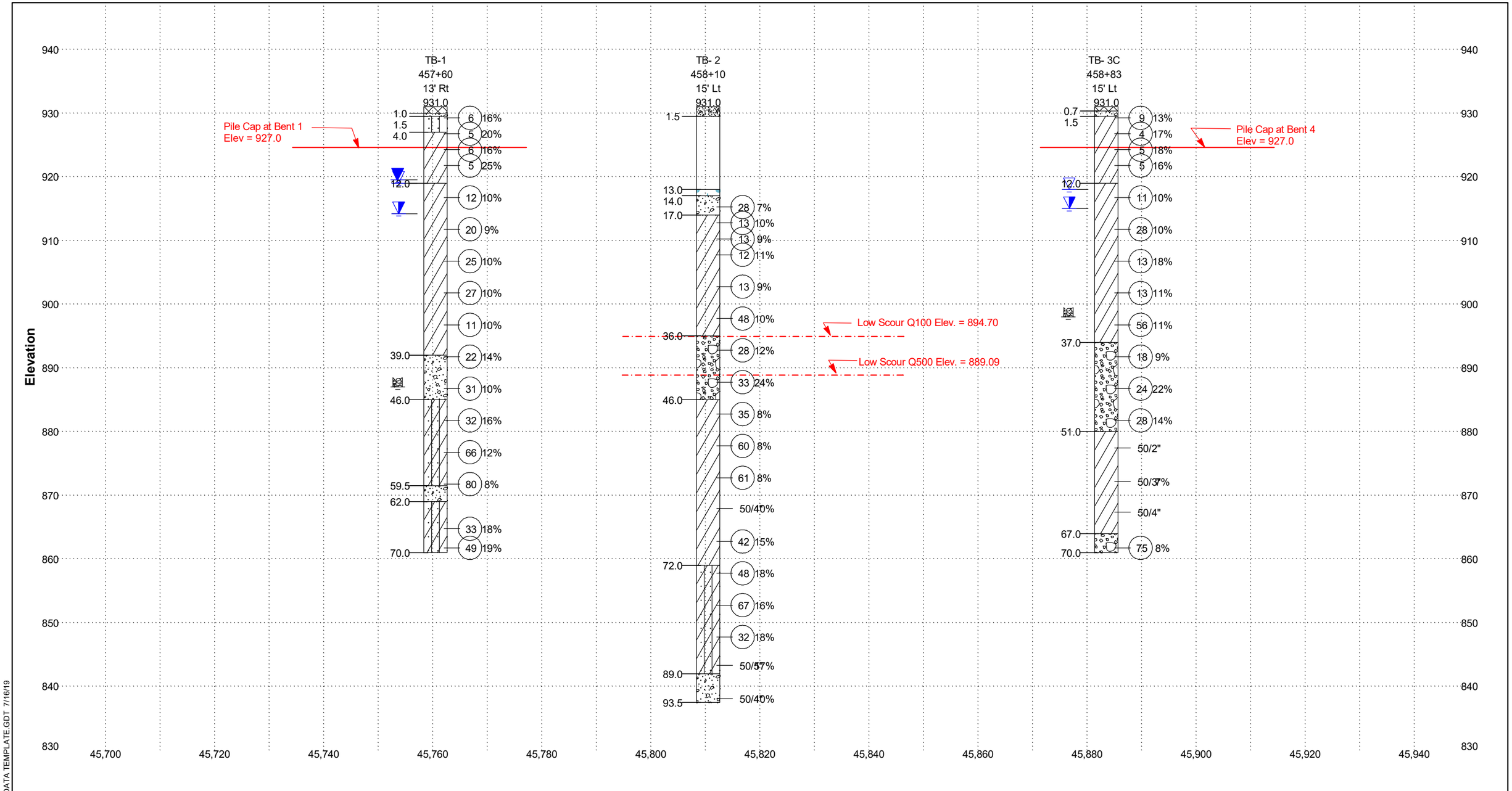
SUMMARY OF SPECIAL LABORATORY TEST RESULTS

Des. No. : 1006266
Project Type : Bridge Replacement
Route : US 52
Location : US 52 over Mud Creek

Project No. : 19050015
County : Rush
CTL Proj. No. : 19050015IND

APPENDIX D

SOIL PROFILE



LEGEND

Asphalt
Sand & Gravel
Sandy Loam
Clay
Sandy Clay Loam
Concrete
Water
Gravelly Sand

(N) STANDARD PENETRATION IN BLOWS PER FOOT (N)
W% PERCENT MOISTURE CONTENT(w)
REC PERCENT ROCK CORE RECOVERY
RQD ROCK QUALITY DESIGNATION (%)

GROUNDWATER DURING DRILLING
GROUND WATER AT COMPLETION OF DRILLING
GROUNDWATER AT "N" HOURS AFTER COMPLETION
CAVED IN DEPTH

CTL Engineering, Inc.
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GENERALIZED SOIL PROFILE

Scale	As Shown
Date	7/16/19
Drawn By	
Reviewed By	

Indiana Department of Transportation
Bridge Replacement
US 52 over Mud Creek
Rush County, Indiana
Des. No.: 1006266

CTL Project No.: 19050015IND

Sheet 1

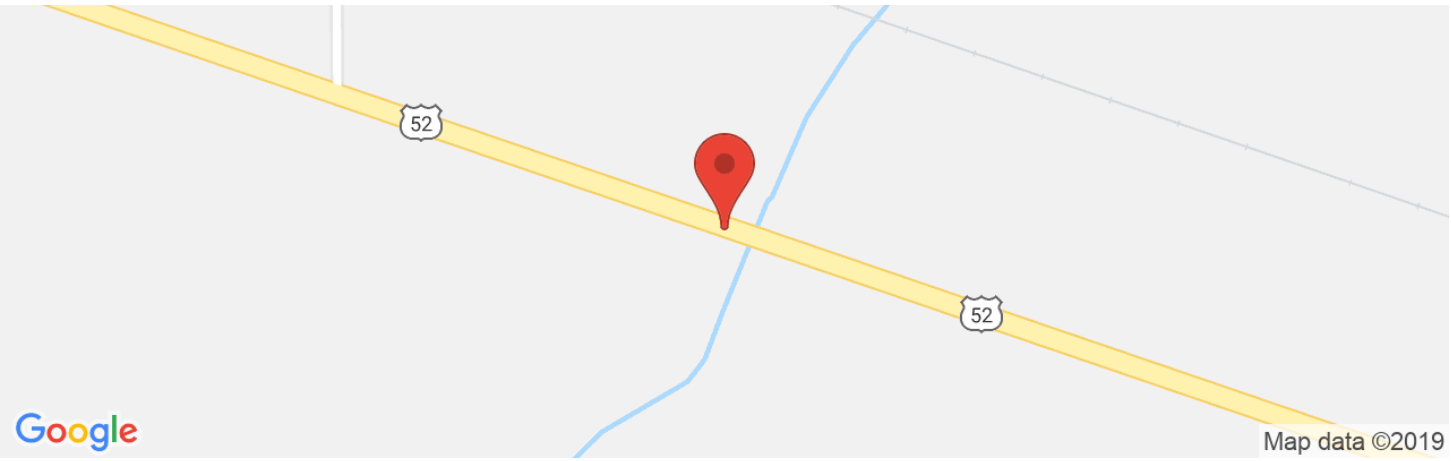
INDOT_RP 19050015IND.GPJ INDOT_DATA TEMPLATE.GDT 7/16/19

APPENDIX E

SEISMIC COEFFICIENTS PILE ANALYSES
WAVE EQUATION ANALYSES

US 52 over Mud Creek

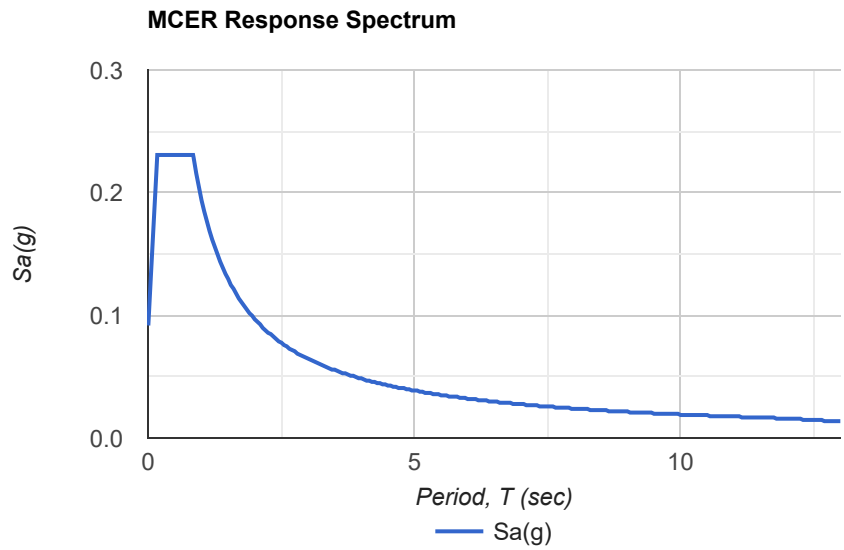
Latitude, Longitude: 39.63308192, -85.54502478

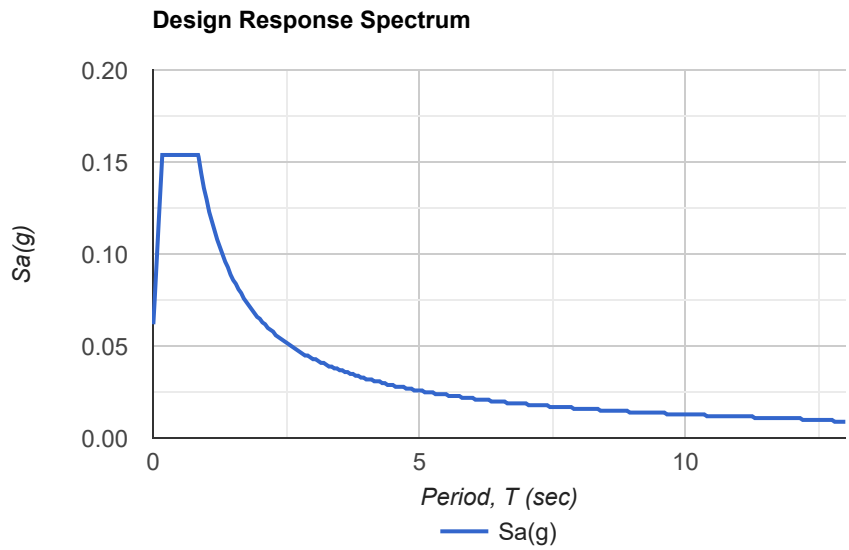


Date	7/23/2019, 9:15:01 AM
Design Code Reference Document	ASCE7-10
Risk Category	II
Site Class	D - Stiff Soil

Type	Value	Description
S_S	0.144	MCE_R ground motion. (for 0.2 second period)
S_1	0.081	MCE_R ground motion. (for 1.0s period)
S_{MS}	0.231	Site-modified spectral acceleration value
S_{M1}	0.194	Site-modified spectral acceleration value
S_{DS}	0.154	Numeric seismic design value at 0.2 second SA
S_{D1}	0.13	Numeric seismic design value at 1.0 second SA

Type	Value	Description
SDC	B	Seismic design category
F_a	1.6	Site amplification factor at 0.2 second
F_v	2.4	Site amplification factor at 1.0 second
PGA	0.066	MCE_G peak ground acceleration
F_{PGA}	1.6	Site amplification factor at PGA
PGA_M	0.105	Site modified peak ground acceleration
T_L	12	Long-period transition period in seconds
SsRT	0.144	Probabilistic risk-targeted ground motion. (0.2 second)
SsUH	0.158	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration
SsD	1.5	Factored deterministic acceleration value. (0.2 second)
S1RT	0.081	Probabilistic risk-targeted ground motion. (1.0 second)
S1UH	0.093	Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration.
S1D	0.6	Factored deterministic acceleration value. (1.0 second)
PGAd	0.5	Factored deterministic acceleration value. (Peak Ground Acceleration)
C_{RS}	0.912	Mapped value of the risk coefficient at short periods
C_{R1}	0.869	Mapped value of the risk coefficient at a period of 1 s





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                 APILE for Windows, Version 2018.8.5

                  Serial Number :  136086088

                  A Program for Analyzing the Axial Capacity
                  and Short-term Settlement of Driven Piles
                            under Axial Loading.
                (c) Copyright ENSOFT, Inc., 1987-2015
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==========================================================================


This program is licensed to :

CTL Engineering, Inc.
Indianapolis, IN

Path to file locations      : K:\PROJECTS\2019\Dept 05- Geotech- In Progress\19050015IND_INDOT 1006266_US 52
over Mud Creek Rush Co\Design\Analysis\Apile Analysis\
Name of input data file     : HP12x53 Bent 1.ap8d
Name of output file         : HP12x53 Bent 1.ap8o
Name of plot output file    : HP12x53 Bent 1.ap8p

--------------------------------------------------------------------------
                     Time and Date of Analysis
--------------------------------------------------------------------------

          Date:  July 16, 2019     Time:  14:32:53



1
          *********************
          * INPUT INFORMATION *
          *********************



          Des 1006266 - US 52 over Mud Creek

          DESIGNER   : AK

          JOB NUMBER : 19050015IND


          METHOD FOR UNIT LOAD TRANSFERS :

          - FHWA (Federal Highway Administration)
            Unfactored Unit Side Friction and Unit Side Resistance are used.



          COMPUTATION METHOD(S) FOR PILE CAPACITY :

          - FHWA (Federal Highway Administration)


          TYPE OF LOADING :
          - COMPRESSION


          PILE TYPE :

          H-Pile/Steel Pile
```

DATA FOR AXIAL STIFFNESS :

- MODULUS OF ELASTICITY = 0.290E+08 PSI
- CROSS SECTION AREA = 141.89 IN2

NONCIRCULAR PILE PROPERTIES :

- TOTAL PILE LENGTH, TL = 60.00 FT.
- BATTER ANGLE = 0.00 DEG
- PILE STICKUP LENGTH, PSL = 0.00 FT.
- ZERO FRICTION LENGTH, ZFL = 4.20 FT.
- PERIMETER OF PILE = 47.65 IN.
- TIP AREA OF PILE = 141.89 IN2
- INCREMENT OF PILE LENGTH USED IN COMPUTATION = 1.00 FT.

SOIL INFORMATIONS :

DEPTH FT.	SOIL TYPE	LATERAL EARTH PRESSURE	EFFECTIVE UNIT WEIGHT LB/CF	FRICTION ANGLE DEGREES	BEARING CAPACITY FACTOR
0.00	CLAY	0.00	125.00	0.00	0.00
4.20	CLAY	0.00	125.00	0.00	0.00
4.20	CLAY	0.00	125.00	0.00	0.00
12.00	CLAY	0.00	125.00	0.00	0.00
12.00	CLAY	0.00	73.00	0.00	0.00
39.00	CLAY	0.00	73.00	0.00	0.00
39.00	SAND	0.00	73.00	34.00	0.00
49.00	SAND	0.00	73.00	34.00	0.00
49.00	CLAY	0.00	78.00	0.00	0.00
70.00	CLAY	0.00	78.00	0.00	0.00

MAXIMUM UNIT FRICTION KSF	MAXIMUM UNIT BEARING KSF	UNDISTURB SHEAR STRENGTH KSF	REMOLDED SHEAR STRENGTH KSF	BLOW COUNT	UNIT SKIN FRICTION KSF	UNIT END BEARING KSF
0.10E+08*	0.10E+08*	1.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	1.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	1.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	1.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	2.20	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	2.20	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	3.50	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	3.50	0.00	0.00	0.00	0.00

* MAXIMUM UNIT FRICTION AND/OR MAXIMUM UNIT BEARING WERE SET TO BE 0.10E+08 BECAUSE THE USER DOES NOT PLAN TO LIMIT THE COMPUTED DATA.

DEPTH FT.	LRFD FACTOR ON UNIT FRICTION	LRFD FACTOR ON UNIT BEARING

0.00	1.000	1.000
4.20	1.000	1.000
4.20	1.000	1.000
12.00	1.000	1.000
12.00	1.000	1.000
39.00	1.000	1.000
39.00	1.000	1.000
49.00	1.000	1.000
49.00	1.000	1.000
70.00	1.000	1.000

1

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**********************
* COMPUTATION RESULT *
**********************
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**********************
*  FED. HWY. METHOD  *
**********************
```

PILE PENETRATION FT.	TOTAL SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	4.4	4.4
1.00	0.0	4.4	4.4
2.00	0.0	8.9	8.9
3.00	0.0	8.9	8.9
4.00	0.0	8.9	8.9
5.00	1.8	8.9	10.7
6.00	5.5	8.9	14.4
7.00	9.2	8.9	18.0
8.00	12.8	8.9	21.7
9.00	16.5	8.9	25.4
10.00	20.2	8.9	29.0
11.00	23.8	11.4	35.2
12.00	27.5	14.2	41.7
13.00	32.7	17.0	49.7
14.00	39.2	19.5	58.7
15.00	45.8	19.5	65.3
16.00	52.3	19.5	71.8
17.00	58.9	19.5	78.4
18.00	65.4	19.5	84.9
19.00	72.0	19.5	91.5
20.00	78.5	19.5	98.0
21.00	85.1	19.5	104.6
22.00	91.6	19.5	111.1
23.00	98.2	19.5	117.7
24.00	104.7	19.5	124.3
25.00	111.3	19.5	130.8
26.00	117.8	19.5	137.4
27.00	124.4	19.5	143.9
28.00	131.0	19.5	150.5
29.00	137.5	19.5	157.0
30.00	144.1	19.5	163.6
31.00	150.6	19.5	170.1
32.00	157.2	19.5	176.7
33.00	163.7	19.5	183.2
34.00	170.3	19.5	189.8
35.00	176.8	19.5	196.3
36.00	183.4	19.5	202.9
37.00	189.9	19.5	209.4
38.00	196.5	32.0	228.5
39.00	203.3	46.0	249.3

40.00	213.1	59.9	273.1
41.00	225.7	72.4	298.2
42.00	238.5	72.4	311.0
43.00	251.6	72.4	324.0
44.00	264.9	72.4	337.4
45.00	278.5	72.4	351.0
46.00	292.4	72.4	364.8
47.00	306.4	72.4	378.9
48.00	320.8	62.7	383.5
49.00	335.4	51.7	387.1
50.00	345.6	40.8	386.4
51.00	351.3	31.0	382.3
52.00	356.9	31.0	388.0
53.00	362.6	31.0	393.6
54.00	368.3	31.0	399.3
55.00	373.9	31.0	405.0
56.00	379.6	31.0	410.6
57.00	385.3	31.0	416.3
58.00	390.9	31.0	422.0
59.00	396.6	31.0	427.6
60.00	402.3	31.0	433.3

NOTES:
- AN ASTERISK IS PLACED IN THE END-BEARING COLUMN IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.

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**************************************************
* COMPUTE LOAD-DISTRIBUTION AND LOAD-SETTLEMENT *
* CURVES FOR AXIAL LOADING                      *
**************************************************
```

T-Z CURVE NO.	NO. OF POINTS	DEPTH TO CURVE FT.	LOAD TRANSFER PSI	PILE MOVEMENT IN.
1	10	0.0000E+00		
			0.0000E+00	0.0000E+00
			0.0000E+00	0.2427E-01
			0.0000E+00	0.4702E-01
			0.0000E+00	0.8645E-01
			0.0000E+00	0.1213E+00
			0.0000E+00	0.1517E+00
			0.0000E+00	0.3033E+00
			0.0000E+00	0.4550E+00
			0.0000E+00	0.7584E+00
			0.0000E+00	0.3033E+01
2	10	0.2125E+01		
			0.0000E+00	0.0000E+00
			0.0000E+00	0.2427E-01
			0.0000E+00	0.4702E-01
			0.0000E+00	0.8645E-01
			0.0000E+00	0.1213E+00
			0.0000E+00	0.1517E+00
			0.0000E+00	0.3033E+00
			0.0000E+00	0.4550E+00
			0.0000E+00	0.7584E+00
			0.0000E+00	0.3033E+01
3	10	0.4158E+01		
			0.0000E+00	0.0000E+00
			0.3045E+00	0.2427E-01
			0.5074E+00	0.4702E-01
			0.7612E+00	0.8645E-01
			0.9134E+00	0.1213E+00

```
                                        0.1015E+01      0.1517E+00
                                        0.9134E+00      0.3033E+00
                                        0.9134E+00      0.4550E+00
                                        0.9134E+00      0.7584E+00
                                        0.9134E+00      0.3033E+01
4         10      0.4200E+01
                                        0.0000E+00      0.0000E+00
                                        0.3846E+00      0.2427E-01
                                        0.6410E+00      0.4702E-01
                                        0.9615E+00      0.8645E-01
                                        0.1154E+01      0.1213E+00
                                        0.1282E+01      0.1517E+00
                                        0.1154E+01      0.3033E+00
                                        0.1154E+01      0.4550E+00
                                        0.1154E+01      0.7584E+00
                                        0.1154E+01      0.3033E+01
5         10      0.8125E+01
                                        0.0000E+00      0.0000E+00
                                        0.1923E+01      0.2427E-01
                                        0.3205E+01      0.4702E-01
                                        0.4807E+01      0.8645E-01
                                        0.5769E+01      0.1213E+00
                                        0.6410E+01      0.1517E+00
                                        0.5769E+01      0.3033E+00
                                        0.5769E+01      0.4550E+00
                                        0.5769E+01      0.7584E+00
                                        0.5769E+01      0.3033E+01
6         10      0.1196E+02
                                        0.0000E+00      0.0000E+00
                                        0.1952E+01      0.2427E-01
                                        0.3253E+01      0.4702E-01
                                        0.4880E+01      0.8645E-01
                                        0.5856E+01      0.1213E+00
                                        0.6506E+01      0.1517E+00
                                        0.5856E+01      0.3033E+00
                                        0.5856E+01      0.4550E+00
                                        0.5856E+01      0.7584E+00
                                        0.5856E+01      0.3033E+01
7         10      0.1200E+02
                                        0.0000E+00      0.0000E+00
                                        0.1953E+01      0.2427E-01
                                        0.3255E+01      0.4702E-01
                                        0.4883E+01      0.8645E-01
                                        0.5860E+01      0.1213E+00
                                        0.6511E+01      0.1517E+00
                                        0.5860E+01      0.3033E+00
                                        0.5860E+01      0.4550E+00
                                        0.5860E+01      0.7584E+00
                                        0.5860E+01      0.3033E+01
8         10      0.2553E+02
                                        0.0000E+00      0.0000E+00
                                        0.3438E+01      0.2427E-01
                                        0.5730E+01      0.4702E-01
                                        0.8596E+01      0.8645E-01
                                        0.1031E+02      0.1213E+00
                                        0.1146E+02      0.1517E+00
                                        0.1031E+02      0.3033E+00
                                        0.1031E+02      0.4550E+00
                                        0.1031E+02      0.7584E+00
                                        0.1031E+02      0.3033E+01
9         10      0.3896E+02
                                        0.0000E+00      0.0000E+00
                                        0.3747E+01      0.2427E-01
                                        0.6245E+01      0.4702E-01
                                        0.9367E+01      0.8645E-01
                                        0.1124E+02      0.1213E+00
                                        0.1249E+02      0.1517E+00
```

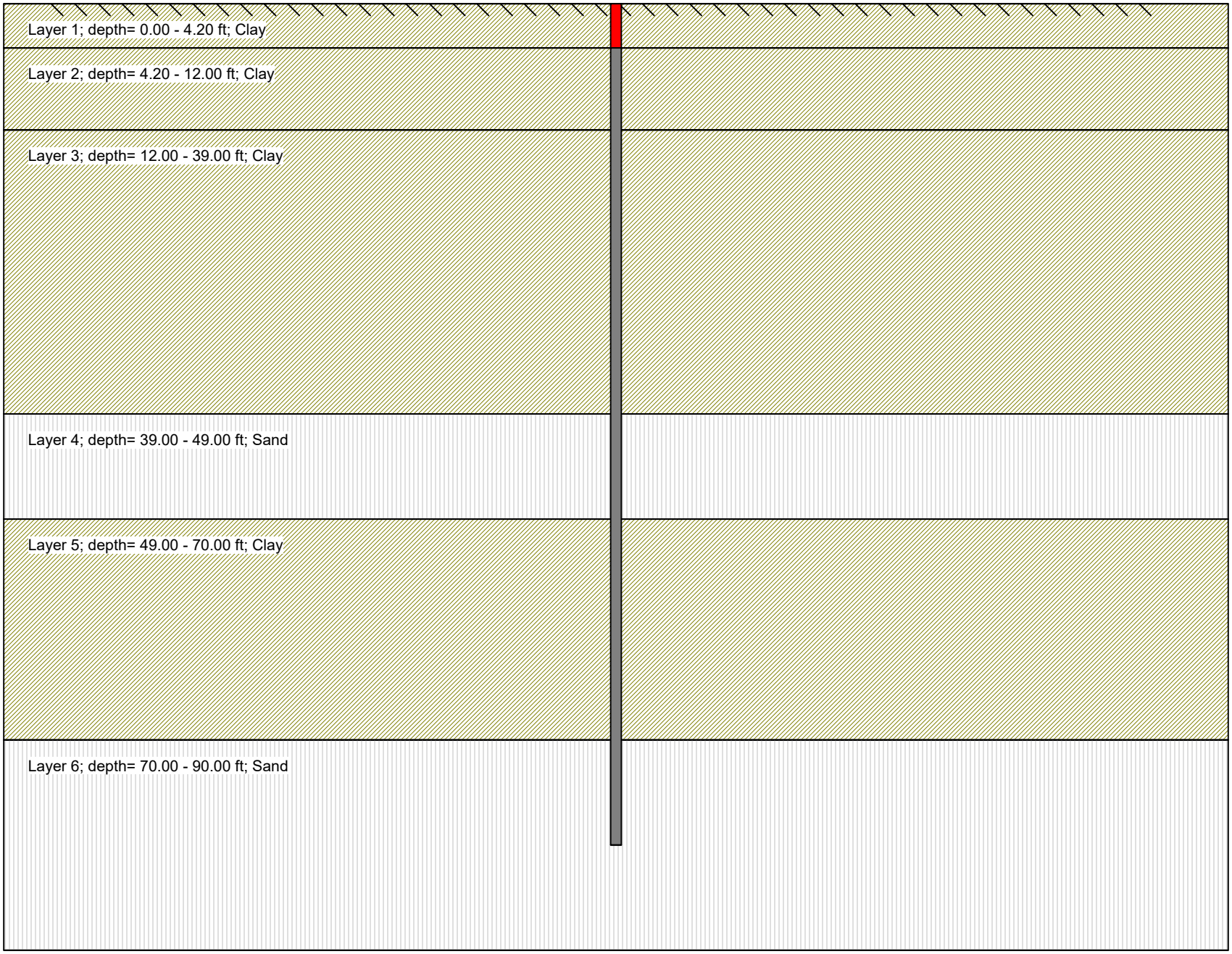
```
                                        0.1124E+02      0.3033E+00
                                        0.1124E+02      0.4550E+00
                                        0.1124E+02      0.7584E+00
                                        0.1124E+02      0.3033E+01
10          10      0.3900E+02
                                        0.0000E+00      0.0000E+00
                                        0.1253E+01      0.1000E-01
                                        0.2507E+01      0.2000E-01
                                        0.5014E+01      0.4000E-01
                                        0.7520E+01      0.6000E-01
                                        0.1003E+02      0.8000E-01
                                        0.1128E+02      0.9000E-01
                                        0.1253E+02      0.1000E+00
                                        0.1253E+02      0.5000E+00
                                        0.1253E+02      0.2000E+01
11          10      0.4403E+02
                                        0.0000E+00      0.0000E+00
                                        0.2354E+01      0.1000E-01
                                        0.4709E+01      0.2000E-01
                                        0.9418E+01      0.4000E-01
                                        0.1413E+02      0.6000E-01
                                        0.1884E+02      0.8000E-01
                                        0.2119E+02      0.9000E-01
                                        0.2354E+02      0.1000E+00
                                        0.2354E+02      0.5000E+00
                                        0.2354E+02      0.2000E+01
12          10      0.4896E+02
                                        0.0000E+00      0.0000E+00
                                        0.2575E+01      0.1000E-01
                                        0.5151E+01      0.2000E-01
                                        0.1030E+02      0.4000E-01
                                        0.1545E+02      0.6000E-01
                                        0.2060E+02      0.8000E-01
                                        0.2318E+02      0.9000E-01
                                        0.2575E+02      0.1000E+00
                                        0.2575E+02      0.5000E+00
                                        0.2575E+02      0.2000E+01
13          10      0.4900E+02
                                        0.0000E+00      0.0000E+00
                                        0.7732E+01      0.2427E-01
                                        0.1289E+02      0.4702E-01
                                        0.1933E+02      0.8645E-01
                                        0.2320E+02      0.1213E+00
                                        0.2577E+02      0.1517E+00
                                        0.2320E+02      0.3033E+00
                                        0.2320E+02      0.4550E+00
                                        0.2320E+02      0.7584E+00
                                        0.2320E+02      0.3033E+01
14          10      0.5953E+02
                                        0.0000E+00      0.0000E+00
                                        0.2973E+01      0.2427E-01
                                        0.4955E+01      0.4702E-01
                                        0.7433E+01      0.8645E-01
                                        0.8919E+01      0.1213E+00
                                        0.9910E+01      0.1517E+00
                                        0.8919E+01      0.3033E+00
                                        0.8919E+01      0.4550E+00
                                        0.8919E+01      0.7584E+00
                                        0.8919E+01      0.3033E+01
15          10      0.6996E+02
                                        0.0000E+00      0.0000E+00
                                        0.2973E+01      0.2427E-01
                                        0.4955E+01      0.4702E-01
                                        0.7433E+01      0.8645E-01
                                        0.8919E+01      0.1213E+00
                                        0.9910E+01      0.1517E+00
                                        0.8919E+01      0.3033E+00
```

0.8919E+01	0.4550E+00
0.8919E+01	0.7584E+00
0.8919E+01	0.3033E+01

TIP LOAD KIP	TIP MOVEMENT IN.
0.0000E+00	0.0000E+00
0.1940E+01	0.7584E-02
0.3880E+01	0.1517E-01
0.7760E+01	0.3033E-01
0.1552E+02	0.1972E+00
0.2328E+02	0.6370E+00
0.2793E+02	0.1107E+01
0.3104E+02	0.1517E+01
0.3104E+02	0.2275E+01
0.3104E+02	0.3033E+01

LOAD VERSUS SETTLEMENT CURVE
****

TOP LOAD KIP	TOP MOVEMENT IN.	TIP LOAD KIP	TIP MOVEMENT IN.
0.4843E+00	0.1491E-03	0.2558E-01	0.1000E-03
0.4843E+01	0.1491E-02	0.2558E+00	0.1000E-02
0.2421E+02	0.7455E-02	0.1279E+01	0.5000E-02
0.4843E+02	0.1491E-01	0.2558E+01	0.1000E-01
0.2310E+03	0.7360E-01	0.8674E+01	0.5000E-01
0.4112E+03	0.1433E+00	0.1100E+02	0.1000E+00
0.4200E+03	0.5450E+00	0.2086E+02	0.5000E+00
0.4260E+03	0.1046E+01	0.2687E+02	0.1000E+01
0.4302E+03	0.2047E+01	0.3104E+02	0.2000E+01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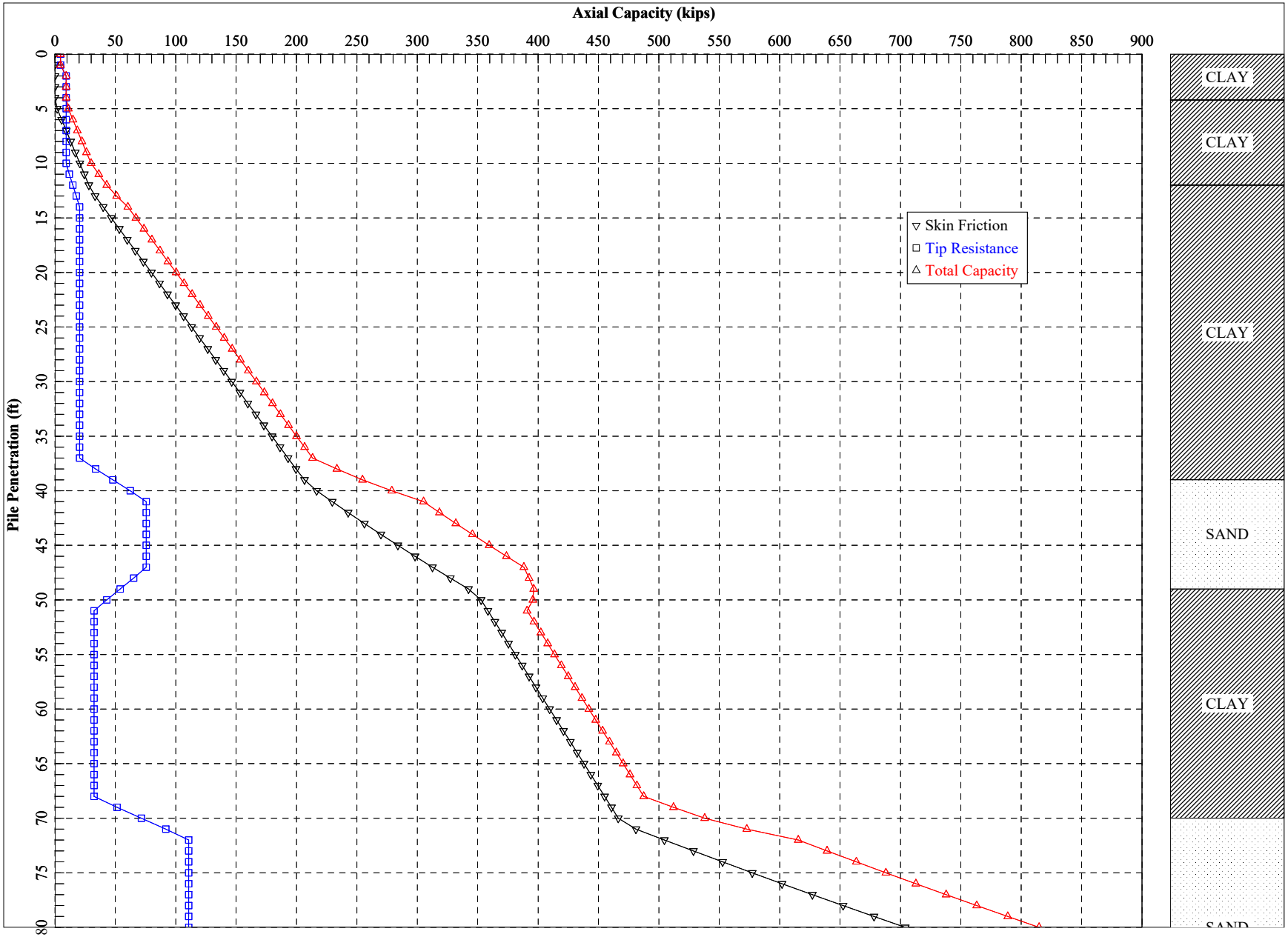
Layer 4; depth= 39.00 - 49.00 ft; Sand
Layer 5; depth= 49.00 - 70.00 ft; Clay
Layer 6; depth= 70.00 - 90.00 ft; Sand


Axial Capacity (kips)
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
Pile Penetration (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Skin Friction
Tip Resistance
Total Capacity
CLAY
CLAY
CLAY
SAND
CLAY
SAND

```
==========================================================================

                 APILE for Windows, Version 2018.8.5

                  Serial Number :  136086088

                  A Program for Analyzing the Axial Capacity
                  and Short-term Settlement of Driven Piles
                            under Axial Loading.
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==========================================================================


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Path to file locations      : K:\PROJECTS\2019\Dept 05- Geotech- In Progress\19050015IND_INDOT 1006266_US 52
over Mud Creek Rush Co\Design\Analysis\Apile Analysis\HP 12x74 revised\
Name of input data file     : HP12x74 Bent 1 revised.ap8d
Name of output file         : HP12x74 Bent 1 revised.ap8o
Name of plot output file    : HP12x74 Bent 1 revised.ap8p

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                     Time and Date of Analysis
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          Date:  July 24, 2019     Time:  17:14:20



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          *********************
          * INPUT INFORMATION *
          *********************



          Des 1006266 - US 52 over Mud Creek

          DESIGNER   : AK

          JOB NUMBER : 19050015IND


          METHOD FOR UNIT LOAD TRANSFERS :

          - FHWA (Federal Highway Administration)
            Unfactored Unit Side Friction and Unit Side Resistance are used.



          COMPUTATION METHOD(S) FOR PILE CAPACITY :

          - FHWA (Federal Highway Administration)


          TYPE OF LOADING :
          - COMPRESSION


          PILE TYPE :

          H-Pile/Steel Pile
```

DATA FOR AXIAL STIFFNESS :

- MODULUS OF ELASTICITY = 0.290E+08 PSI
- CROSS SECTION AREA = 148.17 IN2

NONCIRCULAR PILE PROPERTIES :

- TOTAL PILE LENGTH, TL = 80.00 FT.
- BATTER ANGLE = 0.00 DEG
- PILE STICKUP LENGTH, PSL = 0.00 FT.
- ZERO FRICTION LENGTH, ZFL = 4.20 FT.
- PERIMETER OF PILE = 48.69 IN.
- TIP AREA OF PILE = 148.17 IN2
- INCREMENT OF PILE LENGTH USED IN COMPUTATION = 1.00 FT.

SOIL INFORMATIONS :

DEPTH FT.	SOIL TYPE	LATERAL EARTH PRESSURE	EFFECTIVE UNIT WEIGHT LB/CF	FRICTION ANGLE DEGREES	BEARING CAPACITY FACTOR
0.00	CLAY	0.00	125.00	0.00	0.00
4.20	CLAY	0.00	125.00	0.00	0.00
4.20	CLAY	0.00	125.00	0.00	0.00
12.00	CLAY	0.00	125.00	0.00	0.00
12.00	CLAY	0.00	73.00	0.00	0.00
39.00	CLAY	0.00	73.00	0.00	0.00
39.00	SAND	0.00	73.00	34.00	0.00
49.00	SAND	0.00	73.00	34.00	0.00
49.00	CLAY	0.00	78.00	0.00	0.00
70.00	CLAY	0.00	78.00	0.00	0.00
70.00	SAND	0.00	73.00	35.00	0.00
90.00	SAND	0.00	73.00	35.00	0.00

MAXIMUM UNIT FRICTION KSF	MAXIMUM UNIT BEARING KSF	UNDISTURB SHEAR STRENGTH KSF	REMOLDED SHEAR STRENGTH KSF	BLOW COUNT	UNIT SKIN FRICTION KSF	UNIT END BEARING KSF
0.10E+08*	0.10E+08*	1.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	1.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	1.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	1.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	2.20	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	2.20	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	3.50	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	3.50	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00

* MAXIMUM UNIT FRICTION AND/OR MAXIMUM UNIT BEARING WERE SET TO BE 0.10E+08 BECAUSE THE USER DOES NOT PLAN TO LIMIT THE COMPUTED DATA.

DEPTH FT.	LRFD FACTOR ON UNIT FRICTION	LRFD FACTOR ON UNIT BEARING
0.00	1.000	1.000
4.20	1.000	1.000
4.20	1.000	1.000
12.00	1.000	1.000
12.00	1.000	1.000
39.00	1.000	1.000
39.00	1.000	1.000
49.00	1.000	1.000
49.00	1.000	1.000
70.00	1.000	1.000
70.00	1.000	1.000
90.00	1.000	1.000

1

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**********************
* COMPUTATION RESULT *
**********************
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**********************
*  FED. HWY. METHOD  *
**********************
```

PILE PENETRATION FT.	TOTAL SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	4.6	4.6
1.00	0.0	4.6	4.6
2.00	0.0	9.3	9.3
3.00	0.0	9.3	9.3
4.00	0.0	9.3	9.3
5.00	1.9	9.3	11.1
6.00	5.6	9.3	14.9
7.00	9.4	9.3	18.6
8.00	13.1	9.3	22.4
9.00	16.9	9.3	26.1
10.00	20.6	9.3	29.9
11.00	24.3	11.9	36.3
12.00	28.1	14.8	42.9
13.00	33.3	17.7	51.0
14.00	40.0	20.4	60.4
15.00	46.6	20.4	67.0
16.00	53.3	20.4	73.7
17.00	59.9	20.4	80.3
18.00	66.6	20.4	87.0
19.00	73.2	20.4	93.6
20.00	79.9	20.4	100.3
21.00	86.6	20.4	106.9
22.00	93.2	20.4	113.6
23.00	99.9	20.4	120.2
24.00	106.5	20.4	126.9
25.00	113.2	20.4	133.5
26.00	119.8	20.4	140.2
27.00	126.5	20.4	146.8
28.00	133.1	20.4	153.5
29.00	139.8	20.4	160.1
30.00	146.4	20.4	166.8
31.00	153.1	20.4	173.4
32.00	159.7	20.4	180.1
33.00	166.4	20.4	186.7

34.00	173.0	20.4	193.4
35.00	179.7	20.4	200.0
36.00	186.3	20.4	206.7
37.00	193.0	20.4	213.3
38.00	199.6	33.7	233.4
39.00	206.6	48.0	254.6
40.00	216.7	62.3	278.9
41.00	229.6	75.6	305.2
42.00	242.8	75.6	318.4
43.00	256.2	75.6	331.9
44.00	269.9	75.6	345.6
45.00	283.9	75.6	359.5
46.00	298.1	75.6	373.8
47.00	312.6	75.6	388.3
48.00	327.4	65.2	392.6
49.00	342.4	54.0	396.4
50.00	352.8	42.9	395.7
51.00	358.5	32.4	390.9
52.00	364.2	32.4	396.6
53.00	369.9	32.4	402.3
54.00	375.5	32.4	408.0
55.00	381.2	32.4	413.6
56.00	386.9	32.4	419.3
57.00	392.6	32.4	425.0
58.00	398.3	32.4	430.7
59.00	403.9	32.4	436.4
60.00	409.6	32.4	442.0
61.00	415.3	32.4	447.7
62.00	421.0	32.4	453.4
63.00	426.7	32.4	459.1
64.00	432.3	32.4	464.8
65.00	438.0	32.4	470.4
66.00	443.7	32.4	476.1
67.00	449.4	32.4	481.8
68.00	455.1	32.4	487.5
69.00	460.8	51.4	512.1
70.00	466.4	71.6	538.0
71.00	481.0	91.8	572.8
72.00	504.6	110.7	615.4
73.00	528.6	110.7	639.3
74.00	552.8	110.7	663.5
75.00	577.3	110.7	688.0
76.00	602.0	110.7	712.8
77.00	627.1	110.7	737.8
78.00	652.5	110.7	763.2
79.00	678.1	110.7	788.9
80.00	704.1	110.7	814.8

NOTES:
- AN ASTERISK IS PLACED IN THE END-BEARING COLUMN
  IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION
  OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.

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**************************************************
* COMPUTE LOAD-DISTRIBUTION AND LOAD-SETTLEMENT *
* CURVES FOR AXIAL LOADING                      *
**************************************************
```

T-Z CURVE NO.	NO. OF POINTS	DEPTH TO CURVE FT.	LOAD TRANSFER PSI	PILE MOVEMENT IN.
1	10	0.0000E+00		
			0.0000E+00	0.0000E+00

```
                                   0.0000E+00      0.2480E-01
                                   0.0000E+00      0.4805E-01
                                   0.0000E+00      0.8834E-01
                                   0.0000E+00      0.1240E+00
                                   0.0000E+00      0.1550E+00
                                   0.0000E+00      0.3100E+00
                                   0.0000E+00      0.4650E+00
                                   0.0000E+00      0.7749E+00
                                   0.0000E+00      0.3100E+01
2         10      0.2125E+01
                                   0.0000E+00      0.0000E+00
                                   0.0000E+00      0.2480E-01
                                   0.0000E+00      0.4805E-01
                                   0.0000E+00      0.8834E-01
                                   0.0000E+00      0.1240E+00
                                   0.0000E+00      0.1550E+00
                                   0.0000E+00      0.3100E+00
                                   0.0000E+00      0.4650E+00
                                   0.0000E+00      0.7749E+00
                                   0.0000E+00      0.3100E+01
3         10      0.4158E+01
                                   0.0000E+00      0.0000E+00
                                   0.3045E+00      0.2480E-01
                                   0.5074E+00      0.4805E-01
                                   0.7612E+00      0.8834E-01
                                   0.9134E+00      0.1240E+00
                                   0.1015E+01      0.1550E+00
                                   0.9134E+00      0.3100E+00
                                   0.9134E+00      0.4650E+00
                                   0.9134E+00      0.7749E+00
                                   0.9134E+00      0.3100E+01
4         10      0.4200E+01
                                   0.0000E+00      0.0000E+00
                                   0.3846E+00      0.2480E-01
                                   0.6410E+00      0.4805E-01
                                   0.9615E+00      0.8834E-01
                                   0.1154E+01      0.1240E+00
                                   0.1282E+01      0.1550E+00
                                   0.1154E+01      0.3100E+00
                                   0.1154E+01      0.4650E+00
                                   0.1154E+01      0.7749E+00
                                   0.1154E+01      0.3100E+01
5         10      0.8125E+01
                                   0.0000E+00      0.0000E+00
                                   0.1923E+01      0.2480E-01
                                   0.3205E+01      0.4805E-01
                                   0.4807E+01      0.8834E-01
                                   0.5769E+01      0.1240E+00
                                   0.6410E+01      0.1550E+00
                                   0.5769E+01      0.3100E+00
                                   0.5769E+01      0.4650E+00
                                   0.5769E+01      0.7749E+00
                                   0.5769E+01      0.3100E+01
6         10      0.1196E+02
                                   0.0000E+00      0.0000E+00
                                   0.1950E+01      0.2480E-01
                                   0.3250E+01      0.4805E-01
                                   0.4876E+01      0.8834E-01
                                   0.5851E+01      0.1240E+00
                                   0.6501E+01      0.1550E+00
                                   0.5851E+01      0.3100E+00
                                   0.5851E+01      0.4650E+00
                                   0.5851E+01      0.7749E+00
                                   0.5851E+01      0.3100E+01
7         10      0.1200E+02
                                   0.0000E+00      0.0000E+00
                                   0.1951E+01      0.2480E-01
```

```
                                   0.3252E+01      0.4805E-01
                                   0.4879E+01      0.8834E-01
                                   0.5854E+01      0.1240E+00
                                   0.6505E+01      0.1550E+00
                                   0.5854E+01      0.3100E+00
                                   0.5854E+01      0.4650E+00
                                   0.5854E+01      0.7749E+00
                                   0.5854E+01      0.3100E+01
 8          10      0.2553E+02
                                   0.0000E+00      0.0000E+00
                                   0.3415E+01      0.2480E-01
                                   0.5692E+01      0.4805E-01
                                   0.8538E+01      0.8834E-01
                                   0.1025E+02      0.1240E+00
                                   0.1138E+02      0.1550E+00
                                   0.1025E+02      0.3100E+00
                                   0.1025E+02      0.4650E+00
                                   0.1025E+02      0.7749E+00
                                   0.1025E+02      0.3100E+01
 9          10      0.3896E+02
                                   0.0000E+00      0.0000E+00
                                   0.3746E+01      0.2480E-01
                                   0.6243E+01      0.4805E-01
                                   0.9364E+01      0.8834E-01
                                   0.1124E+02      0.1240E+00
                                   0.1249E+02      0.1550E+00
                                   0.1124E+02      0.3100E+00
                                   0.1124E+02      0.4650E+00
                                   0.1124E+02      0.7749E+00
                                   0.1124E+02      0.3100E+01
10          10      0.3900E+02
                                   0.0000E+00      0.0000E+00
                                   0.1253E+01      0.1000E-01
                                   0.2507E+01      0.2000E-01
                                   0.5014E+01      0.4000E-01
                                   0.7520E+01      0.6000E-01
                                   0.1003E+02      0.8000E-01
                                   0.1128E+02      0.9000E-01
                                   0.1253E+02      0.1000E+00
                                   0.1253E+02      0.5000E+00
                                   0.1253E+02      0.2000E+01
11          10      0.4403E+02
                                   0.0000E+00      0.0000E+00
                                   0.2370E+01      0.1000E-01
                                   0.4740E+01      0.2000E-01
                                   0.9479E+01      0.4000E-01
                                   0.1422E+02      0.6000E-01
                                   0.1896E+02      0.8000E-01
                                   0.2133E+02      0.9000E-01
                                   0.2370E+02      0.1000E+00
                                   0.2370E+02      0.5000E+00
                                   0.2370E+02      0.2000E+01
12          10      0.4896E+02
                                   0.0000E+00      0.0000E+00
                                   0.2592E+01      0.1000E-01
                                   0.5184E+01      0.2000E-01
                                   0.1037E+02      0.4000E-01
                                   0.1555E+02      0.6000E-01
                                   0.2074E+02      0.8000E-01
                                   0.2333E+02      0.9000E-01
                                   0.2592E+02      0.1000E+00
                                   0.2592E+02      0.5000E+00
                                   0.2592E+02      0.2000E+01
13          10      0.4900E+02
                                   0.0000E+00      0.0000E+00
                                   0.7782E+01      0.2480E-01
                                   0.1297E+02      0.4805E-01
```

```
                                        0.1946E+02      0.8834E-01
                                        0.2335E+02      0.1240E+00
                                        0.2594E+02      0.1550E+00
                                        0.2335E+02      0.3100E+00
                                        0.2335E+02      0.4650E+00
                                        0.2335E+02      0.7749E+00
                                        0.2335E+02      0.3100E+01
   14         10      0.5953E+02
                                        0.0000E+00      0.0000E+00
                                        0.2917E+01      0.2480E-01
                                        0.4861E+01      0.4805E-01
                                        0.7292E+01      0.8834E-01
                                        0.8750E+01      0.1240E+00
                                        0.9722E+01      0.1550E+00
                                        0.8750E+01      0.3100E+00
                                        0.8750E+01      0.4650E+00
                                        0.8750E+01      0.7749E+00
                                        0.8750E+01      0.3100E+01
   15         10      0.6996E+02
                                        0.0000E+00      0.0000E+00
                                        0.2917E+01      0.2480E-01
                                        0.4861E+01      0.4805E-01
                                        0.7292E+01      0.8834E-01
                                        0.8750E+01      0.1240E+00
                                        0.9722E+01      0.1550E+00
                                        0.8750E+01      0.3100E+00
                                        0.8750E+01      0.4650E+00
                                        0.8750E+01      0.7749E+00
                                        0.8750E+01      0.3100E+01
   16         10      0.7000E+02
                                        0.0000E+00      0.0000E+00
                                        0.9722E+00      0.1000E-01
                                        0.1944E+01      0.2000E-01
                                        0.3889E+01      0.4000E-01
                                        0.5833E+01      0.6000E-01
                                        0.7778E+01      0.8000E-01
                                        0.8750E+01      0.9000E-01
                                        0.9722E+01      0.1000E+00
                                        0.9722E+01      0.5000E+00
                                        0.9722E+01      0.2000E+01
   17         10      0.8003E+02
                                        0.0000E+00      0.0000E+00
                                        0.4465E+01      0.1000E-01
                                        0.8931E+01      0.2000E-01
                                        0.1786E+02      0.4000E-01
                                        0.2679E+02      0.6000E-01
                                        0.3572E+02      0.8000E-01
                                        0.4019E+02      0.9000E-01
                                        0.4465E+02      0.1000E+00
                                        0.4465E+02      0.5000E+00
                                        0.4465E+02      0.2000E+01
   18         10      0.8996E+02
                                        0.0000E+00      0.0000E+00
                                        0.4465E+01      0.1000E-01
                                        0.8931E+01      0.2000E-01
                                        0.1786E+02      0.4000E-01
                                        0.2679E+02      0.6000E-01
                                        0.3572E+02      0.8000E-01
                                        0.4019E+02      0.9000E-01
                                        0.4465E+02      0.1000E+00
                                        0.4465E+02      0.5000E+00
                                        0.4465E+02      0.2000E+01


TIP   LOAD        TIP MOVEMENT
    KIP               IN.
```

0.0000E+00	0.0000E+00
0.6920E+01	0.7749E-02
0.1384E+02	0.1550E-01
0.2768E+02	0.3100E-01
0.5536E+02	0.2015E+00
0.8304E+02	0.6509E+00
0.9964E+02	0.1131E+01
0.1107E+03	0.1550E+01
0.1107E+03	0.2325E+01
0.1107E+03	0.3100E+01

LOAD VERSUS SETTLEMENT CURVE
****

TOP LOAD KIP	TOP MOVEMENT IN.	TIP LOAD KIP	TIP MOVEMENT IN.
0.1044E+01	0.2405E-03	0.8930E-01	0.1000E-03
0.1044E+02	0.2405E-02	0.8930E+00	0.1000E-02
0.5218E+02	0.1203E-01	0.4465E+01	0.5000E-02
0.1046E+03	0.2406E-01	0.8930E+01	0.1000E-01
0.4874E+03	0.1162E+00	0.3076E+02	0.5000E-01
0.7422E+03	0.2093E+00	0.3888E+02	0.1000E+00
0.7745E+03	0.6170E+00	0.7374E+02	0.5000E+00
0.7959E+03	0.1122E+01	0.9510E+02	0.1000E+01
0.8115E+03	0.2125E+01	0.1107E+03	0.2000E+01

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                 APILE for Windows, Version 2018.8.5

                  Serial Number :  136086088

                  A Program for Analyzing the Axial Capacity
                  and Short-term Settlement of Driven Piles
                            under Axial Loading.
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Indianapolis, IN

Path to file locations      : K:\PROJECTS\2019\Dept 05- Geotech- In Progress\19050015IND_INDOT 1006266_US 52
over Mud Creek Rush Co\Design\Analysis\Apile Analysis\
Name of input data file     : HP12x53 Pier 2.ap8d
Name of output file         : HP12x53 Pier 2.ap8o
Name of plot output file    : HP12x53 Pier 2.ap8p

--------------------------------------------------------------------------
                     Time and Date of Analysis
--------------------------------------------------------------------------

          Date:  July 16, 2019     Time:  15:18:06



1
          *********************
          * INPUT INFORMATION *
          *********************



          Des 1006266 - US 52 over Mud Creek

          DESIGNER   : AK

          JOB NUMBER : 19050015IND


          METHOD FOR UNIT LOAD TRANSFERS :

          - FHWA (Federal Highway Administration)
            Unfactored Unit Side Friction and Unit Side Resistance are used.



          COMPUTATION METHOD(S) FOR PILE CAPACITY :

          - FHWA (Federal Highway Administration)


          TYPE OF LOADING :
          - COMPRESSION


          PILE TYPE :

          H-Pile/Steel Pile
```

DATA FOR AXIAL STIFFNESS :

- MODULUS OF ELASTICITY = 0.290E+08 PSI
- CROSS SECTION AREA = 141.89 IN2

NONCIRCULAR PILE PROPERTIES :

- TOTAL PILE LENGTH, TL = 68.00 FT.
- BATTER ANGLE = 0.00 DEG
- PILE STICKUP LENGTH, PSL = 0.00 FT.
- ZERO FRICTION LENGTH, ZFL = 0.00 FT.
- PERIMETER OF PILE = 47.65 IN.
- TIP AREA OF PILE = 141.89 IN2
- INCREMENT OF PILE LENGTH
  USED IN COMPUTATION = 1.00 FT.

SOIL INFORMATIONS :

DEPTH FT.	SOIL TYPE	LATERAL EARTH PRESSURE	EFFECTIVE UNIT WEIGHT LB/CF	FRICTION ANGLE DEGREES	BEARING CAPACITY FACTOR
0.00	CLAY	0.00	73.00	0.00	0.00
15.00	CLAY	0.00	73.00	0.00	0.00
15.00	SAND	0.00	73.00	34.00	0.00
25.00	SAND	0.00	73.00	34.00	0.00
25.00	CLAY	0.00	78.00	0.00	0.00
68.00	CLAY	0.00	78.00	0.00	0.00
68.00	SAND	0.00	73.00	35.00	0.00
75.00	SAND	0.00	73.00	35.00	0.00

MAXIMUM UNIT FRICTION KSF	MAXIMUM UNIT BEARING KSF	UNDISTURB SHEAR STRENGTH KSF	REMOLDED SHEAR STRENGTH KSF	BLOW COUNT	UNIT SKIN FRICTION KSF	UNIT END BEARING KSF
0.10E+08*	0.10E+08*	2.20	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	2.20	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	3.50	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	4.50	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00

* MAXIMUM UNIT FRICTION AND/OR MAXIMUM UNIT BEARING
  WERE SET TO BE 0.10E+08 BECAUSE THE USER DOES NOT
  PLAN TO LIMIT THE COMPUTED DATA.

DEPTH FT.	LRFD FACTOR ON UNIT FRICTION	LRFD FACTOR ON UNIT BEARING
0.00	1.000	1.000
15.00	1.000	1.000
15.00	1.000	1.000
25.00	1.000	1.000

25.00	1.000	1.000
68.00	1.000	1.000
68.00	1.000	1.000
75.00	1.000	1.000

1

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**********************
* COMPUTATION RESULT *
**********************
```

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**********************
*  FED. HWY. METHOD  *
**********************
```

PILE PENETRATION FT.	TOTAL SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	9.8	9.8
1.00	0.0	9.8	9.8
2.00	2.6	19.5	22.1
3.00	7.9	19.5	27.4
4.00	13.2	19.5	32.7
5.00	18.5	19.5	38.0
6.00	23.8	19.5	43.3
7.00	29.0	19.5	48.5
8.00	34.3	19.5	53.8
9.00	39.6	19.5	59.1
10.00	44.9	19.5	64.4
11.00	50.2	19.5	69.7
12.00	55.4	19.5	74.9
13.00	60.7	19.5	80.2
14.00	66.0	24.6	90.6
15.00	71.7	30.9	102.6
16.00	76.8	37.9	114.7
17.00	81.0	45.1	126.0
18.00	85.5	47.7	133.2
19.00	90.2	50.4	140.6
20.00	95.2	53.0	148.2
21.00	100.4	55.7	156.1
22.00	105.9	58.3	164.3
23.00	111.7	61.0	172.7
24.00	117.7	55.0	172.8
25.00	124.0	47.5	171.5
26.00	130.0	39.3	169.3
27.00	135.6	31.5	167.0
28.00	141.2	31.7	172.9
29.00	146.9	31.9	178.8
30.00	152.6	32.1	184.7
31.00	158.3	32.3	190.6
32.00	164.1	32.5	196.6
33.00	169.9	32.7	202.6
34.00	175.8	32.9	208.7
35.00	181.7	33.1	214.8
36.00	187.6	33.3	220.9
37.00	193.6	33.5	227.1
38.00	199.6	33.7	233.3
39.00	205.6	33.9	239.5
40.00	211.7	34.1	245.8
41.00	217.8	34.3	252.2
42.00	224.0	34.5	258.5
43.00	230.2	34.8	264.9
44.00	236.4	35.0	271.3
45.00	242.6	35.2	277.8

46.00	248.9	35.4	284.3
47.00	255.3	35.6	290.8
48.00	261.6	35.8	297.4
49.00	268.0	36.0	304.0
50.00	274.5	36.2	310.7
51.00	281.0	36.4	317.4
52.00	287.5	36.6	324.1
53.00	294.1	36.8	330.9
54.00	300.6	37.0	337.7
55.00	307.3	37.2	344.5
56.00	313.9	37.4	351.4
57.00	320.6	37.6	358.3
58.00	327.4	37.8	365.2
59.00	334.2	38.1	372.2
60.00	341.0	38.3	379.2
61.00	347.8	38.5	386.3
62.00	354.7	38.7	393.4
63.00	361.6	38.9	400.5
64.00	368.6	39.1	407.7
65.00	375.6	39.3	414.9
66.00	382.6	39.5	422.1
67.00	389.7	55.3	445.0
68.00	396.8	72.9	469.7

NOTES:
- AN ASTERISK IS PLACED IN THE END-BEARING COLUMN
  IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION
  OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.

```
**************************************************
* COMPUTE LOAD-DISTRIBUTION AND LOAD-SETTLEMENT *
* CURVES FOR AXIAL LOADING                      *
**************************************************
```

T-Z CURVE NO.	NO. OF POINTS	DEPTH TO CURVE FT.	LOAD TRANSFER PSI	PILE MOVEMENT IN.
1	10	0.0000E+00		
			0.0000E+00	0.0000E+00
			0.0000E+00	0.2427E-01
			0.0000E+00	0.4702E-01
			0.0000E+00	0.8645E-01
			0.0000E+00	0.1213E+00
			0.0000E+00	0.1517E+00
			0.0000E+00	0.3033E+00
			0.0000E+00	0.4550E+00
			0.0000E+00	0.7584E+00
			0.0000E+00	0.3033E+01
2	10	0.7525E+01		
			0.0000E+00	0.0000E+00
			0.2770E+01	0.2427E-01
			0.4617E+01	0.4702E-01
			0.6925E+01	0.8645E-01
			0.8310E+01	0.1213E+00
			0.9233E+01	0.1517E+00
			0.8310E+01	0.3033E+00
			0.8310E+01	0.4550E+00
			0.8310E+01	0.7584E+00
			0.8310E+01	0.3033E+01
3	10	0.1496E+02		
			0.0000E+00	0.0000E+00
			0.3170E+01	0.2427E-01
			0.5284E+01	0.4702E-01

```
                                        0.7926E+01      0.8645E-01
                                        0.9511E+01      0.1213E+00
                                        0.1057E+02      0.1517E+00
                                        0.9511E+01      0.3033E+00
                                        0.9511E+01      0.4550E+00
                                        0.9511E+01      0.7584E+00
                                        0.9511E+01      0.3033E+01
4         10      0.1500E+02
                                        0.0000E+00      0.0000E+00
                                        0.1063E+01      0.1000E-01
                                        0.2125E+01      0.2000E-01
                                        0.4250E+01      0.4000E-01
                                        0.6375E+01      0.6000E-01
                                        0.8500E+01      0.8000E-01
                                        0.9563E+01      0.9000E-01
                                        0.1063E+02      0.1000E+00
                                        0.1063E+02      0.5000E+00
                                        0.1063E+02      0.2000E+01
5         10      0.2003E+02
                                        0.0000E+00      0.0000E+00
                                        0.8968E+00      0.1000E-01
                                        0.1794E+01      0.2000E-01
                                        0.3587E+01      0.4000E-01
                                        0.5381E+01      0.6000E-01
                                        0.7175E+01      0.8000E-01
                                        0.8071E+01      0.9000E-01
                                        0.8968E+01      0.1000E+00
                                        0.8968E+01      0.5000E+00
                                        0.8968E+01      0.2000E+01
6         10      0.2496E+02
                                        0.0000E+00      0.0000E+00
                                        0.1118E+01      0.1000E-01
                                        0.2236E+01      0.2000E-01
                                        0.4471E+01      0.4000E-01
                                        0.6707E+01      0.6000E-01
                                        0.8942E+01      0.8000E-01
                                        0.1006E+02      0.9000E-01
                                        0.1118E+02      0.1000E+00
                                        0.1118E+02      0.5000E+00
                                        0.1118E+02      0.2000E+01
7         10      0.2500E+02
                                        0.0000E+00      0.0000E+00
                                        0.3359E+01      0.2427E-01
                                        0.5598E+01      0.4702E-01
                                        0.8397E+01      0.8645E-01
                                        0.1008E+02      0.1213E+00
                                        0.1120E+02      0.1517E+00
                                        0.1008E+02      0.3033E+00
                                        0.1008E+02      0.4550E+00
                                        0.1008E+02      0.7584E+00
                                        0.1008E+02      0.3033E+01
8         10      0.4653E+02
                                        0.0000E+00      0.0000E+00
                                        0.3324E+01      0.2427E-01
                                        0.5540E+01      0.4702E-01
                                        0.8310E+01      0.8645E-01
                                        0.9972E+01      0.1213E+00
                                        0.1108E+02      0.1517E+00
                                        0.9972E+01      0.3033E+00
                                        0.9972E+01      0.4550E+00
                                        0.9972E+01      0.7584E+00
                                        0.9972E+01      0.3033E+01
9         10      0.6796E+02
                                        0.0000E+00      0.0000E+00
                                        0.3740E+01      0.2427E-01
                                        0.6233E+01      0.4702E-01
                                        0.9349E+01      0.8645E-01
```

			0.1122E+02	0.1213E+00
			0.1247E+02	0.1517E+00
			0.1122E+02	0.3033E+00
			0.1122E+02	0.4550E+00
			0.1122E+02	0.7584E+00
			0.1122E+02	0.3033E+01
10	10	0.6800E+02		
			0.0000E+00	0.0000E+00
			0.1247E+01	0.1000E-01
			0.2494E+01	0.2000E-01
			0.4987E+01	0.4000E-01
			0.7481E+01	0.6000E-01
			0.9974E+01	0.8000E-01
			0.1122E+02	0.9000E-01
			0.1247E+02	0.1000E+00
			0.1247E+02	0.5000E+00
			0.1247E+02	0.2000E+01
11	10	0.7153E+02		
			0.0000E+00	0.0000E+00
			0.1247E+01	0.1000E-01
			0.2494E+01	0.2000E-01
			0.4987E+01	0.4000E-01
			0.7481E+01	0.6000E-01
			0.9974E+01	0.8000E-01
			0.1122E+02	0.9000E-01
			0.1247E+02	0.1000E+00
			0.1247E+02	0.5000E+00
			0.1247E+02	0.2000E+01
12	10	0.7496E+02		
			0.0000E+00	0.0000E+00
			0.1247E+01	0.1000E-01
			0.2494E+01	0.2000E-01
			0.4987E+01	0.4000E-01
			0.7481E+01	0.6000E-01
			0.9974E+01	0.8000E-01
			0.1122E+02	0.9000E-01
			0.1247E+02	0.1000E+00
			0.1247E+02	0.5000E+00
			0.1247E+02	0.2000E+01

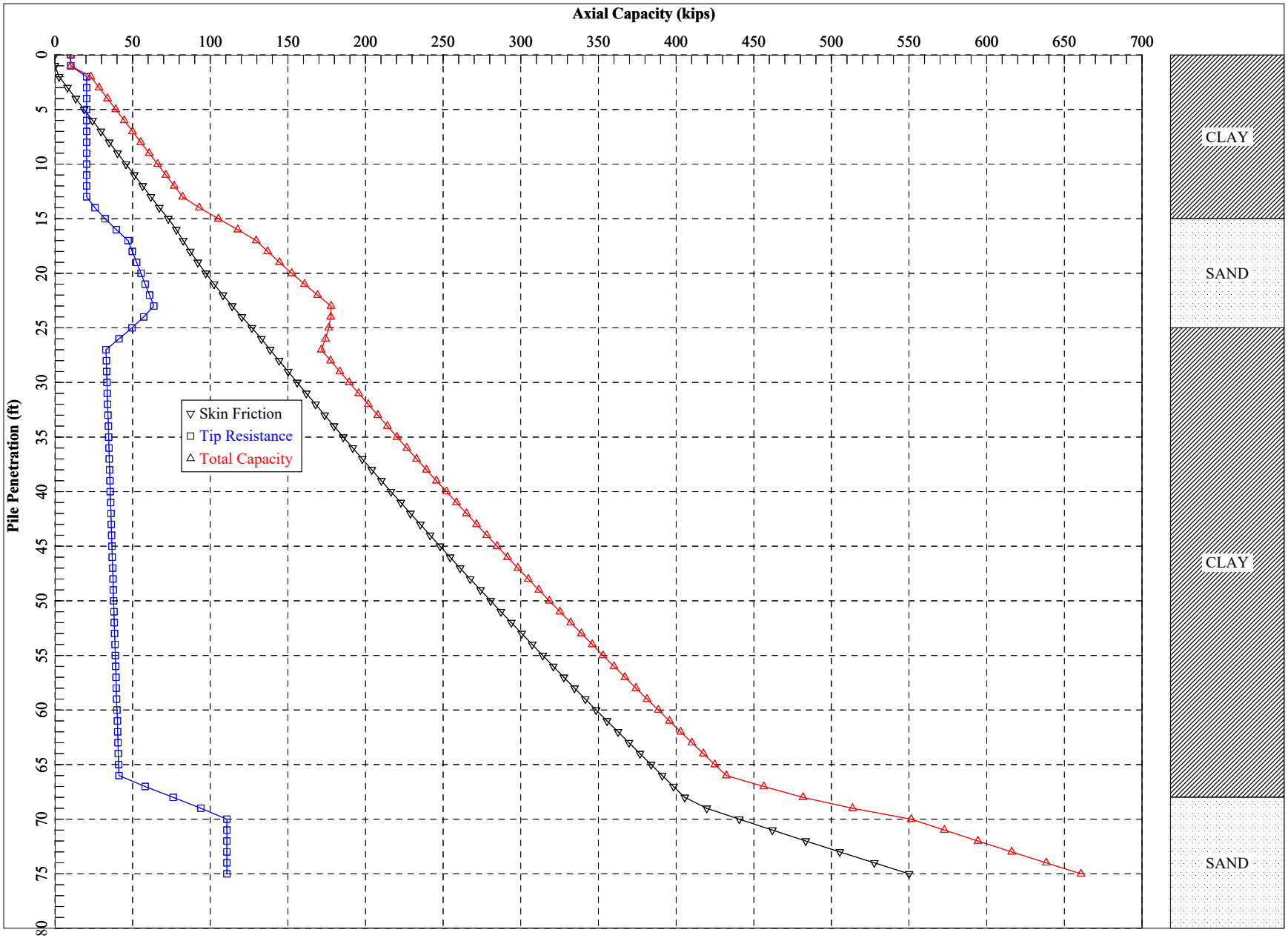
TIP LOAD KIP	TIP MOVEMENT IN.
0.0000E+00	0.0000E+00
0.4554E+01	0.7584E-02
0.9108E+01	0.1517E-01
0.1822E+02	0.3033E-01
0.3643E+02	0.1972E+00
0.5465E+02	0.6370E+00
0.6558E+02	0.1107E+01
0.7286E+02	0.1517E+01
0.7286E+02	0.2275E+01
0.7286E+02	0.3033E+01

LOAD VERSUS SETTLEMENT CURVE
****

TOP LOAD KIP	TOP MOVEMENT IN.	TIP LOAD KIP	TIP MOVEMENT IN.
0.5386E+00	0.1590E-03	0.6005E-01	0.1000E-03
0.5386E+01	0.1590E-02	0.6005E+00	0.1000E-02

0.2693E+02	0.7949E-02	0.3003E+01	0.5000E-02
0.5386E+02	0.1590E-01	0.6005E+01	0.1000E-01
0.2516E+03	0.7728E-01	0.2036E+02	0.5000E-01
0.4219E+03	0.1476E+00	0.2582E+02	0.1000E+00
0.4437E+03	0.5522E+00	0.4897E+02	0.5000E+00
0.4578E+03	0.1055E+01	0.6309E+02	0.1000E+01
0.4676E+03	0.2057E+01	0.7286E+02	0.2000E+01

Layer 1; depth= 0.00 - 15.00 ft; Clay
Layer 2; depth= 15.00 - 25.00 ft; Sand
Layer 3; depth= 25.00 - 68.00 ft; Clay
Layer 4; depth= 68.00 - 80.00 ft; Sand


Axial Capacity (kips)
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
Pile Penetration (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Skin Friction
Tip Resistance
Total Capacity
CLAY
SAND
CLAY
SAND

```
==========================================================================

                 APILE for Windows, Version 2018.8.5

                  Serial Number :  136086088

                  A Program for Analyzing the Axial Capacity
                  and Short-term Settlement of Driven Piles
                            under Axial Loading.
                (c) Copyright ENSOFT, Inc., 1987-2015
                      All Rights Reserved

==========================================================================


This program is licensed to :

CTL Engineering, Inc.
Indianapolis, IN

Path to file locations      : K:\PROJECTS\2019\Dept 05- Geotech- In Progress\19050015IND_INDOT 1006266_US 52
over Mud Creek Rush Co\Design\Analysis\Apile Analysis\HP 12x74 revised\
Name of input data file     : HP12x74 Pier 2 revised.ap8d
Name of output file         : HP12x74 Pier 2 revised.ap8o
Name of plot output file    : HP12x74 Pier 2 revised.ap8p

--------------------------------------------------------------------------
                     Time and Date of Analysis
--------------------------------------------------------------------------

          Date:  July 24, 2019     Time:  17:31:56



1
          *********************
          * INPUT INFORMATION *
          *********************



          Des 1006266 - US 52 over Mud Creek - Pier 2

          DESIGNER   : AK

          JOB NUMBER : 19050015IND


          METHOD FOR UNIT LOAD TRANSFERS :

          - FHWA (Federal Highway Administration)
            Unfactored Unit Side Friction and Unit Side Resistance are used.



          COMPUTATION METHOD(S) FOR PILE CAPACITY :

          - FHWA (Federal Highway Administration)


          TYPE OF LOADING :
          - COMPRESSION


          PILE TYPE :

          H-Pile/Steel Pile
```

DATA FOR AXIAL STIFFNESS :

- MODULUS OF ELASTICITY = 0.290E+08 PSI
- CROSS SECTION AREA = 148.17 IN2

NONCIRCULAR PILE PROPERTIES :

- TOTAL PILE LENGTH, TL = 75.00 FT.
- BATTER ANGLE = 0.00 DEG
- PILE STICKUP LENGTH, PSL = 0.00 FT.
- ZERO FRICTION LENGTH, ZFL = 0.00 FT.
- PERIMETER OF PILE = 48.69 IN.
- TIP AREA OF PILE = 148.17 IN2
- INCREMENT OF PILE LENGTH
  USED IN COMPUTATION = 1.00 FT.

SOIL INFORMATIONS :

DEPTH FT.	SOIL TYPE	LATERAL EARTH PRESSURE	EFFECTIVE UNIT WEIGHT LB/CF	FRICTION ANGLE DEGREES	BEARING CAPACITY FACTOR
0.00	CLAY	0.00	73.00	0.00	0.00
15.00	CLAY	0.00	73.00	0.00	0.00
15.00	SAND	0.00	73.00	34.00	0.00
25.00	SAND	0.00	73.00	34.00	0.00
25.00	CLAY	0.00	78.00	0.00	0.00
68.00	CLAY	0.00	78.00	0.00	0.00
68.00	SAND	0.00	73.00	35.00	0.00
80.00	SAND	0.00	73.00	35.00	0.00

MAXIMUM UNIT FRICTION KSF	MAXIMUM UNIT BEARING KSF	UNDISTURB SHEAR STRENGTH KSF	REMOLDED SHEAR STRENGTH KSF	BLOW COUNT	UNIT SKIN FRICTION KSF	UNIT END BEARING KSF
0.10E+08*	0.10E+08*	2.20	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	2.20	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	3.50	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	4.50	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00

* MAXIMUM UNIT FRICTION AND/OR MAXIMUM UNIT BEARING
  WERE SET TO BE 0.10E+08 BECAUSE THE USER DOES NOT
  PLAN TO LIMIT THE COMPUTED DATA.

DEPTH FT.	LRFD FACTOR ON UNIT FRICTION	LRFD FACTOR ON UNIT BEARING
0.00	1.000	1.000
15.00	1.000	1.000
15.00	1.000	1.000
25.00	1.000	1.000

25.00	1.000	1.000
68.00	1.000	1.000
68.00	1.000	1.000
80.00	1.000	1.000

1

```
**********************
* COMPUTATION RESULT *
**********************
```

```
**********************
*  FED. HWY. METHOD  *
**********************
```

PILE PENETRATION FT.	TOTAL SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	10.2	10.2
1.00	0.0	10.2	10.2
2.00	2.7	20.4	23.1
3.00	8.1	20.4	28.4
4.00	13.4	20.4	33.8
5.00	18.8	20.4	39.2
6.00	24.2	20.4	44.6
7.00	29.6	20.4	49.9
8.00	35.0	20.4	55.3
9.00	40.3	20.4	60.7
10.00	45.7	20.4	66.1
11.00	51.1	20.4	71.5
12.00	56.5	20.4	76.8
13.00	61.8	20.4	82.2
14.00	67.2	25.8	93.0
15.00	73.0	32.3	105.3
16.00	78.2	39.5	117.7
17.00	82.5	47.1	129.6
18.00	87.1	49.8	137.0
19.00	92.0	52.6	144.6
20.00	97.1	55.4	152.5
21.00	102.5	58.1	160.7
22.00	108.2	60.9	169.1
23.00	114.1	63.7	177.8
24.00	120.3	57.2	177.6
25.00	126.8	49.6	176.3
26.00	132.9	41.2	174.2
27.00	138.6	32.8	171.5
28.00	144.4	33.1	177.5
29.00	150.2	33.3	183.5
30.00	156.0	33.5	189.5
31.00	161.9	33.7	195.6
32.00	167.8	33.9	201.7
33.00	173.7	34.1	207.9
34.00	179.7	34.4	214.1
35.00	185.7	34.6	220.3
36.00	191.8	34.8	226.6
37.00	197.9	35.0	232.9
38.00	204.0	35.2	239.2
39.00	210.2	35.4	245.6
40.00	216.4	35.6	252.1
41.00	222.7	35.9	258.5
42.00	228.9	36.1	265.0
43.00	235.3	36.3	271.5
44.00	241.6	36.5	278.1
45.00	248.0	36.7	284.7

46.00	254.5	36.9	291.4
47.00	260.9	37.2	298.1
48.00	267.4	37.4	304.8
49.00	274.0	37.6	311.6
50.00	280.6	37.8	318.4
51.00	287.2	38.0	325.2
52.00	293.9	38.2	332.1
53.00	300.6	38.4	339.0
54.00	307.3	38.7	346.0
55.00	314.1	38.9	352.9
56.00	320.9	39.1	360.0
57.00	327.7	39.3	367.0
58.00	334.6	39.5	374.1
59.00	341.5	39.7	381.3
60.00	348.5	39.9	388.5
61.00	355.5	40.2	395.7
62.00	362.6	40.4	402.9
63.00	369.6	40.6	410.2
64.00	376.7	40.8	417.6
65.00	383.9	41.0	424.9
66.00	391.1	41.2	432.3
67.00	398.3	58.1	456.4
68.00	405.6	76.1	481.7
69.00	419.7	94.0	513.6
70.00	440.7	110.7	551.4
71.00	462.0	110.7	572.7
72.00	483.5	110.7	594.3
73.00	505.4	110.7	616.1
74.00	527.6	110.7	638.3
75.00	550.0	110.7	660.7

NOTES:
- AN ASTERISK IS PLACED IN THE END-BEARING COLUMN IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.

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**************************************************
* COMPUTE LOAD-DISTRIBUTION AND LOAD-SETTLEMENT *
* CURVES FOR AXIAL LOADING                      *
**************************************************
```

T-Z CURVE NO.	NO. OF POINTS	DEPTH TO CURVE FT.	LOAD TRANSFER PSI	PILE MOVEMENT IN.
1	10	0.0000E+00		
			0.0000E+00	0.0000E+00
			0.0000E+00	0.2480E-01
			0.0000E+00	0.4805E-01
			0.0000E+00	0.8834E-01
			0.0000E+00	0.1240E+00
			0.0000E+00	0.1550E+00
			0.0000E+00	0.3100E+00
			0.0000E+00	0.4650E+00
			0.0000E+00	0.7749E+00
			0.0000E+00	0.3100E+01
2	10	0.7525E+01		
			0.0000E+00	0.0000E+00
			0.2761E+01	0.2480E-01
			0.4602E+01	0.4805E-01
			0.6902E+01	0.8834E-01
			0.8283E+01	0.1240E+00
			0.9203E+01	0.1550E+00
			0.8283E+01	0.3100E+00

```
                                   0.8283E+01      0.4650E+00
                                   0.8283E+01      0.7749E+00
                                   0.8283E+01      0.3100E+01
3         10      0.1496E+02
                                   0.0000E+00      0.0000E+00
                                   0.3153E+01      0.2480E-01
                                   0.5255E+01      0.4805E-01
                                   0.7882E+01      0.8834E-01
                                   0.9458E+01      0.1240E+00
                                   0.1051E+02      0.1550E+00
                                   0.9458E+01      0.3100E+00
                                   0.9458E+01      0.4650E+00
                                   0.9458E+01      0.7749E+00
                                   0.9458E+01      0.3100E+01
4         10      0.1500E+02
                                   0.0000E+00      0.0000E+00
                                   0.1057E+01      0.1000E-01
                                   0.2113E+01      0.2000E-01
                                   0.4226E+01      0.4000E-01
                                   0.6340E+01      0.6000E-01
                                   0.8453E+01      0.8000E-01
                                   0.9509E+01      0.9000E-01
                                   0.1057E+02      0.1000E+00
                                   0.1057E+02      0.5000E+00
                                   0.1057E+02      0.2000E+01
5         10      0.2003E+02
                                   0.0000E+00      0.0000E+00
                                   0.9026E+00      0.1000E-01
                                   0.1805E+01      0.2000E-01
                                   0.3611E+01      0.4000E-01
                                   0.5416E+01      0.6000E-01
                                   0.7221E+01      0.8000E-01
                                   0.8124E+01      0.9000E-01
                                   0.9026E+01      0.1000E+00
                                   0.9026E+01      0.5000E+00
                                   0.9026E+01      0.2000E+01
6         10      0.2496E+02
                                   0.0000E+00      0.0000E+00
                                   0.1125E+01      0.1000E-01
                                   0.2250E+01      0.2000E-01
                                   0.4500E+01      0.4000E-01
                                   0.6750E+01      0.6000E-01
                                   0.9000E+01      0.8000E-01
                                   0.1013E+02      0.9000E-01
                                   0.1125E+02      0.1000E+00
                                   0.1125E+02      0.5000E+00
                                   0.1125E+02      0.2000E+01
7         10      0.2500E+02
                                   0.0000E+00      0.0000E+00
                                   0.3381E+01      0.2480E-01
                                   0.5634E+01      0.4805E-01
                                   0.8452E+01      0.8834E-01
                                   0.1014E+02      0.1240E+00
                                   0.1127E+02      0.1550E+00
                                   0.1014E+02      0.3100E+00
                                   0.1014E+02      0.4650E+00
                                   0.1014E+02      0.7749E+00
                                   0.1014E+02      0.3100E+01
8         10      0.4653E+02
                                   0.0000E+00      0.0000E+00
                                   0.3324E+01      0.2480E-01
                                   0.5540E+01      0.4805E-01
                                   0.8310E+01      0.8834E-01
                                   0.9972E+01      0.1240E+00
                                   0.1108E+02      0.1550E+00
                                   0.9972E+01      0.3100E+00
                                   0.9972E+01      0.4650E+00
```

			0.9972E+01	0.7749E+00
			0.9972E+01	0.3100E+01
9	10	0.6796E+02		
			0.0000E+00	0.0000E+00
			0.3740E+01	0.2480E-01
			0.6233E+01	0.4805E-01
			0.9349E+01	0.8834E-01
			0.1122E+02	0.1240E+00
			0.1247E+02	0.1550E+00
			0.1122E+02	0.3100E+00
			0.1122E+02	0.4650E+00
			0.1122E+02	0.7749E+00
			0.1122E+02	0.3100E+01
10	10	0.6800E+02		
			0.0000E+00	0.0000E+00
			0.1247E+01	0.1000E-01
			0.2494E+01	0.2000E-01
			0.4987E+01	0.4000E-01
			0.7481E+01	0.6000E-01
			0.9974E+01	0.8000E-01
			0.1122E+02	0.9000E-01
			0.1247E+02	0.1000E+00
			0.1247E+02	0.5000E+00
			0.1247E+02	0.2000E+01
11	10	0.7403E+02		
			0.0000E+00	0.0000E+00
			0.3819E+01	0.1000E-01
			0.7639E+01	0.2000E-01
			0.1528E+02	0.4000E-01
			0.2292E+02	0.6000E-01
			0.3056E+02	0.8000E-01
			0.3438E+02	0.9000E-01
			0.3819E+02	0.1000E+00
			0.3819E+02	0.5000E+00
			0.3819E+02	0.2000E+01
12	10	0.7996E+02		
			0.0000E+00	0.0000E+00
			0.3868E+01	0.1000E-01
			0.7736E+01	0.2000E-01
			0.1547E+02	0.4000E-01
			0.2321E+02	0.6000E-01
			0.3094E+02	0.8000E-01
			0.3481E+02	0.9000E-01
			0.3868E+02	0.1000E+00
			0.3868E+02	0.5000E+00
			0.3868E+02	0.2000E+01

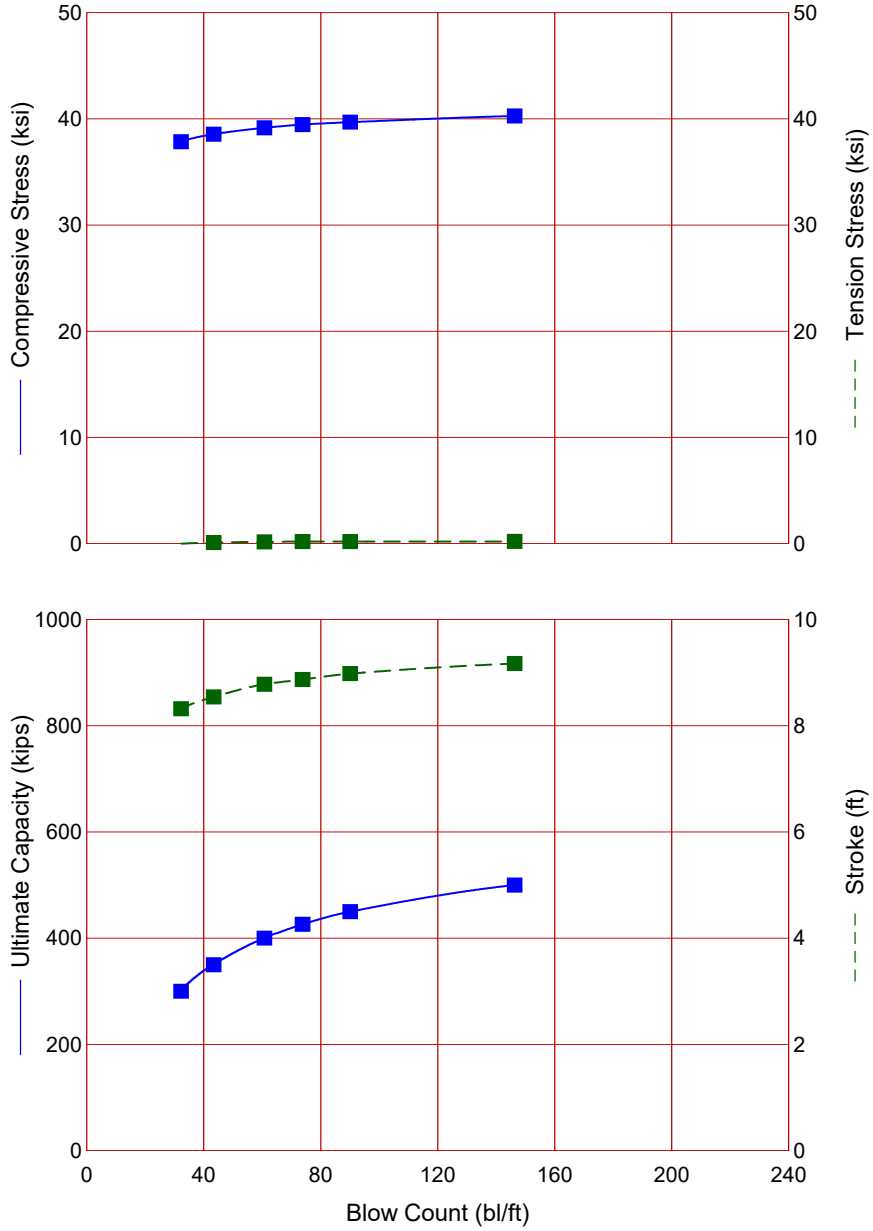
TIP LOAD KIP	TIP MOVEMENT IN.
0.0000E+00	0.0000E+00
0.6920E+01	0.7749E-02
0.1384E+02	0.1550E-01
0.2768E+02	0.3100E-01
0.5536E+02	0.2015E+00
0.8304E+02	0.6509E+00
0.9964E+02	0.1131E+01
0.1107E+03	0.1550E+01
0.1107E+03	0.2325E+01
0.1107E+03	0.3100E+01

LOAD VERSUS SETTLEMENT CURVE
****

TOP LOAD KIP	TOP MOVEMENT IN.	TIP LOAD KIP	TIP MOVEMENT IN.
0.8024E+00	0.1997E-03	0.8930E-01	0.1000E-03
0.8024E+01	0.1997E-02	0.8930E+00	0.1000E-02
0.4012E+02	0.9984E-02	0.4465E+01	0.5000E-02
0.8028E+02	0.1997E-01	0.8930E+01	0.1000E-01
0.3748E+03	0.9644E-01	0.3076E+02	0.5000E-01
0.5886E+03	0.1786E+00	0.3888E+02	0.1000E+00
0.6215E+03	0.5859E+00	0.7374E+02	0.5000E+00
0.6428E+03	0.1090E+01	0.9510E+02	0.1000E+01
0.6584E+03	0.2094E+01	0.1107E+03	0.2000E+01

CTL Engineering Inc
Des 1006266 -US 52 over Mud Crk

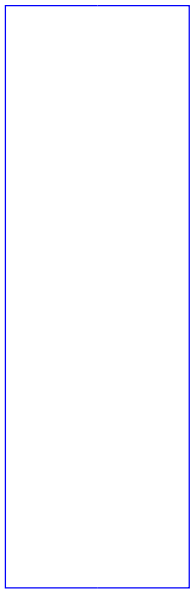
16-Jul-2019
GRLWEAP Version 2010



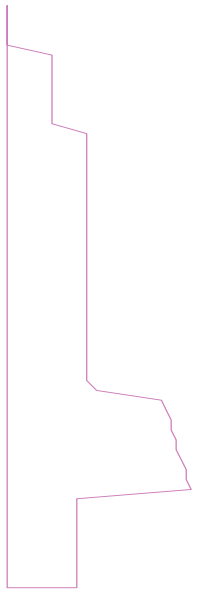
DELMAG D 30-32

Ram Weight	6.60	kips
Efficiency	0.800	
Pressure	1400 (100%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	91401	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.100	in
Skin Damping	0.200	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	59.00	ft
Pile Penetration	59.00	ft
Pile Top Area	15.50	in2

Pile Model



Skin Friction Distribution



Res. Shaft = 276.0 kips
(Constant Res. Shaft)

CTL Engineering Inc 16-Jul-2019
Des 1006266 -US 52 over Mud Crk GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
300.0	37.83	0.00	32.3	8.32	31.43
350.0	38.54	0.11	43.4	8.54	32.33
400.0	39.15	0.17	60.8	8.78	33.14
426.0	39.45	0.20	73.8	8.87	33.59
450.0	39.68	0.20	90.1	8.98	33.96
500.0	40.26	0.20	146.3	9.17	34.79

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: K:\PROJECTS\2019\DEPT 05- GEOTECH- IN PROGRESS\19050015IND_INDOT 1006266_US 52 OVER MUD CREEK RUSH CO\DESIGN\ANALYSIS\APILE ANALYSIS\HP12X53 BENT 1_D 30-32.GWW
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2003.GW
Hammer File Version: 2003 (2/22/2013)

Input File Contents

Des 1006266 -US 52 over Mud Crk

OUT	OSG	HAM	STR	FUL	PEL	N	SPL	N-U	P-D	%SK	ISM	0	PHI	RSA	ITR	H-D	MXT	DEx
6	0	15	0	1	0	0	0	0	3	-92	0	0	0	0	0	0	0	0.000

Pile g	Hammer g	Toe Area	Pile Size	Pile Type
32.170	32.170	141.890	12.040	H Pile

W Cp	A Cp	E Cp	T Cp	CoR	ROut	StCp
1.900	415.460	440.0	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	1.000	0.010

Manufac	Hmr Name	HmrType	No Seg-s
DELMAG	D 30-32	1	5

Ram Wt	Ram L	Ram Dia	MaxStrk	RtdStrk	Efficy
6.60	123.20	16.51	13.73	11.43	0.80

IB. Wt	IB. L	IB.Dia	IB CoR	IB RO
1.36	28.15	16.51	0.900	0.010

CompStrk	A Chamber	V Chamber	C Delay	C Duratn	Exp Coeff	VolCStart	Vol CEnd
17.68	214.03	309.10	0.001	0.002	1.250	0.00	0.00

P atm	P1	P2	P3	P4	P5
14.70	1400.00	1260.00	1134.00	1021.00	0.00

Stroke	Effic.	Pressure	R-Weight	T-Delay	Exp-Coeff	Eps-Str	Total-AW
11.4300	0.8000	1400.0000	0.0000	0.0000	0.0000	0.0100	0.0000

Qs	Qt	Js	Jt	Qx	Jx	Rati	Dept
0.100	0.100	0.200	0.150	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

Res. Distribution

Dpth	Rskn	Dpth	Dpth						
0.00	0.00	59.00	59.00	0.00	0.00	0.00	0.00	0.00	0.0
1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5.00	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6.00	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7.00	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8.00	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9.00	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10.00	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11.00	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12.00	0.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
14.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
15.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
16.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
17.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
18.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
19.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
20.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
21.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
22.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
23.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
24.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0

25.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
26.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
27.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
28.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
29.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
30.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
31.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
32.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
33.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
34.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
35.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
36.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
37.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
38.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
39.00	1.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
40.00	3.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
41.00	3.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
42.00	3.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
43.00	3.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
44.00	3.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
45.00	3.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
46.00	3.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
47.00	3.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
48.00	3.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
49.00	3.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
50.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
51.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
52.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
53.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
54.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
55.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
56.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
57.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
58.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
59.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Rult									
300.0	350.0	400.0	426.0	450.0	500.0	0.0	0.0	0.0	0.0

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

Des 1006266 -US 52 over Mud Crk

Hammer Model: D 30-32 Made by: DELMAG

No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	1.320				
2	1.320	251965.7	1.000	0.0100	
3	1.320	251965.7	1.000	0.0100	
4	1.320	251965.7	1.000	0.0100	
5	1.320	251965.7	1.000	0.0100	
Imp Block	1.360	117606.2	0.900	0.0100	
Helmet	1.900	91401.2	0.800	0.0100	9.6
Combined Pile Top		11428.0			

HAMMER OPTIONS:

Hammer File ID No.	15	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)	123.20
Maximum Stroke	(ft)	13.73			
Rated Stroke	(ft)	11.43	Efficiency		0.800
Maximum Pressure	(psi)	1400.00	Actual Pressure	(psi)	1400.00
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)	415.46	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	440.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	2.00	Thickness	(inch)	0.00
Coeff of Restitution		0.8	Coeff of Restitution		0.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	91401.2	Stiffness	(kips/in)	0.0

PILE PROFILE:

Toe Area	(in2)	141.890	Pile Type	H Pile
Pile Size	(inch)	12.040		

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
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) 300.0

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	0.174	11428	0.010	0.000	1.00	0.0	0.200	0.100	3.28	4.0	15.5
2	0.174	11428	0.000	0.000	1.00	5.2	0.200	0.100	6.56	4.0	15.5
3	0.174	11428	0.000	0.000	1.00	8.4	0.200	0.100	9.83	4.0	15.5
4	0.174	11428	0.000	0.000	1.00	9.6	0.200	0.100	13.11	4.0	15.5
5	0.174	11428	0.000	0.000	1.00	14.9	0.200	0.100	16.39	4.0	15.5
12	0.174	11428	0.000	0.000	1.00	15.5	0.200	0.100	39.33	4.0	15.5
13	0.174	11428	0.000	0.000	1.00	28.2	0.200	0.100	42.61	4.0	15.5
14	0.174	11428	0.000	0.000	1.00	30.8	0.200	0.100	45.89	4.0	15.5
15	0.174	11428	0.000	0.000	1.00	32.7	0.200	0.100	49.17	4.0	15.5
16	0.174	11428	0.000	0.000	1.00	15.1	0.200	0.100	52.44	4.0	15.5
17	0.174	11428	0.000	0.000	1.00	12.9	0.200	0.100	55.72	4.0	15.5
18	0.174	11428	0.000	0.000	1.00	12.9	0.200	0.100	59.00	4.0	15.5
Toe						24.0	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)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile		Pile Segments: Automatic	
No. of Slacks/Splices	0	Pile Damping (%)	3
Pile Penetration (ft)	59.00	Pile Damping Fact.(k/ft/s)	1.632
% Shaft Resistance	92		
Constant Shaft Resist. Bearing Graph			
Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	1	Analysis Time-Input (ms)	0
Output Level: Variable vs Time			
Gravity Mass, Pile, Hammer:	32.170	32.170 32.170	
Output Segment Generation: Automatic			

Rut= 300.0, Rtoe = 24.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	571.6	0.00	36.88	18.22	0.784	31.43
2	0.0	586.4	0.00	37.83	17.75	0.748	30.36
3	0.0	582.3	0.00	37.56	17.08	0.713	28.62
4	0.0	571.2	0.00	36.85	16.24	0.679	26.64
5	0.0	556.8	0.00	35.92	15.21	0.647	24.41
6	0.0	534.9	0.00	34.51	14.21	0.619	22.06
7	0.0	514.0	0.00	33.16	13.25	0.594	19.97
8	0.0	491.6	0.00	31.71	12.33	0.571	18.10
9	0.0	472.5	0.00	30.48	11.47	0.552	16.41
10	0.0	450.3	0.00	29.05	10.67	0.535	14.87
11	0.0	422.8	0.00	27.28	9.93	0.520	13.45
12	0.0	387.3	0.00	24.99	9.13	0.508	12.12
13	0.0	348.7	0.00	22.50	8.16	0.497	10.36
14	0.0	293.0	0.00	18.90	7.34	0.488	8.10
15	0.0	241.7	0.00	15.59	7.17	0.481	5.73
16	0.0	192.6	0.00	12.43	7.46	0.477	3.97
17	0.0	155.1	0.00	10.01	8.49	0.474	2.94
18	0.0	97.3	0.00	6.28	9.30	0.472	2.47

(Eq) Strokes Analyzed and Last Return (ft):
11.43 8.46 8.32 8.30

Max. Combustion Pressure 1400.0 psi

Rut= 350.0, Rtoe= 74.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	581.9	0.00	37.54	18.63	0.792	32.33
2	-1.7	597.4	-0.11	38.54	18.15	0.752	31.11
3	0.0	592.8	0.00	38.24	17.46	0.713	29.18
4	0.0	579.6	0.00	37.40	16.59	0.673	26.99
5	0.0	565.2	0.00	36.46	15.53	0.635	24.51
6	0.0	543.1	0.00	35.04	14.51	0.599	21.95
7	0.0	522.9	0.00	33.73	13.52	0.566	19.67
8	0.0	500.8	0.00	32.31	12.57	0.536	17.66
9	0.0	481.5	0.00	31.07	11.71	0.509	15.88
10	0.0	459.6	0.00	29.65	10.89	0.485	14.31
11	0.0	432.9	0.00	27.93	10.14	0.463	12.91
12	0.0	400.1	0.00	25.81	9.34	0.444	11.65
13	0.0	377.3	0.00	24.34	8.36	0.427	10.11
14	0.0	330.4	0.00	21.32	7.51	0.412	8.25
15	0.0	274.2	0.00	17.69	6.93	0.401	6.39
16	0.0	211.5	0.00	13.64	7.08	0.392	5.05
17	0.0	181.5	0.00	11.71	7.90	0.384	4.28
18	0.0	153.8	0.00	9.92	8.02	0.376	3.92

(Eq) Strokes Analyzed and Last Return (ft):
11.43 8.74 8.54 8.53

Max. Combustion Pressure 1400.0 psi

Rut= 400.0, Rtoe = 124.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	590.3	0.00	38.08	18.96	0.799	33.14
2	-2.7	606.8	-0.17	39.15	18.46	0.757	31.82
3	0.0	602.8	0.00	38.89	17.75	0.716	29.77
4	0.0	587.6	0.00	37.91	16.89	0.673	27.44
5	0.0	573.6	0.00	37.01	15.82	0.631	24.78
6	0.0	549.6	0.00	35.46	14.78	0.590	21.99
7	0.0	530.0	0.00	34.19	13.79	0.551	19.52
8	0.0	508.4	0.00	32.80	12.84	0.515	17.33
9	0.0	489.0	0.00	31.55	11.93	0.482	15.40
10	0.0	468.7	0.00	30.24	11.11	0.451	13.72
11	0.0	455.4	0.00	29.38	10.34	0.423	12.25
12	0.0	437.0	0.00	28.19	9.51	0.397	10.95
13	0.0	415.9	0.00	26.84	8.53	0.373	9.48
14	0.0	373.5	0.00	24.09	7.67	0.353	7.83
15	0.0	322.9	0.00	20.83	7.06	0.336	6.27
16	0.0	266.0	0.00	17.16	7.11	0.322	5.18
17	0.0	240.0	0.00	15.49	7.55	0.309	4.56
18	0.0	216.3	0.00	13.96	7.16	0.297	4.25

(Eq) Strokes Analyzed and Last Return (ft):
11.43 8.98 8.78 8.76

Max. Combustion Pressure 1400.0 psi

Rut= 426.0, Rtoe= 150.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	594.9	0.00	38.38	19.15	0.804	33.59
2	-3.1	611.5	-0.20	39.45	18.66	0.761	32.24
3	0.0	607.3	0.00	39.18	17.94	0.719	30.14
4	0.0	591.7	0.00	38.18	17.03	0.675	27.75
5	0.0	577.6	0.00	37.26	15.94	0.631	25.01
6	0.0	553.3	0.00	35.70	14.89	0.588	22.13
7	0.0	533.9	0.00	34.44	13.89	0.547	19.55
8	0.0	512.4	0.00	33.06	12.94	0.509	17.26
9	0.0	492.9	0.00	31.80	12.04	0.472	15.24
10	0.0	481.6	0.00	31.07	11.20	0.439	13.48
11	0.0	469.1	0.00	30.27	10.41	0.407	11.95
12	0.0	451.9	0.00	29.16	9.61	0.378	10.61
13	0.0	431.4	0.00	27.83	8.61	0.352	9.14
14	0.0	390.7	0.00	25.21	7.73	0.328	7.53
15	0.0	343.5	0.00	22.16	7.12	0.309	6.06
16	0.0	290.2	0.00	18.72	7.13	0.292	5.05
17	0.0	266.2	0.00	17.17	7.42	0.277	4.47
18	0.0	244.3	0.00	15.76	6.80	0.262	4.17

(Eq) Strokes Analyzed and Last Return (ft):
11.43 9.11 8.87 8.86

Max. Combustion Pressure 1400.0 psi

Rut= 450.0, Rtoe = 174.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	599.0	0.00	38.64	19.28	0.807	33.96
2	-3.0	615.0	-0.19	39.68	18.79	0.764	32.57
3	0.0	611.1	0.00	39.43	18.08	0.721	30.43
4	0.0	595.9	0.00	38.44	17.19	0.677	28.00
5	0.0	581.9	0.00	37.54	16.10	0.632	25.21
6	0.0	556.0	0.00	35.87	15.04	0.588	22.26
7	0.0	536.8	0.00	34.63	14.03	0.545	19.60
8	0.0	515.6	0.00	33.26	13.06	0.504	17.22
9	0.0	497.8	0.00	32.12	12.13	0.465	15.12
10	0.0	491.0	0.00	31.68	11.30	0.429	13.29
11	0.0	478.9	0.00	30.90	10.52	0.395	11.70
12	0.0	462.7	0.00	29.85	9.67	0.364	10.31
13	0.0	443.4	0.00	28.61	8.68	0.334	8.82
14	0.0	404.1	0.00	26.07	7.81	0.309	7.23
15	0.0	359.9	0.00	23.22	7.17	0.286	5.81
16	0.0	310.2	0.00	20.01	7.15	0.267	4.84
17	0.0	287.4	0.00	18.54	7.33	0.249	4.29
18	0.0	267.4	0.00	17.25	6.49	0.233	3.99

(Eq) Strokes Analyzed and Last Return (ft):
11.43 9.20 8.98 8.96

Max. Combustion Pressure 1400.0 psi

Rut= 500.0, Rtoe= 224.0 kips, Time Inc. =0.072 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	607.0	0.00	39.16	19.64	0.815	34.79
2	-3.1	624.1	-0.20	40.26	19.14	0.771	33.35
3	0.0	619.7	0.00	39.98	18.41	0.727	31.13
4	0.0	603.7	0.00	38.95	17.49	0.681	28.61
5	0.0	589.0	0.00	38.00	16.37	0.635	25.72
6	0.0	562.2	0.00	36.27	15.29	0.589	22.66
7	0.0	543.5	0.00	35.06	14.25	0.545	19.88
8	0.0	522.6	0.00	33.72	13.26	0.501	17.36
9	0.0	514.6	0.00	33.20	12.34	0.458	15.10
10	0.0	508.0	0.00	32.77	11.48	0.417	13.09
11	0.0	496.0	0.00	32.00	10.69	0.379	11.35
12	0.0	480.7	0.00	31.01	9.85	0.342	9.83
13	0.0	464.9	0.00	29.99	8.81	0.308	8.26
14	0.0	430.2	0.00	27.75	7.93	0.277	6.65
15	0.0	390.1	0.00	25.17	7.27	0.249	5.27
16	0.0	346.6	0.00	22.36	7.18	0.225	4.33
17	0.0	326.5	0.00	21.07	7.14	0.203	3.78
18	0.0	309.3	0.00	19.96	6.01	0.182	3.45

(Eq) Strokes Analyzed and Last Return (ft):
11.43 9.40 9.17 9.14

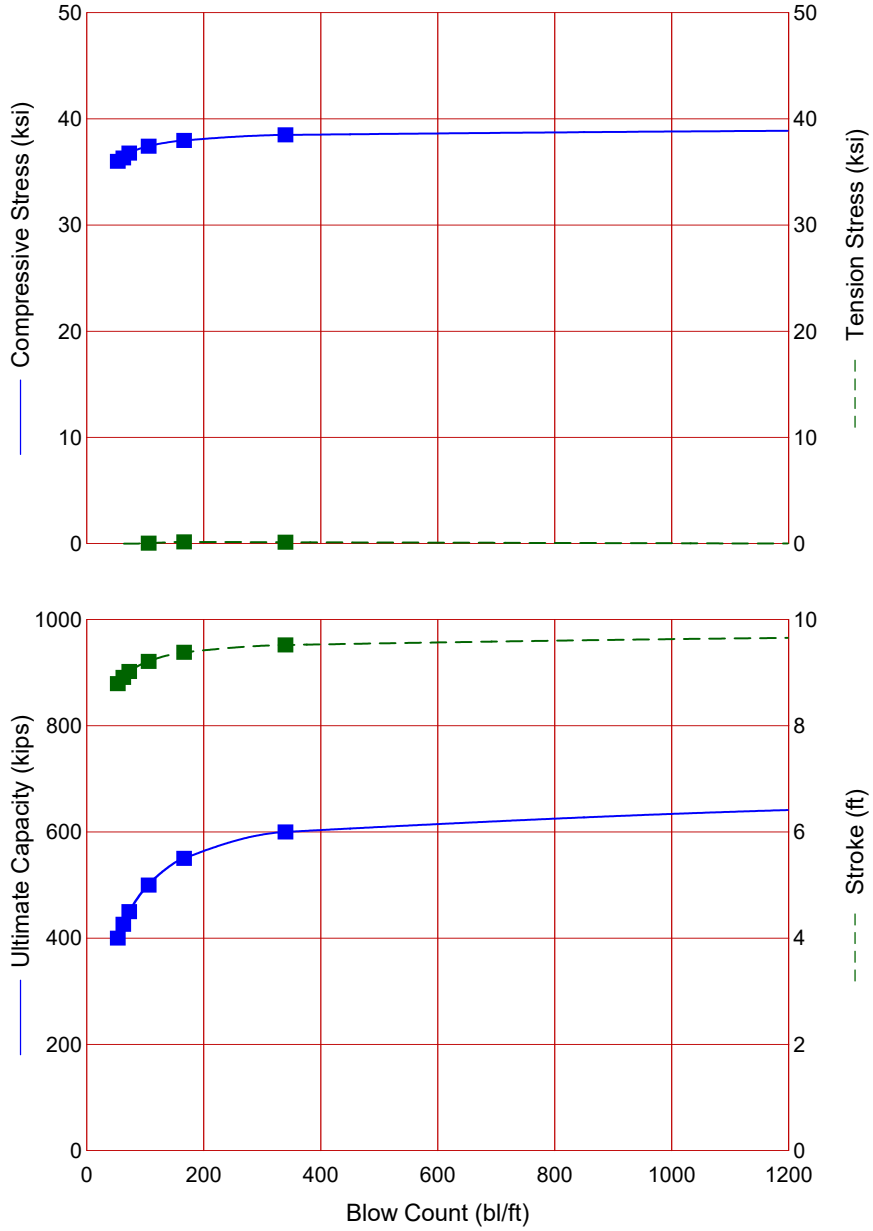
Max. Combustion Pressure 1400.0 psi

Des 1006266 -US 52 over Mud Crk 07/16/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
300.0	32.3	8.32	8.30	0.00	1	0	37.83	2	2	31.4	40.9
350.0	43.4	8.54	8.53	-0.11	2	37	38.54	2	2	32.3	40.4
400.0	60.8	8.78	8.76	-0.17	2	36	39.15	2	2	33.1	39.8
426.0	73.8	8.87	8.86	-0.20	2	36	39.45	2	2	33.6	39.6
450.0	90.1	8.98	8.96	-0.19	2	35	39.68	2	2	34.0	39.4
500.0	146.3	9.17	9.14	-0.20	2	35	40.26	2	2	34.8	39.0

CTL Engineering Inc
Des 1006266 - US 52 over Mud Cree

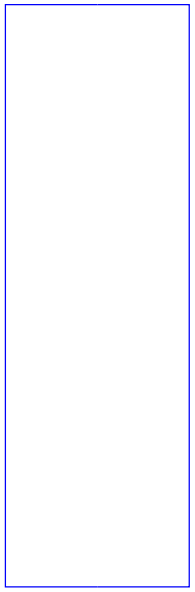
24-Jul-2019
GRLWEAP Version 2010



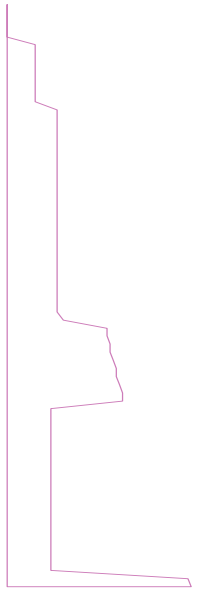
DELMAG D 30-32

Ram Weight	6.60	kips
Efficiency	0.800	
Pressure	1400 (100%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	91401	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.100	in
Skin Damping	0.200	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	72.00	ft
Pile Penetration	72.00	ft
Pile Top Area	21.80	in2

Pile Model



Skin Friction Distribution



Res. Toe = 72.0 kips
(Constant Res. Toe)

CTL Engineering Inc 24-Jul-2019
Des 1006266 - US 52 over Mud Cree GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
400.0	35.99	0.00	53.2	8.79	31.34
426.0	36.31	0.00	62.6	8.91	31.50
450.0	36.76	0.00	72.7	9.02	31.86
500.0	37.41	0.04	105.9	9.21	32.11
550.0	37.96	0.17	166.7	9.38	32.60
600.0	38.48	0.14	339.8	9.52	32.73
650.0	38.95	0.00	1612.7	9.68	33.16
700.0	39.39	0.00	9999.0	9.78	33.29

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: K:\PROJECTS\2019\DEPT 05- GEOTECH- IN PROGRESS\19050015IND_INDOT 1006266_US 52 OVER MUD CREEK RUSH CO\DESIGN\ANALYSIS\APILE ANALYSIS\WEAP\HP12X74 BENT 1.GWW
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2003.GW
Hammer File Version: 2003 (2/22/2013)

Input File Contents

Des 1006266 - US 52 over Mud Cree

OUT	OSG	HAM	STR	FUL	PEL	N	SPL	N-U	P-D	%SK	ISM	0	PHI	RSA	ITR	H-D	MXT	DEx
6	0	15	0	1	0	0	0	0	3	182	0	0	0	0	0	0	0	0.000

Pile g	Hammer g	Toe Area	Pile Size	Pile Type
32.170	32.170	148.160	12.210	H Pile

W Cp	A Cp	E Cp	T Cp	CoR	ROut	StCp
1.900	415.460	440.0	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
72.000	21.80	29000.0	492.000	4.057	0	1.000	0.010

Manufac	Hmr Name	HmrType	No Seg-s
DELMAG	D 30-32	1	5

Ram Wt	Ram L	Ram Dia	MaxStrk	RtdStrk	Efficy
6.60	123.20	16.51	13.73	11.43	0.80

IB. Wt	IB. L	IB.Dia	IB CoR	IB RO
1.36	28.15	16.51	0.900	0.010

CompStrk	A Chamber	V Chamber	C Delay	C Duratn	Exp Coeff	VolCStart	Vol CEnd
17.68	214.03	309.10	0.001	0.002	1.250	0.00	0.00

P atm	P1	P2	P3	P4	P5
14.70	1400.00	1260.00	1134.00	1021.00	0.00

Stroke	Effic.	Pressure	R-Weight	T-Delay	Exp-Coeff	Eps-Str	Total-AW
11.4300	0.8000	1400.0000	0.0000	0.0000	0.0000	0.0100	0.0000

Qs	Qt	Js	Jt	Qx	Jx	Rati	Dept
0.100	0.100	0.200	0.150	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

Res. Distribution

Dpth	Rskn	Dpth	Dpth						
0.00	0.00	72.00	72.00	0.00	0.00	0.00	0.00	0.00	0.0
1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5.00	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6.00	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7.00	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8.00	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9.00	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10.00	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11.00	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12.00	0.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
14.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
15.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
16.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
17.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
18.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
19.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
20.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
21.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
22.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
23.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
24.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0

25.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
26.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
27.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
28.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
29.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
30.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
31.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
32.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
33.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
34.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
35.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
36.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
37.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
38.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
39.00	1.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
40.00	3.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
41.00	3.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
42.00	3.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
43.00	3.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
44.00	3.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
45.00	3.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
46.00	3.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
47.00	3.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
48.00	3.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
49.00	3.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
50.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
51.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
52.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
53.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
54.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
55.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
56.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
57.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
58.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
59.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
60.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
61.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
62.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
63.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
64.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
65.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
66.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
67.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
68.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
69.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
70.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
71.00	5.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
72.00	5.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Rult									
400.0	426.0	450.0	500.0	550.0	600.0	650.0	700.0	0.0	0.0

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

Des 1006266 - US 52 over Mud Cree

Hammer Model: D 30-32 Made by: DELMAG

No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	1.320				
2	1.320	251965.7	1.000	0.0100	
3	1.320	251965.7	1.000	0.0100	
4	1.320	251965.7	1.000	0.0100	
5	1.320	251965.7	1.000	0.0100	
Imp Block	1.360	117606.2	0.900	0.0100	
Helmet	1.900	91401.2	0.800	0.0100	9.6
Combined Pile Top		16097.7			

HAMMER OPTIONS:

Hammer File ID No.	15	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)	123.20
Maximum Stroke	(ft)	13.73			
Rated Stroke	(ft)	11.43	Efficiency		0.800
Maximum Pressure	(psi)	1400.00	Actual Pressure	(psi)	1400.00
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)	415.46	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	440.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	2.00	Thickness	(inch)	0.00
Coeff of Restitution		0.8	Coeff of Restitution		0.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	91401.2	Stiffness	(kips/in)	0.0

PILE PROFILE:

Toe Area	(in2)	148.160	Pile Type	H Pile
Pile Size	(inch)	12.210		

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	21.80	29000.	492.0	4.1	0	16524.	38.3
72.0	21.80	29000.	492.0	4.1	0	16524.	38.3

Wave Travel Time 2L/c (ms) 8.714

Pile and Soil Model — Total Capacity Rut (kips) 400.0

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	0.244	16098	0.010	0.000	1.00	0.0	0.200	0.100	3.27	4.1	21.8
2	0.244	16098	0.000	0.000	1.00	5.0	0.200	0.100	6.55	4.1	21.8
3	0.244	16098	0.000	0.000	1.00	8.0	0.200	0.100	9.82	4.1	21.8
4	0.244	16098	0.000	0.000	1.00	9.1	0.200	0.100	13.09	4.1	21.8
5	0.244	16098	0.000	0.000	1.00	14.1	0.200	0.100	16.36	4.1	21.8
12	0.244	16098	0.000	0.000	1.00	14.6	0.200	0.100	39.27	4.1	21.8
13	0.244	16098	0.000	0.000	1.00	26.8	0.200	0.100	42.55	4.1	21.8
14	0.244	16098	0.000	0.000	1.00	29.5	0.200	0.100	45.82	4.1	21.8
15	0.244	16098	0.000	0.000	1.00	31.4	0.200	0.100	49.09	4.1	21.8
16	0.244	16098	0.000	0.000	1.00	14.6	0.200	0.100	52.36	4.1	21.8
17	0.244	16098	0.000	0.000	1.00	12.1	0.200	0.100	55.64	4.1	21.8
22	0.244	16098	0.000	0.000	1.00	29.5	0.200	0.100	72.00	4.1	21.8
Toe						72.0	0.150	0.100			

5.363 kips total unreduced pile weight (g= 32.17 ft/s2)
5.363 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 (%)	3
Pile Penetration (ft)	72.00	Pile Damping Fact.(k/ft/s)	2.296
% Shaft Resistance	82		
Constant End Bearing Bearing Graph			
Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	1	Analysis Time-Input (ms)	0
Output Level: Variable vs Time			
Gravity Mass, Pile, Hammer:	32.170	32.170 32.170	
Output Segment Generation: Automatic			

Des 1006266 - US 52 over Mud Cree 07/24/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut= 400.0, Rtoe = 72.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	769.2	0.00	35.28	18.30	0.666	31.34
2	0.0	784.6	0.00	35.99	17.96	0.636	30.34
3	0.0	780.5	0.00	35.80	17.47	0.606	28.77
4	0.0	765.2	0.00	35.10	16.84	0.577	27.03
5	0.0	751.4	0.00	34.47	16.06	0.549	25.04
6	0.0	717.3	0.00	32.90	15.30	0.527	23.06
7	0.0	684.0	0.00	31.38	14.55	0.506	21.25
8	0.0	651.7	0.00	29.89	13.83	0.486	19.55
9	0.0	620.5	0.00	28.46	13.17	0.466	17.99
10	0.0	590.5	0.00	27.08	12.52	0.447	16.58
11	0.0	562.4	0.00	25.80	11.86	0.430	15.29
12	0.0	540.2	0.00	24.78	11.14	0.415	14.11
13	0.0	528.4	0.00	24.24	10.21	0.400	12.64
14	0.0	481.7	0.00	22.09	9.36	0.387	10.83
15	0.0	427.4	0.00	19.61	8.70	0.377	9.03
16	0.0	370.6	0.00	17.00	8.35	0.368	7.72
17	0.0	351.6	0.00	16.13	8.04	0.360	6.97
18	0.0	337.4	0.00	15.48	7.78	0.352	6.32
19	0.0	321.7	0.00	14.76	7.66	0.345	5.69
20	0.0	296.8	0.00	13.61	8.14	0.338	5.08
21	0.0	250.3	0.00	11.48	9.07	0.331	4.48
22	0.0	188.1	0.00	8.63	9.13	0.325	4.17

(Eq) Strokes Analyzed and Last Return (ft):
11.43 8.96 8.79 8.76

Max. Combustion Pressure 1400.0 psi

Des 1006266 - US 52 over Mud Cree 07/24/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut= 426.0, Rtoe = 72.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	776.1	0.00	35.60	18.44	0.657	31.50
2	0.0	791.6	0.00	36.31	18.07	0.626	30.44
3	0.0	787.6	0.00	36.13	17.53	0.595	28.76
4	0.0	771.4	0.00	35.38	16.84	0.564	26.88
5	0.0	756.8	0.00	34.72	16.01	0.535	24.75
6	0.0	719.7	0.00	33.02	15.21	0.508	22.54
7	0.0	683.7	0.00	31.36	14.44	0.487	20.64
8	0.0	649.0	0.00	29.77	13.69	0.465	18.88
9	0.0	615.4	0.00	28.23	12.96	0.444	17.24
10	0.0	583.2	0.00	26.75	12.28	0.423	15.76
11	0.0	553.5	0.00	25.39	11.61	0.404	14.42
12	0.0	530.1	0.00	24.31	10.88	0.387	13.21
13	0.0	518.1	0.00	23.77	9.92	0.371	11.74
14	0.0	468.8	0.00	21.50	9.09	0.357	9.96
15	0.0	413.9	0.00	18.99	8.39	0.346	8.21
16	0.0	358.3	0.00	16.44	8.06	0.336	6.96
17	0.0	338.9	0.00	15.55	7.76	0.327	6.24
18	0.0	325.1	0.00	14.91	7.47	0.319	5.63
19	0.0	309.2	0.00	14.18	7.34	0.312	5.03
20	0.0	285.0	0.00	13.07	7.76	0.304	4.46
21	0.0	240.8	0.00	11.04	8.71	0.298	3.90
22	0.0	178.5	0.00	8.19	8.79	0.292	3.62

(Eq) Strokes Analyzed and Last Return (ft):
11.43 9.08 8.91 8.90

Max. Combustion Pressure 1400.0 psi

Des 1006266 - US 52 over Mud Cree 07/24/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut= 450.0, Rtoe = 72.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	783.5	0.00	35.94	18.66	0.652	31.86
2	0.0	801.5	0.00	36.76	18.26	0.620	30.74
3	0.0	796.5	0.00	36.54	17.68	0.588	28.96
4	0.0	778.7	0.00	35.72	16.94	0.556	26.95
5	0.0	762.8	0.00	34.99	16.03	0.525	24.68
6	0.0	723.1	0.00	33.17	15.15	0.496	22.29
7	0.0	684.7	0.00	31.41	14.34	0.472	20.24
8	0.0	647.7	0.00	29.71	13.56	0.450	18.41
9	0.0	612.3	0.00	28.09	12.81	0.427	16.72
10	0.0	578.4	0.00	26.53	12.10	0.405	15.17
11	0.0	547.0	0.00	25.09	11.42	0.385	13.78
12	0.0	522.3	0.00	23.96	10.67	0.366	12.54
13	0.0	508.9	0.00	23.35	9.70	0.349	11.05
14	0.0	457.9	0.00	21.01	8.86	0.334	9.29
15	0.0	403.7	0.00	18.52	8.16	0.322	7.59
16	0.0	348.4	0.00	15.98	7.82	0.311	6.37
17	0.0	329.0	0.00	15.09	7.52	0.302	5.68
18	0.0	315.1	0.00	14.45	7.24	0.294	5.09
19	0.0	299.4	0.00	13.73	7.09	0.286	4.52
20	0.0	275.9	0.00	12.66	7.46	0.278	3.98
21	0.0	233.0	0.00	10.69	8.40	0.271	3.46
22	0.0	172.9	0.00	7.93	8.52	0.265	3.20

(Eq) Strokes Analyzed and Last Return (ft):
11.43 9.20 9.02 8.99

Max. Combustion Pressure 1400.0 psi

Des 1006266 - US 52 over Mud Cree 07/24/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut= 500.0, Rtoe = 72.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	796.5	0.00	36.54	18.94	0.637	32.11
2	-1.0	815.6	-0.04	37.41	18.49	0.604	30.88
3	0.0	809.1	0.00	37.11	17.82	0.571	28.91
4	0.0	788.1	0.00	36.15	16.99	0.537	26.70
5	0.0	769.4	0.00	35.29	15.96	0.504	24.19
6	0.0	724.5	0.00	33.23	14.98	0.473	21.57
7	0.0	681.5	0.00	31.26	14.07	0.443	19.22
8	0.0	640.4	0.00	29.38	13.22	0.418	17.23
9	0.0	601.3	0.00	27.58	12.40	0.395	15.47
10	0.0	563.9	0.00	25.87	11.68	0.372	13.87
11	0.0	529.5	0.00	24.29	10.97	0.349	12.41
12	0.0	507.1	0.00	23.26	10.23	0.327	11.09
13	0.0	488.0	0.00	22.39	9.25	0.307	9.59
14	0.0	433.7	0.00	19.90	8.39	0.290	7.89
15	0.0	382.3	0.00	17.54	7.71	0.275	6.29
16	0.0	327.8	0.00	15.04	7.35	0.264	5.17
17	0.0	309.0	0.00	14.18	7.03	0.253	4.54
18	0.0	294.5	0.00	13.51	6.77	0.244	4.01
19	0.0	280.1	0.00	12.85	6.61	0.235	3.51
20	0.0	258.1	0.00	11.84	6.90	0.227	3.05
21	0.0	217.6	0.00	9.98	7.79	0.220	2.62
22	0.0	164.0	0.00	7.52	7.99	0.213	2.39

(Eq) Strokes Analyzed and Last Return (ft):
11.43 9.43 9.21 9.20

Max. Combustion Pressure 1400.0 psi

Des 1006266 - US 52 over Mud Cree 07/24/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut= 550.0, Rtoe = 72.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	806.8	0.00	37.01	19.16	0.628	32.60
2	-3.7	827.5	-0.17	37.96	18.65	0.593	31.26
3	0.0	820.3	0.00	37.63	17.90	0.558	29.11
4	0.0	796.9	0.00	36.56	16.96	0.523	26.68
5	0.0	776.2	0.00	35.60	15.85	0.489	23.95
6	0.0	726.0	0.00	33.30	14.80	0.455	21.10
7	0.0	678.2	0.00	31.11	13.80	0.424	18.57
8	0.0	632.8	0.00	29.03	12.87	0.394	16.33
9	0.0	589.8	0.00	27.05	12.05	0.369	14.47
10	0.0	551.9	0.00	25.32	11.28	0.345	12.82
11	0.0	530.3	0.00	24.32	10.59	0.322	11.35
12	0.0	504.5	0.00	23.14	9.80	0.299	10.00
13	0.0	478.6	0.00	21.95	8.84	0.276	8.47
14	0.0	415.0	0.00	19.04	7.98	0.256	6.80
15	0.0	363.4	0.00	16.67	7.27	0.240	5.27
16	0.0	310.0	0.00	14.22	6.93	0.227	4.23
17	0.0	291.0	0.00	13.35	6.63	0.215	3.65
18	0.0	277.3	0.00	12.72	6.35	0.204	3.17
19	0.0	262.4	0.00	12.04	6.17	0.195	2.73
20	0.0	241.8	0.00	11.09	6.41	0.186	2.34
21	0.0	203.7	0.00	9.35	7.26	0.179	1.97
22	0.0	155.5	0.00	7.13	7.47	0.172	1.78

(Eq) Strokes Analyzed and Last Return (ft):
11.43 9.63 9.38 9.34

Max. Combustion Pressure 1400.0 psi

Des 1006266 - US 52 over Mud Cree 07/24/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut= 600.0, Rtoe = 72.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	816.2	0.00	37.44	19.39	0.616	32.73
2	-3.0	838.9	-0.14	38.48	18.81	0.581	31.29
3	0.0	829.8	0.00	38.06	17.98	0.544	28.98
4	0.0	803.0	0.00	36.84	16.96	0.508	26.38
5	0.0	779.5	0.00	35.75	15.70	0.472	23.47
6	0.0	724.3	0.00	33.23	14.57	0.438	20.44
7	0.0	672.3	0.00	30.84	13.51	0.404	17.76
8	0.0	622.9	0.00	28.57	12.56	0.373	15.41
9	0.0	576.5	0.00	26.45	11.71	0.345	13.40
10	0.0	553.0	0.00	25.37	10.92	0.320	11.73
11	0.0	528.0	0.00	24.22	10.21	0.296	10.25
12	0.0	498.9	0.00	22.88	9.43	0.273	8.93
13	0.0	469.3	0.00	21.53	8.45	0.249	7.44
14	0.0	403.5	0.00	18.51	7.60	0.228	5.82
15	0.0	345.8	0.00	15.86	6.89	0.209	4.38
16	0.0	293.2	0.00	13.45	6.55	0.195	3.41
17	0.0	275.0	0.00	12.61	6.25	0.182	2.87
18	0.0	261.1	0.00	11.98	5.97	0.170	2.44
19	0.0	247.1	0.00	11.33	5.79	0.160	2.06
20	0.0	227.2	0.00	10.42	5.97	0.151	1.72
21	0.0	191.7	0.00	8.79	6.77	0.142	1.42
22	0.0	145.5	0.00	6.67	7.03	0.135	1.27

(Eq) Strokes Analyzed and Last Return (ft):
11.43 9.77 9.52 9.49

Max. Combustion Pressure 1400.0 psi

Des 1006266 - US 52 over Mud Cree 07/24/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut= 650.0, Rtoe = 72.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	827.1	0.00	37.94	19.60	0.609	33.16
2	0.0	849.2	0.00	38.95	18.97	0.572	31.61
3	0.0	838.1	0.00	38.45	18.06	0.535	29.12
4	0.0	809.9	0.00	37.15	16.98	0.497	26.34
5	0.0	785.3	0.00	36.02	15.61	0.460	23.23
6	0.0	724.9	0.00	33.25	14.36	0.424	20.03
7	0.0	668.1	0.00	30.65	13.27	0.390	17.20
8	0.0	614.8	0.00	28.20	12.27	0.357	14.74
9	0.0	583.3	0.00	26.76	11.41	0.327	12.61
10	0.0	557.0	0.00	25.55	10.58	0.300	10.87
11	0.0	528.7	0.00	24.25	9.87	0.276	9.38
12	0.0	497.3	0.00	22.81	9.08	0.252	8.07
13	0.0	464.6	0.00	21.31	8.11	0.228	6.63
14	0.0	396.3	0.00	18.18	7.26	0.206	5.09
15	0.0	330.5	0.00	15.16	6.55	0.187	3.72
16	0.0	278.9	0.00	12.79	6.21	0.172	2.82
17	0.0	260.8	0.00	11.96	5.92	0.158	2.31
18	0.0	247.2	0.00	11.34	5.63	0.145	1.91
19	0.0	233.4	0.00	10.71	5.45	0.134	1.58
20	0.0	214.7	0.00	9.85	5.59	0.124	1.29
21	0.0	180.9	0.00	8.30	6.35	0.115	1.03
22	0.0	134.6	0.00	6.17	6.63	0.107	0.90

(Eq) Strokes Analyzed and Last Return (ft):
11.43 9.88 9.68 9.64

Max. Combustion Pressure 1400.0 psi

Des 1006266 - US 52 over Mud Cree 07/24/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut= 700.0, Rtoe = 72.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	833.4	0.00	38.23	19.77	0.599	33.29
2	0.0	858.6	0.00	39.39	19.08	0.562	31.64
3	0.0	846.3	0.00	38.82	18.08	0.523	28.99
4	0.0	813.5	0.00	37.32	16.89	0.485	26.06
5	0.0	787.2	0.00	36.11	15.43	0.447	22.79
6	0.0	722.1	0.00	33.12	14.15	0.410	19.45
7	0.0	661.1	0.00	30.32	12.98	0.375	16.52
8	0.0	611.4	0.00	28.05	11.99	0.341	13.98
9	0.0	586.2	0.00	26.89	11.07	0.310	11.80
10	0.0	557.1	0.00	25.56	10.28	0.281	9.98
11	0.0	525.9	0.00	24.12	9.51	0.256	8.50
12	0.0	492.8	0.00	22.61	8.76	0.232	7.23
13	0.0	459.3	0.00	21.07	7.78	0.208	5.85
14	0.0	387.9	0.00	17.79	6.90	0.186	4.40
15	0.0	315.7	0.00	14.48	6.25	0.167	3.15
16	0.0	265.8	0.00	12.19	5.88	0.152	2.33
17	0.0	247.2	0.00	11.34	5.60	0.138	1.87
18	0.0	234.3	0.00	10.75	5.34	0.126	1.52
19	0.0	220.9	0.00	10.13	5.14	0.115	1.23
20	0.0	203.5	0.00	9.34	5.25	0.105	0.99
21	0.0	171.2	0.00	7.85	5.98	0.097	0.78
22	0.0	119.9	0.00	5.50	6.29	0.090	0.67

Activated Capacity 685.9 k
(Eq) Strokes Analyzed and Last Return (ft):
11.43 10.00 9.78 9.75

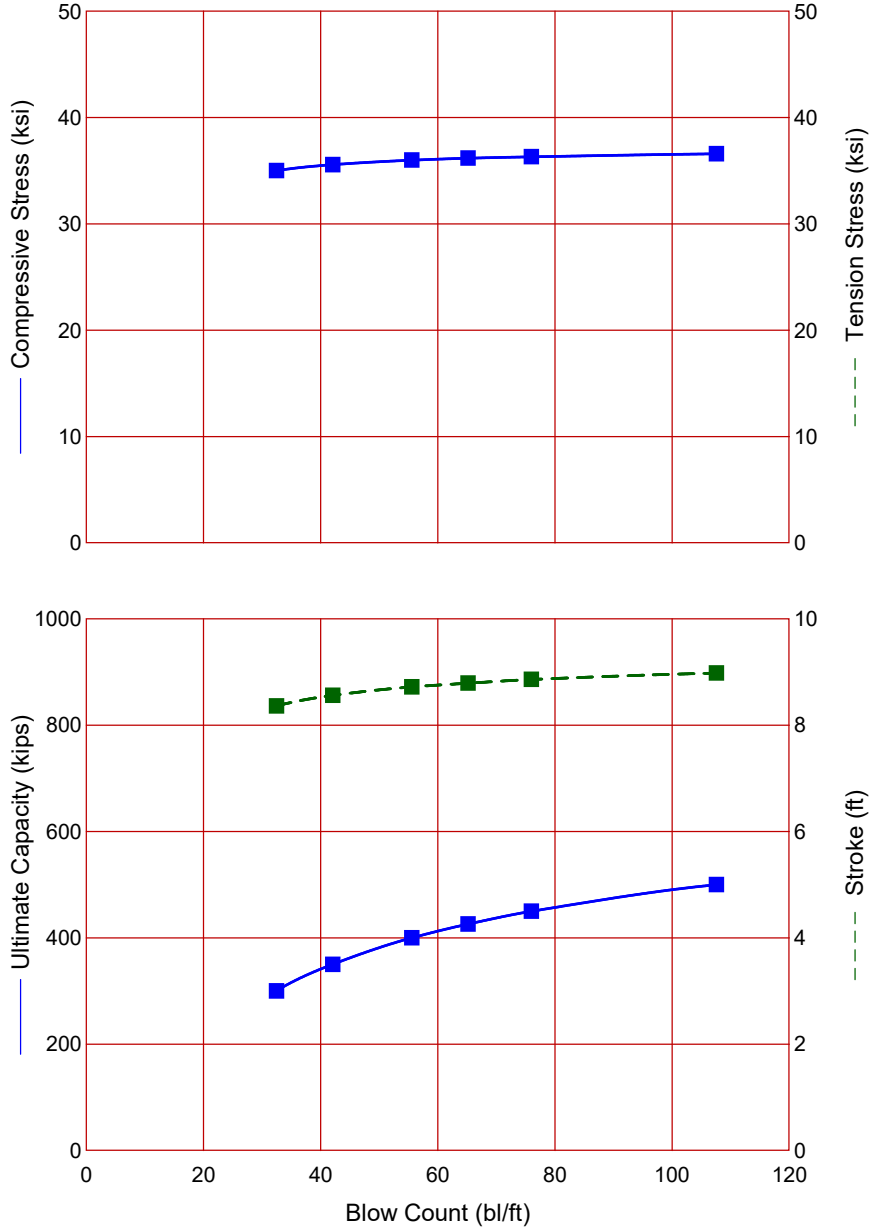
Max. Combustion Pressure 1400.0 psi

Des 1006266 - US 52 over Mud Cree 07/24/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
400.0	53.2	8.79	8.76	0.00	1	0	35.99	2	2	31.3	39.9
426.0	62.6	8.91	8.90	0.00	1	0	36.31	2	2	31.5	39.6
450.0	72.7	9.02	8.99	0.00	1	0	36.76	2	2	31.9	39.4
500.0	105.9	9.21	9.20	-0.04	2	34	37.41	2	2	32.1	38.9
550.0	166.7	9.38	9.34	-0.17	2	32	37.96	2	2	32.6	38.6
600.0	339.8	9.52	9.49	-0.14	2	49	38.48	2	2	32.7	38.3
650.0	1612.7	9.68	9.64	0.00	1	0	38.95	2	2	33.2	38.1
700.0	9999.0	9.78	9.75	0.00	1	0	39.39	2	2	33.3	37.9

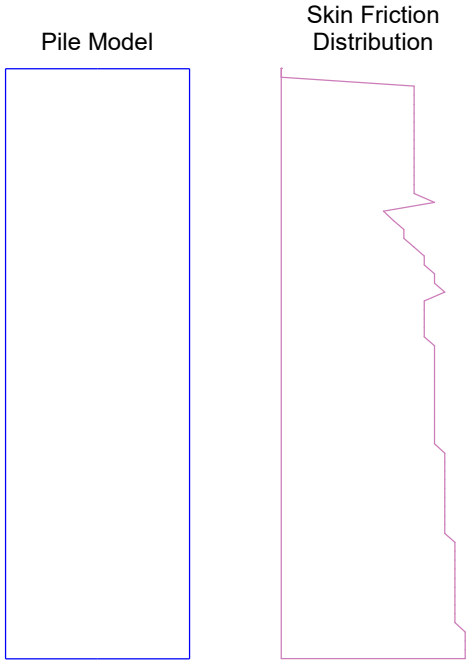
CTL Engineering Inc
Des 1006266 - US 52 over Mud Crk

16-Jul-2019
GRLWEAP Version 2010



DELMAG D 30-32

Ram Weight	6.60	kips
Efficiency	0.800	
Pressure	1400 (100%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	91401	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.100	in
Skin Damping	0.200	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	66.00	ft
Pile Penetration	66.00	ft
Pile Top Area	21.80	in2



Res. Shaft = 270.0 kips
(Constant Res. Shaft)

CTL Engineering Inc 16-Jul-2019
Des 1006266 - US 52 over Mud Crk GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
300.0	34.99	0.00	32.5	8.36	28.74
350.0	35.56	0.00	42.1	8.56	29.54
400.0	35.99	0.00	55.6	8.72	30.18
426.0	36.17	0.00	65.2	8.79	30.41
450.0	36.30	0.00	76.0	8.86	30.62
500.0	36.59	0.00	107.6	8.98	31.08

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: K:\PROJECTS\2019\DEPT 05- GEOTECH- IN PROGRESS\19050015IND_INDOT 1006266_US 52 OVER MUD CREEK RUSH CO\DESIGN\ANALYSIS\APILE ANALYSIS\HP 12X53 \HP12X53 PIER 2.GWW
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2003.GW
Hammer File Version: 2003 (2/22/2013)

Input File Contents

Des 1006266 - US 52 over Mud Crk

OUT	OSG	HAM	STR	FUL	PEL	N	SPL	N-U	P-D	%SK	ISM	0	PHI	RSA	ITR	H-D	MXT	DEx
6	0	15	0	1	0	0	0	0	3	-90	0	0	0	0	0	0	0	0.000

Pile g	Hammer g	Toe Area	Pile Size	Pile Type
32.170	32.170	148.160	12.210	H Pile

W Cp	A Cp	E Cp	T Cp	CoR	ROut	StCp
1.900	415.460	440.0	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
66.000	21.80	29000.0	492.000	4.057	0	1.000	0.010

Manufac	Hmr Name	HmrType	No Seg-s
DELMAG	D 30-32	1	5

Ram Wt	Ram L	Ram Dia	MaxStrk	RtdStrk	Efficy
6.60	123.20	16.51	13.73	11.43	0.80

IB. Wt	IB. L	IB.Dia	IB CoR	IB RO
1.36	28.15	16.51	0.900	0.010

CompStrk	A Chamber	V Chamber	C Delay	C Duratn	Exp Coeff	VolCStart	Vol CEnd
17.68	214.03	309.10	0.001	0.002	1.250	0.00	0.00

P atm	P1	P2	P3	P4	P5
14.70	1400.00	1260.00	1134.00	1021.00	0.00

Stroke	Effic.	Pressure	R-Weight	T-Delay	Exp-Coeff	Eps-Str	Total-AW
11.4300	0.8000	1400.0000	0.0000	0.0000	0.0000	0.0100	0.0000

Qs	Qt	Js	Jt	Qx	Jx	Rati	Dept
0.100	0.100	0.200	0.150	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

Res. Distribution

Dpth	Rskn	Dpth	Dpth						
0.00	0.00	66.00	66.00	0.00	0.00	0.00	0.00	0.00	0.0
1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
14.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
15.00	1.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
16.00	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
17.00	1.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
18.00	1.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
19.00	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
20.00	1.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
21.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
22.00	1.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
23.00	1.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
24.00	1.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
25.00	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0

26.00	1.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
27.00	1.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
28.00	1.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
29.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
30.00	1.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
31.00	1.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
32.00	1.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
33.00	1.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
34.00	1.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
35.00	1.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
36.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
37.00	1.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
38.00	1.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
39.00	1.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
40.00	1.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
41.00	1.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
42.00	1.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
43.00	1.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
44.00	1.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
45.00	1.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
46.00	1.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
47.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
48.00	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
49.00	1.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
50.00	1.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
51.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
52.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
53.00	1.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
54.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
55.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
56.00	1.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
57.00	1.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
58.00	1.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
59.00	1.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
60.00	1.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
61.00	1.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
62.00	1.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
63.00	1.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
64.00	1.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
65.00	1.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
66.00	1.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Rult									
300.0	350.0	400.0	426.0	450.0	500.0	0.0	0.0	0.0	0.0

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

Des 1006266 - US 52 over Mud Crk

Hammer Model: D 30-32 Made by: DELMAG

No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	1.320				
2	1.320	251965.7	1.000	0.0100	
3	1.320	251965.7	1.000	0.0100	
4	1.320	251965.7	1.000	0.0100	
5	1.320	251965.7	1.000	0.0100	
Imp Block	1.360	117606.2	0.900	0.0100	
Helmet	1.900	91401.2	0.800	0.0100	9.6
Combined Pile Top		15964.6			

HAMMER OPTIONS:

Hammer File ID No.	15	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)	123.20
Maximum Stroke	(ft)	13.73			
Rated Stroke	(ft)	11.43	Efficiency		0.800
Maximum Pressure	(psi)	1400.00	Actual Pressure	(psi)	1400.00
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)	415.46	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	440.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	2.00	Thickness	(inch)	0.00
Coeff of Restitution		0.8	Coeff of Restitution		0.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	91401.2	Stiffness	(kips/in)	0.0

PILE PROFILE:

Toe Area	(in2)	148.160	Pile Type	H Pile
Pile Size	(inch)	12.210		

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	21.80	29000.	492.0	4.1	0	16524.	38.3
66.0	21.80	29000.	492.0	4.1	0	16524.	38.3

Wave Travel Time 2L/c (ms) 7.988

Pile and Soil Model — Total Capacity Rut (kips) 300.0

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	0.246	15965	0.010	0.000	1.00	6.7	0.200	0.100	3.30	4.1	21.8
2	0.246	15965	0.000	0.000	1.00	12.3	0.200	0.100	6.60	4.1	21.8
5	0.246	15965	0.000	0.000	1.00	12.0	0.200	0.100	16.50	4.1	21.8
6	0.246	15965	0.000	0.000	1.00	10.8	0.200	0.100	19.80	4.1	21.8
7	0.246	15965	0.000	0.000	1.00	12.8	0.200	0.100	23.10	4.1	21.8
8	0.246	15965	0.000	0.000	1.00	14.1	0.200	0.100	26.40	4.1	21.8
9	0.246	15965	0.000	0.000	1.00	13.1	0.200	0.100	29.70	4.1	21.8
10	0.246	15965	0.000	0.000	1.00	13.4	0.200	0.100	33.00	4.1	21.8
11	0.246	15965	0.000	0.000	1.00	13.7	0.200	0.100	36.30	4.1	21.8
12	0.246	15965	0.000	0.000	1.00	14.0	0.200	0.100	39.60	4.1	21.8
13	0.246	15965	0.000	0.000	1.00	14.3	0.200	0.100	42.90	4.1	21.8
14	0.246	15965	0.000	0.000	1.00	14.6	0.200	0.100	46.20	4.1	21.8
15	0.246	15965	0.000	0.000	1.00	14.9	0.200	0.100	49.50	4.1	21.8
16	0.246	15965	0.000	0.000	1.00	15.2	0.200	0.100	52.80	4.1	21.8
17	0.246	15965	0.000	0.000	1.00	15.4	0.200	0.100	56.10	4.1	21.8
18	0.246	15965	0.000	0.000	1.00	15.7	0.200	0.100	59.40	4.1	21.8
19	0.246	15965	0.000	0.000	1.00	16.0	0.200	0.100	62.70	4.1	21.8
20	0.246	15965	0.000	0.000	1.00	16.3	0.200	0.100	66.00	4.1	21.8
Toe						30.0	0.150	0.100			

4.916 kips total unreduced pile weight (g= 32.17 ft/s2)
4.916 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 (%)	3
Pile Penetration (ft)	66.00	Pile Damping Fact.(k/ft/s)	2.296
% Shaft Resistance	90		
Constant Shaft Resist. Bearing Graph			
Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	1	Analysis Time-Input (ms)	0
Output Level: Variable vs Time			
Gravity Mass, Pile, Hammer:	32.170	32.170 32.170	
Output Segment Generation: Automatic			

Des 1006266 - US 52 over Mud Crk 07/16/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut= 300.0, Rtoe = 30.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	762.9	0.00	34.99	17.24	0.623	28.74
2	0.0	759.7	0.00	34.85	16.62	0.599	27.01
3	0.0	731.7	0.00	33.56	15.98	0.587	25.27
4	0.0	703.0	0.00	32.25	15.36	0.575	23.64
5	0.0	674.2	0.00	30.93	14.76	0.563	22.12
6	0.0	646.1	0.00	29.64	14.19	0.553	20.77
7	0.0	625.6	0.00	28.70	13.55	0.543	19.46
8	0.0	599.7	0.00	27.51	12.91	0.534	18.06
9	0.0	569.2	0.00	26.11	12.31	0.526	16.71
10	0.0	543.2	0.00	24.92	11.75	0.518	15.45
11	0.0	517.4	0.00	23.73	11.20	0.511	14.21
12	0.0	491.7	0.00	22.56	10.66	0.504	12.99
13	0.0	466.2	0.00	21.39	10.17	0.498	11.77
14	0.0	441.5	0.00	20.25	9.69	0.492	10.56
15	0.0	417.7	0.00	19.16	9.24	0.487	9.34
16	0.0	394.0	0.00	18.07	8.83	0.482	8.10
17	0.0	367.9	0.00	16.88	9.17	0.478	6.84
18	0.0	330.5	0.00	15.16	9.83	0.475	5.55
19	0.0	265.8	0.00	12.19	10.92	0.472	4.22
20	0.0	165.6	0.00	7.60	11.59	0.469	3.54

(Eq) Strokes Analyzed and Last Return (ft):
11.43 8.49 8.36 8.35

Max. Combustion Pressure 1400.0 psi

Des 1006266 - US 52 over Mud Crk 07/16/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut= 350.0, Rtoe = 80.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	775.3	0.00	35.56	17.57	0.629	29.54
2	0.0	772.4	0.00	35.43	16.93	0.603	27.76
3	0.0	744.1	0.00	34.13	16.28	0.579	25.71
4	0.0	715.1	0.00	32.80	15.65	0.562	23.96
5	0.0	686.0	0.00	31.47	15.04	0.545	22.32
6	0.0	657.6	0.00	30.16	14.44	0.528	20.86
7	0.0	636.9	0.00	29.21	13.79	0.512	19.47
8	0.0	610.8	0.00	28.02	13.14	0.498	18.03
9	0.0	580.0	0.00	26.61	12.54	0.484	16.67
10	0.0	553.9	0.00	25.41	11.96	0.471	15.41
11	0.0	528.0	0.00	24.22	11.39	0.460	14.21
12	0.0	502.2	0.00	23.04	10.85	0.449	13.06
13	0.0	476.7	0.00	21.87	10.35	0.438	11.95
14	0.0	452.4	0.00	20.75	9.85	0.429	10.87
15	0.0	428.8	0.00	19.67	9.40	0.420	9.81
16	0.0	406.0	0.00	18.62	8.98	0.412	8.78
17	0.0	381.1	0.00	17.48	8.72	0.404	7.75
18	0.0	346.1	0.00	15.88	9.16	0.397	6.73
19	0.0	287.0	0.00	13.16	10.11	0.391	5.71
20	0.0	209.8	0.00	9.62	10.14	0.385	5.19

(Eq) Strokes Analyzed and Last Return (ft):
11.43 8.71 8.56 8.54

Max. Combustion Pressure 1400.0 psi

Des 1006266 - US 52 over Mud Crk 07/16/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut= 400.0, Rtoe = 130.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	784.5	0.00	35.99	17.81	0.633	30.18
2	0.0	781.4	0.00	35.84	17.16	0.608	28.36
3	0.0	752.8	0.00	34.53	16.50	0.583	26.26
4	0.0	723.6	0.00	33.19	15.86	0.561	24.35
5	0.0	694.3	0.00	31.85	15.24	0.541	22.62
6	0.0	665.9	0.00	30.54	14.64	0.520	21.06
7	0.0	645.1	0.00	29.59	13.98	0.499	19.54
8	0.0	618.9	0.00	28.39	13.32	0.478	17.96
9	0.0	588.1	0.00	26.98	12.70	0.459	16.50
10	0.0	562.0	0.00	25.78	12.12	0.441	15.17
11	0.0	536.0	0.00	24.59	11.55	0.425	13.93
12	0.0	510.2	0.00	23.40	10.99	0.409	12.77
13	0.0	484.8	0.00	22.24	10.49	0.394	11.67
14	0.0	460.6	0.00	21.13	9.99	0.381	10.63
15	0.0	437.2	0.00	20.05	9.53	0.368	9.65
16	0.0	414.7	0.00	19.02	9.10	0.356	8.72
17	0.0	390.6	0.00	17.92	8.82	0.345	7.82
18	0.0	357.5	0.00	16.40	9.09	0.334	6.97
19	0.0	304.3	0.00	13.96	9.64	0.325	6.14
20	0.0	286.7	0.00	13.15	9.14	0.316	5.71

(Eq) Strokes Analyzed and Last Return (ft):
11.43 8.89 8.72 8.70

Max. Combustion Pressure 1400.0 psi

Des 1006266 - US 52 over Mud Crk 07/16/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut= 426.0, Rtoe = 156.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	788.6	0.00	36.17	17.92	0.635	30.41
2	0.0	786.3	0.00	36.07	17.27	0.609	28.58
3	0.0	757.8	0.00	34.76	16.61	0.584	26.46
4	0.0	728.6	0.00	33.42	15.96	0.561	24.52
5	0.0	699.1	0.00	32.07	15.33	0.540	22.76
6	0.0	670.3	0.00	30.75	14.72	0.519	21.16
7	0.0	649.4	0.00	29.79	14.04	0.497	19.61
8	0.0	623.0	0.00	28.58	13.39	0.474	17.98
9	0.0	591.9	0.00	27.15	12.79	0.452	16.42
10	0.0	565.4	0.00	25.94	12.19	0.431	15.04
11	0.0	539.3	0.00	24.74	11.60	0.411	13.75
12	0.0	513.4	0.00	23.55	11.07	0.393	12.55
13	0.0	488.1	0.00	22.39	10.54	0.376	11.43
14	0.0	463.9	0.00	21.28	10.05	0.360	10.40
15	0.0	440.5	0.00	20.21	9.59	0.345	9.42
16	0.0	418.3	0.00	19.19	9.15	0.331	8.52
17	0.0	394.7	0.00	18.10	8.86	0.318	7.66
18	0.0	362.2	0.00	16.62	9.07	0.306	6.86
19	0.0	324.7	0.00	14.89	9.45	0.295	6.10
20	0.0	320.1	0.00	14.68	8.71	0.284	5.70

(Eq) Strokes Analyzed and Last Return (ft):
11.43 8.97 8.79 8.77

Max. Combustion Pressure 1400.0 psi

Des 1006266 - US 52 over Mud Crk 07/16/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut= 450.0, Rtoe = 180.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	791.4	0.00	36.30	17.98	0.636	30.62
2	0.0	789.8	0.00	36.23	17.34	0.610	28.78
3	0.0	761.3	0.00	34.92	16.68	0.585	26.65
4	0.0	732.2	0.00	33.59	16.02	0.562	24.68
5	0.0	702.6	0.00	32.23	15.39	0.540	22.88
6	0.0	673.7	0.00	30.90	14.77	0.518	21.27
7	0.0	652.8	0.00	29.95	14.12	0.495	19.69
8	0.0	626.2	0.00	28.73	13.47	0.472	18.03
9	0.0	594.8	0.00	27.29	12.85	0.448	16.43
10	0.0	568.2	0.00	26.07	12.24	0.424	14.96
11	0.0	541.9	0.00	24.86	11.67	0.402	13.61
12	0.0	516.2	0.00	23.68	11.12	0.382	12.37
13	0.0	491.2	0.00	22.53	10.58	0.363	11.22
14	0.0	466.8	0.00	21.41	10.10	0.345	10.16
15	0.0	443.7	0.00	20.35	9.63	0.328	9.18
16	0.0	421.1	0.00	19.32	9.19	0.312	8.28
17	0.0	397.8	0.00	18.25	8.90	0.297	7.45
18	0.0	370.6	0.00	17.00	9.05	0.283	6.68
19	0.0	352.0	0.00	16.15	9.30	0.270	5.97
20	0.0	347.8	0.00	15.95	8.37	0.258	5.58

(Eq) Strokes Analyzed and Last Return (ft):
11.43 9.04 8.86 8.84

Max. Combustion Pressure 1400.0 psi

Des 1006266 - US 52 over Mud Crk 07/16/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut= 500.0, Rtoe = 230.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	797.6	0.00	36.59	18.15	0.640	31.08
2	0.0	796.3	0.00	36.53	17.49	0.614	29.21
3	0.0	767.8	0.00	35.22	16.83	0.588	27.05
4	0.0	738.5	0.00	33.88	16.16	0.564	25.04
5	0.0	708.8	0.00	32.51	15.53	0.541	23.19
6	0.0	679.7	0.00	31.18	14.94	0.518	21.53
7	0.0	658.8	0.00	30.22	14.27	0.495	19.91
8	0.0	632.1	0.00	29.00	13.60	0.470	18.20
9	0.0	600.5	0.00	27.55	12.98	0.445	16.56
10	0.0	573.7	0.00	26.32	12.36	0.419	15.01
11	0.0	547.5	0.00	25.12	11.79	0.392	13.52
12	0.0	522.0	0.00	23.95	11.23	0.367	12.13
13	0.0	496.8	0.00	22.79	10.70	0.343	10.87
14	0.0	472.2	0.00	21.66	10.21	0.320	9.73
15	0.0	449.3	0.00	20.61	9.72	0.299	8.70
16	0.0	427.0	0.00	19.59	9.29	0.279	7.77
17	0.0	421.8	0.00	19.35	8.98	0.261	6.93
18	0.0	415.7	0.00	19.07	9.04	0.243	6.19
19	0.0	399.1	0.00	18.31	9.03	0.227	5.52
20	0.0	394.6	0.00	18.10	7.75	0.212	5.14

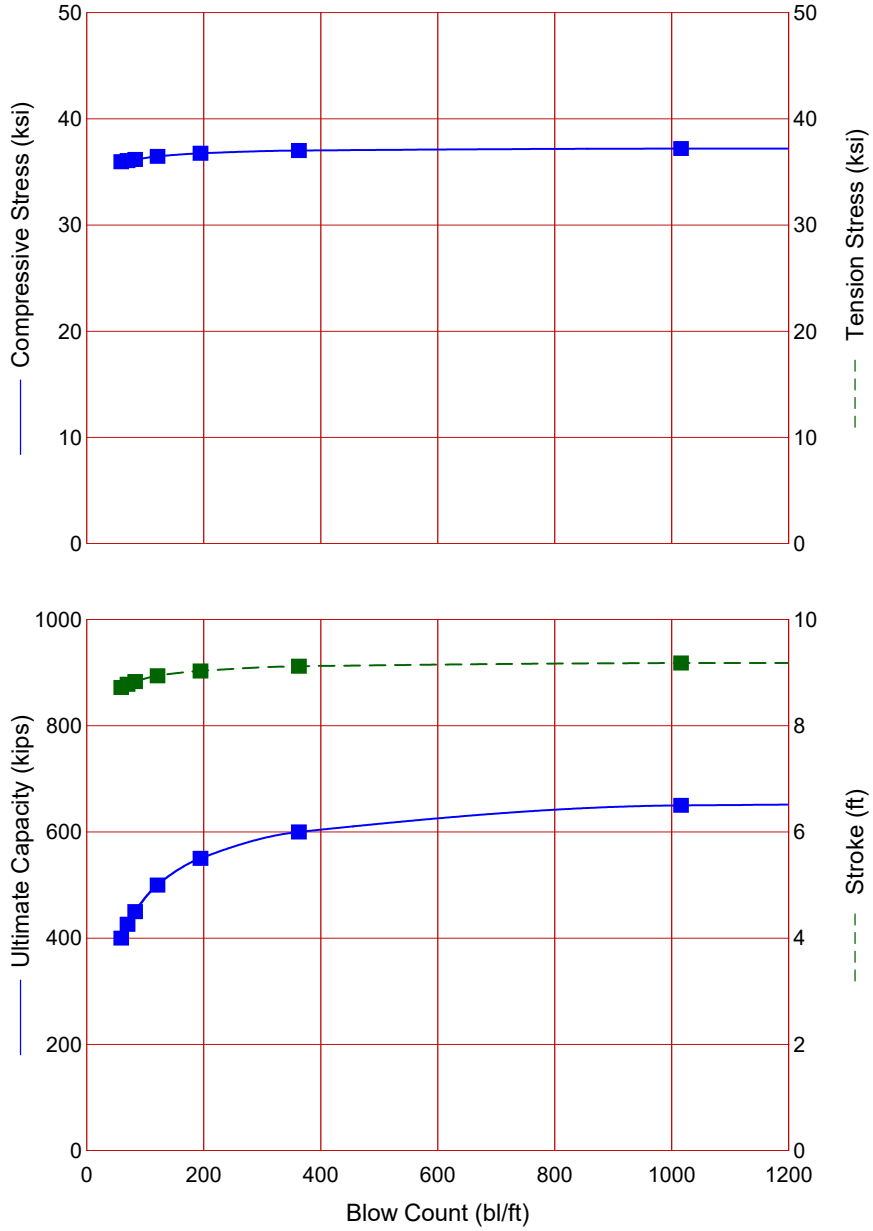
(Eq) Strokes Analyzed and Last Return (ft):
11.43 9.18 8.98 8.97

Max. Combustion Pressure 1400.0 psi

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
300.0	32.5	8.36	8.35	0.00	1	0	34.99	1	2	28.7	40.8
350.0	42.1	8.56	8.54	0.00	1	0	35.56	1	2	29.5	40.4
400.0	55.6	8.72	8.70	0.00	1	0	35.99	1	2	30.2	40.0
426.0	65.2	8.79	8.77	0.00	1	0	36.17	1	2	30.4	39.8
450.0	76.0	8.86	8.84	0.00	1	0	36.30	1	2	30.6	39.7
500.0	107.6	8.98	8.97	0.00	1	0	36.59	1	1	31.1	39.4

CTL Engineering Inc
Des 1006266 - US 52 over Mud Creek - Pie

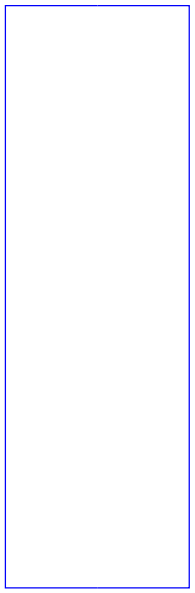
24-Jul-2019
GRLWEAP Version 2010



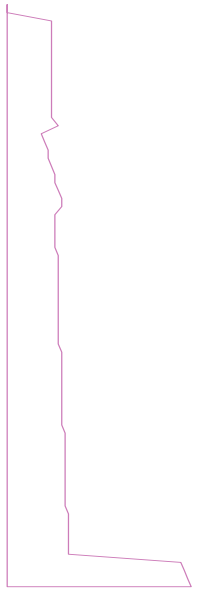
DELMAG D 30-32

Ram Weight	6.60	kips
Efficiency	0.800	
Pressure	1400 (100%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	91401	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.100	in
Skin Damping	0.200	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	72.00	ft
Pile Penetration	72.00	ft
Pile Top Area	21.80	in2

Pile Model



Skin Friction Distribution



Res. Shaft = 328.0 kips
(Constant Res. Shaft)

CTL Engineering Inc 24-Jul-2019
Des 1006266 - US 52 over Mud Creek - Pie GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
400.0	35.95	0.00	58.9	8.72	30.23
426.0	36.06	0.00	69.9	8.78	30.40
450.0	36.16	0.00	82.8	8.83	30.54
500.0	36.46	0.00	121.2	8.94	31.04
550.0	36.75	0.00	194.5	9.03	31.36
600.0	37.01	0.00	362.7	9.12	31.72
650.0	37.19	0.00	1016.1	9.18	31.99
700.0	37.35	0.00	9999.0	9.24	32.25

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: K:\PROJECTS\2019\DEPT 05- GEOTECH- IN PROGRESS\19050015IND_INDOT 1006266_US 52 OVER MUD CREEK RUSH CO\DESIGN\ANALYSIS\APILE ANALYSIS\WEAP\HP12X74 PIER 2.GWW
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2003.GW
Hammer File Version: 2003 (2/22/2013)

Input File Contents

Des 1006266 - US 52 over Mud Creek - Pie

OUT	OSG	HAM	STR	FUL	PEL	N	SPL	N-U	P-D	%SK	ISM	0	PHI	RSA	ITR	H-D	MXT	DEx
6	0	15	0	1	0	0	0	0	3	-82	0	0	0	0	0	0	0	0.000

Pile g	Hammer g	Toe Area	Pile Size	Pile Type
32.170	32.170	148.160	12.210	H Pile

W Cp	A Cp	E Cp	T Cp	CoR	ROut	StCp
1.900	415.460	440.0	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
72.000	21.80	29000.0	492.000	4.057	0	1.000	0.010

Manufac	Hmr Name	HmrType	No Seg-s
DELMAG	D 30-32	1	5

Ram Wt	Ram L	Ram Dia	MaxStrk	RtdStrk	Efficy
6.60	123.20	16.51	13.73	11.43	0.80

IB. Wt	IB. L	IB.Dia	IB CoR	IB RO
1.36	28.15	16.51	0.900	0.010

CompStrk	A Chamber	V Chamber	C Delay	C Duratn	Exp Coeff	VolCStart	Vol CEnd
17.68	214.03	309.10	0.001	0.002	1.250	0.00	0.00

P atm	P1	P2	P3	P4	P5
14.70	1400.00	1260.00	1134.00	1021.00	0.00

Stroke	Effic.	Pressure	R-Weight	T-Delay	Exp-Coeff	Eps-Str	Total-AW
11.4300	0.8000	1400.0000	0.0000	0.0000	0.0000	0.0100	0.0000

Qs	Qt	Js	Jt	Qx	Jx	Rati	Dept
0.100	0.100	0.200	0.150	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

Res. Distribution

Dpth	Rskn	Dpth	Dpth						
0.00	0.00	72.00	72.00	0.00	0.00	0.00	0.00	0.00	0.0
1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
14.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
15.00	1.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
16.00	1.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
17.00	1.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
18.00	1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
19.00	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
20.00	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
21.00	1.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
22.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
23.00	1.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
24.00	1.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0

25.00	1.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
26.00	1.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
27.00	1.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
28.00	1.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
29.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
30.00	1.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
31.00	1.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
32.00	1.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
33.00	1.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
34.00	1.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
35.00	1.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
36.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
37.00	1.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
38.00	1.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
39.00	1.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
40.00	1.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
41.00	1.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
42.00	1.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
43.00	1.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
44.00	1.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
45.00	1.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
46.00	1.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
47.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
48.00	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
49.00	1.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
50.00	1.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
51.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
52.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
53.00	1.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
54.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
55.00	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
56.00	1.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
57.00	1.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
58.00	1.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
59.00	1.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
60.00	1.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
61.00	1.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
62.00	1.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
63.00	1.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
64.00	1.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
65.00	1.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
66.00	1.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
67.00	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
68.00	1.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
69.00	5.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
70.00	5.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
71.00	5.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
72.00	5.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Rult									
400.0	426.0	450.0	500.0	550.0	600.0	650.0	700.0	0.0	0.0

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

Des 1006266 - US 52 over Mud Creek - Pie

Hammer Model: D 30-32 Made by: DELMAG

No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	1.320				
2	1.320	251965.7	1.000	0.0100	
3	1.320	251965.7	1.000	0.0100	
4	1.320	251965.7	1.000	0.0100	
5	1.320	251965.7	1.000	0.0100	
Imp Block	1.360	117606.2	0.900	0.0100	
Helmet	1.900	91401.2	0.800	0.0100	9.6
Combined Pile Top		16097.7			

HAMMER OPTIONS:

Hammer File ID No.	15	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)	123.20
Maximum Stroke	(ft)	13.73			
Rated Stroke	(ft)	11.43	Efficiency		0.800
Maximum Pressure	(psi)	1400.00	Actual Pressure	(psi)	1400.00
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)	415.46	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	440.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	2.00	Thickness	(inch)	0.00
Coeff of Restitution		0.8	Coeff of Restitution		0.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	91401.2	Stiffness	(kips/in)	0.0

PILE PROFILE:

Toe Area	(in2)	148.160	Pile Type	H Pile
Pile Size	(inch)	12.210		

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	21.80	29000.	492.0	4.1	0	16524.	38.3
72.0	21.80	29000.	492.0	4.1	0	16524.	38.3

Wave Travel Time 2L/c (ms) 8.714

Pile and Soil Model — Total Capacity Rut (kips) 400.0

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	0.244	16098	0.010	0.000	1.00	6.5	0.200	0.100	3.27	4.1	21.8
2	0.244	16098	0.000	0.000	1.00	12.0	0.200	0.100	6.55	4.1	21.8
5	0.244	16098	0.000	0.000	1.00	11.8	0.200	0.100	16.36	4.1	21.8
6	0.244	16098	0.000	0.000	1.00	10.5	0.200	0.100	19.64	4.1	21.8
7	0.244	16098	0.000	0.000	1.00	12.4	0.200	0.100	22.91	4.1	21.8
8	0.244	16098	0.000	0.000	1.00	13.8	0.200	0.100	26.18	4.1	21.8
9	0.244	16098	0.000	0.000	1.00	12.8	0.200	0.100	29.45	4.1	21.8
10	0.244	16098	0.000	0.000	1.00	13.1	0.200	0.100	32.73	4.1	21.8
11	0.244	16098	0.000	0.000	1.00	13.4	0.200	0.100	36.00	4.1	21.8
12	0.244	16098	0.000	0.000	1.00	13.7	0.200	0.100	39.27	4.1	21.8
13	0.244	16098	0.000	0.000	1.00	13.9	0.200	0.100	42.55	4.1	21.8
14	0.244	16098	0.000	0.000	1.00	14.2	0.200	0.100	45.82	4.1	21.8
15	0.244	16098	0.000	0.000	1.00	14.4	0.200	0.100	49.09	4.1	21.8
16	0.244	16098	0.000	0.000	1.00	14.7	0.200	0.100	52.36	4.1	21.8
17	0.244	16098	0.000	0.000	1.00	15.0	0.200	0.100	55.64	4.1	21.8
18	0.244	16098	0.000	0.000	1.00	15.2	0.200	0.100	58.91	4.1	21.8
19	0.244	16098	0.000	0.000	1.00	15.5	0.200	0.100	62.18	4.1	21.8
20	0.244	16098	0.000	0.000	1.00	15.8	0.200	0.100	65.45	4.1	21.8
21	0.244	16098	0.000	0.000	1.00	18.5	0.200	0.100	68.73	4.1	21.8
22	0.244	16098	0.000	0.000	1.00	46.8	0.200	0.100	72.00	4.1	21.8
Toe						72.0	0.150	0.100			

5.363 kips total unreduced pile weight (g= 32.17 ft/s2)
5.363 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 (%)	3
Pile Penetration (ft)	72.00	Pile Damping Fact.(k/ft/s)	2.296
% Shaft Resistance	82		
Constant Shaft Resist. Bearing Graph			
Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	1	Analysis Time-Input (ms)	0
Output Level: Variable vs Time			
Gravity Mass, Pile, Hammer:	32.170	32.170	32.170
Output Segment Generation: Automatic			

Des 1006266 - US 52 over Mud Creek - Pie 07/24/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut= 400.0, Rtoe = 72.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	783.6	0.00	35.95	17.81	0.637	30.23
2	0.0	781.9	0.00	35.87	17.19	0.611	28.45
3	0.0	754.3	0.00	34.60	16.55	0.587	26.38
4	0.0	726.1	0.00	33.31	15.91	0.562	24.44
5	0.0	697.5	0.00	32.00	15.30	0.539	22.64
6	0.0	669.0	0.00	30.69	14.70	0.519	21.11
7	0.0	648.9	0.00	29.77	14.07	0.501	19.68
8	0.0	623.2	0.00	28.59	13.43	0.482	18.16
9	0.0	592.1	0.00	27.16	12.84	0.463	16.71
10	0.0	566.0	0.00	25.96	12.24	0.444	15.40
11	0.0	540.1	0.00	24.78	11.68	0.427	14.17
12	0.0	515.3	0.00	23.64	11.15	0.412	13.01
13	0.0	490.7	0.00	22.51	10.62	0.397	11.93
14	0.0	466.4	0.00	21.39	10.14	0.383	10.92
15	0.0	443.3	0.00	20.34	9.67	0.370	9.96
16	0.0	420.9	0.00	19.31	9.23	0.358	9.05
17	0.0	400.0	0.00	18.35	8.81	0.347	8.18
18	0.0	379.3	0.00	17.40	8.42	0.337	7.35
19	0.0	357.3	0.00	16.39	8.19	0.328	6.55
20	0.0	325.4	0.00	14.93	8.53	0.319	5.78
21	0.0	274.6	0.00	12.59	9.19	0.311	4.97
22	0.0	230.5	0.00	10.58	8.93	0.304	4.54

(Eq) Strokes Analyzed and Last Return (ft):
11.43 8.90 8.72 8.70

Max. Combustion Pressure 1400.0 psi

Des 1006266 - US 52 over Mud Creek - Pie 07/24/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut= 426.0, Rtoe = 98.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	786.1	0.00	36.06	17.87	0.638	30.40
2	0.0	784.5	0.00	35.99	17.25	0.612	28.61
3	0.0	757.0	0.00	34.72	16.61	0.588	26.53
4	0.0	728.6	0.00	33.42	15.97	0.563	24.58
5	0.0	700.0	0.00	32.11	15.35	0.540	22.76
6	0.0	671.4	0.00	30.80	14.77	0.519	21.20
7	0.0	651.3	0.00	29.88	14.13	0.499	19.73
8	0.0	625.6	0.00	28.70	13.49	0.479	18.19
9	0.0	594.3	0.00	27.26	12.88	0.459	16.71
10	0.0	568.1	0.00	26.06	12.28	0.438	15.34
11	0.0	542.7	0.00	24.90	11.73	0.418	14.05
12	0.0	517.8	0.00	23.75	11.19	0.400	12.84
13	0.0	493.0	0.00	22.62	10.66	0.383	11.73
14	0.0	468.7	0.00	21.50	10.18	0.366	10.69
15	0.0	445.8	0.00	20.45	9.70	0.351	9.73
16	0.0	423.4	0.00	19.42	9.27	0.337	8.82
17	0.0	402.7	0.00	18.47	8.84	0.324	7.97
18	0.0	382.4	0.00	17.54	8.45	0.312	7.18
19	0.0	360.5	0.00	16.54	8.22	0.301	6.43
20	0.0	329.8	0.00	15.13	8.49	0.290	5.71
21	0.0	281.6	0.00	12.92	8.95	0.280	4.99
22	0.0	264.6	0.00	12.14	8.51	0.272	4.59

(Eq) Strokes Analyzed and Last Return (ft):
11.43 8.97 8.78 8.77

Max. Combustion Pressure 1400.0 psi

Des 1006266 - US 52 over Mud Creek - Pie 07/24/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut= 450.0, Rtoe = 122.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	788.2	0.00	36.16	17.93	0.639	30.54
2	0.0	786.5	0.00	36.08	17.30	0.613	28.75
3	0.0	759.0	0.00	34.82	16.66	0.588	26.66
4	0.0	730.7	0.00	33.52	16.03	0.564	24.70
5	0.0	701.9	0.00	32.20	15.43	0.540	22.87
6	0.0	673.2	0.00	30.88	14.85	0.519	21.28
7	0.0	653.1	0.00	29.96	14.20	0.498	19.80
8	0.0	627.3	0.00	28.77	13.54	0.478	18.23
9	0.0	596.7	0.00	27.37	12.92	0.457	16.73
10	0.0	571.0	0.00	26.19	12.34	0.435	15.33
11	0.0	545.6	0.00	25.03	11.78	0.413	13.99
12	0.0	520.2	0.00	23.86	11.21	0.392	12.73
13	0.0	495.2	0.00	22.71	10.71	0.372	11.57
14	0.0	471.2	0.00	21.61	10.21	0.354	10.50
15	0.0	448.1	0.00	20.56	9.75	0.337	9.51
16	0.0	426.2	0.00	19.55	9.30	0.321	8.59
17	0.0	405.1	0.00	18.58	8.86	0.306	7.75
18	0.0	385.3	0.00	17.67	8.50	0.292	6.97
19	0.0	363.7	0.00	16.69	8.25	0.279	6.24
20	0.0	333.9	0.00	15.32	8.45	0.267	5.57
21	0.0	305.5	0.00	14.01	8.80	0.255	4.90
22	0.0	292.6	0.00	13.42	8.13	0.245	4.53

(Eq) Strokes Analyzed and Last Return (ft):
11.43 9.03 8.83 8.83

Max. Combustion Pressure 1400.0 psi

Des 1006266 - US 52 over Mud Creek - Pie 07/24/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut= 500.0, Rtoe = 172.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	794.8	0.00	36.46	18.10	0.643	31.04
2	0.0	793.7	0.00	36.41	17.47	0.617	29.22
3	0.0	766.0	0.00	35.14	16.82	0.592	27.10
4	0.0	737.5	0.00	33.83	16.17	0.568	25.11
5	0.0	708.6	0.00	32.50	15.57	0.544	23.25
6	0.0	679.7	0.00	31.18	14.99	0.521	21.62
7	0.0	659.5	0.00	30.25	14.34	0.499	20.08
8	0.0	633.6	0.00	29.06	13.68	0.478	18.47
9	0.0	602.1	0.00	27.62	13.06	0.456	16.93
10	0.0	576.5	0.00	26.44	12.46	0.433	15.49
11	0.0	551.0	0.00	25.27	11.89	0.410	14.10
12	0.0	525.7	0.00	24.11	11.33	0.386	12.76
13	0.0	500.7	0.00	22.97	10.82	0.362	11.47
14	0.0	476.4	0.00	21.85	10.32	0.339	10.28
15	0.0	453.5	0.00	20.80	9.84	0.317	9.20
16	0.0	431.5	0.00	19.79	9.40	0.296	8.22
17	0.0	410.6	0.00	18.84	8.95	0.277	7.33
18	0.0	390.9	0.00	17.93	8.58	0.260	6.53
19	0.0	377.6	0.00	17.32	8.32	0.243	5.82
20	0.0	370.1	0.00	16.98	8.43	0.227	5.17
21	0.0	353.2	0.00	16.20	8.51	0.213	4.57
22	0.0	340.6	0.00	15.63	7.51	0.199	4.21

(Eq) Strokes Analyzed and Last Return (ft):
11.43 9.15 8.94 8.93

Max. Combustion Pressure 1400.0 psi

Des 1006266 - US 52 over Mud Creek - Pie 07/24/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut= 550.0, Rtoe = 222.0 kips, Time Inc. =0.073 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	801.1	0.00	36.75	18.28	0.645	31.36
2	0.0	798.1	0.00	36.61	17.63	0.619	29.52
3	0.0	770.1	0.00	35.32	16.97	0.594	27.38
4	0.0	741.5	0.00	34.01	16.33	0.570	25.37
5	0.0	712.7	0.00	32.69	15.71	0.545	23.49
6	0.0	684.2	0.00	31.39	15.11	0.522	21.83
7	0.0	664.0	0.00	30.46	14.45	0.500	20.27
8	0.0	638.3	0.00	29.28	13.77	0.478	18.63
9	0.0	607.2	0.00	27.85	13.15	0.455	17.05
10	0.0	581.2	0.00	26.66	12.56	0.432	15.59
11	0.0	555.5	0.00	25.48	11.98	0.408	14.17
12	0.0	529.9	0.00	24.31	11.42	0.383	12.79
13	0.0	504.5	0.00	23.14	10.90	0.357	11.47
14	0.0	480.7	0.00	22.05	10.38	0.331	10.19
15	0.0	457.4	0.00	20.98	9.92	0.305	8.99
16	0.0	435.7	0.00	19.98	9.46	0.281	7.91
17	0.0	417.4	0.00	19.15	9.03	0.258	6.94
18	0.0	414.0	0.00	18.99	8.64	0.236	6.08
19	0.0	408.8	0.00	18.75	8.36	0.216	5.33
20	0.0	403.2	0.00	18.49	8.40	0.196	4.67
21	0.0	389.5	0.00	17.87	8.27	0.178	4.08
22	0.0	376.0	0.00	17.25	6.99	0.162	3.71

(Eq) Strokes Analyzed and Last Return (ft):
11.43 9.25 9.03 9.02

Max. Combustion Pressure 1400.0 psi

Des 1006266 - US 52 over Mud Creek - Pie 07/24/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut= 600.0, Rtoe = 272.0 kips, Time Inc. =0.072 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	806.9	0.00	37.01	18.43	0.648	31.72
2	0.0	804.2	0.00	36.89	17.78	0.622	29.86
3	0.0	775.9	0.00	35.59	17.12	0.597	27.70
4	0.0	747.0	0.00	34.27	16.46	0.572	25.66
5	0.0	718.1	0.00	32.94	15.84	0.548	23.77
6	0.0	689.3	0.00	31.62	15.23	0.524	22.08
7	0.0	668.9	0.00	30.68	14.56	0.501	20.49
8	0.0	643.0	0.00	29.50	13.88	0.479	18.82
9	0.0	611.9	0.00	28.07	13.25	0.455	17.22
10	0.0	585.8	0.00	26.87	12.66	0.431	15.73
11	0.0	559.9	0.00	25.69	12.08	0.407	14.28
12	0.0	534.3	0.00	24.51	11.50	0.381	12.88
13	0.0	508.9	0.00	23.34	10.98	0.355	11.52
14	0.0	484.8	0.00	22.24	10.47	0.328	10.22
15	0.0	461.6	0.00	21.17	9.99	0.301	8.97
16	0.0	441.7	0.00	20.26	9.54	0.273	7.80
17	0.0	439.1	0.00	20.14	9.09	0.246	6.72
18	0.0	436.0	0.00	20.00	8.71	0.221	5.77
19	0.0	431.8	0.00	19.81	8.42	0.197	4.94
20	0.0	427.0	0.00	19.59	8.38	0.174	4.23
21	0.0	418.9	0.00	19.21	8.08	0.153	3.61
22	0.0	402.6	0.00	18.47	6.54	0.133	3.19

(Eq) Strokes Analyzed and Last Return (ft):
11.43 9.33 9.12 9.10

Max. Combustion Pressure 1400.0 psi

Des 1006266 - US 52 over Mud Creek - Pie 07/24/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut= 650.0, Rtoe = 322.0 kips, Time Inc. =0.066 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	810.8	0.00	37.19	18.52	0.650	31.99
2	0.0	809.2	0.00	37.12	17.87	0.624	30.12
3	0.0	781.4	0.00	35.84	17.22	0.599	27.95
4	0.0	751.9	0.00	34.49	16.56	0.574	25.90
5	0.0	722.8	0.00	33.16	15.91	0.549	23.99
6	0.0	694.2	0.00	31.84	15.30	0.526	22.28
7	0.0	673.7	0.00	30.90	14.65	0.502	20.67
8	0.0	647.0	0.00	29.68	13.98	0.479	18.98
9	0.0	615.6	0.00	28.24	13.35	0.455	17.35
10	0.0	589.5	0.00	27.04	12.74	0.431	15.84
11	0.0	563.6	0.00	25.85	12.15	0.406	14.37
12	0.0	537.9	0.00	24.68	11.58	0.380	12.95
13	0.0	512.7	0.00	23.52	11.04	0.353	11.58
14	0.0	488.3	0.00	22.40	10.54	0.326	10.25
15	0.0	464.9	0.00	21.32	10.06	0.297	8.97
16	0.0	456.7	0.00	20.95	9.60	0.269	7.77
17	0.0	454.8	0.00	20.86	9.16	0.241	6.65
18	0.0	452.1	0.00	20.74	8.75	0.213	5.63
19	0.0	448.1	0.00	20.55	8.45	0.186	4.70
20	0.0	443.8	0.00	20.36	8.34	0.160	3.90
21	0.0	438.0	0.00	20.09	7.89	0.135	3.22
22	0.0	423.1	0.00	19.41	6.17	0.112	2.74

(Eq) Strokes Analyzed and Last Return (ft):
11.43 9.41 9.18 9.16

Max. Combustion Pressure 1400.0 psi

Des 1006266 - US 52 over Mud Creek - Pie 07/24/2019
CTL Engineering Inc GRLWEAP Version 2010

Rut= 700.0, Rtoe = 372.0 kips, Time Inc. =0.061 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	814.3	0.00	37.35	18.60	0.652	32.25
2	0.0	813.6	0.00	37.32	17.97	0.626	30.37
3	0.0	785.6	0.00	36.03	17.31	0.600	28.18
4	0.0	755.7	0.00	34.67	16.64	0.575	26.11
5	0.0	727.3	0.00	33.36	16.02	0.551	24.19
6	0.0	697.5	0.00	32.00	15.40	0.527	22.47
7	0.0	677.6	0.00	31.08	14.73	0.503	20.84
8	0.0	651.1	0.00	29.87	14.06	0.480	19.13
9	0.0	619.6	0.00	28.42	13.42	0.456	17.48
10	0.0	592.9	0.00	27.20	12.81	0.431	15.95
11	0.0	566.9	0.00	26.01	12.22	0.405	14.47
12	0.0	540.9	0.00	24.81	11.65	0.379	13.03
13	0.0	515.8	0.00	23.66	11.11	0.352	11.63
14	0.0	491.4	0.00	22.54	10.59	0.324	10.28
15	0.0	468.3	0.00	21.48	10.10	0.295	8.99
16	0.0	469.6	0.00	21.54	9.63	0.266	7.76
17	0.0	468.0	0.00	21.47	9.19	0.237	6.61
18	0.0	465.9	0.00	21.37	8.79	0.208	5.57
19	0.0	462.0	0.00	21.19	8.48	0.180	4.62
20	0.0	458.7	0.00	21.04	8.31	0.152	3.77
21	0.0	452.5	0.00	20.76	7.70	0.125	3.02
22	0.0	437.7	0.00	20.08	5.82	0.099	2.47

(Eq) Strokes Analyzed and Last Return (ft):
11.43 9.47 9.24 9.20

Max. Combustion Pressure 1400.0 psi

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
400.0	58.9	8.72	8.70	0.00	1	0	35.95	1	2	30.2	40.0
426.0	69.9	8.78	8.77	0.00	1	0	36.06	1	2	30.4	39.9
450.0	82.8	8.83	8.83	0.00	1	0	36.16	1	1	30.5	39.8
500.0	121.2	8.94	8.93	0.00	1	0	36.46	1	2	31.0	39.5
550.0	194.5	9.03	9.02	0.00	1	0	36.75	1	1	31.4	39.3
600.0	362.7	9.12	9.10	0.00	1	0	37.01	1	1	31.7	39.1
650.0	1016.1	9.18	9.16	0.00	1	0	37.19	1	1	32.0	39.0
700.0	9999.0	9.24	9.20	0.00	1	0	37.35	1	1	32.3	38.9

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Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
400.0	35.95	0.00	58.9	8.72	30.23
425.0	36.13	0.00	69.0	8.78	30.53
450.0	36.16	0.00	82.8	8.83	30.54
475.0	36.40	0.00	98.6	8.88	30.92
480.0	36.40	0.00	102.8	8.91	30.93
485.0	36.45	0.00	107.6	8.91	30.88
490.0	36.47	0.00	111.7	8.93	30.95
495.0	36.48	0.00	115.8	8.94	31.07
500.0	36.46	0.00	121.2	8.94	31.04

APPENDIX F

SPECIAL PROVISIONS FOR MODIFIED SUBGRADE TREATMENT

SUBGRADE TREATMENT TYPE ID

The Standard Specifications are revised as follows:

SECTION 207, AFTER LINE 9, INSERT AS FOLLOWS:

207.02 Materials

Materials shall be in accordance with the following.

Chemical Modifiers……215.02
Coarse Aggregate, Class D or Higher,
Size No 5, 8, 43, 53 or 73……..904
Geogrid, Type IB……918.05
Geocell Confining System……..214
Geotextile for Pavement and Subgrade……..918.02(c)
Water…….....913.01

Air-cooled blast furnace slag shall not be used.

Section 207, AFTER LINE 31, INSERT AS FOLLOWS:

207.03 Construction Requirements

(a) Subgrade Construction Methods

The subgrade shall be constructed uniformly transversely across the width of the pavement including shoulders or curbs unless shown otherwise on the plans, by one of the following methods:

(a) chemical modification in accordance with 215;

(b) aggregate No. 53 in accordance with 301;

(c) geogid in accordance with 214 placed under aggregate No. 53 in accordance with 301, or

(d) soil compaction to 100% of maximum dry density;

(e) Geotextile in accordance with 214 placed under aggregate No. 5, 8, and 53 in accordance with 301.

Longitudinally, the treatment may vary depending on the method of construction.

Section 207, BEGIN LINE 71, INSERT AS FOLLOWS:

207.04 Subgrade Treatment Types

The subgrade treatment type shall be as specified on the contract plans. If required, the subgrade foundation shall be corrected as directed by the Engineer prior to subgrade treatment.

Type	Subgrade Description
I	24 in. of soil compacted in accordance with 203.23
IA	[blank]
IB	14 in. chemical soil modification
IC	12 in. coarse aggregate No. 53 in accordance with 301

ID	12 in. of coarse aggregate with a geotextile in accordance with 918.02(c)
II	6 in. coarse aggregate No. 53 in accordance with 301
IIA	8 in. chemical soil modification
III	In-place compaction in accordance with 203.23
IV	12 in. coarse aggregate No. 53 with Type IB geogrid in accordance with 214
IVA	12 in. coarse aggregate with Geocell confining system in accordance with 214
V	3 in. of subgrade excavated and replaced with 3 in. coarse aggregate No. 53

Type ID subgrade treatment shall be constructed with 9 in. of coarse aggregate No. 53 over 3 in. of coarse aggregate No. 5 or No. 8. A geotextile in accordance with 918.02(c) shall be placed above and below the layer of No. 5 or No. 8 coarse aggregate.

In areas where shallow utilities are encountered or chemical modification is not allowed, the Contractor may submit a request to the Engineer to substitute Type IC for Type IB.

SECTION 207, AFTER LINE 107, INSERT AS FOLLOWS:

207.05 Method of Measurement

Subgrade treatment will be measured in both cut and fill areas by the square yard per type. Chemicals for modification, excavation, aggregates, *geotextile and geogrid* materials will not be measured.

The undercutting of rock, where encountered, will be measured in accordance with 203.27(b).

SECTION 207, BEGIN LINE 124, INSERT AS FOLLOWS:

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Subgrade Treatment, Type _____	.....SYS

The cost of subgrade treatments including testing, sampling, aggregates, chemicals for modification, geogrid, geotextile and geocell confining system, coarse aggregate for subgrade Type IC, *Type ID,* Type II, Type IV, Type IVA, Type V, water, and the excavation required, shall be included in the cost of the pay item.