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To: Project Files Date: December 29, 2025  
From: Kevin Kuhl, P.E. HNTB Job No: 71886  
Subject: **GEOTECHNICAL ENGINEERING RECOMMENDATIONS  
RAMP 61S-70E OVER RAMP 64W-70W & 61N (MODOT BRIDGE NO. A9685)  
IMPROVE I-70 PROGRAM, WARRENTON TO WENTZVILLE  
ST. CHARLES, MISSOURI  
JOB NO. JST0020**

This memorandum provides foundation recommendations for the proposed ramp from Route 61 Southbound to I-70 Eastbound over US-61 Northbound (Bridge A9685) and supporting information. This bridge will replace the existing bridge (Bridge A2543) and will be supported by a total of four bents. Bents 1 and 4 will be supported by HP12x53 driven piles while Bents 2 and 3 will be supported on drilled shafts with rock sockets. The drilled shafts and driven piles will be constructed by I-70 Alliance, a Joint Venture (JV).

## **SUBSURFACE EXPLORATION AND LABORATORY TESTING PROGRAM**

The boring location plan (Figure 1) and subsurface profile (Appendix A) are attached for reference. A total of five borings were performed at this bridge location in support of the proposed bridge. These borings are identified as BR-53, BR-54, BR-55, BR-57, and BR-58. Also considered was the preaward boring K-2 performed by TSi Geotechnical Inc. in 2023.

The HNTB geotechnical investigation for this bridge was performed between January 22<sup>th</sup> and March 13<sup>th</sup>, 2025, by Palmerton & Parrish, Inc. (PPI). A geotechnical engineer from HNTB was present to sample and log the soil and rock material. The boring locations were selected by HNTB and staked by Bartlett & West Inc. prior to drilling. Some of the boring locations were offset for various reasons. Offset measurements were recorded to acquire the as-drilled coordinates, or the as-drilled location was surveyed. The as-drilled boring locations are shown in Figure 1.

Borings were advanced through overburden soils to top of rock using 4.5" Solid Stem Augers. At select intervals, soil samples were obtained in accordance with ASTM D-1586 (Standard Penetration Test) or ASTM D-1587 (Thin Walled Tube Sampler). Automatic safety hammers with rated efficiency values were used for SPTs (hammer specific efficiency values are noted

on the boring logs). All soil samples were visually examined and classified in general accordance with ASTM D-2488 (Standard Practice for Description and Identification of Soils), also referred to as the Unified Soil Classification System. Upon encountering auger refusal on rock, four-inch diameter HQ casing was set (if needed), and bedrock was cored using an NQ2, wireline, double tube core barrel. The core was logged noting features such as color, weathering, lithology, hardness, and discontinuities. Percent recovery of the core run and RQD were calculated and placed on the logs. Boring logs are included in Appendix D.

Laboratory testing was performed by PPI on soil samples selected by HNTB. Index test results are presented on the boring logs. Approximately one unconfined compression strength (UCS) test was performed on each 5-foot length of rock core. Unconfined compression tests on rock core samples are noted on the boring logs. UCS, sieve, triaxial strength and consolidation test results, if any, are provided in Appendix E.

## **SUBSURFACE CONDITIONS AND GEOLOGY**

Subsurface materials encountered in the borings predominantly consist of native loessial soils underlain by relatively shallow bedrock. A desktop study of the available published resources indicates the presence of fill soils is also to be expected at this location from various existing embankments and underground utilities. The native soil consists generally of lean clays except for an isolated layer of fat clay which was encountered in Boring BR-54 (Bent 2), while the bedrock consists of limestone of the Burlington-Keokuk Formation.

**Table 1: Subsurface Stratum and Material**

<b>Stratum</b>	<b>Material</b>	<b>Geologic Unit</b>
1	Lean Clay (CL)	Loess
2	Fat Clay (CH)	Loess
R1	Limestone	Burlington-Keokuk

### **Stratum 1**

Stratum 1 is a native loessial soil consisting of lean clay with occasional trace amounts of sand and gravel. This stratum was encountered in all borings except BR-54. Stratum 1 clays were typically described as brown and gray. Standard Penetration Test (SPT) N-values ranged from 7 to 34 blows per foot (bpf). Results of Atterberg Limits testing confirmed the soil to be lean clay (medium plasticity) with liquid limits of 36 and 37 with corresponding plasticity indices of 15 and 21.

## **Stratum 2**

Stratum 2 consists of fat clay with trace amounts of chert fragments and was only observed in BR-54. This soil was classified as native but may be derived from fills used from the original interchange construction or backfill for the nearby underground utilities. This layer was described as brown and gray. The single SPT N-value obtained in this stratum was 12 bpf. Results of a single Atterberg Limits testing confirmed the soil to be fat clay (high plasticity) with a liquid limit of 56 and a corresponding plasticity index of 23.

## **Stratum R1**

Stratum R1 is characterized as the massive general Burlington-Keokuk limestone at this site and was cored in all borings. This material is described as light gray and tan, slightly to highly weathered and moderately hard to hard. Twenty-two (UCS) tests were performed in this material with a reported range between 6,354 psi and 22,021 pounds per square inch (psi).

## **DRILLED SHAFT FOUNDATIONS**

As provided by HNTB structural engineers, Bents 2 and 3 will be supported on 5.0-foot diameter drilled shafts with 4.5-foot diameter rock sockets. These bents will be constructed at varying skews, with Bent 2 supported on 4 drilled shafts and Bent 3 supported on 3 drilled shafts. Each drilled shaft will support a 4.5-foot diameter column. Approximate top of shaft elevations and anticipated top of sound rock elevations are summarized in Table 2.

The Bent 2 shafts will have permanent casing installed through overburden soils to prevent caving of these soils during construction, whereas permanent casing may not be needed at the Bent 3 shafts due to the shallow depth to bedrock. At Bent 2 and as needed at Bent 3, permanent casings will be extended into rock to provide a positive seal and to stabilize the shaft excavation against collapse, excessive deformation, or flow of water. At Bent 3, it is possible that permanent casing will not be necessary and caving of soils during construction could be managed by surficial grading instead or through the use of a temporary casing (may also be required if finished top of shaft is set above existing grade). In consideration of rock type, variations in top of rock, and the condition of the rock, deepest anticipated permanent casing tip elevations were selected based on experience and are summarized in Table 2. Rock socket lengths and bottom of rock socket elevations must satisfy both axial and lateral requirements.

**Table 2: Drilled Shaft Size, Depths and Elevation Summary**

	<b>Bent 2</b>	<b>Bent 3</b>
Drilled Shaft Diameter (ft)	5.0	
Rock Socket Diameter (ft)	4.5	
Top of Drilled Shaft Elevation (ft)	591.2	591.5
Anticipated Top of Sound Rock Elevation (ft)	582.2	589.2
Deepest Anticipated Permanent Casing Tip Elevation (ft)	581.2	588.2

AXIAL RESISTANCE AND SETTLEMENT

Design top of rock socket elevations were set equal to the deepest anticipated casing tip elevations. Axial resistance was neglected above the design top of rock socket. The rock strength data gathered from the borings were statistically analyzed to determine the design properties for the limestone rock layer.

The largest factored axial load on the rock socket at Bent 2 is 1265 kips and at Bent 3 is 1388 kips. The nominal axial unit side and tip resistances and resistance factors were calculated in accordance with MoDOT’s Engineering Policy Guide (EPG) Section 751.37.3. The foundation data table in Appendix B provides the following information for each planned drilled shaft: anticipated top of rock elevation, stratification of rock bearing layers (starting at design top of rock socket), design properties for each rock layer, nominal axial unit side and tip resistances and resistance factors. The results indicate that the factored loads can be resisted primarily by factored side resistance along the rock socket. Accordingly, settlement of these shafts is considered negligible.

LATERAL RESISTANCE

Recommended LPILE design parameters for Bents 2 and 3 drilled shafts are provided in Appendix B. Since the shafts are in a single line, with a center-to-center spacing of about 4 diameters (i.e. 20.7 feet) or more, group effects are considered negligible.

At Bents 2 and 3, to transmit lateral loads to the encountered rock (Stratum R1), a minimum socket length of 2 shaft diameters (9 feet) is recommended. Lateral requirements control socket design.

## **DRIVEN PILES**

Six steel HP12x53 driven piles with minimum yield strength 50 kips per square inch (ksi) will be utilized at each end bent. As piles will be driven to hard rock, pile points will be required for all piling. Pre-bores will also be required at both end bents as noted in Appendix B. A pre-bore of 5 feet into bedrock is required at End Bent 4 to meet the minimum requirements in MoDOT's EPG 751.35. At End Bent 1, an existing 48-inch storm sewer is estimated to be as close as 8 feet with an approximate invert elevation of 583 feet. To minimize the risk of damaging this nearby existing storm sewer, a pre-bore to elevation 583 feet is recommended. This elevation should be verified by the JV to be below the storm sewer prior to the start of driving.

Design elevations and corresponding pile lengths provided in this report are based on the most recent information available at time of issue. It is understood that final design elevations are subject to change and may fluctuate based on final abutment cap elevations and required minimum pile embedment. No changes to design recommendations are anticipated based on these changes.

Pile Driving Analyzer (PDA) is selected as the appropriate method for verification of pile resistance at End Bent 1 and 4. This method is appropriate for prebored piles where pile lengths are based on minimum penetration into rock (whereas End Bent 1 will utilize PDA due to longer pile lengths, founding bedrock material and the variable nature of the fill).

## **OTHER ANALYSIS PERFORMED**

### **Global Stability**

Following a review of the existing geometry and soil conditions, the west approach embankment was analyzed for global stability. The assessment was performed based on the proposed embankment height, potential geometry, underlying soil conditions, and performance criteria of the structure. The spill slope on the east abutment was chosen as the critical section for the analysis. A 2:1 slope was assumed for this spill slope, and is considered Condition 2. Condition 2 is required to be constructed with a two-foot-thick Type 2 rock blanket over three feet of lean clay. These layers should be keyed two feet below the toe of the slope. The engineering parameters used for the stability assessments are based on the results of the field and laboratory investigations and engineering judgement.

The limit equilibrium program, GeoStudio, version 2024.2.1.28 by Bentley Systems was used to analyze global stability. This program was used to model the geometry of critical sections of the proposed slopes to complete a search for the critical slip surfaces. The factors of safety were determined using Spencer's method. A minimum short- and long-term factor of safety of 1.5 was used in accordance with AASHTO LRFD Bridge Design Specification, 9<sup>th</sup> Edition.

## SETTLEMENT

The approach embankments will be added onto the north side of the existing embankment at both end bents. 18 feet of firm lean clay was observed above the limestone bedrock at end bent 1 while 13 feet of stiff lean clay was observed at end bent 4. A settlement analysis was performed at end bent 1 and consolidation parameters were determined from similar materials throughout the project. The total settlement is anticipated to be 3 inches with the majority occurring during the construction of the embankments.

## SEISMIC

Calculations were completed to determine seismic site class, performance category and acceleration coefficients for Route 61S over I-70E Ramp. Summarized below in Table 3 are the seismic design values.

**Table 3: Seismic Design Values**

<b>Category</b>	<b>Value</b>
Seismic Site Class	C
Seismic Design Category	A
PGA (g)	0.107
A <sub>s</sub> (g)	0.129
S <sub>1</sub> (g)	0.077
S <sub>D1</sub> (g)	0.131

## DOWNDRAW

As stated above, 3 inches of settlement is anticipated at end bent 1 with the majority occurring during construction. Settlement-induced downdrag resulting from the application of net fills is not anticipated to generate a drag force (in addition with permanent bridge loading) in excess of the axial structural resistance of the pile. Downdrag is evaluated according to the methodology presented in FHWA GEC 10 (2018), based on procedures originally developed by Fellenius (1989).

## UTILITY IMPACTS

As discussed, an existing 48-inch reinforced concrete pipe storm sewer crosses approximately 8 feet in front of the line of piles at End Bent 1 with an approximate invert elevation of 583 feet. In addition, there appears to be several communication/fiber lines near the bent 2 drilled shafts. These utilities should be relocated or the existing locations confirmed to not be in conflict with proposed foundations prior to construction beginning.

## **CONSTRUCTION CONSIDERATIONS**

The approved Additional Applicable Standard for drilled shafts, AAS-15, "Drilled Shaft Specifications -Revised" (a modified version of the MoDOT Drilled Shaft Specification Section 701) provided with the project proposal will be used for drilled shaft construction and inspection. A drilled shaft construction submittal for these drilled shafts will be developed by the JV.

The method of inspection of the drilled shafts shall be in accordance with the AAS-15 – Drilled Shaft Construction Specification – Revised (AAS – 15). The contractor has elected to use video inspection which is an acceptable method of inspection per the AAS-15 Section 701.4.10.3.

As noted previously, permanent smooth steel casing seated into the bedrock is recommended for construction. Explorations at these bents did not encounter significant groundwater. While groundwater was not directly observed during drilling, it is assumed that groundwater may be present as perched water at the soil/rock interface. Groundwater elevations and conditions can vary seasonally. Surface water should be directed away from the construction area during wall construction. The contractor should be prepared to implement wet construction methods, but dry construction methods may be feasible.

To facilitate integrity testing, each shaft will include a minimum of 4, 2-inch nominal inside diameter steel pipes (ASTM A 53, standard weight) for Crosshole Sonic Logging (CSL) testing. CSL testing shall be performed on all drilled shafts with the results to be furnished to the Geotechnical Engineer of Record for approval. If dry method is used, CSL testing will be at the discretion of the Geotechnical Engineer of Record.

For prebored driven piles, prebore holes should be backfilled with sand (or other approved material) in accordance with MoDOT Standard Specifications Section 702 before piles are driven to termination.

Borrow materials used to construct approach embankments with slopes steeper than 3:1 shall have a liquid limit less than 50 and a plastic limit less than 30. Embankments with slopes steeper than 3:1 shall be compacted in accordance with MoDOT Standard specification 203, to at least 95 percent of the maximum density, as determined by the Standard Compaction Test. Slopes steeper than 3:1 shall be protected by a Type 2 rock blanket.

It is anticipated that fills along an existing embankment will be placed to construct new embankment spill slopes and side slopes. As noted in MoDOT Standard Specification Section 203.4.11, existing slopes steeper than 6H:1V will be benched in rises no less than 12 inches in areas of new embankment fill placement.

Rob Jeronimus, P.E.  
Geotechnical Engineer

Kevin Kuhl, P.E.  
Geotechnical Engineer

Attachments:      Figure 1:      Boring Location Plan  
                         Appendix A:      Subsurface Profiles  
                         Appendix B:      Foundation Design Tables  
                         Appendix C:      Global Stability Model  
                         Appendix D:      Boring Logs & Rock Core Photographs  
                         Appendix E:      Laboratory Data

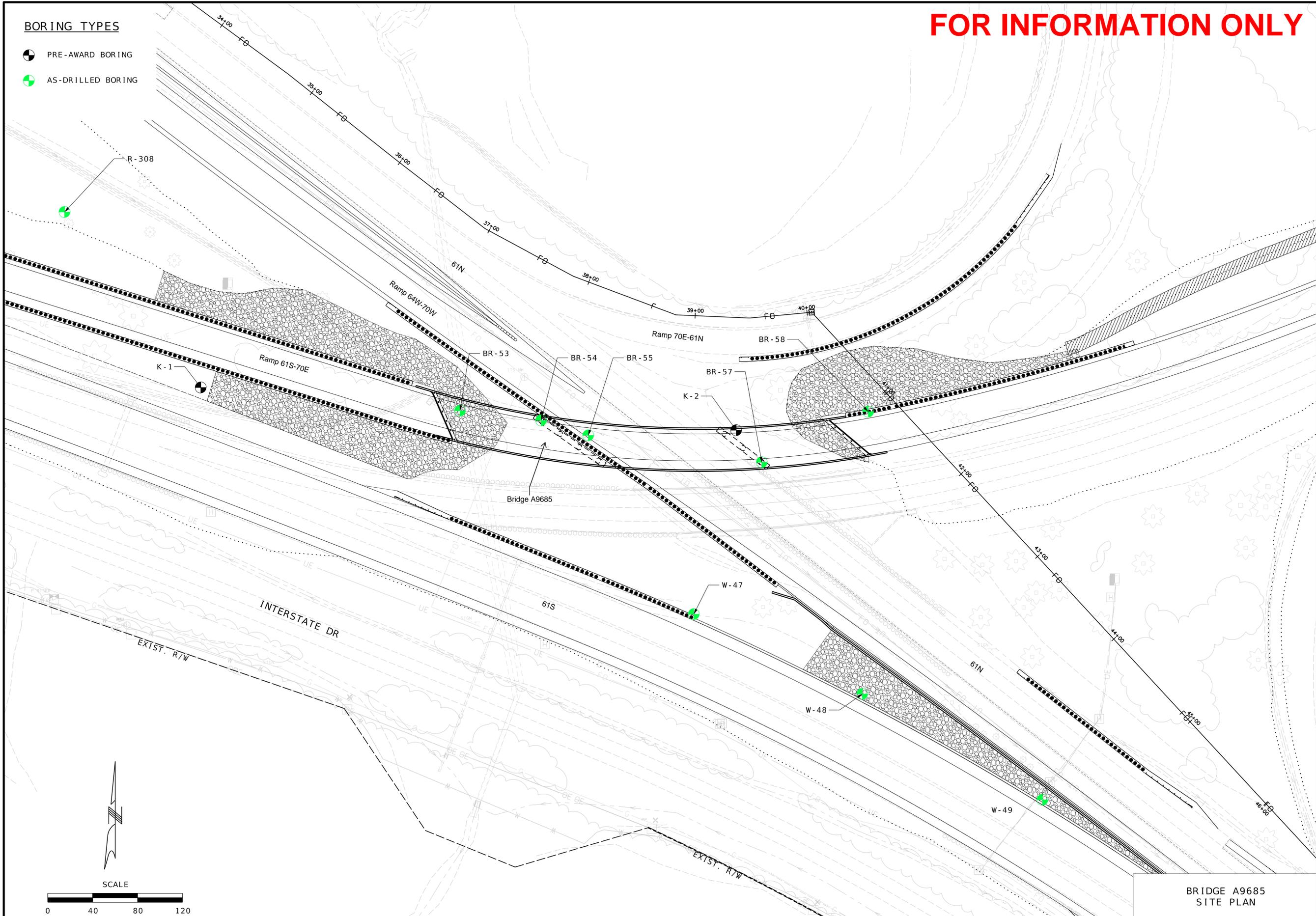
**FIGURE 1**



**FOR INFORMATION ONLY**

**BORING TYPES**

-  PRE-AWARD BORING
-  AS-DRILLED BORING



"THIS MEDIA SHOULD NOT BE CONSIDERED A CERTIFIED DOCUMENT."

DATE PREPARED		10/24/2025	
ROUTE	STATE	I - 70	MO
DISTRICT	SHEET NO.	SL	N/A
COUNTY		ST. CHARLES	
JOB NO.		J613033	
CONTRACT ID.			
PROJECT NO.			
BRIDGE NO.			

DATE	DESCRIPTION

MISSOURI HIGHWAYS AND TRANSPORTATION COMMISSION



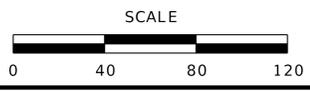
105 WEST CAPITOL  
JEFFERSON CITY, MO 65102  
1-888-ASK-MODOT (1-888-275-6636)



211 N. BROADWAY STE. 2915  
ST LOUIS, MO 63102  
CERTIFICATE OF AUTHORITY  
NO. 001270



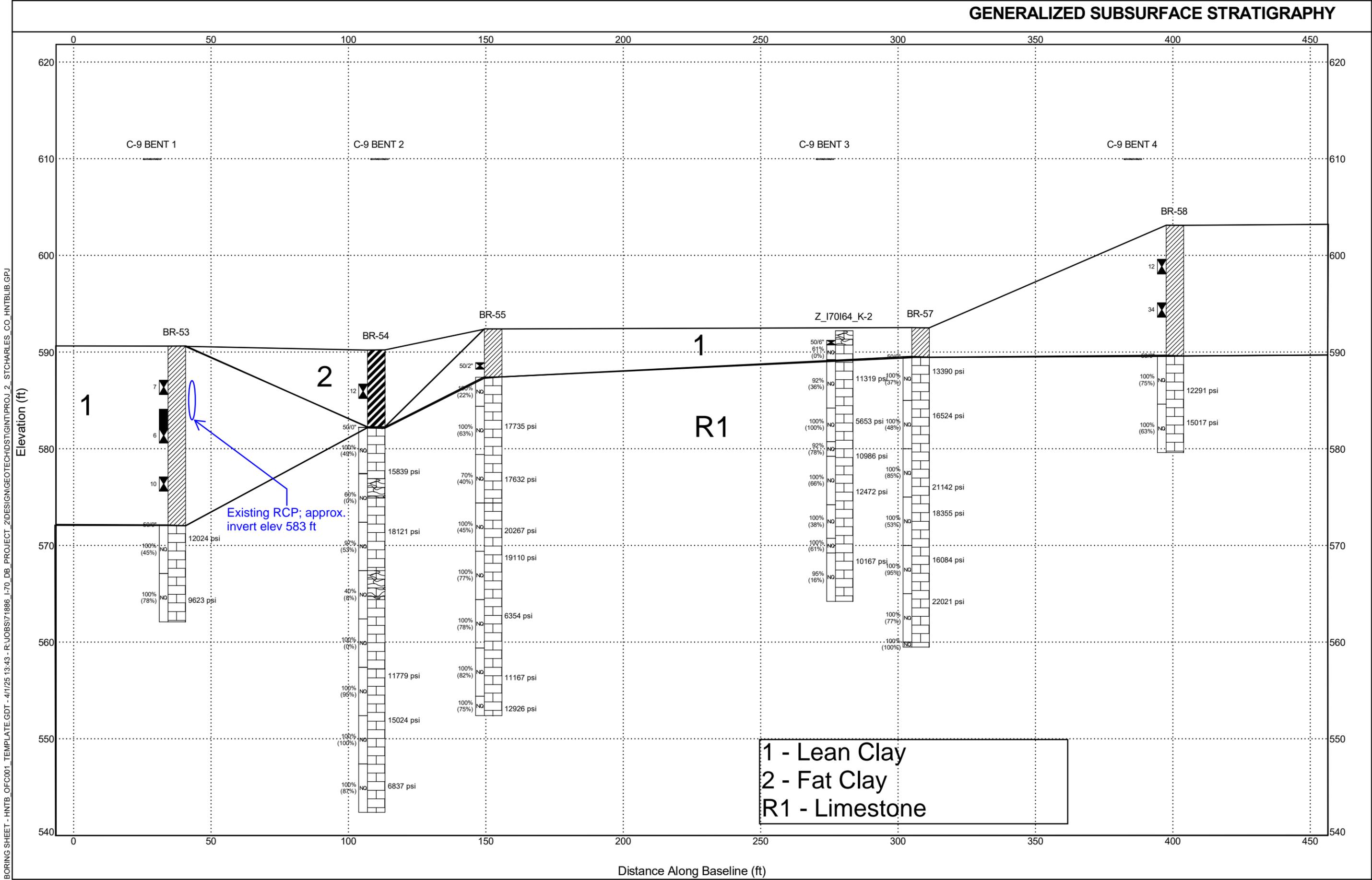
**Bartlett & West**  
601 MONROE ST. SUITE 201 - JEFFERSON CITY, MO 65101  
PHONE: 873-603-5181  
CERTIFICATE OF AUTHORITY  
NO. 001270  
WWW.BARTLETTWEST.COM



BRIDGE A9685  
SITE PLAN

# APPENDIX A

# GENERALIZED SUBSURFACE STRATIGRAPHY



BORING SHEET - HNTB\_OFC001\_TEMPLATE.GDT - 4/1/25 13:43 - R:\JOBS\1886\_1-70\_DB\_PROJECT\_2\DESIGN\GEO\HNTB\PROJ\_2\_STCHARLES\_CO\_HNTBLIB.GPJ

# APPENDIX B

Drilled Shaft Foundation Data Table: Ramp 61S-70E over 61N (A9685) Bridge												
Bent	Anticipated Top of Rock	Deepest Anticipated Tip of Casing	Bearing Layer	Rock Type	Elevation, ft. From - To	Nominal Unit Side Resistance ( $q_s$ ), ksf	Side Resistance Factor	Nominal Unit Tip Resistance ( $q_p$ ), ksf	Tip Resistance Factor	Mean Unconfined Compressive Strength ( $q_u$ ), ksf	COV <sub>qu</sub>	GSI
2	582.2	581.2	Layer R1	Limestone	582.2-542.4	35.0	0.47	400	0.50	1534	0.07	67
3	589.2	588.2	Layer R1	Limestone	589.2-560.0	35.0	0.47	400	0.50	1534	0.07	67

Notes for Bent 2 and 3

To satisfy stability requirements, the minimum length of rock socket below tip of casing is 9 feet.

Axial resistance was computed per EPG 751.37 using the method for "strong" rock ( $q_u$  not less than 100 ksf)

The COV<sub>qu</sub> has been modified based on the number of samples.

Resistance factors for Major Route classification.

# Ramp Route 61S to I-70E over 61N (A9685 Bridge)



Foundation Data			
Type	Design Data	Bent Number	
		Bent 1	Bent 4
<b>Load Bearing Pile</b>	Pile Type and Size	HP12x53	HP12x53
	Number <span style="float:right">ea</span>	6	6
	Orientation of Piles	Weak	Weak
	Pipe Pile Spacers?	No	No
	Bottom of Beam Cap <sup>(1)</sup> (Elev.) <span style="float:right">ft</span>	610.13	613.8
	Existing Grade (Elev.) <span style="float:right">ft</span>	586.9	602.01
	Estimated Bottom of Prebore (Elev.), if required <span style="float:right">ft</span>	583.0 <sup>(2)</sup>	584.6
	Estimated Top of Rock (Elev.) <span style="float:right">ft</span>	572.1	589.6
	Type of Rock/Description	Limestone	Limestone
	Estimated Pile Penetration into Rock <span style="float:right">ft</span>	0.5	0.5
	Estimated Pile Tip (Elev.)	571.6	584.1
	Raw Approximate Length Per Each <span style="float:right">ft</span>	40.03	31.2
	Approximate Length Per Each <span style="float:right">ft</span>	41	32
	Pile Point Reinforcement	All	All
	Lowest Bottom of MSE Wall (=top of leveling pad) Along End Bent (Elev.)	N/A	N/A
	Min. Galvanized Penetration (Elev.)	Full Length	Full Length
	Minimum Tip Penetration (Elev.)	-	-
	Criteria for Min. Tip Penetration	-	-
	Pile Driving Verification Method	PDA	PDA
	Resistance Factor	0.65	0.65
Minimum Nominal Axial Compressive Resistance <span style="float:right">kip</span>	322	268	

<sup>(1)</sup> Due to the superelevation at the bridge abutments, the highest pile elevation was used.

<sup>(2)</sup> Pre-bore at Bent 1 is to extend below the existing nearby 48" RCP

PDA = Pile Driving Analysis



The HNTB Companies  
Engineers Architects Planners

Made	JMR	Date	8/21/2025	Job No.	71886
Checked		Date			
Backch'k'd		Date			

For

**Recommendations for Lateral Design of Drilled Shaft/Pile Foundations**

**Design References:**

1. AASHTO LRFD Bridge Design Specifications 2020
2. L-Pile User's Manual - 2022
3. L-Pile Technical Manual - 2022
4. MoDOT EPG - p-y Curve Criteria

[https://epg.modot.org/documents/321\\_p-y\\_Curve\\_Criteria.pdf](https://epg.modot.org/documents/321_p-y_Curve_Criteria.pdf)

Structural No.	Reference Boring(s)	Top of DS/Pile Elevation	Depth @ Top of Soil/Rock Layer <sup>10</sup>	Depth @ Bottom of Soil/Rock Layer	p-y Model <sup>7</sup>	Effective Unit Weight (pcf) <sup>4</sup>	LPILE Parameters						
							Clay		Sand		Rock		
							Cohesion, c (psf)	$e_{s0}^{2,9}$ , for Clay	$\phi^{3,4}$ (deg)	Soil Modulus k (pci) <sup>3</sup>	Strain Factor, k <sub>rm</sub> <sup>8</sup>	Avg. Rock qu, psi <sup>5,6</sup>	Initial Modulus of Rock Mass, E <sub>m</sub> , psi
Bent 2	BR-54/BR-55	591.2	0.0	5.0	Soft Clay (Matlock)	131	1	0.007					
			5.0	8.0	Modified Stiff Clay without Free Water	131	1,500	0.007					
			8.0	47.8	Weak Rock (Reese)	97.6			0.0005	14,966	984,320	59	
Bent 3	BR-57/K-2	591.5	0.0	2.0	Soft Clay (Matlock)	127	1	0.006					
			2.0	33.0	Weak Rock (Reese)	97.6			0.0005	14,966	984,320	59	

# APPENDIX C

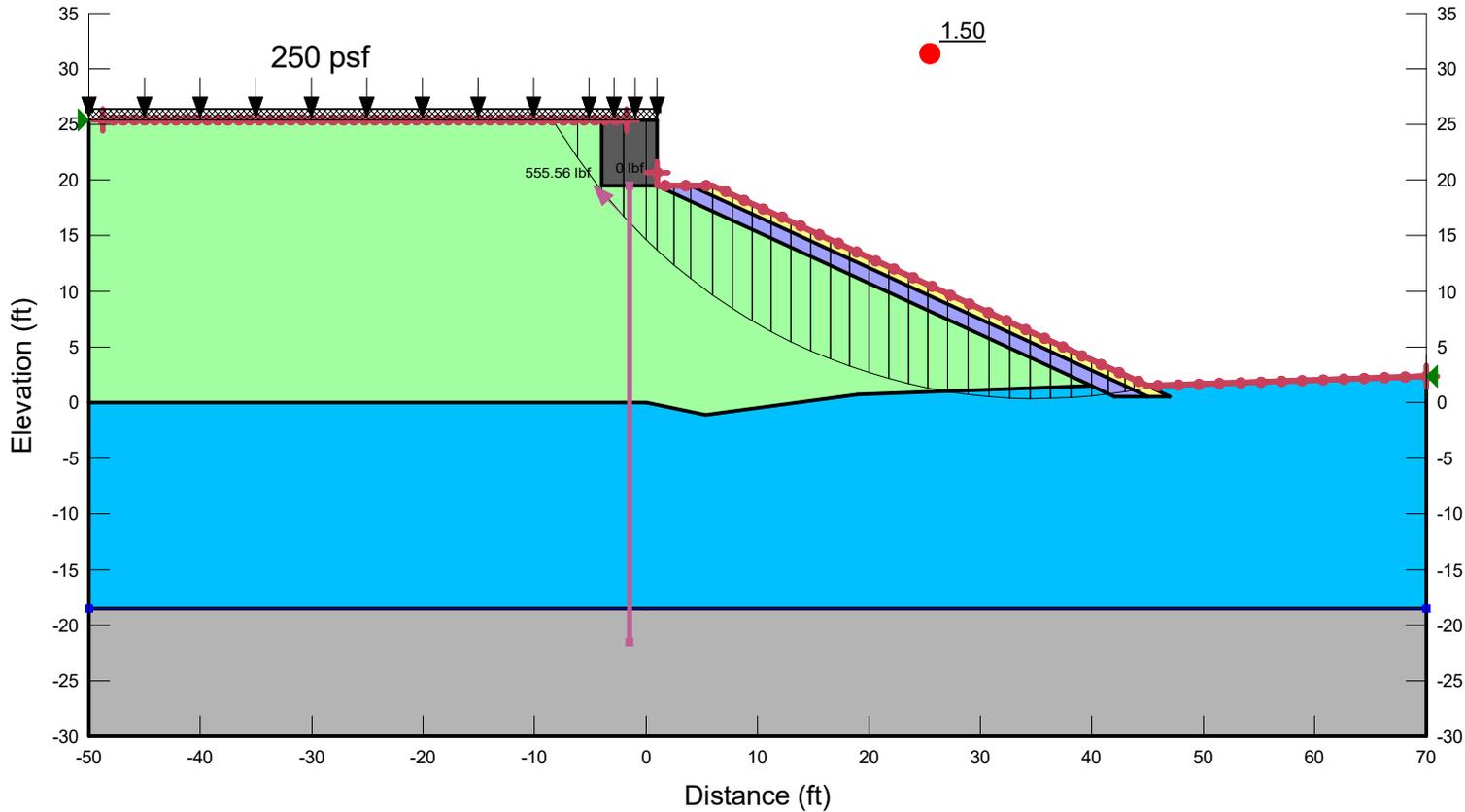
**GENERAL NOTES:**

**CLASSIFICATION, STRATIFICATION AND ENGINEERING PROPERTIES OF THE SUBSURFACE MATERIAL WERE BASED ON AVAILABLE BORING INFORMATION AND THE RESULTS OF AVAILABLE TEST DATA.**

**PROPOSED PAVEMENT MATERIAL/ROAD BASE NOT MODELLED.**

**SPENCER'S METHOD OF ANALYSIS USED.**

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
Blue	CL - LT	Mohr-Coulomb	127	25	28
Grey	Limestone	Bedrock (Impenetrable)			
Light Green	New Fill - CH - LT	Mohr-Coulomb	125	110	26
Purple	New Fill - CL - LT	Mohr-Coulomb	125	25	27
Dark Grey	Reinforced Zone	High Strength	130		
Yellow	Rock Blanket	Mohr-Coulomb	125	0	34



*Project* Improve I-70 Program - Warrenton to Wentzville

*Analysis Description* Bridge A9685 - Long Term

*Designer/Author* JMR

*Station* West Embankment

*Project Number* 71886

*Date* 12/23/2025

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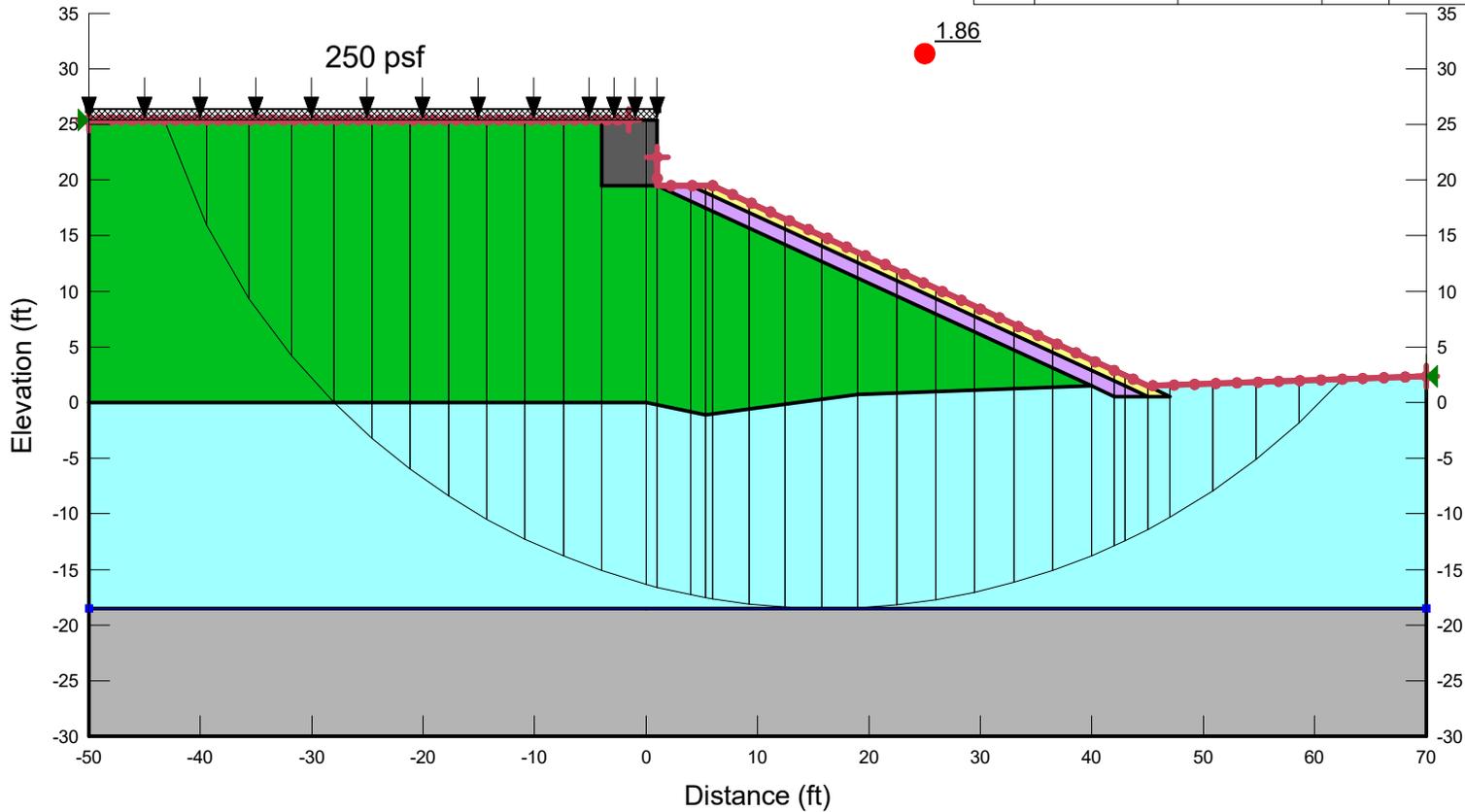
**GENERAL NOTES:**

**CLASSIFICATION, STRATIFICATION AND ENGINEERING PROPERTIES OF THE SUBSURFACE MATERIAL WERE BASED ON AVAILABLE BORING INFORMATION AND THE RESULTS OF AVAILABLE TEST DATA.**

**PROPOSED PAVEMENT MATERIAL/ROAD BASE NOT MODELLED.**

**SPENCER'S METHOD OF ANALYSIS USED.**

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Friction Angle (°)	Undrained Shear Strength (psf)
Light Blue	CL - ST	Undrained (Phi=0)	127		1,000
Grey	Limestone	Bedrock (Impenetrable)			
Green	New Fill - CH - ST	Undrained (Phi=0)	125		1,000
Purple	New Fill - CL - ST	Undrained (Phi=0)	125		1,000
Dark Grey	Reinforced Zone	High Strength	130		
Yellow	Rock Blanket	Mohr-Coulomb	125	34	



*Project* Improve I-70 Program - Warrenton to Wentzville

*Analysis Description* Bridge A9685 - Short Term

*Designer/Author* JMR

*Station* West Embankment

*Project Number* 71886

*Date* 12/23/2025

*File Name* C-9 West Embankment.gsz

# APPENDIX D



# LOG OF BORING

BORING NO. **BR-53**  
 PAGE **1** OF **1**

PROJECT I-70 Program: Warrenton to Wentzville STATION / NORTHING / 1082046.2  
 LOCATION St. Charles County OFFSET / EASTING / 725297.5  
 DATE STARTED 03/13/2025 DATE COMPLETED 03/13/2025 SURFACE ELEVATION 590.6 ft  
 EXPLORATION CONTRACTOR Palmerton & Parrish Inc. DATUM NAVD88  
 DRILLER David Allen DRILL RIG CME 55 GROUND WATER LEVELS:  
 HAMMER TYPE Auto HAMMER EFFICIENCY 78.0  AT TIME OF DRILLING NATD  
 LOGGED BY Pradip Adhikari CHECKED BY RFJ 03/28/2025  AFTER N/A

BORING LOG W/ LAB DATA COLUMNS - HNTB OFC001\_TEMPLATE.GDT - 4/22/25 12:20 - R:\JOBS\171886\_I-70\_DB\_PROJECT\_2\DESIGN\GEOTECH\STG\INT\PROJ\_2\_STCHARLES\_CO\_HNTBLIB.GPJ

DRILLING METHOD	DEPTH (ft)	SAMPLE TYPE NUMBER	SAMPLE RECOVERY (in) CORE REC % (RQD %)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	UNCONFINED (tsf)	DRY DENSITY (pcf)	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PASSING #200 (%)	GRAPHIC LOG	MATERIAL DESCRIPTION Unified (Visual) Classification System	ELEVATION (ft)	
	0													590.6	
SSA 4.5"	5	SPT J-1	13	4-3-4 (7)	2.5								Brown and gray, firm LEAN CLAY, trace sand, moist	590	
		ST U-1	22		2.0	1.02	100.7	24.4	37	21				585	
	10	SPT J-2	18	3-3-3 (6)	1.0										580
	15	SPT J-3	18	3-4-6 (10)	2.0			22.7							575
CORE BARREL NQ	18.5	SPT J-4	0	50/0"									LIMESTONE, Light gray, crystalline, thin bedded, moderately weathered, hard, few chert nodules	18.5	
	20	NQ C-1	100% (45%)			12024 psi	161.7	0.9							570
	25	NQ C-2	100% (78%)			9623 psi	168.4	0.2							565
	28.5												28.5		

Bottom of borehole at 28.5 feet.

<b>Project Name:</b> I-70 Program: Warrenton to Wentzville	<b>Project Number:</b> 71886	<b>Location:</b> St. Charles County, Missouri
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Boring No.	Date
BR-53	3/13/25
<b>Description</b>	
C-1: 18.5 – 23.5 ft Recovery: 100% RQD: 45%	
C-2: 23.5 – 28.5 ft Recovery: 100% RQD: 78%	





# LOG OF BORING

BORING NO. **BR-54**  
 PAGE **1** OF **2**

**PROJECT** I-70 Program: Warrenton to Wentzville **STATION / NORTHING** / 1082037.6  
**LOCATION** St. Charles County **OFFSET / EASTING** / 725369.8  
**DATE STARTED** 01/23/2025 **DATE COMPLETED** 01/27/2025 **SURFACE ELEVATION** 590.2 ft  
**EXPLORATION CONTRACTOR** Palmerton & Parrish Inc. **DATUM** NAVD88  
**DRILLER** David Allen **DRILL RIG** CME 55 **GROUND WATER LEVELS:**  
**HAMMER TYPE** Auto **HAMMER EFFICIENCY** 78.0 **▽ AT TIME OF DRILLING** NATD  
**LOGGED BY** Pradip Adhikari **CHECKED BY** RFJ 03/28/2025 **▼ AFTER** N/A

BORING LOG W/ LAB DATA COLUMNS - HNTB\_OF001\_TEMPLATE.GDT - 4/8/25 10:52 - R:\JOBS\1886\_I-70\_DB\_PROJECT\_2\DESIGN\GEO\TECH\ID\GINT\PROJ\_2\_STCHARLES\_CO\_HNTB\LB.GPJ

DRILLING METHOD	DEPTH (ft)	SAMPLE TYPE NUMBER	SAMPLE RECOVERY (in) CORE REC % (RQD %)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	UNCONFINED (tsf)	DRY DENSITY (pcf)	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PASSING #200 (%)	GRAPHIC LOG	MATERIAL DESCRIPTION Unified (Visual) Classification System	ELEVATION (ft)
	0													590.2
SSA 4.5"	5	SPT J-1	12	6-6-6 (12)	2.0			29.9	56	33			Gray and brown, stiff, FAT CLAY, trace chert fragments, moist	590
	8	SPT J-2	0	50/0"										585
CORE BARREL NQ	10	NQ C-1	100% (49%)										LIMESTONE, very fine grained, medium bedded, slightly weathered, hard	580
	12.8					15839 psi	156.4	0.2					11.0' - 2 inch shale seam	13.3
	15	NQ C-2	60% (0%)										Core loss, possible clay seam	15.3
	17.8					18121 psi	163.9	0.1					LIMESTONE, very fine grained, thin bedded, weathered, moderately hard to hard	17.8
	20	NQ C-3	97% (53%)											20
	22.8												Core loss, possible clay seam	22.8
	25	NQ C-4	40% (8%)											25
	27.8												LIMESTONE, tan and gray, very fine grained, thick bedded, highly weathered, moderately hard	27.8
	30	NQ C-5	100% (0%)											30
	32.8					11779 psi	161.2	0.3						32.8
	35	NQ C-6	100% (95%)										LIMESTONE, very fine grained, thick bedded, fresh to slightly weathered, hard	35
	37.8					15024 psi	157.9	0.3						37.8
	40													40

(Continued Next Page)



# LOG OF BORING

BORING NO. **BR-54**  
 PAGE **2** OF **2**

PROJECT I-70 Program: Warrenton to Wentzville STATION / NORTHING / 1082037.6  
 LOCATION St. Charles County OFFSET / EASTING / 725369.8

DRILLING METHOD	DEPTH (ft)	SAMPLE TYPE NUMBER	SAMPLE RECOVERY (in) CORE REC % (RQD %)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	UNCONFINED (tsf)	DRY DENSITY (pcf)	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PASSING #200 (%)	GRAPHIC LOG	MATERIAL DESCRIPTION Unified (Visual) Classification System	ELEVATION (ft)
	40	NQ C-7	100% (100%)											550
	42.8													
	45	NQ C-8	100% (87%)		6837 psi		145.7	0.5						545
	47.8													47.8

Bottom of borehole at 47.8 feet.

BORING LOG W/ LAB DATA COLUMNS - HNTB\_OF001\_TEMPLATE.GDT - 4/8/25 10:52 - R:\JOBS\1886\_I-70\_DB\_PROJECT\_2\DESIGN\GEO\TECH\ID\GINT\PROJ\_2\_STCHARLES\_CO\_HNTBLIB.GPJ

<b>Project Name:</b> I-70 Program: Warrenton to Wentzville	<b>Project Number:</b> 71886	<b>Location:</b> St. Charles County, Missouri
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Boring No.	Date
BR-54	1/27/25
<b>Description</b>	
C-1: 8.0 – 12.8 ft Recovery: 100% RQD: 49%	
C-2: 12.8 – 17.8 ft Recovery: 60% RQD: 0%	
C-3: 17.8 – 22.8 ft Recovery: 97% RQD: 53%	



Boring No.	Date
BR-54	1/27/25
<b>Description</b>	
C-3: 17.8 – 22.8 ft Recovery: 97% RQD: 53%	
C-4: 22.8 – 27.8 ft Recovery: 40% RQD: 8%	
C-5: 27.8 – 32.8 ft Recovery: 100% RQD: 0%	



Boring No.	Date
BR-54	1/27/25
<b>Description</b>	
C-5: 27.8 – 32.8 ft Recovery: 100% RQD: 0%	
C-6: 32.8 – 37.8 ft Recovery: 100% RQD: 95%	
C-7: 37.8 – 42.8 ft Recovery: 100% RQD: 100%	



Boring No.	Date
BR-54	1/27/25
<b>Description</b>	
C-7: 37.8 – 42.8 ft Recovery: 100% RQD: 100%	
C-8: 42.8 – 47.8 ft Recovery: 100% RQD: 87%	





# LOG OF BORING

BORING NO. **BR-55**  
 PAGE **1** OF **1**

PROJECT I-70 Program: Warrenton to Wentzville STATION / NORTHING / 1082024.3  
 LOCATION St. Charles County OFFSET / EASTING / 725411.7  
 DATE STARTED 01/23/2025 DATE COMPLETED 01/28/2025 SURFACE ELEVATION 592.4 ft  
 EXPLORATION CONTRACTOR Palmerton & Parrish Inc. DATUM NAVD88  
 DRILLER David Allen DRILL RIG CME 55 GROUND WATER LEVELS:  
 HAMMER TYPE Auto HAMMER EFFICIENCY 78.0  AT TIME OF DRILLING NATD  
 LOGGED BY Pradip Adhikari CHECKED BY RFJ 03/28/2025  AFTER N/A

BORING LOG W/ LAB DATA COLUMNS - HNTB\_OF001\_TEMPLATE.GDT - 4/1/25 10:17 - R:\JOBS\1886\_I-70\_DB\_PROJECT\_2\DESIGN\GEO\TECH\INT\PROJ\_2\_STCHARLES\_CO\_HNTBLIB.GPJ

DRILLING METHOD	DEPTH (ft)	SAMPLE TYPE NUMBER	SAMPLE RECOVERY (in) CORE REC % (RQD %)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	UNCONFINED (tsf)	DRY DENSITY (pcf)	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PASSING #200 (%)	GRAPHIC LOG	MATERIAL DESCRIPTION Unified (Visual) Classification System	ELEVATION (ft)
	0													592.4
SSA 4.5"	0-5												Brown, stiff, LEAN CLAY, moist	
	5	SPT J-1	8	38-50/2"	1.5			19.8						590
CORE BARREL NQ	5-5.5	NQ C-1	100% (22%)										4.0' - limestone fragments	5.0
	5.5-8												LIMESTONE, light gray, thin bedded, moderately weathered, moderately hard	
	8-10	NQ C-2	100% (63%)			17735 psi	161.9	0.3					7.0' - chert nodules	585
	10-13													580
	13-15	NQ C-3	70% (40%)			17632 psi	166.1	0.1						575
	15-18												LIMESTONE, light gray, medium to thick bedded, slightly weathered, hard, chert nodules through	18.0
	18-20	NQ C-4	100% (45%)			20267 psi	166.3	0.1						570
	20-23					19110 psi	168.1	0.1						565
	23-25	NQ C-5	100% (77%)											560
	25-28													555
	28-30	NQ C-6	100% (78%)			6354 psi	139.0	0.3					31.0' to 33.0' - some sand and chert	550
	30-33													555
	33-35	NQ C-7	100% (82%)			11167 psi	150.7	0.5						555
	35-38					12926 psi	155.8	0.3						555
	38-40	NQ C-8	100% (75%)											40.0

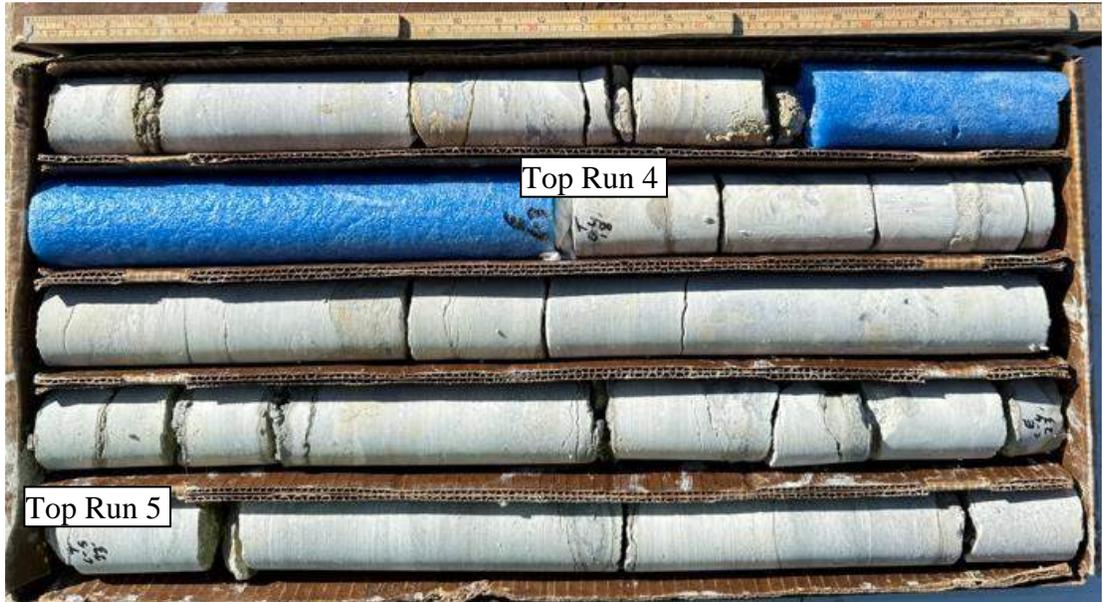
Bottom of borehole at 40.0 feet.

<b>Project Name:</b> I-70 Program: Warrenton to Wentzville	<b>Project Number:</b> 71886	<b>Location:</b> St. Charles County, Missouri
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Boring No.	Date
BR-55	1/28/25
<b>Description</b>	
C-1: 5.0 – 8.0 ft Recovery: 100% RQD: 22%	
C-2: 8.0 – 13.0 ft Recovery: 100% RQD: 63%	
C-3: 13.0 – 18.0 ft Recovery: 70% RQD: 40%	



Boring No.	Date
BR-55	1/28/25
<b>Description</b>	
C-3: 13.0 – 18.0 ft Recovery: 70% RQD: 40%	
C-4: 18.0 – 23.0 ft Recovery: 100% RQD: 45%	
C-5: 23.0 – 28.0 ft Recovery: 100% RQD: 77%	



Boring No.	Date
BR-55	1/28/25
Description	
C-5: 23.0 – 28.0 ft Recovery: 100% RQD: 77%	
C-6: 28.0 – 33.0 ft Recovery: 100% RQD: 78%	
C-7: 33.0 – 38.0 ft Recovery: 100% RQD: 82%	

Boring No.	Date
BR-55	1/28/25
Description	
C-7: 33.0 – 38.0 ft Recovery: 100% RQD: 82%	
C-8: 38.0 – 40.0 ft Recovery: 100% RQD: 75%	



# LOG OF BORING

BORING NO. **BR-57**  
 PAGE **1** OF **1**

**PROJECT** I-70 Program: Warrenton to Wentzville **STATION / NORTHING** / 1082000.4  
**LOCATION** St. Charles County **OFFSET / EASTING** / 725566.3  
**DATE STARTED** 01/22/2025 **DATE COMPLETED** 01/23/2025 **SURFACE ELEVATION** 592.5 ft  
**EXPLORATION CONTRACTOR** Palmerton & Parrish Inc. **DATUM** NAVD88  
**DRILLER** David Allen **DRILL RIG** CME 55 **GROUND WATER LEVELS:**  
**HAMMER TYPE** Auto **HAMMER EFFICIENCY** 78.0  **AT TIME OF DRILLING** NATD  
**LOGGED BY** Pradip Adhikari **CHECKED BY** RFJ 03/28/2025  **AFTER** N/A

BORING LOG W/ LAB DATA COLUMNS - HNTB\_OF001\_TEMPLATE.GDT - 4/1/25 10:17 - R:\JOBS\1886\_I-70\_DB\_PROJECT\_2\DESIGN\GEO\TECH\GINT\PROJ\_2\_STCHARLES\_CO\_HNTBLIB.GPJ

DRILLING METHOD	DEPTH (ft)	SAMPLE TYPE NUMBER	SAMPLE RECOVERY (in) CORE REC % (RQD %)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	UNCONFINED (tsf)	DRY DENSITY (pcf)	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PASSING #200 (%)	GRAPHIC LOG	MATERIAL DESCRIPTION Unified (Visual) Classification System	ELEVATION (ft)
	0													592.5
	3	SPT J-1	0	50/0*									Brown, stiff, LEAN CLAY, trace gravel, moist	590
SSA 4.5" CORE BARREL NQ	5	NQ C-1	100% (37%)			13390 psi	161.1	0.3					LIMESTONE, light gray, very fine grained, thin to thick bedded, weathered to slightly weathered, moderately hard to hard, few laminated clay seams	585
	7.5													580
	10	NQ C-2	100% (48%)			16524 psi	164.6	0.2						575
	12.5													570
	15	NQ C-3	100% (85%)			21142 psi	158.4	0.4						565
	17.5													560
	20	NQ C-4	100% (53%)			18355 psi	164.5	0.3						555
	22.5													550
	25	NQ C-5	100% (95%)			16084 psi	162.8	0.3						545
	27.5													540
	30	NQ C-6	100% (77%)			22021 psi	155.9	0.2						535
	32.5	NQ C-7	100%											530

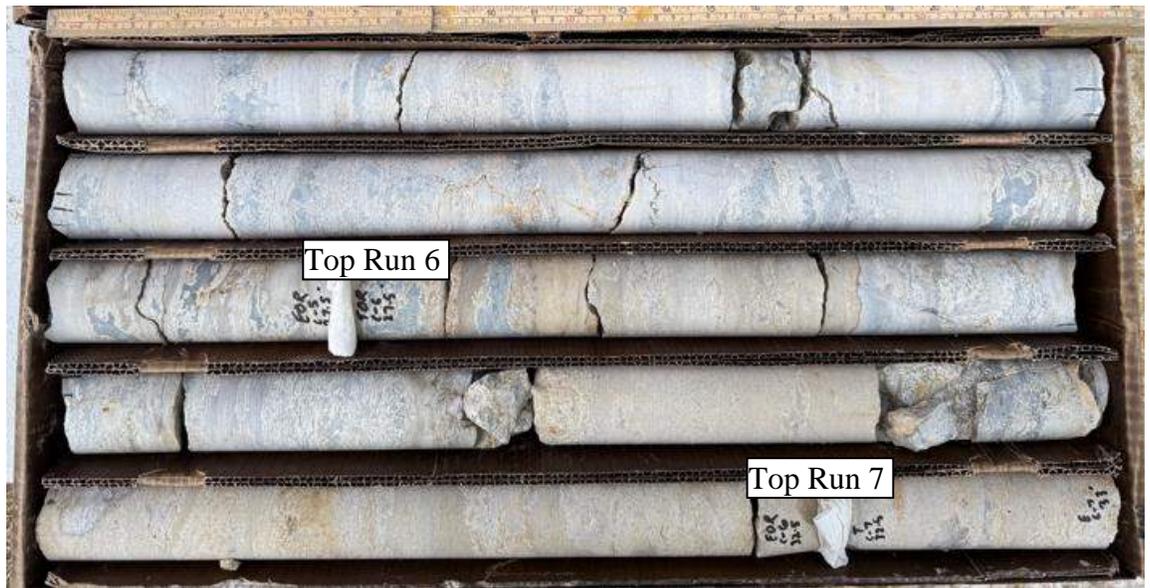
Bottom of borehole at 33.0 feet.

<b>Project Name:</b> I-70 Program: Warrenton to Wentzville	<b>Project Number:</b> 71886	<b>Location:</b> St. Charles County, Missouri
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Boring No.	Date
BR-57	1/23/25
<b>Description</b>	
C-1: 3.0 – 7.5 ft Recovery: 100% RQD: 37%	
C-2: 7.5 – 12.5 ft Recovery: 100% RQD: 48%	
C-3: 12.5 – 17.5 ft Recovery: 100% RQD: 85%	

Boring No.	Date
BR-57	1/23/25
<b>Description</b>	
C-3: 12.5 – 17.5 ft Recovery: 100% RQD: 85%	
C-4: 17.5 – 22.5 ft Recovery: 100% RQD: 53%	
C-5: 22.5 – 27.5 ft Recovery: 100% RQD: 95%	

Boring No.	Date
BR-57	1/23/25
<b>Description</b>	
C-5: 22.5 – 27.5 ft Recovery: 100% RQD: 95%	
C-6: 27.5 – 32.5 ft Recovery: 100% RQD: 77%	
C-7: 32.5 – 33.0 ft Recovery: 100% RQD: 100%	





# LOG OF BORING

BORING NO. **BR-58**  
 PAGE **1** OF **1**

**PROJECT** I-70 Program: Warrenton to Wentzville  
**LOCATION** St. Charles County  
**DATE STARTED** 01/23/2025 **DATE COMPLETED** 01/23/2025  
**EXPLORATION CONTRACTOR** Palmerton & Parrish Inc.  
**DRILLER** David Allen **DRILL RIG** CME 55  
**HAMMER TYPE** Auto **HAMMER EFFICIENCY** 78.0  
**LOGGED BY** Pradip Adhikari **CHECKED BY** RFJ 03/28/2025

**STATION / NORTHING** / 1082045.4  
**OFFSET / EASTING** / 725661.1  
**SURFACE ELEVATION** 603.1 ft  
**DATUM** NAVD88

**GROUND WATER LEVELS:**  
 ▽ **AT TIME OF DRILLING** NATD  
 ▼ **AFTER** N/A

BORING LOG W/ LAB DATA COLUMNS - HNTB\_OF001\_TEMPLATE.GDT - 4/1/25 10:17 - R:\JOBS\1886 I-70 DB\_PROJECT\_2\DESIGN\GEO\TECH\ID\GINT\PROJ\_2\_STCHARLES\_CO\_HNTB\LIB.GPJ

DRILLING METHOD	DEPTH (ft)	SAMPLE TYPE NUMBER	SAMPLE RECOVERY (in) CORE REC % (RQD %)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	UNCONFINED (tsf)	DRY DENSITY (pcf)	WATER CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PASSING #200 (%)	GRAPHIC LOG	MATERIAL DESCRIPTION Unified (Visual) Classification System	ELEVATION (ft)
SSA 4.5"	0											[Diagonal Hatching]	Brown, stiff to hard, LEAN CLAY, moist	603.1
	5	SPT J-1	16	5-6-6 (12)	3.0			19.4	36	15				
CORE BARREL NQ	10	SPT J-2	8	22-12-22 (34)	>4.5			9.7				[Diagonal Hatching]	6.5' - some silt	595
	13.5	SPT J-3	0	50/0"										
CORE BARREL NQ	15	NQ C-1	100% (75%)			12291 psi	159.7	0.3				[Brick Pattern]	LIMESTONE, tan to light gray, fine grained, medium bedded, slightly weathered, hard, few laminated clay seams	590
	18.5	NQ C-2	100% (63%)			15017 psi	163.9	0.3						
	20													23.5

Bottom of borehole at 23.5 feet.

<b>Project Name:</b> I-70 Program: Warrenton to Wentzville	<b>Project Number:</b> 71886	<b>Location:</b> St. Charles County, Missouri
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Boring No.	Date
BR-58	1/23/25
<b>Description</b>	
C-1: 13.5 – 18.5 ft Recovery: 100% RQD: 75%	
C-2: 18.5 – 23.5 ft Recovery: 100% RQD: 63%	





**Missouri Department of Transportation  
Construction and Materials**

**BORING NO. K-2**  
Page 1 of 1

Job No.: 20221168.00  
 Design: \_\_\_\_\_  
 Bent: \_\_\_\_\_  
 Station: \_\_\_\_\_  
 Offset: \_\_\_\_\_  
 Elevation: 592.2  
 Requested Station: \_\_\_\_\_  
 Requested Offset: \_\_\_\_\_  
 Requested Elevation: \_\_\_\_\_  
 Drill No.: \_\_\_\_\_

County: Saint Charles  
 Skew: \_\_\_\_\_  
 Logged By: JE  
 Northing: 1082025.088  
 Easting: 725539.629  
 Requested Northing: \_\_\_\_\_  
 Requested Easting: \_\_\_\_\_  
 Equipment: CME 550, Split-Spoon Sampler, NQ  
 Location Note: \_\_\_\_\_  
 Hammer Efficiency: 96%

Route: I-64/I-70/US 61 Interchange (J613527)  
 Location: St. Charles County  
 Operator: RM  
 Date of Work: 05/25/23-05/25/23  
 Depth to Water: \_\_\_\_\_  
 Depth Hole Open: \_\_\_\_\_  
 Time Change: \_\_\_\_\_  
 Drilling Method: HSA

LETTER BOREHOLE - MODOT 20150728.GDT - 7/28/23 13:21 - \\TSI\PROJECTS\STL\GEOTECH\2022 PROJECTS\2022 1168.00 I-64 I-70 US 61 INTERCHANGE (J613527)\WORKING FILES\MODOT GINTV1-70\_I-64\_US-61 INTERCHANGE.GPJ

Depth (ft)	Graphic	Description	Elevation (ft)	Sample Type	REC % (RQD %)	Blow Counts (N <sub>60</sub> )	Shear Data	Field Tests	Index Tests
0									
0.0-1.5'		0.0-1.5' Gray and tan, highly weathered LIMESTONE			73	50/0.5'			
1.5-28.0'		1.5-28.0' LIMESTONE, gray and tan, moderately hard, slightly to moderately weathered, aphanitic, thin to medium bedded, clay seams throughout	590		61 (0)				
5			585		92 (36)		Qu Test Results UCS = 1630 ksf		
10			580		100 (100)		Qu Test Results UCS = 814 ksf		
15			575		92 (78)		Qu Test Results UCS = 1580 ksf		
20			570		100 (66)		Qu Test Results UCS = 1800 ksf		
25			565		100 (38)		Qu Test Results UCS = 1460 ksf		
23.0'		23.0' -cherty below 23.0 ft.			100 (61)				
		Refusal at 1.5 feet. Bottom of borehole at 28.0 feet.			95 (16)				

N<sub>60</sub> = (Em/60)Nm    N<sub>60</sub> - Corrected N value for standard 60% SPT efficiency; Em - Measured hammer efficiency in percent; Nm - Observed N-value  
 (1) = Assumed, (2) = Actual

Coordinate System: U.S. State Plane 1983      Coordinate Zone: Missouri East      Coordinate Proj. Factor: 1.0000878  
 Coordinate Datum: NAD 83 (CONUS)      Coordinate Units: U.S. Survey Feet

\* Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "log of materials" is limited thereby and by judgement of the operator. THIS INFORMATION IS FOR DESIGN PURPOSES ONLY.

# APPENDIX E

**ASTM D7012-14: Compressive Strength Intact Rock Core Specimens**

CLIENT:	HNTB Corporation				
PROJECT:	Project 2 - I-70 Program - Warrenton to Wentzville				
BORING NO:	BR 53	SAMPLE DEPTH:	19.6'	PPI PROJECT NO:	
DESCRIPTION OF SAMPLE:	Limestone			DATE TESTED:	3/26/2025

**WATER CONTENT DETERMINATION**

Wet Weight of Specimen	543.5 g
Dry Weight of Specimen	538.8 g

**WATER CONTENT**

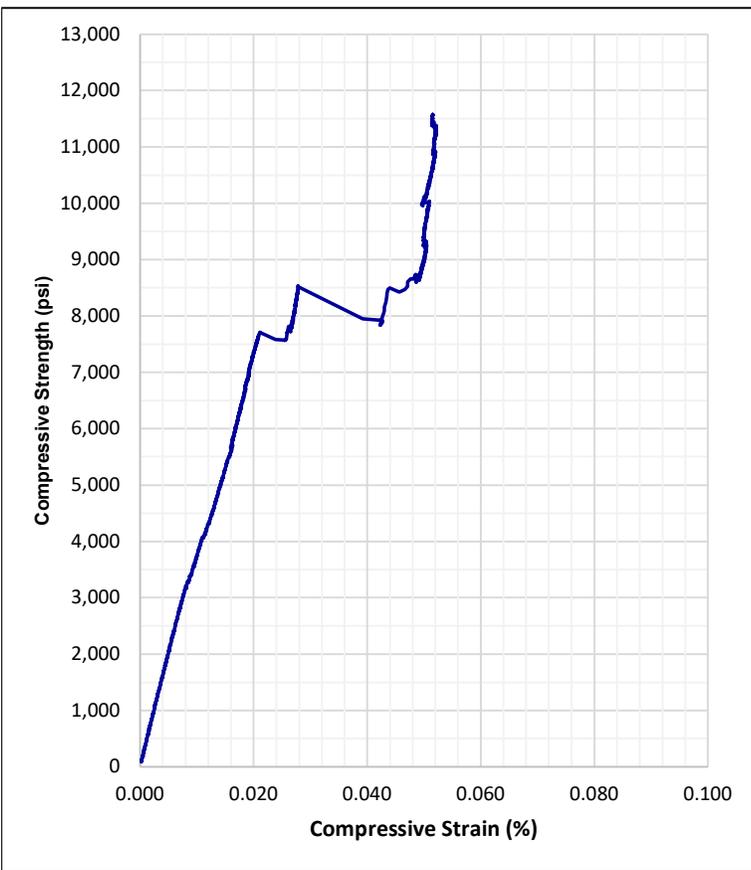
0.9 %
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**DIMENSIONS**

Initial Diameter	1.99 in.
Initial Area	3.11 in. <sup>2</sup>
Initial Height	4.08 in.
Initial Volume	12.69 in. <sup>3</sup>

**DENSITY**

Wet Unit Weight	163.2 lbs/ft <sup>3</sup>
Dry Unit Weight	161.7 lbs/ft <sup>3</sup>



**PRE-TEST PHOTOGRAPH**



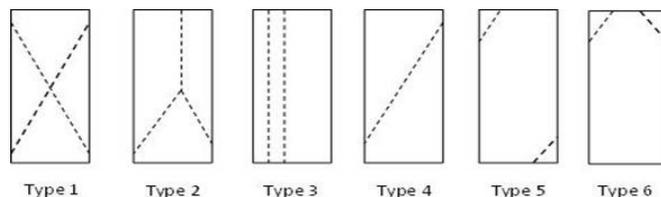
**FAILURE PHOTOGRAPH**



Load	37,398 lbs
Deformation	0.0022 in.
Strain	0.054 %

Break: Type 3

Compressive Strength (Qu):	12,024 psi
	866 tsf



**ASTM D7012-14: Compressive Strength Intact Rock Core Specimens**

CLIENT:	HNTB Corporation		
PROJECT:	Project 2 - I-70 Program - Warrenton to Wentzville		
BORING NO:	BR 53	SAMPLE DEPTH:	26.0'
DESCRIPTION OF SAMPLE:	Limestone	PPI PROJECT NO:	
		DATE TESTED:	3/26/2025

**WATER CONTENT DETERMINATION**

Wet Weight of Specimen	566.5 g
Dry Weight of Specimen	565.1 g

**WATER CONTENT**

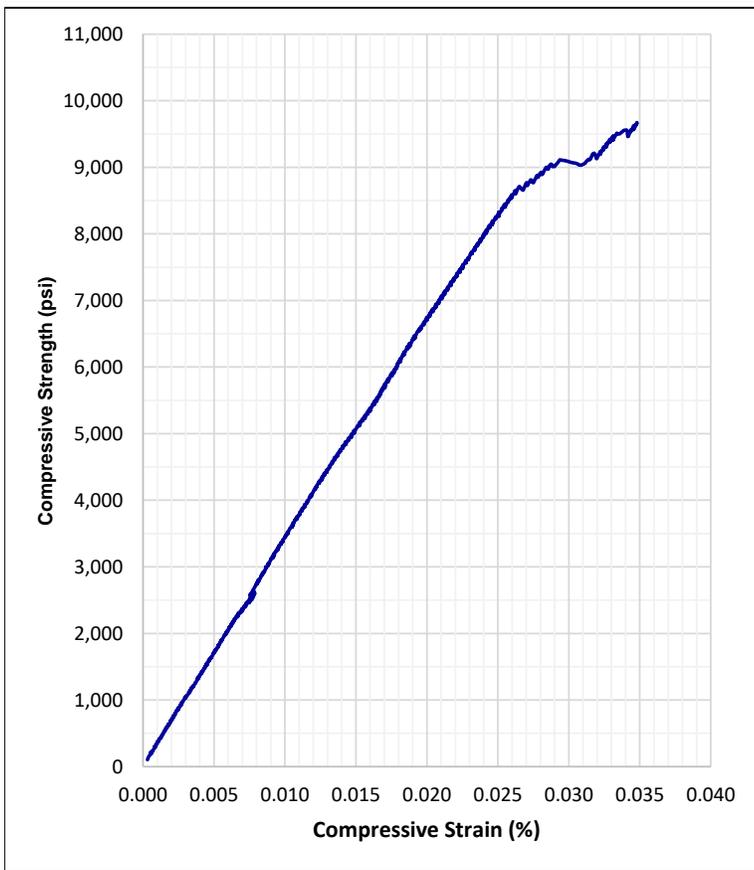
0.2 %
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**DIMENSIONS**

Initial Diameter	1.99 in.
Initial Area	3.11 in. <sup>2</sup>
Initial Height	4.11 in.
Initial Volume	12.78 in. <sup>3</sup>

**DENSITY**

Wet Unit Weight	168.8 lbs/ft <sup>3</sup>
Dry Unit Weight	168.4 lbs/ft <sup>3</sup>



**PRE-TEST PHOTOGRAPH**



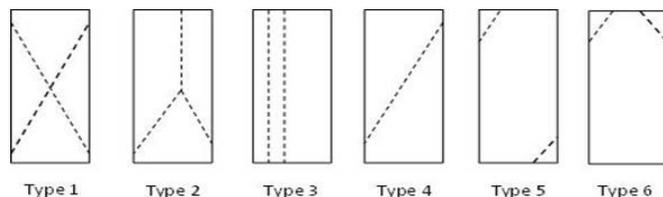
**FAILURE PHOTOGRAPH**



Load	29,929 lbs
Deformation	0.0014 in.
Strain	0.035 %

Break: Type 3

Compressive Strength (Qu):	9,623 psi
	693 tsf



### ASTM D7012-14: Compressive Strength Intact Rock Core Specimens

CLIENT:	HNTB Corporation				
PROJECT:	Project 2 - I-70 Program - Warrenton to Wentzville				
BORING NO:	BR 54	SAMPLE DEPTH:	12.3'	PPI PROJECT NO:	
DESCRIPTION OF SAMPLE:	Limestone			DATE TESTED:	3/3/2025

#### WATER CONTENT DETERMINATION

Wet Weight of Specimen	530.9 g
Dry Weight of Specimen	530.0 g

#### WATER CONTENT

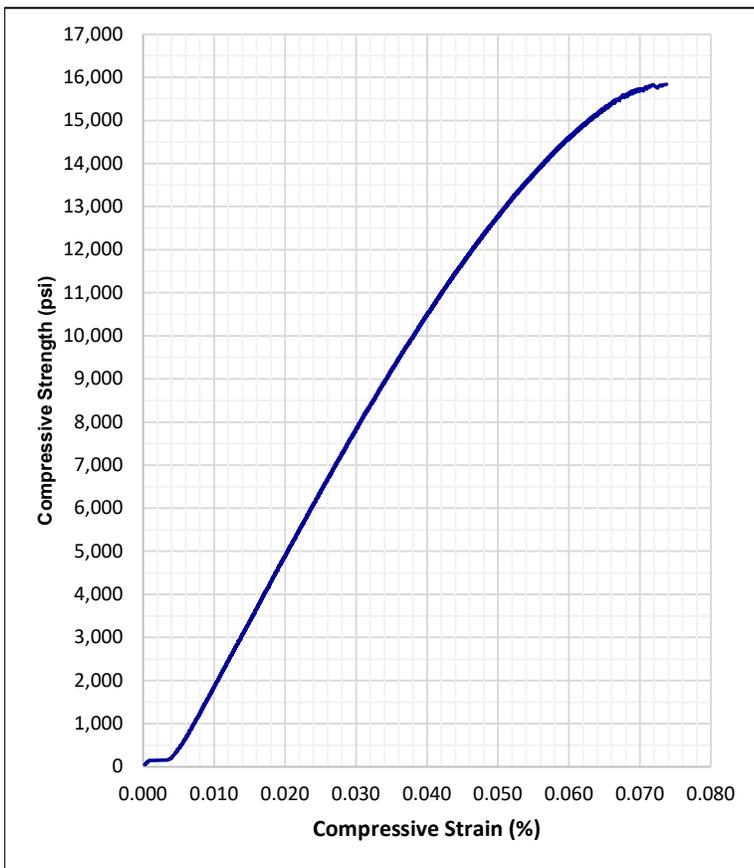
0.2 %
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#### DIMENSIONS

Initial Diameter	2 in.
Initial Area	3.14 in. <sup>2</sup>
Initial Height	4.11 in.
Initial Volume	12.91 in. <sup>3</sup>

#### DENSITY

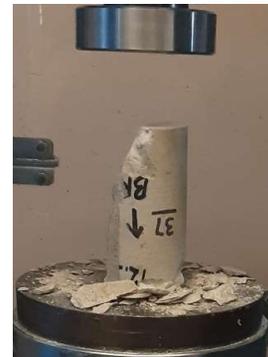
Wet Unit Weight	156.6 lbs/ft <sup>3</sup>
Dry Unit Weight	156.4 lbs/ft <sup>3</sup>



#### PRE-TEST PHOTOGRAPH

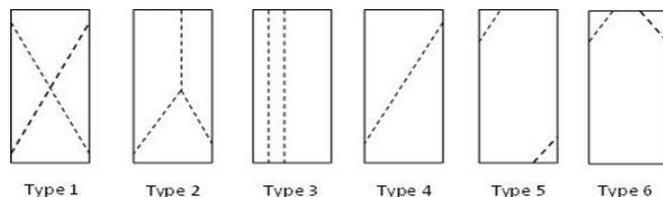


#### FAILURE PHOTOGRAPH



Load	49,761 lbs
Deformation	0.0030 in.
Strain	0.074 %

Break: Type 6



Compressive Strength (Qu):	15,839 psi
	1,140 tsf

**ASTM D7012-14: Compressive Strength Intact Rock Core Specimens**

CLIENT:	HNTB Corporation				
PROJECT:	Project 2 - I-70 Program - Warrenton to Wentzville				
BORING NO:	BR 54	SAMPLE DEPTH:	18.5'	PPI PROJECT NO:	
DESCRIPTION OF SAMPLE:	Limestone			DATE TESTED:	3/3/2025

**WATER CONTENT DETERMINATION**

Wet Weight of Specimen	549.5 g
Dry Weight of Specimen	548.8 g

**WATER CONTENT**

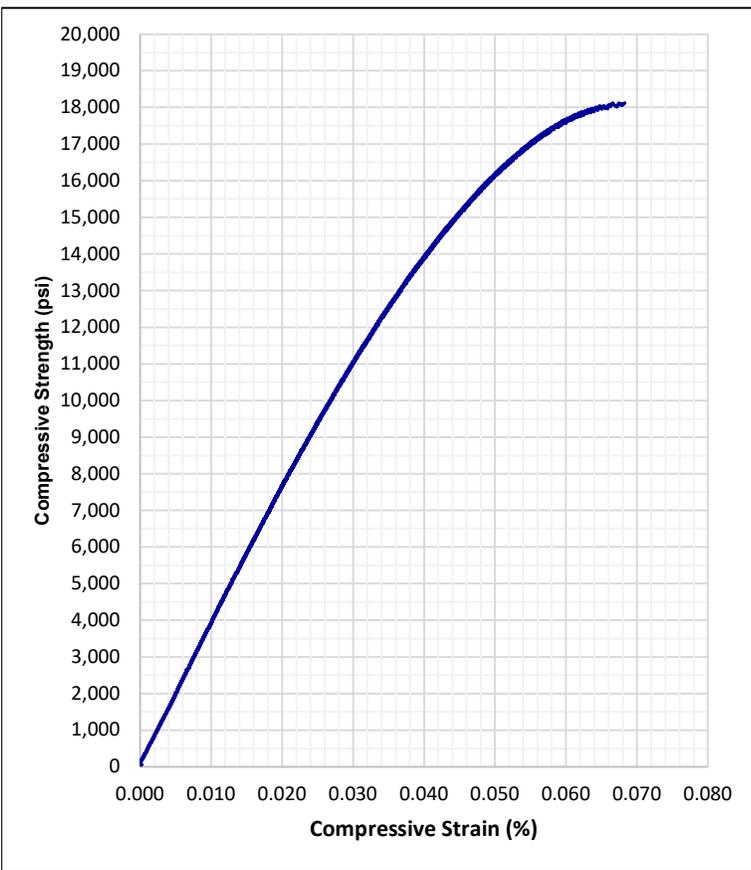
0.1 %
-------

**DIMENSIONS**

Initial Diameter	1.99 in.
Initial Area	3.11 in. <sup>2</sup>
Initial Height	4.10 in.
Initial Volume	12.75 in. <sup>3</sup>

**DENSITY**

Wet Unit Weight	164.2 lbs/ft <sup>3</sup>
Dry Unit Weight	163.9 lbs/ft <sup>3</sup>



**PRE-TEST PHOTOGRAPH**



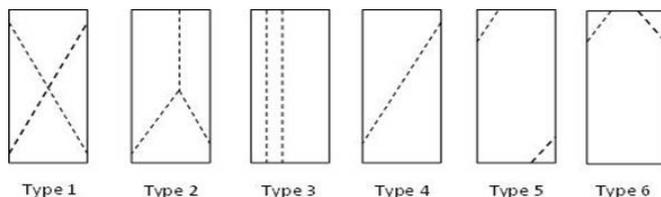
**FAILURE PHOTOGRAPH**



Load	56,360 lbs
Deformation	0.0028 in.
Strain	0.068 %

Break: Type 6

Compressive Strength (Qu):	18,121 psi
	1,305 tsf



### ASTM D7012-14: Compressive Strength Intact Rock Core Specimens

CLIENT:	HNTB Corporation				
PROJECT:	Project 2 - I-70 Program - Warrenton to Wentzville				
BORING NO:	BR 54	SAMPLE DEPTH:	33.4'	PPI PROJECT NO:	
DESCRIPTION OF SAMPLE:	Limestone			DATE TESTED:	3/3/2025

#### WATER CONTENT DETERMINATION

Wet Weight of Specimen	539.7 g
Dry Weight of Specimen	538.2 g

#### WATER CONTENT

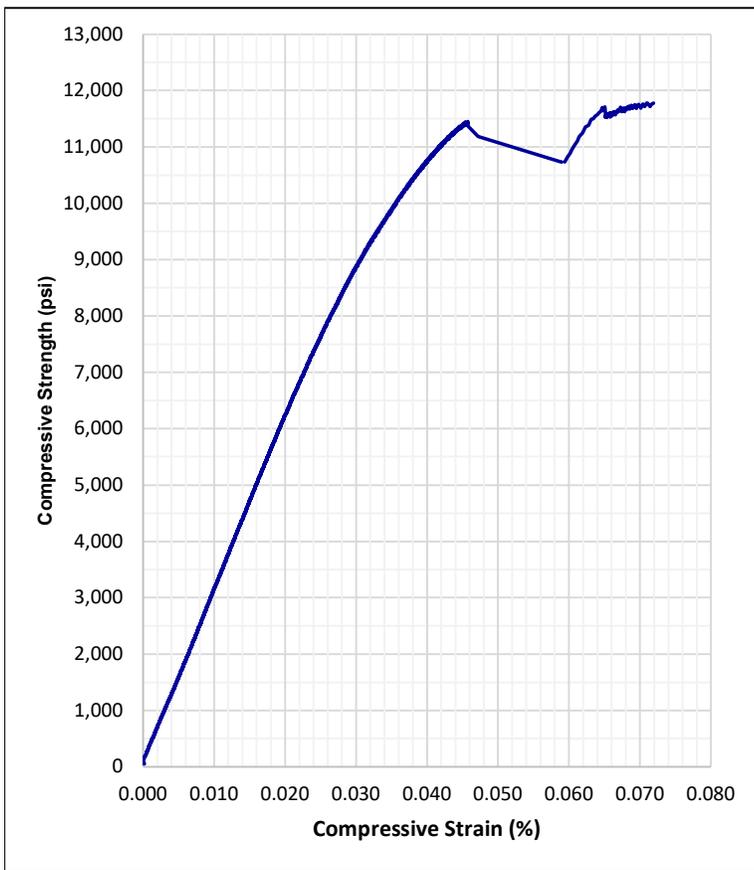
0.3 %
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#### DIMENSIONS

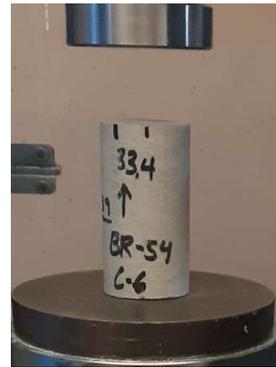
Initial Diameter	1.99 in.
Initial Area	3.11 in. <sup>2</sup>
Initial Height	4.09 in.
Initial Volume	12.72 in. <sup>3</sup>

#### DENSITY

Wet Unit Weight	161.6 lbs/ft <sup>3</sup>
Dry Unit Weight	161.2 lbs/ft <sup>3</sup>



#### PRE-TEST PHOTOGRAPH



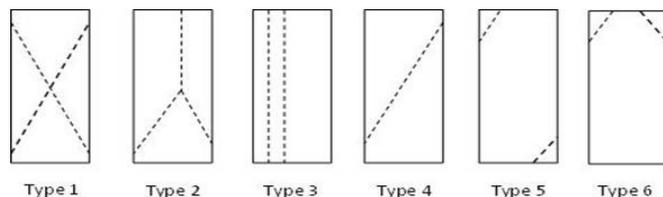
#### FAILURE PHOTOGRAPH



Load	36,636 lbs
Deformation	0.0029 in.
Strain	0.072 %

Break: Type 3

Compressive Strength (Qu):	11,779 psi
	848 tsf



**ASTM D7012-14: Compressive Strength Intact Rock Core Specimens**

CLIENT:	HNTB Corporation				
PROJECT:	Project 2 - I-70 Program - Warrenton to Wentzville				
BORING NO:	BR 54	SAMPLE DEPTH:	38.0'	PPI PROJECT NO:	
DESCRIPTION OF SAMPLE:	Limestone			DATE TESTED:	3/3/2025

**WATER CONTENT DETERMINATION**

Wet Weight of Specimen	530.2 g
Dry Weight of Specimen	528.6 g

**WATER CONTENT**

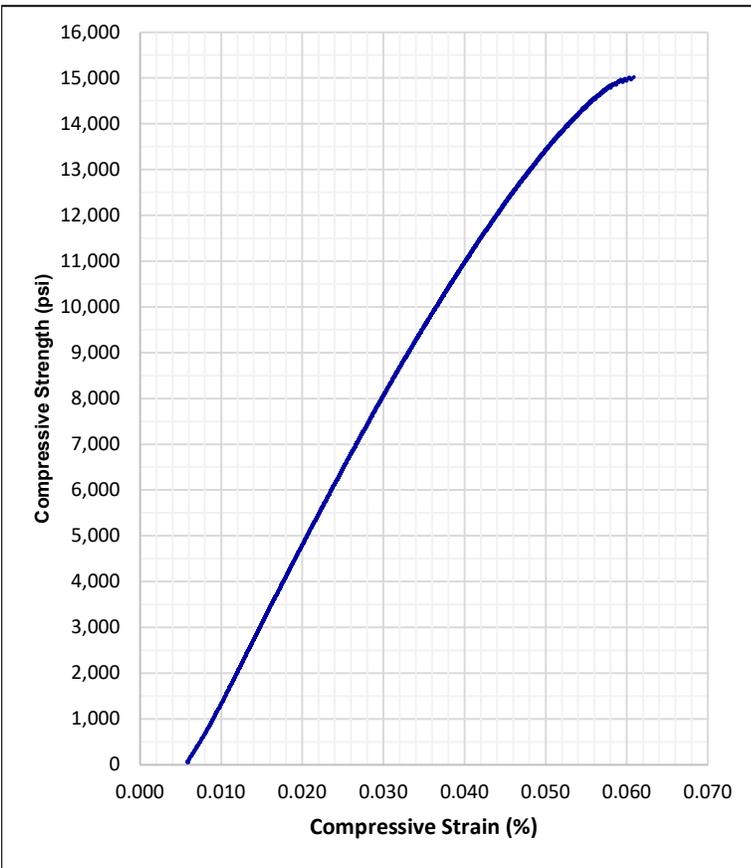
0.3 %
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**DIMENSIONS**

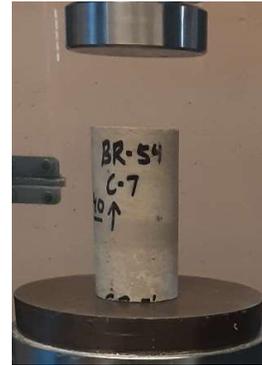
Initial Diameter	1.99 in.
Initial Area	3.11 in. <sup>2</sup>
Initial Height	4.10 in.
Initial Volume	12.75 in. <sup>3</sup>

**DENSITY**

Wet Unit Weight	158.4 lbs/ft <sup>3</sup>
Dry Unit Weight	157.9 lbs/ft <sup>3</sup>



**PRE-TEST PHOTOGRAPH**



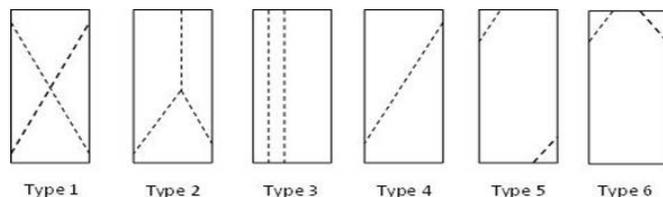
**FAILURE PHOTOGRAPH**



Load	46,727 lbs
Deformation	0.0025 in.
Strain	0.061 %

Break: Type 3

Compressive Strength (Qu):	15,024 psi
	1,082 tsf



**ASTM D7012-14: Compressive Strength Intact Rock Core Specimens**

CLIENT:	HNTB Corporation				
PROJECT:	Project 2 - I-70 Program - Warrenton to Wentzville				
BORING NO:	BR 54	SAMPLE DEPTH:	44.8'	PPI PROJECT NO:	
DESCRIPTION OF SAMPLE:	Limestone			DATE TESTED:	3/3/2025

**WATER CONTENT DETERMINATION**

Wet Weight of Specimen	493.6 g
Dry Weight of Specimen	491.3 g

**WATER CONTENT**

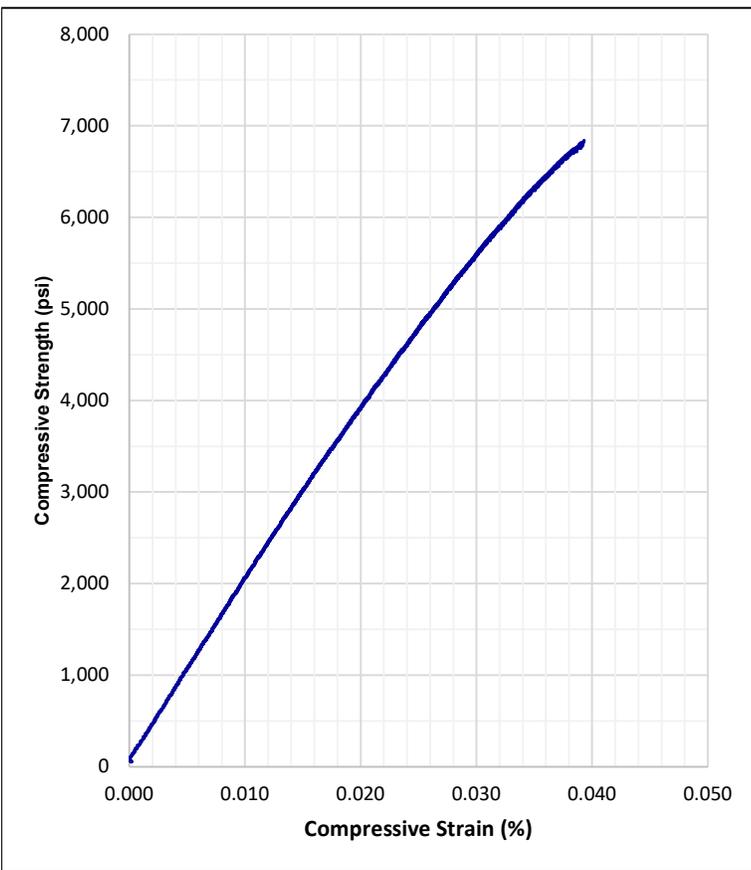
0.5 %
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**DIMENSIONS**

Initial Diameter	1.99 in.
Initial Area	3.11 in. <sup>2</sup>
Initial Height	4.13 in.
Initial Volume	12.85 in. <sup>3</sup>

**DENSITY**

Wet Unit Weight	146.4 lbs/ft <sup>3</sup>
Dry Unit Weight	145.7 lbs/ft <sup>3</sup>



**PRE-TEST PHOTOGRAPH**



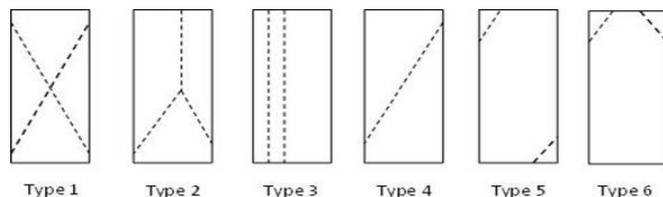
**FAILURE PHOTOGRAPH**



Load	21,266 lbs
Deformation	0.0016 in.
Strain	0.039 %

Break: Type 3

Compressive Strength (Qu):	6,837 psi
	492 tsf



**ASTM D7012-14: Compressive Strength Intact Rock Core Specimens**

CLIENT:	HNTB Corporation				
PROJECT:	Project 2 - I-70 Program - Warrenton to Wentzville				
BORING NO:	BR 55	SAMPLE DEPTH:	9.8'	PPI PROJECT NO:	
DESCRIPTION OF SAMPLE:	Limestone			DATE TESTED:	3/3/2025

**WATER CONTENT DETERMINATION**

Wet Weight of Specimen	561.3 g
Dry Weight of Specimen	559.5 g

**WATER CONTENT**

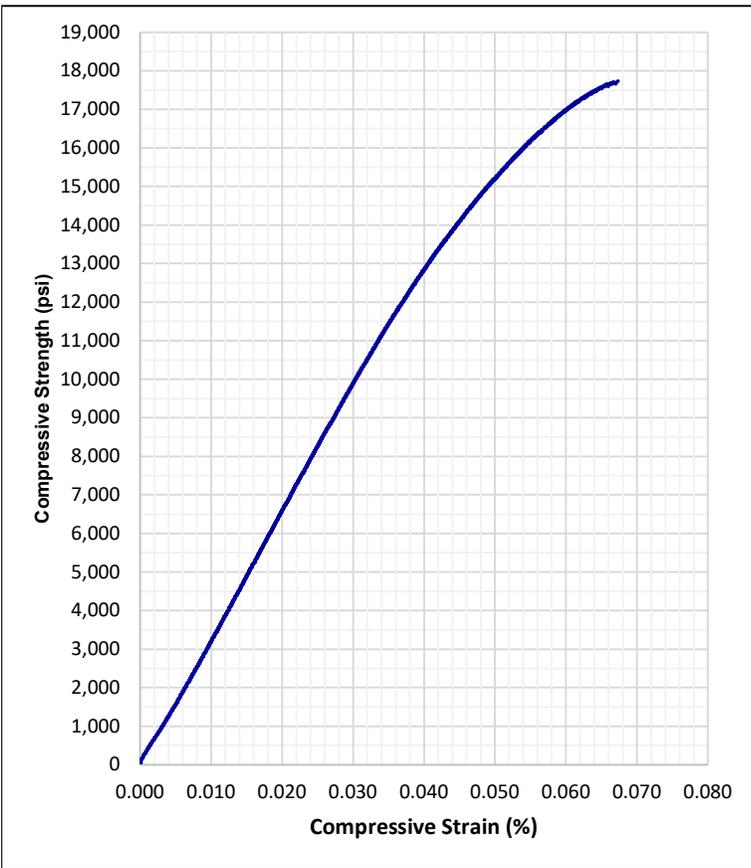
0.3 %
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**DIMENSIONS**

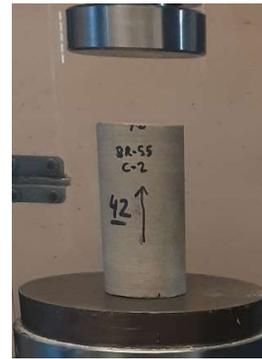
Initial Diameter	2.01 in.
Initial Area	3.17 in. <sup>2</sup>
Initial Height	4.15 in.
Initial Volume	13.17 in. <sup>3</sup>

**DENSITY**

Wet Unit Weight	162.4 lbs/ft <sup>3</sup>
Dry Unit Weight	161.9 lbs/ft <sup>3</sup>



**PRE-TEST PHOTOGRAPH**



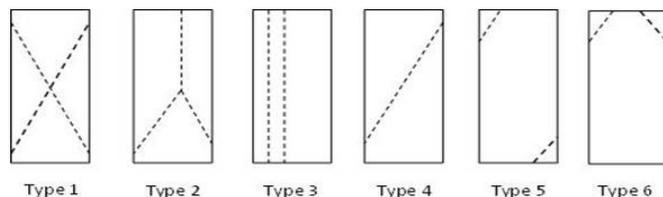
**FAILURE PHOTOGRAPH**



Load	56,274 lbs
Deformation	0.0028 in.
Strain	0.067 %

Break: Type 3

Compressive Strength (Qu):	17,735 psi
	1,277 tsf



**ASTM D7012-14: Compressive Strength Intact Rock Core Specimens**

CLIENT:	HNTB Corporation				
PROJECT:	Project 2 - I-70 Program - Warrenton to Wentzville				
BORING NO:	BR 55	SAMPLE DEPTH:	15.3'	PPI PROJECT NO:	
DESCRIPTION OF SAMPLE:	Limestone			DATE TESTED:	3/3/2025

**WATER CONTENT DETERMINATION**

Wet Weight of Specimen	562.5 g
Dry Weight of Specimen	561.7 g

**WATER CONTENT**

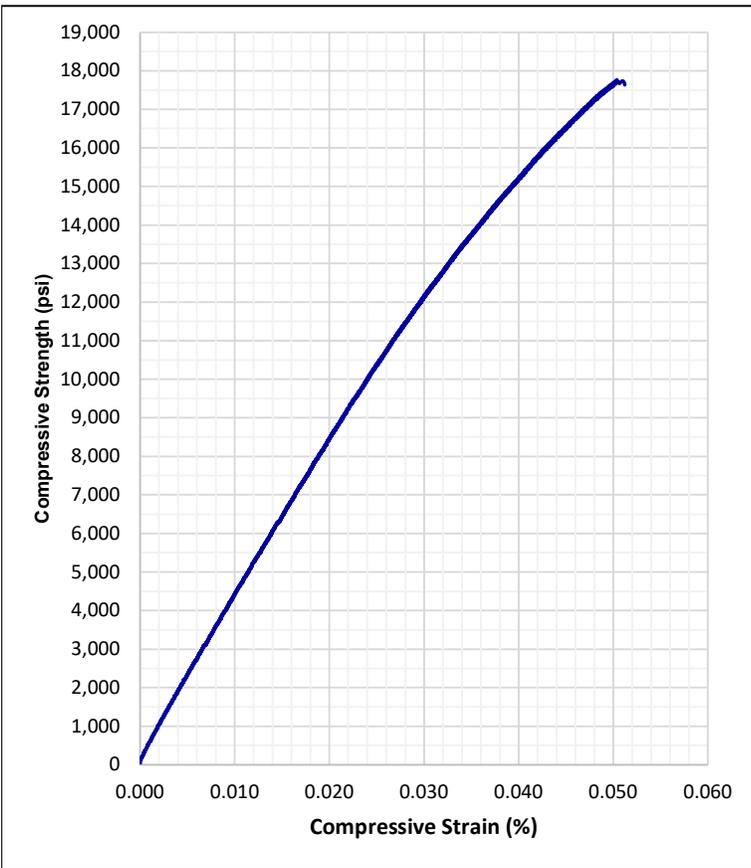
0.1 %
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**DIMENSIONS**

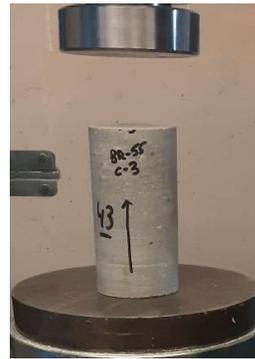
Initial Diameter	2 in.
Initial Area	3.14 in. <sup>2</sup>
Initial Height	4.10 in.
Initial Volume	12.88 in. <sup>3</sup>

**DENSITY**

Wet Unit Weight	166.4 lbs/ft <sup>3</sup>
Dry Unit Weight	166.1 lbs/ft <sup>3</sup>



**PRE-TEST PHOTOGRAPH**

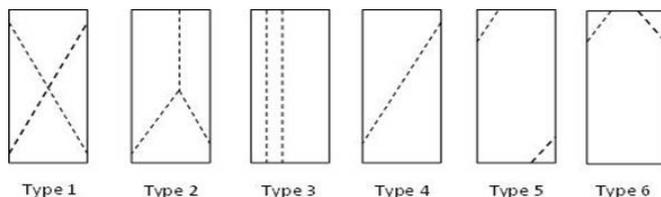


**FAILURE PHOTOGRAPH**



Load	55,391 lbs
Deformation	0.0021 in.
Strain	0.051 %

Break: Type 6



Compressive Strength (Qu):	17,632 psi
	1,269 tsf

**ASTM D7012-14: Compressive Strength Intact Rock Core Specimens**

CLIENT:	HNTB Corporation				
PROJECT:	Project 2 - I-70 Program - Warrenton to Wentzville				
BORING NO:	BR 55	SAMPLE DEPTH:	20.6'	PPI PROJECT NO:	
DESCRIPTION OF SAMPLE:	Limestone			DATE TESTED:	3/3/2025

**WATER CONTENT DETERMINATION**

Wet Weight of Specimen	558.9 g
Dry Weight of Specimen	558.2 g

**WATER CONTENT**

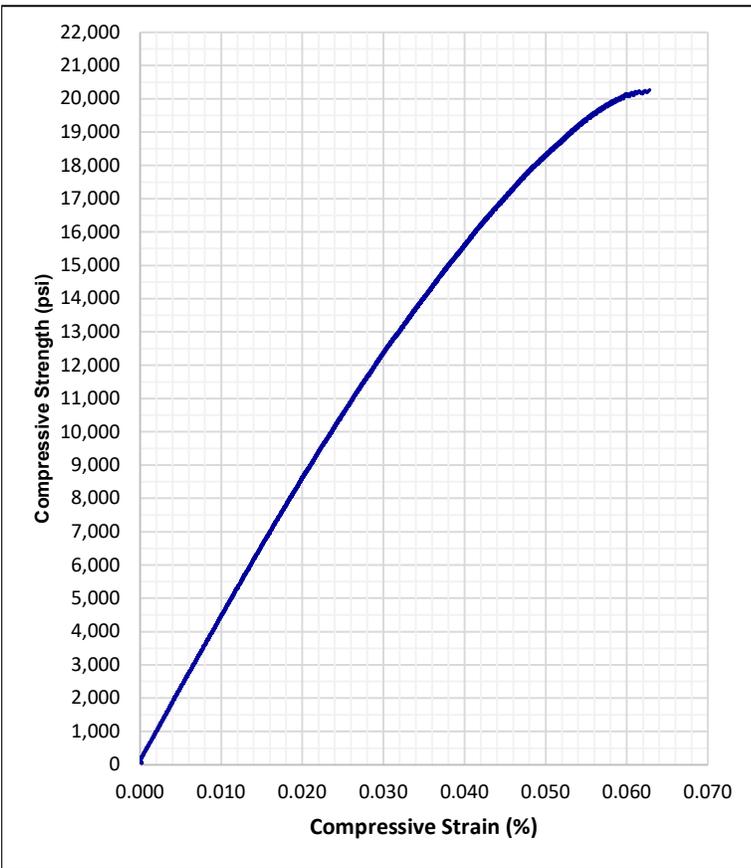
0.1 %
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**DIMENSIONS**

Initial Diameter	1.99 in.
Initial Area	3.11 in. <sup>2</sup>
Initial Height	4.11 in.
Initial Volume	12.78 in. <sup>3</sup>

**DENSITY**

Wet Unit Weight	166.6 lbs/ft <sup>3</sup>
Dry Unit Weight	166.3 lbs/ft <sup>3</sup>



**PRE-TEST PHOTOGRAPH**



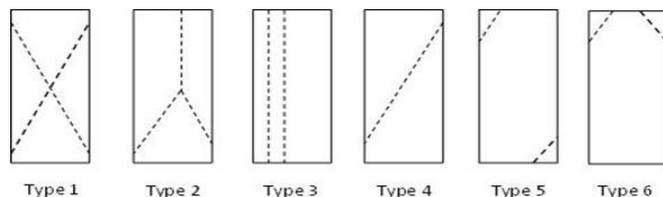
**FAILURE PHOTOGRAPH**



Load	63,035 lbs
Deformation	0.0026 in.
Strain	0.063 %

Break: Type 6

Compressive Strength (Qu):	20,267 psi
	1,459 tsf



**ASTM D7012-14: Compressive Strength Intact Rock Core Specimens**

CLIENT:	HNTB Corporation				
PROJECT:	Project 2 - I-70 Program - Warrenton to Wentzville				
BORING NO:	BR 55	SAMPLE DEPTH:	23.4'	PPI PROJECT NO:	
DESCRIPTION OF SAMPLE:	Limestone			DATE TESTED:	3/3/2025

**WATER CONTENT DETERMINATION**

Wet Weight of Specimen	564.9 g
Dry Weight of Specimen	564.1 g

**WATER CONTENT**

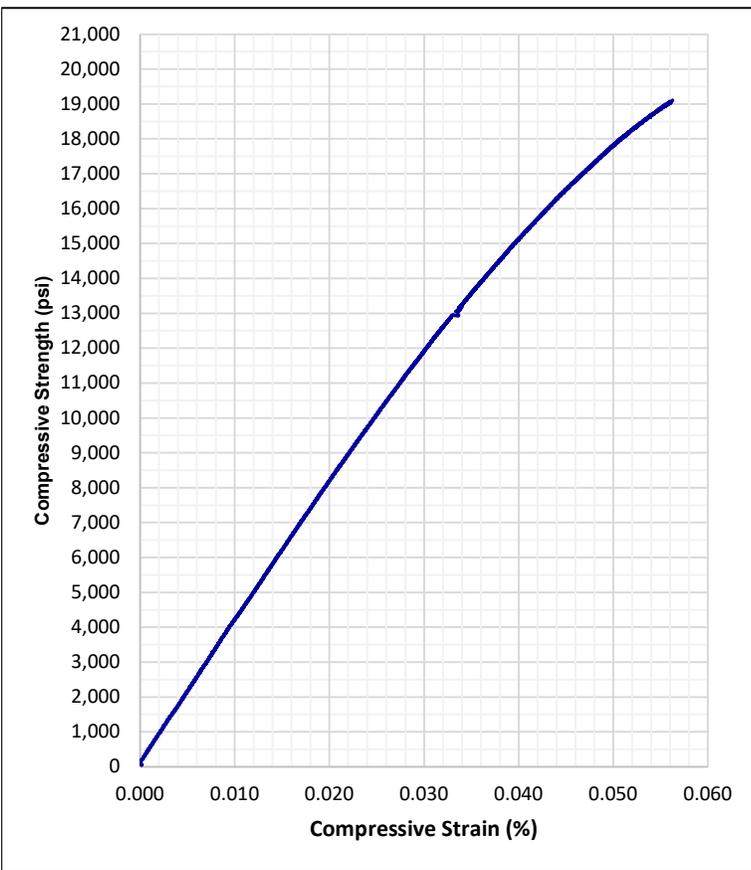
0.1 %
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**DIMENSIONS**

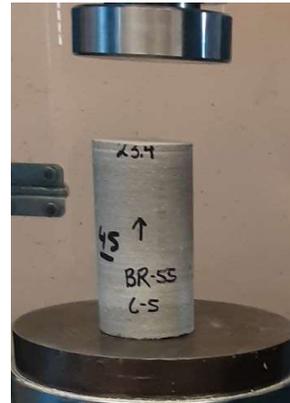
Initial Diameter	1.99 in.
Initial Area	3.11 in. <sup>2</sup>
Initial Height	4.11 in.
Initial Volume	12.78 in. <sup>3</sup>

**DENSITY**

Wet Unit Weight	168.3 lbs/ft <sup>3</sup>
Dry Unit Weight	168.1 lbs/ft <sup>3</sup>



**PRE-TEST PHOTOGRAPH**



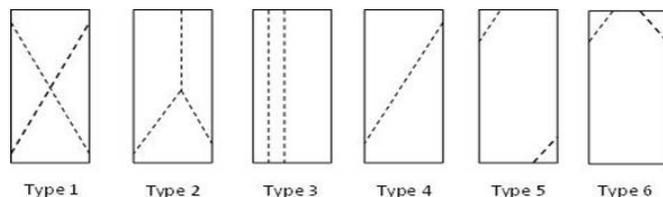
**FAILURE PHOTOGRAPH**



Load	59,436 lbs
Deformation	0.0023 in.
Strain	0.056 %

Break: Type 3

Compressive Strength (Qu):	19,110 psi
	1,376 tsf



**ASTM D7012-14: Compressive Strength Intact Rock Core Specimens**

CLIENT:	HNTB Corporation		
PROJECT:	Project 2 - I-70 Program - Warrenton to Wentzville		
BORING NO:	BR 55	SAMPLE DEPTH:	29.4'
DESCRIPTION OF SAMPLE:	Limestone	PPI PROJECT NO:	
		DATE TESTED:	3/3/2025

**WATER CONTENT DETERMINATION**

Wet Weight of Specimen	480.8 g
Dry Weight of Specimen	479.4 g

**WATER CONTENT**

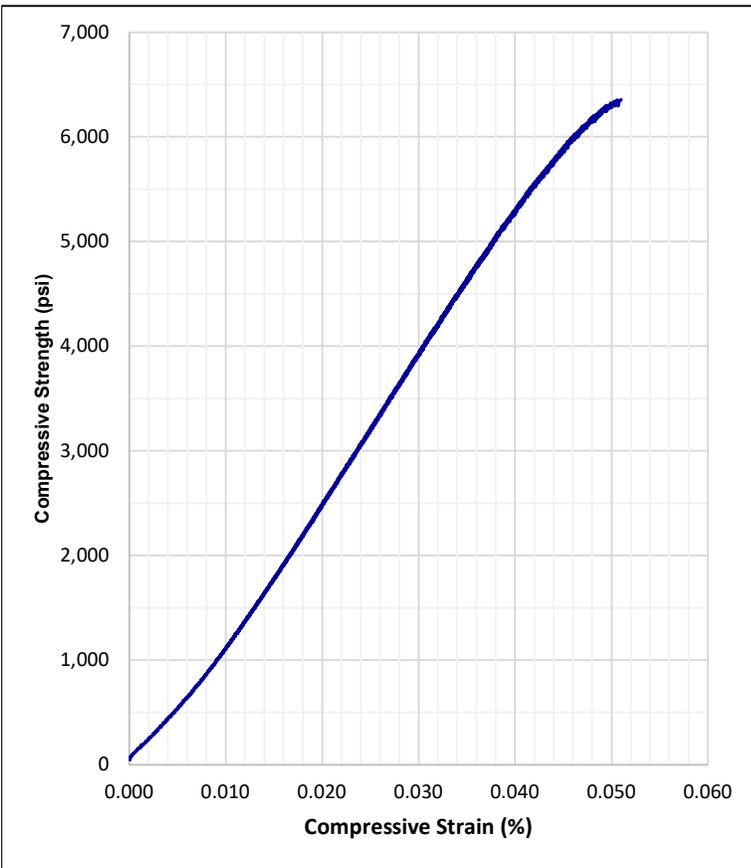
0.3 %
-------

**DIMENSIONS**

Initial Diameter	2.01 in.
Initial Area	3.17 in. <sup>2</sup>
Initial Height	4.14 in.
Initial Volume	13.14 in. <sup>3</sup>

**DENSITY**

Wet Unit Weight	139.4 lbs/ft <sup>3</sup>
Dry Unit Weight	139.0 lbs/ft <sup>3</sup>



**PRE-TEST PHOTOGRAPH**



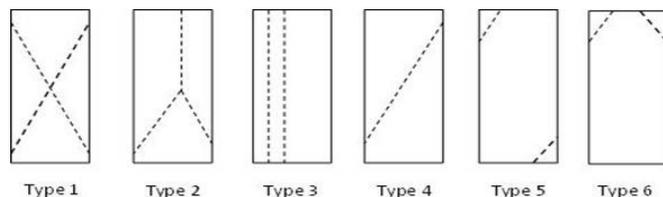
**FAILURE PHOTOGRAPH**



Load	20,163 lbs
Deformation	0.0021 in.
Strain	0.051 %

Break: Type 6

Compressive Strength (Qu):	6,354 psi
	458 tsf



**ASTM D7012-14: Compressive Strength Intact Rock Core Specimens**

CLIENT:	HNTB Corporation				
PROJECT:	Project 2 - I-70 Program - Warrenton to Wentzville				
BORING NO:	BR 55	SAMPLE DEPTH:	35.8'	PPI PROJECT NO:	
DESCRIPTION OF SAMPLE:	Limestone			DATE TESTED:	3/3/2025

**WATER CONTENT DETERMINATION**

Wet Weight of Specimen	515.6 g
Dry Weight of Specimen	513.1 g

**WATER CONTENT**

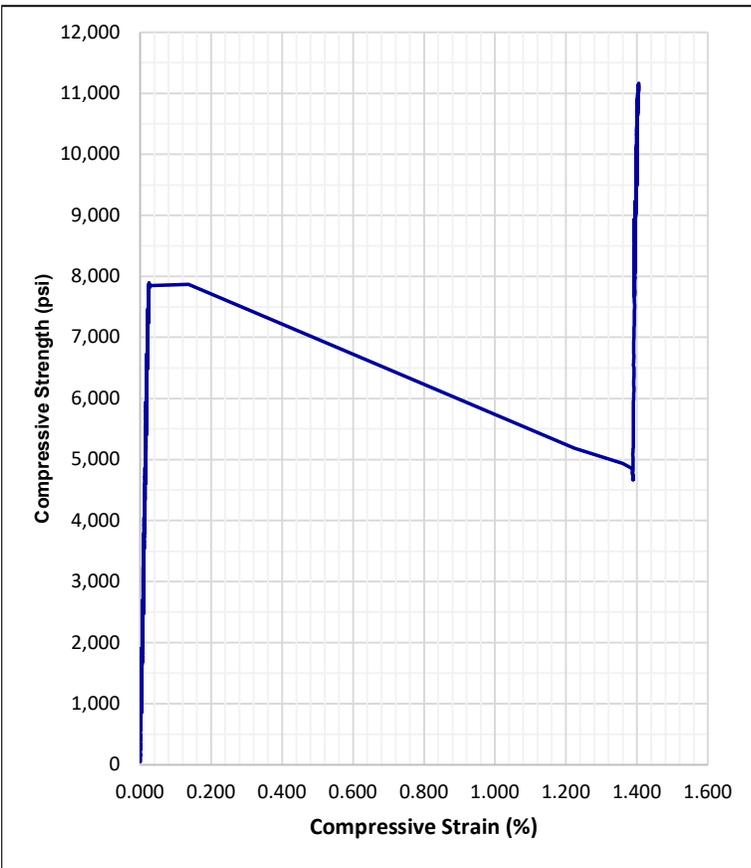
0.5 %
-------

**DIMENSIONS**

Initial Diameter	2.0 in.
Initial Area	3.14 in. <sup>2</sup>
Initial Height	4.13 in.
Initial Volume	12.97 in. <sup>3</sup>

**DENSITY**

Wet Unit Weight	151.4 lbs/ft <sup>3</sup>
Dry Unit Weight	150.7 lbs/ft <sup>3</sup>



**PRE-TEST PHOTOGRAPH**



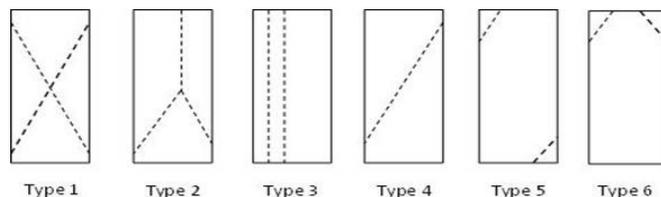
**FAILURE PHOTOGRAPH**



Load	35,083 lbs
Deformation	0.0580 in.
Strain	1.404 %

Break: Type 6

Compressive Strength (Qu):	11,167 psi
	804 tsf



**ASTM D7012-14: Compressive Strength Intact Rock Core Specimens**

CLIENT:	HNTB Corporation				
PROJECT:	Project 2 - I-70 Program - Warrenton to Wentzville				
BORING NO:	BR 55	SAMPLE DEPTH:	38.0'	PPI PROJECT NO:	
DESCRIPTION OF SAMPLE:	Limestone			DATE TESTED:	3/3/2025

**WATER CONTENT DETERMINATION**

Wet Weight of Specimen	520.4 g
Dry Weight of Specimen	519.1 g

**WATER CONTENT**

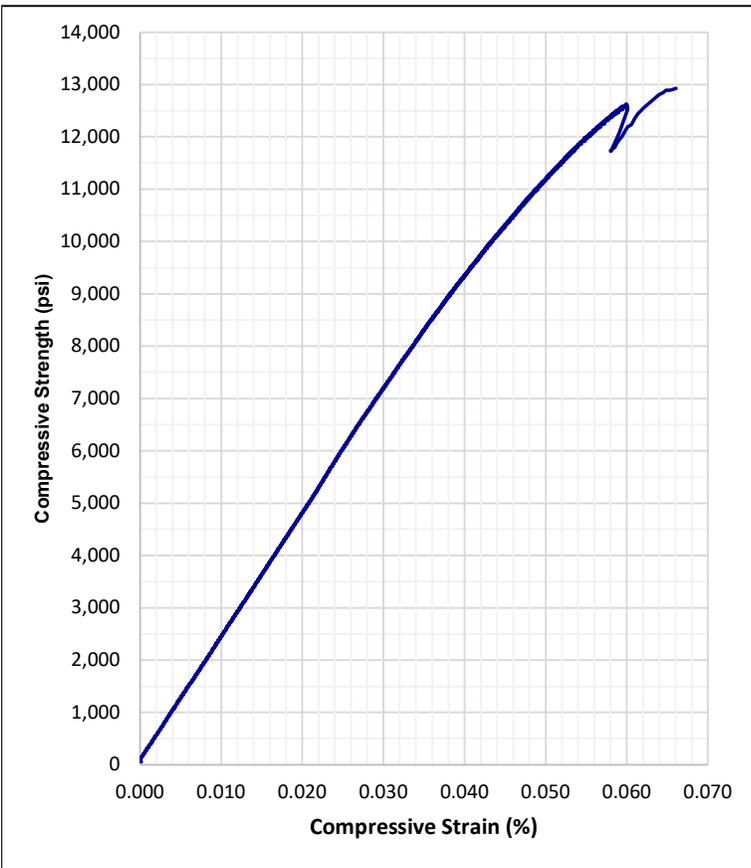
0.3 %
-------

**DIMENSIONS**

Initial Diameter	1.99 in.
Initial Area	3.11 in. <sup>2</sup>
Initial Height	4.08 in.
Initial Volume	12.69 in. <sup>3</sup>

**DENSITY**

Wet Unit Weight	156.2 lbs/ft <sup>3</sup>
Dry Unit Weight	155.8 lbs/ft <sup>3</sup>



**PRE-TEST PHOTOGRAPH**



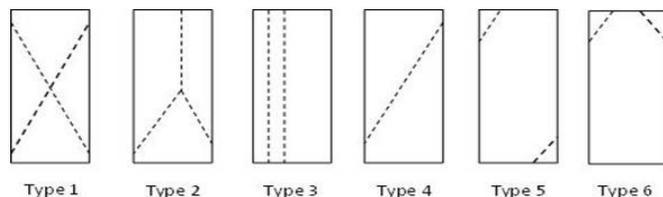
**FAILURE PHOTOGRAPH**



Load	40,202 lbs
Deformation	0.0027 in.
Strain	0.066 %

Break: Type 6

Compressive Strength (Qu):	12,926 psi
	931 tsf



**ASTM D7012-14: Compressive Strength Intact Rock Core Specimens**

CLIENT:	HNTB Corporation				
PROJECT:	Project 2 - I-70 Program - Warrenton to Wentzville				
BORING NO:	BR 57	SAMPLE DEPTH:	4.2'	PPI PROJECT NO:	
DESCRIPTION OF SAMPLE:	Limestone			DATE TESTED:	3/3/2025

**WATER CONTENT DETERMINATION**

Wet Weight of Specimen	519.7 g
Dry Weight of Specimen	518.1 g

**WATER CONTENT**

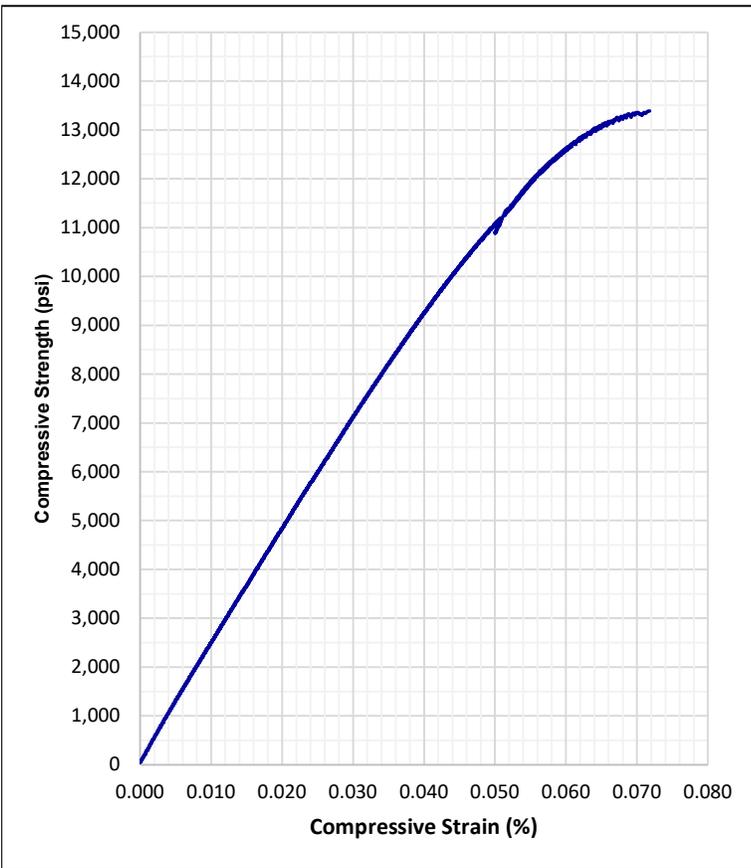
0.3 %
-------

**DIMENSIONS**

Initial Diameter	1.98 in.
Initial Area	3.08 in. <sup>2</sup>
Initial Height	3.98 in.
Initial Volume	12.25 in. <sup>3</sup>

**DENSITY**

Wet Unit Weight	161.6 lbs/ft <sup>3</sup>
Dry Unit Weight	161.1 lbs/ft <sup>3</sup>



**PRE-TEST PHOTOGRAPH**



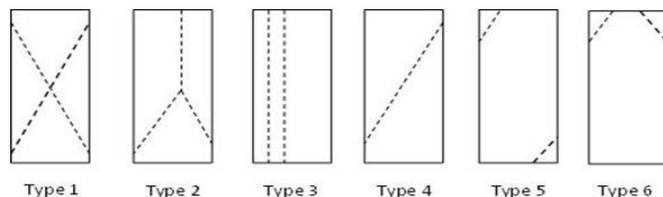
**FAILURE PHOTOGRAPH**



Load	41,229 lbs
Deformation	0.0029 in.
Strain	0.072 %

Break: Type 3

Compressive Strength (Qu):	13,390 psi
	964 tsf



**ASTM D7012-14: Compressive Strength Intact Rock Core Specimens**

CLIENT:	HNTB Corporation				
PROJECT:	Project 2 - I-70 Program - Warrenton to Wentzville				
BORING NO:	BR 57	SAMPLE DEPTH:	8.8'	PPI PROJECT NO:	
DESCRIPTION OF SAMPLE:	Limestone			DATE TESTED:	3/3/2025

**WATER CONTENT DETERMINATION**

Wet Weight of Specimen	558.7 g
Dry Weight of Specimen	557.8 g

**WATER CONTENT**

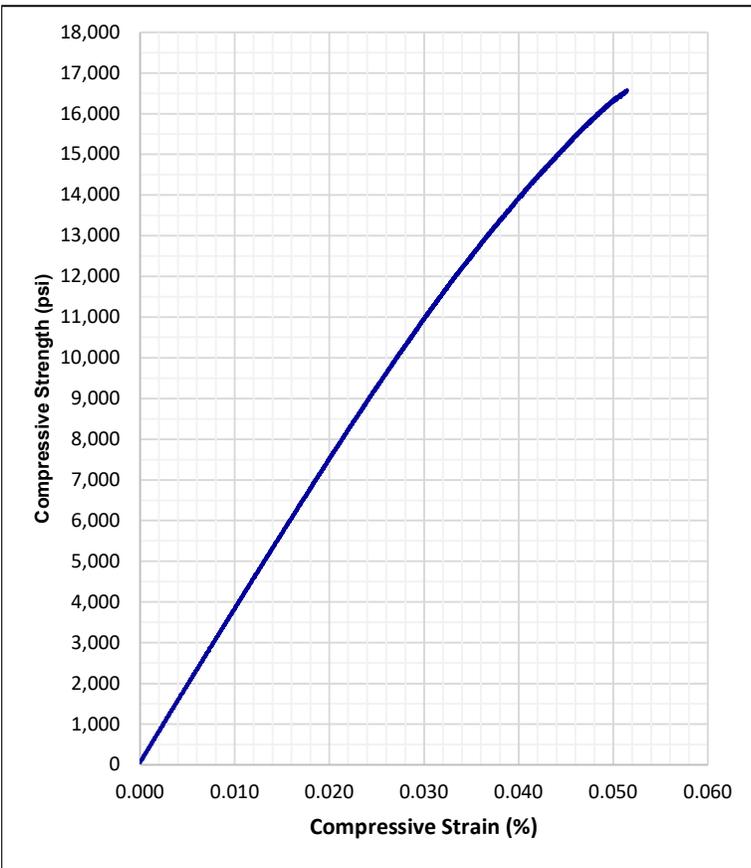
0.2 %
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**DIMENSIONS**

Initial Diameter	2 in.
Initial Area	3.14 in. <sup>2</sup>
Initial Height	4.11 in.
Initial Volume	12.91 in. <sup>3</sup>

**DENSITY**

Wet Unit Weight	164.8 lbs/ft <sup>3</sup>
Dry Unit Weight	164.6 lbs/ft <sup>3</sup>



**PRE-TEST PHOTOGRAPH**

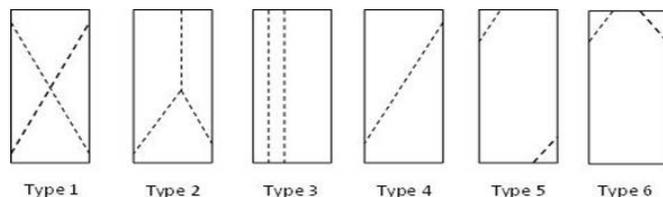


**FAILURE PHOTOGRAPH**



Load	51,911 lbs
Deformation	0.0021 in.
Strain	0.051 %

Break: Type 3



Compressive Strength (Qu):	16,524 psi
	1,190 tsf

### ASTM D7012-14: Compressive Strength Intact Rock Core Specimens

CLIENT:	HNTB Corporation				
PROJECT:	Project 2 - I-70 Program - Warrenton to Wentzville				
BORING NO:	BR 57	SAMPLE DEPTH:	16.2'	PPI PROJECT NO:	
DESCRIPTION OF SAMPLE:	Limestone			DATE TESTED:	3/3/2025

#### WATER CONTENT DETERMINATION

Wet Weight of Specimen	531.1 g
Dry Weight of Specimen	529.0 g

#### WATER CONTENT

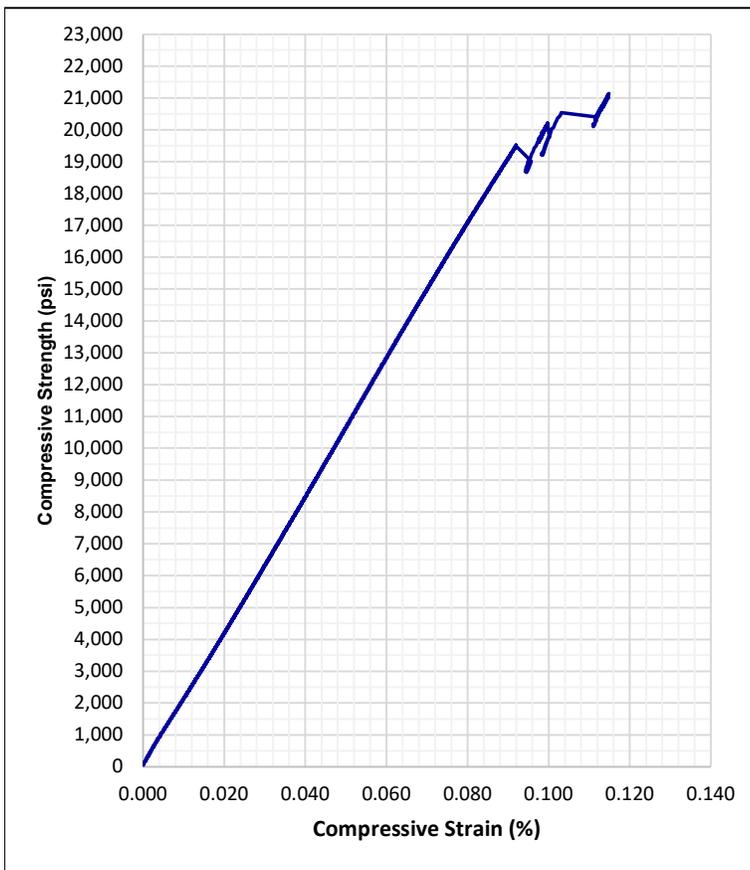
0.4 %
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#### DIMENSIONS

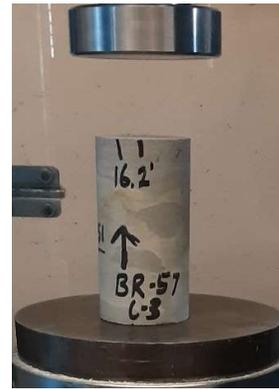
Initial Diameter	1.99 in.
Initial Area	3.11 in. <sup>2</sup>
Initial Height	4.09 in.
Initial Volume	12.72 in. <sup>3</sup>

#### DENSITY

Wet Unit Weight	159.0 lbs/ft <sup>3</sup>
Dry Unit Weight	158.4 lbs/ft <sup>3</sup>



#### PRE-TEST PHOTOGRAPH

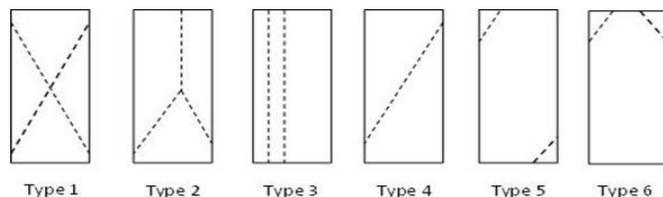


#### FAILURE PHOTOGRAPH



Load	65,756 lbs
Deformation	0.0047 in.
Strain	0.115 %

Break: Type 3



Compressive Strength (Qu):	21,142 psi
	1,522 tsf

**ASTM D7012-14: Compressive Strength Intact Rock Core Specimens**

CLIENT:	HNTB Corporation				
PROJECT:	Project 2 - I-70 Program - Warrenton to Wentzville				
BORING NO:	BR 57	SAMPLE DEPTH:	18.9'	PPI PROJECT NO:	
DESCRIPTION OF SAMPLE:	Limestone			DATE TESTED:	3/3/2025

**WATER CONTENT DETERMINATION**

Wet Weight of Specimen	552.0 g
Dry Weight of Specimen	550.6 g

**WATER CONTENT**

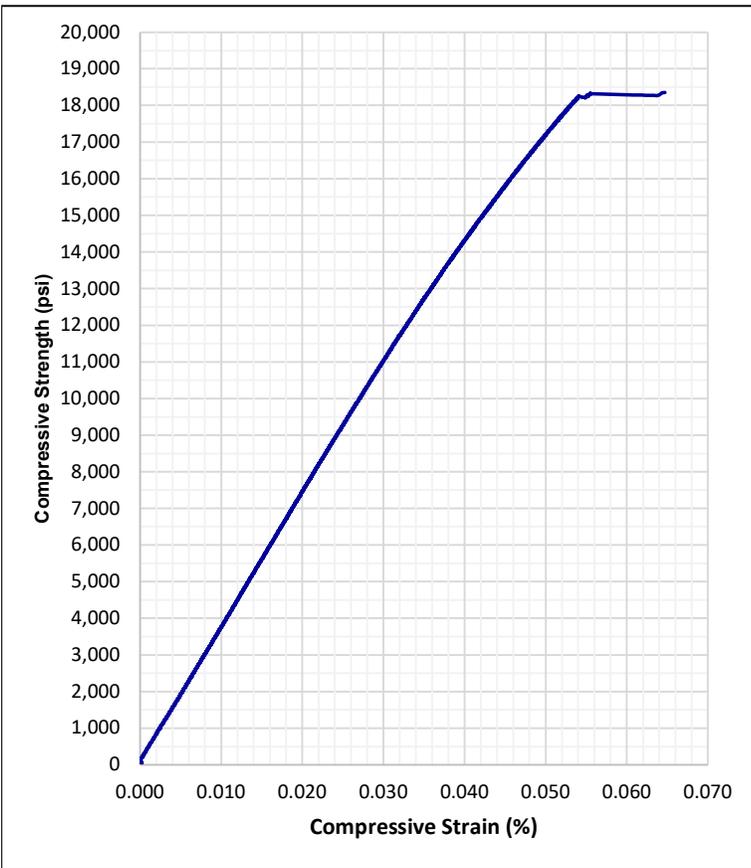
0.3 %
-------

**DIMENSIONS**

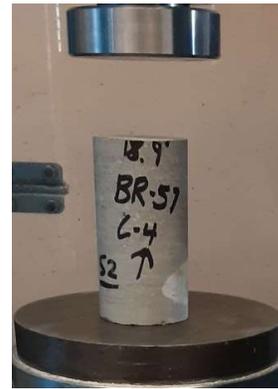
Initial Diameter	1.99 in.
Initial Area	3.11 in. <sup>2</sup>
Initial Height	4.10 in.
Initial Volume	12.75 in. <sup>3</sup>

**DENSITY**

Wet Unit Weight	164.9 lbs/ft <sup>3</sup>
Dry Unit Weight	164.5 lbs/ft <sup>3</sup>



**PRE-TEST PHOTOGRAPH**



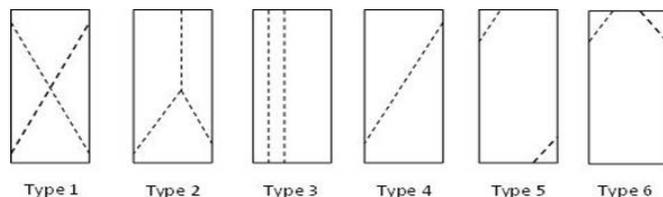
**FAILURE PHOTOGRAPH**



Load	57,088 lbs
Deformation	0.0027 in.
Strain	0.065 %

Break: Type 3

Compressive Strength (Qu):	18,355 psi
	1,322 tsf



### ASTM D7012-14: Compressive Strength Intact Rock Core Specimens

CLIENT:	HNTB Corporation				
PROJECT:	Project 2 - I-70 Program - Warrenton to Wentzville				
BORING NO:	BR 57	SAMPLE DEPTH:	23.7'	PPI PROJECT NO:	
DESCRIPTION OF SAMPLE:	Limestone			DATE TESTED:	3/3/2025

#### WATER CONTENT DETERMINATION

Wet Weight of Specimen	543.7 g
Dry Weight of Specimen	542.2 g

#### WATER CONTENT

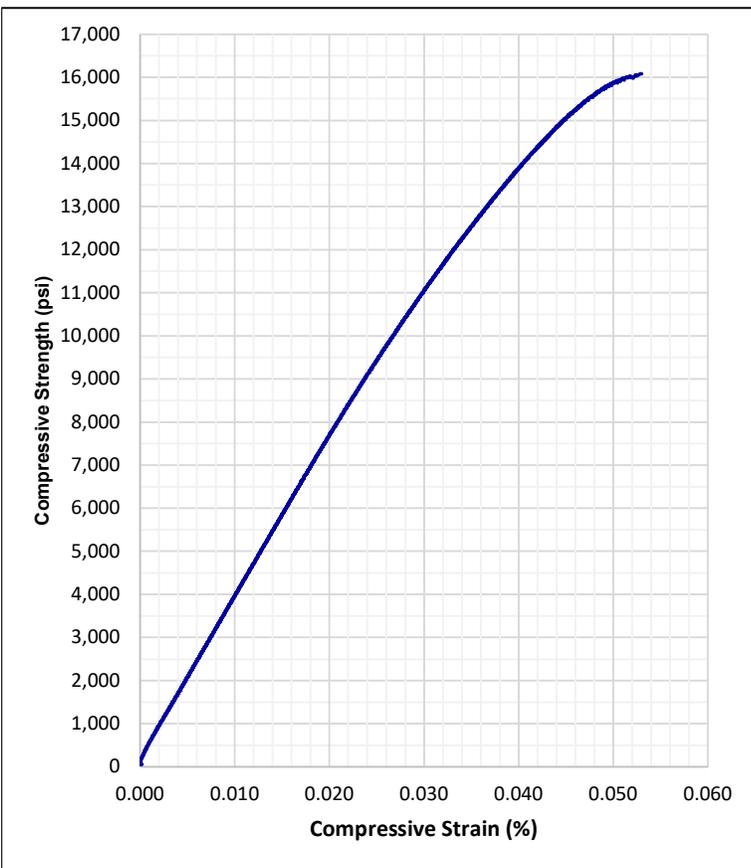
0.3 %
-------

#### DIMENSIONS

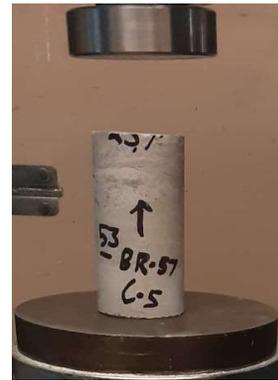
Initial Diameter	1.98 in.
Initial Area	3.08 in. <sup>2</sup>
Initial Height	4.12 in.
Initial Volume	12.69 in. <sup>3</sup>

#### DENSITY

Wet Unit Weight	163.3 lbs/ft <sup>3</sup>
Dry Unit Weight	162.8 lbs/ft <sup>3</sup>



#### PRE-TEST PHOTOGRAPH

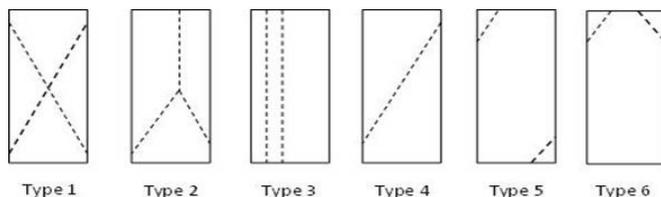


#### FAILURE PHOTOGRAPH



Load	49,525 lbs
Deformation	0.0022 in.
Strain	0.053 %

Break: Type 3



Compressive Strength (Qu):	16,084 psi
	1,158 tsf

### ASTM D7012-14: Compressive Strength Intact Rock Core Specimens

CLIENT:	HNTB Corporation				
PROJECT:	Project 2 - I-70 Program - Warrenton to Wentzville				
BORING NO:	BR 57	SAMPLE DEPTH:	28.0'	PPI PROJECT NO:	
DESCRIPTION OF SAMPLE:	Limestone			DATE TESTED:	3/3/2025

#### WATER CONTENT DETERMINATION

Wet Weight of Specimen	524.2 g
Dry Weight of Specimen	523.0 g

#### WATER CONTENT

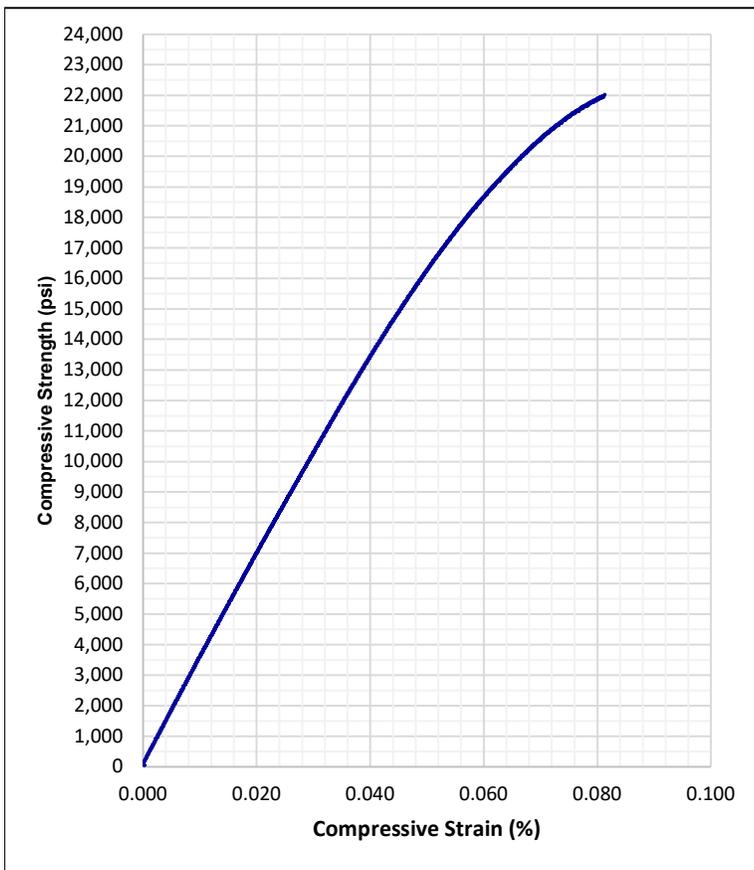
0.2 %
-------

#### DIMENSIONS

Initial Diameter	1.99 in.
Initial Area	3.11 in. <sup>2</sup>
Initial Height	4.11 in.
Initial Volume	12.78 in. <sup>3</sup>

#### DENSITY

Wet Unit Weight	156.2 lbs/ft <sup>3</sup>
Dry Unit Weight	155.9 lbs/ft <sup>3</sup>



#### PRE-TEST PHOTOGRAPH



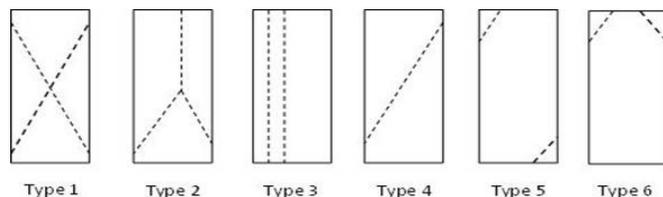
#### FAILURE PHOTOGRAPH



Load	68,492 lbs
Deformation	0.0033 in.
Strain	0.081 %

Break: Type 5

Compressive Strength (Qu):	22,021 psi
	1,586 tsf



**ASTM D7012-14: Compressive Strength Intact Rock Core Specimens**

CLIENT:	HNTB Corporation				
PROJECT:	Project 2 - I-70 Program - Warrenton to Wentzville				
BORING NO:	BR 58	SAMPLE DEPTH:	16.8'	PPI PROJECT NO:	
DESCRIPTION OF SAMPLE:	Limestone			DATE TESTED:	3/3/2025

**WATER CONTENT DETERMINATION**

Wet Weight of Specimen	542.6 g
Dry Weight of Specimen	541.1 g

**WATER CONTENT**

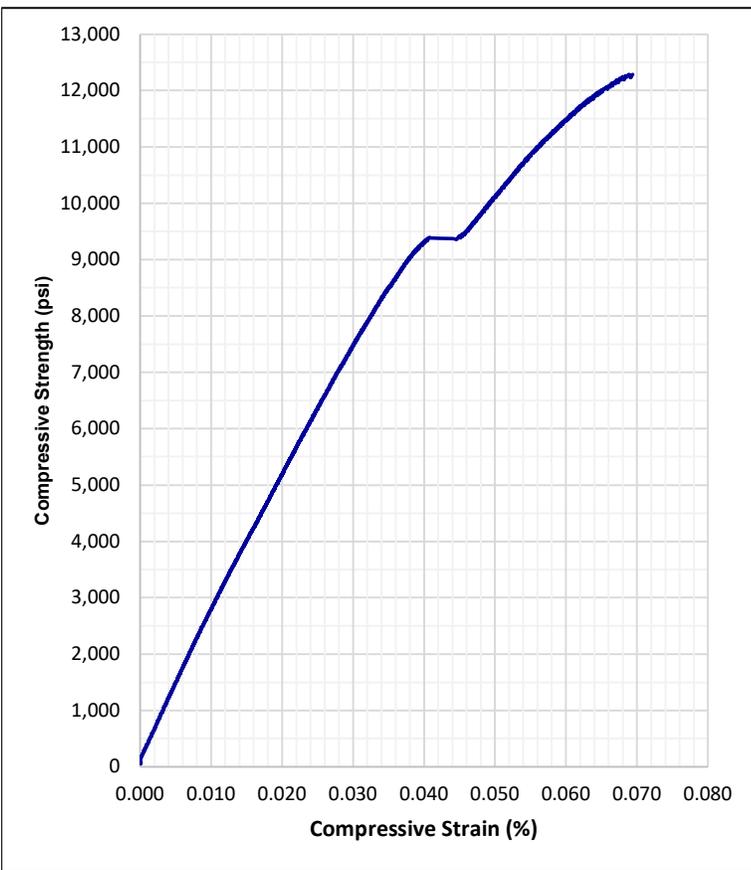
0.3 %
-------

**DIMENSIONS**

Initial Diameter	1.99 in.
Initial Area	3.11 in. <sup>2</sup>
Initial Height	4.15 in.
Initial Volume	12.91 in. <sup>3</sup>

**DENSITY**

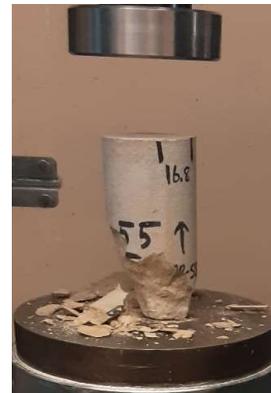
Wet Unit Weight	160.1 lbs/ft <sup>3</sup>
Dry Unit Weight	159.7 lbs/ft <sup>3</sup>



**PRE-TEST PHOTOGRAPH**



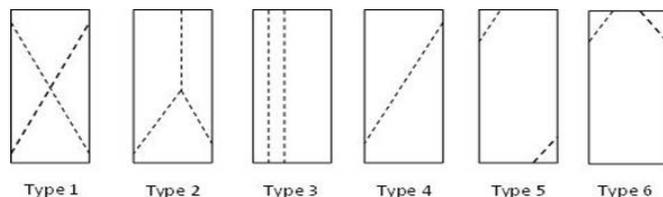
**FAILURE PHOTOGRAPH**



Load	38,229 lbs
Deformation	0.0029 in.
Strain	0.069 %

Break: Type 6

Compressive Strength (Qu):	12,291 psi
	885 tsf



**ASTM D7012-14: Compressive Strength Intact Rock Core Specimens**

CLIENT:	HNTB Corporation				
PROJECT:	Project 2 - I-70 Program - Warrenton to Wentzville				
BORING NO:	BR 58	SAMPLE DEPTH:	20.1'	PPI PROJECT NO:	
DESCRIPTION OF SAMPLE:	Limestone			DATE TESTED:	3/3/2025

**WATER CONTENT DETERMINATION**

Wet Weight of Specimen	552.7 g
Dry Weight of Specimen	551.3 g

**WATER CONTENT**

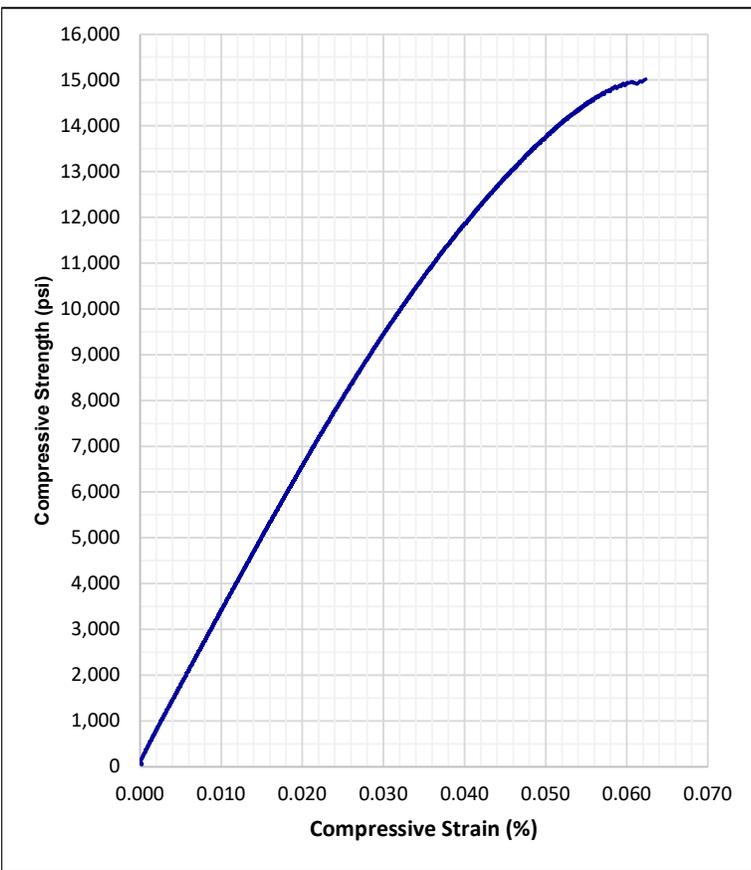
0.3 %
-------

**DIMENSIONS**

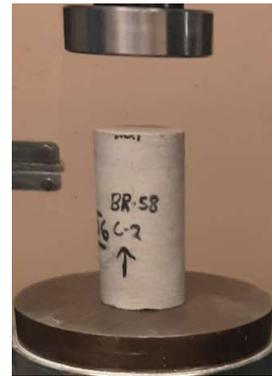
Initial Diameter	1.99 in.
Initial Area	3.11 in. <sup>2</sup>
Initial Height	4.12 in.
Initial Volume	12.81 in. <sup>3</sup>

**DENSITY**

Wet Unit Weight	164.3 lbs/ft <sup>3</sup>
Dry Unit Weight	163.9 lbs/ft <sup>3</sup>



**PRE-TEST PHOTOGRAPH**



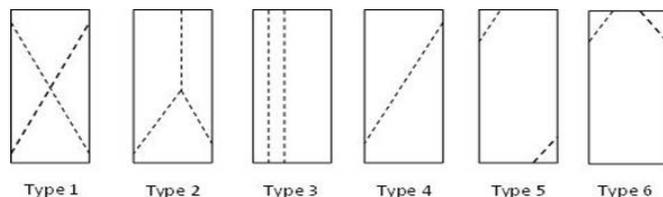
**FAILURE PHOTOGRAPH**



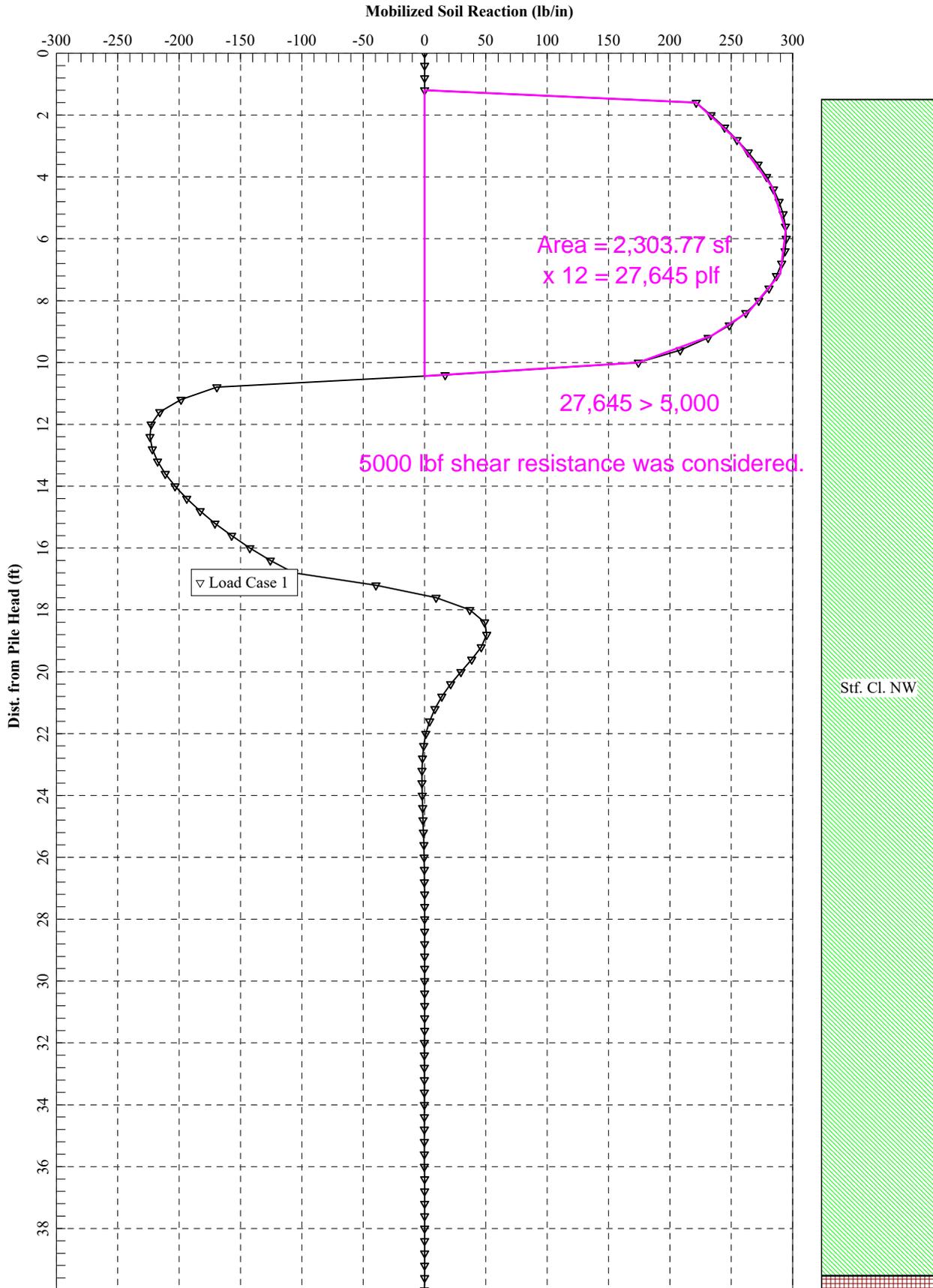
Load	46,706 lbs
Deformation	0.0026 in.
Strain	0.062 %

Break: Type 6

Compressive Strength (Qu):	15,017 psi
	1,081 tsf



# APPENDIX F



=====  
LPIle for Windows, Version 2022-12.009

Analysis of Individual Piles and Drilled Shafts  
Subjected to Lateral Loading Using the p-y Method  
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=====  
This copy of LPIle is being used by:

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Serial Number of Security Device: 239146357

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Use of this software by employees of HNTB  
other than those of the office site in LP Global Backup, Global Backup  
is a violation of the software license agreement.

-----  
Files Used for Analysis  
-----

Path to file locations:

\jobs\71886\_I-70\_DB\_Project\_2\Design\Geotech\Analysis\3\_Bridges\70&64\_DP5-7\_Ramp61S-70E--C9\LPFILE\

Name of input data file:

Shear for Global Resistance C-9 B1.lp12d

Name of output report file:

Shear for Global Resistance C-9 B1.lp12o

Name of plot output file:

Shear for Global Resistance C-9 B1.lp12p

Name of runtime message file:

Shear for Global Resistance C-9 B1.lp12r  
-----

Date and Time of Analysis

---

Date: December 5, 2025

Time: 15:13:07

---

Problem Title

---

Project Name: I-70 Improvement: Warrenton to Wentzville

Job Number: 71886

Client: I-70 Alliance

Engineer: Rob Jeronimus - HNTB

Description: C-9 B1 Shear force calculation from driven piles

---

Program Options and Settings

---

Computational Options:

- Conventional Analysis

Engineering Units Used for Data Input and Computations:

- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

- Maximum number of iterations allowed = 500
- Deflection tolerance for convergence = 1.0000E-05 in
- Maximum allowable deflection = 100.0000 in
- Number of pile increments = 100

Loading Type and Number of Cycles of Loading:

- Static loading specified
- Use of p-y modification factors for p-y curves not selected
- Analysis uses layering correction (Method of Georgiadis)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:

- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

-----  
 Pile Structural Properties and Geometry  
 -----

Number of pile sections defined = 1  
 Total length of pile = 40.000 ft  
 Depth of ground surface below top of pile = 1.5000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.0000
2	40.000	12.0000

Input Structural Properties for Pile Sections:  
 -----

Pile Section No. 1:

Section 1 is a H strong axis steel pile

Length of section = 40.000000 ft  
Pile width = 12.000000 in

---

Soil and Rock Layering Information

---

The soil profile is modelled using 2 layers

Layer 1 is stiff clay without free water

Distance from top of pile to top of layer = 1.500000 ft  
Distance from top of pile to bottom of layer = 39.530000 ft  
Effective unit weight at top of layer = 131.000000 pcf  
Effective unit weight at bottom of layer = 131.000000 pcf  
Undrained cohesion at top of layer = 1500. psf  
Undrained cohesion at bottom of layer = 1500. psf  
Epsilon-50 at top of layer = 0.007000  
Epsilon-50 at bottom of layer = 0.007000

Layer 2 is massive rock, p-y criteria by Liang et al., 2009

Distance from top of pile to top of layer = 39.530000 ft  
Distance from top of pile to bottom of layer = 45.000000 ft  
Effective unit weight at top of layer = 97.600000 pcf  
Effective unit weight at bottom of layer = 97.600000 pcf  
Uniaxial compressive strength at top of layer = 1500. psi  
Uniaxial compressive strength at bottom of layer = 1500. psi  
Poisson's ratio at top of layer = 0.230000  
Poisson's ratio at bottom of layer = 0.230000  
Option 1: Intact rock modulus at top of layer = 0.0000 psi  
Intact rock modulus at bottom of layer = 0.0000 psi  
Option 1: Geologic Strength Index for layer = 67.000000  
Option 2: Rock mass modulus at top of layer = 984320. psi  
Rock mass modulus at bottom of layer = 984320. psi  
Option 2 will use the input value of rock mass modulus to compute the p-y curve in massive rock.

The rock type is (sedimentary) crystalline limestones, Hoek-Brown Material  
Constant  $m_i = 12$

(Depth of the lowest soil layer extends 5.000 ft below the pile tip)

---

Summary of Input Soil Properties

Layer E50 Num. or krm	Soil Type Rock Mass Name Modulus (p-y Curve Type) psi	Geologic Strength Index	Layer Int. Depth ft	Effective Rock Unit Wt. Modulus psi	Hoek-Brown Material Index, mi	Cohesion psf	Poisson's Ratio	Uniaxial qu psi
1	Stiff Clay	--	1.5000	131.0000	--	1500.	--	--
0.00700	--	--	39.5300	131.0000	--	1500.	0.00	--
	w/o Free Water	--						
0.00700	--	--	39.5300	131.0000	--	1500.	0.00	--
2	Massive	67.0000	39.5300	97.6000	--	--	0.2300	1500.
--	984320.	67.0000	45.0000	97.6000	--	--	0.2300	1500.
--	Rock	67.0000	45.0000	97.6000	--	--	0.2300	1500.

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load Compute No. vs. Pile Length	Load Top y Type	Condition Run Analysis 1	Condition 2	Axial Thrust Force, lbs
1	1	V = -14800. lbs Yes	M = 0.0000 in-lbs	209000.

V = shear force applied normal to pile axis

M = bending moment applied to pile head

y = lateral deflection normal to pile axis

S = pile slope relative to original pile batter angle

R = rotational stiffness applied to pile head

Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).

Thrust force is assumed to be acting axially for all pile batter angles.

-----  
Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness  
-----

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:  
-----

Dimensions and Properties of Steel H Strong Axis:  
-----

Length of Section	=	40.000000 ft
Flange Width	=	12.000000 in
Section Depth	=	11.800000 in
Flange Thickness	=	0.435000 in
Web Thickness	=	0.435000 in
Yield Stress of Pipe	=	36.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	15.194550 sq. in.
Moment of Inertia	=	384.614130 in <sup>4</sup>
Elastic Bending Stiffness	=	11153810. kip-in <sup>2</sup>
Plastic Modulus, Z	=	72.317108in <sup>3</sup>
Plastic Moment Capacity = Fy Z	=	2603.in-kip

Axial Structural Capacities:  
-----

Nom. Axial Structural Capacity = Fy As	=	547.004 kips
Nominal Axial Tensile Capacity	=	-547.004 kips

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
-----	-----
1	209.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 209.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.00000341	37.9774686	11142283.	145.0581371	14.3322790	
0.00000682	75.9549371	11142283.	75.4790686	14.9096262	
0.00001023	113.9324057	11142283.	52.2860457	15.4869736	
0.00001363	151.9098742	11142283.	40.6895343	16.0643206	
0.00001704	189.8873428	11142283.	33.7316274	16.6416676	
0.00002045	227.8648113	11142283.	29.0930229	17.2190149	
0.00002386	265.8422799	11142283.	25.7797339	17.7963620	
0.00002727	303.8197484	11142283.	23.2947671	18.3737093	
0.00003068	341.7972170	11142283.	21.3620152	18.9510565	
0.00003408	379.7746855	11142283.	19.8158137	19.5284037	
0.00003749	417.7521541	11142283.	18.5507397	20.1057508	
0.00004090	455.7296226	11142283.	17.4965114	20.6830980	
0.00004431	493.7070912	11142283.	16.6044721	21.2604452	
0.00004772	531.6845597	11142283.	15.8398669	21.8377924	
0.00005113	569.6620283	11142283.	15.1772091	22.4151395	
0.00005453	607.6394968	11142283.	14.5973836	22.9924867	
0.00005794	645.6169654	11142283.	14.0857728	23.5698340	
0.00006135	683.5944339	11142283.	13.6310076	24.1471811	
0.00006476	721.5719025	11142283.	13.2241125	24.7245283	
0.00006817	759.5493710	11142283.	12.8579069	25.3018755	
0.00007158	797.5268396	11142283.	12.5265780	25.8792227	
0.00007499	835.5043082	11142283.	12.2253699	26.4565698	
0.00007839	873.4817767	11142283.	11.9503538	27.0339171	
0.00008180	911.4592453	11142283.	11.6982557	27.6112642	
0.00008521	949.4367138	11142283.	11.4663255	28.1886114	
0.00008862	987.4141824	11142283.	11.2522360	28.7659586	
0.00009203	1025.	11142283.	11.0540051	29.3433058	
0.00009544	1063.	11142283.	10.8699335	29.9206529	
0.00009884	1101.	11142283.	10.6985565	30.4980002	
0.0001023	1139.	11142283.	10.5386046	31.0753473	
0.0001057	1177.	11142283.	10.3889722	31.6526945	
0.0001091	1215.	11142283.	10.2486918	32.2300417	
0.0001125	1253.	11142283.	10.1169132	32.8073888	
0.0001159	1291.	11142283.	9.9928864	33.3847360	
0.0001193	1329.	11142283.	9.8759468	33.9620832	
0.0001227	1367.	11142283.	9.7655038	34.5394304	
0.0001261	1405.	11142283.	9.6610307	35.1167776	
0.0001295	1443.	11142283.	9.5620562	35.6941248	
0.0001329	1479.	11123656.	9.4753945	36.0000000	Y
0.0001397	1522.	10890693.	9.3936751	36.0000000	Y
0.0001466	1546.	10545154.	9.3740910	36.0000000	Y
0.0001534	1567.	10216198.	9.3623697	36.0000000	Y

0.0001602	1586.	9903514.	9.3569601	36.0000000	Y
0.0001670	1604.	9606303.	9.3567520	36.0000000	Y
0.0001738	1621.	9323925.	9.3607471	36.0000000	Y
0.0001806	1636.	9055643.	9.3681494	36.0000000	Y
0.0001875	1650.	8800720.	9.3782980	36.0000000	Y
0.0001943	1663.	8558285.	9.3907264	36.0000000	Y
0.0002011	1675.	8327566.	9.4050235	36.0000000	Y
0.0002079	1686.	8107873.	9.4208240	36.0000000	Y
0.0002147	1696.	7898587.	9.4378003	36.0000000	Y
0.0002215	1706.	7699148.	9.4556568	36.0000000	Y
0.0002284	1715.	7508749.	9.4743243	36.0000000	Y
0.0002352	1723.	7326998.	9.4935253	36.0000000	Y
0.0002420	1731.	7153271.	9.5131842	36.0000000	Y
0.0002488	1739.	6987269.	9.5330489	36.0000000	Y
0.0002556	1745.	6828185.	9.5532786	36.0000000	Y
0.0002624	1752.	6675897.	9.5735688	36.0000000	Y
0.0002693	1758.	6529971.	9.5938784	36.0000000	Y
0.0002761	1764.	6390014.	9.6141692	36.0000000	Y
0.0002829	1770.	6255670.	9.6344059	36.0000000	Y
0.0002897	1775.	6126606.	9.6545604	36.0000000	Y
0.0002965	1780.	6002533.	9.6745958	36.0000000	Y
0.0003033	1785.	5883191.	9.6944725	36.0000000	Y
0.0003102	1789.	5768307.	9.7141831	36.0000000	Y
0.0003170	1793.	5657660.	9.7336933	36.0000000	Y
0.0003238	1797.	5551037.	9.7529783	36.0000000	Y
0.0003306	1801.	5448241.	9.7720143	36.0000000	Y
0.0003374	1805.	5349091.	9.7907783	36.0000000	Y
0.0003442	1808.	5253415.	9.8092483	36.0000000	Y
0.0003511	1812.	5160913.	9.8275520	36.0000000	Y
0.0003579	1815.	5071512.	9.8455992	36.0000000	Y
0.0003647	1818.	4985132.	9.8633130	36.0000000	Y
0.0003715	1821.	4901581.	9.8807410	36.0000000	Y
0.0003783	1824.	4820611.	9.8980153	36.0000000	Y
0.0003852	1826.	4742293.	9.9149184	36.0000000	Y
0.0003920	1829.	4666397.	9.9315769	36.0000000	Y
0.0003988	1832.	4592790.	9.9480213	36.0000000	Y
0.0004056	1834.	4521533.	9.9640575	36.0000000	Y
0.0004329	1843.	4256542.	10.0260776	36.0000000	Y
0.0004601	1850.	4020378.	10.0840433	36.0000000	Y
0.0004874	1856.	3808575.	10.1383272	36.0000000	Y
0.0005147	1862.	3617611.	10.1891714	36.0000000	Y
0.0005419	1867.	3444665.	10.2367208	36.0000000	Y
0.0005692	1871.	3287258.	10.2813638	36.0000000	Y

-----  
Summary of Results for Nominal Moment Capacity for Section 1  
-----

Nominal

Load No.	Axial Thrust kips	Moment Capacity in-kips
1	209.0000000000	1871.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

-----  
Layering Correction Equivalent Depths of Soil & Rock Layers  
-----

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	1.5000	0.00	N.A.	No	0.00	467445.
2	39.5300	38.0300	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

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

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = -14800.0 lbs

Applied moment at pile head = 0.0 in-lbs  
 Axial thrust load on pile head = 209000.0 lbs

Depth	Deflect.	Bending	Shear	Slope	Total	Bending	Soil
Res. Soil	Spr. Distrib.	Moment	Force	S	Stress	Stiffness	p
X	y	Lat. Load					
Es*H	Lat. Load						
feet	inches	in-lbs	lbs	radians	psi*	lb-in^2	
lb/inch	lb/inch	lb/inch					
0.00	-0.506	-8.59E-07	-14800.	0.00674	13755.	1.11E+10	
0.00	0.00	0.00					
0.4000	-0.474	-77800.	-14800.	0.00672	14969.	1.11E+10	
0.00	0.00	0.00					
0.8000	-0.442	-155567.	-14800.	0.00667	16182.	1.11E+10	
0.00	0.00	0.00					
1.2000	-0.410	-233266.	-14800.	0.00659	17394.	1.11E+10	
0.00	0.00	0.00					
1.6000	-0.378	-310865.	-14268.	0.00647	18604.	1.11E+10	
221.4721	2810.	0.00					
2.0000	-0.348	-383226.	-13177.	0.00632	19733.	1.11E+10	
233.4829	3225.	0.00					
2.4000	-0.318	-450043.	-12029.	0.00614	20776.	1.11E+10	
244.5652	3696.	0.00					
2.8000	-0.289	-511030.	-10831.	0.00593	21727.	1.11E+10	
254.6747	4236.	0.00					
3.2000	-0.261	-565928.	-9587.	0.00570	22583.	1.11E+10	
263.7662	4858.	0.00					
3.6000	-0.234	-614505.	-8301.	0.00545	23341.	1.11E+10	
271.7932	5580.	0.00					
4.0000	-0.208	-656554.	-6980.	0.00517	23997.	1.11E+10	
278.7072	6422.	0.00					
4.4000	-0.184	-691898.	-5629.	0.00488	24549.	1.11E+10	
284.4575	7415.	0.00					
4.8000	-0.161	-720389.	-4252.	0.00458	24993.	1.11E+10	
288.9902	8594.	0.00					
5.2000	-0.140	-741911.	-2857.	0.00427	25329.	1.11E+10	
292.2472	10008.	0.00					
5.6000	-0.120	-756378.	-1450.	0.00394	25554.	1.11E+10	
294.1647	11721.	0.00					
6.0000	-0.102	-763741.	-36.846	0.00361	25669.	1.11E+10	
294.6717	13823.	0.00					
6.4000	-0.08576	-763985.	1375.	0.00329	25673.	1.11E+10	
293.6861	16437.	0.00					
6.8000	-0.07078	-757132.	2779.	0.00296	25566.	1.11E+10	
291.1109	19742.	0.00					
7.2000	-0.05736	-743244.	4166.	0.00263	25350.	1.11E+10	
286.8265	24000.	0.00					
7.6000	-0.04549	-722427.	5528.	0.00232	25025.	1.11E+10	

280.6787	29620.	0.00				
8.0000	-0.03510	-694831.	6855.	0.00201	24594.	1.11E+10
272.4568	37259.	0.00				
8.4000	-0.02615	-660657.	8138.	0.00172	24061.	1.11E+10
261.8530	48064.	0.00				
8.8000	-0.01857	-620165.	9362.	0.00145	23430.	1.11E+10
248.3762	64208.	0.00				
9.2000	-0.01227	-573682.	10513.	0.00119	22704.	1.11E+10
231.1476	90444.	0.00				
9.6000	-0.00715	-521625.	11568.	9.53E-04	21892.	1.11E+10
208.2983	139775.	0.00				
10.0000	-0.00312	-464544.	12486.	7.41E-04	21002.	1.11E+10
174.3740	268476.	0.00				
10.4000	-4.26E-05	-403244.	12945.	5.54E-04	20046.	1.11E+10
16.7685	1890878.	0.00				
10.8000	0.00220	-341384.	12579.	3.93E-04	19081.	1.11E+10
-169.178	369349.	0.00				
11.2000	0.00373	-283274.	11697.	2.59E-04	18174.	1.11E+10
-198.495	255170.	0.00				
11.6000	0.00468	-229615.	10703.	1.48E-04	17337.	1.11E+10
-215.740	221111.	0.00				
12.0000	0.00516	-180827.	9650.	6.00E-05	16576.	1.11E+10
-222.693	207232.	0.00				
12.4000	0.00526	-137092.	8579.	-8.53E-06	15894.	1.11E+10
-223.775	204247.	0.00				
12.8000	0.00508	-98454.	7509.	-5.93E-05	15291.	1.11E+10
-221.807	209737.	0.00				
13.2000	0.00469	-64884.	6455.	-9.44E-05	14767.	1.11E+10
-217.464	222565.	0.00				
13.6000	0.00417	-36296.	5426.	-1.16E-04	14321.	1.11E+10
-211.164	243093.	0.00				
14.0000	0.00357	-12557.	4432.	-1.27E-04	13951.	1.11E+10
-203.186	272879.	0.00				
14.4000	0.00295	6506.	3479.	-1.28E-04	13856.	1.11E+10
-193.714	314914.	0.00				
14.8000	0.00234	21102.	2576.	-1.22E-04	14084.	1.11E+10
-182.867	374368.	0.00				
15.2000	0.00178	31477.	1727.	-1.11E-04	14246.	1.11E+10
-170.706	460255.	0.00				
15.6000	0.00128	37904.	939.9949	-9.58E-05	14346.	1.11E+10
-157.227	589130.	0.00				
16.0000	8.60E-04	40693.	221.0552	-7.89E-05	14390.	1.11E+10
-142.331	794278.	0.00				
16.4000	5.23E-04	40185.	-422.259	-6.15E-05	14382.	1.11E+10
-125.717	1152941.	0.00				
16.8000	2.70E-04	36763.	-979.655	-4.49E-05	14328.	1.11E+10
-106.532	1895716.	0.00				
17.2000	9.21E-05	30870.	-1331.	-3.04E-05	14237.	1.11E+10
-39.692	2068476.	0.00				
17.6000	-2.17E-05	24050.	-1403.	-1.85E-05	14130.	1.11E+10

9.3479	2068476.	0.00					
18.0000	-8.58E-05	17434.	-1292.	-9.59E-06	14027.	1.11E+10	
36.9578	2068476.	0.00					
18.4000	-1.14E-04	11663.	-1086.	-3.33E-06	13937.	1.11E+10	
49.0321	2068476.	0.00					
18.8000	-1.18E-04	7016.	-846.520	6.98E-07	13864.	1.11E+10	
50.7137	2068476.	0.00					
19.2000	-1.07E-04	3535.	-614.064	2.97E-06	13810.	1.11E+10	
46.1430	2068476.	0.00					
19.6000	-8.92E-05	1115.	-411.107	3.97E-06	13772.	1.11E+10	
38.4223	2068476.	0.00					
20.0000	-6.89E-05	-419.492	-247.595	4.12E-06	13761.	1.11E+10	
29.7077	2068476.	0.00					
20.4000	-4.96E-05	-1270.	-125.016	3.76E-06	13775.	1.11E+10	
21.3668	2068476.	0.00					
20.8000	-3.29E-05	-1627.	-39.758	3.13E-06	13780.	1.11E+10	
14.1574	2068476.	0.00					
21.2000	-1.95E-05	-1658.	14.3749	2.43E-06	13781.	1.11E+10	
8.3980	2068476.	0.00					
21.6000	-9.55E-06	-1494.	44.4080	1.75E-06	13778.	1.11E+10	
4.1158	2068476.	0.00					
22.0000	-2.70E-06	-1235.	57.0815	1.16E-06	13774.	1.11E+10	
1.1649	2068476.	0.00					
22.4000	1.59E-06	-948.408	58.2316	6.90E-07	13770.	1.11E+10	
-0.686	2068476.	0.00					
22.8000	3.92E-06	-677.283	52.5275	3.40E-07	13765.	1.11E+10	
-1.691	2068476.	0.00					
23.2000	4.86E-06	-444.827	43.4460	9.85E-08	13762.	1.11E+10	
-2.093	2068476.	0.00					
23.6000	4.87E-06	-260.399	33.3868	-5.34E-08	13759.	1.11E+10	
-2.098	2068476.	0.00					
24.0000	4.34E-06	-124.206	23.8581	-1.36E-07	13757.	1.11E+10	
-1.872	2068476.	0.00					
24.4000	3.56E-06	-31.088	15.6824	-1.70E-07	13755.	1.11E+10	
-1.535	2068476.	0.00					
24.8000	2.71E-06	26.6856	9.1918	-1.71E-07	13755.	1.11E+10	
-1.170	2068476.	0.00					
25.2000	1.92E-06	57.4962	4.3957	-1.53E-07	13756.	1.11E+10	
-0.829	2068476.	0.00					
25.6000	1.25E-06	69.1906	1.1141	-1.25E-07	13756.	1.11E+10	
-0.539	2068476.	0.00					
26.0000	7.20E-07	68.4433	-0.924	-9.56E-08	13756.	1.11E+10	
-0.310	2068476.	0.00					
26.4000	3.32E-07	60.5134	-2.013	-6.78E-08	13756.	1.11E+10	
-0.143	2068476.	0.00					
26.8000	6.93E-08	49.2579	-2.428	-4.42E-08	13756.	1.11E+10	
-0.02986	2068476.	0.00					
27.2000	-9.18E-08	37.2930	-2.405	-2.55E-08	13756.	1.11E+10	
0.03958	2068476.	0.00					
27.6000	-1.76E-07	26.2240	-2.128	-1.19E-08	13755.	1.11E+10	

0.07579	2068476.	0.00					
28.0000	-2.06E-07	16.8899	-1.733	-2.57E-09	13755.	1.11E+10	
0.08864	2068476.	0.00					
28.4000	-2.01E-07	9.5907	-1.313	3.13E-09	13755.	1.11E+10	
0.08643	2068476.	0.00					
28.8000	-1.76E-07	4.2789	-0.924	6.12E-09	13755.	1.11E+10	
0.07568	2068476.	0.00					
29.2000	-1.42E-07	0.7089	-0.596	7.19E-09	13755.	1.11E+10	
0.06112	2068476.	0.00					
29.6000	-1.07E-07	-1.453	-0.339	7.03E-09	13755.	1.11E+10	
0.04593	2068476.	0.00					
30.0000	-7.43E-08	-2.556	-0.152	6.17E-09	13755.	1.11E+10	
0.03203	2068476.	0.00					
30.4000	-4.73E-08	-2.921	-0.02575	4.99E-09	13755.	1.11E+10	
0.02040	2068476.	0.00					
30.8000	-2.64E-08	-2.814	0.05054	3.75E-09	13755.	1.11E+10	
0.01138	2068476.	0.00					
31.2000	-1.13E-08	-2.443	0.08955	2.62E-09	13755.	1.11E+10	
0.00487	2068476.	0.00					
31.6000	-1.24E-09	-1.959	0.1025	1.67E-09	13755.	1.11E+10	
5.34E-04	2068476.	0.00					
32.0000	4.77E-09	-1.462	0.09887	9.37E-10	13755.	1.11E+10	
-0.00206	2068476.	0.00					
32.4000	7.76E-09	-1.012	0.08591	4.04E-10	13755.	1.11E+10	
-0.00334	2068476.	0.00					
32.8000	8.65E-09	-0.638	0.06894	4.90E-11	13755.	1.11E+10	
-0.00373	2068476.	0.00					
33.2000	8.23E-09	-0.350	0.05148	-1.64E-10	13755.	1.11E+10	
-0.00355	2068476.	0.00					
33.6000	7.08E-09	-0.144	0.03565	-2.70E-10	13755.	1.11E+10	
-0.00305	2068476.	0.00					
34.0000	5.63E-09	-0.00743	0.02250	-3.03E-10	13755.	1.11E+10	
-0.00243	2068476.	0.00					
34.4000	4.17E-09	0.07292	0.01236	-2.89E-10	13755.	1.11E+10	
-0.00180	2068476.	0.00					
34.8000	2.86E-09	0.1118	0.00509	-2.49E-10	13755.	1.11E+10	
-0.00123	2068476.	0.00					
35.2000	1.78E-09	0.1223	2.89E-04	-1.99E-10	13755.	1.11E+10	
-7.68E-04	2068476.	0.00					
35.6000	9.54E-10	0.1150	-0.00254	-1.47E-10	13755.	1.11E+10	
-4.11E-04	2068476.	0.00					
36.0000	3.66E-10	0.09819	-0.00391	-1.02E-10	13755.	1.11E+10	
-1.58E-04	2068476.	0.00					
36.4000	-2.02E-11	0.07771	-0.00426	-6.36E-11	13755.	1.11E+10	
8.71E-06	2068476.	0.00					
36.8000	-2.45E-10	0.05740	-0.00399	-3.45E-11	13755.	1.11E+10	
1.06E-04	2068476.	0.00					
37.2000	-3.52E-10	0.03950	-0.00337	-1.37E-11	13755.	1.11E+10	
1.52E-04	2068476.	0.00					
37.6000	-3.76E-10	0.02507	-0.00262	0.00	13755.	1.11E+10	

1.62E-04	2068476.	0.00					
38.0000	-3.49E-10	0.01437	-0.00187	8.74E-12	13755.	1.11E+10	
1.51E-04	2068476.	0.00					
38.4000	-2.93E-10	0.00713	-0.00120	1.34E-11	13755.	1.11E+10	
1.26E-04	2068476.	0.00					
38.8000	-2.21E-10	0.00280	-6.72E-04	1.55E-11	13755.	1.11E+10	
9.52E-05	2068476.	0.00					
39.2000	-1.44E-10	6.52E-04	-2.95E-04	1.63E-11	13755.	1.11E+10	
6.19E-05	2068476.	0.00					
39.6000	-6.50E-11	-6.55E-05	-6.45E-05	1.64E-11	13755.	1.11E+10	
3.40E-05	2511552.	0.00					
40.0000	1.36E-11	0.00	0.00	1.64E-11	13755.	1.11E+10	
-7.12E-06	1255776.	0.00					

\* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

#### Output Summary for Load Case No. 1:

Pile-head deflection = -0.5060337 inches  
 Computed slope at pile head = 0.00673865 radians  
 Maximum bending moment = -763985. inch-lbs  
 Maximum shear force = -14800. lbs  
 Depth of maximum bending moment = 6.40000000 feet below pile head  
 Depth of maximum shear force = 1.20000000 feet below pile head  
 Number of iterations = 27  
 Number of zero deflection points = 7  
 Pile deflection at ground = -0.3861051 inches

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#### Summary of Pile-head Responses for Conventional Analyses

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#### Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs  
 Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians  
 Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.  
 Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs  
 Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load	Load	Load	Axial	Pile-head	Pile-head	Max
Shear	Max	Moment				

Case No.	Type	Pile-head in-lbs	Type	Pile-head Load	Loading lbs	Deflection inches	Rotation radians	in lbs
1	V	-14800.	M	in-lb	0.00	209000.	-0.506	0.00674
		-763985.						

Maximum pile-head deflection = -0.5060336952 inches  
Maximum pile-head rotation = 0.0067386493 radians = 0.386096 deg.

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Summary of Warning Messages  
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The following warning was reported 56 times

WARNING: The ratio of rock mass modulus to uniaxial compressive strength  
for massive rock appears to be outside the usual range of values.

The analysis ended normally.