DocuSign Envelope ID: 68E798FF-7224-412C-AACA-1EDD7462C864

FOUNDATION RECOMMENDATIONS

DUAL BRIDGES ON US 17 OVER GUM SWAMP CREEK BETWEEN SR 1421 AND SR 1420

REVISION 1

TIP NO. R-2511

BEAUFORT COUNTY, NORTH CAROLINA

DOCUMENT NOT CONSIDERED FINAL
UNLESS ALL SIGNATURES COMPLETED

May 3, 2021

DocuSign Envelope ID: 68E798FF-7224-412C-AACA-1EDD7462C864

FOUNDATION RECOMMENDATIONS

STATE NO.	35494.1.1	DESCRIPTION	BRIDGE ON US 17 OVER GUM SWAMP CREEK BETWEEN SR 1421 AND SR 1420
TIP NO.	R-2511		**LEFT LANE - REVISION 1**
COUNTY	BEAUFORT		
STATION	156+55.00 -L-		

	INITIALS	DATE
DESIGN	MS	4/5/21
CHECK	AA	4/14/21
APPROVE	GT	4/30/21

P.E. SEAL

NORTH CAROLINA PROFESSIONAL SEAL 018580 ENGINEER GARY R. TAYLOR

DocuSigned by:
Gary Taylor
6/8/2021
194B327A8527485...

SIGNATURE

	BENT STATION	FOUNDATION TYPE	FACTORED RESISTANCE	ADDITIONAL INFORMATION
END BENT 1	156+21.18 -L-	CAP ON HP 12 x 53 STEEL H-PILES	98 Tons/Pile	Bottom of Cap Elev. = 34.6 ft ± (LT) 33.2 ft ± (RT) Avg. Estimated Pile Length = 80 ft Number of Piles/Cap = 6
End BENT 2	156+80.76 -L-	CAP ON HP 12 x 53 STEEL H-PILES	98 Tons/Pile	Bottom of Cap Elev. = 34.8 ft ± (LT) 33.5 ft ± (RT) Avg. Estimated Pile Length = 80 ft Number of Piles/Cap = 6

(SEE NOTES ON PLANS AND COMMENTS ON FOLLOWING PAGES.)

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FOUNDATION RECOMMENDATIONS

BRIDGE ON US 17 OVER GUM SWAMP CREEK BETWEEN SR 1421 AND SR 1420 **LEFT LANE**

FOUNDATION RECOMMENDATION NOTES ON PLANS

1. FOR PILES, SEE SECTION 450 OF THE STANDARD SPECIFICATIONS.
2. PILES AT END BENTS NO. 1 AND NO. 2 ARE DESIGNED FOR A FACTORED RESISTANCE OF 98 TONS PER PILE.
3. DRIVE PILES AT END BENTS NO. 1 AND NO. 2 TO A REQUIRED DRIVING RESISTANCE OF 165 TONS PER PILE.
4. TESTING PILES WITH THE PDA DURING DRIVING, RESTRIKING OR REDRIVING MAY BE REQUIRED. THE ENGINEER WILL DETERMINE THE NEED FOR PDA TESTING. FOR PDA TESTING, SEE SECTION 450 OF THE STANDARD SPECIFICATIONS.
5. THE SCOUR CRITICAL ELEVATION FOR END BENTS NO. 1 AND NO. 2 IS ELEVATION 12 FT. SCOUR CRITICAL ELEVATIONS ARE USED TO MONITOR POSSIBLE SCOUR PROBLEMS DURING THE LIFE OF THE STRUCTURE.
6. OBSERVE A 6 MONTH WAITING PERIOD AFTER CONSTRUCTING THE EMBANKMENT TO WITHIN 2 FT OF FINISHED GRADE BEFORE BEGINNING END BENT CONSTRUCTION AT END BENTS NO. 1 AND NO. 2. FOR BRIDGE WAITING PERIODS, SEE ROADWAY PLANS AND SECTION 235 OF THE STANDARD SPECIFICATIONS.
7. SEE ROADWAY PLANS AND SECTION 235 OF THE STANDARD SPECIFICATIONS FOR THE SETTLEMENT GAUGES REQUIRED AT END BENTS NO. 1 AND NO. 2.

SPECIAL FOUNDATION RECOMMENDATION NOTES ON PLANS

1. INSTALL PZ27 OR EQUIVALENT SHEET PILE SECTION TO A TIP ELEVATION NO HIGHER THAN -10 FEET AT END BENTS NO. 1 AND NO. 2.

FOUNDATION RECOMMENDATIONS COMMENTS

1. PILE LENGTHS ARE BASED ON PLUMB PILES FROM BOTTOM OF CAP TO THE TIP ELEVATION PLUS 2 FEET EMBEDMENT, ROUNDED UP TO THE NEAREST FIVE FEET.
2. THE REQUIRED DRIVING RESISTANCE USES A RESISTANCE FACTOR OF 0.6
3. TYPE I - STANDARD BRIDGE APPROACH FILLS OR TYPE A - ALTERNATIVE APPROACH FILLS ARE REQUIRED FOR THE END BENTS IN ACCORDANCE WITH THE 2018 NCDOT STANDARD DRAWING 422.01 OR 422.03.
4. SCOUR CRITICAL ELEVATION IS 3 FEET BELOW DESIGN SCOUR ELEVATION.
5. THE DESIGN SCOUR ELEVATION AT END BENTS NO. 1 AND NO. 2 IS ELEVATION 15 FEET FOR DESIGN OF PZ27 SHEET PILING.
6. THE CORROSION PROTECTION OF SHEET PILES SHALL BE ADDRESSED BY THE STRUCTURE MANAGEMENT UNIT.

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PILE PAY ITEMS

(Revised 8/11/15)

WBS ELEMENT 35494.1.1 DATE 4/14/2021

TIP NO. R-2511 DESIGNED BY MS

COUNTY BEAUFORT CHECKED BY AA

STATION 156+55 -L-

DESCRIPTION BRIDGE ON US 17 OVER GUM SWAMP CREEK BETWEEN SR 1421 AND SR 1420 **LEFT LANE**

NUMBER OF BENTS WITH PILES ______
NUMBER OF PILES PER BENT ______
NUMBER OF END BENTS WITH PILES ______
NUMBER OF PILES PER END BENT ______

Only required for "Predrilling for Piles" & "Pile Excavation" pay items

Bent # or End Bent #	PILE PAY ITEM QUANTITIES						
	Steel Pile Points (yes/no)	**Pipe Pile Plates (yes/no/maybe)**	**Predrilling For Piles (per linear ft)**	**Pile Redrives (per each)**	**Pile Excavation (per linear ft)**		**PDA Testing (per each)**
					In Soil	**Not In Soil**	
END BENT NO. 1	No			3			
END BENT NO. 2	No			3			
TOTALS	0		0	6	0	0	1

<u>*Notes:*</u>
Blanks or "no" represent quantity of zero.

If steel pile points are required, calculate quantity of "Steel Pile Points" as equal to the number of steel piles.

If pipe pile plates are or may be required, calculate the quantity of "Pipe Pile Plates" as equal to the number of pipe piles.

Show quantity of "PDA Testing" on the plans as total only.

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FOUNDATION RECOMMENDATIONS

STATE NO.	35494.1.1	DESCRIPTION	BRIDGE ON US 17 OVER GUM
TIP NO.	R-2511		SWAMP CREEK BETWEEN SR 1421 AND SR 1420
COUNTY	BEAUFORT		**RIGHT LANE - REVISION 1**
STATION	156+55.00 -L-		

	INITIALS	DATE
DESIGN	MS	4/5/21
CHECK	AA	4/14/21
APPROVE	GT	4/30/21

P.E. SEAL

NORTH CAROLINA
PROFESSIONAL
SEAL
018580
ENGINEER
GARY R. TAYLOR

DocuSigned by:
Gary Taylor 6/8/2021
194B327A8527485...

SIGNATURE

	BENT STATION	FOUNDATION TYPE	FACTORED RESISTANCE	ADDITIONAL INFORMATION
END BENT 1	156+28.87 -L-	CAP ON HP 12 x 53 STEEL H-PILES	98 Tons/Pile	Bottom of Cap Elev. = 33.5 ft ± (LT) 32.2 ft ± (RT) Avg. Estimated Pile Length = 80 ft Number of Piles/Cap = 6
End BENT 2	156+89.29 -L-	CAP ON HP 12 x 53 STEEL H-PILES	98 Tons/Pile	Bottom of Cap Elev. = 33.7 ft ± (LT) 32.4 ft ± (RT) Avg. Estimated Pile Length = 80 ft Number of Piles/Cap = 6

(SEE NOTES ON PLANS AND COMMENTS ON FOLLOWING PAGES.)

DocuSign Envelope ID: 68E798FF-7224-412C-AACA-1EDD7462C864

FOUNDATION RECOMMENDATIONS

BRIDGE ON US 17 OVER GUM SWAMP CREEK BETWEEN SR 1421 AND SR 1420 **RIGHT LANE**

FOUNDATION RECOMMENDATION NOTES ON PLANS

1. FOR PILES, SEE SECTION 450 OF THE STANDARD SPECIFICATIONS.
2. PILES AT END BENTS NO. 1 AND NO. 2 ARE DESIGNED FOR A FACTORED RESISTANCE OF 98 TONS PER PILE.
3. DRIVE PILES AT END BENTS NO. 1 AND NO. 2 TO A REQUIRED DRIVING RESISTANCE OF 165 TONS PER PILE.
4. TESTING PILES WITH THE PDA DURING DRIVING, RESTRIKING OR REDRIVING MAY BE REQUIRED. THE ENGINEER WILL DETERMINE THE NEED FOR PDA TESTING. FOR PDA TESTING, SEE SECTION 450 OF THE STANDARD SPECIFICATIONS.
5. THE SCOUR CRITICAL ELEVATION FOR END BENTS NO. 1 AND NO. 2 IS ELEVATION 12 FT. SCOUR CRITICAL ELEVATIONS ARE USED TO MONITOR POSSIBLE SCOUR PROBLEMS DURING THE LIFE OF THE STRUCTURE.
6. OBSERVE A 4 MONTH WAITING PERIOD AFTER CONSTRUCTING THE EMBANKMENT TO WITHIN 2 FT OF FINISHED GRADE BEFORE BEGINNING END BENT CONSTRUCTION AT END BENTS NO. 1 AND NO. 2. FOR BRIDGE WAITING PERIODS, SEE ROADWAY PLANS AND SECTION 235 OF THE STANDARD SPECIFICATIONS.
7. SEE ROADWAY PLANS AND SECTION 235 OF THE STANDARD SPECIFICATIONS FOR THE SETTLEMENT GAUGES REQUIRED AT END BENTS NO. 1 AND NO. 2.

SPECIAL FOUNDATION RECOMMENDATION NOTES ON PLANS

1. INSTALL PZ27 OR EQUIVALENT SHEET PILE SECTION TO A TIP ELEVATION NO HIGHER THAN -10 FEET AT END BENTS NO. 1 AND NO. 2.

FOUNDATION RECOMMENDATIONS COMMENTS

1. PILE LENGTHS ARE BASED ON PLUMB PILES FROM BOTTOM OF CAP TO THE TIP ELEVATION PLUS 2 FEET EMBEDMENT, ROUNDED UP TO THE NEAREST FIVE FEET.
2. THE REQUIRED DRIVING RESISTANCE USES A RESISTANCE FACTOR OF 0.6
3. TYPE I - STANDARD BRIDGE APPROACH FILLS OR TYPE A - ALTERNATIVE APPROACH FILLS ARE REQUIRED FOR THE END BENTS IN ACCORDANCE WITH THE 2018 NCDOT STANDARD DRAWING 422.01 OR 422.03.
4. SCOUR CRITICAL ELEVATION IS 3 FEET BELOW DESIGN SCOUR ELEVATION.
5. THE DESIGN SCOUR ELEVATION AT END BENTS NO. 1 AND NO. 2 IS ELEVATION 15 FEET FOR DESIGN OF PZ27 SHEET PILING.
6. THE CORROSION PROTECTION OF SHEET PILES SHALL BE ADDRESSED BY THE STRUCTURE MANAGEMENT UNIT.

PILE PAY ITEMS
(Revised 8/11/15)

WBS ELEMENT 35494.1.1

DATE 4/14/2021

TIP NO. R-2511

DESIGNED BY MS

COUNTY BEAUFORT

CHECKED BY AA

STATION 156+55 -L-

DESCRIPTION BRIDGE ON US 17 OVER GUM SWAMP CREEK BETWEEN SR 1421 AND SR 1420 **RIGHT LANE**

NUMBER OF BENTS WITH PILES ______
NUMBER OF PILES PER BENT ______
NUMBER OF END BENTS WITH PILES ______
NUMBER OF PILES PER END BENT ______

Only required for "Predrilling for Piles" & "Pile Excavation" pay items

Bent # or End Bent #	PILE PAY ITEM QUANTITIES						
	Steel Pile Points (yes/no)	Pipe Pile Plates (yes/no/maybe)	Predrilling For Piles (per linear ft)	Pile Redrives (per each)	Pile Excavation (per linear ft) In Soil	Pile Excavation (per linear ft) Not In Soil	PDA Testing (per each)
END BENT NO. 1	No			3			
END BENT NO. 2	No			3			
TOTALS	0		0	6	0	0	1

<u>*Notes:*</u>
Blanks or "no" represent quantity of zero.

If steel pile points are required, calculate quantity of "Steel Pile Points" as equal to the number of steel piles.

If pipe pile plates are or may be required, calculate the quantity of "Pipe Pile Plates" as equal to the number of pipe piles.

Show quantity of "PDA Testing" on the plans as total only.

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PROVIDED INFORMATION

STRUCTURAL INFORMATION

PRELIMINARY GENERAL DRAWINGS

BRIDGE SURVEY REPORT

SUBSURFACE INFO

8/26/2019

INFORMATION FROM STRUCTURAL ENGINEER

Project: R2511-US17 **Bridge:** Left Bridge over Gum Swamp

Bent No.: EB1 **Prefered Pile Type:** HP12x53

Number of Piles per bent: 6 **Number of Wing Wall Piles per bent:** 0

Bent Station: 156+21.18 **Bot. of Cap El.:** 34.56 L / 33.24 R (ft above mean sea level)

MSE Wall (yes/no): no **Bottom of Leveling Pad El.:** n/a

Integral Abutment (yes/no) yes **Pile Spacing:** 8'-4"

Load Combination (Load is per pile)	Fx	Fy	Fz	Lateral Deflection if Integral	Mx	My	Mz
	kip	kip	kip	inch	kip-ft	kip-ft	kip-ft
Strength I		195		n/a			
Service I		140		n/a			

Bent No.: EB2 **Prefered Pile Type:** HP12x53

Number of Piles per bent: 6 **Number of Wing Wall Piles per bent:** 0

Bent Station: 156+80.76 **Bot. of Cap El.:** 34.79 L / 33.46 R (ft above mean sea level)

MSE Wall (yes/no): no **Bottom of Leveling Pad El.:** n/a

Integral Abutment (yes/no) yes **Pile Spacing:** 8'-4"

Load Combination (Load is per pile)	Fx	Fy	Fz	Lateral Deflection if Integral	Mx	My	Mz
	kip	kip	kip	inch	kip-ft	kip-ft	kip-ft
Strength I		195		n/a			
Service I		140		n/a			

8/26/2019

INFORMATION FROM STRUCTURAL ENGINEER

Project: R2511-US17 **Bridge:** Right Bridge over Gum Swamp

Bent No.: EB1 **Prefered Pile Type:** HP12x53

Number of Piles per bent: 6 **Number of Wing Wall Piles per bent:** 0

Bent Station: 156+28.87 **Bot. of Cap El.:** 33.49 L / 32.17 R (ft)

MSE Wall (yes/no): no **Bottom of Leveling Pad El.:** n/a

Integral Abutment (yes/no) yes **Pile Spacing:** 8'-4"

Load Combination (Load is per pile)	Fx	Fy	Fz	Lateral Deflection if Integral	Mx	My	Mz
	kip	kip	kip	inch	kip-ft	kip-ft	kip-ft
Strength I		195		n/a			
Service I		140		n/a			

Bent No.: EB2 **Prefered Pile Type:** HP12x53

Number of Piles per bent: 6 **Number of Wing Wall Piles per bent:** 0

Bent Station: 156+89.29 **Bot. of Cap El.:** 33.72 L / 32.40 R (ft)

MSE Wall (yes/no): no **Bottom of Leveling Pad El.:** n/a

Integral Abutment (yes/no) yes **Pile Spacing:** 8'-4"

Load Combination (Load is per pile)	Fx	Fy	Fz	Lateral Deflection if Integral	Mx	My	Mz
	kip	kip	kip	inch	kip-ft	kip-ft	kip-ft
Strength I		195		n/a			
Service I		140		n/a			

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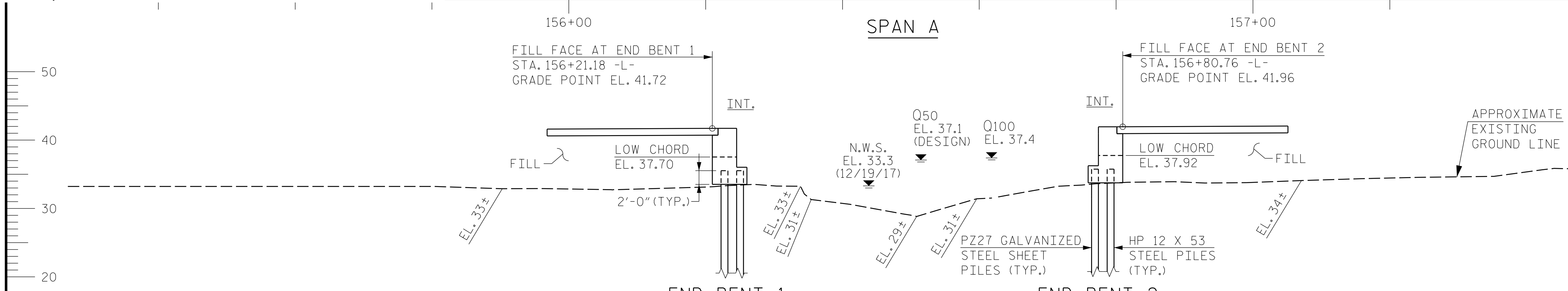


SECTION ALONG LEFT LANE GRADE LINE

(ELEVATION AT END BENTS TAKEN AT RIGHT ANGLES TO END BENTS)

P.V.I. = 158+25.00 -L-
EL. = 42.54
V.C. = 180.00 FT.
(+)0.4000% △ (-)0.3093%

-L- GRADE DATA

HYDRAULIC DATA

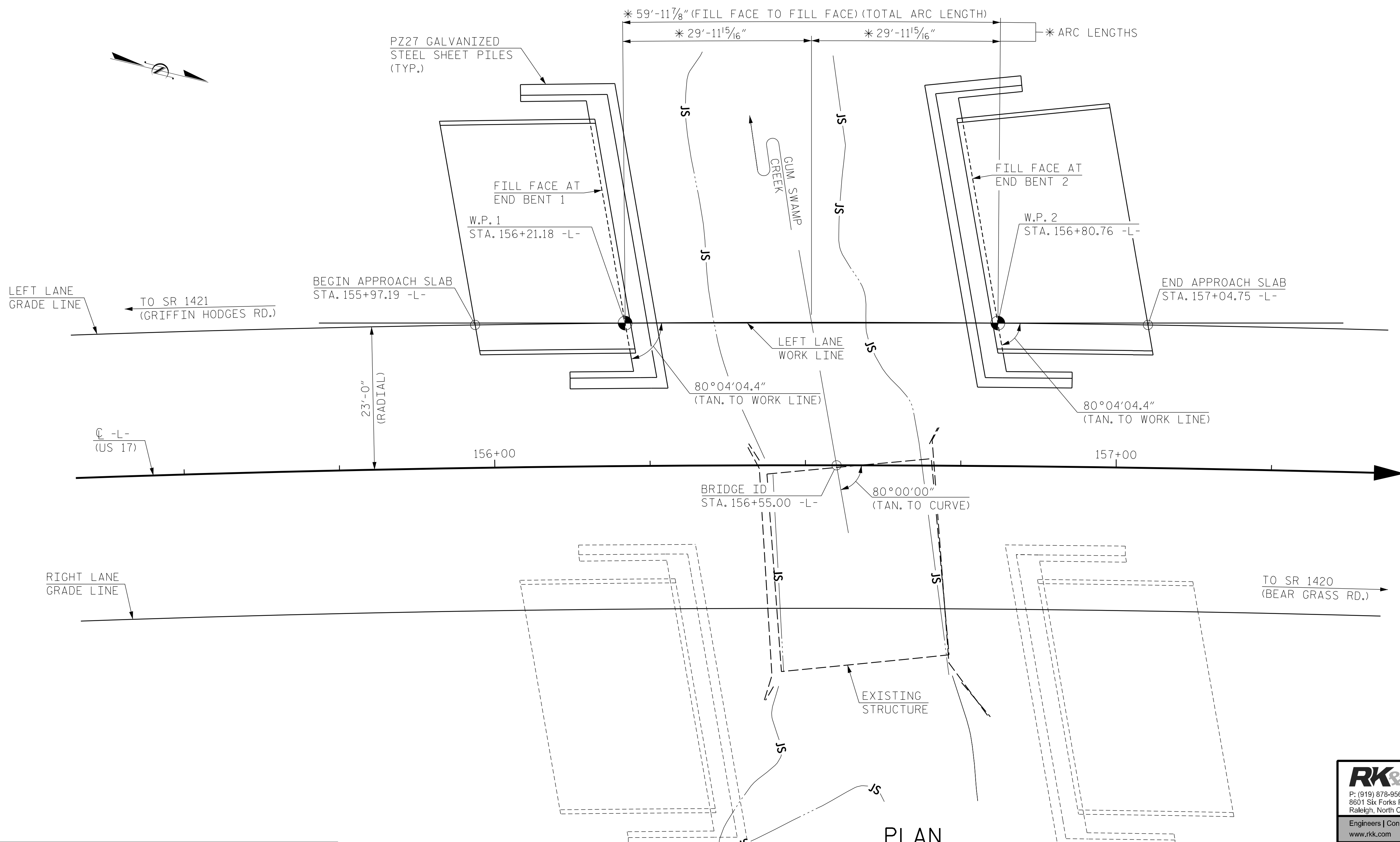
DESIGN DISCHARGE............................ 1,165 C.F.S.
FREQUENCY OF DESIGN FLOOD........... 50 YR.
DESIGN HIGH WATER ELEVATION....... 37.1
DRAINAGE AREA.................................. 3.86 SQ. MI.
BASE DISCHARGE (Q100)..................... 1,436 C.F.S.
BASE HIGH WATER ELEVATION........... 37.4

OVERTOPPING FLOOD DATA

OVERTOPPING DISCHARGE...................... 2,790 C.F.S.
FREQUENCY OF OVERTOPPING FLOOD.... 500 YR.+
OVERTOPPING FLOOD ELEVATION.......... 41.0

HORIZONTAL CURVE DATA -L-

P.I. STA. 158+92.32
△ = 17°05'49.9" (RT.)
D = 1°41'06.6"
L = 1,014.57'
T = 511.08'
R = 3,400.00'



PLAN

(HP 12x53 STEEL PILES NOT SHOWN FOR CLARITY)
* MEASURED ALONG LEFT LANE GRADE LINE (ARC LENGTHS)

PROJECT NO. R-2511
BEAUFORT COUNTY
STATION: 156+55.00 -L-

SHEET 1 OF 5
REPLACES BRIDGE NO. 0056

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
RALEIGH

GENERAL DRAWING
FOR BRIDGE ON US 17
OVER GUM SWAMP BETWEEN
SR 1421 AND SR 1420
LEFT LANE

BR. NO. 0364 - LEFT

PRELIMINARY PLANS DO NOT USE FOR CONSTRUCTION

RK&K
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REVISIONS						SHEET NO.
NO.	BY:	DATE:	NO.	BY:	DATE:	SL-1
1			3			TOTAL SHEETS
2			4			26

DRAWN BY : B. A. HAAG DATE : OCT 2021
CHECKED BY : M. ZIEHL DATE : OCT 2021
DESIGN ENGINEER OF RECORD : O. J. PAITEL DATE : OCT 2021

bgonfa
3/18/2021 R:\Structures\Bridge\DGN\LEFT\FINAL\R2511_SMU_GD_060364L.dgn

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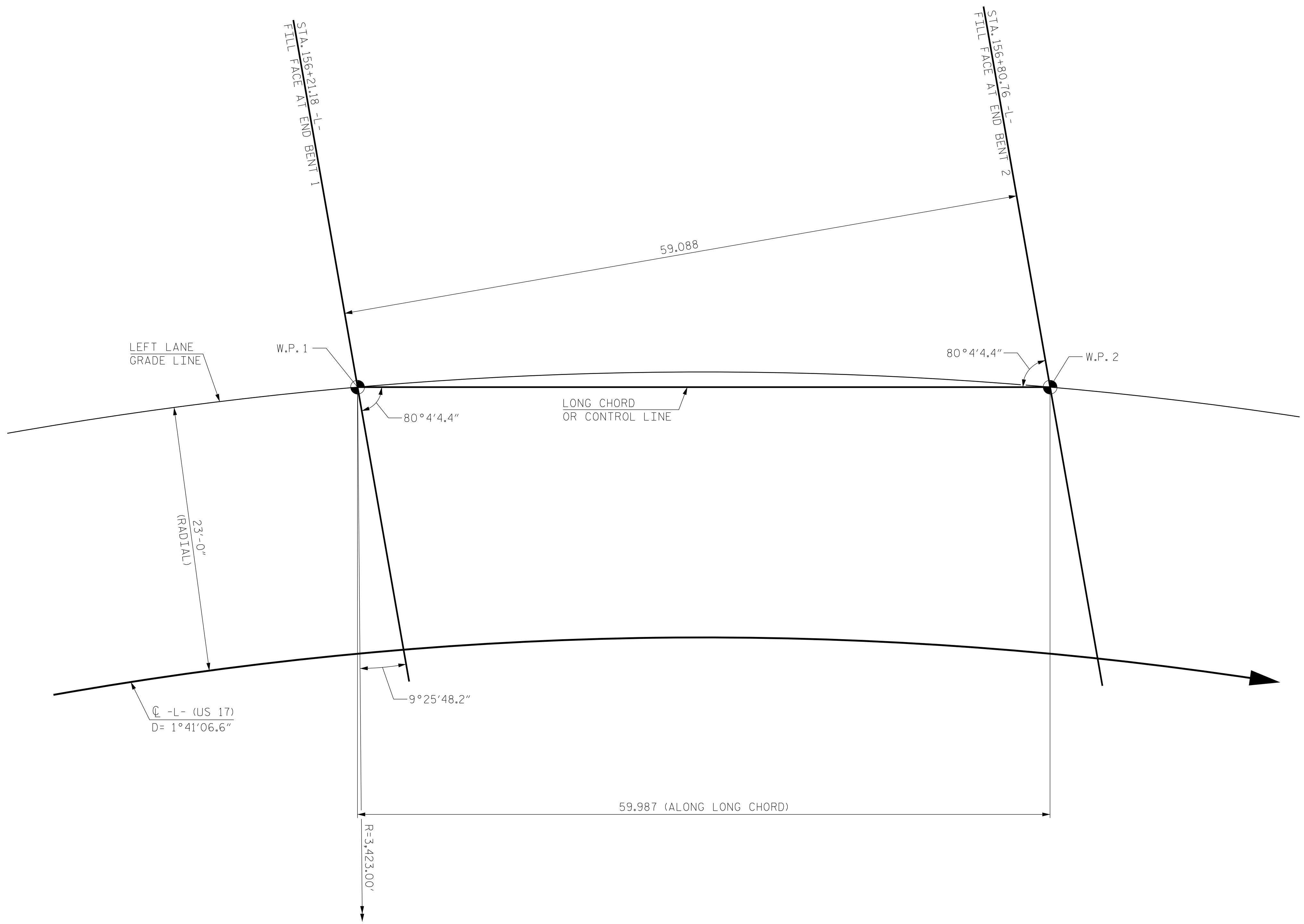

LONG CHORD LAYOUT

NOTE: END BENTS ARE PARALLEL

PROJECT NO. R-2511

BEAUFORT COUNTY

STATION: 156+55.00 -L-

SHEET 2 OF 3

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
RALEIGH

PRELIMINARY
GENERAL DRAWING
FOR BRIDGE ON US 17 OVER
GUM SWAMP BETWEEN SR 1421
(GRIFFIN HODGES RD.) AND
SR 1420 (BEAR GRASS RD.)
LEFT LANE

BR. NO. 0364 - LEFT

PRELIMINARY PLANS DO NOT USE FOR CONSTRUCTION

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REVISIONS						SHEET NO.
NO.	BY:	DATE:	NO.	BY:	DATE:	SL-2
1			3			TOTAL SHEETS
2			4			3

DRAWN BY : B. A. HAAG DATE : JAN 2020
CHECKED BY : M. ZIEHL DATE : JAN 2020
DESIGN ENGINEER OF RECORD : O. J. PAITEL DATE : JAN 2020

tboyd
1/13/2020 R:\Structures\Bridge\DGN\LEFT\PRELIM\R2511_SMU_PGD02_060364L.dgn

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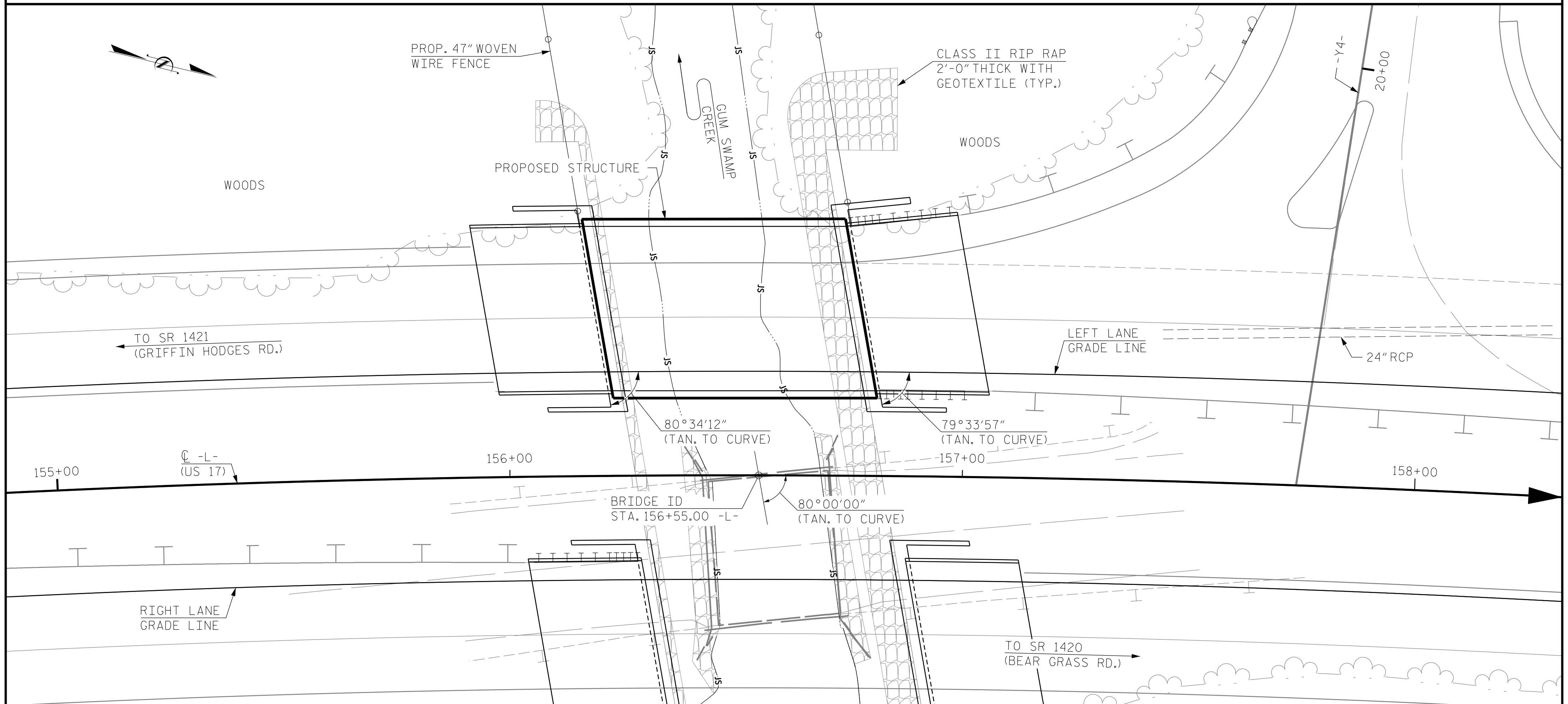
BENCH MARK #6 ON -L- STA. 152+76.20, 155.65' RT, RR SPIKE SET IN 14" PINE TREE, EL. 38.73



LOCATION SKETCH

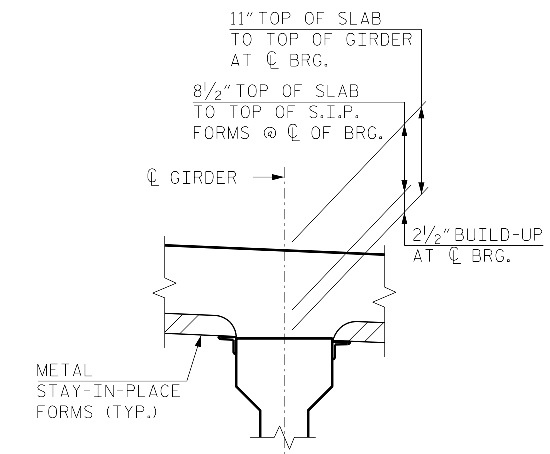
FOR UTILITY INFORMATION, SEE UTILITY PLANS AND SPECIAL PROVISIONS.

NOTES:

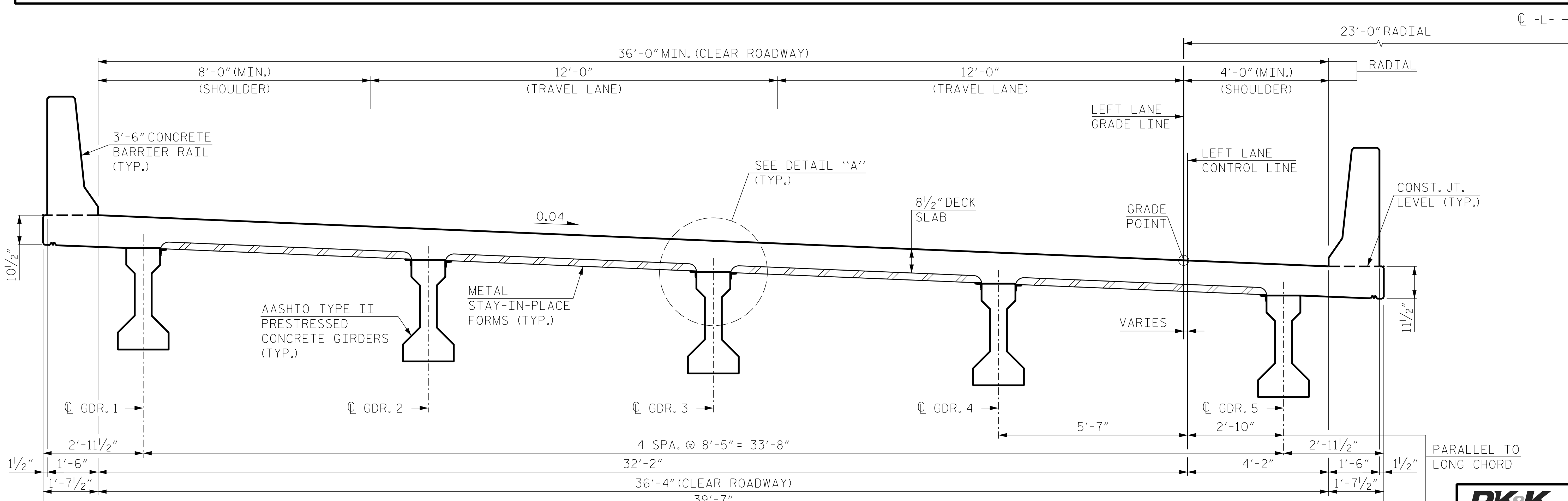
ASSUMED LIVE LOAD= HL-93 OR ALTERNATE LOADING.

THIS BRIDGE HAS BEEN DESIGNED IN ACCORDANCE WITH THE REQUIREMENTS OF THE AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS.

THIS BRIDGE IS LOCATED IN SEISMIC ZONE 1.



DETAIL "A"



TYPICAL SECTION

ONE SPAN CONTINUOUS FOR LIVE LOAD WITH TANGENT COMPOSITE DECK ON AASHTO TYPE II GIRDERS.

DRAWN BY : B. A. HAAG DATE : JAN 2020
CHECKED BY : M. ZIEHL DATE : JAN 2020
DESIGN ENGINEER OF RECORD : O. J. PAITEL DATE : JAN 2020

tboyd 1/13/2020 R:\Structures\Bridge\DGN\LEFT\PRELIM\R2511_SMU_PGD03_060364L.dgn

PROJECT NO. R-2511
BEAUFORT COUNTY
STATION: 156+55.00 -L-

SHEET 3 OF 3

BR. NO. 0364 - LEFT

PRELIMINARY PLANS DO NOT USE FOR CONSTRUCTION

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STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
RALEIGH

PRELIMINARY
GENERAL DRAWING
FOR BRIDGE ON US 17 OVER GUM SWAMP BETWEEN SR 1421 (GRIFFIN HODGES RD.) AND SR 1420 (BEAR GRASS RD.)
LEFT LANE

REVISIONS						
NO.	BY:	DATE:	NO.	BY:	DATE:	
1			3			
2			4			

SHEET NO. SL-3
TOTAL SHEETS 3

DOCUMENT NOT CONSIDERED FINAL UNLESS ALL SIGNATURES COMPLETED

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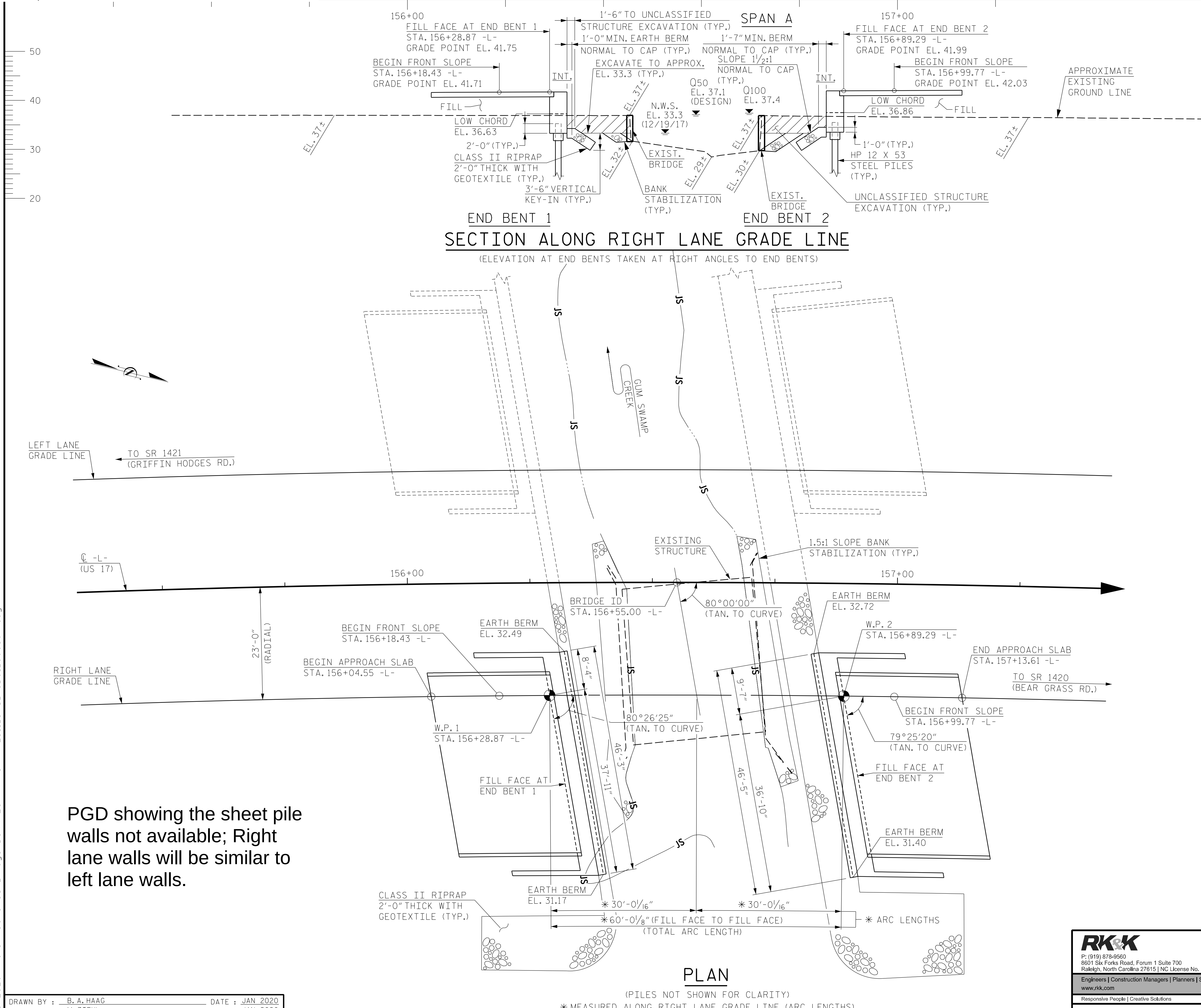

PGD showing the sheet pile walls not available; Right lane walls will be similar to left lane walls.

P.V.I. = 158+25.00 -L-
EL. = 42.54
V.C. = 180.00 FT.
(+)0.4000% △ (-)0.3093%

-L- GRADE DATA

HYDRAULIC DATA

DESIGN DISCHARGE............ 1,165 C.F.S.
FREQUENCY OF DESIGN FLOOD........ 50 YR.
DESIGN HIGH WATER ELEVATION...... 37.1
DRAINAGE AREA............ 3.86 SQ. MI.
BASE DISCHARGE (Q100)............ 1,436 C.F.S.
BASE HIGH WATER ELEVATION........ 37.4

OVERTOPPING FLOOD DATA

OVERTOPPING DISCHARGE............ 2,790 C.F.S.
FREQUENCY OF OVERTOPPING FLOOD.... 500 YR.+
OVERTOPPING FLOOD ELEVATION........ 41.0

HORIZONTAL CURVE DATA -L-

P.I. STA. 158+92.32
Δ = 17°05'49.9" (RT.)
D = 1°41'06.6"
L = 1,014.57'
T = 511.08'
R = 3,400.00'

I HEREBY CERTIFY THESE PLANS ARE THE AS-BUILT PLANS

PROJECT NO. R-2511
BEAUFORT COUNTY
STATION: 156+55.00 -L-

SHEET 1 OF 3 REPLACES BRIDGE NO. 0364

BR. NO. 0364 - RIGHT

PRELIMINARY PLANS DO NOT USE FOR CONSTRUCTION

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
RALEIGH

PRELIMINARY
GENERAL DRAWING
FOR BRIDGE ON US 17 OVER GUM SWAMP BETWEEN SR 1421 (GRIFFIN HODGES RD.) AND SR 1420 (BEAR GRASS RD.)
RIGHT LANE

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REVISIONS								SHEET NO.
NO.	BY:	DATE:		NO.	BY:	DATE:		SR-1
1				3				TOTAL SHEETS
2				4				3

DRAWN BY : B. A. HAAG DATE : JAN 2020
CHECKED BY : M. ZIEHL DATE : JAN 2020
DESIGN ENGINEER OF RECORD : O. J. PAITEL DATE : JAN 2020

tboyd 1/13/2020 R:\Structures\Bridge\DGN\RIGHT\Prelim\R2511_SMU_PGD01_060364R.dgn

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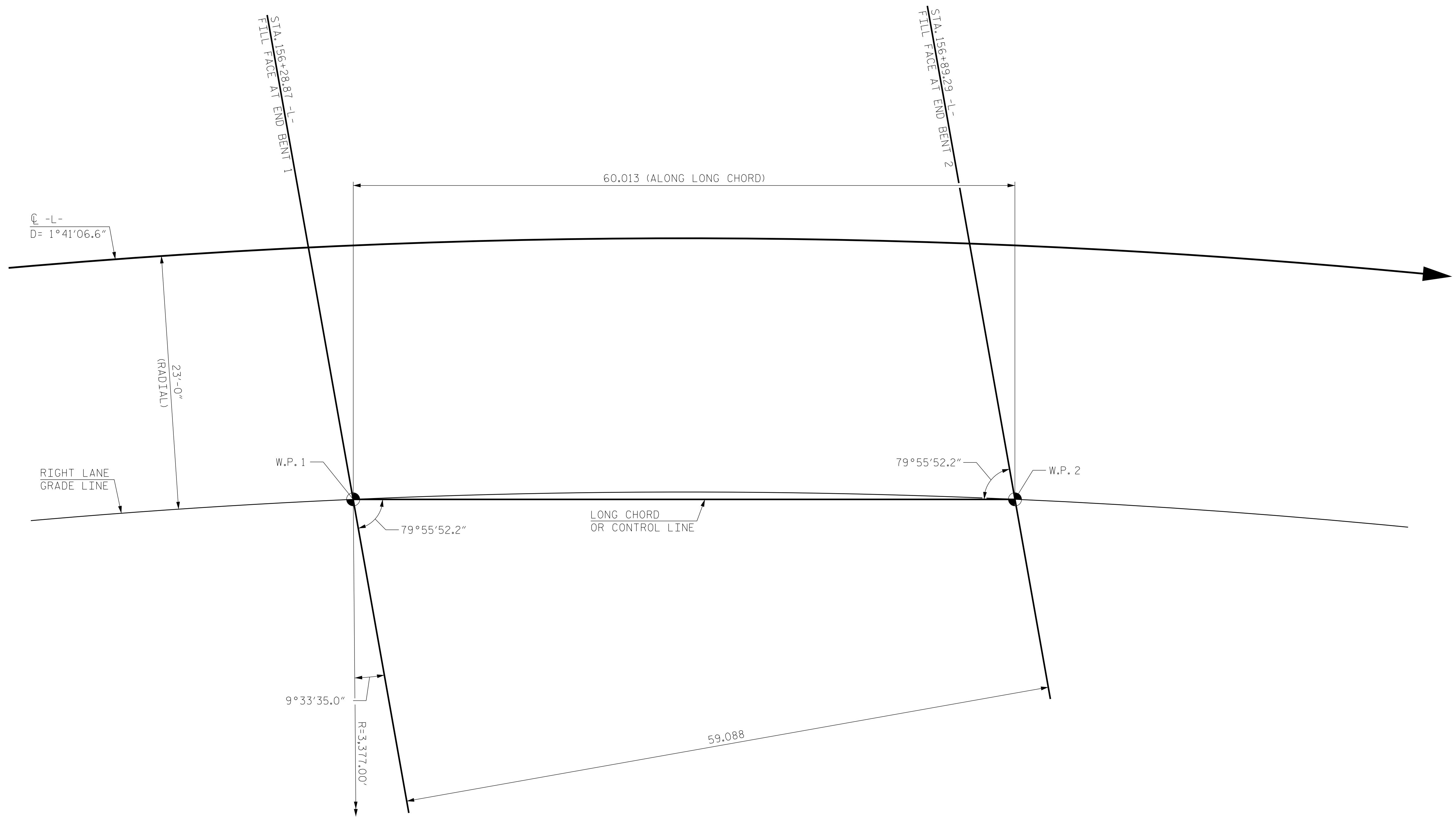

LONG CHORD LAYOUT

NOTE: END BENTS ARE PARALLEL

PROJECT NO. R-2511

BEAUFORT COUNTY

STATION: 156+55.00 -L-

SHEET 2 OF 3

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
RALEIGH

PRELIMINARY
GENERAL DRAWING
FOR BRIDGE ON US 17 OVER GUM SWAMP BETWEEN SR 1421 (GRIFFIN HODGES RD.) AND SR 1420 (BEAR GRASS RD.)
RIGHT LANE

BR. NO. 0364 - RIGHT

PRELIMINARY PLANS DO NOT USE FOR CONSTRUCTION

RK&K
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REVISIONS						SHEET NO.
NO.	BY:	DATE:	NO.	BY:	DATE:	SR-2
1			3			TOTAL SHEETS
2			4			3

DRAWN BY : B. A. HAAG DATE : JAN 2020
CHECKED BY : M. ZIEHL DATE : JAN 2020
DESIGN ENGINEER OF RECORD : O. J. PAITEL DATE : JAN 2020

tboyd 1/13/2020 R:\Structures\Bridge\DGN\RIGHT\Prelim\R2511_SMU_PGD02_060364R.dgn

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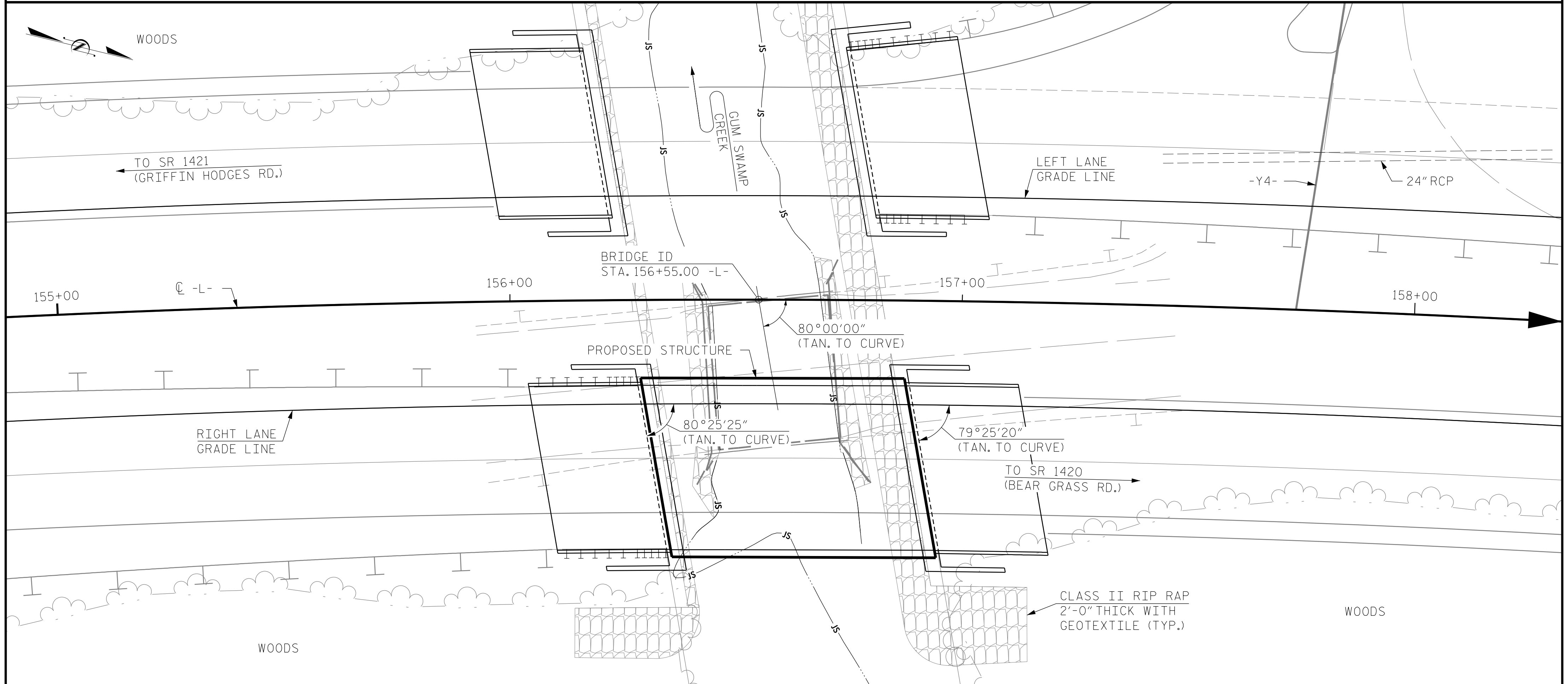
BENCH MARK #6 ON -L- STA. 152+76.20, 155.65' RT, RR SPIKE SET IN 14" PINE TREE, EL. 38.73



LOCATION SKETCH

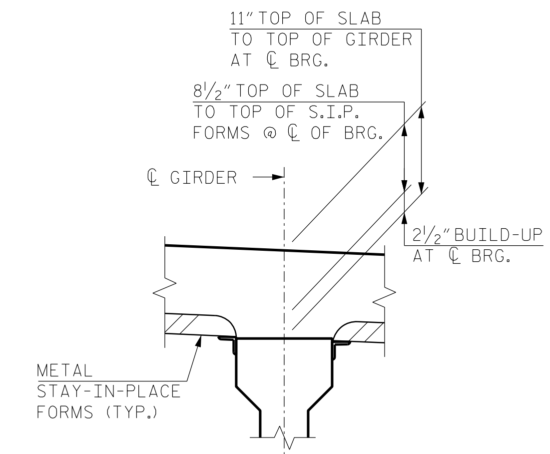
FOR UTILITY INFORMATION, SEE UTILITY PLANS AND SPECIAL PROVISIONS.

NOTES:

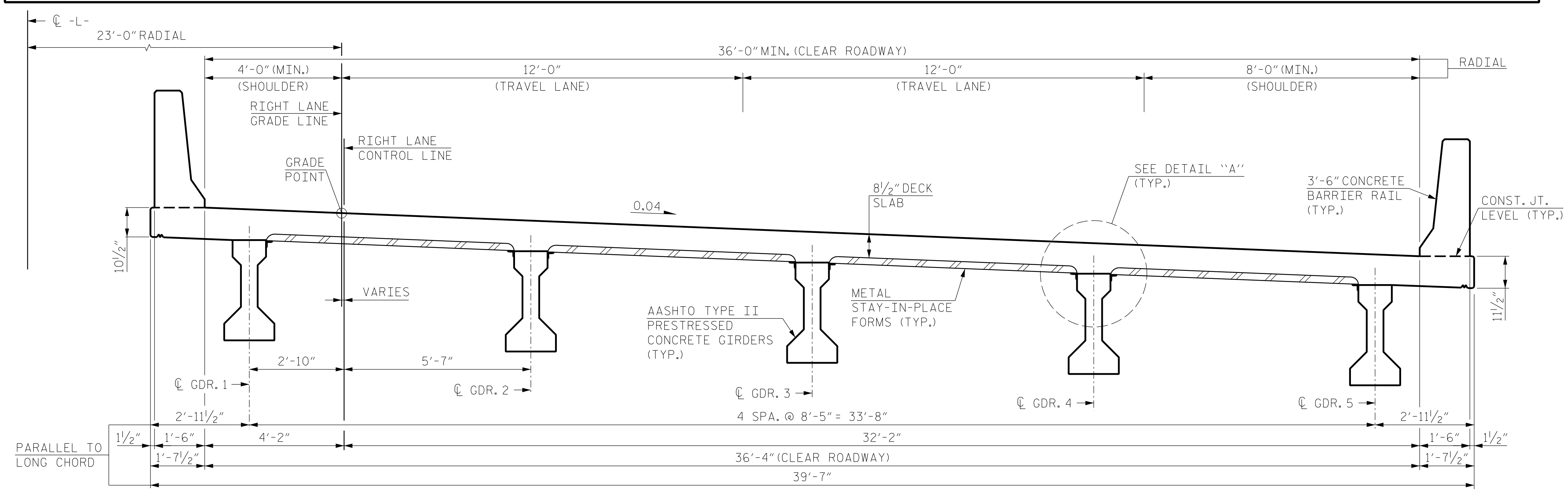
ASSUMED LIVE LOAD= HL-93 OR ALTERNATE LOADING.

THIS BRIDGE HAS BEEN DESIGNED IN ACCORDANCE WITH THE REQUIREMENTS OF THE AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS.

THIS BRIDGE IS LOCATED IN SEISMIC ZONE 1.



DETAIL "A"



TYPICAL SECTION

ONE SPAN CONTINUOUS FOR LIVE LOAD WITH TANGENT COMPOSITE DECK ON AASHTO TYPE II GIRDERS.

PROJECT NO. R-2511

BEAUFORT COUNTY

STATION: 156+55.00 -L-

SHEET 3 OF 3

BR. NO. 0364 - RIGHT

PRELIMINARY PLANS DO NOT USE FOR CONSTRUCTION

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DEPARTMENT OF TRANSPORTATION
RALEIGH

PRELIMINARY
GENERAL DRAWING
FOR BRIDGE ON US 17 OVER
GUM SWAMP BETWEEN SR 1421
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REVISIONS						SHEET NO.
NO.	BY:	DATE:	NO.	BY:	DATE:	SR-3
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2			4			3

DRAWN BY : B. A. HAAG DATE : JAN 2020
CHECKED BY : M. ZIEHL DATE : JAN 2020
DESIGN ENGINEER OF RECORD : O. J. PAITEL DATE : JAN 2020

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bhaag
1/7/2020

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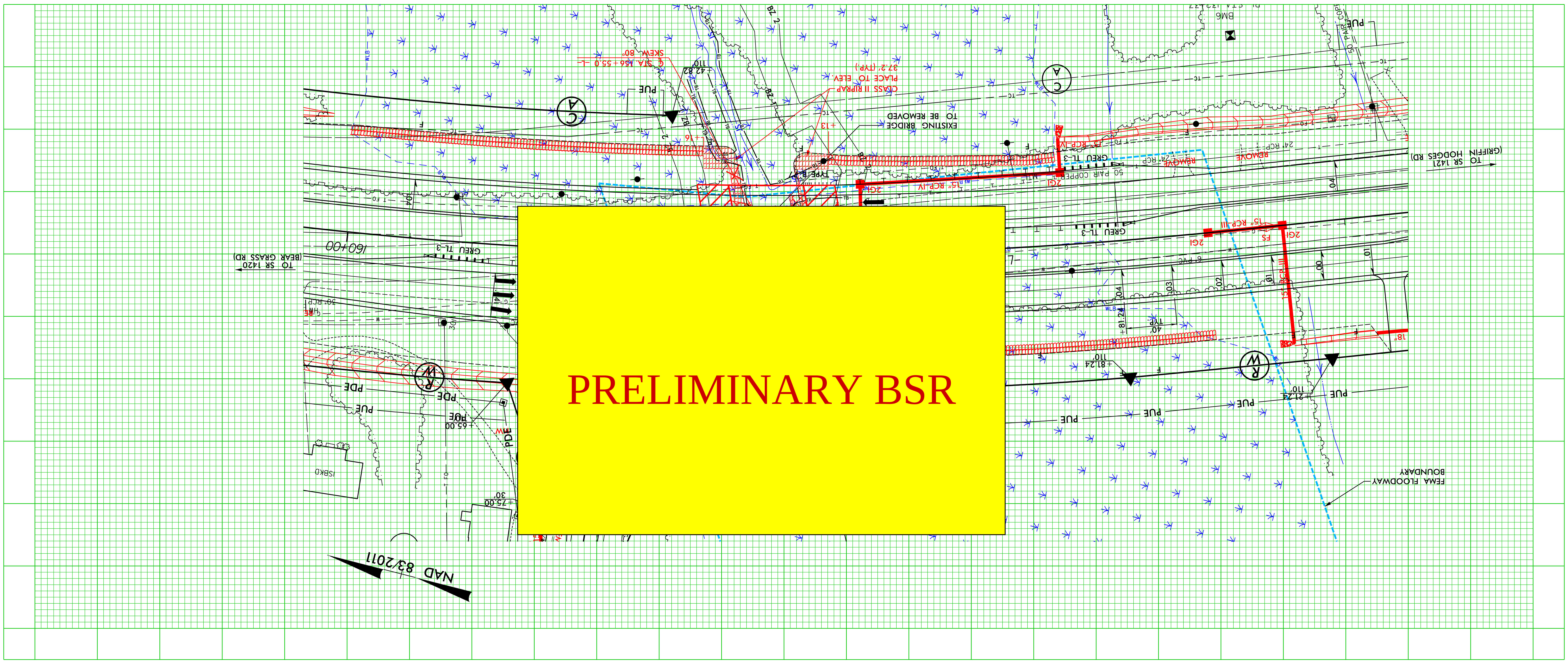

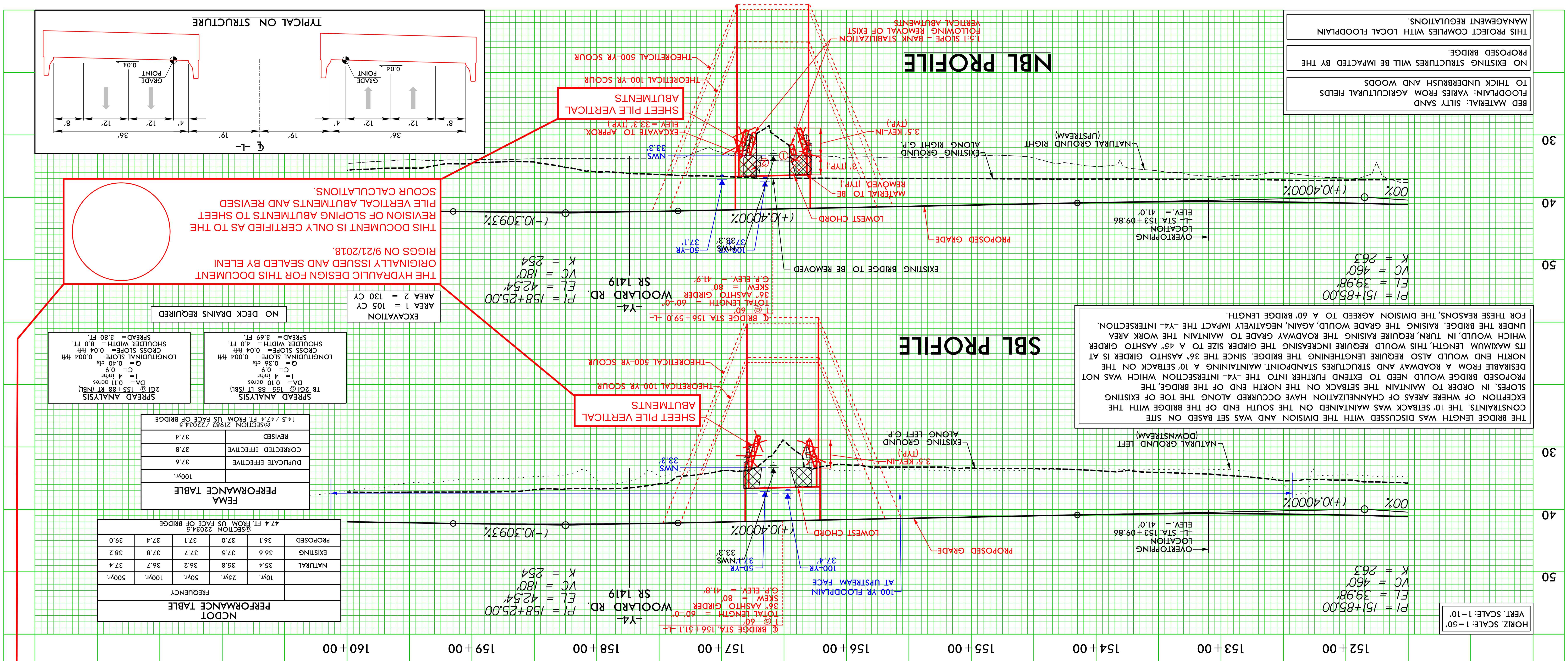

INFORMATION TO BE SHOWN ON PLANS

WS EL. Taken @ River Station 22034.5

Design:	Discharge 1,165 c.f.s.	Frequency 50 yr.	Elev. 37.1 ft.
Base Flood:	Discharge 1,436 c.f.s.	Frequency 100 yr.	Elev. 37.4 ft.
Overtopping:	Discharge 2,790 c.f.s.	Frequency 500+ yr.	Elev. 41.0 ft.

ADDITIONAL INFORMATION AND COMPUTATIONS

DISCHARGE CALCULATIONS (SIR 2009–5158) — **FEMA**

DRAINAGE AREA = 3.86 SQ. MI.
100% HYDRAULIC REGION 4,
RURAL CONDITION

FEMA: DRAINAGE AREA = 5.86 SQ. MI.
EFFECTIVE: 7–7–2014
PRELIMINARY: 6–30–2016

			FEMA
$Q_{10} =$	$174\ (DA)^{0.617} =$ 400 c.f.s.	SAY 400 c.f.s.	644 c.f.s.
$Q_{25} =$	$245\ (DA)^{0.606} =$ 557 c.f.s.	SAY 560 c.f.s.	– –
$Q_{50} =$	$309\ (DA)^{0.600} =$ 695 c.f.s.	SAY 700 c.f.s.	1,165 c.f.s.
$Q_{100} =$	$380\ (DA)^{0.594} =$ 848 c.f.s.	SAY 850 c.f.s.	1,436 c.f.s.
$Q_{500} =$	$550\ (DA)^{0.583} =$ 1,210 c.f.s.	SAY 1,200 c.f.s.	2,194 c.f.s.

SINCE THE FEMA FLOWS ARE HIGHER AND MORE CONSERVATIVE THAN THE USGS RURAL REGRESSION EQUATIONS, THEY WILL BE USED IN THE REVISED HEC–RAS MODEL. THE PUBLISHED FEMA FLOWS DO NOT INCLUDE THE 25–YEAR STORM EVENT, HOWEVER, THE PRELIMINARY HEC–RAS MODEL DOES INCLUDE THE FLOWS FOR THE 25–YEAR STORM EVENT WHICH WILL BE INCLUDED IN THE REVISED HEC–RAS MODEL.

SCOUR CALCULATIONS (HEC–18, 5th EDITION, APRIL 2012)

ABUTMENT SCOUR (NCHRP 24–20 EQUATION) $Y_{MAX} = \alpha(Y_C) = \alpha[Y_1(q_{2C}/q_1)^{6/7}]$ $Y_S = Y_{MAX} - Y_O$

100–YR:
FROM RS 22348.8: $Y_1 = 6.86$ ft. $Q_1 = 286.16$ c.f.s. $W_1 = 27.52$ ft. $q_1 = 286.16/27.52 = 10.40$
FROM RS 21950 BRU: $Y_0 = 130.33/53.00 = 2.46$ ft.
$Q_2 = 1207.57$ c.f.s. $W_2 = 53.00$ ft. $q_{2C} = 1207.57/53.00 = 22.78$
$\alpha = 1.17$ (HEC–18, FIGURE 8.9)
$Y_{MAX} = \alpha(Y_C) = 1.17\,[6.86\,(22.78/10.40)^{6/7}] = 15.72$ ft.
$Y_S = Y_{MAX} - Y_O = 15.72 - 2.46 =$ 13.3 ft.

500–YR:
FROM RS 22348.8: $Y_1 = 8.56$ ft. $Q_1 = 356.86$ c.f.s. $W_1 = 27.52$ ft. $q_1 = 356.86/27.52 = 12.96$
FROM RS 21950 BRU: $Y_0 = 130.33/53.00 = 2.46$ ft.
$Q_2 = 1844.99$ c.f.s. $W_2 = 53.00$ ft. $q_{2C} = 1844.99/53.0 = 34.81$
$\alpha = 1.13$ (HEC–18, FIGURE 8.9)
$Y_{MAX} = \alpha(Y_C) = 1.10\,[8.56\,(34.81/12.96)^{6/7}] = 21.99$ ft.
$Y_S = Y_{MAX} - Y_O = 21.99 - 2.46 =$ 19.5 ft.

OVERTOPPING
OCCURS AT LOW POINT LOCATED AT –L– STA. 153+09.86 AT AN ELEVATION OF 41.0 ft. ROADWAY IS SUPERELEVATED AT 2.5% AT THIS LOCATION. THE DISCHARGE REQUIRED TO BEGIN OVERTOPPING IS 2,790 c.f.s. WHICH IS THE 500–YR+ EVENT (Fut20 EVENT IN PRELIMINARY MODEL).

HISTORICAL FLOOD INFORMATION
BERNICE TYSON IS A LOCAL RESIDENT OF ABOUT 41 YEARS. DURING ANY MAJOR RAIN EVENT THE WATER WILL GET UP TO THE BARN AND WILL OCCASIONALLY GET TO THE HOUSE.
PER BEAUFORT COUNTY MAINTENANCE ENGINEER OF 7 YEARS, APPROXIMATELY 6"–8" OF WATER WILL CROSS THE BRIDGE DURING MAJOR RAIN EVENTS.

SITE DATA

Drainage Area 3.86 SQ MI — Source USGS STREAM STATS 4.0, VERIFIED W/ USGS QUAD MAP – OLD FORD, NC

River Basin TAR–PAMLICO — Character RURAL – COASTAL PLAINS (REGION 4)

Stream Classification (Such as Trout, High Quality Water, etc.) WS–IV

Data on Existing Structure SINGLE SPAN, 1@21'–10", WHEN PREVIOUSLY WIDENED AN H–PILE BENT @ CENTER SPAN ADDED FOR NEW OUTSIDE GIRDERS, REINFORCED CONCRETE FLOOR ON I–BEAMS W/A REINFORCED CONCRETE SLAB, 32'–0" OUT–TO–OUT — Total Waterway Opening 76.9 s.f. — Waterway Opening Below 100yr. WS EL. 76.9 s.f.

Debris Potential: Low ..... Moderate X High .....

Data on Structures Up and Down Stream 1.9 MI. UPSTREAM MARTIN CO. BRIDGE #570188 ON SR 1534 SINGLE SPAN, 1@60'–0"; PPC CORED SLAB WITH PPC CAPS.
1.6 MI. DOWNSTREAM BEAUFORT CO. CONFLUENCE WITH LATHAM CREEK.

Design Control Elev. 37.8' (CORRECTED EFFECTIVE 100–YEAR @ RS 22034.5)

Gage Station No. N/A — Period of Records N/A yrs.

Max. Discharge N/A c.f.s. — Date N/A — Frequency N/A

Historical Flood Information: SEE NOTE IN ADDITIONAL INFORMATION SECTION

Date	Elev.	Est. Freq.	Source	Period of Knowledge
–	35.5 ft.	<10 yr.	BERNICE TYSON – LOCAL RESIDENT	41 yrs.
–	37.5 ft.	25 yr.	BEAUFORT COUNTY MAINTENANCE ENGINEER	7 yrs.
N/A	N/A ft.	N/A yr.	N/A	N/A yrs.

Historical Scour Info. : General N/A ft. Contraction N/A ft. Local N/A ft.

Channel Slope 0.0015 ft/ft Source FIELD SURVEY — Normal Water Surface Elev. 33.3 ft.

Manning's n: Left O.B. 0.08–0.14 Channel 0.05 Right O.B. 0.08–0.14 Source FIELD SURVEY 12/19/2017

Flood Study /Status DETAILED FLOOD STUDY, PANEL #5770 (BEAUFORT CO. FIS REPORT–EFF. 7/7/14, PRELIM. 6/30/16) — Floodway Established? YES

Flood Study 100yr. Discharge 1,436 c.f.s. WS Elev.: With Floodway 38.3 ft. Without Floodway 37.6 ft. @ River Station 21982

DESIGN DATA

Hydrological Method USGS RURAL REGRESSION EQUATIONS (SIR 2009–5158)

Hydraulic Design Method HEC–RAS 4.1.0 FILENAME: R–2511_GumSwamp_US17.prj

Floods Evaluated: @ River Station 22034.5

Freq. (yr.)	Q (c.f.s)	Elev. (ft.)	Backwater (ft.)	Bridge Opening Velocity (f.p.s.)
10	644	36.1	0.7	3.7
25	924	37.0	1.2	4.6
50 (DESIGN)	1,165	37.1	0.9	4.9
100	1,436	37.4	0.7	6.0
500	2,194	39.0	1.6	9.2

Waterway Opening Provided Below:Design W.S. Elev. 237.8 s.f., 100yr W.S. Elev. 237.8 s.f., Total 237.8 s.f.,

Average Channel Velocity (Design) 1.4 f.p.s. @ APPROACH RS 22348.8 — Average Overbank Velocity (Design) 0.3 LT 0.4 RT f.p.s.

Computed Scour : General ..... ft. Abutment/Contraction 100–yr: 12.4 500–yr: 18.6 ft. Local ..... ft.

Is a Floodway Revision Required? MOA TYPE 2a (MAX. DECREASE OF 0.4' @ RS 22034.5)

BRIDGE SURVEY & HYDRAULIC DESIGN REPORT

N. C. DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
HYDRAULICS UNIT
RALEIGH, N. C.

I.D. No. R–2511 — Project No. 35494.1.1 — Proj. Station STA. 156+55.0 –L–

County BEAUFORT — Bridge Over GUM SWAMP — Bridge Inv. No. 0056

On Highway US 17 — Between SR 1421 (GRIFFIN HODGES RD) and SR 1420 (BEAR GRASS RD)

Recommended Structure DUAL STRUCTURES: SINGLE SPAN, 1 @ 60'–0", 36" AASHTO GIRDERS, 4' END BENT CAPS W/ VERTICAL ABUTMENTS, 42" CONCRETE RAILS

Recommended Width of Roadway 36'–0" CLR RDWY (SBL) 36'–0" CLR RDWY (NBL) — Skew 80°

Recommended Location is ~~(Up, (At) Down) Stream from~~ Existing Crossing.

Latitude 35.67993° — Longitude –77.07518°

Statewide Tier ☒ Regional Tier ☐ Sub–Regional Tier ☐

Bench Mark is BM6, ON –L– STA. 152+76.2, 155.6' RT, RR SPIKE SET IN 14" PINE TREE

Northing 707087.6 Easting 2570501.6 Elev. 38.73' ft. Datum: NAVD 88

Temporary Crossing NOT REQUIRED, STAGED CONSTRUCTION

RK&K ENGINEERS, LLP
900 RIDGEFIELD DRIVE, STE.350
RALEIGH,NC 27609, LICENSE NO- F-0112

Designed by: ELENI RIGGS, PE
Assisted by: JONATHAN WHITTINGTON, PE
Project Engineer: ELENI RIGGS, PE
Reviewed by: DocuSigned by: Amit Sachan 08E08823ABD2417... 10/31/2018
Date 9/21/2018

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 036821 ELENI M. RIGGS — DocuSigned by: Eleni M. Riggs C32AE1B67AB5432...

Stream GUM SWAMP Struc. Inv. No. 0056 I.D. No. R–2511 Project No. 35494.1.1 PDF File 06 0056 2018 R–2511 GUM SWAMP US17.PDF

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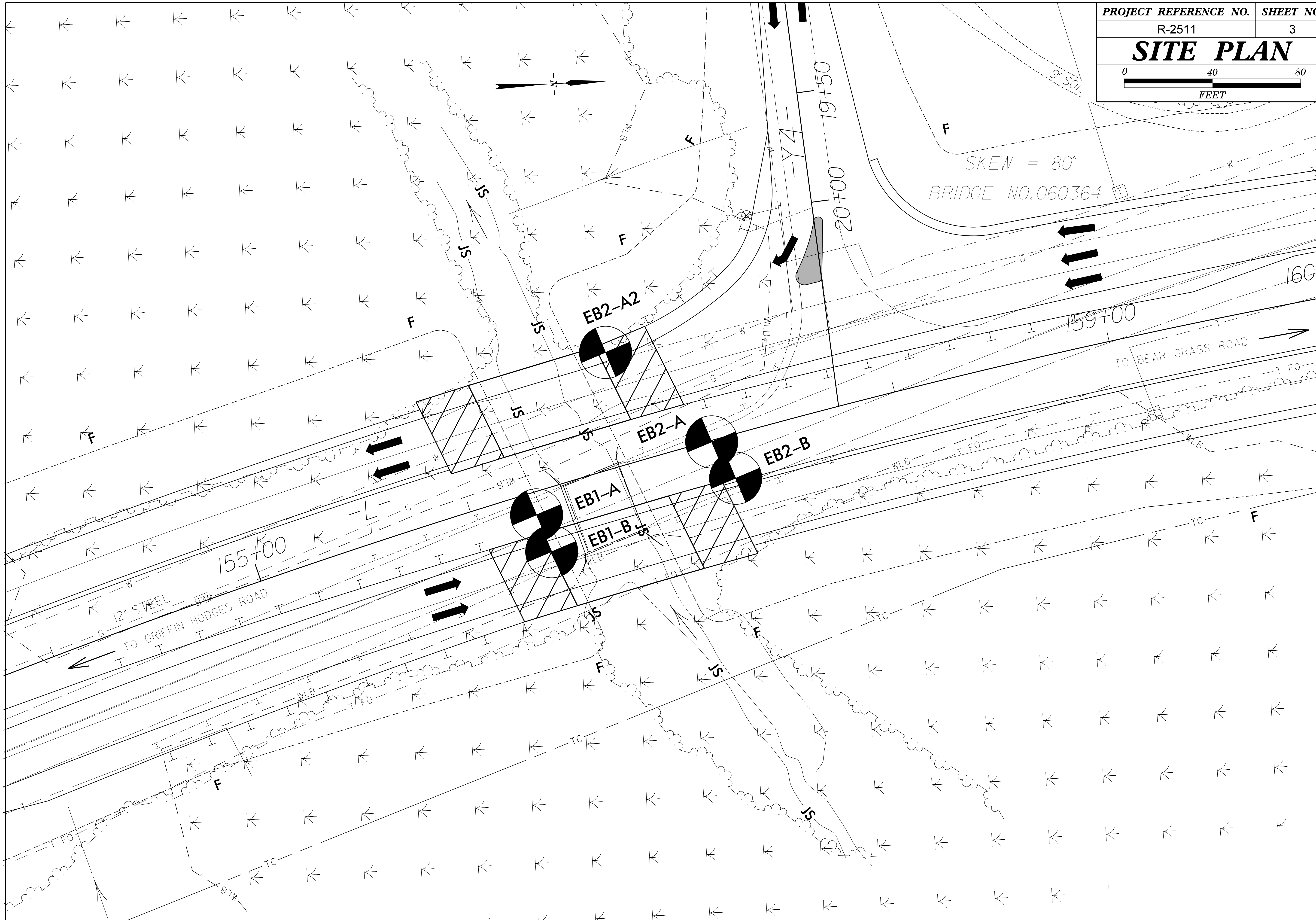
PROJECT REFERENCE NO.	SHEET NO.
R-2511	3

SITE PLAN



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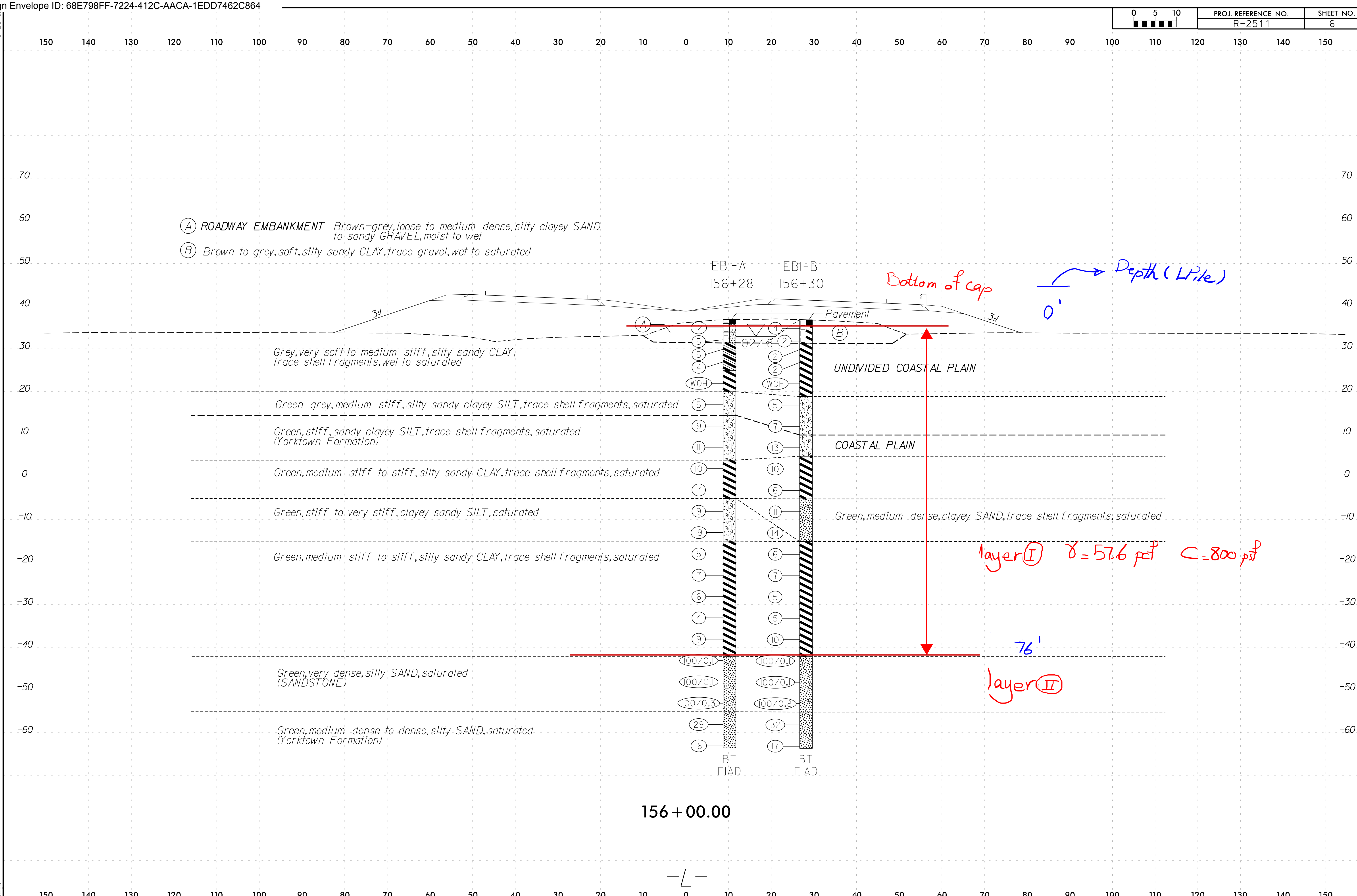

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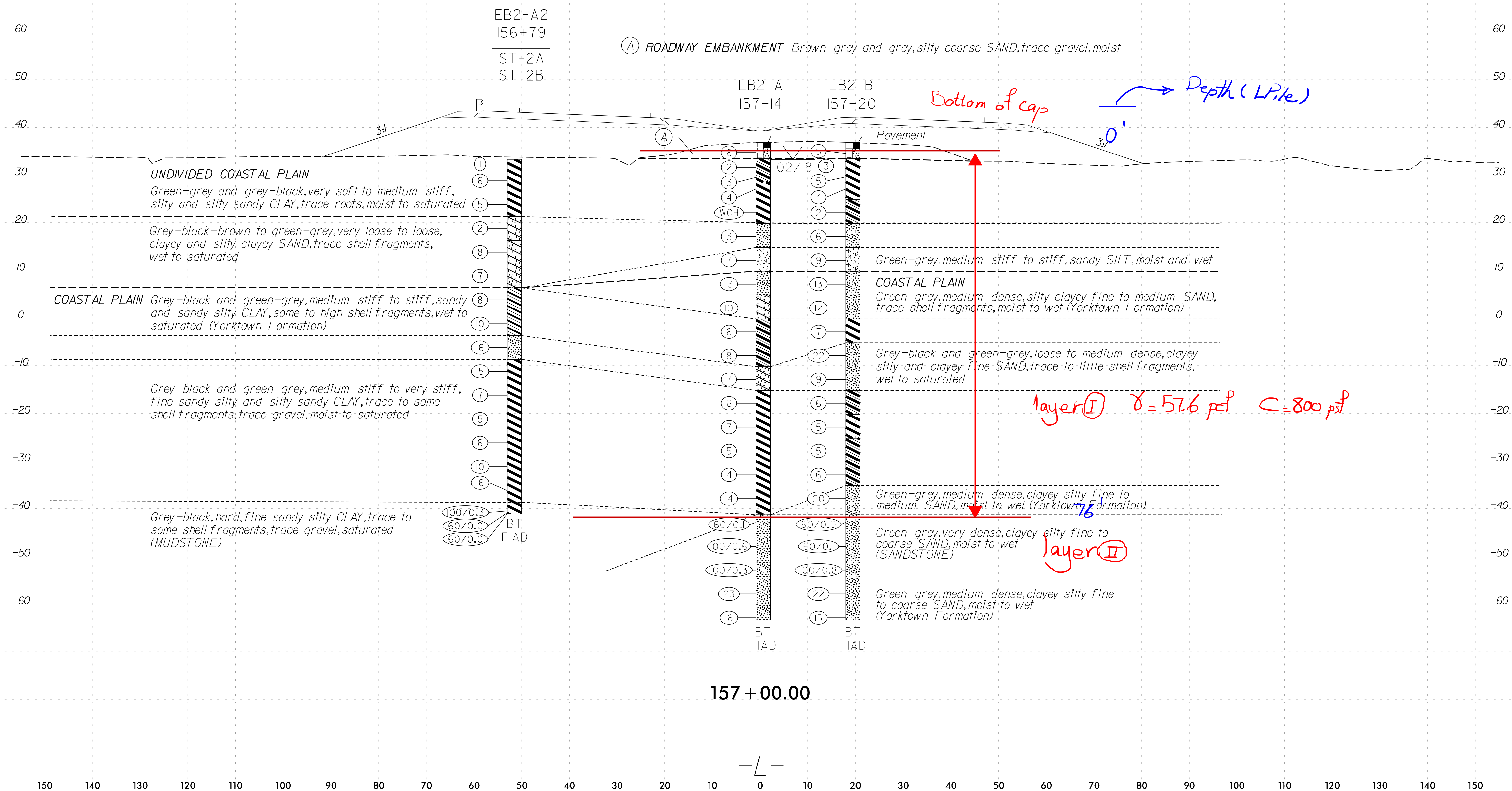
SOIL TEST RESULTS

SAMPLE NO.	STATION	LINE	DEPTH INTERVAL	AASHTO CLASS.	L.L.	P.I.	% BY WEIGHT				% PASSING SIEVE			% MOISTURE	% ORGANIC
							C. SAND	F. SAND	SILT	CLAY	10	40	200		
ST-2A/2B	156+79	-L-	10.4 - 10.8	A-7-6 (53)	71	47	0.5	3.7	27.7	68.1	100.0	99.7	97.7	90	-

Note: ST-2A and ST-2B were extruded from the shelby tube at a depth of 10.4'-10.8' and mixed together to obtain a representative sample of the two tubes.



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FOUNDATION CALCULATIONS

END BENT NO. 1

END BENT NO.2

SHEET PILE DESIGN

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CALCULATIONS FOR

END BENT NO. 1

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RK&K	
Job No.:	R-2511
Task:	Foundation Recommendations
Job Name:	Bridge over Gum Swamp
By:	AB — Date: 2/24/2021
Checked By:	MS — Date: 2/24/2021

End Bent #1

References: AASHTO LRFD (8th Ed.) and NCDOT LRFD Driven Pile Foundation Policy (6th Update)

PROVIDED INFORMATION

- Location of End Bent #1:
  - -L- Sta. 156+21 (Left Bridge)
  - -L- Sta. 156+29 (Ridge Bridge)
- Type of Abutment: Integral abutment
  Vertical abutment with Steel Sheet Piles
- Foundation Type: Vertical HP 12x53 steel piles
- Number of piles: 6
- Bottom of Cap (B/C) Elev. (ft): 34.6LT / 33.2 RT (Left Bridge)
  33.5 LT / 32.2 RT (Ridge Bridge)
- Design Scour Elev. (ft): 15-ft (100-Yr)
  (from BSR) 9-ft (500-Yr)

Factored Loads (Provided by Structures)

- Max Axial Load (Strength I): 195 kips per pile
- Max Axial Load (Service I): 140 kips per pile

BORING SUMMARY

Boring	Ground Surface Elev. (ft)	Top of Very Dense Layer Elev. (ft)	Groundwater Elev. (ft)	Boring Termination Elev. (ft)
EB1-A	36.9	-42.1	32.9 (1)	-63.6
EB1-B	36.8	-42.2	33.3 (2)	-63.7

(1) 0-hr Groundwater

(2) NWS = Normal Water Surface (See BSR)

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End Bent #1 (Continued)

References: AASHTO LRFD (8th Ed.) and NCDOT LRFD Driven Pile Foundation Policy (6th Update)

STRUCTURAL CAPACITY

Nominal Structural Capacity of Pile, P_n

- Use NCDOT SMU chart for preliminary estimate of nominal compressive resistance for steel piles
- Unbraced length (L) = B/C EL - DSE = 0-ft

P_n = 775 kips (for unbraced length (L) = 0.0-ft)

Factored Structural Capacity of Pile, P_r

$P_r = \phi_c P_n$ = 387.5 kips (> P_f = 195-kips)

where: ϕ_c = 0.50 — NCDOT Pile Policy 1.3.1 (severe driving conditions)

Bridge Approach Settlement

- See attached settlement calculation report.
- A 6-month waiting period is recommended to leave less than 1-in of remaining settlement.
- Two settlement gauges are required at each end bent.

DOWNDRAG

- It is recommended to drive piles after the settlement waiting peroid. Therefore, downdrag force is not anticipated to develop.

STATIC ANALYSIS

$R_n = R_f / \phi_{stat}$ = 279 kips (Use 280 kips)

where: R_f = 195 kips

ϕ_{stat} = 0.70 — NCDOT Pile Policy 3.1.1

According to the Apile results:

- The required resistance can be achieved by driving piles approximately 1-ft into the very dense SAND layer at elevation -42 feet
- Skin friction = 270 kips

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End Bent #1 (Continued)

References: AASHTO LRFD (8th Ed.) and NCDOT LRFD Driven Pile Foundation Policy (6th Update)

DYNAMIC ANALYSIS

$R_{ndr} = (R_f + \gamma DD)/\phi_{dyn} + DD$= 325 kips (Use 330 kips) = **165 tons**

where: R_f = 195 kips

ϕ_{dyn} = 0.60 NCDOT Pile Policy 3.2

γ = 1.25 NCDOT Pile Policy 6.2

DD = 0 kips

% Shaft resistance = F_{skin} / R_{ndr} = 82%

where: F_{skin} = 270 kips From static axial analysis with Apile

Min blow count = 30 bpf NCDOT Pile Policy 2.1.1

Max blow count = 180 bpf NCDOT Pile Policy 2.1.2

σ_{dr} = 45 ksi NCDOT Pile Policy 2.2.1

Hammer	Energy (kip-ft)	Max. Comp. Stress (ksi)	Max. Tensile Stress (ksi)	Stroke (ft)	Blow Count (bpf)
D 19-32	43	36	0.1	11	70

Delmag D 19-32 OK

Actual driving system to be evaluated prior to construction.

SUMMARY

Bridge	Location	B/C Elev. (ft)	Approximate Top of Very Dense Layer Elev. (ft)	Est. Pile Tip Elev. (ft)	Recommended Pile Length (ft)
Left	Left	34.6	-42.0	-43.0	80
	Right	33.2		-43.0	80
Right	Left	33.5	-42.0	-43.0	80
	Right	32.2		-43.0	80

Estimated Pile Tip Elevation = Top of Very Dense Layer EL - (1 ft)

Recommended Pile Length = (B/C EL) - (Estimated Pile Tip Elevation) + (2 ft Pile Embedment into Cap)

(Round up to nearest 5-ft)

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

                 APILE for Windows, Version 2015.7.8

                  Serial Number :  139303838

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

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


This program is licensed to :

RK&K
Raleigh, NC

Path to file locations      :
\\ad.rkk.com\fs\Cloud\Projects\2015\15213_NCEastLSA\I01_R-2511_US17\Design\Geotech\InvestigationDesign\NON_CADD\Bridge\Recommendations\EB1\Apile\
Name of input data file     : .ap7d
Name of output file         : .ap7o
Name of plot output file    : .ap7p

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

          Date:  February 21, 2021     Time:  18:47:51


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



     R-2511 Dual Bridge EB1

     DESIGNER   : AB

     JOB NUMBER : R-2511


     METHOD FOR UNIT LOAD TRANSFERS :

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



     COMPUTATION METHOD(S) FOR PILE CAPACITY :

     - FHWA (Federal Highway Administration)


     TYPE OF LOADING :
     - COMPRESSION


     PILE TYPE :

     H-Pile/Steel Pile
```

DATA FOR AXIAL STIFFNESS :

- MODULUS OF ELASTICITY = 0.290E+08 PSI
- CROSS SECTION AREA = 15.50 IN2

NONCIRCULAR PILE PROPERTIES :

- TOTAL PILE LENGTH, TL = 76.00 FT.
- PILE STICKUP LENGTH, PSL = 0.00 FT.
- ZERO FRICTION LENGTH, ZFL = 0.00 FT.
- PERIMETER OF PILE = 69.13 IN.
- TIP AREA OF PILE = 15.50 IN2
- INCREMENT OF PILE LENGTH USED IN COMPUTATION = 1.00 FT.

SOIL INFORMATIONS :

DEPTH FT.	SOIL TYPE	LATERAL EARTH PRESSURE	EFFECTIVE UNIT WEIGHT LB/CF	FRICTION ANGLE DEGREES	BEARING CAPACITY FACTOR
0.00	CLAY	0.00	57.60	0.00	0.00
76.00	CLAY	0.00	57.60	0.00	0.00
76.00	SAND	0.00	67.60	0.00	0.00
100.00	SAND	0.00	67.60	0.00	0.00

MAXIMUM UNIT FRICTION KSF	MAXIMUM UNIT BEARING KSF	UNDISTURB SHEAR STRENGTH KSF	REMOLDED SHEAR STRENGTH KSF	BLOW COUNT	UNIT SKIN FRICTION KSF	UNIT END BEARING KSF
0.10E+08*	0.10E+08*	0.80	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.80	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00

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

DEPTH FT.	LRFD FACTOR ON UNIT FRICTION	LRFD FACTOR ON UNIT BEARING
0.00	1.000	1.000
76.00	1.000	1.000
76.00	1.000	1.000
100.00	1.000	1.000

1

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* COMPUTATION RESULT *
****

****
* FED. HWY. METHOD *

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PILE PENETRATION FT.	TOTAL SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	0.4	0.4
1.00	0.0	0.4	0.4
2.00	1.8	0.5	2.3
3.00	5.4	0.8	6.2
4.00	9.0	0.8	9.8
5.00	12.6	0.8	13.4
6.00	16.3	0.8	17.0
7.00	19.9	0.8	20.6
8.00	23.5	0.8	24.2
9.00	27.1	0.8	27.9
10.00	30.7	0.8	31.5
11.00	34.3	0.8	35.1
12.00	37.9	0.8	38.7
13.00	41.5	0.8	42.3
14.00	45.1	0.8	45.9
15.00	48.8	0.8	49.5
16.00	52.4	0.8	53.1
17.00	56.0	0.8	56.8
18.00	59.6	0.8	60.4
19.00	63.2	0.8	64.0
20.00	66.8	0.8	67.6
21.00	70.4	0.8	71.2
22.00	74.0	0.8	74.8
23.00	77.6	0.8	78.4
24.00	81.3	0.8	82.0
25.00	84.9	0.8	85.6
26.00	88.5	0.8	89.3
27.00	92.1	0.8	92.9
28.00	95.7	0.8	96.5
29.00	99.3	0.8	100.1
30.00	102.9	0.8	103.7
31.00	106.5	0.8	107.3
32.00	110.1	0.8	110.9
33.00	113.8	0.8	114.5
34.00	117.4	0.8	118.1
35.00	121.0	0.8	121.8
36.00	124.6	0.8	125.4
37.00	128.2	0.8	129.0
38.00	131.8	0.8	132.6
39.00	135.4	0.8	136.2
40.00	139.0	0.8	139.8
41.00	142.6	0.8	143.4
42.00	146.3	0.8	147.0
43.00	149.9	0.8	150.6
44.00	153.5	0.8	154.3
45.00	157.1	0.8	157.9
46.00	160.7	0.8	161.5
47.00	164.3	0.8	165.1
48.00	167.9	0.8	168.7
49.00	171.5	0.8	172.3
50.00	175.1	0.8	175.9
51.00	178.8	0.8	179.5
52.00	182.4	0.8	183.1
53.00	186.0	0.8	186.8
54.00	189.6	0.8	190.4
55.00	193.2	0.8	194.0
56.00	196.8	0.8	197.6
57.00	200.4	0.8	201.2
58.00	204.0	0.8	204.8
59.00	207.7	0.8	208.4
60.00	211.3	0.8	212.0
61.00	214.9	0.8	215.6
62.00	218.5	0.8	219.3
63.00	222.1	0.8	222.9

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64.00	225.7	0.8	226.5
65.00	229.3	0.8	230.1
66.00	232.9	0.8	233.7
67.00	236.5	0.8	237.3
68.00	240.2	0.8	240.9
69.00	243.8	0.8	244.5
70.00	247.4	0.8	248.2
71.00	251.0	0.8	251.8
72.00	254.6	0.8	255.4
73.00	258.2	0.8	259.0
74.00	261.8	0.8	262.6
75.00	265.4	0.8	266.2
76.00	269.0	0.8	269.9

NOTES:

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

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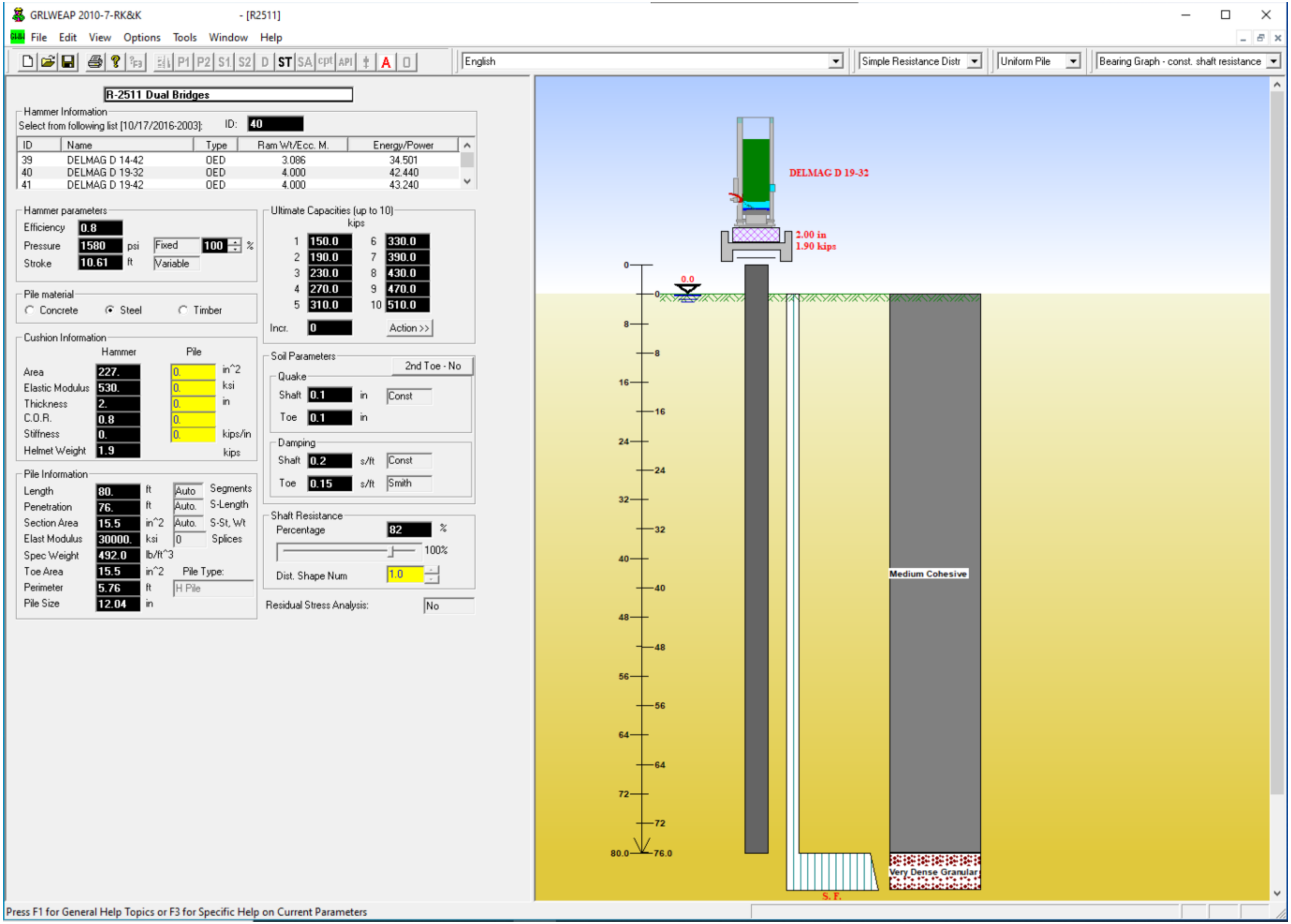

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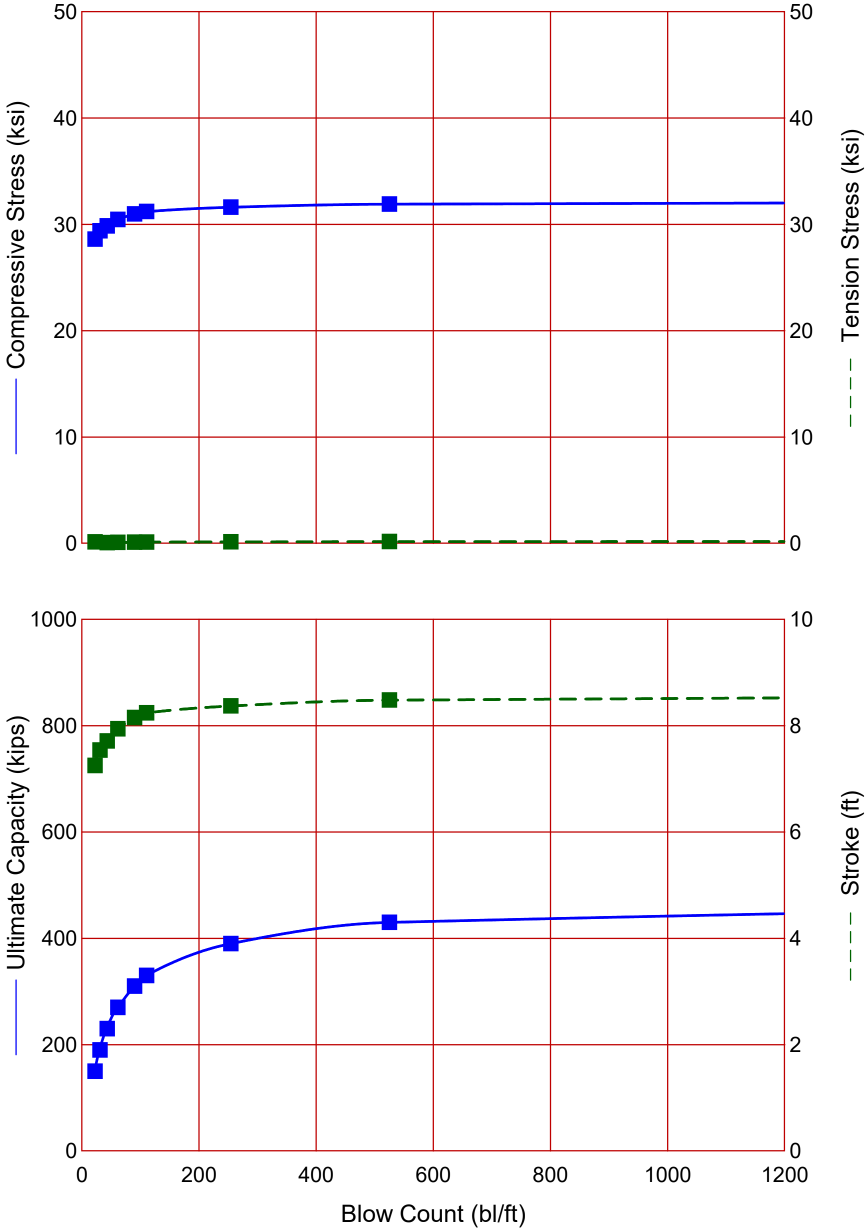
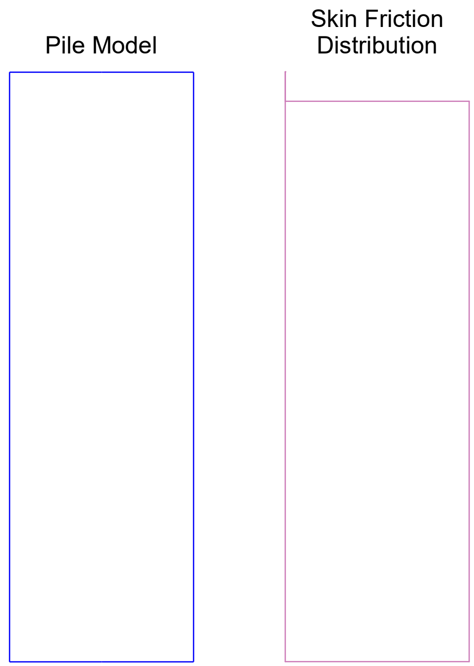


DELMAG D 19-32

Ram Weight	4.00	kips
Efficiency	0.800	
Pressure	1580 (100%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	60155	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.100	in
Skin Damping	0.200	s/ft
Toe Damping	0.150	s/ft
Pile Length	80.00	ft
Pile Penetration	76.00	ft
Pile Top Area	15.50	in2



Res. Shaft = 123.0 kips
(Constant Res. Shaft)

RK&K
R-2511 Dual Bridges

24-Feb-2021
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
150.0	28.60	0.13	23.1	7.25	17.61
190.0	29.39	0.00	31.4	7.54	17.52
230.0	29.85	0.06	43.7	7.71	17.89
270.0	30.45	0.09	62.0	7.94	18.42
310.0	30.97	0.11	90.4	8.15	18.95
330.0	31.20	0.12	111.1	8.24	19.18
390.0	31.61	0.15	254.8	8.37	19.47
430.0	31.90	0.17	525.5	8.48	19.78
470.0	32.15	0.19	2759.4	8.58	19.98
510.0	32.27	0.21	9999.0	8.62	20.13

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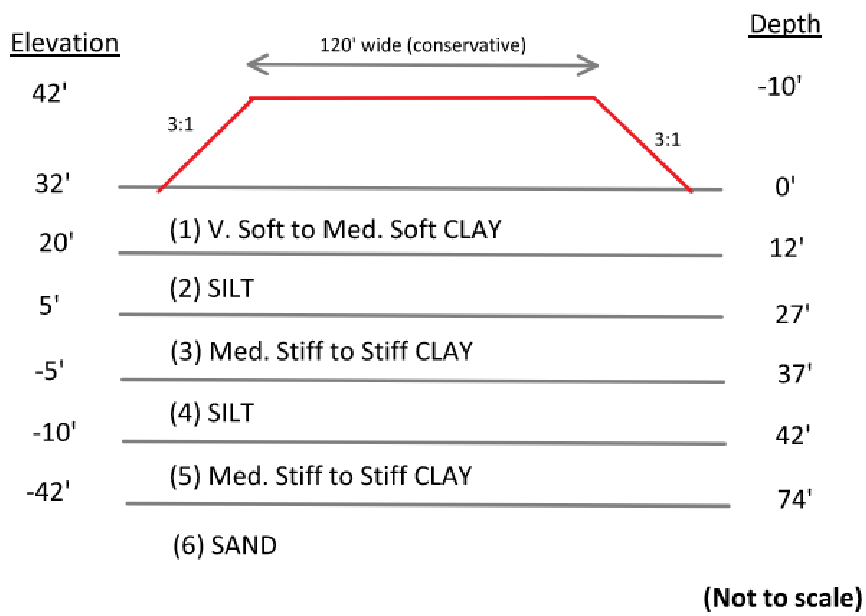
REVISED
4/5/2021

R-2511
Left Bridge Settlement Summary:

- A 6-month waiting period is expected to reach less than 1-in of remaining settlement.
- This analysis is for both end bents.
- See the inventory report for the boring plan and subsurface profile.
- The subsurface profile under the bridge is assumed to be:



Consolidation tests:

- -L-Sta. 156+79: Two samples were tested (Sample A and Sample B) from a tube roughly between 11'-6" and 11'-9"; Sample ST-2A and Sample ST-2B.
- -L-Sta. 159+00: One sample (ST-2) was tested from a tube taken from 5.5'-7.5'.

-The consolidation coefficients of the three samples are calculated/summarized on the attached sheets.
-Samples ST-2A and ST-2B test results were fairly similar. Therefore, Sample A was used for both CLAY layers (No. 1 and No. 3) in the consolidation settlement results presented here.
-Layer No. 5 includes silty sandy CLAY with trace gravel. Similar materials had been encountered in a boring at Sta. 159+00. Therefore
-See attached NCDOT Spreadsheet for the settlement analysis.

Summary of the results:

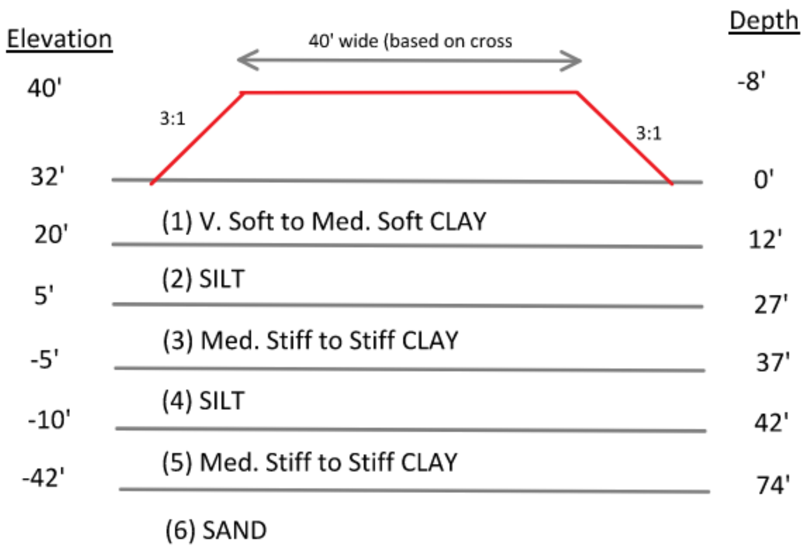
- Total Settlement = 11.5-in
- Time:
  - About 150-days to reach U=90%
  - About 180-days to reach less than 1-in of remaining settlement (criteria for bridge approach slabs*)

*This criteria is usually noted in the NCDOT RFPs for Design-Build projects.

REVISED
4/5/2021

R-2511
Right Bridge Settlement Summary

- A 4-month waiting period is expected to reach less than 1-in of remaining settlement.
- This analysis is for both end bents.
- See the inventory report for the boring plan and subsurface profile.
- The subsurface profile under the bridge is assumed to be:



(Not to scale)

Consolidation tests:

- -L-Sta. 156+79: Two samples were tested (Sample A and Sample B) from a tube roughly between 11'-6" and 11'-9"; Sample ST-2A and Sample ST-2B.
- -L-Sta. 159+00: One sample (ST-2) was tested from a tube taken from 5.5'-7.5'.

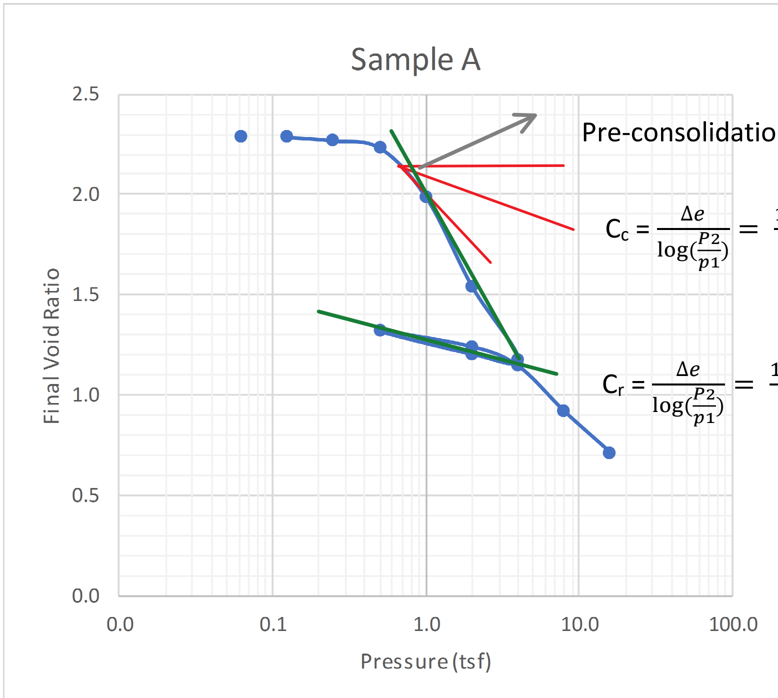
-The consolidation coefficients of the three samples are calculated/summarized on the attached sheets.
-Samples ST-2A and ST-2B test results were fairly similar. Therefore, Sample A was used for both CLAY layers (No. 1 and No. 3) in the consolidation settlement results presented here.
-Layer No. 5 includes silty sandy CLAY with trace gravel. Similar materials had been encountered in a boring at Sta. 159+00. Therefore
-See attached NCDOT Spreadsheet for the settlement analysis.

Summary of the results:

- Total Settlement = 9.3-in
- Time:
  - About 120-days to reach U=90%
  - About 120-days to reach less than 1-in of remaining settlement (criteria for bridge approach slabs*)

*This criteria is usually noted in the NCDOT RFPs for Design-Build projects.

Sample ST-2A



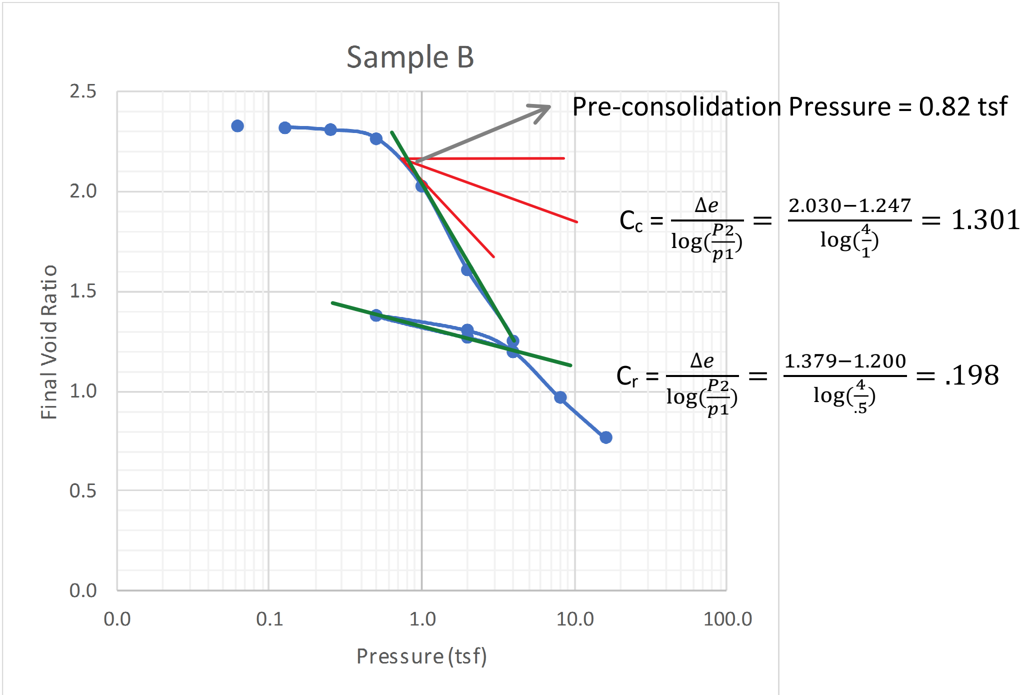
Pre-consolidation Pressure = 0.78 tsf

$$C_c = \frac{\Delta e}{\log(\frac{P2}{p1})} = \frac{1.987-1.179}{\log(\frac{4}{1})} = 1.337$$

$$C_r = \frac{\Delta e}{\log(\frac{P2}{p1})} = \frac{1.32-1.145}{\log(\frac{4}{.5})} = 0.194$$

Index	Loading Sequence (tsf)	Void Ratio	T90 Cv (in²/Min)
0	0.0000	2.296	0.00000
1	0.0625	2.289	0.00000
2	0.1250	2.283	0.14604
3	0.2500	2.267	0.16884
4	0.5000	2.230	0.13863
5	1.0000	1.984	0.02960
6	2.0000	1.539	0.00482
7	4.0000	1.179	0.00218
8	2.0000	1.205	0.00000
9	0.5000	1.320	0.00000
10	2.0000	1.242	0.00586
11	4.0000	1.145	0.00431
12	8.0000	0.920	0.00088
13	16.0000	0.715	0.00015

Sample ST2-B



Index	Loading Sequence (tsf)	Void Ratio	T90 Cv (in²/Min)
0	0.0000	2.327	0.00000
1	0.0625	2.326	0.00000
2	0.1250	2.321	0.58661
3	0.2500	2.307	0.06872
4	0.5000	2.267	0.15983
5	1.0000	2.030	0.01834
6	2.0000	1.607	0.00382
7	4.0000	1.247	0.00231
8	2.0000	1.270	0.00000
9	0.5000	1.379	0.00000
10	2.0000	1.305	0.00737
11	4.0000	1.200	0.00363
12	8.0000	0.972	0.00096
13	16.0000	0.768	0.00022

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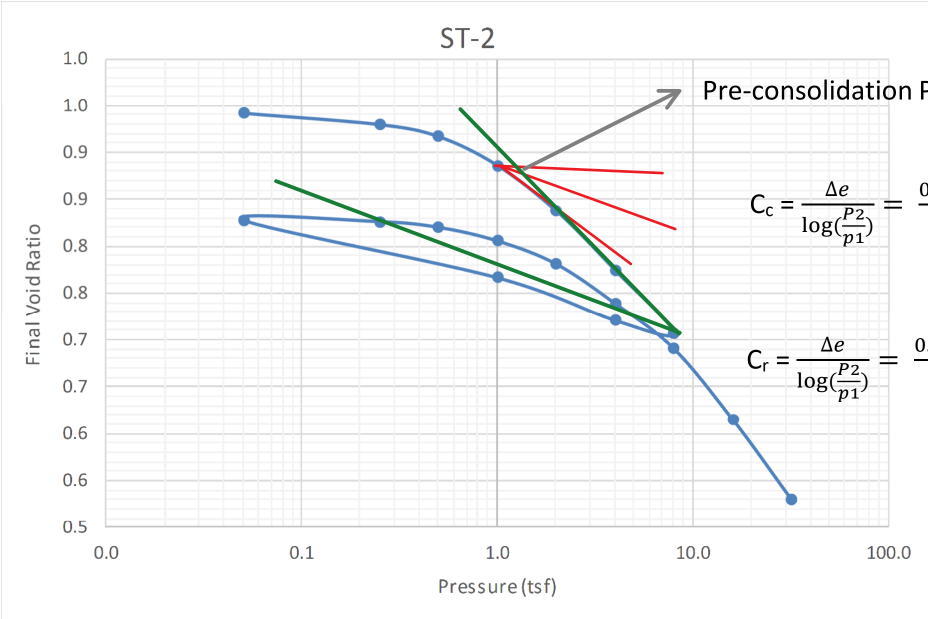
Sample ST-2



$$C_c = \frac{\Delta e}{\log(\frac{P2}{p1})} = \frac{0.8381-0.7075}{\log(\frac{8}{2})} = .217$$

$$C_r = \frac{\Delta e}{\log(\frac{P2}{p1})} = \frac{0.8262-0.7393}{\log(\frac{4}{0.25})} = 0.07$$

Index	Stress (TSF)	Voids Ratio (ef)	Cv (ft2/day)
1	0.050	0.9418	0.417
2	0.250	0.9297	0.018
3	0.500	0.9171	0.021
4	1.000	0.8865	0.018
5	2.000	0.8381	0.010
6	4.000	0.7749	0.010
7	8.000	0.7075	0.009
8	4.000	0.7210	
9	1.000	0.7667	
10	0.050	0.8282	
11	0.250	0.8262	0.048
12	0.500	0.8202	0.020
13	1.000	0.8058	0.010
14	2.000	0.7813	0.009
15	4.000	0.7393	0.008
16	8.000	0.6910	0.008
17	16.000	0.6155	0.006
18	32.000	0.5301	0.005

Summary of Consolidation test results

Boring Number			EB2-A2		L 158+80 RT*
Alignment			-L-		-L-
Station			156+79		158+80
Offset			52' LT		46' RT
Sample No. (in the geotech report)			ST-2A	ST-B	ST-2
Blow Count			5		4
Shelby tube depth			10.0 - 12.0		5.5-7.5
Sample depth	*D (ft)*		11.5	11.8	6.5
AASHTO Class			A-7-6		A-7-6
PI			47		34
Liquid limit	*LL*		71		53
Dry Unit weight	γ_{dry} *(pcf)*		50.6	50.1	86.1
Unit weight	γ_{moist} *(pcf)*		91.3	91.7	116.3
Moisture content	*w (%)*		80.4	83.1	35.1
Degree of saturation	S_r *(%)*		93.5	95.4	99.7
Initial void ratio - e_0	e_0		2.30	2.33	0.94
Preconsolidation pressure	σ'_P *(ksf)*		1.56	1.64	2.4
Vertical (effective) overburden stress	σ'_{v0} *(ksf)*		1.05	1.08	0.76
Overconsolidation ratio	*OCR*		1.49	1.52	3.17
Coefficient of compression index	C_c	*lab*	1.337	1.301	0.217
		Correlation	0.55		0.39
Coefficient of recompression index	C_r	*lab*	0.194	0.198	0.07
		Correlation	0.11		0.08
Coefficient of secondary compression	C_α	*Correlation*	0.040	0.039	0.01
Coefficient of consolidation	c_v *(ft^2/day)*	*lab*	0.3 (for 1 TSF)	0.2 (for 1 TSF)	0.02 (fot 1 TSF)
		Correlation	-		0.60

* Lab results are included in the roadway inventory report.

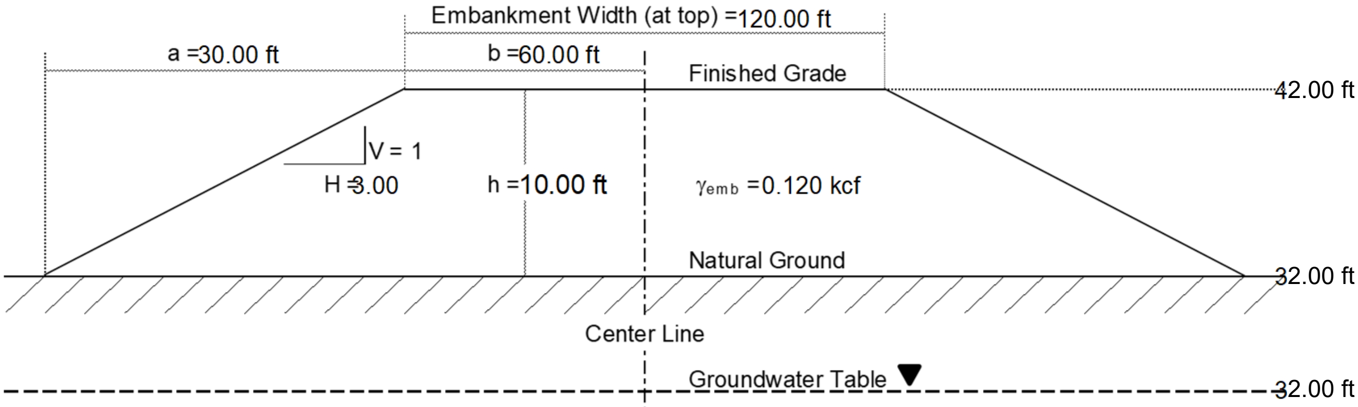
Correlations:

Coefficient of compression index: Cc = 0.009*(LL-10)
Coefficient of recompression index: Cr = 0.2*Cc
Coefficient of secondary compression: Cα = .03*Cc
Coefficient of consolidation: FHWA NHI-06-088 - Figure 5-10

DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNIT
1589 MAIL SERVICE CENTER
RALEIGH, NC 27699

T: R-2511 COUNTY:
SUBJECT: Settlement Calculations for Roadway Embankments (Consolidation Theory)
Dual Bridge over US17 (Left Lane Bridge)
PREPARED BY: AB DATE: 11/23/20 STATION:
CHECKED BY: MS DATE: 11/23/20 STR. NO.: PAGE: 1 OF 8

DISCLAIMER: *The application of this spreadsheet is the responsibility of the user. It is imperative that the user understands the potential accuracy limitations and examines the reasonableness of the results with engineering knowledge and experience. There are no expressed or implied warranties.*



Typical Embankment (Not to Scale)

General Project Information

Units System = English   Embankment Side Slope (H:V) = 3 : 1   Service Life of Structure = 50 years

Finished Grade Elev. =	42.0 ft	Embankment Width (at top) =	120.0 ft
Natural Ground Elev. =	32.0 ft	Embankment Unit Weight =	0.120 kcf
Groundwater Table Elev. =	32.0 ft	Unit Weight of Water =	0.0624 kcf

Consolidation Information

Check box if no specific lab test data is available to determine parameters

	Name of Test Sample or Description of Cohesive Material if not using test sample	☐	OCR	Sample Depth (ft)	ρ_c (ksf)	e_o	C_c	C_r	c_v (ft^2/day)	C_α
1	Sample A	☐		11.5	1.560	2.300	1.337	0.194	0.300	0.04011
2	Sample B	☐		11.8	1.640	2.330	1.301	0.198	0.200	0.03903
3	Correlation	☑	2.35			0.940	0.200	0.070	0.600	0.01000
4		☐								
5		☐								

Existing Soil Layer Information

Soil Layer No.	Soil Layer Material Description	Layer Elevations Top (ft)	Layer Elevations Bottom (ft)	Total Unit Wt. (kcf)	Depth to Midpoint (ft)	Select Test Sample Number to use for Soil Layer
1	Cohesive Soil (Clay)	32.0	20.0	0.092	6.0	1 - Sample A
2	Cohesionless Soil (Sand)	20.0	5.0	0.120	19.5	N/A - Layer is Cohesionless
3	Cohesive Soil (Clay)	5.0	-5.0	0.092	32.0	1 - Sample A
4	Cohesionless Soil (Sand)	-5.0	-10.0	0.120	39.5	N/A - Layer is Cohesionless
5	Cohesive Soil (Clay)	-10.0	-42.0	0.116	58.0	3 - Correlation
6	Cohesionless Soil (Sand)	-42.0	-45.0	0.120	75.5	N/A - Layer is Cohesionless
7						
8						
9						
10						

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Calculate the total increase in vertical stress due to the weight of the embankment

$\Delta\rho$ = total stress increase from embankment fill = $(h)(\gamma_{emb})$ = 1.200 ksf

h = height of embankment = 10.0 ft

γ_{emb} = unit weight of embankment = 0.120 kcf

Calculate initial vertical stress, vertical stress increase, and final vertical stress at the center of each soil layer

$\rho_{o(n)}$ = initial effective vertical stress at the center of layer n

= initial total vertical stress - pore water pressure at the center of layer n

$\Delta\rho_{(n)}$ = stress increase from embankment fill at the center of layer n = $2(I)(\Delta\rho)$

I = influence factor for stress underneath an embankment *NAVFAC DM-7.01, p. 7.1-170 (Figure 6)*

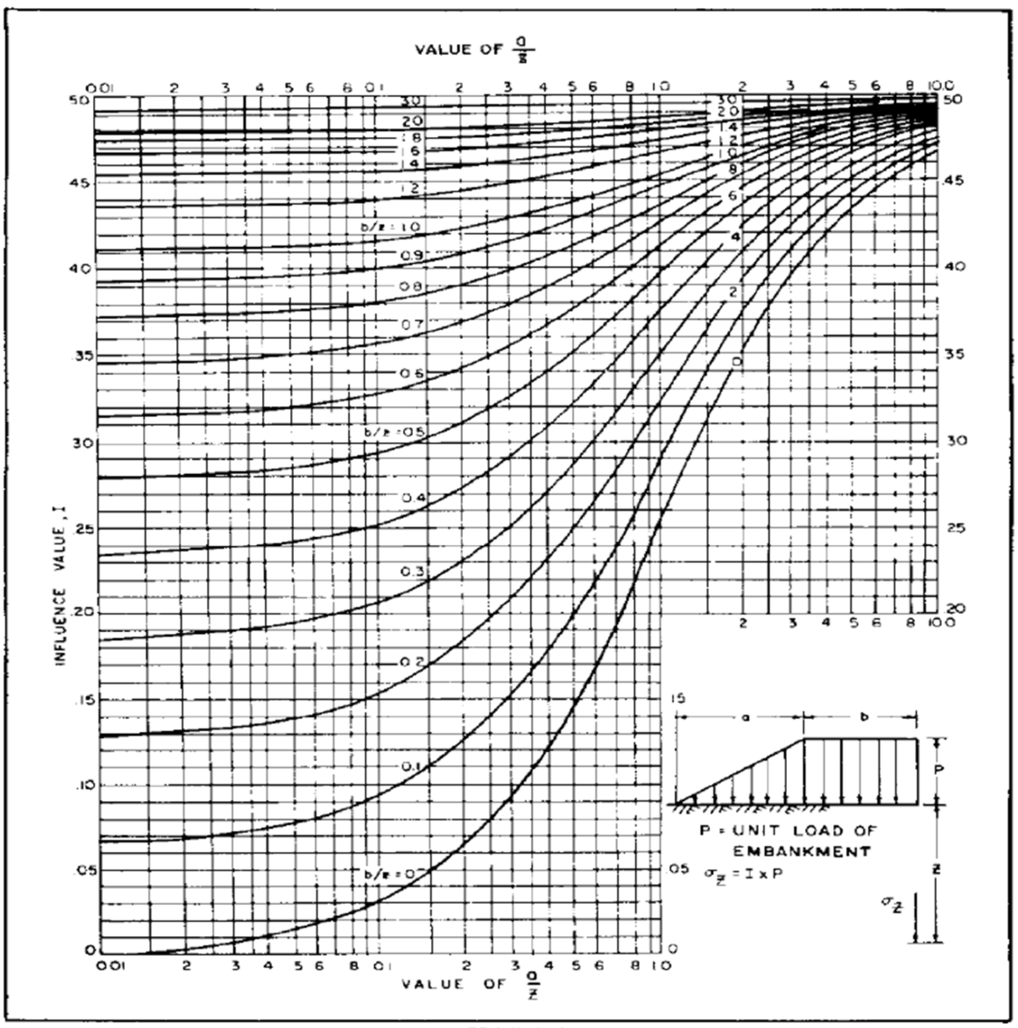

FIGURE 6
Influence Value for Vertical Stress Under Embankment Load of Infinite Length
(Boussinesq Case)

Notes about Fig 6

(1) I from Fig 6 is only for half of the embankment. Use I x 2 to calculate influence factor for whole embankment.

(2) Numerical methods that replicate the values in Fig 6 were used to calculate I values in this spreadsheet. See "Murthy, V.N.S., Geotechnical Engineering: Principles and Practices of Soil Mechanics and Engineering, Chapter 6.

$\Delta\rho$ = total stress increase from embankment fill = 1.200 ksf

$\rho_{f(n)}$ = final effective vertical stress at the center of layer n = $\rho_{o(n)} + \Delta\rho_{(n)}$

T: R-2511 COUNTY:

DEPARTMENT OF TRANSPORTATION SUBJECT: Settlement Calculations for Roadway Embankments (Consolidation Theory)

GEOTECHNICAL ENGINEERING UNIT Dual Bridge over US17 (Left Lane Bridge)

1589 MAIL SERVICE CENTER PREPARED BY: AB DATE: 11/23/20 STATION:

RALEIGH, NC 27699 CHECKED BY: MS DATE: 11/23/20 STR. NO.:

Calculate initial vertical stress, vertical stress increase, and final vertical stress at the midpoint of each soil layer (con'

Soil Layer No.	Layer Thickness Δz (ft)	Depth to Center z (ft)	γ (kcf)	Total Stress (ksf)	Pore Water Pressure (ksf)	$\rho_{o(n)}$ (ksf)	$\frac{a}{z}$	$\frac{b}{z}$	$2(I)$	$\Delta\rho_{(n)}$ (ksf)	$\rho_{f(n)}$ (ksf)
1	12.0	6.0	0.092	0.552	0.374	0.178	5.0	10.0	1.000	1.200	1.4
2	15.0	19.5	0.120	2.004	1.217	0.787	1.5	3.1	0.993	1.191	2.0
3	10.0	32.0	0.092	3.364	1.997	1.367	0.9	1.9	0.971	1.166	2.5
4	5.0	39.5	0.120	4.124	2.465	1.659	0.8	1.5	0.951	1.142	2.8
5	32.0	58.0	0.116	6.280	3.619	2.661	0.5	1.0	0.885	1.062	3.7
6	3.0	75.5	0.120	8.316	4.711	3.605	0.4	0.8	0.812	0.974	4.6

Determine the overconsolidation ratio, degree of consolidation, and the overconsolidation margin for each test sampl

$$OCR = \text{overconsolidation ratio} = \frac{\rho_c}{\rho_o} = \frac{\text{preconsolidation pressure of the test sample}}{\text{initial effective vertical stress at the depth of the test sample}}$$

ρ_m = overconsolidation margin = $\rho_c - \rho_o$ *ρ_m = 0 for normally consolidated soils*

Test Sample / Consolidation Parameters Used	Depth (ft)	ρ_o (ksf)	ρ_c (ksf)	OCR	Degree of Consolidation	ρ_m (ksf)
1 - Sample A	11.5	0.340	1.560	4.58	overconsolidated (OCR > 1.2)	1.220
2 - Sample B	11.8	0.349	1.640	4.70	overconsolidated (OCR > 1.2)	1.291
3 - Correlation	N/A	N/A	N/A	2.35	overconsolidated (OCR > 1.2)	N/A

Determine the preconsolidation pressure and overconsolidation ratio at the midpoint of each cohesive soil layer

ρ_c = preconsolidation pressure at the center of layer n = $\rho_o + \rho_m$

Soil Layer No.	Soil Layer Material Description	Test Sample / Consolidation Parameters used for Soil Layer	ρ_o (ksf)	ρ_m (ksf)	ρ_c (ksf)	OCR
1	Cohesive Soil (Clay)	1 - Sample A	0.178	1.560	1.738	9.78
2	Cohesionless Soil (Sand)	N/A	N/A	N/A	N/A	N/A
3	Cohesive Soil (Clay)	1 - Sample A	1.367	1.560	2.927	2.14
4	Cohesionless Soil (Sand)	N/A	N/A	N/A	N/A	N/A
5	Cohesive Soil (Clay)	3 - Correlation	2.661	N/A	6.253	2.35
6	Cohesionless Soil (Sand)	N/A	N/A	N/A	N/A	N/A

DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNIT
1589 MAIL SERVICE CENTER
RALEIGH, NC 27699

Calculate the primary consolidation settlement at the midpoint of each cohesive soil layer

For normally consolidated soils, $\rho_c \approx \rho_o$ (0.8 ≤ OCR ≤ 1.2)

$$S_c = \sum_i^n \frac{C_c}{1+e_o} H_o \log_{10}\left(\frac{\rho_f}{\rho_o}\right)$$

FHWA NHI-06-089 Eq. 7-2

For overconsolidated soils where, $\rho_0 < \rho_c \le \rho_f$ (OCR > 1.2)

$$S_c = \sum_i^n \frac{H_o}{1+e_o}\left(C_r \log_{10}\frac{\rho_c}{\rho_o} + C_c \log_{10}\frac{\rho_f}{\rho_c}\right)$$

FHWA NHI-06-089 Eq. 7-4

For overconsolidated soils where, $\rho_0 < \rho_f \le \rho_c$ (OCR > 1.2)

$$S_c = \sum_i^n \frac{C_r}{1+e_o} H_o \log_{10}\left(\frac{\rho_f}{\rho_o}\right)$$

FHWA NHI-06-089 Eq. 7-2
(modified per FHWA NHI-06-089 p. A.6.9-10)

For underconsolidated soils, $\rho_c < \rho_o$ (OCR < 0.8)

$$S_c = \sum_i^n \frac{H_o}{1+e_o}\left(C_c \log_{10}\frac{\rho_o}{\rho_c} + C_c \log_{10}\frac{\rho_f}{\rho_o}\right)$$

FHWA NHI-06-089 Eq. 7-6

Where,
S_c = settlement
H_o = layer thickness
e_o = initial void ratio
C_c = compression index
C_r = recompression index
ρ_o = initial effective vertical stress at the center of layer n
ρ_f = final effective vertical stress at the center of layer n
ρ_c = preconsolidation pressure at the center of layer n

Soil Layer No.	H_o (ft)	ρ_o (ksf)	ρ_c (ksf)	ρ_f (ksf)	OCR	FHWA Settlement Equation	e_o	C_c	C_r	δ (in)
1	12.0	0.178	1.738	1.377	9.78	FHWA Eq. 7-2 (modified)	2.300	1.337	0.194	7.53
2	15.0	N/A	N/A	N/A	N/A	N/A (Cohesionless Layer)	N/A	N/A	N/A	0.00
3	10.0	1.367	2.927	2.533	2.14	FHWA Eq. 7-2 (modified)	2.300	1.337	0.194	1.89
4	5.0	N/A	N/A	N/A	N/A	N/A (Cohesionless Layer)	N/A	N/A	N/A	0.00
5	32.0	2.661	6.253	3.723	2.35	FHWA Eq. 7-2 (modified)	0.940	0.200	0.070	2.02
6	3.0	N/A	N/A	N/A	N/A	N/A (Cohesionless Layer)	N/A	N/A	N/A	0.00

Total Primary Consolidation Settlement = 11.44 in

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STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
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RALEIGH, NC 27699

Calculate the time rate of settlement for the cohesive layers to reach 90% consolidation, (t_{90})

$$t = \frac{T_v H_d^2}{c_v}$$ *FHWA NHI-06-089 Eq. 7-8*

Where, t = time

T_v = time factor based on the percent consolidation (U) *FHWA NHI-06-089 Table 7-4*

c_v = coefficient of consolidation

H_d = length of longest drainage path in compressible layer *AASHTO 10.6.2.4.3, page 10-61*

The length of the drainage path is the longest distance from any point in a compressible layer to a drainage boundary at the top or bottom of the compressible soil unit. Where a compressible layer is located between two drainage boundaries, H_d equals one-half the actual height of the layer. Where a compressible layer is adjacent to an impermeable boundary (usually below), H_d equals the full height of the layer. (AASHTO 10.6.2.4.3, page 10-61)

Where a compressible layer is not adjacent to a drainage boundary, H_d will include the full height of any additional layers that are necessary to reach a drainage boundary. For this situation the calculation of t becomes;

$$t = T_v \Sigma(H_{di}^2/c_{vi})$$

Layer No.	Material Description	Layer Thickness H_0 (ft)	Drainage Path H_d (ft)	c_v (ft²/day)	$\Sigma (H_d^2/c_v)$ (days)	At 90% Consolidation: Time Factor T_v	Time (t_{90}) (days)	Settlement (S_{c_90}) (in)
1	Cohesive Soil (Clay)	12.00	6.00	0.300	120	0.848	102	6.777
2	Cohesionless Soil (Sand)	15.00	N/A	N/A	N/A	N/A	N/A	N/A
3	Cohesive Soil (Clay)	10.00	5.00	0.300	83	0.848	71	1.701
4	Cohesionless Soil (Sand)	5.00	N/A	N/A	N/A	N/A	N/A	N/A
5	Cohesive Soil (Clay)	32.00	16.00	0.600	427	0.848	362	1.818
6	Cohesionless Soil (Sand)	3.00	N/A	N/A	N/A	N/A	N/A	N/A
7								
8								
9								
10								

DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNIT
1589 MAIL SERVICE CENTER
RALEIGH, NC 27699

T: R-2511 COUNTY:
SUBJECT: Settlement Calculations for Roadway Embankments (Consolidation Theory)
Dual Bridge over US17 (Left Lane Bridge)
PREPARED BY: AB DATE: 11/23/20 STATION:
CHECKED BY: MS DATE: 11/23/20 STR. NO.:

Calculate the Overall Percent Consolidation as a function of time

$$T_v = \frac{tc_v}{H_d^2} = \Sigma\, t(c_v / H_d^2)$$

Rearranging FHWA NHI-06-089 Eq. 7-8 and solving for T_v

Layer No.	Σ (H^2/c_v) (days)	Time Factor (T_v) for different values of time (t) — Time, t (days): 60	120	180	240	300	360	420	480	540	600
1	120.000	0.500	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500	5.000
3	83.333	0.720	1.440	2.160	2.880	3.600	4.320	5.040	5.760	6.480	7.200
5	426.667	0.141	0.281	0.422	0.563	0.703	0.844	0.984	1.125	1.266	1.406

Time Factor (T), Percent Consolidation (U), and Primary Consolidation Settlement (S_c) for different values of time

Soil Layer		Time, t (days): 60	120	180	240	300	360	420	480	540	600
1	T_v =	0.500	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500	5.000
	U =	76%	93%	98%	99%	100%	100%	100%	100%	100%	100%
	S_c =	5.723	7.003	7.379	7.455	7.53	7.53	7.53	7.53	7.53	7.53
2	T =	0.720	1.440	2.160	2.880	3.600	4.320	5.040	5.760	6.480	7.200
	U =	86%	98%	100%	100%	100%	100%	100%	100%	100%	100%
	S_c =	1.625	1.852	1.89	1.89	1.89	1.89	1.89	1.89	1.89	1.89
3	T =	0.141	0.281	0.422	0.563	0.703	0.844	0.984	1.125	1.266	1.406
	U =	42%	60%	71%	80%	86%	90%	93%	95%	96%	97%
	S_c =	0.848	1.212	1.434	1.616	1.737	1.818	1.879	1.919	1.939	1.959
4	T =										
	U =										
	S_c =										
5	T =										
	U =										
	S_c =										
6	T =										
	U =										
	S_c =										
7	T =										
	U =										
	S_c =										
8	T =										
	U =										
	S_c =										
Total	S_c =	8.196	10.067	10.703	10.961	11.157	11.238	11.299	11.339	11.359	11.379
	U =	72%	88%	94%	96%	98%	98%	99%	99%	99%	99%

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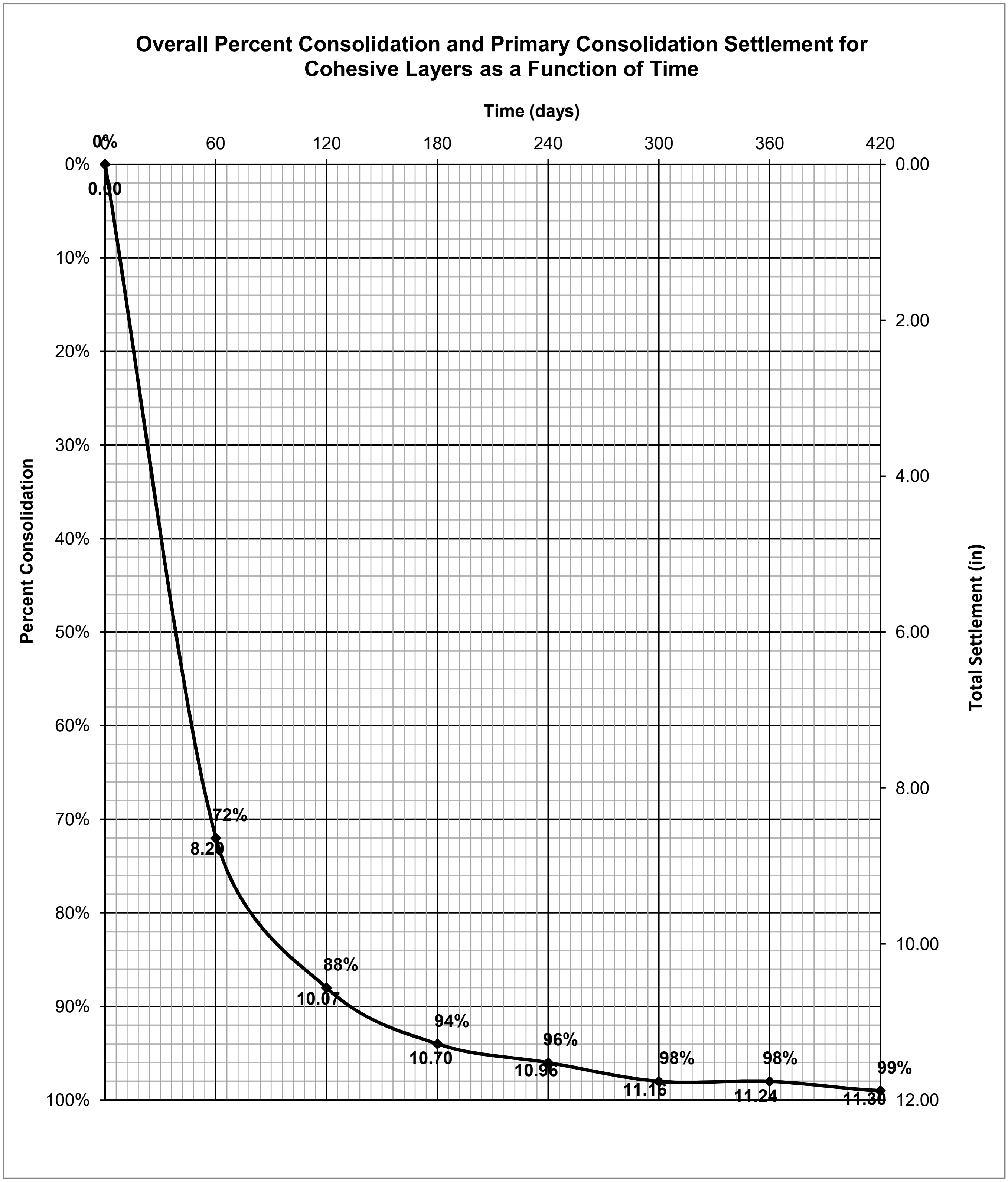
Overall Percent Consolidation and Consolidation Settlement as a function of time



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DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNIT
1589 MAIL SERVICE CENTER
RALEIGH, NC 27699

SUBJECT: Settlement Calculations for Roadway Embankments (Consolidation Theory)
Dual Bridge over US17 (Left Lane Bridge)
PREPARED BY: AB DATE: 11/23/20 STATION:
CHECKED BY: MS DATE: 11/23/20 STR. NO.:

Calculate the amount of secondary compression

$$S_s = \frac{C_\alpha}{1+e_o} H_c \log_{10}\frac{t_2}{t_1}$$

FHWA NHI-06-089 Equation 7-10

Where, S_c = secondary compression
C_α = coefficient of secondary compression
The values of C_α can be determined using FHWA NHI-06-089 Equation 7-9 or by using the ratio of C_α / C_c presented in FHWA-NHI-06-089 Section 5.4.6.4.
e_o = initial void ratio
H_c = layer thickness
t_1 = time when approximately 90% of primary compression has occurred for the actual clay layer being considered as determined from FHWA NHI-06-089 Equation 7-8.
t_2 = the service life of the structure or any other time of interest (typically assumed to be 50 years)
If t_1 is greater than t_2, then there will be no secondary compression in that soil layer.

Soil Layer No.	Soil Layer Material Description	Layer Elevations		C_a	e_o	H_c	t_1	t_2	δ_S
		Top (ft)	Bottom (ft)			(ft)	(years)	(years)	(in)
1	Cohesive Soil (Clay)	32.00	20.0	0.04011	2.300	12	50.00	50.00	0
2	Cohesionless Soil (Sand)	20.00	5.0	N/A	N/A	15	50.00	50.00	N/A
3	Cohesive Soil (Clay)	5.00	-5.0	0.04011	2.300	10	50.00	50.00	0
4	Cohesionless Soil (Sand)	-5.00	-10.0	N/A	N/A	5	50.00	50.00	N/A
5	Cohesive Soil (Clay)	-10.00	-42.0	0.01	0.940	32	50.00	50.00	0
6	Cohesionless Soil (Sand)	-42.00	-45.0	N/A	N/A	3	50.00	50.00	N/A
7									
8									
9									
10									

Total Secondary Consolidation Settlement= 0.00 in

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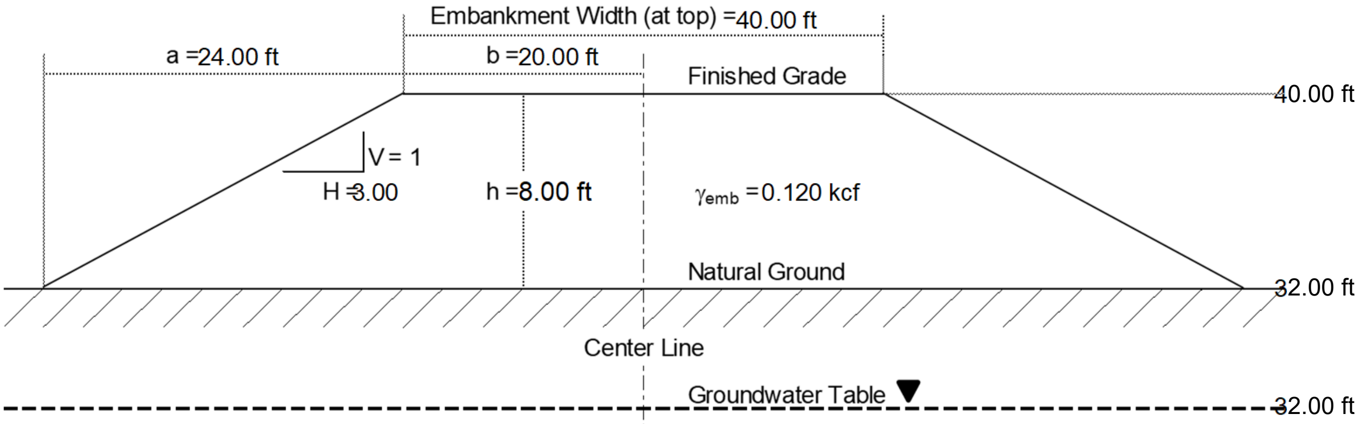
T: R-2511 COUNTY:

DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNIT
1589 MAIL SERVICE CENTER
RALEIGH, NC 27699

SUBJECT: Settlement Calculations for Roadway Embankments (Consolidation Theory)
Dual Bridge over US17 (Right Lane Bridge) ADDED

PREPARED BY: MS DATE: 03/30/21 STATION: 4/5/2021
CHECKED BY: AA DATE: 03/31/21 STR. NO.: PAGE: 1 OF 8

DISCLAIMER: *The application of this spreadsheet is the responsibility of the user. It is imperative that the user understands the potential accuracy limitations and examines the reasonableness of the results with engineering knowledge and experience. There are no expressed or implied warranties.*



Typical Embankment (Not to Scale)

General Project Information

Units System = English   Embankment Side Slope (H:V) = 3 : 1   Service Life of Structure = 50 years

Finished Grade Elev. =	40.0 ft	Embankment Width (at top) =	40.0 ft
Natural Ground Elev. =	32.0 ft	Embankment Unit Weight =	0.120 kcf
Groundwater Table Elev. =	32.0 ft	Unit Weight of Water =	0.0624 kcf

Consolidation Information

Check box if no specific lab test data is available to determine parameters

	Name of Test Sample or Description of Cohesive Material if not using test sample		OCR	Sample Depth (ft)	ρ_c (ksf)	e_o	C_c	C_r	c_v (ft^2/day)	C_α
1	Sample A	☐		11.5	1.560	2.300	1.337	0.194	0.300	0.04011
2	Sample B	☐		11.8	1.640	2.330	1.301	0.198	0.200	0.03903
3	Correlation	☑	2.35			0.940	0.200	0.070	0.600	0.01000
4		☐								
5		☐								

Existing Soil Layer Information

Soil Layer No.	Soil Layer Material Description	Layer Elevations Top (ft)	Layer Elevations Bottom (ft)	Total Unit Wt. (kcf)	Depth to Midpoint (ft)	Select Test Sample Number to use for Soil Layer
1	Cohesive Soil (Clay)	32.0	20.0	0.092	6.0	1 - Sample A
2	Cohesionless Soil (Sand)	20.0	5.0	0.120	19.5	N/A - Layer is Cohesionless
3	Cohesive Soil (Clay)	5.0	-5.0	0.092	32.0	1 - Sample A
4	Cohesionless Soil (Sand)	-5.0	-10.0	0.120	39.5	N/A - Layer is Cohesionless
5	Cohesive Soil (Clay)	-10.0	-42.0	0.116	58.0	3 - Correlation
6	Cohesionless Soil (Sand)	-42.0	-45.0	0.120	75.5	N/A - Layer is Cohesionless
7						
8						
9						
10						

Calculate the total increase in vertical stress due to the weight of the embankment

$\Delta\rho$ = total stress increase from embankment fill = $(h)(\gamma_{emb})$ = 0.960 ksf

h = height of embankment = 8.0 ft

γ_{emb} = unit weight of embankment = 0.120 kcf

Calculate initial vertical stress, vertical stress increase, and final vertical stress at the center of each soil layer

$\rho_{o(n)}$ = initial effective vertical stress at the center of layer n

= initial total vertical stress - pore water pressure at the center of layer n

$\Delta\rho_{(n)}$ = stress increase from embankment fill at the center of layer n = $2(I)(\Delta\rho)$

I = influence factor for stress underneath an embankment *NAVFAC DM-7.01, p. 7.1-170 (Figure 6)*

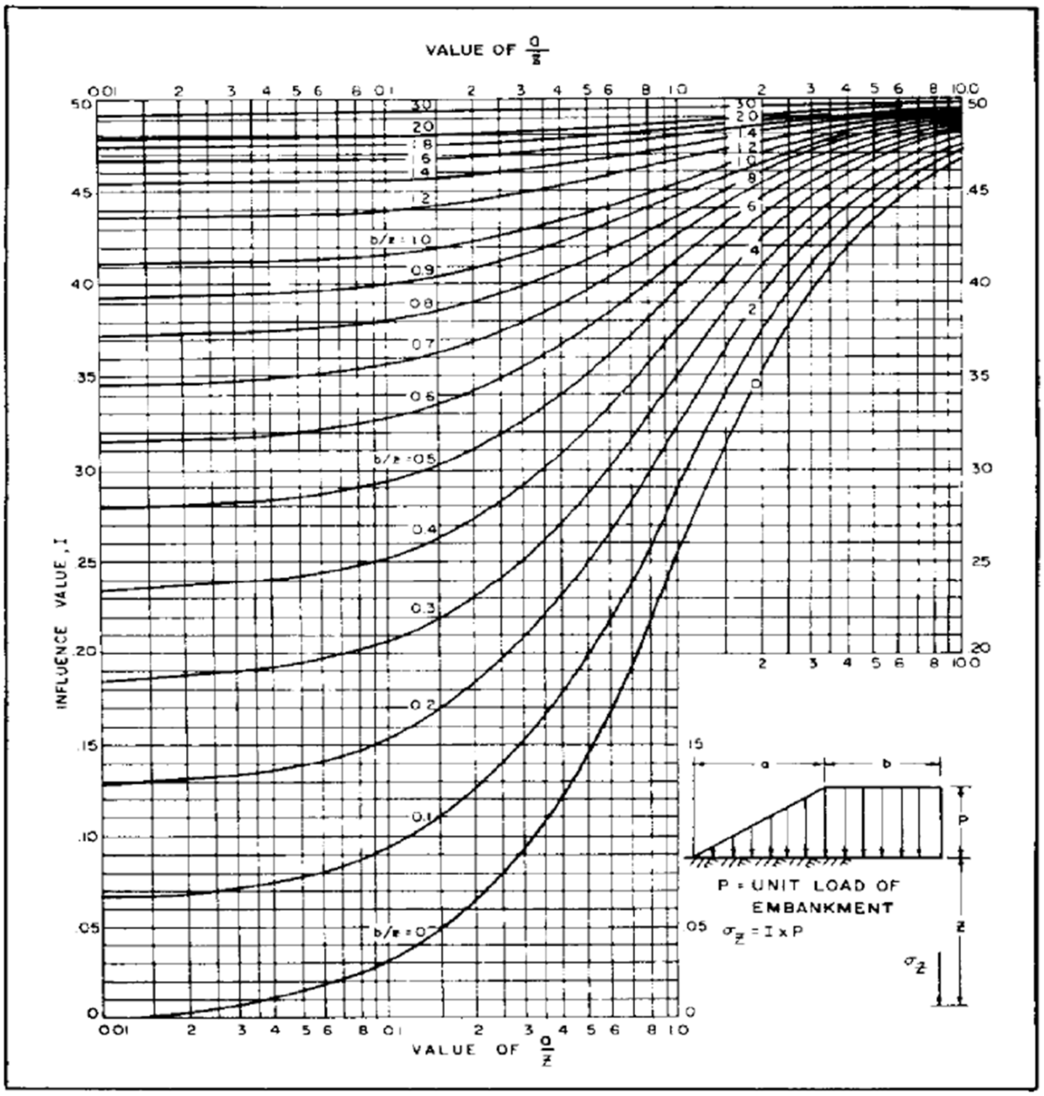


FIGURE 6
Influence Value for Vertical Stress Under Embankment Load of Infinite Length
(Boussinesq Case)

Notes about Fig 6

(1) I from Fig 6 is only for half of the embankment. Use I x 2 to calculate influence factor for whole embankment.

(2) Numerical methods that replicate the values in Fig 6 were used to calculate I values in this spreadsheet. See "Murthy, V.N.S., Geotechnical Engineering: Principles and Practices of Soil Mechanics and Engineering, Chapter 6, 2003" for details.

$\Delta\rho$ = total stress increase from embankment fill = 0.960 ksf

$\rho_{f(n)}$ = final effective vertical stress at the center of layer n = $\rho_{o(n)} + \Delta\rho_{(n)}$

Calculate initial vertical stress, vertical stress increase, and final vertical stress at the midpoint of each soil layer (con't)

Soil Layer No.	Layer Thickness Δz (ft)	Depth to Center z (ft)	γ (kcf)	Total Stress (ksf)	Pore Water Pressure (ksf)	$\rho_{o(n)}$ (ksf)	$\frac{a}{z}$	$\frac{b}{z}$	$2(I)$	$\Delta\rho_{(n)}$ (ksf)	$\rho_{f(n)}$ (ksf)
1	12.0	6.0	0.092	0.552	0.374	0.178	4.0	3.3	0.996	0.957	1.1
2	15.0	19.5	0.120	2.004	1.217	0.787	1.2	1.0	0.923	0.886	1.7
3	10.0	32.0	0.092	3.364	1.997	1.367	0.8	0.6	0.803	0.771	2.1
4	5.0	39.5	0.120	4.124	2.465	1.659	0.6	0.5	0.731	0.702	2.4
5	32.0	58.0	0.116	6.280	3.619	2.661	0.4	0.3	0.581	0.558	3.2
6	3.0	75.5	0.120	8.316	4.711	3.605	0.3	0.3	0.478	0.459	4.1

Determine the overconsolidation ratio, degree of consolidation, and the overconsolidation margin for each test sample

$$\text{OCR} = \text{overconsolidation ratio} = \frac{\rho_c}{\rho_o} = \frac{\text{preconsolidation pressure of the test sample}}{\text{initial effective vertical stress at the depth of the test sample}}$$

ρ_m = overconsolidation margin = $\rho_c - \rho_o$ *ρ_m = 0 for normally consolidated soils*

Test Sample / Consolidation Parameters Used	Depth (ft)	ρ_o (ksf)	ρ_c (ksf)	OCR	Degree of Consolidation	ρ_m (ksf)
1 - Sample A	11.5	0.340	1.560	4.58	overconsolidated (OCR > 1.2)	1.220
2 - Sample B	11.8	0.349	1.640	4.70	overconsolidated (OCR > 1.2)	1.291
3 - Correlation	N/A	N/A	N/A	2.35	overconsolidated (OCR > 1.2)	N/A

Determine the preconsolidation pressure and overconsolidation ratio at the midpoint of each cohesive soil layer

ρ_c = preconsolidation pressure at the center of layer n = $\rho_o + \rho_m$

Soil Layer No.	Soil Layer Material Description	Test Sample / Consolidation Parameters used for Soil Layer	ρ_o (ksf)	ρ_m (ksf)	ρ_c (ksf)	OCR
1	Cohesive Soil (Clay)	1 - Sample A	0.178	1.560	1.738	9.78
2	Cohesionless Soil (Sand)	N/A	N/A	N/A	N/A	N/A
3	Cohesive Soil (Clay)	1 - Sample A	1.367	1.560	2.927	2.14
4	Cohesionless Soil (Sand)	N/A	N/A	N/A	N/A	N/A
5	Cohesive Soil (Clay)	3 - Correlation	2.661	N/A	6.253	2.35
6	Cohesionless Soil (Sand)	N/A	N/A	N/A	N/A	N/A

Calculate the primary consolidation settlement at the midpoint of each cohesive soil layer

For normally consolidated soils, $\rho_c \approx \rho_o$ $(0.8 \le OCR \le 1.2)$

$$S_c = \sum_i^n \frac{C_c}{1+e_o} H_o \log_{10}\left(\frac{\rho_f}{\rho_o}\right)$$

FHWA NHI-06-089 Eq. 7-2

For overconsolidated soils where, $\rho_0 < \rho_c \le \rho_f$ $(OCR > 1.2)$

$$S_c = \sum_i^n \frac{H_o}{1+e_o}\left(C_r \log_{10}\frac{\rho_c}{\rho_o} + C_c \log_{10}\frac{\rho_f}{\rho_c}\right)$$

FHWA NHI-06-089 Eq. 7-4

For overconsolidated soils where, $\rho_0 < \rho_f \le \rho_c$ $(OCR > 1.2)$

$$S_c = \sum_i^n \frac{C_r}{1+e_o} H_o \log_{10}\left(\frac{\rho_f}{\rho_o}\right)$$

FHWA NHI-06-089 Eq. 7-2
(modified per FHWA NHI-06-089 p. A.6.9-10)

For underconsolidated soils, $\rho_c < \rho_o$ $(OCR < 0.8)$

$$S_c \approx \sum_i^n \frac{H_o}{1+e_o}\left(C_c \log_{10}\frac{\rho_o}{\rho_c} + C_c \log_{10}\frac{\rho_f}{\rho_o}\right)$$

FHWA NHI-06-089 Eq. 7-6

Where, S_c = settlement
H_o = layer thickness
e_o = initial void ratio
C_c = compression index
C_r = recompression index
ρ_o = initial effective vertical stress at the center of layer n
ρ_f = final effective vertical stress at the center of layer n
ρ_c = preconsolidation pressure at the center of layer n

Soil Layer No.	H_o (ft)	ρ_o (ksf)	ρ_c (ksf)	ρ_f (ksf)	OCR	FHWA Settlement Equation	e_o	C_c	C_r	δ (in)
1	12.0	0.178	1.738	1.134	9.78	FHWA Eq. 7-2 (modified)	2.300	1.337	0.194	6.82
2	15.0	N/A	N/A	N/A	N/A	N/A (Cohesionless Layer)	N/A	N/A	N/A	0.00
3	10.0	1.367	2.927	2.138	2.14	FHWA Eq. 7-2 (modified)	2.300	1.337	0.194	1.37
4	5.0	N/A	N/A	N/A	N/A	N/A (Cohesionless Layer)	N/A	N/A	N/A	0.00
5	32.0	2.661	6.253	3.219	2.35	FHWA Eq. 7-2 (modified)	0.940	0.200	0.070	1.15
6	3.0	N/A	N/A	N/A	N/A	N/A (Cohesionless Layer)	N/A	N/A	N/A	0.00

Total Primary Consolidation Settlement = 9.34 in

Calculate the time rate of settlement for the cohesive layers to reach 90% consolidation, (t_{90})

$$t = \frac{T_v H_d^2}{c_v}$$

FHWA NHI-06-089 Eq. 7-8

Where, t = time

T_v = time factor based on the percent consolidation (U) *FHWA NHI-06-089 Table 7-4*

c_v = coefficient of consolidation

H_d = length of longest drainage path in compressible layer *AASHTO 10.6.2.4.3, page 10-61*

The length of the drainage path is the longest distance from any point in a compressible layer to a drainage boundary at the top or bottom of the compressible soil unit. Where a compressible layer is located between two drainage boundaries, H_d equals one-half the actual height of the layer. Where a compressible layer is adjacent to an impermeable boundary (usually below), H_d equals the full height of the layer. (AASHTO 10.6.2.4.3, page 10-61)

Where a compressible layer is not adjacent to a drainage boundary, H_d will include the full height of any additional layers that are necessary to reach a drainage boundary. For this situation the calculation of t becomes;

$$t = T_v \Sigma(H_{di}^2/c_{vi})$$

Layer No.	Material Description	Layer Thickness H_0 (ft)	Drainage Path H_d (ft)	c_v (ft²/day)	$\Sigma (H_d^2/c_v)$ (days)	At 90% Consolidation: Time Factor T_v	At 90% Consolidation: Time (t_{90}) (days)	At 90% Consolidation: Settlement (S_{c_90}) (in)
1	Cohesive Soil (Clay)	12.00	6.00	0.300	120	0.848	102	6.138
2	Cohesionless Soil (Sand)	15.00	N/A	N/A	N/A	N/A	N/A	N/A
3	Cohesive Soil (Clay)	10.00	5.00	0.300	83	0.848	71	1.233
4	Cohesionless Soil (Sand)	5.00	N/A	N/A	N/A	N/A	N/A	N/A
5	Cohesive Soil (Clay)	32.00	16.00	0.600	427	0.848	362	1.035
6	Cohesionless Soil (Sand)	3.00	N/A	N/A	N/A	N/A	N/A	N/A
7								
8								
9								
10								

Calculate the Overall Percent Consolidation as a function of time

$$T_v = \frac{tc_v}{H_d^2} = \Sigma\, t(c_v / H_d^2)$$

Rearranging FHWA NHI-06-089 Eq. 7-8 and solving for T_v

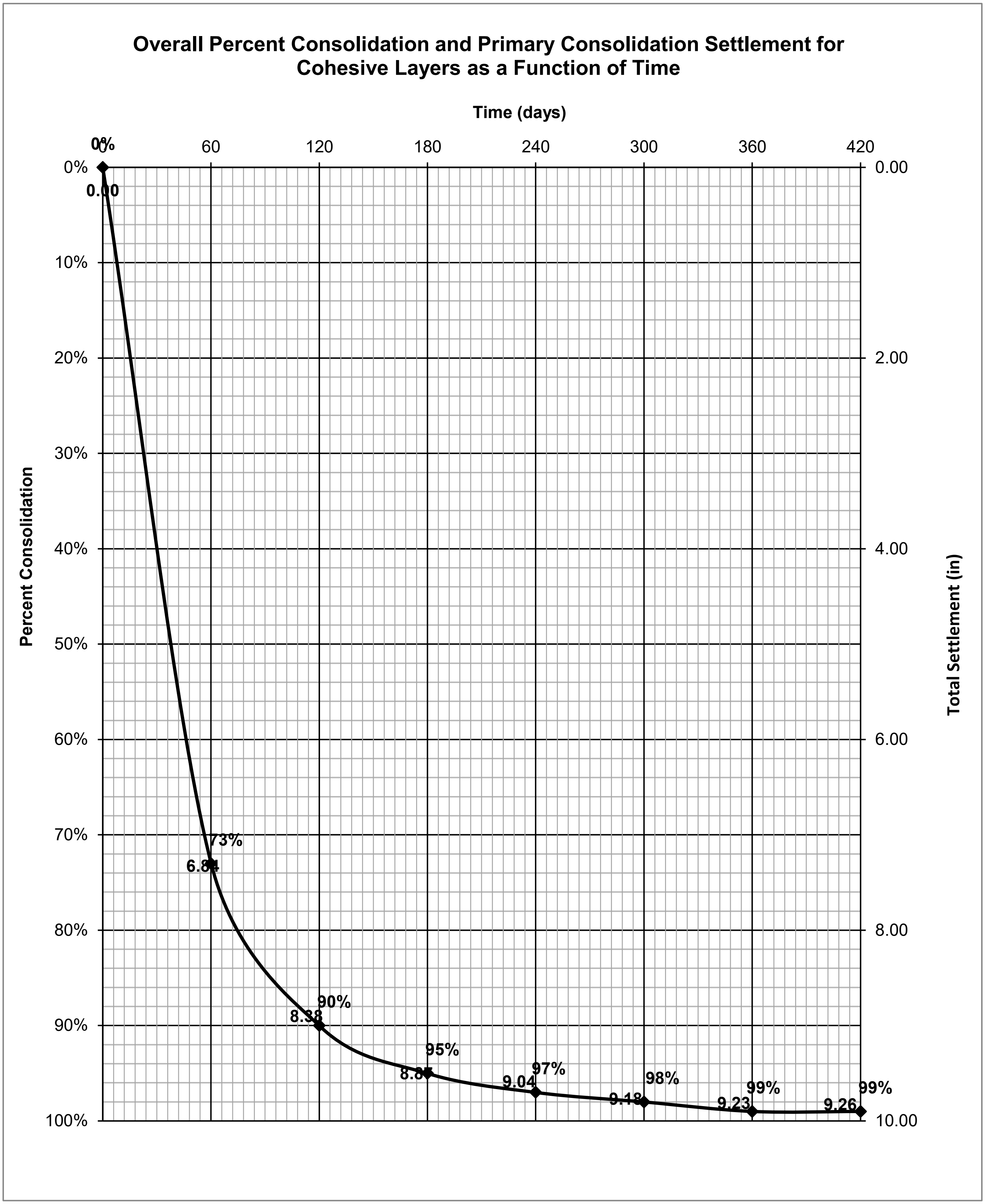
Layer No.	$\Sigma (H^2/c_v)$ (days)	Time Factor (T_v) for different values of time (t) — Time, t (days)									
		60	120	180	240	300	360	420	480	540	600
1	120.000	0.500	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500	5.000
3	83.333	0.720	1.440	2.160	2.880	3.600	4.320	5.040	5.760	6.480	7.200
5	426.667	0.141	0.281	0.422	0.563	0.703	0.844	0.984	1.125	1.266	1.406

Time Factor (T), Percent Consolidation (U), and Primary Consolidation Settlement (S_c) for different values of time

Soil Layer		Time, t (days)									
		60	120	180	240	300	360	420	480	540	600
1	T_v =	0.500	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500	5.000
	U =	76%	93%	98%	99%	100%	100%	100%	100%	100%	100%
	S_c =	5.183	6.343	6.684	6.752	6.82	6.82	6.82	6.82	6.82	6.82
2	T =	0.720	1.440	2.160	2.880	3.600	4.320	5.040	5.760	6.480	7.200
	U =	86%	98%	100%	100%	100%	100%	100%	100%	100%	100%
	S_c =	1.178	1.343	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37
3	T =	0.141	0.281	0.422	0.563	0.703	0.844	0.984	1.125	1.266	1.406
	U =	42%	60%	71%	80%	86%	90%	93%	95%	96%	97%
	S_c =	0.483	0.69	0.817	0.92	0.989	1.035	1.07	1.093	1.104	1.116
4	T =										
	U =										
	S_c =										
5	T =										
	U =										
	S_c =										
6	T =										
	U =										
	S_c =										
7	T =										
	U =										
	S_c =										
8	T =										
	U =										
	S_c =										
	S_c =	6.844	8.376	8.871	9.042	9.179	9.225	9.26	9.283	9.294	9.306
Total	U =	73%	90%	95%	97%	98%	99%	99%	99%	100%	100%

DEPARTMENT OF TRANSPORTATION	T:	R-2511			COUNTY:				
GEOTECHNICAL ENGINEERING UNIT	SUBJECT:	Settlement Calculations for Roadway Embankments (Consolidation Theory)							
1589 MAIL SERVICE CENTER		Dual Bridge over US17 (Right Lane Bridge)							
RALEIGH, NC 27699	PREPARED BY:	MS	DATE:	03/30/21	STATION:				
	CHECKED BY:	AA	DATE:	03/31/21	STR. NO.:		PAGE:	7	OF 8

Overall Percent Consolidation and Consolidation Settlement as a function of time



DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNIT
1589 MAIL SERVICE CENTER
RALEIGH, NC 27699

T: R-2511 COUNTY:
SUBJECT: Settlement Calculations for Roadway Embankments (Consolidation Theory)
Dual Bridge over US17 (Right Lane Bridge)
PREPARED BY: MS DATE: 03/30/21 STATION:
CHECKED BY: AA DATE: 03/31/21 STR. NO.: PAGE: 7 OF 8

Calculate the amount of secondary compression

$$S_s = \frac{C_\alpha}{1+e_o} H_c \log_{10} \frac{t_2}{t_1}$$

FHWA NHI-06-089 Equation 7-10

Where,
S_c = secondary compression
C_α = coefficient of secondary compression
The values of C_α can be determined using FHWA NHI-06-089 Equation 7-9 or by using the ratio of C_α / C_c presented in FHWA-NHI-06-089 Section 5.4.6.4.
e_o = initial void ratio
H_c = layer thickness
t_1 = time when approximately 90% of primary compression has occurred for the actual clay layer being considered as determined from FHWA NHI-06-089 Equation 7-8.
t_2 = the service life of the structure or any other time of interest (typically assumed to be 50 years)
If t_1 is greater than t_2, then there will be no secondary compression in that soil layer.

Soil Layer No.	Soil Layer Material Description	Layer Elevations Top (ft)	Layer Elevations Bottom (ft)	C_a	e_o	H_c (ft)	t_1 (years)	t_2 (years)	δ_S (in)
1	Cohesive Soil (Clay)	32.00	20.0	0.04011	2.300	12	50.00	50.00	0
2	Cohesionless Soil (Sand)	20.00	5.0	N/A	N/A	15	50.00	50.00	N/A
3	Cohesive Soil (Clay)	5.00	-5.0	0.04011	2.300	10	50.00	50.00	0
4	Cohesionless Soil (Sand)	-5.00	-10.0	N/A	N/A	5	50.00	50.00	N/A
5	Cohesive Soil (Clay)	-10.00	-42.0	0.01	0.940	32	50.00	50.00	0
6	Cohesionless Soil (Sand)	-42.00	-45.0	N/A	N/A	3	50.00	50.00	N/A
7									
8									
9									
10									

Total Primary Consolidation Settlement = 0.00 in

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CALCULATIONS FOR

END BENT NO. 2

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End Bent #2

References: AASHTO LRFD (8th Ed.) and NCDOT LRFD Driven Pile Foundation Policy (6th Update)

PROVIDED INFORMATION

- Location of End Bent #2:
  - -L- Sta. 156+81 (Left Bridge)
  - -L- Sta. 156+89 (Right Bridge)
- Type of Abutment: Integral abutment
  Vertical abutment with Steel Sheet Piles
- Foundation Type: Vertical HP 12x53 steel piles
- Number of piles: 6
- Bottom of Cap (B/C) Elev. (ft): 34.8 LT / 33.5 RT (Left Bridge)
  33.7 LT / 32.4 RT (Ridge Bridge)
- Design Scour Elev. (ft): 15-ft (100-Yr)
  (From BSR) 9-ft (500-Yr)

Factored Loads (Provided by Structures)

- Max Axial Load (Strength I): 195 kips per pile
- Max Axial Load (Service I): 140 kips per pile

BORING SUMMARY

Boring	Ground Surface Elev. (ft)	Top of Very Dense Layer Elev. (ft)	Groundwater Elev. (ft)	Boring Termination Elev. (ft)
EB2-A2	33.3	-38.7	33.3(1)	-41.1
EB2-A	36.8	-41.3	33.2(2)	-63.4
EB2-B	36.8	-41.3	33.3(1)	-63.4

(1) NWS = Normal Water Surface (See BSR)

(2) 0-hr Groundwater

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End Bent #2 (Continued)

References: AASHTO LRFD (8th Ed.) and NCDOT LRFD Driven Pile Foundation Policy (6th Update)

Embankment Settlement, Axial, Lateral, and Dynamic Analyses

* See EB1 calculations

SUMMARY

Bridge	Location	B/C Elev. (ft)	Approximate Top of Very Dense Layer Elev. (ft)	Est. Pile Tip Elev. (ft)	Recommended Pile Length (ft)
Left	Left	34.8	-42.0	-43.0	80
	Right	33.5		-43.0	80
Right	Left	33.7		-43.0	80
	Right	32.4		-43.0	80

Estimated Pile Tip Elevation = Top of Very Dense Layer EL - (1 ft)
Recommended Pile Length = (B/C EL) - (Estimated Pile Tip Elevation) + (2 ft Pile Embedment into Cap)
(Round up to nearest 5-ft)

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CALCULATIONS FOR

SHEET PILE DESIGN

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Calculation Summary

<u>Assumptions:</u>

- Model Geometry:
  - Grade Point: EL 41.7 ft
  - Ground water: EL 33.3 ft (NWS)
  - Top of wall: EL 34.6 ft (Bottom of Cap)
  - DSE EL 15 ft
- LRFD design method:
  - Load factors: (AASHTO LRFD Tables 3.4.1-1)
    - Active horizontal earth pressure, γ_{EH} = 1.50 (Strength I)
    - Live load γ_{LL} = 1.75
  - Resistance factor (AASHTO LRFD Table 11.5.6-1)
    - Passive resistance of vertical elements for non-gravity cantilevered walls, φ_{PEP} = 0.75 (Strength I)
- Subsurface:
  - See the "Provided Information" section.
- Soil Properties:
  - c = 800 psf ≈ **φ' = 30-deg** (Drained condition)
  - γ = 120 pcf / **γ ' = 57.6 pcf** (Drained condition)

<u>Sheet Pile Wall</u>

- Calculations show embedment of 25 ft below the DSE is required for sheet piles (sheet pile tip at Elev. -10 ft).
- PZ27 or similar sections with 50 ksi steel.

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Sheet Pile Wall Design - Embedment Design REVISED

(2016 AASHTO LRFD Bridge Design Specifications)

RK&K

Project: R-2511 **Design:** MS **Check:** AA

Section: Dual Bridge Abutment **Date:** 4/5/2021 **Date:** 4/5/2021

Soil Input

Soil Unit Weight (pcf) =	120
Friction Angle (deg) =	30
K_a (Rankine) =	0.333
K_p (Rankine) =	3.000
Cohesion (psf) =	0
GWT Elev. (ft) =	33.3

Wall Geometry

Grade Point Elev., E_1 =	41.7
Bottom of Cap Elev., BOC =	34.6
Design Scour Elev., E_2 =	15.0
Bottom of Wall Elev., E_3 =	-9.6
Front Slope, β (deg) =	0.0

Load/Resistance Factors

(AASHTO LRFD Tables 3.4.1-1, 3.4.1-2, and 11.5.7-1)

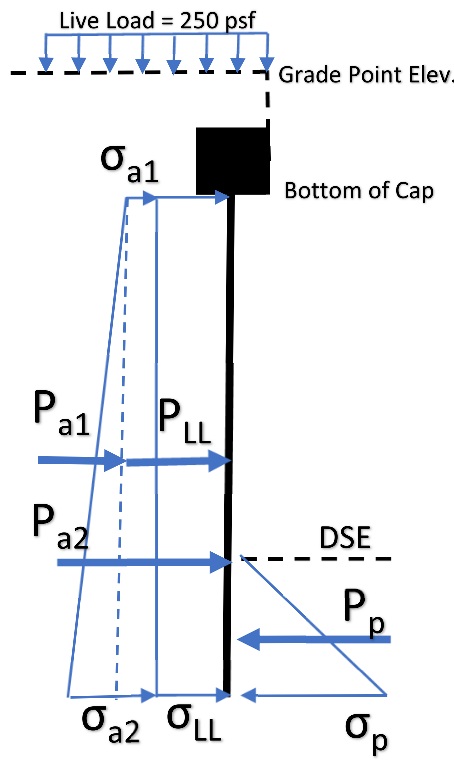
Active Horizontal EP, γ_{EH} =	1.5
Live Load Surcharge , γ_{LL} =	1.75
Passive Horizontal EP, ϕ_{PEP} =	0.75

Factored Soil Pressure

Active EP at Bottom of Cap, σ_{a1} (psf) =	426
Active EP at Tip, σ_{a2} (psf) =	1,741
Live Load Stress at Tip, σ_{LL} (psf) =	146
Passive EP at Tip, σ_p (psf) =	3,193

Factored Loads

Active EP (uniform), P_{a1} (lb) =	18,846
Active EP (triangular), P_{a2} (lb) =	29,079
Live Load Pressure, P_{LL} (lb) =	6,451
Passive EP, P_p (lb) =	39,337



(A typical simplified earth pressure diagram)

NWS EL 33.3 used for GWT

Sheet Pile Wall Design - Embedment Design REVISED

(2016 AASHTO LRFD Bridge Design Specifications)

Project: R-2511 **Design:** MS **Check:** AA

Section: Dual Bridge Abutment **Date:** 4/5/2021 **Date:** 4/5/2021

Moment Arm - From the Bottom of Cap

Active EP - P_{a1} (ft) =	22
Active EP - P_{a2} (ft) =	29
Live Load - P_{LL} (ft) =	22
Passive EP - P_P (ft) =	36

Factored Moment

Active EP - P_{a1} (kip-ft) =	417
Active EP - P_{a2} (kip-ft) =	858
Live Load - P_{LL} (kip-ft) =	143
Passive EP - P_P (kip-ft) =	1,417
Sum of moments (kip-ft) =	0

Find Bottom of Wall Elevation using Excel Solver to set moment equal to zero:

Minimum Embedment Below DSE, D (ft) = **25** **Use 25 ft**

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Sheet Pile Wall Design - Section Design/Check REVISED

(2016 AASHTO LRFD Bridge Design Specifications)

RK&K

Project: R-2511 **Design:** MS **Check:** AA

Section: Dual Bridge Abutment **Date:** 4/5/2021 **Date:** 4/5/2021

Soil Input

Soil Unit Weight (pcf) =	120.0
Friction Angle (deg) =	30
K_a (Rankine) =	0.33
K_p (Rankine) =	3.00
Cohesion (psf) =	0.0
GWT Depth (ft) =	33.3

Wall Geometry

Grade Point Elev., E_1 =	41.7
Bottom of Cap Elev., BOC =	34.6
Design Scour Elev., E_2 =	15.0
Elev. at $y = P^*/(\gamma'(K_p-K_a))$	7.3
Point of Zero Shear Elev., POZS =	**-3.4**
Bottom of Wall Elev., E_3 =	-9.6
Front Slope, β (deg) =	0.0

Load/Resistance Factors

(AASHTO LRFD Tables 3.4.1-1, 3.4.1-2, and 11.5.7-1)

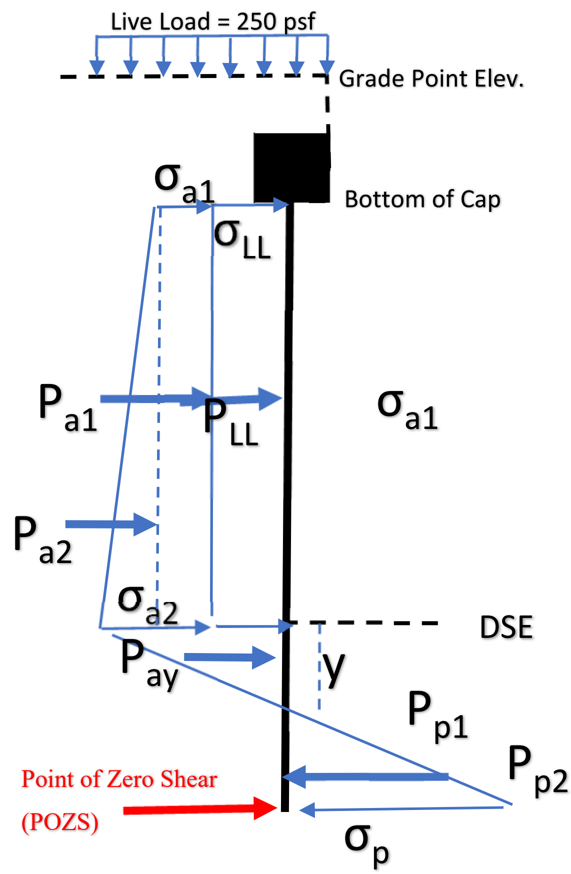
Active Horizontal EP, γ_{EH} =	1.5
Live Load Surcharge , γ_{LL} =	1.75
Passive Horizontal EP, ϕ_{PEP} =	0.75

Factored Soil Pressure

Active EP at Bottom of Cap, σ_{a1} (psf) =	426
Active EP at DSE, σ_{a2} (psf) =	1,031
Live Load Stress at DSE, σ_{LL} (psf) =	146
Passive EP at POZS, σ_p (psf) =	1,234

Factored Loads - Find Point of Zero Shear using Excel Solver:

Pull at the cap, P_{cap} (lb) =	-15,038
Active EP (uniform), P_{a1} (lb) =	8,350
Active EP (triangular), P_{a2} (lb) =	5,929
Live Load Pressure, P_{LL} (lb) =	2,858
Active EP (triangular), P_{ay} (lb) =	4,509
Passive EP (triangular), P_{p2} (lb) =	-6,607
Sum of Horizontal Forces (lb) =	0



(A typical fixed earth support pressure diagram)

NWS EL 33.3 used for GWT

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Sheet Pile Wall Design - Section Design/Check REVISED

(2016 AASHTO LRFD Bridge Design Specifications)

Project: R-2511 **Design:** MS **Check:** AA

Section: Dual Bridge Abutment **Date:** 4/5/2021 **Date:** 4/5/2021

Moment Arm - From the Point of Zero Shear

Pull at the cap - P_{cap} (ft) =	38
Active EP - P_{a1} (ft) =	28
Active EP - P_{a2} (ft) =	25
Live Load - P_{LL} (ft) =	28
Active EP - P_{ax} (ft) =	16
Passive EP - P_{P2} (ft) =	4

Maximum Moment at Point of Zero Shear

Pull at the cap - P_{cap} (kip-ft) =	-571
Active EP - P_{a1} (kip-ft) =	235
Active EP - P_{a2} (kip-ft) =	148
Live Load - P_{LL} (kip-ft) =	81
Active EP - P_{ax} (ft) =	71
Passive EP - P_{P2} (kip-ft) =	-24
Sum of moments (kip-ft) =	-60

Required Section Modulus

F_y of steel, ksi =	50
M_{max}, kip-in/ft =	719
$S_{req.} = M_{max} / (0.9*F_y)$, in^3/ft =	16.0
Section modulus of PZ27, in^3 =	30.2
Is $S > S_{req}$?	YES

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STATE	STATE PROJECT REFERENCE NO.	SHEET NO.	TOTAL SHEETS
N.C.	R-2511	1	30

REFERENCE: R-2511

PROJECT: 35494

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
GEOTECHNICAL ENGINEERING UNIT

STRUCTURE SUBSURFACE INVESTIGATION

COUNTY ***BEAUFORT***

PROJECT DESCRIPTION ***US 17 FROM NORTH OF NC 171 TO EXISTING MULTI-LANES SOUTH OF WILLIAMSTON***

SITE DESCRIPTION ***DUAL BRIDGE ON US 17 OVER GUM SWAMP CREEK BETWEEN SR 1421 (GRIFFIN HODGES ROAD) AND SR 1420 (BEAR GRASS ROAD)***

INVENTORY

CONTENTS

CAUTION NOTICE

THE SUBSURFACE INFORMATION AND THE SUBSURFACE INVESTIGATION ON WHICH IT IS BASED WERE MADE FOR THE PURPOSE OF STUDY, PLANNING AND DESIGN, AND NOT FOR CONSTRUCTION OR PAY PURPOSES. THE VARIOUS FIELD BORING LOGS, ROCK CORES AND SOIL TEST DATA AVAILABLE MAY BE REVIEWED OR INSPECTED IN RALEIGH BY CONTACTING THE N.C. DEPARTMENT OF TRANSPORTATION, GEOTECHNICAL ENGINEERING UNIT AT (919) 707-6850. THE SUBSURFACE PLANS AND REPORTS, FIELD BORING LOGS, ROCK CORES AND SOIL TEST DATA ARE NOT PART OF THE CONTRACT.

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PERSONNEL

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G. GOSLIN
M. METRY
S&ME PERSONNEL
GET PERSONNEL

INVESTIGATED BY ***RK&K, LLP***
DRAWN BY ***M. METRY, P. CARY***
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NORTH CAROLINA PROFESSIONAL SEAL 041709 ENGINEER GREGORY K. GOINS

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PROJECT REFERENCE NO.	SHEET NO.
R-2511	2

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS

GEOTECHNICAL ENGINEERING UNIT

SUBSURFACE INVESTIGATION

SOIL AND ROCK LEGEND, TERMS, SYMBOLS, AND ABBREVIATIONS

SOIL DESCRIPTION

SOIL IS CONSIDERED UNCONSOLIDATED, SEMI-CONSOLIDATED, OR WEATHERED EARTH MATERIALS THAT CAN BE PENETRATED WITH A CONTINUOUS FLIGHT POWER AUGER AND YIELD LESS THAN 100 BLOWS PER FOOT ACCORDING TO THE STANDARD PENETRATION TEST (AASHTO T 206, ASTM D1586). SOIL CLASSIFICATION IS BASED ON THE AASHTO SYSTEM. BASIC DESCRIPTIONS GENERALLY INCLUDE THE FOLLOWING: CONSISTENCY, COLOR, TEXTURE, MOISTURE, AASHTO CLASSIFICATION, AND OTHER PERTINENT FACTORS SUCH AS MINERALOGICAL COMPOSITION, ANGULARITY, STRUCTURE, PLASTICITY, ETC. FOR EXAMPLE,

VERY STIFF, GRAY, SILTY CLAY, MOIST WITH INTERBEDDED FINE SAND LAYERS, HIGHLY PLASTIC, A-7-6

SOIL LEGEND AND AASHTO CLASSIFICATION

GENERAL CLASS.	GRANULAR MATERIALS (≤ 35% PASSING #200)							SILT-CLAY MATERIALS (> 35% PASSING #200)				ORGANIC MATERIALS		
GROUP CLASS.	A-1		A-3	A-2				A-4	A-5	A-6	A-7	A-1, A-2 A-3	A-4, A-5 A-6, A-7	
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5 A-7-6			
SYMBOL														
% PASSING #10	50 MX											GRANULAR SOILS	SILT-CLAY SOILS	MUCK, PEAT
#40	30 MX	50 MX	51 MN											
#200	15 MX	25 MX	10 MX	35 MX	35 MX	35 MX	35 MX	36 MN	36 MN	36 MN	36 MN			
MATERIAL PASSING #40 LL	—		—	40 MX	41 MN	40 MX	41 MN	40 MX	41 MN	40 MX	41 MN	SOILS WITH LITTLE OR MODERATE AMOUNTS OF ORGANIC MATTER		HIGHLY ORGANIC SOILS
PI	6 MX		NP	10 MX	10 MX	11 MN	11 MN	10 MX	10 MX	11 MN	11 MN			
GROUP INDEX	0		0	0		4 MX		8 MX	12 MX	16 MX	NO MX			
USUAL TYPES OF MAJOR MATERIALS	STONE FRAGS., GRAVEL, AND SAND		FINE SAND	SILTY OR CLAYEY GRAVEL AND SAND				SILTY SOILS		CLAYEY SOILS				
GEN. RATING AS SUBGRADE	EXCELLENT TO GOOD							FAIR TO POOR				FAIR TO POOR	POOR	UNSUITABLE

PI OF A-7-5 SUBGROUP IS ≤ LL - 30 ; PI OF A-7-6 SUBGROUP IS > LL - 30

CONSISTENCY OR DENSENESS

PRIMARY SOIL TYPE	COMPACTNESS OR CONSISTENCY	RANGE OF STANDARD PENETRATION RESISTENCE (N-VALUE)	RANGE OF UNCONFINED COMPRESSIVE STRENGTH ($TONS/FT^2$)
GENERALLY GRANULAR MATERIAL (NON-COHESIVE)	VERY LOOSE	< 4	N/A
	LOOSE	4 TO 10	
	MEDIUM DENSE	10 TO 30	
	DENSE	30 TO 50	
	VERY DENSE	> 50	
GENERALLY SILT-CLAY MATERIAL (COHESIVE)	VERY SOFT	< 2	< 0.25
	SOFT	2 TO 4	0.25 TO 0.5
	MEDIUM STIFF	4 TO 8	0.5 TO 1.0
	STIFF	8 TO 15	1 TO 2
	VERY STIFF	15 TO 30	2 TO 4
	HARD	> 30	> 4

TEXTURE OR GRAIN SIZE

U.S. STD. SIEVE SIZE	4	10	40	60	200	270
OPENING (MM)	4.76	2.00	0.42	0.25	0.075	0.053

BOULDER (BLDR.)	COBBLE (COB.)	GRAVEL (GR.)	COARSE SAND (CSE. SD.)	FINE SAND (F SD.)	SILT (SL.)	CLAY (CL.)

GRAIN SIZE	MM	305	75	2.0	0.25	0.05	0.005
	IN.	12	3				

SOIL MOISTURE - CORRELATION OF TERMS

SOIL MOISTURE SCALE (ATTERBERG LIMITS)	FIELD MOISTURE DESCRIPTION	GUIDE FOR FIELD MOISTURE DESCRIPTION
	- SATURATED - (SAT.)	USUALLY LIQUID; VERY WET, USUALLY FROM BELOW THE GROUND WATER TABLE
LL — LIQUID LIMIT; PLASTIC RANGE (PI)	- WET - (W)	SEMISOLID; REQUIRES DRYING TO ATTAIN OPTIMUM MOISTURE
PL — PLASTIC LIMIT		
OM — OPTIMUM MOISTURE; SL — SHRINKAGE LIMIT	- MOIST - (M)	SOLID; AT OR NEAR OPTIMUM MOISTURE
	- DRY - (D)	REQUIRES ADDITIONAL WATER TO ATTAIN OPTIMUM MOISTURE

PLASTICITY

	PLASTICITY INDEX (PI)	DRY STRENGTH
NON PLASTIC	0-5	VERY LOW
SLIGHTLY PLASTIC	6-15	SLIGHT
MODERATELY PLASTIC	16-25	MEDIUM
HIGHLY PLASTIC	26 OR MORE	HIGH

COLOR

DESCRIPTIONS MAY INCLUDE COLOR OR COLOR COMBINATIONS (TAN, RED, YELLOW-BROWN, BLUE-GRAY). MODIFIERS SUCH AS LIGHT, DARK, STREAKED, ETC. ARE USED TO DESCRIBE APPEARANCE.

GRADATION

WELL GRADED - INDICATES A GOOD REPRESENTATION OF PARTICLE SIZES FROM FINE TO COARSE.
UNIFORMLY GRADED - INDICATES THAT SOIL PARTICLES ARE ALL APPROXIMATELY THE SAME SIZE.
GAP-GRADED - INDICATES A MIXTURE OF UNIFORM PARTICLE SIZES OF TWO OR MORE SIZES.

ANGULARITY OF GRAINS

THE ANGULARITY OR ROUNDNESS OF SOIL GRAINS IS DESIGNATED BY THE TERMS: ANGULAR, SUBANGULAR, SUBROUNDED, OR ROUNDED.

MINERALOGICAL COMPOSITION

MINERAL NAMES SUCH AS QUARTZ, FELDSPAR, MICA, TALC, KAOLIN, ETC. ARE USED IN DESCRIPTIONS WHEN THEY ARE CONSIDERED OF SIGNIFICANCE.

COMPRESSIBILITY

SLIGHTLY COMPRESSIBLE	LL < 31
MODERATELY COMPRESSIBLE	LL = 31 - 50
HIGHLY COMPRESSIBLE	LL > 50

PERCENTAGE OF MATERIAL

ORGANIC MATERIAL	GRANULAR SOILS	SILT - CLAY SOILS	OTHER MATERIAL	
TRACE OF ORGANIC MATTER	2 - 3%	3 - 5%	TRACE	1 - 10%
LITTLE ORGANIC MATTER	3 - 5%	5 - 12%	LITTLE	10 - 20%
MODERATELY ORGANIC	5 - 10%	12 - 20%	SOME	20 - 35%
HIGHLY ORGANIC	> 10%	> 20%	HIGHLY	35% AND ABOVE

GROUND WATER

- ▽ WATER LEVEL IN BORE HOLE IMMEDIATELY AFTER DRILLING
- ▼ STATIC WATER LEVEL AFTER 24 HOURS
- ▽PW PERCHED WATER, SATURATED ZONE, OR WATER BEARING STRATA
- SPRING OR SEEP

MISCELLANEOUS SYMBOLS

- ROADWAY EMBANKMENT (RE) WITH SOIL DESCRIPTION
- 25/025 DIP & DIP DIRECTION OF ROCK STRUCTURES
- SOIL SYMBOL
- SPT OPT DMT VST PMT TEST BORING
- SLOPE INDICATOR INSTALLATION
- ARTIFICIAL FILL (AF) OTHER THAN ROADWAY EMBANKMENT
- AUGER BORING
- CONE PENETROMETER TEST
- INFERRED SOIL BOUNDARY
- CORE BORING
- SOUNDING ROD
- INFERRED ROCK LINE
- MW MONITORING WELL
- TEST BORING WITH CORE
- ALLUVIAL SOIL BOUNDARY
- PIEZOMETER INSTALLATION
- SPT N-VALUE

RECOMMENDATION SYMBOLS

- UNDERCUT
- SHALLOW UNDERCUT
- UNCLASSIFIED EXCAVATION - UNSUITABLE WASTE
- UNCLASSIFIED EXCAVATION - ACCEPTABLE DEGRADABLE ROCK
- UNCLASSIFIED EXCAVATION - ACCEPTABLE, BUT NOT TO BE USED IN THE TOP 3 FEET OF EMBANKMENT OR BACKFILL

ABBREVIATIONS

AR - AUGER REFUSAL
BT - BORING TERMINATED
CL. - CLAY
CPT - CONE PENETRATION TEST
CSE. - COARSE
DMT - DILATOMETER TEST
DPT - DYNAMIC PENETRATION TEST
e - VOID RATIO
F - FINE
FOSS. - FOSSILIFEROUS
FRAC. - FRACTURED, FRACTURES
FRAGS. - FRAGMENTS
HI. - HIGHLY
MED. - MEDIUM
MICA. - MICACEOUS
MOD. - MODERATELY
NP - NON PLASTIC
ORG. - ORGANIC
PMT - PRESSUREMETER TEST
SAP. - SAPROLITIC
SD. - SAND, SANDY
SL. - SILT, SILTY
SLI. - SLIGHTLY
TCR - TRICONE REFUSAL
w - MOISTURE CONTENT
V - VERY
VST - VANE SHEAR TEST
WEA. - WEATHERED
γ - UNIT WEIGHT
γ_d - DRY UNIT WEIGHT

SAMPLE ABBREVIATIONS
S - BULK
SS - SPLIT SPOON
ST - SHELBY TUBE
RS - ROCK
RT - RECOMPACTED TRIAXIAL
CBR - CALIFORNIA BEARING RATIO

EQUIPMENT USED ON SUBJECT PROJECT

DRILL UNITS:
- [X] CME-45C
- [ ] CME-55
- [X] CME-550
- [ ] VANE SHEAR TEST
- [ ] PORTABLE HOIST
- [ ] ______

ADVANCING TOOLS:
- [ ] CLAY BITS
- [ ] 6" CONTINUOUS FLIGHT AUGER
- [X] 8" HOLLOW AUGERS
- [ ] HARD FACED FINGER BITS
- [ ] TUNG.-CARBIDE INSERTS
- [X] CASING [ ] W/ ADVANCER
- [X] TRICONE 2 15/16 " STEEL TEETH
- [ ] TRICONE ______ " TUNG.-CARB.
- [ ] CORE BIT
- [ ] ______

HAMMER TYPE: [X] AUTOMATIC [ ] MANUAL

CORE SIZE:
- [ ] -B ______
- [ ] -H ______
- [ ] -N ______

HAND TOOLS:
- [ ] POST HOLE DIGGER
- [ ] HAND AUGER
- [ ] SOUNDING ROD
- [ ] VANE SHEAR TEST
- [ ] ______

ROCK DESCRIPTION

HARD ROCK IS NON-COASTAL PLAIN MATERIAL THAT WOULD YIELD SPT REFUSAL IF TESTED. AN INFERRED ROCK LINE INDICATES THE LEVEL AT WHICH NON-COASTAL PLAIN MATERIAL WOULD YIELD SPT REFUSAL. SPT REFUSAL IS PENETRATION BY A SPLIT SPOON SAMPLER EQUAL TO OR LESS THAN 0.1 FOOT PER 60 BLOWS IN NON-COASTAL PLAIN MATERIAL, THE TRANSITION BETWEEN SOIL AND ROCK IS OFTEN REPRESENTED BY A ZONE OF WEATHERED ROCK.
ROCK MATERIALS ARE TYPICALLY DIVIDED AS FOLLOWS:

WEATHERED ROCK (WR)		NON-COASTAL PLAIN MATERIAL THAT WOULD YIELD SPT N VALUES > 100 BLOWS PER FOOT IF TESTED.
CRYSTALLINE ROCK (CR)		FINE TO COARSE GRAIN IGNEOUS AND METAMORPHIC ROCK THAT WOULD YIELD SPT REFUSAL IF TESTED. ROCK TYPE INCLUDES GRANITE, GNEISS, GABBRO, SCHIST, ETC.
NON-CRYSTALLINE ROCK (NCR)		FINE TO COARSE GRAIN METAMORPHIC AND NON-COASTAL PLAIN SEDIMENTARY ROCK THAT WOULD YEILD SPT REFUSAL IF TESTED. ROCK TYPE INCLUDES PHYLLITE, SLATE, SANDSTONE, ETC.
COASTAL PLAIN SEDIMENTARY ROCK (CP)		COASTAL PLAIN SEDIMENTS CEMENTED INTO ROCK, BUT MAY NOT YIELD SPT REFUSAL. ROCK TYPE INCLUDES LIMESTONE, SANDSTONE, CEMENTED SHELL BEDS, ETC.

WEATHERING

FRESH	ROCK FRESH, CRYSTALS BRIGHT, FEW JOINTS MAY SHOW SLIGHT STAINING. ROCK RINGS UNDER HAMMER IF CRYSTALLINE.
VERY SLIGHT (V SLI.)	ROCK GENERALLY FRESH, JOINTS STAINED, SOME JOINTS MAY SHOW THIN CLAY COATINGS IF OPEN, CRYSTALS ON A BROKEN SPECIMEN FACE SHINE BRIGHTLY. ROCK RINGS UNDER HAMMER BLOWS IF OF A CRYSTALLINE NATURE.
SLIGHT (SLI.)	ROCK GENERALLY FRESH, JOINTS STAINED AND DISCOLORATION EXTENDS INTO ROCK UP TO 1 INCH. OPEN JOINTS MAY CONTAIN CLAY. IN GRANITOID ROCKS SOME OCCASIONAL FELDSPAR CRYSTALS ARE DULL AND DISCOLORED. CRYSTALLINE ROCKS RING UNDER HAMMER BLOWS.
MODERATE (MOD.)	SIGNIFICANT PORTIONS OF ROCK SHOW DISCOLORATION AND WEATHERING EFFECTS. IN GRANITOID ROCKS, MOST FELDSPARS ARE DULL AND DISCOLORED, SOME SHOW CLAY. ROCK HAS DULL SOUND UNDER HAMMER BLOWS AND SHOWS SIGNIFICANT LOSS OF STRENGTH AS COMPARED WITH FRESH ROCK.
MODERATELY SEVERE (MOD. SEV.)	ALL ROCK EXCEPT QUARTZ DISCOLORED OR STAINED. IN GRANITOID ROCKS, ALL FELDSPARS DULL AND DISCOLORED AND A MAJORITY SHOW KAOLINIZATION. ROCK SHOWS SEVERE LOSS OF STRENGTH AND CAN BE EXCAVATED WITH A GEOLOGIST'S PICK. ROCK GIVES "CLUNK" SOUND WHEN STRUCK. *IF TESTED, WOULD YIELD SPT REFUSAL*
SEVERE (SEV.)	ALL ROCK EXCEPT QUARTZ DISCOLORED OR STAINED. ROCK FABRIC CLEAR AND EVIDENT BUT REDUCED IN STRENGTH TO STRONG SOIL. IN GRANITOID ROCKS ALL FELDSPARS ARE KAOLINIZED TO SOME EXTENT. SOME FRAGMENTS OF STRONG ROCK USUALLY REMAIN. *IF TESTED, WOULD YIELD SPT N VALUES > 100 BPF*
VERY SEVERE (V SEV.)	ALL ROCK EXCEPT QUARTZ DISCOLORED OR STAINED. ROCK FABRIC ELEMENTS ARE DISCERNIBLE BUT MASS IS EFFECTIVELY REDUCED TO SOIL STATUS, WITH ONLY FRAGMENTS OF STRONG ROCK REMAINING. SAPROLITE IS AN EXAMPLE OF ROCK WEATHERED TO A DEGREE THAT ONLY MINOR VESTIGES OF ORIGINAL ROCK FABRIC REMAIN. *IF TESTED, WOULD YIELD SPT N VALUES < 100 BPF*
COMPLETE	ROCK REDUCED TO SOIL. ROCK FABRIC NOT DISCERNIBLE, OR DISCERNIBLE ONLY IN SMALL AND SCATTERED CONCENTRATIONS. QUARTZ MAY BE PRESENT AS DIKES OR STRINGERS. SAPROLITE IS ALSO AN EXAMPLE.

ROCK HARDNESS

VERY HARD	CANNOT BE SCRATCHED BY KNIFE OR SHARP PICK. BREAKING OF HAND SPECIMENS REQUIRES SEVERAL HARD BLOWS OF THE GEOLOGIST'S PICK.
HARD	CAN BE SCRATCHED BY KNIFE OR PICK ONLY WITH DIFFICULTY. HARD HAMMER BLOWS REQUIRED TO DETACH HAND SPECIMEN.
MODERATELY HARD	CAN BE SCRATCHED BY KNIFE OR PICK. GOUGES OR GROOVES TO 0.25 INCHES DEEP CAN BE EXCAVATED BY HARD BLOW OF A GEOLOGIST'S PICK. HAND SPECIMENS CAN BE DETACHED BY MODERATE BLOWS.
MEDIUM HARD	CAN BE GROOVED OR GOUGED 0.05 INCHES DEEP BY FIRM PRESSURE OF KNIFE OR PICK POINT. CAN BE EXCAVATED IN SMALL CHIPS TO PEICES 1 INCH MAXIMUM SIZE BY HARD BLOWS OF THE POINT OF A GEOLOGIST'S PICK.
SOFT	CAN BE GROVED OR GOUGED READILY BY KNIFE OR PICK. CAN BE EXCAVATED IN FRAGMENTS FROM CHIPS TO SEVERAL INCHES IN SIZE BY MODERATE BLOWS OF A PICK POINT. SMALL, THIN PIECES CAN BE BROKEN BY FINGER PRESSURE.
VERY SOFT	CAN BE CARVED WITH KNIFE. CAN BE EXCAVATED READILY WITH POINT OF PICK. PIECES 1 INCH OR MORE IN THICKNESS CAN BE BROKEN BY FINGER PRESSURE. CAN BE SCRATCHED READILY BY FINGERNAIL.

FRACTURE SPACING

TERM	SPACING
VERY WIDE	MORE THAN 10 FEET
WIDE	3 TO 10 FEET
MODERATELY CLOSE	1 TO 3 FEET
CLOSE	0.16 TO 1 FOOT
VERY CLOSE	LESS THAN 0.16 FEET

BEDDING

TERM	THICKNESS
VERY THICKLY BEDDED	4 FEET
THICKLY BEDDED	1.5 - 4 FEET
THINLY BEDDED	0.16 - 1.5 FEET
VERY THINLY BEDDED	0.03 - 0.16 FEET
THICKLY LAMINATED	0.008 - 0.03 FEET
THINLY LAMINATED	< 0.008 FEET

INDURATION

FOR SEDIMENTARY ROCKS, INDURATION IS THE HARDENING OF MATERIAL BY CEMENTING, HEAT, PRESSURE, ETC.

FRIABLE	RUBBING WITH FINGER FREES NUMEROUS GRAINS; GENTLE BLOW BY HAMMER DISINTEGRATES SAMPLE.
MODERATELY INDURATED	GRAINS CAN BE SEPARATED FROM SAMPLE WITH STEEL PROBE; BREAKS EASILY WHEN HIT WITH HAMMER.
INDURATED	GRAINS ARE DIFFICULT TO SEPARATE WITH STEEL PROBE; DIFFICULT TO BREAK WITH HAMMER.
EXTREMELY INDURATED	SHARP HAMMER BLOWS REQUIRED TO BREAK SAMPLE; SAMPLE BREAKS ACROSS GRAINS.

TERMS AND DEFINITIONS

ALLUVIUM (ALLUV.) - SOILS THAT HAVE BEEN TRANSPORTED BY WATER.

AQUIFER - A WATER BEARING FORMATION OR STRATA.

ARENACEOUS - APPLIED TO ROCKS THAT HAVE BEEN DERIVED FROM SAND OR THAT CONTAIN SAND.

ARGILLACEOUS - APPLIED TO ALL ROCKS OR SUBSTANCES COMPOSED OF CLAY MINERALS, OR HAVING A NOTABLE PROPORTION OF CLAY IN THEIR COMPOSITION, SUCH AS SHALE, SLATE, ETC.

ARTESIAN - GROUND WATER THAT IS UNDER SUFFICIENT PRESSURE TO RISE ABOVE THE LEVEL AT WHICH IT IS ENCOUNTERED, BUT WHICH DOES NOT NECESSARILY RISE TO OR ABOVE THE GROUND SURFACE.

CALCAREOUS (CALC.) - SOILS THAT CONTAIN APPRECIABLE AMOUNTS OF CALCIUM CARBONATE.

COLLUVIUM - ROCK FRAGMENTS MIXED WITH SOIL DEPOSITED BY GRAVITY ON SLOPE OR AT BOTTOM OF SLOPE.

CORE RECOVERY (REC.) - TOTAL LENGTH OF ALL MATERIAL RECOVERED IN THE CORE BARREL DIVIDED BY TOTAL LENGTH OF CORE RUN AND EXPRESSED AS A PERCENTAGE.

DIKE - A TABULAR BODY OF IGNEOUS ROCK THAT CUTS ACROSS THE STRUCTURE OF ADJACENT ROCKS OR CUTS MASSIVE ROCK.

DIP - THE ANGLE AT WHICH A STRATUM OR ANY PLANAR FEATURE IS INCLINED FROM THE HORIZONTAL.

DIP DIRECTION (DIP AZIMUTH) - THE DIRECTION OR BEARING OF THE HORIZONTAL TRACE OF THE LINE OF DIP, MEASURED CLOCKWISE FROM NORTH.

FAULT - A FRACTURE OR FRACTURE ZONE ALONG WHICH THERE HAS BEEN DISPLACEMENT OF THE SIDES RELATIVE TO ONE ANOTHER PARALLEL TO THE FRACTURE.

FISSILE - A PROPERTY OF SPLITTING ALONG CLOSELY SPACED PARALLEL PLANES.

FLOAT - ROCK FRAGMENTS ON SURFACE NEAR THEIR ORIGINAL POSITION AND DISLODGED FROM PARENT MATERIAL.

FLOOD PLAIN (FP) - LAND BORDERING A STREAM, BUILT OF SEDIMENTS DEPOSITED BY THE STREAM.

FORMATION (FM.) - A MAPPABLE GEOLOGIC UNIT THAT CAN BE RECOGNIZED AND TRACED IN THE FIELD.

JOINT - FRACTURE IN ROCK ALONG WHICH NO APPRECIABLE MOVEMENT HAS OCCURRED.

LEDGE - A SHELF-LIKE RIDGE OR PROJECTION OF ROCK WHOSE THICKNESS IS SMALL COMPARED TO ITS LATERAL EXTENT.

LENS - A BODY OF SOIL OR ROCK THAT THINS OUT IN ONE OR MORE DIRECTIONS.

MOTTLED (MOT.) - IRREGULARLY MARKED WITH SPOTS OF DIFFERENT COLORS. MOTTLING IN SOILS USUALLY INDICATES POOR AERATION AND LACK OF GOOD DRAINAGE.

PERCHED WATER - WATER MAINTAINED ABOVE THE NORMAL GROUND WATER LEVEL BY THE PRESENCE OF AN INTERVENING IMPERVIOUS STRATUM.

RESIDUAL (RES.) SOIL - SOIL FORMED IN PLACE BY THE WEATHERING OF ROCK.

ROCK QUALITY DESIGNATION (RQD) - A MEASURE OF ROCK QUALITY DESCRIBED BY TOTAL LENGTH OF ROCK SEGMENTS EQUAL TO OR GREATER THAN 4 INCHES DIVIDED BY THE TOTAL LENGTH OF CORE RUN AND EXPRESSED AS A PERCENTAGE.

SAPROLITE (SAP.) - RESIDUAL SOIL THAT RETAINS THE RELIC STRUCTURE OR FABRIC OF THE PARENT ROCK.

SILL - AN INTRUSIVE BODY OF IGNEOUS ROCK OF APPROXIMATELY UNIFORM THICKNESS AND RELATIVELY THIN COMPARED WITH ITS LATERAL EXTENT, THAT HAS BEEN EMPLACED PARALLEL TO THE BEDDING OR SCHISTOSITY OF THE INTRUDED ROCKS.

SLICKENSIDE - POLISHED AND STRIATED SURFACE THAT RESULTS FROM FRICTION ALONG A FAULT OR SLIP PLANE.

STANDARD PENETRATION TEST (PENETRATION RESISTANCE) (SPT) - NUMBER OF BLOWS (N OR BPF) OF A 140 LB. HAMMER FALLING 30 INCHES REQUIRED TO PRODUCE A PENETRATION OF 1 FOOT INTO SOIL WITH A 2 INCH OUTSIDE DIAMETER SPLIT SPOON SAMPLER. SPT REFUSAL IS PENETRATION EQUAL TO OR LESS THAN 0.1 FOOT PER 60 BLOWS.

STRATA CORE RECOVERY (SREC.) - TOTAL LENGTH OF STRATA MATERIAL RECOVERED DIVIDED BY TOTAL LENGTH OF STRATUM AND EXPRESSED AS A PERCENTAGE.

STRATA ROCK QUALITY DESIGNATION (SRQD) - A MEASURE OF ROCK QUALITY DESCRIBED BY TOTAL LENGTH OF ROCK SEGMENTS WITHIN A STRATUM EQUAL TO OR GREATER THAN 4 INCHES DIVIDED BY THE TOTAL LENGTH OF STRATA AND EXPRESSED AS A PERCENTAGE.

TOPSOIL (TS.) - SURFACE SOILS USUALLY CONTAINING ORGANIC MATTER.

BENCH MARK: K #6 ON -L- STA. 152+76.20, 155.65' RT, RR SPIKE SET IN 14" PINE TREE

ELEVATION: 38.73 FEET

NOTES:

COLLAR ELEVATIONS FOR BORINGS EBI-A, EBI-B, EB2-A, EB2-B DETERMINED USING SURVEY-GRADE GPS

COLLAR ELEVATION FOR BORING EB2-A2 DETERMINED FROM PROVIDED .TIN FILE DATED 07/26/2017

ABBREVIATIONS:

FIAD = FILLED IMMEDIATELY AFTER DRILLING

DATE: 8-15-14

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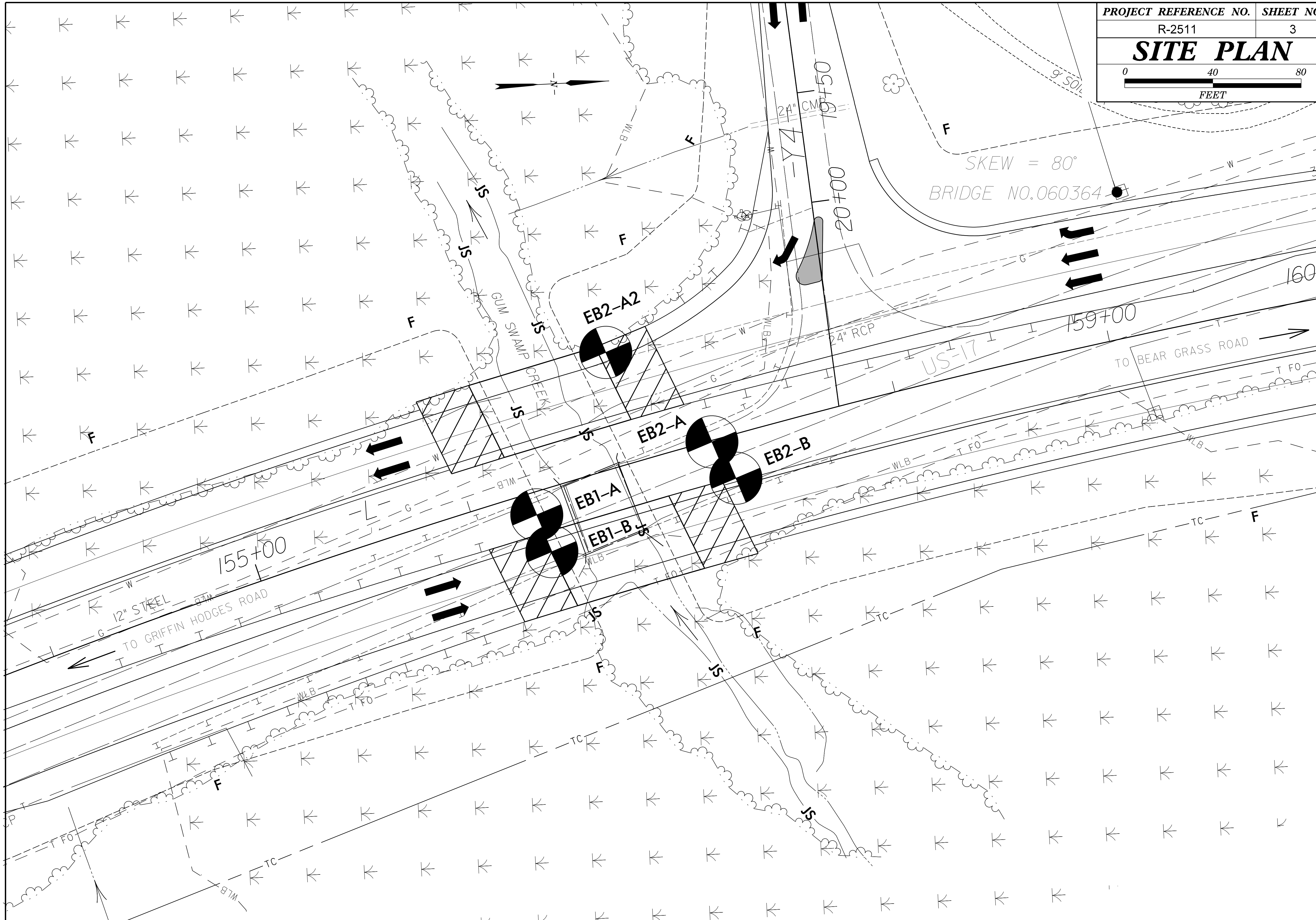
PROJECT REFERENCE NO.	SHEET NO.
R-2511	3

SITE PLAN



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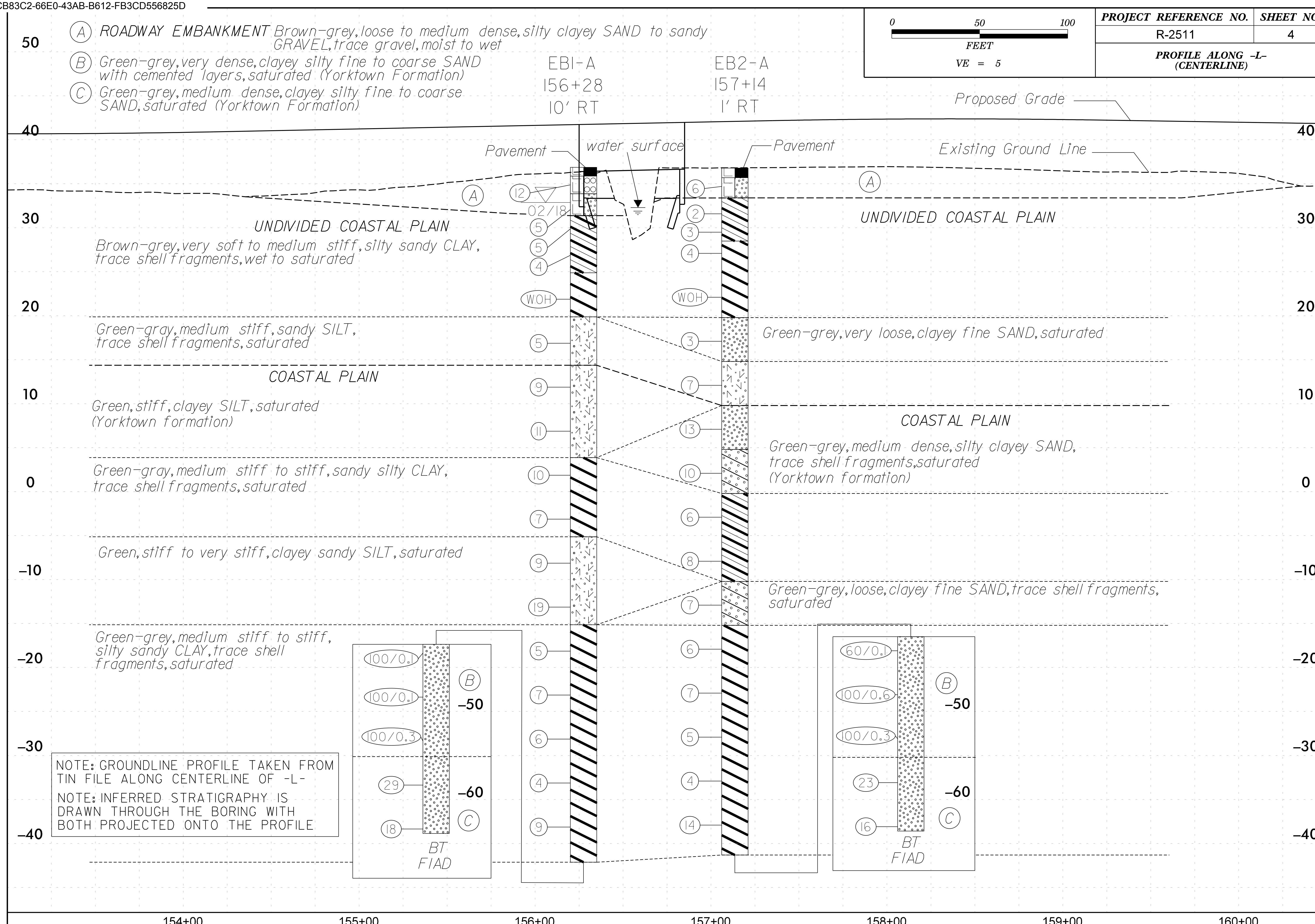

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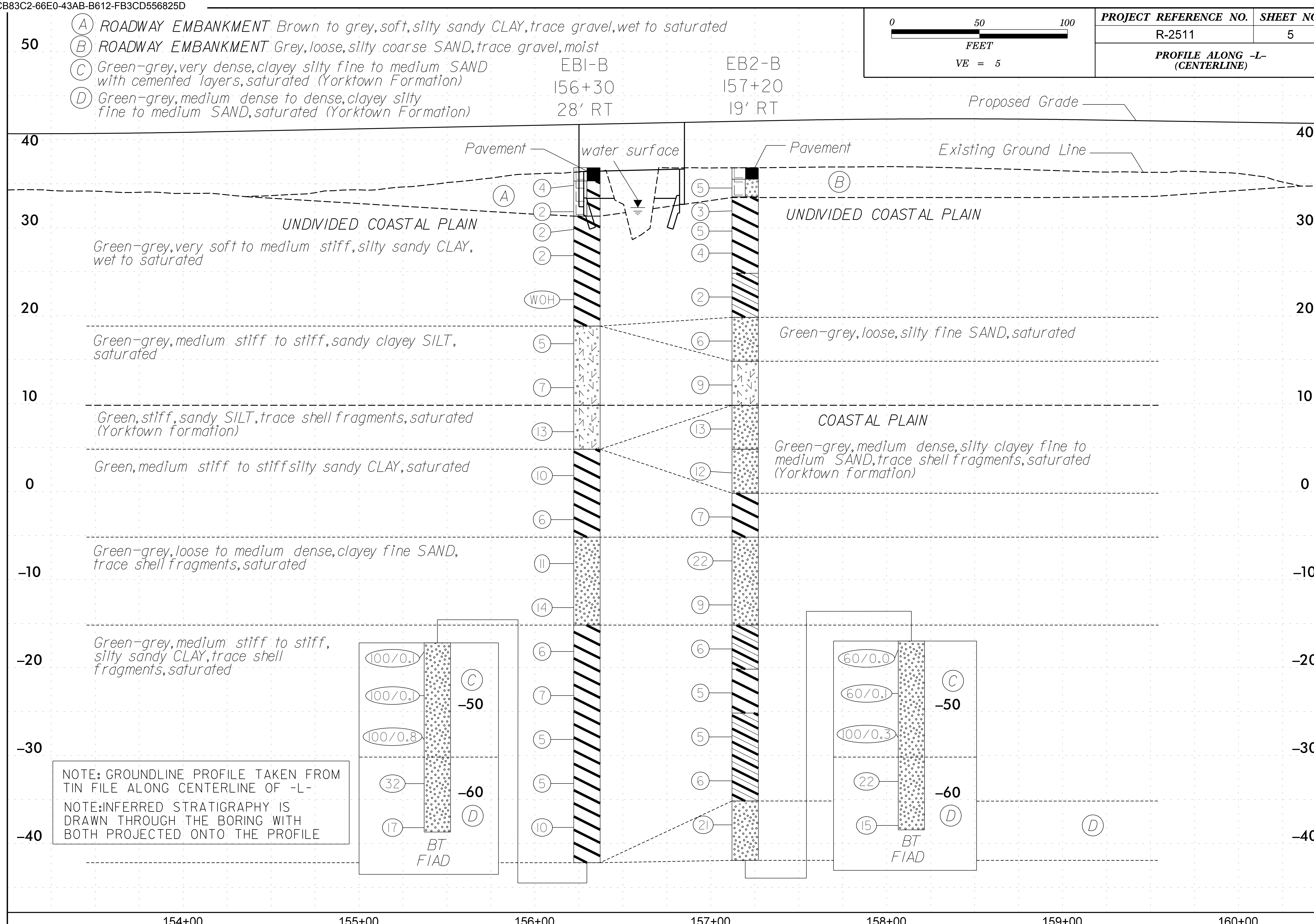

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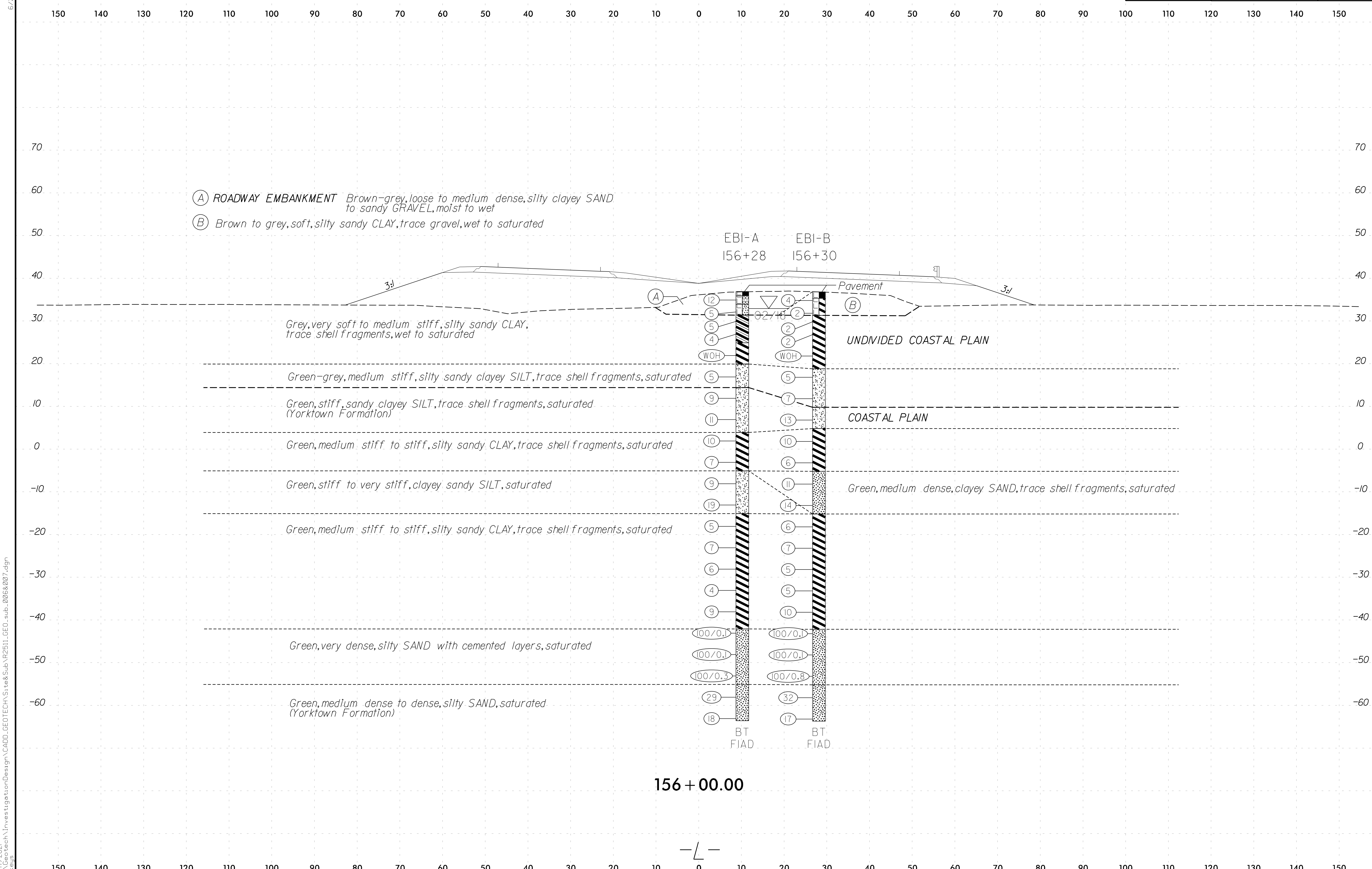
PROJ. REFERENCE NO.	SHEET NO.
R-2511	6



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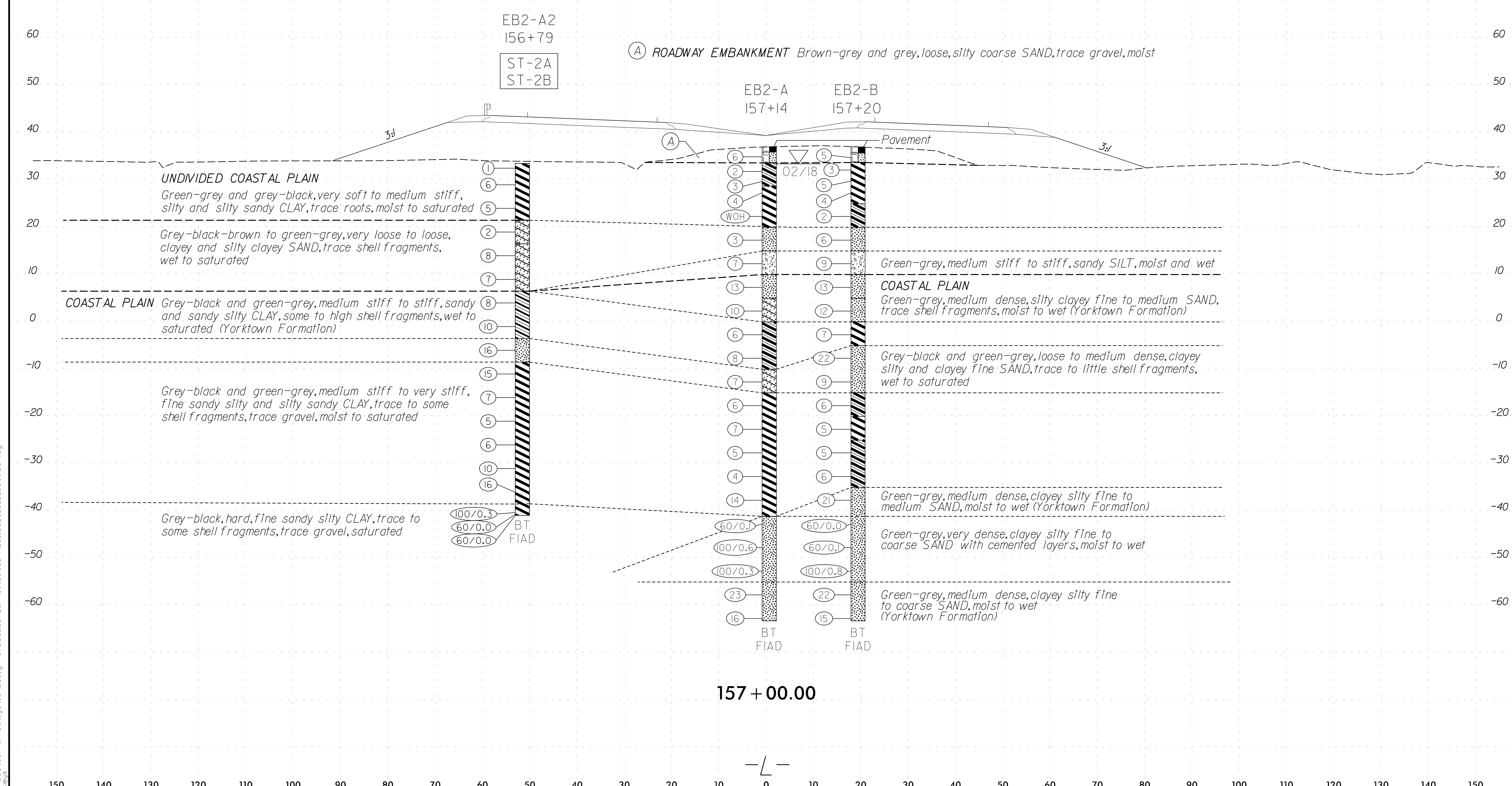
SOIL TEST RESULTS

SAMPLE NO.	STATION	OFFSET	LINE	DEPTH INTERVAL	AASHTO CLASS.	L.L.	P.I.	% BY WEIGHT				% PASSING SIEVE			% MOISTURE	% ORGANIC
								C. SAND	F. SAND	SILT	CLAY	10	40	200		
ST-2A/2B	156+79	49' LT	-L-	10.4 - 10.8	A-7-6 (53)	71	47	0.5	3.7	27.7	68.1	100.0	99.7	97.7	90	-

Note: ST-2A and ST-2B were extruded from the shelby tube at a depth of 10.4'-10.8' and mixed together to obtain a representative sample of the two tubes.



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GEOTECHNICAL BORING REPORT
BORE LOG

WBS 35494.1.1	**TIP** R-2511	**COUNTY** BEAUFORT	**GEOLOGIST** A Bozorgi
SITE DESCRIPTION Dual Bridge on US 17 over Gum Swamp Creek between SR 1421 and SR 1420			**GROUND WTR (ft)**
BORING NO. EB1-A	**STATION** 156+28	**OFFSET** 10 ft RT	**ALIGNMENT** -L- / **0 HR.** 4.0
COLLAR ELEV. 36.9 ft	**TOTAL DEPTH** 100.5 ft	**NORTHING** 707,375	**EASTING** 2,570,262 / **24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE SME9403 CME-550X 83% 02/02/2018	**DRILL METHOD** Mud Rotary		**HAMMER TYPE** Automatic
DRILLER S. Hardee	**START DATE** 02/08/18	**COMP. DATE** 02/08/18	**SURFACE WATER DEPTH** N/A

Samples

DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT	MOI
35.9	1.0	4	6	6	12	M
33.1	3.8	2	3	2	5	W
30.9	6.0	2	2	3	5	W
27.9	9.0	WOH	2	2	4	Sat.
22.9	14.0	WOH	WOH	WOH	0	Sat.
17.9	19.0	2	2	3	5	Sat.
12.9	24.0	2	3	6	9	Sat.
7.9	29.0	3	4	7	11	Sat.
2.9	34.0	3	4	6	10	Sat.
-2.1	39.0	2	3	4	7	Sat.
-7.1	44.0	4	4	5	9	Sat.
-12.1	49.0	4	8	11	19	Sat.
-17.1	54.0	3	2	3	5	Sat.
-22.1	59.0	2	3	4	7	Sat.
-27.1	64.0	2	3	3	6	Sat.
-32.1	69.0	2	2	2	4	Sat.
-37.1	74.0	2	3	6	9	Sat.

Match Line

DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT	MOI
-42.1	79.0	100/0.1			100/0.1	Sat.
-47.1	84.0	100/0.1			100/0.1	Sat.
-52.1	89.0	100/0.3			100/0.3	Sat.
-57.1	94.0	10	13	16	29	Sat.
-62.1	99.0	5	8	10	18	Sat.

Soil and Rock Description

ELEV. (ft)	DESCRIPTION	DEPTH (ft)
36.9	GROUND SURFACE	0.0
35.9	Asphalt	1.0
	ROADWAY EMBANKMENT Brown, sandy GRAVEL (A-1-b)	
33.9	Brown-grey, clayey SAND (A-2-5), trace gravel	3.0
31.4	**UNDIVIDED COASTAL PLAIN** Grey, sandy CLAY (A-6)	5.5
24.9	Grey, silty CLAY (A-7-5), trace shell fragments	12.0
19.9	Green, sandy SILT (A-5), trace shell fragments	17.0
14.4	**COASTAL PLAIN** Green, clayey SILT (A-5) (Yorktown Formation)	22.5
3.9	Green, silty CLAY (A-7-5), trace shell fragments	33.0
-5.1	Green, clayey sandy SILT (A-5)	42.0
-15.1	Green, silty CLAY (A-7-5)	52.0
	Green, silty CLAY (A-7-5) *(continued)*	
-42.1	Green, silty SAND (A-2-5) with cemented layers	79.0
-55.1	Green, silty SAND (A-2-5) (Yorktown Formation)	92.0
-63.6	Boring Terminated at Elevation -63.6 ft in Coastal Plain: silty SAND (Yorktown Formation)	100.5

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GEOTECHNICAL BORING REPORT
BORE LOG

WBS 35494.1.1	**TIP** R-2511	**COUNTY** BEAUFORT	**GEOLOGIST** A Bozorgi
SITE DESCRIPTION Dual Bridge on US 17 over Gum Swamp Creek between SR 1421 and SR 1420			**GROUND WTR (ft)**
BORING NO. EB1-B	**STATION** 156+30	**OFFSET** 28 ft RT	**ALIGNMENT** -L-
COLLAR ELEV. 36.8 ft	**TOTAL DEPTH** 100.5 ft	**NORTHING** 707,381	**EASTING** 2,570,279
0 HR. N/A	**24 HR.** FIAD		
DRILL RIG/HAMMER EFF./DATE SME9403 CME-550X 83% 02/02/2018	**DRILL METHOD** Mud Rotary	**HAMMER TYPE** Automatic	
DRILLER S. Hardee	**START DATE** 02/09/18	**COMP. DATE** 02/09/18	**SURFACE WATER DEPTH** N/A

WBS 35494.1.1 TIP R-2511 COUNTY BEAUFORT GEOLOGIST A Bozorgi
SITE DESCRIPTION Dual Bridge on US 17 over Gum Swamp Creek between SR 1421 and SR 1420 GROUND WTR (ft)
BORING NO. EB1-B STATION 156+30 OFFSET 28 ft RT ALIGNMENT -L- 0 HR. N/A
COLLAR ELEV. 36.8 ft TOTAL DEPTH 100.5 ft NORTHING 707,381 EASTING 2,570,279 24 HR. FIAD
DRILL RIG/HAMMER EFF./DATE SME9403 CME-550X 83% 02/02/2018 DRILL METHOD Mud Rotary HAMMER TYPE Automatic
DRILLER S. Hardee START DATE 02/09/18 COMP. DATE 02/09/18 SURFACE WATER DEPTH N/A

DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT	SAMP. NO.	MOI
35.8	1.0	2	2	2	4		W
32.8	4.0	2	1	1	2		Sat.
30.8	6.0	WOH	1	1	2		Sat.
27.8	9.0	1	1	1	2		Sat.
22.8	14.0	WOH	WOH	WOH	0		Sat.
17.8	19.0	1	2	3	5		Sat.
12.8	24.0	2	3	4	7		Sat.
7.8	29.0	3	5	8	13		Sat.
2.8	34.0	4	5	5	10		Sat.
-2.2	39.0	2	2	4	6		Sat.
-7.2	44.0	5	4	7	11		Sat.
-12.2	49.0	4	4	10	14		Sat.
-17.2	54.0	3	2	4	6		Sat.
-22.2	59.0	2	3	4	7		Sat.
-27.2	64.0	1	2	3	5		Sat.
-32.2	69.0	2	2	3	5		Sat.
-37.2	74.0	2	3	7	10		Sat.
-42.2	79.0	100/0.1			100/0.1		Sat.
-47.2	84.0	100/0.1			100/0.1		Sat.
-52.2	89.0	100/0.8			100/0.8		Sat.
-57.2	94.0	12	14	18	32		Sat.
-62.2	99.0	5	7	10	17		Sat.

Match Line

SOIL AND ROCK DESCRIPTION

ELEV. (ft)	DESCRIPTION	DEPTH (ft)
36.8	GROUND SURFACE	0.0
35.3	Asphalt	1.5
	ROADWAY EMBANKMENT Brown to grey, silty sandy CLAY (A-7-5), trace gravel	
31.3	**UNDIVIDED COASTAL PLAIN** Grey, silty sandy CLAY (A-7-5)	5.5
18.8	Green-grey, sandy clayey SILT (A-5), trace shell fragments	18.0
9.8	**COASTAL PLAIN** Green, sandy SILT (A-5), trace shell fragments (Yorktown Formation)	27.0
4.8	Green, silty sandy CLAY (A-7-5)	32.0
-5.2	Green, clayey SAND (A-2-7), trace shell fragments	42.0
-15.2	Green, sandy CLAY (A-7-5), trace shell fragments	52.0
-42.2	Green, silty SAND (A-2-5) with cemented layers	79.0
-55.2	Green, silty SAND (A-2-5) (Yorktown Formation)	92.0
-63.7		100.5

Boring Terminated at Elevation -63.7 ft in Coastal Plain: silty SAND (Yorktown Formation)

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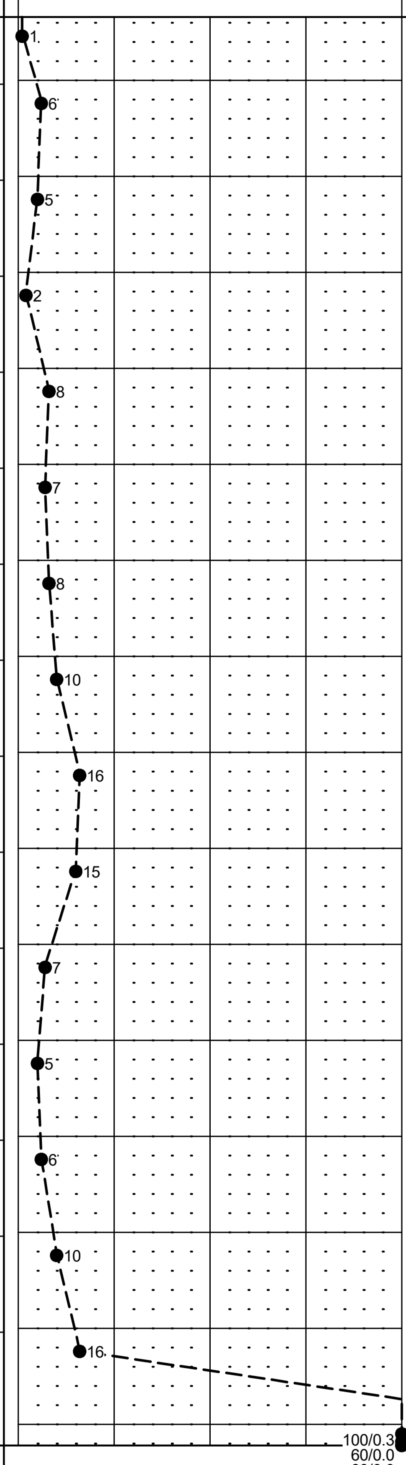
GEOTECHNICAL BORING REPORT
BORE LOG

WBS 35494.1.1	**TIP** R-2511	**COUNTY** BEAUFORT	**GEOLOGIST** M. Metry	
SITE DESCRIPTION Dual Bridge on US 17 over Gum Swamp Creek between SR 1421 and SR 1420				**GROUND WTR (ft)**
BORING NO. EB2-A2	**STATION** 156+79	**OFFSET** 51 ft LT	**ALIGNMENT** -L-	**0 HR.** N/A
COLLAR ELEV. 33.3 ft	**TOTAL DEPTH** 74.4 ft	**NORTHING** 707,410	**EASTING** 2,570,190	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE GET0674 CME-45C 86% 02/24/2019		**DRILL METHOD** Mud Rotary	**HAMMER TYPE** Automatic	
DRILLER T. Donahue	**START DATE** 03/02/20	**COMP. DATE** 03/02/20	**SURFACE WATER DEPTH** N/A	

DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	SAMP. NO.	MOI
33.3	0.0	WOH	WOH	1		Sat.
29.8	3.5	3	3	3		Sat.
24.8	8.5	3	3	2		Sat.
19.8	13.5	1	1	1		Sat.
14.8	18.5	2	3	5		Sat.
9.8	23.5	3	3	4		Sat.
4.8	28.5	3	4	4		Sat.
-0.2	33.5	4	5	5		Sat.
-5.2	38.5	4	5	11		Sat.
-10.2	43.5	6	7	8		Sat.
-15.2	48.5	2	3	4		Sat.
-20.2	53.5	2	2	3		Sat.
-25.2	58.5	3	3	3		Sat.
-30.2	63.5	3	5	5		Sat.
-35.2	68.5	9	8	8		Sat.
-40.2	73.5	100/0.3				Sat.
-40.9	74.2	60/0.0				Sat.
-41.1	74.4	60/0.0				Sat.

BLOWS PER FOOT (0, 25, 50, 75, 100)



SOIL AND ROCK DESCRIPTION

ELEV. (ft)	Description	DEPTH (ft)
33.3	GROUND SURFACE	0.0
	UNDIVIDED COASTAL PLAIN Grey-black, silty CLAY (A-7-6), trace roots	
21.3	Grey-black-brown, clayey fine SAND (A-2-7) (Yorktown Formation)	12.0
16.3	Black-grey, silty clayey fine SAND (A-2-6), trace shells	17.0
6.3	**COASTAL PLAIN** Grey-black, sandy CLAY (A-6), some to high shells (Yorktown Formation)	27.0
-3.7	Grey-black, clayey silty SAND (A-2-5), little shells	37.0
-8.7	Grey-black, fine sandy silty CLAY (A-7-6), trace to some shells, trace gravel	42.0
-38.7	Grey-black, fine sandy silty CLAY (A-7-6), trace to some shells, trace gravel	72.0
-41.1	Boring Terminated at Elevation -41.1 ft in Coastal Plain: fine sandy silty CLAY (Yorktown Formation)	74.4

WBS 35494.1.1	**TIP** R-2511	**COUNTY** BEAUFORT	**GEOLOGIST** M. Metry	
SITE DESCRIPTION Dual Bridge on US 17 over Gum Swamp Creek between SR 1421 and SR 1420				**GROUND WTR (ft)**
BORING NO. EB2-A2	**STATION** 156+79	**OFFSET** 51 ft LT	**ALIGNMENT** -L-	**0 HR.** N/A
COLLAR ELEV. 33.3 ft	**TOTAL DEPTH** 74.4 ft	**NORTHING** 707,410	**EASTING** 2,570,190	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE GET0674 CME-45C 86% 02/24/2019		**DRILL METHOD** Mud Rotary	**HAMMER TYPE** Automatic	
DRILLER T. Donahue	**START DATE** 03/02/20	**COMP. DATE** 03/02/20	**SURFACE WATER DEPTH** N/A	

-45 Match Line

ST-2 taken at the following location:
Station: 156+79
Offset: 49' LT

Other Samples:
ST-2 (9.0 - 11.0)

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GEOTECHNICAL BORING REPORT
BORE LOG

WBS 35494.1.1	**TIP** R-2511	**COUNTY** BEAUFORT	**GEOLOGIST** G. Goslin
SITE DESCRIPTION Dual Bridge on US 17 over Gum Swamp Creek between SR 1421 and SR 1420			**GROUND WTR (ft)**
BORING NO. EB2-A	**STATION** 157+14	**OFFSET** 1 ft RT	**ALIGNMENT** -L- / **0 HR.** 3.6
COLLAR ELEV. 36.8 ft	**TOTAL DEPTH** 100.2 ft	**NORTHING** 707,456	**EASTING** 2,570,233 / **24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE SME9563 CME-550X 88% 08/10/2017	**DRILL METHOD** Mud Rotary		**HAMMER TYPE** Automatic
DRILLER J. White	**START DATE** 02/08/18	**COMP. DATE** 02/08/18	**SURFACE WATER DEPTH** N/A

Drive Elev (ft)	Depth (ft)	Blow Count 0.5ft	0.5ft	0.5ft	Blows per Foot	Samp. No.	Moi
35.7	1.1	12	4	2	6		M
32.6	4.2	2	1	1	2		W
30.5	6.3	2	1	2	3		W
28.1	8.7	2	2	2	4		Sat.
23.1	13.7	WOH	WOH	WOH	0		Sat.
18.1	18.7	1	1	2	3		Sat.
13.1	23.7	3	3	4	7		Sat.
8.1	28.7	4	5	8	13		Sat.
3.1	33.7	4	4	6	10		Sat.
-1.9	38.7	3	3	3	6		Sat.
-6.9	43.7	3	3	5	8		Sat.
-11.9	48.7	4	3	4	7		Sat.
-16.9	53.7	2	3	3	6		Sat.
-21.9	58.7	3	3	4	7		Sat.
-26.9	63.7	2	2	3	5		Sat.
-31.9	68.7	2	2	2	4		Sat.
-36.9	73.7	3	6	8	14		Sat.
-41.9	78.7	60/0.1			60/0.1		
-46.9	83.7	28	43	57/0.1	100/0.6		Sat.
-51.9	88.7	100/0.3			100/0.3		Sat.
-56.9	93.7	11	10	13	23		Sat.
-61.9	98.7	9	8	8	16		Sat.

Match Line

SOIL AND ROCK DESCRIPTION

Elev. (ft)	Description	Depth (ft)
36.8	GROUND SURFACE	0.0
35.7	Asphalt	1.1
	ROADWAY EMBANKMENT Brown-grey, silty coarse SAND (A-2-4), trace gravel	
33.4	**UNDIVIDED COASTAL PLAIN** Brown-grey, silty sandy CLAY (A-6)	3.4
28.5	Green-grey, sandy CLAY (A-7-6)	8.3
19.8	Green-gey, clayey fine SAND (A-2-6)	17.0
14.8	green-grey, sandy SILT (A-5)	22.0
9.8	**COASTAL PLAIN** Green-grey, silty fine SAND (A-2-5), trace shell fragments (Yorktown Formation)	27.0
4.8	Green-grey, clayey medium SAND (A-2-7), trace shell fragments	32.0
-0.2	Green-gray, sandy silty CLAY (A-6), trace shell fragments	37.0
-10.2	Green-grey, clayey fine SAND (A-2-6), trace shell fragments	47.0
-15.2	Green-grey, silty sandy CLAY (A-7-6), trace shell fragments	52.0
-41.3	Green-grey, clayey silty fine to coarse SAND (A-2-5) with cemented layers	78.1
-55.2	Green-grey, clayey silty fine to coarse SAND (A-2-5) (Yorktown Formation)	92.0
-63.4		100.2

Boring Terminated at Elevation -63.4 ft in Coastal Plain: clayey silty SAND (Yorktown Formation)

NCDOT BORE DOUBLE R-2511_GEO_BRDG.GPJ NC_DOT.GDT 3/31/21

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GEOTECHNICAL BORING REPORT
BORE LOG

WBS 35494.1.1	**TIP** R-2511	**COUNTY** BEAUFORT	**GEOLOGIST** G. Goslin
SITE DESCRIPTION Dual Bridge on US 17 over Gum Swamp Creek between SR 1421 and SR 1420			**GROUND WTR (ft)**
BORING NO. EB2-B	**STATION** 157+20	**OFFSET** 19 ft RT	**ALIGNMENT** -L- / **0 HR.** N/A
COLLAR ELEV. 36.8 ft	**TOTAL DEPTH** 100.2 ft	**NORTHING** 707,466	**EASTING** 2,570,250 / **24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE SME9563 CME-550X 88% 08/10/2017	**DRILL METHOD** Mud Rotary		**HAMMER TYPE** Automatic
DRILLER J. White	**START DATE** 02/09/18	**COMP. DATE** 02/09/18	**SURFACE WATER DEPTH** N/A

DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT	MOI
35.5	1.3	7	3	2	5	M
32.9	3.9	1	2	1	3	W
30.6	6.2	2	2	3	5	Sat.
28.1	8.7	2	2	2	4	Sat.
23.1	13.7	1	1	1	2	Sat.
18.1	18.7	2	3	3	6	Sat.
13.1	23.7	3	4	5	9	Sat.
8.1	28.7	4	6	7	13	Sat.
3.1	33.7	5	5	7	12	Sat.
-1.9	38.7	3	3	4	7	Sat.
-6.9	43.7	6	9	13	22	Sat.
-11.9	48.7	4	4	5	9	Sat.
-16.9	53.7	2	2	4	6	Sat.
-21.9	58.7	2	2	3	5	Sat.
-26.9	63.7	2	2	3	5	Sat.
-31.9	68.7	2	3	3	6	Sat.
-36.9	73.7	3	8	13	21	Sat.

Match Line

DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT	MOI
-41.9	78.7	60/0.0			60/0.0	
-46.9	83.7	60/0.1			60/0.1	
-51.9	88.7	26	63	47/0.3	100/0.8	
-56.9	93.7	10	10	12	22	Sat.
-61.9	98.7	8	7	8	15	Sat.

SOIL AND ROCK DESCRIPTION

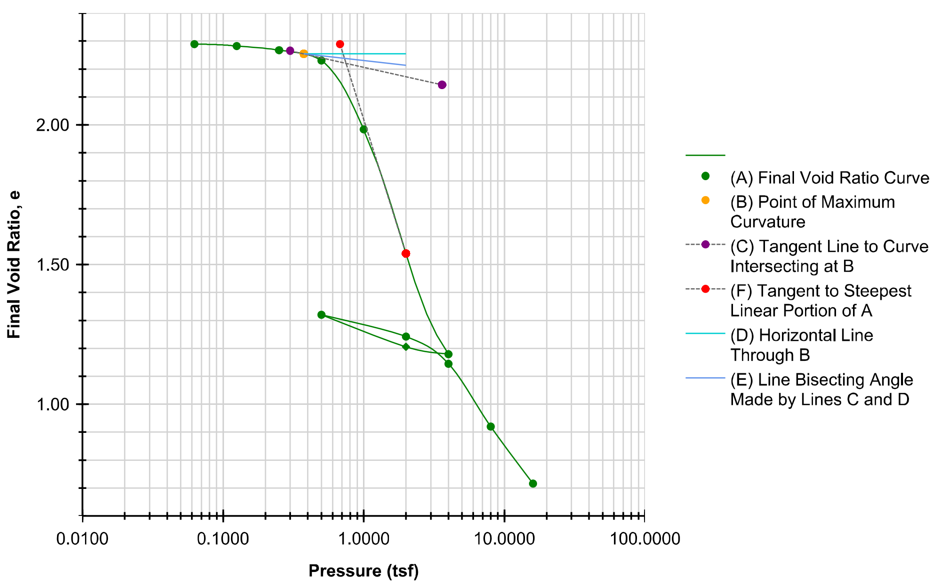
ELEV. (ft)	DESCRIPTION	DEPTH (ft)
36.8	GROUND SURFACE	0.0
35.5	Asphalt	1.3
33.5	**ROADWAY EMBANKMENT** Grey, silty coarse SAND (A-2-4), trace gravel	3.3
24.8	**UNDIVIDED COASTAL PLAIN** Green-grey, silty sandy CLAY (A-7-6)	12.0
19.8	Green-grey, silty sandy CLAY (A-6)	17.0
14.8	Green-grey, silty fine SAND (A-2-5)	22.0
9.8	Green-grey, sandy SILT (A-5)	27.0
4.8	**COASTAL PLAIN** Green-grey, silty fine SAND (A-2-5), trace shell fragments (Yorktown Formation)	32.0
-0.2	Green-grey, clayey fine to medium SAND (A-2-6)	37.0
-5.2	Green-grey, silty CLAY (A-7-6)	42.0
-15.2	Green-grey, clayey fine SAND (A-2-6), trace shell fragments	52.0
-20.2	Green-grey, silty sandy CLAY (A-6), trace shell fragments	57.0
-25.2	Green-grey, silty sandy CLAY (A-7-6), trace shell fragments	62.0
-35.2	Green-grey, silty CLAY (A-6), trace shell fragments	72.0
-41.3	Green-grey, clayey silty fine to medium SAND (A-2-4)	78.1
-55.2	Green-grey, clayey silty fine to medium SAND (A-2-4) with cemented layers	92.0
-63.4	Green-grey, clayey silty fine to medium SAND (A-2-4) (Yorktown Formation)	100.2

Boring Terminated at Elevation -63.4 ft in Coastal Plain: clayey silty SAND (Yorktown Formation)

WBS 35494.1.1 TIP R-2511 COUNTY BEAUFORT GEOLOGIST G. Goslin
SITE DESCRIPTION Dual Bridge on US 17 over Gum Swamp Creek between SR 1421 and SR 1420 GROUND WTR (ft)
BORING NO. EB2-B STATION 157+20 OFFSET 19 ft RT ALIGNMENT -L- 0 HR. N/A
COLLAR ELEV. 36.8 ft TOTAL DEPTH 100.2 ft NORTHING 707,466 EASTING 2,570,250 24 HR. FIAD
DRILL RIG/HAMMER EFF./DATE SME9563 CME-550X 88% 08/10/2017 DRILL METHOD Mud Rotary HAMMER TYPE Automatic
DRILLER J. White START DATE 02/09/18 COMP. DATE 02/09/18 SURFACE WATER DEPTH N/A

Final Voids [Log]

AASHTO T-216



Preconsolidation Stress (tsf)	0.7296	Cc	1.337	Cr	0.037

	BEFORE	AFTER	Liquid Limits	71	Test Date 3/17/2020
Moisture (%)	80.4	37.8	Plastic Limits	24	
Dry Density (pcf)	50.6	82.9			
Saturation (%)	93.5	100.0			
Void Ratio	2.30	1.01	Specific Gravity	2.67	ASSUMED

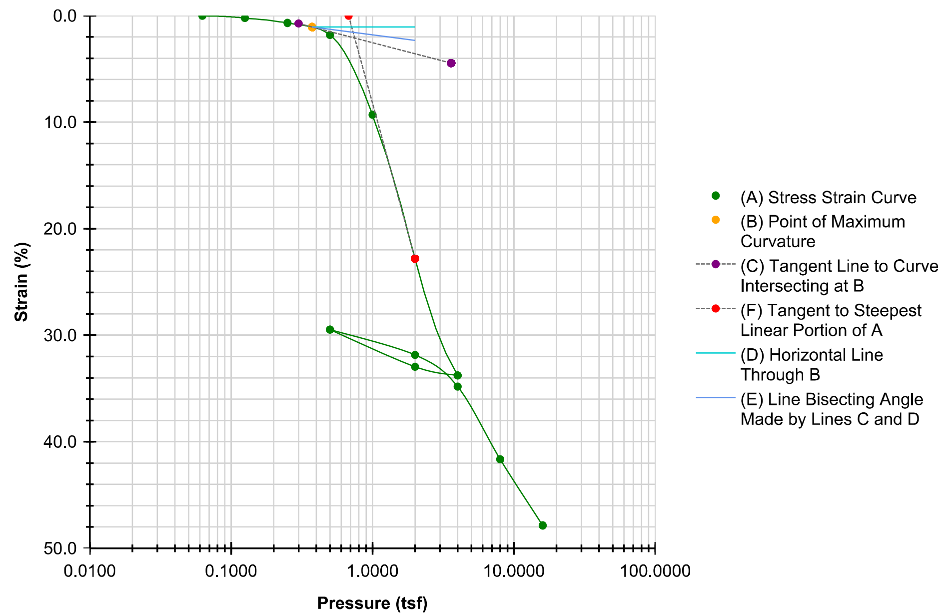
Sample Description	Gray, A-7-6 (53)			
Project Number	66Y-0050	Depth (ft)	9.0' - 11.0'	Remarks
Sample Number	ST-2A	Boring Number	EB2-A2	NA
Project	R-2511: US17 Widening			
Client	RK&K			
Location	EB2-A2			

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Consolidation Test - Results

Percent Strain [Log]

AASHTO T-216



Preconsolidation Stress (tsf)	0.7296	Cc	ND	Cr	ND

	BEFORE	AFTER	Liquid Limits	71	Test Date 3/17/2020
Moisture (%)	80.4	37.8	Plastic Limits	24	
Dry Density (pcf)	50.6	82.9			
Saturation (%)	93.5	100.0			
Void Ratio	2.30	1.01	Specific Gravity	2.67	ASSUMED

Sample Description	Gray, A-7-6 (53)			
Project Number	66Y-0050	Depth (ft)	9.0' - 11.0'	Remarks
Sample Number	ST-2A	Boring Number	EB2-A2	NA
Project	R-2511: US17 Widening			
Client	RK&K			
Location	EB2-A2			

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Consolidation Test - Results

Summary

AASHTO T-216

Sample Description	Gray, A-7-6 (53)				
Project Number	66Y-0050	**Depth (ft)**	9.0' - 11.0'	**Remarks**	
Sample Number	ST-2A	**Boring Number**	EB2-A2	NA	
Project	R-2511: US17 Widening				
Client	RK&K				
Location	EB2-A2				

Index	Loading Sequence (tsf)	Cummulative Change in Height (in)	Specimen Height (in)	Height of Voids (in)	Vertical Strain (%)	Void Ratio	T90 Fitting Time (Hr)	T50 Fitting Time (Hr)	T90 Cv (in²/Min)	T50 Cv (in²/Min)	Sequence Status
0	0.0000	0.0000	1.0000	0.0000	0.0	2.296	0.000	0.000	0.00000	0.00000	ENABLED
1	0.0625	0.0002	0.9998	0.6959	0.0	2.289	0.000	0.000	0.00000	0.00000	ENABLED
2	0.1250	0.0023	0.9977	0.6938	0.2	2.283	0.102	0.024	0.14604	0.03393	ENABLED
3	0.2500	0.0069	0.9931	0.6892	0.7	2.267	0.092	0.020	0.16884	0.03922	ENABLED
4	0.5000	0.0182	0.9818	0.6779	1.8	2.230	0.107	0.024	0.13863	0.03220	ENABLED
5	1.0000	0.0931	0.9069	0.6030	9.3	1.984	0.357	0.091	0.02960	0.00688	ENABLED
6	2.0000	0.2282	0.7718	0.4679	22.8	1.539	1.229	0.288	0.00482	0.00112	ENABLED
7	4.0000	0.3378	0.6622	0.3583	33.8	1.179	1.047	0.248	0.00218	0.00051	ENABLED
8	2.0000	0.3297	0.6703	0.3664	33.0	1.205	0.000	0.000	0.00000	0.00000	ENABLED
9	0.5000	0.2948	0.7052	0.4013	29.5	1.320	0.000	0.000	0.00000	0.00000	ENABLED
10	2.0000	0.3186	0.6814	0.3775	31.9	1.242	0.359	0.085	0.00586	0.00136	ENABLED
11	4.0000	0.3482	0.6518	0.3479	34.8	1.145	0.363	0.085	0.00431	0.00100	ENABLED
12	8.0000	0.4165	0.5835	0.2796	41.7	0.920	0.772	0.177	0.00088	0.00020	ENABLED
13	16.0000	0.4786	0.5214	0.2175	47.9	0.715	0.660	0.157	0.00015	0.00003	ENABLED

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Consolidation Test - Information - Section 1

Consolidated Test Results

AASHTO T-216

Project:	R-2511: US17 Widening
Project Number:	66Y-0050
Job Number:	66Y-0050-01
Test Date:	3/17/2020

Sampling Date:	3/16/2020
Sample Number:	ST-2A
Depth (ft)	9.0' - 11.0'
Boring Number:	EB2-A2
Location:	EB2-A2
Client Name:	RK&K
Remarks:	NA

Specific Gravity:	2.67	Plastic Limit:	24	Liquid Limit:	71
Specific Gravity Method:	ASSUMED			Weight of Ring (g)	110.3
Sampling Method:	Undisturbed	Soil Classification:			
Specimen Description:	Gray, A-7-6 (53)				

Parameters	Initial	Final
Height (in)	1.0000	0.5214
Height Source	NA	TEST RESULTS
Diameter (in)	2.5000	NA
Area (in²)	4.909	NA
Volume (in³)	4.9087	2.5594
Weight of Container (g)	15.5	30.8
Weight of Wet Soil + Container (g)	61.7	112.5
Weight of Dry Soil + Container (g)	41.1	90.1
Moisture Content (%)	80.4	37.8
Moist Weight + Ring Weight (g)	227.9	187.1
Dry Density (pcf)	50.6	82.9
Wet Density (pcf)	91.2	114.3
Saturation (%)	93.5	100.0
Void Ratio	2.3	1.0

Consolidation Test Results

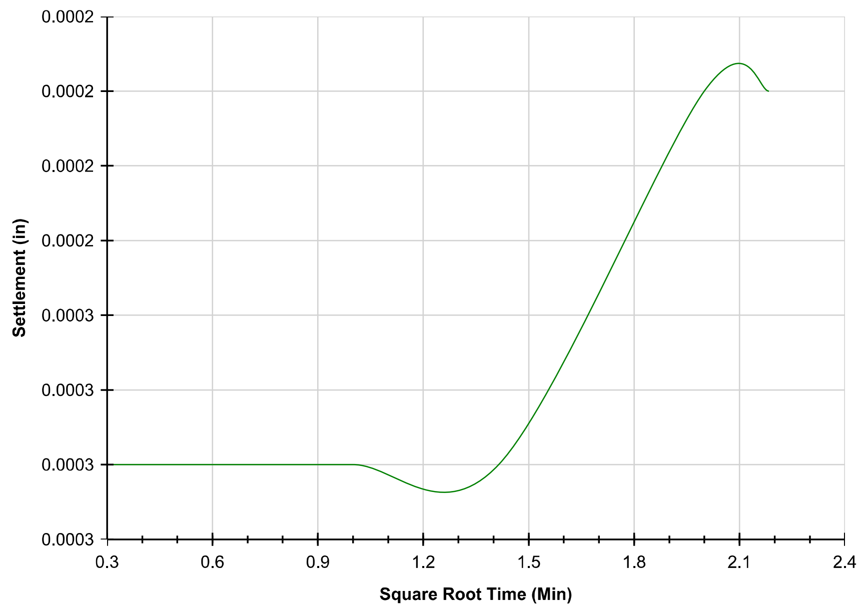
AASHTO T-216

Specimen 1			
Test Description:	One-Dimensional Consolidation		
Other Associated Tests:	NA		
Device Details:	Oedometer 1		
Test Specification:	AASHTO-216		
Test Time:	3/17/2020 12:00:00 AM		
Technician:	Drew Council	Sampling Method:	Undisturbed
Specimen Code:	ST-2A	Specimen Lab #:	ST-2 (A)
Specimen Description:	Gray, A-7-6 (53)		
Specimen Preparation:	Ring-Lined Sampler		
Large Particle:	NA		
Moisture Content:	Natural Moisture		
Test Condition:	Soaked		
Test Procedure:	AASHTO T-216 [Changes - NA]		
Seating Pressure Used:	YES	Seating Pressure (kPa):	5.0000
Preconsolidation Stress:			
Percent Strain [LOG] Graph (tsf):	0.7296	Final Voids Graph (tsf):	0.7296

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Square Root Time [1] 0.0625 tsf

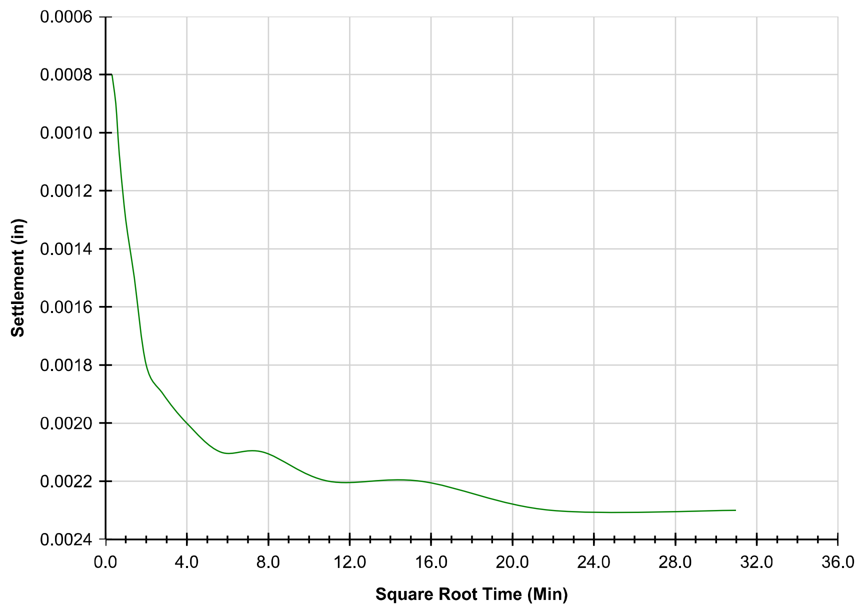
AASHTO T-216



Tangent Construction Results	
T90 (Min)	NA
T50 (Min)	NA
Cv (in²/Min)	NA

Square Root Time [2] 0.1250 tsf

AASHTO T-216



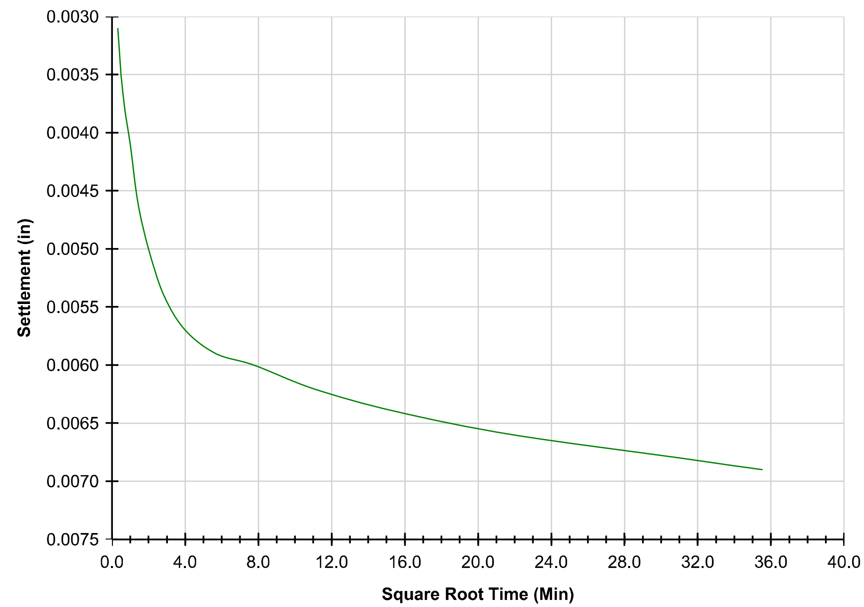
Tangent Construction Results	
T90 (Min)	NA
T50 (Min)	NA
Cv (in²/Min)	NA

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Consolidation Test - Results

Square Root Time [3] 0.2500 tsf

AASHTO T-216

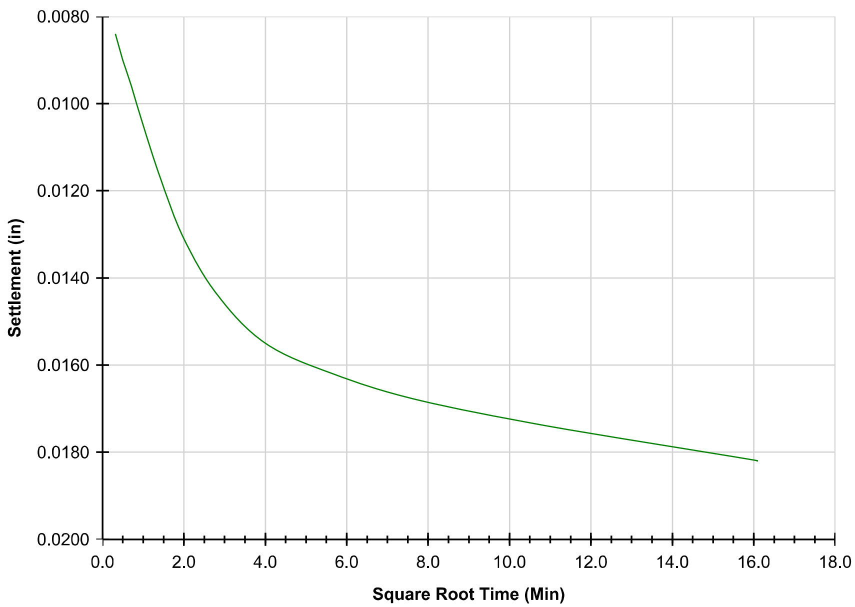


Tangent Construction Results	
T90 (Min)	NA
T50 (Min)	NA
Cv (in²/Min)	NA

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Square Root Time [4] 0.5000 tsf

AASHTO T-216



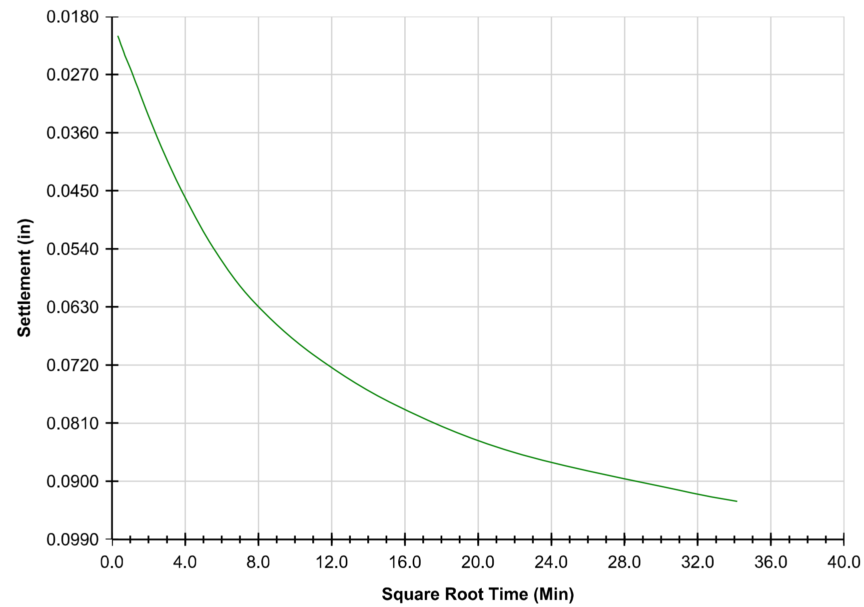
Tangent Construction Results	
T90 (Min)	NA
T50 (Min)	NA
Cv (in²/Min)	NA

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Consolidation Test - Results

Square Root Time [5] 1.0000 tsf

AASHTO T-216

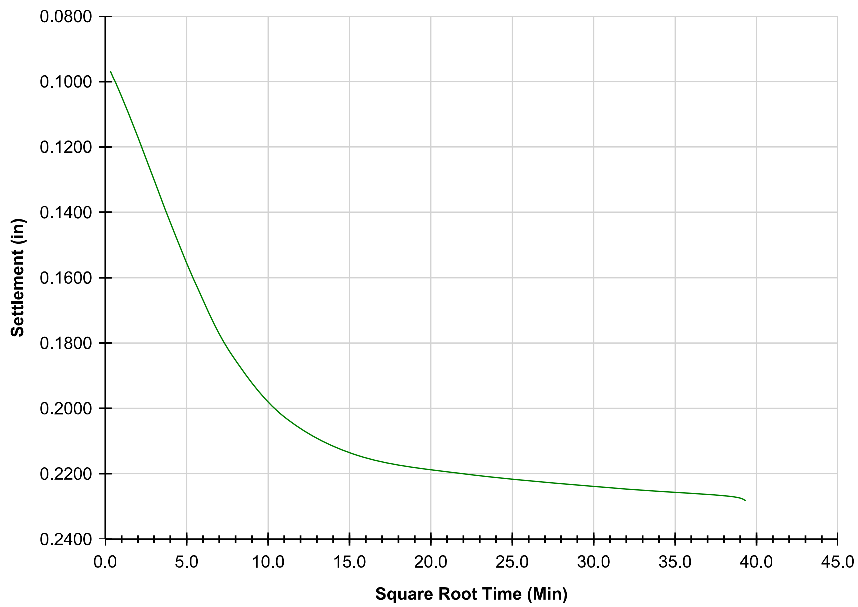


Tangent Construction Results	
T90 (Min)	NA
T50 (Min)	NA
Cv (in²/Min)	NA

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Square Root Time [6] 2.0000 tsf

AASHTO T-216



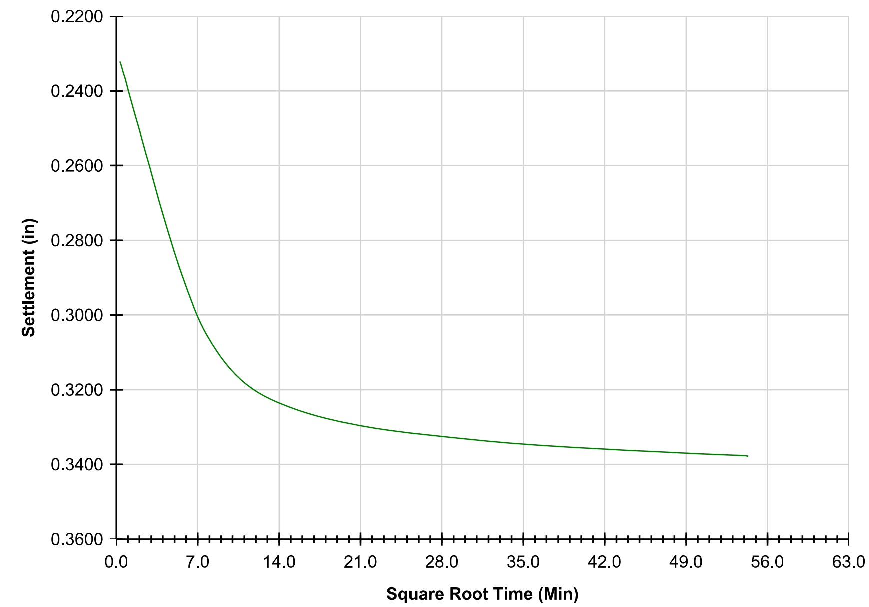
Tangent Construction Results	
T90 (Min)	NA
T50 (Min)	NA
Cv (in²/Min)	NA

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Consolidation Test - Results

Square Root Time [7] 4.0000 tsf

AASHTO T-216

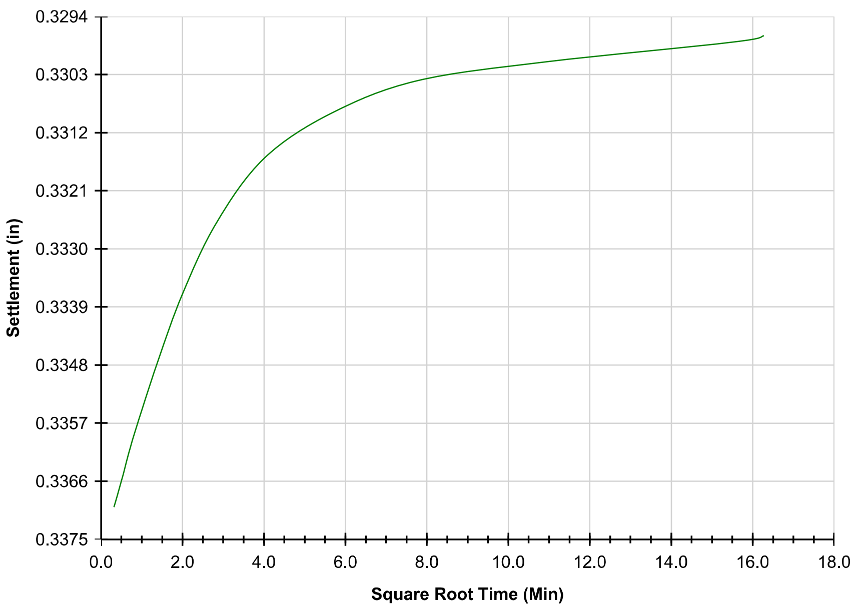


Tangent Construction Results	
T90 (Min)	NA
T50 (Min)	NA
Cv (in²/Min)	NA

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Square Root Time [8] 2.0000 tsf

AASHTO T-216



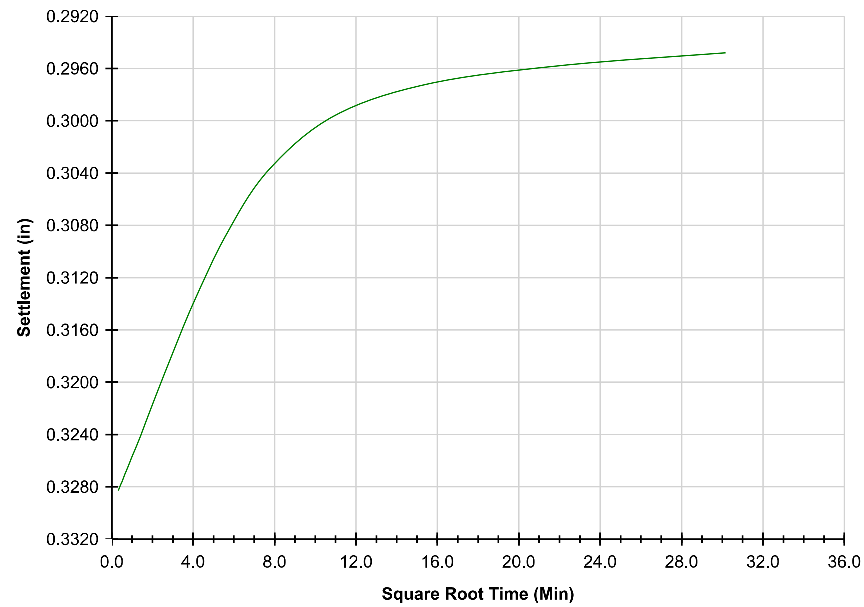
Tangent Construction Results	
T90 (Min)	NA
T50 (Min)	NA
Cv (in²/Min)	NA

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Consolidation Test - Results

Square Root Time [9] 0.5000 tsf

AASHTO T-216

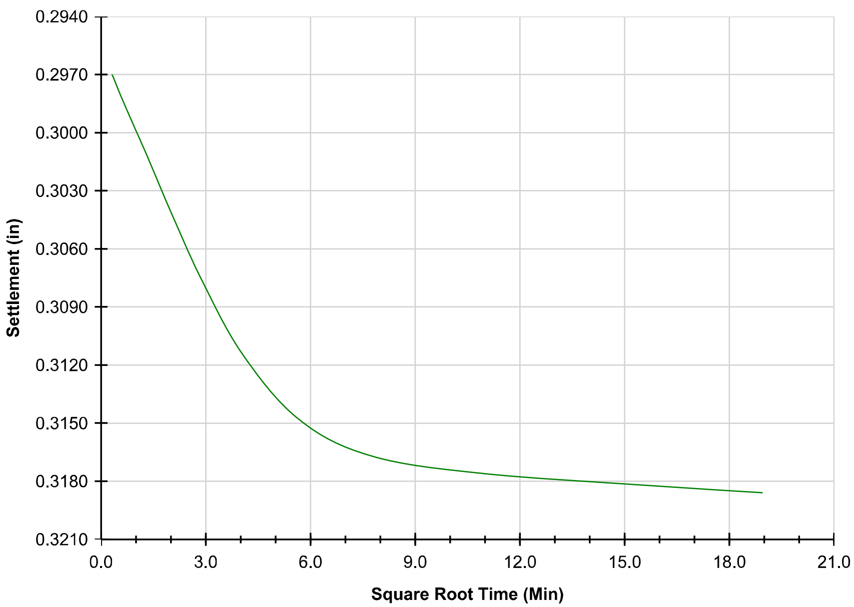


Tangent Construction Results	
T90 (Min)	NA
T50 (Min)	NA
Cv (in²/Min)	NA

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Square Root Time [10] 2.0000 tsf

AASHTO T-216



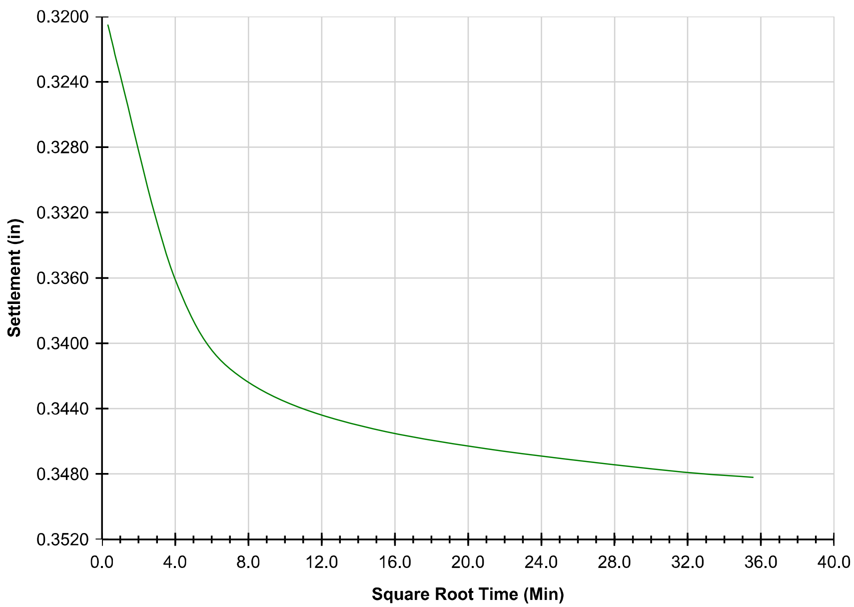
Tangent Construction Results	
T90 (Min)	NA
T50 (Min)	NA
Cv (in²/Min)	NA

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Consolidation Test - Results

Square Root Time [11] 4.0000 tsf

AASHTO T-216

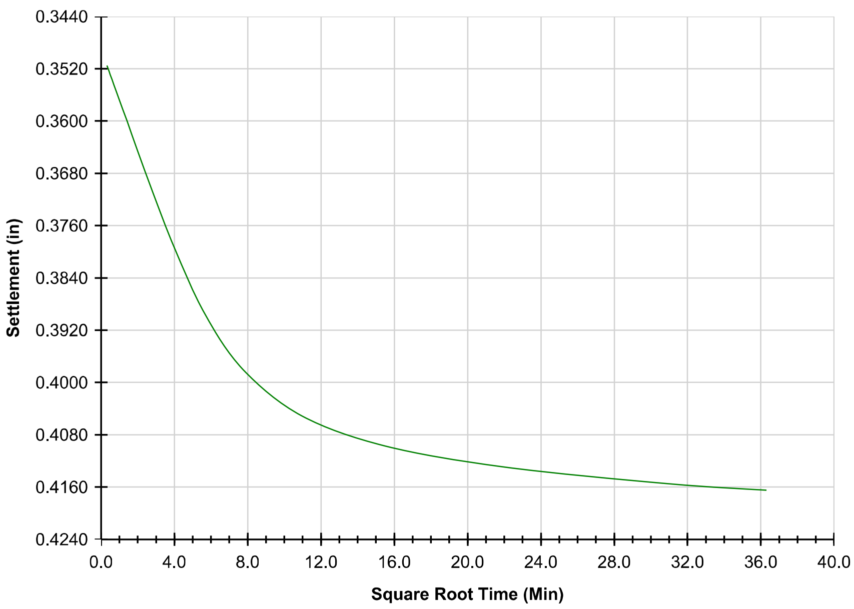


Tangent Construction Results	
T90 (Min)	NA
T50 (Min)	NA
Cv (in²/Min)	NA

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Square Root Time [12] 8.0000 tsf

AASHTO T-216



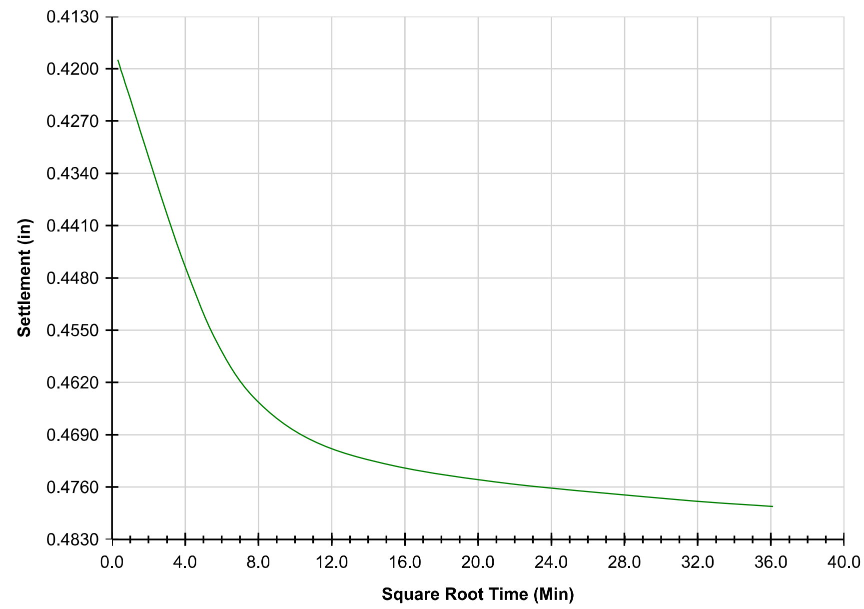
Tangent Construction Results	
T90 (Min)	NA
T50 (Min)	NA
Cv (in²/Min)	NA

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Consolidation Test - Results

Square Root Time [13] 16.0000 tsf

AASHTO T-216

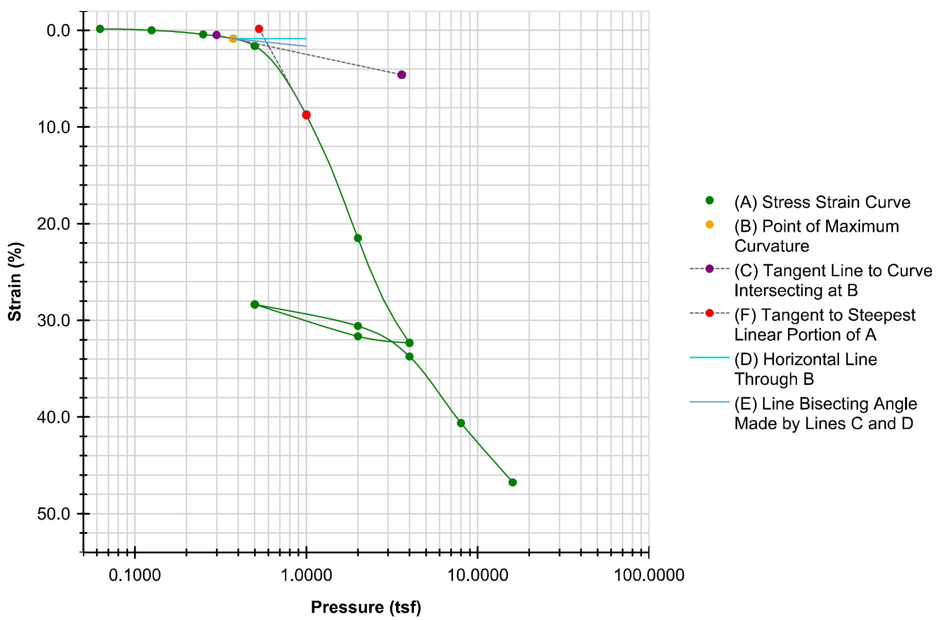


Tangent Construction Results	
T90 (Min)	NA
T50 (Min)	NA
Cv (in²/Min)	NA

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Percent Strain [Log]

AASHTO T-216



Preconsolidation Stress (tsf) 0.5837		Cc 39.166	Cr 0.947

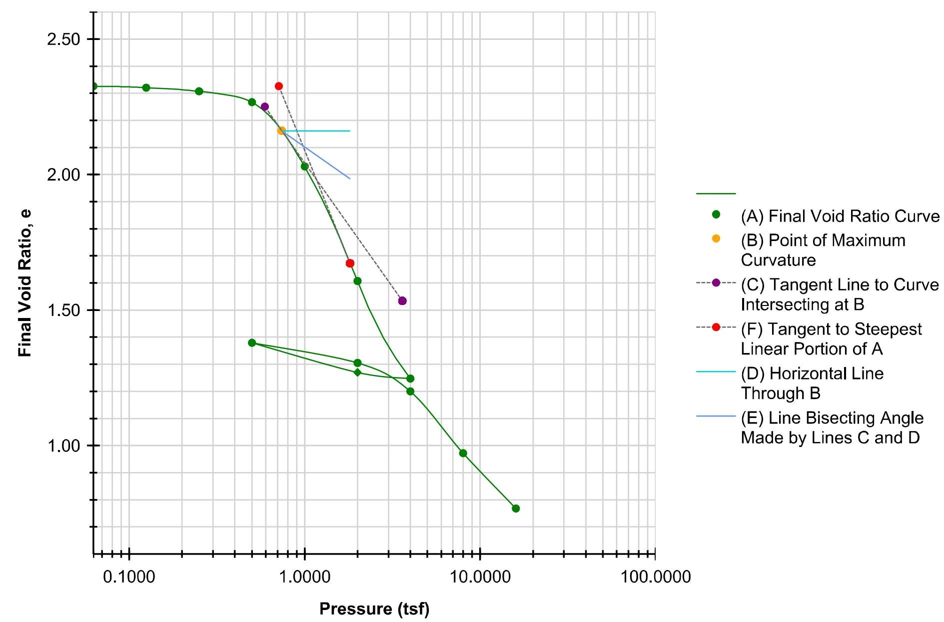
	BEFORE	AFTER			
			Liquid Limits	71	Test Date 3/17/2020
Moisture (%)	83.1	37.6	Plastic Limits	24	
Dry Density (pcf)	50.1	88.3			
Saturation (%)	95.4	113.2			
Void Ratio	2.33	0.89	Specific Gravity	2.67	ASSUMED

Sample Description	Gray, A-7-6 (53)			
Project Number	66Y-0050	Depth (ft)	9.0' - 11.0'	Remarks
Sample Number	ST-2B	Boring Number	EB2-A2	NA
Project	R-2511: US17 Widening			
Client	RK&K			
Location	EB2-A2			

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Final Voids [Log]

AASHTO T-216



Preconsolidation Stress (tsf) 0.9732		Cc 1.301	Cr 0.031

	BEFORE	AFTER			
			Liquid Limits	71	Test Date 3/17/2020
Moisture (%)	83.1	37.6	Plastic Limits	24	
Dry Density (pcf)	50.1	88.3			
Saturation (%)	95.4	113.2			
Void Ratio	2.33	0.89	Specific Gravity	2.67	ASSUMED

Sample Description	Gray, A-7-6 (53)			
Project Number	66Y-0050	Depth (ft)	9.0' - 11.0'	Remarks
Sample Number	ST-2B	Boring Number	EB2-A2	NA
Project	R-2511: US17 Widening			
Client	RK&K			
Location	EB2-A2			

Consolidation Test - Results

Summary

AASHTO T-216

Sample Description	Gray, A-7-6 (53)			
Project Number	66Y-0050	**Depth (ft)**	9.0' - 11.0'	**Remarks**
Sample Number	ST-2B	**Boring Number**	EB2-A2	NA
Project	R-2511: US17 Widening			
Client	RK&K			
Location	EB2-A2			

Index	Loading Sequence (tsf)	Cummulative Change in Height (in)	Specimen Height (in)	Height of Voids (in)	Vertical Strain (%)	Void Ratio	T90 Fitting Time (Hr)	T50 Fitting Time (Hr)	T90 Cv (in^2/Min)	T50 Cv (in^2/Min)	Sequence Status
0	0.0000	0.0000	1.0000	0.0000	0.0	2.327	0.000	0.000	0.00000	0.00000	ENABLED
1	0.0625	-0.0015	1.0015	0.7004	-0.2	2.326	0.000	0.000	0.00000	0.00000	ENABLED
2	0.1250	0.0000	1.0000	0.6989	0.0	2.321	0.026	0.006	0.58661	0.13628	ENABLED
3	0.2500	0.0042	0.9958	0.6947	0.4	2.307	0.292	0.051	0.06872	0.01596	ENABLED
4	0.5000	0.0162	0.9838	0.6827	1.6	2.267	0.089	0.021	0.15983	0.03713	ENABLED
5	1.0000	0.0875	0.9125	0.6114	8.8	2.030	0.624	0.147	0.01834	0.00426	ENABLED
6	2.0000	0.2149	0.7851	0.4840	21.5	1.607	1.899	0.382	0.00382	0.00089	ENABLED
7	4.0000	0.3233	0.6767	0.3756	32.3	1.247	1.157	0.269	0.00231	0.00054	ENABLED
8	2.0000	0.3164	0.6836	0.3825	31.6	1.270	0.000	0.000	0.00000	0.00000	ENABLED
9	0.5000	0.2836	0.7164	0.4153	28.4	1.379	0.000	0.000	0.00000	0.00000	ENABLED
10	2.0000	0.3059	0.6941	0.3930	30.6	1.305	0.313	0.077	0.00737	0.00171	ENABLED
11	4.0000	0.3374	0.6626	0.3615	33.7	1.200	0.538	0.116	0.00363	0.00084	ENABLED
12	8.0000	0.4063	0.5937	0.2926	40.6	0.972	0.826	0.196	0.00096	0.00022	ENABLED
13	16.0000	0.4676	0.5324	0.2313	46.8	0.768	0.714	0.169	0.00022	0.00005	ENABLED

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Consolidation Test - Information - Section 1

Consolidated Test Results

AASHTO T-216

Project:	R-2511: US17 Widening
Project Number:	66Y-0050
Job Number:	66Y-0050-01
Test Date:	3/17/2020

Sampling Date:	3/16/2020
Sample Number:	ST-2B
Depth (ft)	9.0' - 11.0'
Boring Number:	EB2-A2
Location:	EB2-A2
Client Name:	RK&K
Remarks:	NA

Specific Gravity:	2.67	Plastic Limit:	24	Liquid Limit:	71
Specific Gravity Method:	ASSUMED			Weight of Ring (g)	104.3
Sampling Method:	Undisturbed	Soil Classification:			
Specimen Description:	Gray, A-7-6 (53)				

Parameters	Initial	Final
Height (in)	1.0000	0.5324
Height Source	NA	TEST RESULTS
Diameter (in)	2.5000	NA
Area (in^2)	4.909	NA
Volume (in^3)	4.9087	2.6134
Weight of Container (g)	32.2	30.7
Weight of Wet Soil + Container (g)	79.9	113.6
Weight of Dry Soil + Container (g)	58.2	91.0
Moisture Content (%)	83.1	37.6
Moist Weight + Ring Weight (g)	222.6	187.7
Dry Density (pcf)	50.1	88.3
Wet Density (pcf)	91.8	121.5
Saturation (%)	95.4	113.2
Void Ratio	2.3	0.9

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Consolidation Test Results

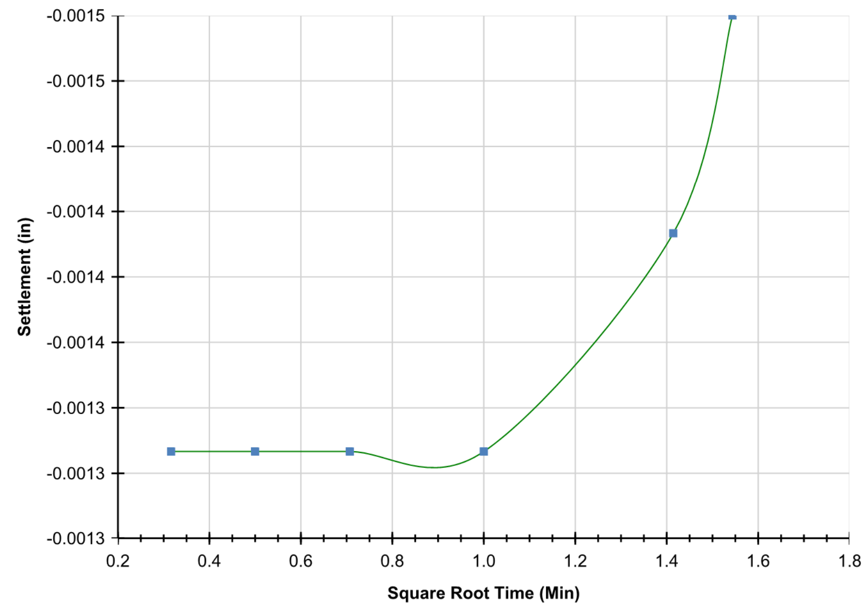
AASHTO T-216

Specimen 1			
Test Description:	One-Dimensional Consolidation		
Other Associated Tests:	NA		
Device Details:	Oedometer 2		
Test Specification:	AASHTO T-216		
Test Time:	3/17/2020 12:00:00 AM		
Technician:	Drew Council	Sampling Method:	Undisturbed
Specimen Code:	ST-2B	Specimen Lab #:	ST-2 (B)
Specimen Description:	Gray, A-7-6 (53)		
Specimen Preparation:	Ring-Lined Sampler		
Large Particle:	NA		
Moisture Content:	Natural Moisture		
Test Condition:	Soaked		
Test Procedure:	AASHTO T-216 [Changes - NA]		
Seating Pressure Used:	NO	Seating Pressure (tsf):	0.0000
Preconsolidation Stress:			
Percent Strain [LOG] Graph (tsf):	0.5837	Final Voids Graph (tsf):	0.9732

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Square Root Time [1] 0.0625 tsf

AASHTO T-216



Tangent Construction Results	
T90 (Min)	NA
T50 (Min)	NA
Cv (in²/Min)	NA

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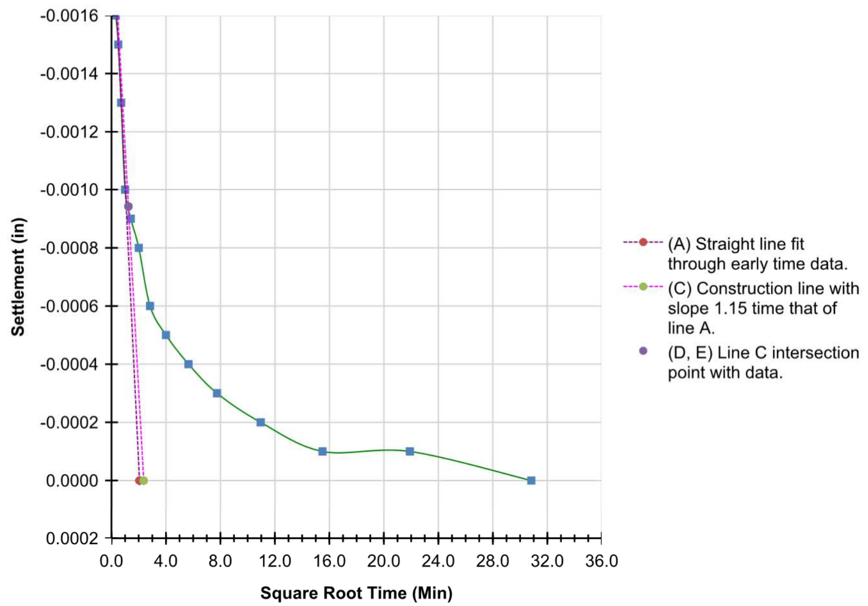
Square Root Time [2] 0.1250 tsf

AASHTO T-216



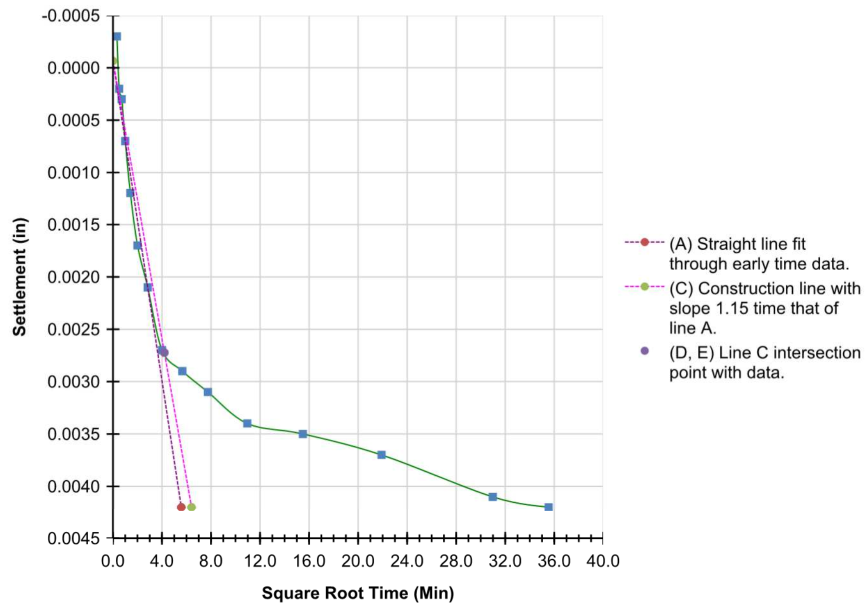
Tangent Construction Results	
T90 (Min)	1.536
T50 (Min)	0.362
Cv (in²/Min)	0.5866

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Consolidation Test - Results

Square Root Time [3] 0.2500 tsf

AASHTO T-216



Tangent Construction Results	
T90 (Min)	17.539
T50 (Min)	3.050
Cv (in²/Min)	0.0687

Location	EB2-A2
Station	L 156+79
Offset	49' LT

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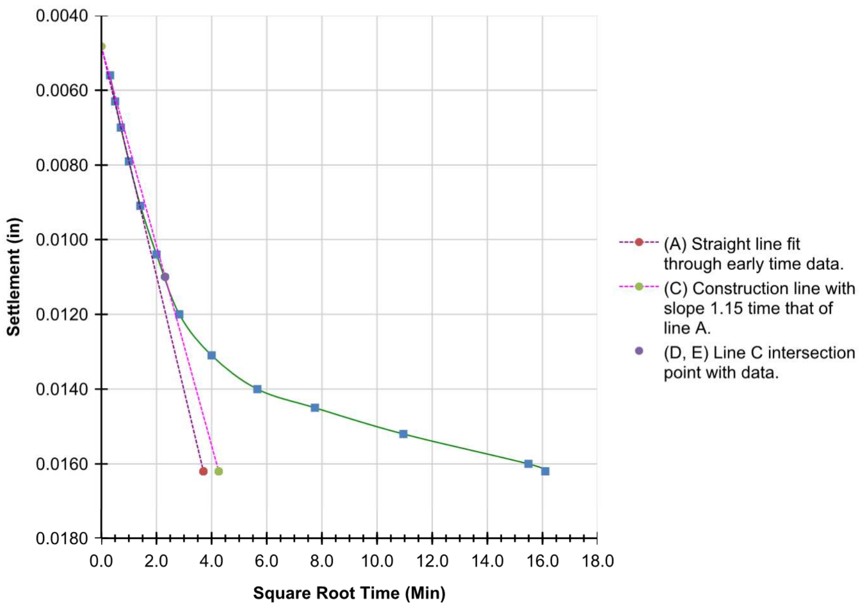
Square Root Time [4] 0.5000 tsf

AASHTO T-216



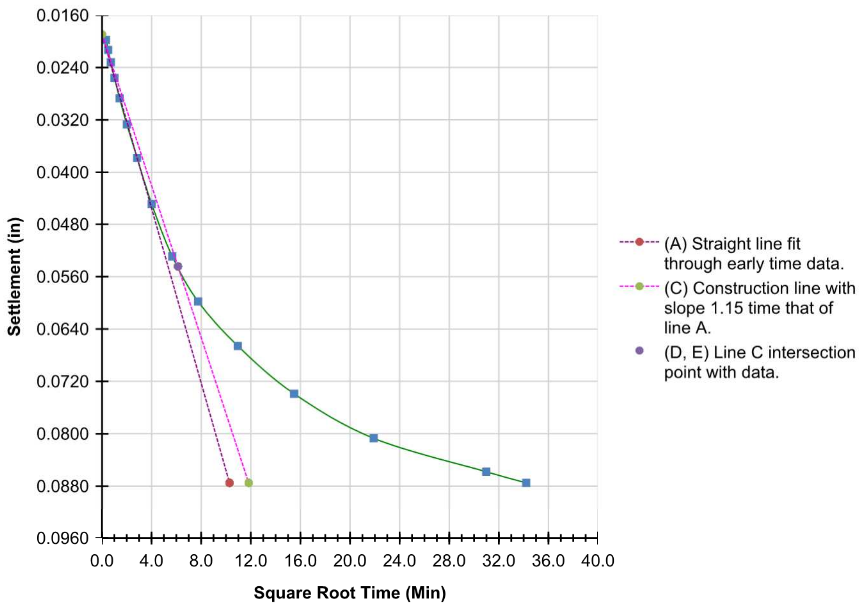
Tangent Construction Results	
T90 (Min)	5.331
T50 (Min)	1.262
Cv (in²/Min)	0.1598

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Consolidation Test - Results

Square Root Time [5] 1.0000 tsf

AASHTO T-216



Tangent Construction Results	
T90 (Min)	37.422
T50 (Min)	8.829
Cv (in²/Min)	0.0183

Location	EB2-A2
Station	L 156+79
Offset	49' LT

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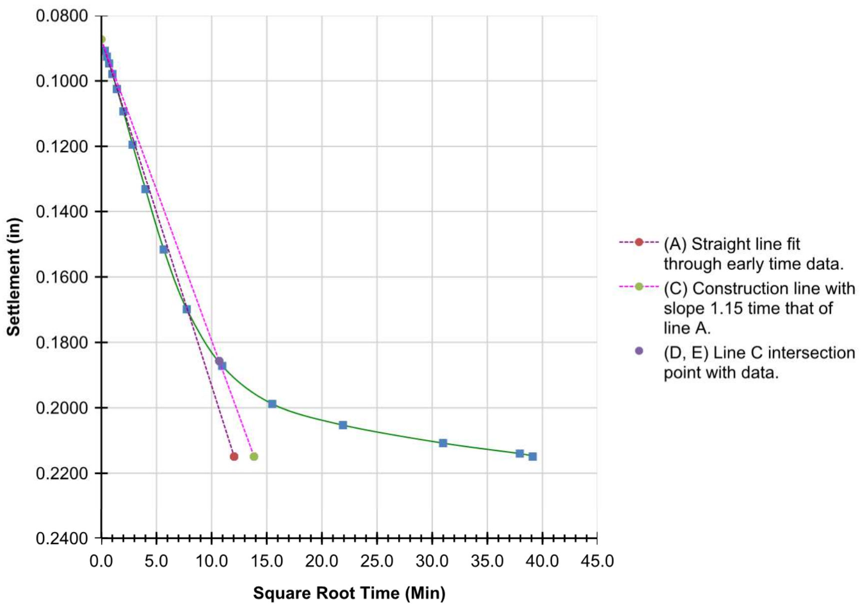
Square Root Time [6] 2.0000 tsf

AASHTO T-216



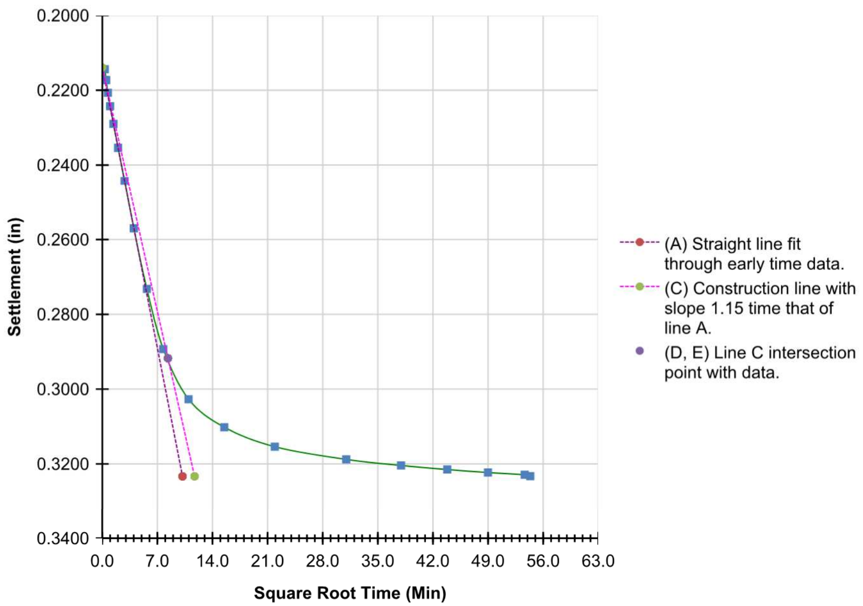
Tangent Construction Results	
T90 (Min)	113.944
T50 (Min)	22.937
Cv (in²/Min)	0.0038

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Consolidation Test - Results

Square Root Time [7] 4.0000 tsf

AASHTO T-216

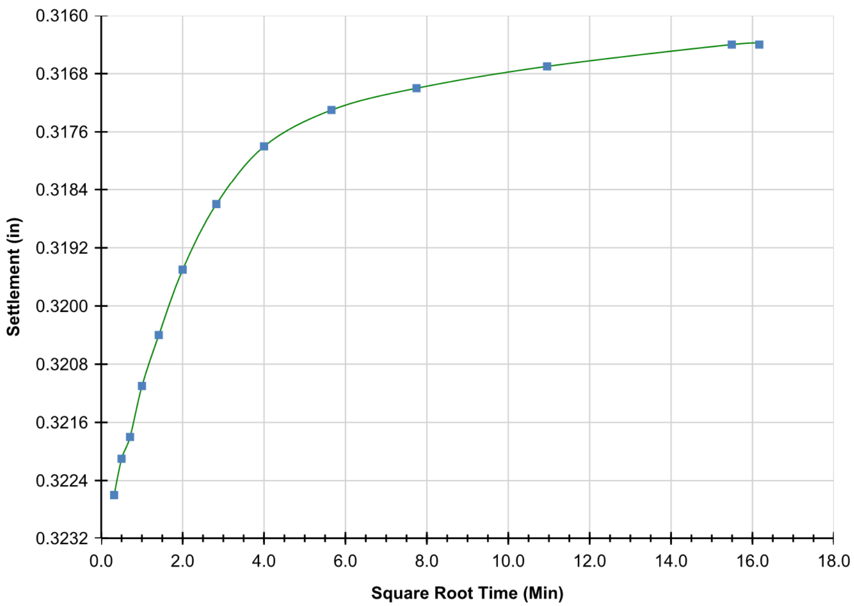


Tangent Construction Results	
T90 (Min)	69.413
T50 (Min)	16.139
Cv (in²/Min)	0.0023

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Square Root Time [8] 2.0000 tsf

AASHTO T-216



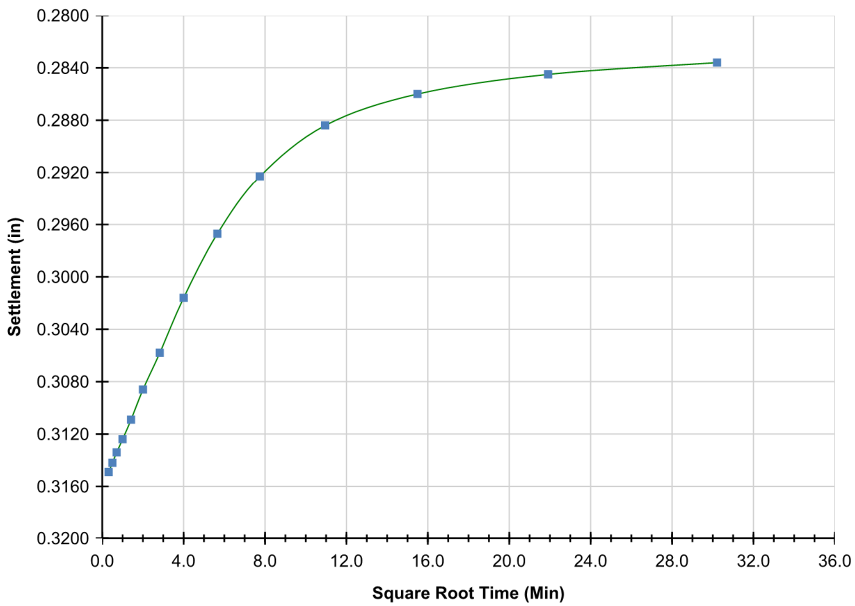
Tangent Construction Results	
T90 (Min)	NA
T50 (Min)	NA
Cv (in²/Min)	NA

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Consolidation Test - Results

Square Root Time [9] 0.5000 tsf

AASHTO T-216



Tangent Construction Results	
T90 (Min)	NA
T50 (Min)	NA
Cv (in²/Min)	NA

Location	EB2-A2
Station	L 156+79
Offset	49' LT

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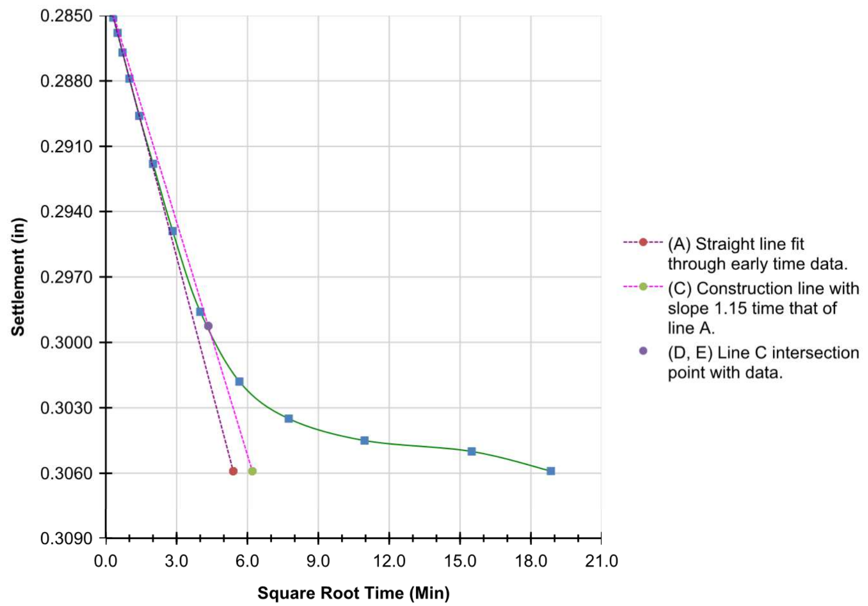
Square Root Time [10] 2.0000 tsf

AASHTO T-216

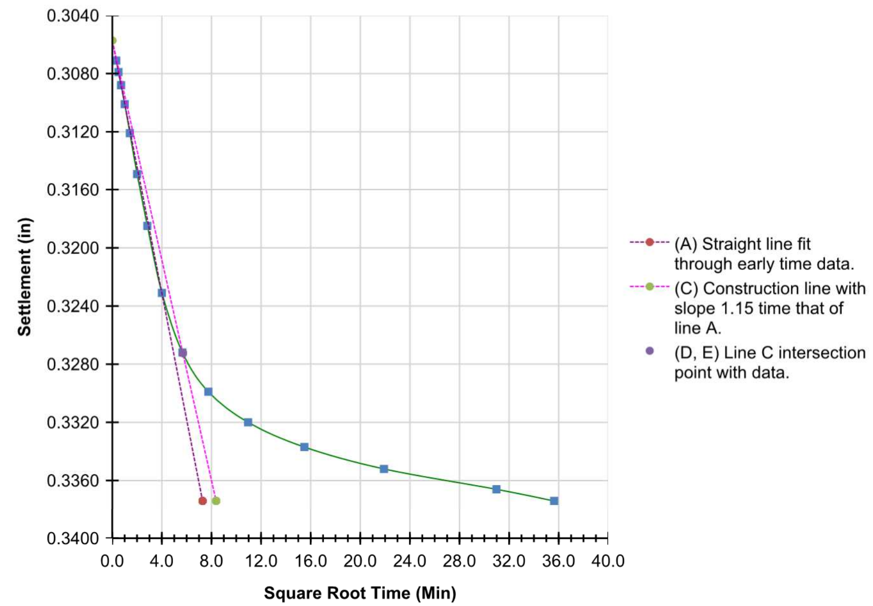


Tangent Construction Results	
T90 (Min)	18.793
T50 (Min)	4.643
Cv (in²/Min)	0.0074

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Square Root Time [11] 4.0000 tsf

AASHTO T-216



Tangent Construction Results	
T90 (Min)	32.286
T50 (Min)	6.956
Cv (in²/Min)	0.0036

Location	EB2-A2
Station	L 156+79
Offset	49' LT

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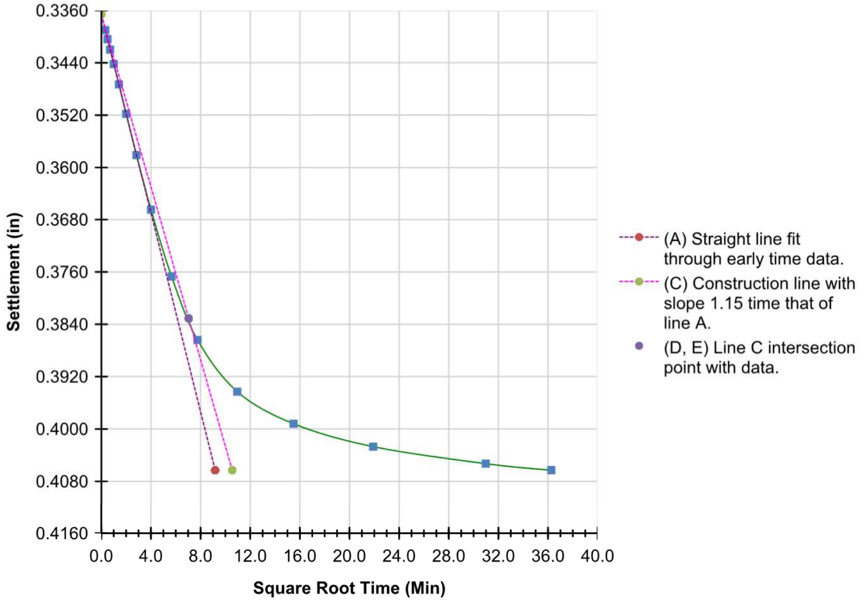
Square Root Time [12] 8.0000 tsf

AASHTO T-216



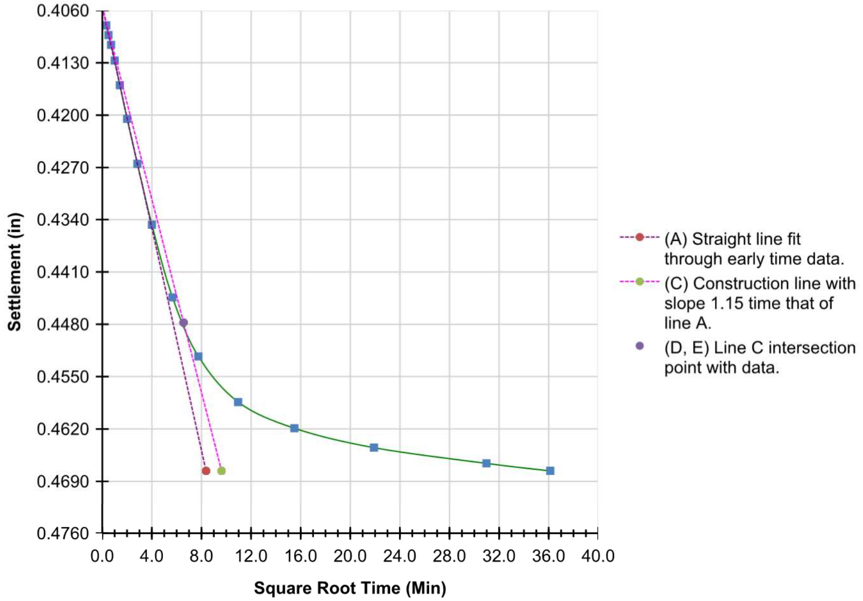
Tangent Construction Results	
T90 (Min)	49.540
T50 (Min)	11.787
Cv (in²/Min)	0.0010

Location	EB2-A2
Station	L 156+79
Offset	49' LT

Consolidation Test - Results

Square Root Time [13] 16.0000 tsf

AASHTO T-216



Tangent Construction Results	
T90 (Min)	42.851
T50 (Min)	10.131
Cv (in²/Min)	0.0002

Location	EB2-A2
Station	L 156+79
Offset	49' LT