

11/4/2020

To Whom it may concern,

The following document describes the installation and testing of a sacrificial ground anchor. The document is being included for information purposes only. The ground anchor test results are representative of conditions at the location and elevation of the sacrificial anchor and the installation means and methods used by the contractor, as indicated herein. Anchor capacity could vary across the site and will depend on the installation means and methods. Contractors will need to make their own determination of the installation techniques that will be necessary considering their equipment, personnel, and experience.

Colter Schwagler, PE NDDOT Materials & Research 701-328-6975





# GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

May 21, 2020

Mr. Colter Schwagler, PE North Dakota Department of Transportation 608 East Boulevard Avenue Bismarck, ND 58505-0700

#### RE: SACRIFICIAL GROUND ANCHOR INSTALLATION AND VERIFICATION TESTING, HORSESHOE BEND LANDSLIDE, 7-085(110)127, PCN 22304, MCKENZIE COUNTY, ND

Dear Mr. Schwagler:

This letter documents the installation and verification testing of a pre-production sacrificial ground anchor that was installed as part of the Horseshoe Bend Landslide mitigation project.

#### SACRIFICIAL GROUND ANCHOR INSTALLATION

On April 23, 2020, Malcolm Drilling (Malcolm) installed a 9-strand sacrificial ground anchor for verification testing at the site. The ground anchor included DSI DynaForce sensors to measure the distribution of load along the length of the anchor. Sensors were installed 5 feet into the free length and 5, 20, and 35 feet into the bond zone. The anchor was installed adjacent to borings RP-127-01 and RP-127-01A and oriented vertically. The anchor had a bond length of 45 feet and free length of 115 feet. The ground anchor was installed with a single post-grouting tube, with tube-a-manchette (TAM) ports spaced at 5-foot intervals in the bond zone.

Malcolm drilled the anchor with a 6 3/8-inch diameter drag drill bit and 7-inch outside diameter temporary casing for the full length of the anchor. The drill hole was advanced with a combination of air and water to remove drill cuttings from the casing. Malcolm completed the initial grouting of the anchor on April 23, 2020. On April 24, 2020, Malcolm completed one cycle of post-grouting, which resulted in a grout take of approximately 15 gallons at injection pressures of 600 to 700 pounds per square inch (psi). An installation log summarizing the anchor installation is attached. After completion of the test (see below), the ground anchor strands were cut off just below the ground surface and covered with soil. Selected photos of the installation are shown below

102116 - HSB Anchor VT Summary.docx



Exhibit 1: Installation of sacrificial ground anchor.



Exhibit 2: Drill bit and casing used to install sacrificial ground anchor.

## Verification Testing

Malcolm completed verification testing of the sacrificial ground anchor on May 2, 2020. A photograph of the test apparatus is shown below. During testing, the anchor was incrementally loaded to a maximum load of 423 kips (the maximum allowable load for a 9-strand anchor and the reaction apparatus). At each increment, the load was held constant for 60 minutes and load measured by the DynaForce sensors and displacement at the jack was recorded. During verification testing, the anchor held the maximum test load of 423 kips without pullout occurring. The test results are attached.



Exhibit 3: Verification testing setup.

#### LIMITATIONS

The ground anchor test results are representative of conditions at the location and elevation of the sacrificial anchor and the installation means and methods used by the contractor, as indicated herein. Anchor capacity could vary across the site and will depend on the installation means and methods. Contractors will need to make their own determination of

the installation techniques that will be necessary considering their equipment, personnel, and experience.

We appreciate the opportunity to be of service to you on this project. If you have questions concerning this report, or we may be of further service, please contact us.

Sincerely,

SHANNON & WILSON



David A. Varathungarajan, PE Senior Associate

DAV:GRF/dav

Enc. Ground Anchor Installation Log Verification Test Results (5 sheets)

	BEDTECHNICAL AND ENVIRON	<b>ILSON, INC.</b>	G	RO	UND	ANCHOR IN	STALLATION LOG		
Job Name: Long X Bridge Construction				Anc	hor No:	HSB Sacrificial			
Job	Number:	103766		Anchor Installation Date:			4/23/2020		
Prir	ne Contractor:	Ames		Obs	served E	By:	ALL		
Sub	contractor:	Malcolm Drilling		Rev	viewed E	DAV			
	An	chor Details				Soil Pr	rofile		
Loc	ation / Station:	20 feet northeast of	RP-127-01	1	Depth	Description			
Bar	/ Strand Type:	Strand			(ft)				
Nur	nber of Strands:	9			0	Light brown, clayey sandy Fill to Fat			
Bor	nd Length (ft):	45				Clay			
Fre	e Length (ft):	115							
Tail	Length (ft):	9							
	Dri	illing Details							
Rig		Klemm KR 806-5GF	)						
Met	hod:	Cased Drilling with A	Air and Water		30	Added water at 3	0 feet.		
Bit	ype:	Drag							
Hol	e Diameter (in.):	7							
Incl	ination (degrees):	90							
Cas	sing Length (ft):	165							
Cas	sing O.D. (in.)	7							
Cas	sing I.D. (in.)	6 3/4"							
Tot	al Hole Depth (ft):	165							
Dril	ling Start Time:	4/23/20 8:00							
Dril	ling End Time:	4/23/20 8:50			60	Red sandstone fragments at 60 feet.			
	Gro	outing Details							
	Grout Tube:	Encapsulation	Annulus		70				
	Start Date and Time:	4/23/2020 10:20	4/23/2020 10:30			Red-brown, blocky, Claystone			
tial	End Time:	4/23/2020 10:30	4/23/2020 10:50						
Ē	Pressure (psi):	Min	Min						
	Actual Vol. (gal):	50	~200						
	Theoretical Vol. (gal)	55	150		100	Gray below 100 feet Lignite encountered			
-	Post Grout Tube:	Upper	Lower		110				
out	Start Date and Time:		4/24/2020 9:00						
Ģ	End Time:		4/24/2020 9:10						
Pos	Grout Take (gal):		15						
	Pressure (psi):		600-700	_					
2	Post Grout Tube:	Upper	Lower	_	115	Gray, blocky, Cla	ystone		
rout	Start Date and Time:								
Ū	End Time:								
Pos	Grout Take (gal):								
	Pressure (psi):								
0.10	ut an a sifis and its at 1.00	Remarks	-	140	Light gray, massi	ve, Siltstone			
GIC	ou specific gravity at 1.69.								
					165	Bottom of Excava	ation		
					I	·			

	NNON &	WILSON IRONMENTAL CON	, INC.		GROUND	) ANC	HOR	SACRIFI	CIAL TEST	
Job Name:	Long X Brid	Anchor No:				HSB Sacrificial Anchor				
Job Number:	103766			Tes	at Date and Time:			5/2/2020 0810 - 1630		
Contractor:	Malcolm Dri	alcolm Drilling			al Grout Date:			4/2	3/2020	
Stressor:	Shane (Mal	colm)		Pos	st Grout Stage 1 I	Date:		4/24/2020		
Observed by:	ALL			Pos	st Grout Stage 2 I	Date:	N/A			
Reviewed by:	DAV			Jac	k Length (ft):		3.8			
P	Jack	Fre	e Length, LF (ft):			118.4				
Jack					essing Length, LS	S (ft):		123.6		
			$\square$	Bor	nd Length, LB (ft)	:		45		
F	Free Length		$\neg$	МU	TS (kips):			527		
				Des	sign Lock-off Loa	d (kips): N/A		Gauge (psi)	N/A	
Stress	ng Strength	Bond Len	gth	Act	ual Lock-off Load	d (kips): N/A		Gauge (psi)	N/A	
LOAD INCREMENT	LOAD (kips)	GAUGE (psi)	HOL TIMI (min	D E I)	DIAL GAUGELoad Cell,AVG.Uncorrected(in.)(kips)		Remarks			
AL (0.05 MUTS)	28.0	400	Stab	le	0.000	14.0000				
	53.1	750	Stab	e	0.534	24.9	000			
			1		0.534	24.7	000			
			2		0.538	25.1000		bump pressure		
			3		0.539	24.9000 24.8000 24.8000				
0.10 M013			4		0.539					
			5		0.539					
			6	0.558		25.9000		bump pressure		
			10		0.565	26.3000		bump pressure		
	106.9		Stab	le	1.923	55.7	000			
		1500	1		1.925 56.7000		000	bump pressure		
			2		1.923	55.5000				
			5		1.924	56.3000		bump pressure		
0.20 101010			10		1.925	56.5000		bump pressure		
			20		1.925	56.2000		bump pressure		
			30		1.926	56.0000		bump pressure		
			60		1.933	56.1000		bump pressure		

	NNON &	WILSON IRONMENTAL COM	I, INC.	GROUND	ANCHOR	SACRIFICIAL TEST		
Job Name:	Long X Brid	lge	А	nchor No:		HSB Sacrificial Anchor		
Job Number: ##		Т	est Date and Time:	5/2/2020 0810 - 1630				
LOAD LOAD GAUGE INCREMENT (kips) (psi)		HOLD TIME (min)	DIAL GAUGE AVG. (in )	Load Cell, Uncorrected (kins)	Remarks			
		2200	Stable	3.309	85.3000			
			1	3.309	84.2000	bump pressure		
			2	3.314	85.2000	bump pressure		
	457.0		5	3.314	85.0000			
0.30 M015	157.2		10	3.317	85.3000			
			20	3.319	85.6000	bump pressure		
			30	3.322	86.0000	bump pressure		
			60	3.323	85.1000			
	211.0	2950	Stable	4.830	117.0000			
			1	4.833	116.0000	bump pressure		
			2	4.836	116.4000			
			5	4.835	116.3000	bump pressure		
0.40 1013			10	4.838	116.3000	bump pressure		
			20	4.844	117.0000			
			30	4.844	115.9000	bump pressure		
			60	4.851	116.0000	bump pressure		
	264.8	3700	Stable	6.295	146.4000			
			1	6.304	146.7000	bump pressure		
			2	6.302	144.7000			
			5	6.304	145.1000	bump pressure		
0.00 101010			10	6.302	144.8000	bump pressure		
			20	6.306	145.2000	bump pressure		
			30	6.320	147.0000	bump pressure		
			60	6.330	147.2000	bump pressure		

GROUND ANCHOR SACRIFICIAL TEST										
Job Name:	Long X Brid	lge	Ar	nchor No:	HSB Sacrificial Anchor					
Job Number: ##			Те	est Date and Time	:	5/2/2020 0810 - 1630				
LOAD INCREMENT	LOAD (kips)	LOAD GAUGE HOL (kips) (psi) (min		DIAL GAUGE AVG. (in.)	Load Cell, Uncorrected (kips)	Remarks				
			Stable	7.800	175.5000					
			1	7.800	174.7000					
			2	7.800	174.3000	bump pressure				
	315.0	4400	5	7.811	175.5000	bump pressure				
0.00 MOTS	515.0	4400	10	7.811	175.7000	bump pressure				
			20	7.816	175.0000	bump pressure				
			30	7.819	175.5000	bump pressure				
			60	7.831	174.2000	bump pressure				
	368.8	5150	Stable	9.402	204.7000					
			1	9.402	202.1000					
			2	9.402	203.1000	bump pressure				
			5	9.405	204.2000	bump pressure				
0.70 MOTO			10	9.420	204.0000	bump pressure				
			20	9.421	204.1000	bump pressure				
			30	9.424	204.0000	bump pressure				
			60	9.465	203.0000	bump pressure				
	422.6		Stable	11.025	231.0000					
		5900	1	11.017	227.9000					
			2	11.038	230.4000	bump pressure				
			5	11.026	231.2000	bump pressure				
0.00 1013			10	11.042	230.2000	bump pressure				
			20	11.051	230.3000	bump pressure				
			30	11.052	230.7000	bump pressure				
			60	11.075	231.1000	bump pressure				
AL (0.05 DL)	28.0	400	Stable	1.497	18.2000					

# GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

## ANCHOR TEST RESULTS HSB



Apparent Free Length				Elongation at 0.80 MUTS			Creep at 0	.80 MUTS
Min. Allowable (ft)	Min. Allowable L <sub>app</sub> Max. Allowable (ft) (ft) (ft)			Elastic, δ <sub>e</sub> (in.)	Residual, δ <sub>r</sub> (in.)		1 to 10 min (in.)	5 to 60 min (in.)
98.5	112.6	146.1		9.578	1.497		0.025	0.049

GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

# ANCHOR TEST RESULTS HSB

