



gai consultants

Large Scale Soil Nail Walls for a Landfill Application

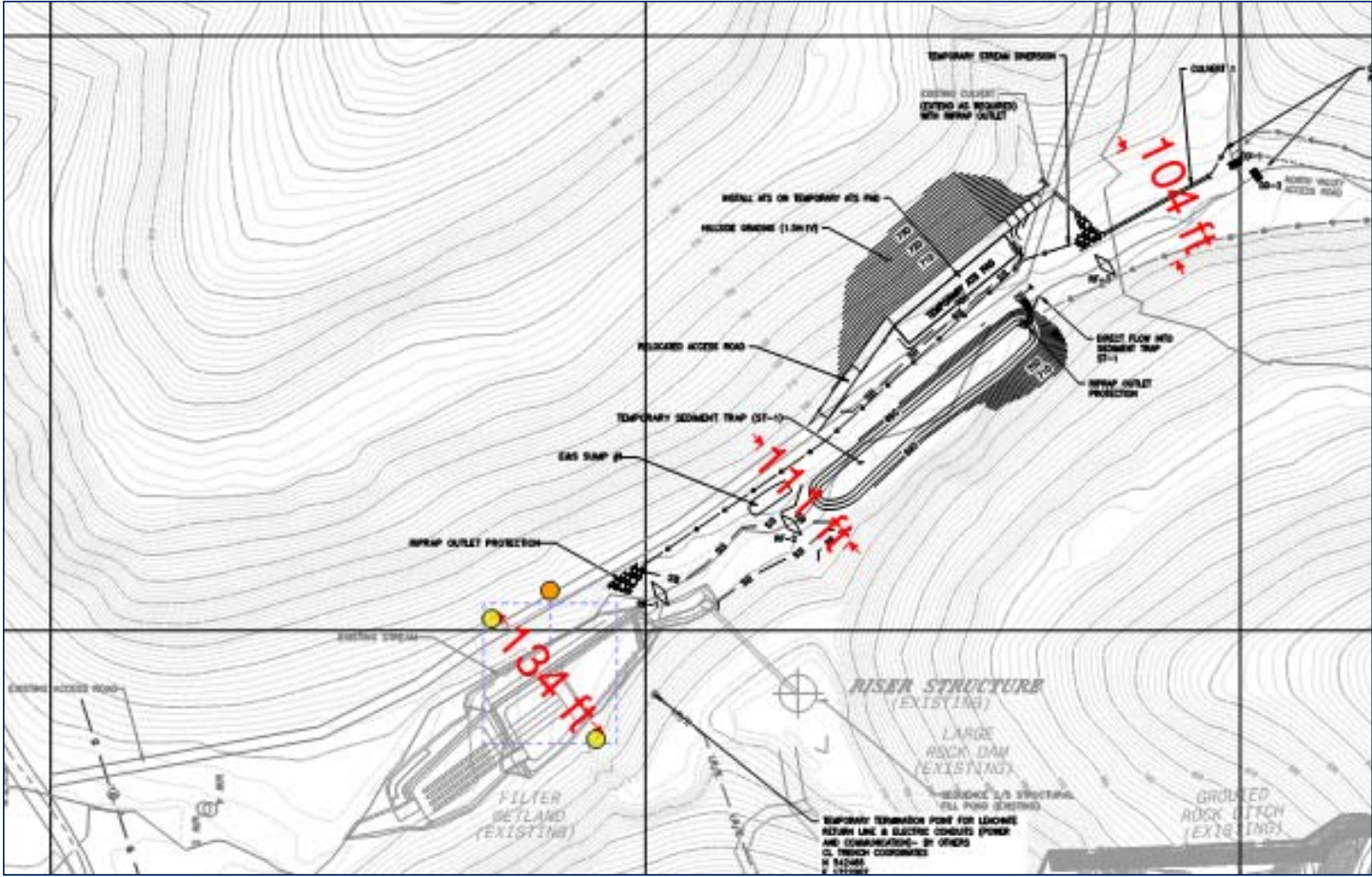
ASHE Altoona/District 9-0 Joint Workshop
April 17, 2018

Project Situation/Application

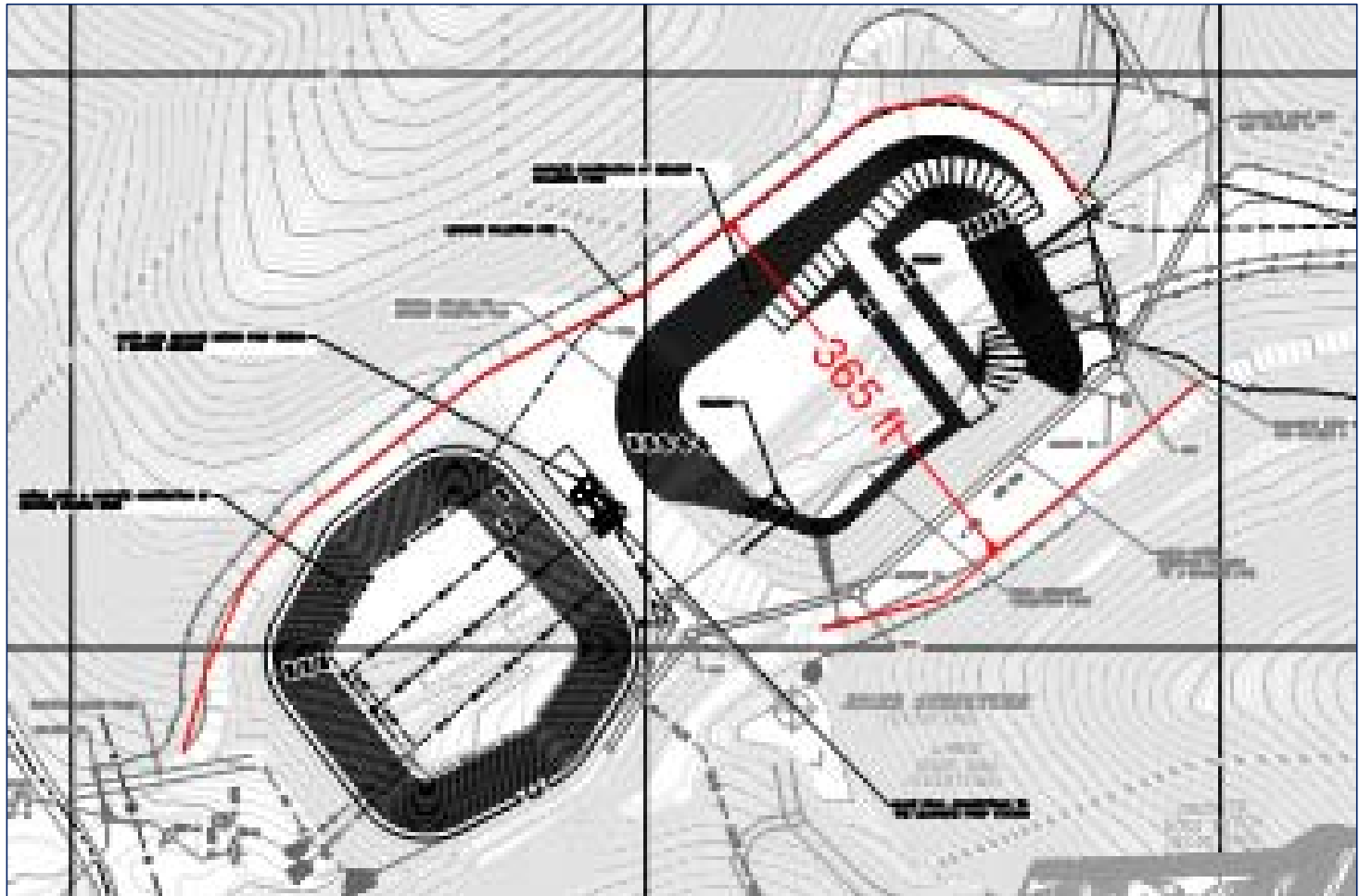
- New valley opened for a Proposed Landfill
- History of clay particle runoff challenges
- Sedimentation ponds and ATS needed
- Narrow valley at the edge of the property



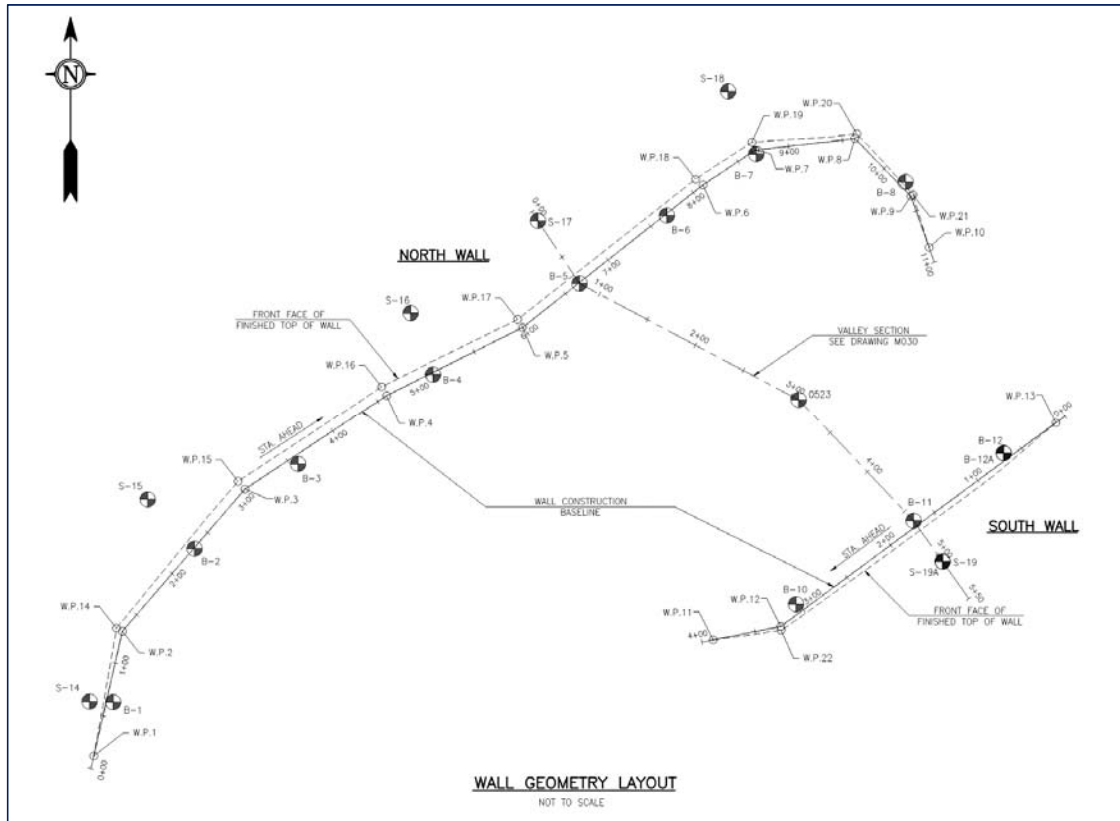
Project Situation/Application



Project Situation/Application



Geotechnical Exploration



- 17 borings placed, or one every 100 ft of wall.
- FHWA GEC Circular No. 7 recommends borings in front, in line with and behind the wall at 100 to 200 ft on center.
- Toe borings eliminated due to rock.
- Hindsight indicates we should have had 25-30 borings.

Geology and Topography

- Marginally Stable Existing Slopes Approximately 2H:1V
- Primarily composed of claystone and clayshale, with thin sandstone seams and lesser amounts of siltstone
- Regional Dip – north-northwest at 20-feet per mile
- Groundwater at top of rock



Design Process

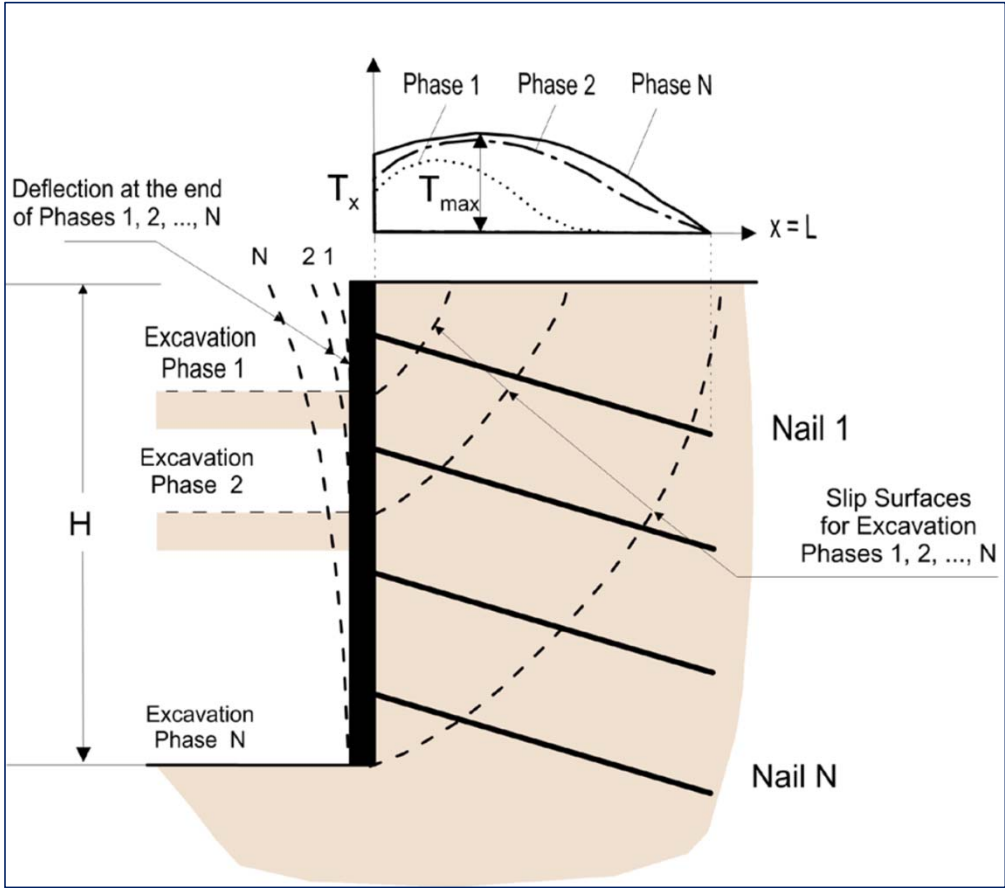
FHWA GEC No. 7 (2015 rev)

Soil Nailing Field Inspectors Manual (1993)

(PennDOT DM4 Appendix O)

- MSE Analogy – an earth mass with reinforcement
- Global Stability – Just like MSE
- Internal Stability
 - Pullout, tension failure, face connection failure
 - Facing Failure – Yield line theory

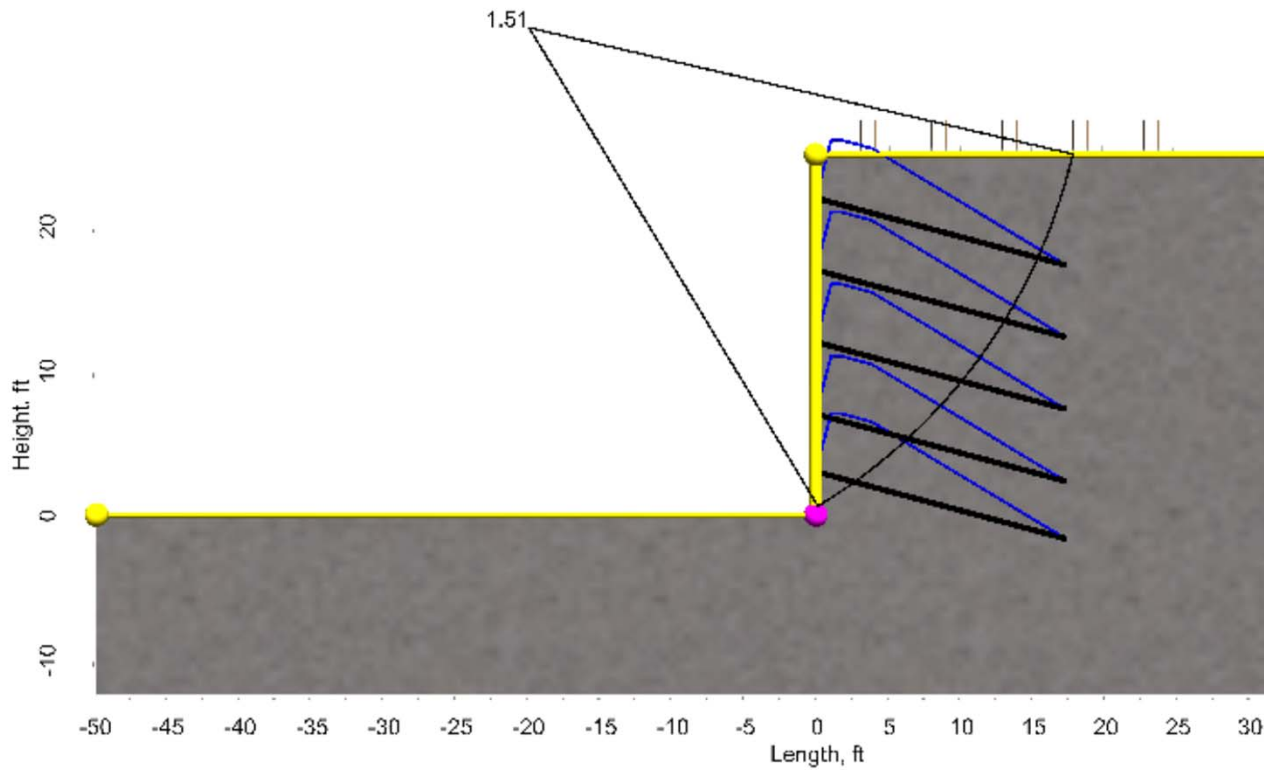
Design Process



Staged analysis must be performed at each excavation level

GEC #7 Figure 5.1: Potential slip surfaces and PHASED soil nail tensile forces.

Design Process



Combinations of soil shear failure, nail failure, facing failure and pullout failure may control

GEC #7 Figure C.3: NAIL LoAD and Stability check interaction

Design Process

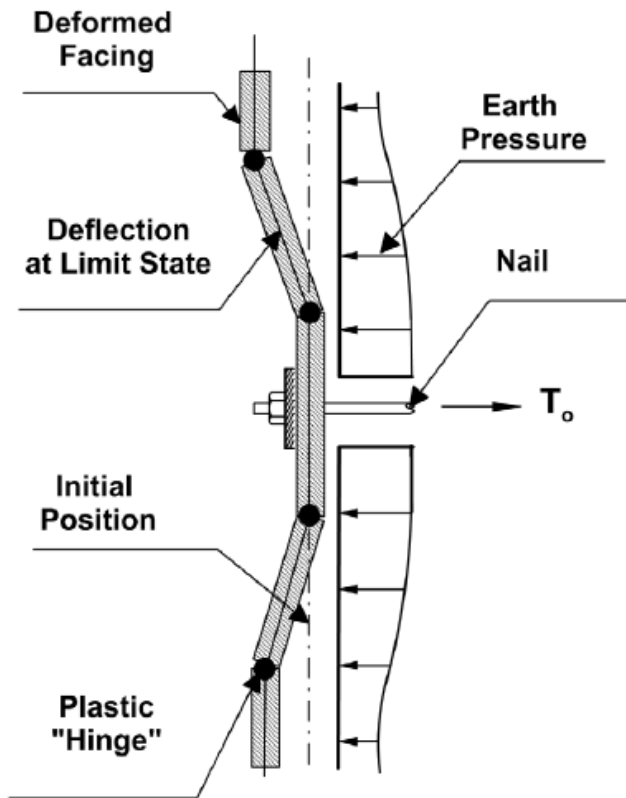


Figure 5.14: Illustration. Bending mechanism and nail force in facing. Modified after Lazarte (2011).

Same bending strength calculation as parapet and deck checks under impact

Implications of Yield Line Theory on cracking

Design Details

Considerations:

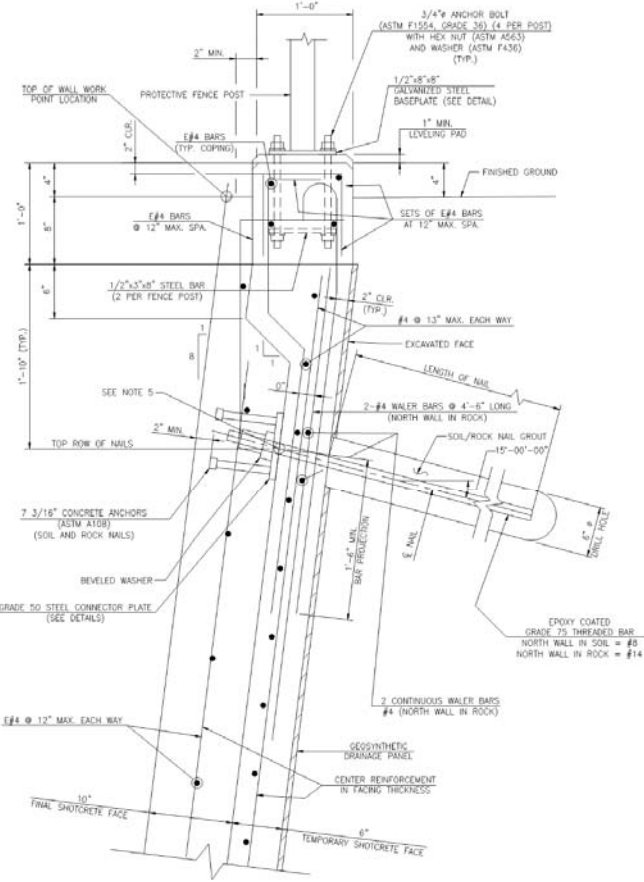
- Frost Depth
- Ease of Placement
- Temperature and Shrinkage Considerations



Design Details

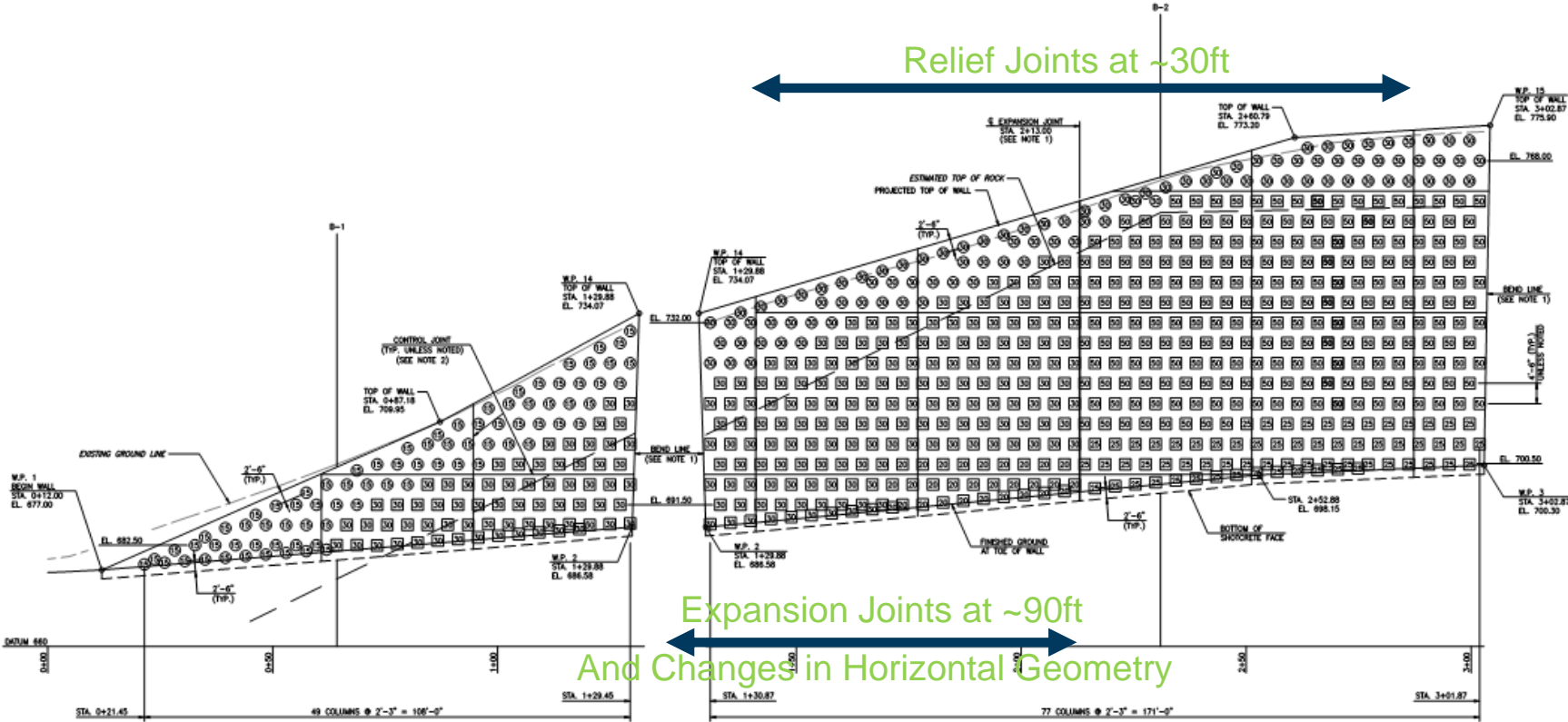
Considerations:

- Frost Depth
 - Ease of Placement – time
 - Temperature and Shrinkage
- Considerations – Construction and Expansion Joints



TOP OF WALL/COPING REINFORCEMENT DETAIL NORTH WALL
NOT TO SCALE

Design Details



Temperature and Shrinkage Considerations

TABULATION OF SOIL NAIL WALL BID ITEMS AND APPROXIMATE QUANTITIES		
QUANTITY	ITEM NUMBER	DESCRIPTION
	UNIT	
8366		TEMPORARY SHOTCRETE FACE
	SY	
8366		FINAL SHOTCRETE FACE
	SY	
98185		SOIL NAILS NO. 14 (1)
	LF	
6380		SOIL NAILS NO. 7 (2)
	LF	
4610		SOIL NAILS NO. 6 (3)
	LF	
18025		SOIL NAILS NO. 8 (4)
	LF	
1496		PROTECTIVE FENCE
	LF	



1 3/4 Acres



24.1 miles

- (1) TOTAL LF QUANTITY IS FOR 2403 ROCK NAILS IN THE NORTH WALL
- (2) TOTAL LF QUANTITY IS FOR 399 ROCK NAILS IN THE SOUTH WALL.
- (3) TOTAL LF QUANTITY IS FOR 240 SOIL NAILS IN THE SOUTH WALL.
- (4) TOTAL LF QUANTITY IS FOR 683 SOIL NAILS IN THE NORTH WALL.

Nail Verification Testing

Load Cell and Pressure Gages
Redundant Elongation Gages



Nail Verification Testing

ANCHOR STRESSING FORM (Verification Test)

Job Name: Ames North Pond Complex Unstressed Tail (ft): 2
 Anchor Designation: RN1 Tail Length (ft): 2.0
 Design Load (k): 51 Free Length (ft): 2.5
 No. of Strands: 1 Bond Length (ft): 13.5 Date: 7/18 Test By: ELG

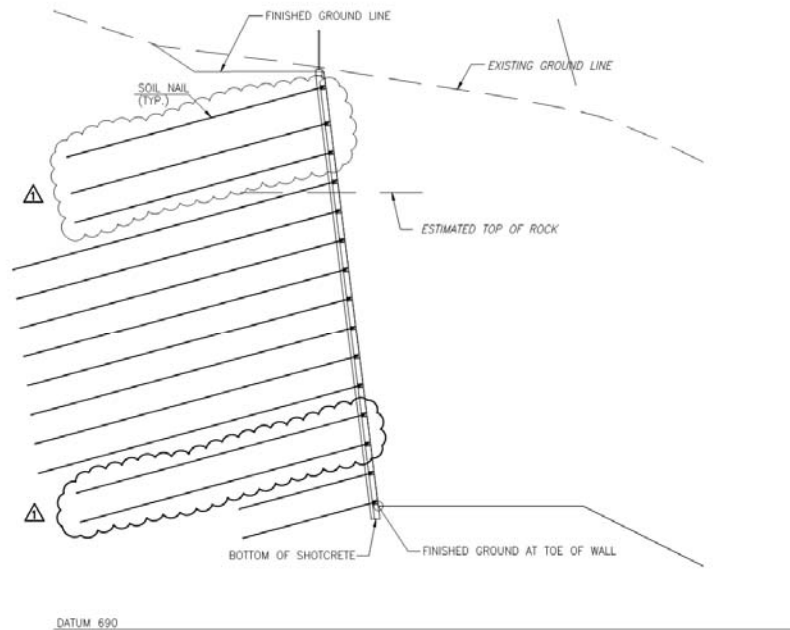
MORNING 7/18

Anchor Load %	Hold Time (min)	Actual Load (kips)	Anchor Load (kips)	JACK Pressure Gauge (psi)		Backup Gauge (psi)	LOAD CELL GK2512 (psi)		Anchor Elongations		NOTES	
				Calc	ACTUAL		Readout	ACTUAL	Dial Gauge Reading (thous)	Actual Elong (in)		MAX FL. 0.8% EL
5%	1	2.53	30	1000			-2810	117	1000	1000	0.000	0.000
25%	1	12.65	270	3000			-2385	1119	1009	1052	0.007	0.020
25%	10	10.00	270	3000			-2385	1103	1009	1052	0.007	0.020
50%	1	25.30	570	6000			-2105	1120	1036	1051	0.015	0.046
50%	10	25.30	570	6000			-2105	1087	1037	1051	0.015	0.046
75%	1	37.95	870	9000			-1825	2193	1058	1065	0.023	0.072
75%	10	37.95	870	9000			-1825	2261	1061	1065	0.023	0.072
100%	1	50.60	1180	12000			-1545	2150	1081	1080	0.031	0.097
100%	10	50.60	1180	12000			-1545	2195	1083	1085	0.031	0.097
125%	9.1	63.25	1480	15000			-1260	3067	1105	1095	0.039	0.123
125%	10	63.25	1480	15000			-1260	3269	1105	1095	0.039	0.123
150%	1	75.90	1780	18000			-980	3810	1129	1110	0.047	0.148
150%	2	75.90	1780	18000			-980	3852	do	do	0.047	0.148
150%	3	75.90	1780	18000			-980	3797	do	do	0.047	0.148
150%	5	75.90	1780	18000			-980	3757	do	do	0.047	0.148
150%	8	75.90	1780	18000			-980	3786	do	do	0.047	0.148
150%	10	75.90	1780	18000			-980	3822	do	do	0.047	0.148
150%	20	75.90	1780	18000			-980	3777	do	do	0.047	0.148
150%	30	75.90	1780	18000			-980	3772	do	do	0.047	0.148
150%	50	75.90	1780	18000			-980	3857	1131	1110	0.047	0.148
150%	60	75.90	1780	18000			-980	3838	1131	1110	0.047	0.148
175%	1	88.55	2080	21000			-700	4403	1157	1129	0.058	0.174
175%	10	88.55	2080	21000			-700	4413	1157	1129	0.058	0.174
200%	1	101.20	2380	24000			-420	4897	1180	1143	0.084	0.199
200%	10	101.20	2380	24000			-420	4882	1180	1144	0.084	0.199
5%	1.0	2.53	30	1000			-2810	113	1003	1004	0.000	0.000
225%	1	113.85	2690				-140				0.072	0.225
225%	10	113.85	2690				-140				0.072	0.225
5%	1	2.53	30	1000			-2810				0.000	0.000

A 1.4072 kips 120.11
 B 0.0416 kips/psi 0.0451
 ZERO 50 psi -450

NCC _____ CLIENT _____

Nail Verification Testing



STA. 8+00

- Redesign During Construction

Nail Verification Testing

- A word about Safety!
- Keep the testing area clear!



Construction Challenges

- Shotcrete Cap Attempt
- Thickness Control Methods
- Form Deflections
- Shotcrete Curing and Weather

Shotcrete Cap Attempt



Shotcrete Cap Attempt



Shotcrete Cap Attempt



Form Deflections



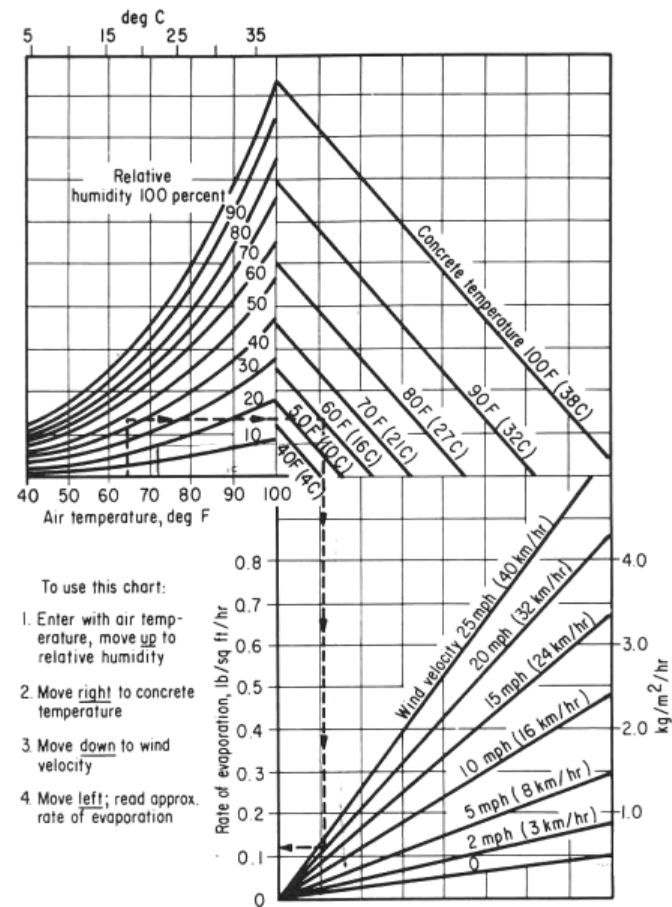
Form Deflections



Shotcrete Curing and Weather

Figure 2 – ACI nomograph for estimating surface water evaporation rate of concrete i.e. the "ACI Hot Weather Concreting Evaporation Nomograph" [5].

- History of difficulty with prompt application of curing compound
- Direct sunshine during the construction season
- Temperature and shrinkage cracking on the South Wall



Large Scale Soil Nail Walls for a Landfill application

ASHE ALTOONA/DISTRICT 9-0 JOINT WORKSHOP

Questions?