East Coast Signals

^Traffic Signals ^Highway, Site & Ornamental Lighting

LETTER OF TRANSMITTAL

TO: Beck & Bellucci, Inc. PO Box 429 Franklin, NH 03235	DATE: 11/26/14 ECS JOB NO. 1433	ATTENTION: Chris Schroeder RE: Waterbury IM 089-2(43)

WE ARE SENDING YOU X Attached ☐ Under separate cover via _____ the following items:

X Shop drawings ☐ Prints ☐ Plans ☐ Samples ☐ Specifications

☐ Copy of letter ☐ Change order ☐ Certificates of Compliance ☐ Contract Documents

Submittal Progress

	Original	Submitted	DESCRIPTION
	1	11-26-14	Cross Engineering SB Ramp Mast Arm Foundation Design

THESE ARE TRANSMITTED as checked below:

X For approval ☐ Approved as submitted ☐ Resubmit_____copies for approval
☐ For your use ☐ Approved as noted ☐ Submit _____copies for distribution
☐ As requested ☐ Returned for corrections ☐ Return_____corrected prints
☐ For review and comment ☐ _____
☐ FOR BIDS DUE _____200___

REMARKS:
Chris, please find the foundation design from Cross Engineering for approval.

COPY TO: _____FILE_____ SIGNED: _____

Matthew S. Fisher
Vice President

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Phone: 603.463.5450 Fax: 603. 463. 5451
www.eastcoastsignals.com

If enclosures are not as noted, kindly notify us at once.

APPROVED FOR SUBMITTAL
EAST COAST SIGNALS INC.
NOV 26 2014
X

EAST COAST SIGNALS
Traffic Signal Foundation Design
Waterbury, VT

Prepared

November 2014

By

CROSS CONSULTING ENGINEERS, P.C.
103 Fairfax Road
St. Albans, Vermont 05478-6271
Telephone: (802) 524-2113
Facsimile: (802) 524-9681
dwoolridge@crossconsultingengineers.com

As Project Number 14091

SHOP DRAWINGS ARE REVIEWED UNLESS NOTED OTHERWISE

NO EXCEPTION TAKEN	X
REVISE AS NOTED RESUBMISSION NOT REQUIRED	
REVISE AS NOTED RESUBMISSION REQUIRED	
REJECTED	

Stantec

DATE 12/9/14

SIGNATURE

REVIEW BY STANTEC IS FOR THE SOLE PURPOSE OF ASCERTAINING GENERAL CONFORMITY WITH DESIGN. CONTRACTOR IS RESPONSIBLE FOR DIMENSIONS, FABRICATION AND CONSTRUCTION METHODS, COORDINATION OF SUB-TRADES, DETAIL DESIGN OF COMPONENTS, AND ERRORS OR OMISSIONS ON SHOP DRAWINGS.

Vermont Agency of Transportation
RECEIVED
Milling Signals Foundation Design Approved.pdf
CK'D BY D Bonneau OK'D BY D Bonneau
December 4, 2014
RESUBMIT No Approved AsNoted
BY D Bonneau DATE 02/05/2015

Table of Contents

GENERAL NOTES:

1) FOR ADDITIONAL DETAILS, SEE VTRANS STANDARDS E-172 & E-173.
2) FOR SIGNS & PAVEMENT MARKINGS SEE SHEET SPM 5.
3) ALL WORK SHOWN ON THIS SHEET AND INCIDENTAL NECESSARY TO COMPLETE THE SIGNAL SYSTEM, SHALL BE INCLUDED IN THE UNIT PRICE BID FOR ITEM 678.15 TRAFFIC CONTROL SIGNAL SYSTEM, INTERSECTION (VT RTE. 100 @ I-89, SOUTHBOUND OFF RAMP) UNLESS OTHERWISE NOTED.
4) PAID AS ITEM 678.30 ELECTRICAL CONDUIT SLEEVE (10"). THE ELECTRICAL CONDUIT SLEEVE (10") SHALL BE INSTALLED BY BEING DIRECTIONALLY BORED UNDER THE ROADWAY.
5) NEW FOUNDATION FOR MAP 1 SHALL BE SET TO ACHIEVE THE REQUIRED SIGNAL HEAD CLEARANCE. CONTRACTOR SHALL SUBMIT FOUNDATION DESIGN FOR RELOCATED MAST ARM. SEE REFERENCE PLAN SHEETS.
6) VIDEO DETECTION CAMERAS SHALL BE INSTALLED AND/OR ADJUSTED PER RHYTHM REQUIREMENTS AT THIS AND THREE OTHER LOCATIONS.
7) ONE BACK UP CAMERA SHALL BE PROVIDED BY THE CONTRACTOR.
8) SEE SHEET RTS 6 FOR LOCATIONS OF ADAPTIVE TRAFFIC CONTROL SYSTEM INSTALLATIONS.

QUANTITIES

ITEM 678.23 WIRED CONDUIT
575 LF (2") (PVC) (SCH 80) INCL SPARES

ITEM 678.25 PULL BOX, STANDARD

DESC.	STATION	OFFSET
PB4	10+98.5	RT.
PB5	10+97.7	LT.

ITEM 678.30 ELECTRICAL CONDUIT SLEEVE (10")
SEE TABLE THIS SHEET

ITEM 900.620 SPECIAL PROVISION (ADAPTIVE TRAFFIC CONTROL SYSTEM, INSYNC) (VT ROUTE 100 @ I-89 SB OFF RAMP) (TYP.)
1 EA

ITEM 900.620 SPECIAL PROVISION (ADAPTIVE TRAFFIC CONTROL SYSTEM, INSYNC) (VT ROUTE 100 @ I-89 NB OFF RAMP) (TYP.)
1 EA

ITEM 900.620 SPECIAL PROVISION (ADAPTIVE TRAFFIC CONTROL SYSTEM, INSYNC) (VT ROUTE 100 @ STOWE STREET) (TYP.)
1 EA

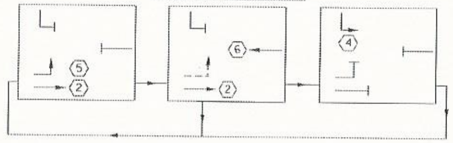
ITEM 900.620 SPECIAL PROVISION (ADAPTIVE TRAFFIC CONTROL SYSTEM, INSYNC) (VT ROUTE 100 @ SHAWS PLAZA) (TYP.)
1 EA

EXISTING	NEW	LEGEND
		UTILITY POLE
		LUMINAIRE
		LIGHT OR WOOD POLE
		STRAIN POLE/CANTILEVER
		CONTROLLER CABINET
		JUNCTION BOX/PULL BOX (JB/PB)
		SIGNAL HEAD
		CONDUIT
		VIDEO DETECTION AREA
		PEDESTAL POST
		MAST ARM (MA) / CANTILEVER
		DRAINAGE STRUCTURE
		VIDEO DETECTOR
		SLEEVE
		PREEMPT OPTICAL DETECTOR

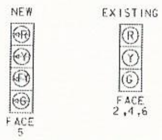
CONTROLLER TIMINGS (SECONDS)

PHASE	MIN. GREEN	PASSAGE	YELLOW	RED	MAX 1	MAX 2	MAX 3
2	5	2	4	2	41	45	47
4	5	2	4	2	25	23	25
5	5	2	4	2	8	10	12
6	5	2	4	2	27	29	29

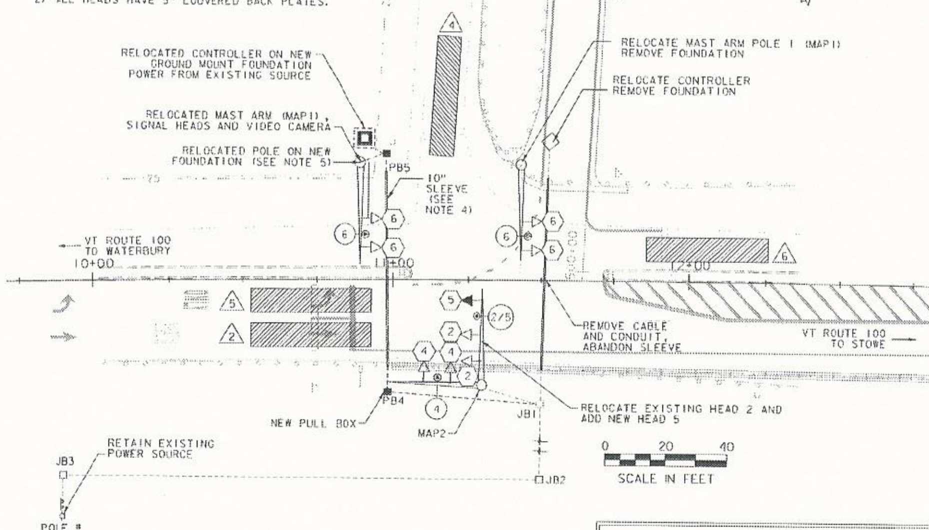
PHASING SEQUENCE



SIGNAL FACE ARRANGEMENT



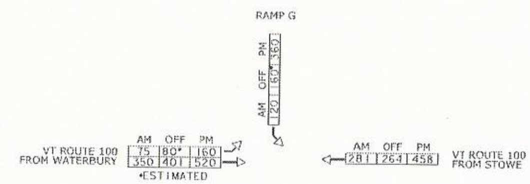
1) SIGNALS 2,4,6 INCLUDE 3 SECTIONS & 12" LENS.
3) SIGNAL 5 INCLUDES 4 SECTIONS & 12" LENS.
2) ALL HEADS HAVE 5" LOUVERED BACK PLATES.

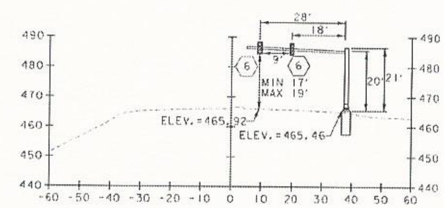


SIGNAL PHASE CLEARANCE – VT ROUTE 100 / I-89 RAMP F /I-89 RAMP D SPUR

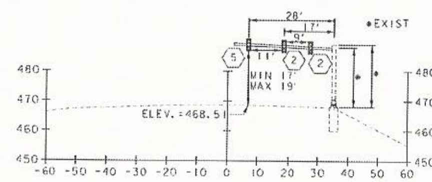
Face	Phase 2+5 R/W	Phase 2+5 Clear to Phase 2+6		Phase 2+5 Clear to Phase 4		Phase 2+6 R/W	Phase 2+6 Clear to Phase 2+5		Phase 2+6 Clear to Phase 4		Phase 4 R/W	Phase 4 Clear To Phase 2+5		Phase 4 Clear To Phase 2+6		Flashing Operation
2	G	G	G	Y	R	G	G	G	Y	R	R	R	R	R	R	FY
4	R	R	R	R	R	R	R	R	R	R	G	Y	R	Y	R	FR
5	←G	←Y	←FY	←Y	←R	←FY	←FY	←FY	←Y	←R	←R	←R	←R	←R	←R	←FR
6	R	R	R	R	R	G	Y	R	Y	R	R	R	R	R	R	FY

2014 PEAK HOUR (AVERAGE WEEKDAY) VOLUMES





MAST ARM #1 CROSS SECTION LOOKING WEST ON VT 100



MAST ARM #2 CROSS SECTION LOOKING EAST ON VT 100

NEW WIRED CONDUIT (PVC)

LOCATION	2 ½"	2"	1 ½"	REMARKS
MAP1 - JB5		3		SIGNAL, VIDEO AND SPARE
JB4 - JB5		4		SIGNAL, VIDEO AND SPARES
JB5 - CONTROLLER		4		SIGNAL, VIDEO AND SPARES
JB1 - JB4		4		SIGNAL, VIDEO AND SPARES

ELECTRICAL CONDUIT SLEEVE (PVC) (SCH 80)

LOCATION	DIA.	STATION
EXISTING - ACROSS ROUTE 100 - ABANDON	6"	11+50.3 RT. - 11+52.0 LT.
NEW - ACROSS ROUTE 100	10"	10+97.7 LT. - 10+98.6 RT.

MAST ARM SUPPORTS

LOCATION	ARM	REMARKS	STATION
MAP1		EXISTING - RELOCATE	10+89.1 LT.
MAP2		EXISTING - RETAIN	11+30.2 RT.

LIST OF MAJOR ITEMS

ITEM 678.15 TRAFFIC CONTROL SIGNAL SYSTEM, INTERSECTION (VT ROUTE 100 @ I-89 SOUTHBOUND OFF RAMP)

1	EA	4-SECTION SIGNAL HEADS (12")
4	EA	RELOCATE SIGNAL HEAD
1	EA	RELOCATE MAST ARM WITH NEW FOUNDATION
1	EA	MAST ARM FOUNDATION
1	EA	RELOCATED CONTROLLER WITH NEW FOUNDATION AND PAD
1	EA	VIDEO VEHICLE DETECTION SYSTEM
550	LF	SIGNAL CABLE

JUNCTION/PULL BOX

LOCATION AND DESCRIPTION	STATION
JB1 - SOUTHSIDE - RETAIN	11+50.1 RT.
JB2 - SOUTHSIDE - RETAIN (POWER)	11+50.8 RT.
JB3 - SOUTHSIDE - RETAIN (POWER)	9+89.4 RT.
PB4 - SOUTHSIDE - NEW	10+98.5 RT.
PB5 - NW CORNER - NEW	10+97.7 LT.

VIDEO DETECTION

NO.	APPROACH/LANE	SIZE	CALL Ø	MODE	NOTE
2/5	EB-LEFT	6X40	5	PRESENCE	NEW
	EB-THRU	6X40	2	PRESENCE	
4	SB-LEFT	6X40	4	PRESENCE	NEW
6	WB-THRU	6X40	6	PRESENCE	NEW

EX-01 Traffic Signal Plan

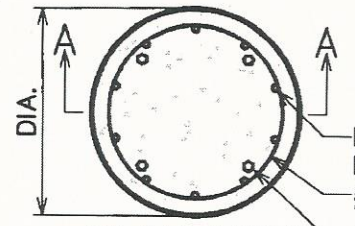
Stantec

PROJECT NAME: WATERBURY
PROJECT NUMBER: IM 089-2(43)

FILE NAME: ...\Ramp E Route 100_SIGNAL.dgn
PROJECT LEADER: G. BOGUE
DESIGNED BY: D. DEBAIE
SIGNAL PLAN - SIG 1

PLOT DATE: 6/2/2014
DRAWN BY: C. GENDRON
CHECKED BY: G. GOYETTE
SHEET 65 OF 252

6/2/2014 4:45:25 PM ...\transportation\drawing\Plot Files\Ramp E Route 100_SIGNAL.dgn

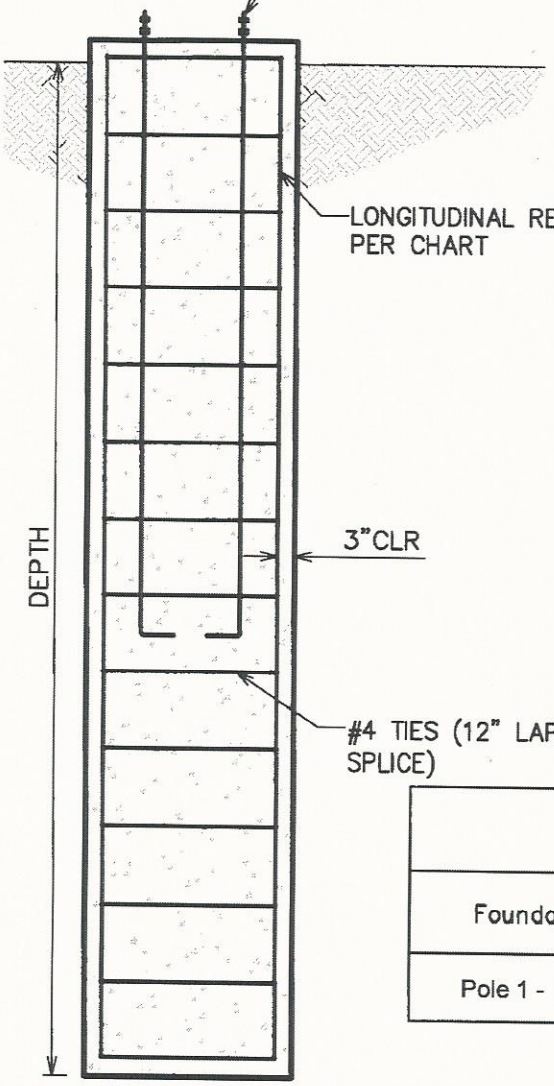


PLAN VIEW

LONGITUDINAL REINFORCING PER CHART

#4 TIES @ SPACING PER CHART

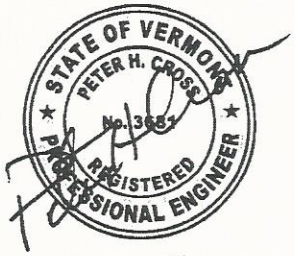
ANCHOR BOLT QTY., SIZE AND PLACEMENT PER POLE MANUFACTURER'S SPECIFICATIONS



SECTION A–A

Notes:

1. Foundation soil properties area based on 62.6 pcf effective unit weight and ϕ=35° friction angle.
2. Min. concrete compressive strength: 3500 psi @ 28 days
3. Reinforcing: ASTM A615 Grade 60
4. Cast foundation against undisturbed earth or within a permanent steel casing.
5. Install conduit per Owner specification.
6. Extend foundation 4" above ground when in earth. Construct foundation flush when in concrete island or sidewalk.
7. The design of the foundation follows VTrans MREI 10–01.
8. Construct foundation in accordance with the current edition of the VTrans Standard Specifications for Construction.
9. Refer to the plans prepared by Stantec (Project No. IM 089–2(43)) for the location of underground utilities.
10. Design Factors of Safety:
    - 10.1. Overturning: 3.0
    - 10.2. Bearing Capacity: 3.0
    - 10.3. Torsion: 1.1



Concrete Foundation Data

Foundation ID	Diameter	Depth	Long. Bars	Tie Spacing	Concrete Vol. (CY)
Pole 1 - 35ft Arm	3'-0"	7'-0"	12-#6	1'-0"	2.8

Traffic Pole Foundation Design
Intersection of Route 100 and Exit 10

PROJECT: 14091
DATE: 2014–11–24
DRAWN: DSW

EX–2

CCE CROSS CONSULTING ENGINEERS, P.C.
Tel. 802–524–2113
Fax. 802–524–9681
103 Fairfax Rd.
St. Albans, Vermont 05478

Q:\2014 Drawings\14091 Waterbury Signal\Current\EX–02_Traffic Pole Foundation Design.dwg Plotted: 11/25/2014 10:33:34 AM

CROSS CONSULTING ENGINEERS, P.C.
103 Fairfax Road, St. Albans, Vermont 05478-6271 • Tel.: 802.524.2113 • Fax: 802.524.9681
E-mail: pcross@crossconsultingengineers.com

Traffic Pole Foundation Design

Design Case: Single 35-ft Mast Arm
Intersection: I89, Exit 10, SB Ramp and VT Route 100, Pole MAP 1

References:

Geotechnical Design Procedures for Mast Arm and Overhead Sign Support Foundations, MREI 10-01, VTrans, March 2010.
Standard Specifications for Highway Bridges, 17th Edition, AASHTO, 2002.
Geotechnical Engineering Circular No. 6 - Shallow Foundations, FHWA, 2002.

Input Values:

Undercapacity Factor: $F_u := 0.7$
Overload Factor: $F_o := 2.1$
Overturning Factor of Safety: $FS_{OT} := \frac{F_o}{F_u}$ $FS_{OT} = 3$

Torsion Factor of Safety: $FS_{TOR} := 1.1$
Allowable Stress Increase for Wind: $A := 1.33$
Diameter of Drilled Shaft: $D := 3 \cdot ft$

Reference: Boring **BH-1**
Blows at Depth of 8'-10': $N' := 85$ from Geotechnical Report
Soil Friction Angle: $\phi := 35 \cdot deg$
At-Rest Earth Pressure Coefficient: $K_o := 1 - \sin(\phi)$ $K_o = 0.426$
No Groundwater encountered within borehole. Assume within 2 feet of surface.
Soil Wt: $\gamma := 125 \cdot pcf$
Soil Effective Unit Wt: $\gamma' := \gamma - 62.4 \cdot pcf$ $\gamma' = 62.6\ pcf$

Loads

Loads provided by Valmont Industries (No. 60287-P1)

Axial Shear Load: $P := 1426 \cdot lbf$
Shear Service Load: $V := 948 \cdot lbf$
Overturning Moment Service Load: $M := 22896 \cdot ft \cdot lbf$
Torsional Service Load: $T := 16983 \cdot ft \cdot lbf$

Check Overturning

Passive Earth Pressure Coef. $K_p := \tan\left(45\ ° + \frac{\phi}{2}\right)^2$ $K_p = 3.69$

Factored Shear Load $V_F := FS_{OT} \cdot V$ $V_F = 2.844\ kip$

Factored Overturning Moment $M_F := FS_{OT} \cdot M$ $M_F = 68.688\ ft \cdot kip$

For cohesionless soil, the embedment length is given by Broms' equation:

$$L^3 - \frac{2 \cdot V_F \cdot L}{K_p \cdot \gamma' \cdot D} - \frac{2 \cdot M_F}{K_p \cdot \gamma' \cdot D} \geq 0$$

By trial and error:

$L := 7 \cdot ft$ $\quad L^3 - \frac{2 \cdot V_F \cdot L}{K_p \cdot \gamma' \cdot D} - \frac{2 \cdot M_F}{K_p \cdot \gamma' \cdot D} = 87\ ft^3$ $\quad > 0$ **OK**

The maximum (unfactored) moment in the shaft is:

$$M_{max} := V \cdot \left(\frac{M}{V} + 0.54 \cdot \sqrt{\frac{V}{\gamma' \cdot D \cdot K_p}} \right) \qquad M_{max} = 23.495\ ft \cdot kip$$

The maxmimum moment occurs at a depth below the ground of:

$$d := 0.82 \cdot \sqrt{\frac{V}{\gamma' \cdot D \cdot K_p}} \qquad d = 0.959\ ft$$

Comment addressed in separate submittal,no change necessary

Soil Bearing Pressure

From AASHTO 4.6.5.1, Soil Bearing Capacity: $Q_{ult} = Q_s + Q_T - W$

where, $Q_s = \pi \cdot D \cdot \sum_{i=1}^{N} \gamma'_i \cdot z_i \cdot \beta_i \cdot \Delta z_i$ $\qquad Q_T = q_T \cdot A_t$

(Ignore top 2 feet)

$$Q_s := \pi \cdot D \cdot \sum_{i=3}^{\frac{L}{ft}} \gamma' \cdot i \cdot ft \cdot \min\left(\max\left(1.5 - 0.135 \cdot \sqrt{i}, 0.25\right), 1.2\right) \cdot 1 \cdot ft$$

$Q_s = 17.349\ kip$

Does this apply if permanent casing is used? is it reduced? (I do understand the design has plenty of tip resistance regardless)

$$A_t := \frac{\pi \cdot D^2}{4} \qquad A_t = 7.069\ ft^2$$

From Geotechnical Report, unfactored N is $N := 100$ at depth of $L + 2 \cdot D = 13\ ft$

from Table 4.6.5.1.4.A: $q_T := 1.20 \cdot N \cdot ksf$ $\quad q_T = 120\ ksf$

$Q_T := q_T \cdot A_t$ $\quad Q_T = 848.2\ kip$

$W := A_t \cdot L \cdot 150 \cdot pcf$ $\quad W = 7.422\ kip$

$Q_{ult} := Q_s + Q_T - W$ $\quad Q_{ult} = 858.2\ kip$

$FS_{bearing} := 3.0$ $\quad Q_{all} := \frac{Q_{ult}}{FS_{bearing}}$ $\quad Q_{all} = 286.1\ kip$

Axial Load:

$P = 1426\ lbf$ $\quad SF := \frac{Q_{all}}{P}$ $\quad SF = 200.6$ OK

Any reduction required here if permanent casing is used?

Comment addressed in separate submittal, no change necessary

Check Torsion:

Friction of soil: $f_t = \sigma'_v \cdot \beta$

where: mid depth is $h := \frac{L - 2 \cdot ft}{2} + 2 \cdot ft$ $h = 4.5\ ft$

$\sigma'_v := \gamma' \cdot h$ $\sigma'_v = 281.7\ psf$

$\beta := min\left(\max\left(1.5 - 0.135 \cdot \sqrt{\frac{h}{ft}}, 0.25\right), 1.2\right)$ $\beta = 1.2$

$f_t := \sigma'_v \cdot \beta$ $f_t = 338\ psf$

The torsional moment resistance of the soil is given by:

Factor of safety: $FS_{TOR} = 1.1$

(Ignore top 2 feet) $T_r := \frac{f_t \cdot \pi \cdot D \cdot (L - 2 \cdot ft) \cdot \frac{D}{2}}{FS_{TOR}}$ $T_r = 21.7\ kip \cdot ft$

Torsional Load is $T = 17\ kip \cdot ft$ < T_r OK

Check Settlement:

From GEC No. 6, Section 5.3.4

$$\Delta H = H_o \cdot \frac{1}{C'} \cdot log\left(\frac{\sigma'_v + \Delta\sigma'_{vf}}{\sigma'_v}\right)$$

Use N' as the geotechnical report has already adjusted the SPT values for overburden pressure.

$N' = 85$ From Figure 5-19 $C' := 275$

$H_o := L$ $H_o = 7\ ft$ $h := \frac{H_o}{2}$ $h = 3.5\ ft$

$\sigma'_v := \gamma' \cdot h$ $\sigma'_v = 219.1\ psf$

$\Delta\sigma'_{vf} := \frac{P}{(D + h)^2}$ $\Delta\sigma'_{vf} = 33.75\ psf$

$\Delta H := H_o \cdot \frac{1}{C'} \cdot \log\left(\frac{\sigma'_v + \Delta\sigma'_{vf}}{\sigma'_v}\right)$ $\Delta H = 0.019\ in$ OK

Maximum settlement allowed is 2 inches (MREI 10-01)

Design of Concrete Reinforcing

Parameters:

Concrete Design Load Factor: $LF_{conc} := 1.3$

Concrete Compressive Strength: $f'_c := 3500 \cdot psi$

Reinforcing Steel Yield Strength: $f_y := 60 \cdot ksi$

Diameter of drilled shaft: $D = 3\ ft$

Concrete Cover: $c := 3 \cdot in$

Diameter of Tie Bar $d_{tie} := 0.5 \cdot in$

Diameter of Longitidunal Bar $d_{long} := 0.75 \cdot in$

Quantity of Longitudinal Bars $N := 12$

Check Steel Requirements for Eccentric Axial Load:

Concrete Strength Reduction Factor $\phi_b := 0.70$

Load Eccentricity $e := \frac{M_{max}}{P}$ $e = 197.71\ in$

Area of Longitudinal Bars $A_s := N \cdot \frac{\pi \cdot d_{long}^2}{4}$ $A_s = 5.3\ in^2$

Gross Area of Concrete $A_g := \frac{\pi \cdot D^2}{4}$ $A_g = 1017.88\ in^2$

Diameter of Longitudinal Reinforcing Circle $D_s := D - 2\ c - 2\ d_{tie} - d_{long}$ $D_s = 28.25\ in$

Bending Reinforcement Ratio $\rho_b := \frac{A_s}{A_g}$ $\rho_b = 0.0052$

Concrete Design Strength

$$\phi P_n := \phi_b \cdot 0.85 \cdot f'_c \cdot D^2 \cdot \left(\sqrt{\left(\frac{0.85 \cdot e}{D} - 0.38 \right)^2 + \frac{\rho_b \cdot f_y \cdot D_s}{2.5 \cdot D \cdot 0.85 \cdot f'_c}} - \left(\frac{0.85 \cdot e}{D} - 0.38 \right) \right)$$

$\phi P_n = 10371\ lbf$

Concrete Required Strength: $P_u := LF_{conc} \cdot P$ $P_u = 1854\ lbf$

$\phi P_n \geq P_u$ OK

Minimum Bending Reinforcement Ratio:

$$\rho_{b\_min} := \left[\left(\frac{P_u}{\phi_b \cdot 0.85 \cdot f'_c \cdot D^2} + \frac{0.85 \cdot e}{D} - 0.38 \right)^2 - \left(\frac{0.85 \cdot e}{D} - 0.38 \right)^2 \right] \cdot \frac{2.5 \cdot D \cdot 0.85 \cdot f'_c}{f_y \cdot D_s}$$

$\rho_{b\_min} = 0.0009$ < $\rho_b = 0.0052$ OK

Check Steel Requirements for Eccentric Axial Load:

Concrete Strength Reduction Factor: $\phi_{tor} := 0.85$

Perimeter of Centerline of Tie Bar $P_h := \pi \cdot (D - 2\ c - d_{tie})$ $P_h = 92.7\ in$

Area of Inside Shear Flow $A_o := 0.85 \cdot \frac{\pi \cdot (D - 2 \cdot c - d_{tie})^2}{4}$ $A_o = 581\ in^2$

Area of Tie Bar $A_T := \frac{\pi \cdot d_{tie}^2}{4}$ $A_T = 0.196\ in^2$

Concrete Required Strength $T_u := LF_{conc} \cdot T$ $T_u = 22.078\ ft \cdot kip$

Maximum Tie Bar Spacing $S_{max} := \frac{\phi_{tor} \cdot 2 \cdot A_o \cdot A_T \cdot f_y}{T_u}$ $S_{max} = 43.9\ in$

Tie Bar Spacing Provided $S := 12 \cdot in$

Concrete Design Strength $\phi T_n := \frac{\phi_{tor} \cdot 2 \cdot A_o \cdot A_T \cdot f_y}{S_{max}}$ $\phi T_n = 22.078\ ft \cdot kip$

Area of Longitudinal Steel for Torsion $A_{tor} := \frac{A_T}{S_{max}} \cdot P_h$ $A_{tor} = 0.414\ in^2$

Longitudinal Reinforcement Ratio for Torsion $\rho_{tor} := \frac{A_{tor}}{A_g}$ $\rho_{tor} = 0.0004$

Total Longitudinal Reinforcement Ratio $\rho_{total} := \rho_{b\_min} + \rho_{tor}$ $\rho_{total} = 0.0013$

Minimum Flexural Reinforcement Ratio $\rho_{F\_min} := \rho_{total} \cdot \frac{4}{3}$ $\rho_{F\_min} = 0.0018$

Minimum Compression Reinforcement Ratio $\rho_{c\_min} := 1\% \cdot \frac{1}{2}$ $\rho_{c\_min} = 0.005$

Longitudinal Reinforcement Ratio Required
Greater of $\rho_{req} := \max(\rho_{c\_min}, \rho_{F\_min})$ $\rho_{req} = 0.0050$

Longitudinal Reinforcement Ratio Provided $\rho_b = 0.0052$ > $\rho_{req} = 0.0050$ OK

Design Summary:

$L = 7\ ft$ $D = 3\ ft$ Rebar, longitudinal: $d_{long} = 0.75\ in$ $N = 12$

Volume of Concrete $Conc_{vol} := \left(\frac{\pi \cdot D^2}{4} \cdot L\right) + 1 \cdot yd^3$ $Conc_{vol} = 2.833\ yd^3$

valmont

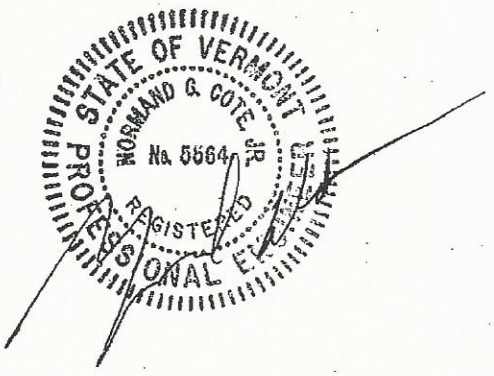
Valmont Industries, Inc.
West Highway 275
P.O. Box 358
Valley, Nebraska 68064-0358 USA
(402) 359-2201

Clarification: the two sheets from Valmont included here are excerpted from approved Mast Arm design calcs submitted when the MA that is to be relocated was originally constructed (2008), and provided to the contractor by VTrans.

A Light & Traffic Structure Proposal
for
VERMONT
WATERBURY

Valmont Order No.: 60287-P1
Customer P.O. No.: 4167

Prepared By:
MIKE SEIDL, P.E.
March 5, 2008



ANALYSIS OF VALMONT INDUSTRIES LIGHTING STRUCTURE
IN ACCORDANCE WITH AASHTO-2001 RQMTS. (FINAL DEFLECTED POSITION)
BY MLS 03/05/2008 VERSION Fuse 1.7.0.232

SUBJECT: VERMONT, 35' MAST ARM, VTTR23

FOLDER: VTTR24 FILE: 35

R E S U L T S S U M M A R Y

MAXIMUM COMBINED STRESS RATIO
IN EACH MAJOR COMPONENT
====(GROUPS I,II & III)====

POLE (AT 20.00 (FT))	= 0.52
SIGNAL AND SIGN ARM 1	= 0.44
BASE PLATE	= 0.20
ANCHOR BOLTS	= 0.32
S/S ARM 1 ATTACH. BOLTS	= 0.34
S/S ARM 1 ATTACH. PLATE	= 0.56

MAXIMUM FATIGUE STRESS
RATIO IN EACH MAJOR COMPONENT
==========(GROUP IV)==========

POLE (AT 0.00 FT)	= 0.69
SIGNAL AND SIGN ARM 1	
ARM TUBE	= 0.87
BUILT-UP BOX GUSSET	= 0.47
SIMPLEX BOLTS	= 0.42
ANCHOR BOLT	= 0.38

MAXIMUM REACTIONS APPLIED TO FOUNDATION
==========

BENDING MOMENT	=	22896 FT-LBS
TORSION	=	16983 FT-LBS
SHEAR FORCE	=	948 LBS
AXIAL FORCE	=	1426 LBS

MAXIMUM BENDING + AXIAL DEAD WT. STRESS
==========

POLE	=	14.20 KSI
SIGN/SIGNAL ARM 1	=	11.42 KSI

RESULTANT DEFLECTION OF POLE TOP
CAUSED BY DEAD WEIGHT
==========
1.08 DEGREES

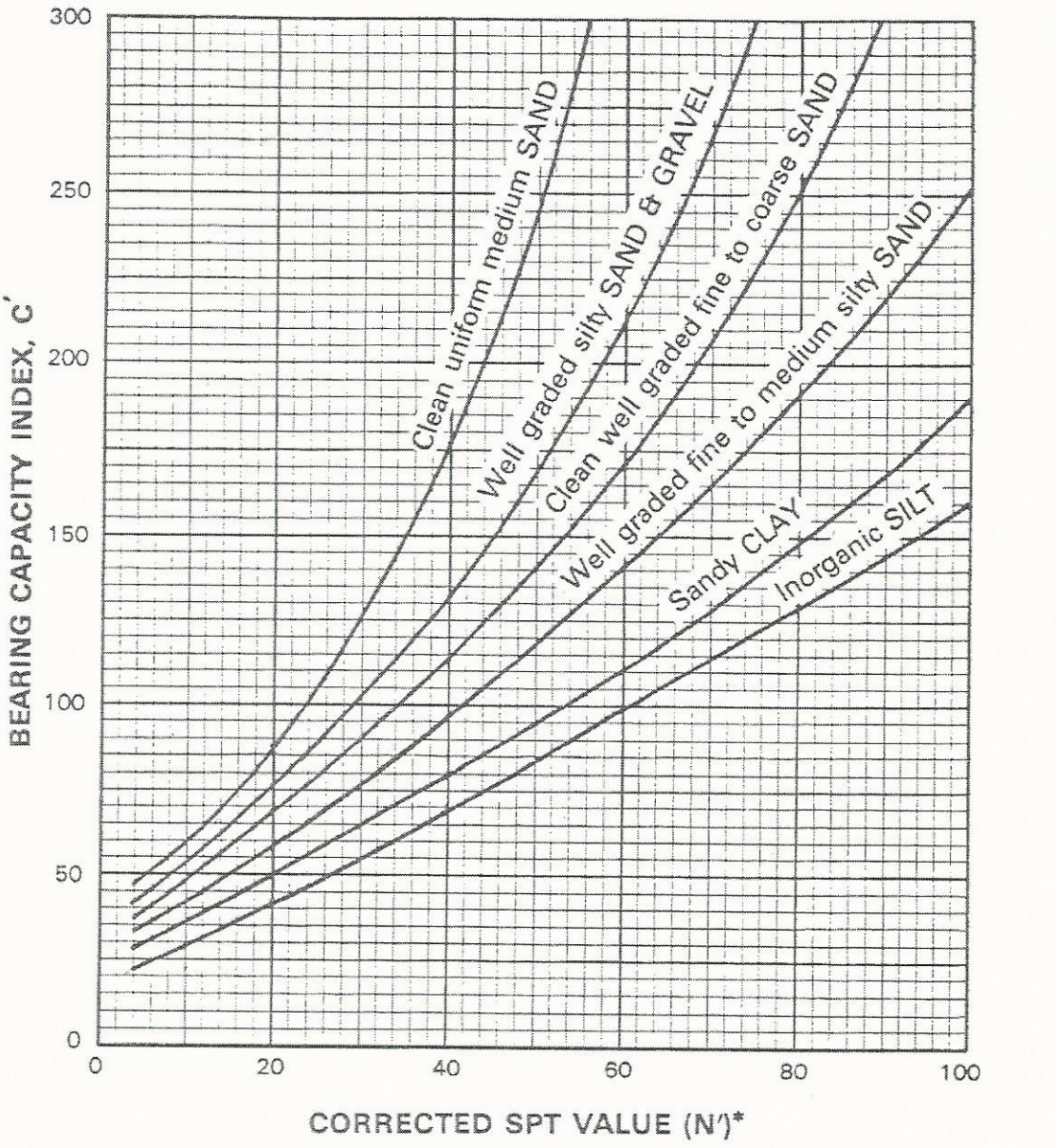


Figure 5-19: Bearing Capacity Index versus Corrected SPT
(Cheney & Chassie, 2000, modified from Hough, 1959)

MIKE'S BORING & CORING LLC.
PO Box 75 ° East Barre, Vermont 05649 ° 802 476-5073

TO: Matt Fisher East Coast Signals 69 North Road Deerfield, NH 03037	PROJECT NAME: Light Pole –SB Lane LOCATION: Waterbury, VT MBC JOB #: 14082	SHEET: 1 DATE: 11-13-14 HOLE #: B-1 LINE & STA. OFFSET:

Ground Water Observations at _ hours	Augers-Size I.D. 3.25" Split Spoon 2" Hammer Wt. 140# Hammer Fall 30"	Surface Elevation: Date Started: 11-13-14 Date Completed: 11-1314 Boring Foreman: Mike McGinley Inspector: Soils Engineer: Dereck

LOCATION OF BORING: As staked

Sample Depths From/To (Feet)	Type of Sample	Blows per 6" on Sampler	Moisture Density or Consist.	Strata Change Elev.	Soil Identification	Sample No.	Pen. Inches	Rec. Inches
0'-2'	Dry	8/20/28/25	Damp	6"	Brown silty fine sand into brown medium coarse gravel	1	24	18
2'-4'	Dry	21/20/19/20	Damp		Brown/gray medium coarse gravel	2	24	1
4'-6'	Dry	17/14/15/26	Damp	5'	Brown/gray medium coarse gravel into gray silt and stones	3	24	18
6'-8'	Dry	100 for 4.5"	Damp		Gray silt and weathered rock	4	4.5	3
8'-10'	Dry	24/12/18/31	Damp		Gray medium coarse gravel and weathered rock	5	24	20
10'-12'	Dry	13/18/94/11	Damp		Weathered rock with some coarse gravel and a trace of silt	6	24	16
15'-17'	Dry	4/5/5/38	Damp		Gray/brown silty clay with some stones	7	24	18
20'-22'	Dry	3/4/13/19	Damp	21' 21.5'	Gray silty clay with some weathered rock into brown silty fine sand into gray weathered rock	8	24	18
25'-27'	Dry	54/11/12/24	Damp		Gary silty clay with some weathered rock	9	24	11

Ground Surface to 25' Used 3.25" augers: Then SS to 27'

Earth Boring	27'
Rock Coring	
Samples:	9
HOLE NUMBER	B-1

Geotechnical Report

Analysis of Soil Boring Logs

Soils Borings performed by: Mike's Boring and Coring, LLC

Hammer Type	Safety	E_M	0.55	$N_{60} = \frac{E_m \cdot C_B \cdot C_S \cdot C_R \cdot N}{0.60}$
Borehole Diameter	2 5/8 inch	C_B	1.00	
Sampling Method	Standard	C_S	1.00	
Rod Length Factor	up to 13 ft	C_R	0.75	$N' = 0.77 \cdot N_{60} \cdot \log\left(\frac{20}{\sigma'}\right)$
	13 to 20 ft	C_R	0.85	
	20 to 30 ft	C_R	0.95	where σ' is ton per sf

The soils area generally gravelly sands; therefore assume the unit weight is 125 pcf

The soils area generally gravelly sands; therefore assume the internal angle of friction is 35 deg

Borehole ID	Depth	N	N_{60}	Y	σ'	N'
BH-1	0-2 ft	48	33.0	125 pcf	0.125 tsf	56.0
	2-4 ft	39	26.8	125 pcf	0.250 tsf	39.3
	4-6 ft	29	19.9	125 pcf	0.375 tsf	26.5
	6-8 ft	100	68.8	125 pcf	0.500 tsf	84.9
	8-10 ft	30	20.6	125 pcf	0.625 tsf	23.9
	10-12 ft	100	68.8	125 pcf	0.750 tsf	75.5
	15-17 ft	10	7.8	125 pcf	1.063 tsf	7.7
	20-22 ft	17	14.8	125 pcf	1.375 tsf	13.3
	25-27 ft	23	20.0	125 pcf	1.688 tsf	16.5