BEFORE
THE OHIO POWER SITING BOARD

In the Matter of the Application of Seneca Wind, LLC for a Certificate of Environmental Compatibility and Public Need for a Wind-Powered Electric Generating Facility in Seneca County, Ohio.	)))))	Case No. 18-488-EL-BGN

SENECA WIND, LLC'S RESPONSES TO STAFF'S SEVENTH SET OF DATA REQUESTS

Geology/Foundation

1) Please provide a status update on additional geotech boring work.

RESPONSE: *33 additional borings have been drilled, however due to persistent rains an additional mobilization will be required to complete some downhole camera work, piezometer readings, and abandonment work.*

- *Video was collected at eight sites where limestone was encountered;*
  - *Of the six sites where limestone was encountered and downhole video was collected, three (T-14, T-60, T-78) may require remediation and require further review and analysis.*
  - *Two sites had slurry intrusion into the casing and video of the entire borehole could not be collected.*
- *Eleven holes are still open and will need abandonment. Of those eleven, five (T-14, T-55, T-59A, T-60, T-70, T-85) still require televising prior to abandonment. Note that some of these that need televising were previously televised but clarity issues arose and they should be re-televised.*

2) Please list any concrete standards/specifications that Seneca Wind intends to adhere to for its foundation design.

RESPONSE: *See Attachment A, which is list of references used for typically used when designing foundations. Other resources may be relied upon in the final design and construction phases, however.*

3) Please list any electrical standards/specifications that Seneca Wind intends to adhere to when designing the underground collection system.

<u>RESPONSE</u>: *sPower has not completed the process of finalizing identification of the all the applicable standards for this project yet. However, the electrical standards/specifications will resemble the attached project another sPower project, Prevailing Wind. Attachments B- D are materials related to the Prevailing Wind project. These documents include the collection system design study (Attachment B), trenching cross section and cable installation details (Attachment C), and the foundation details general notes (Attachment D).*

In addition, below is a general summary codes, standards, and regulations that are taken into account for each design:

General

1. *All design documents, studies, reports, and calculations furnished will be stamped and signed by a registered professional engineer by the applicable engineering discipline.*
2. *The electrical collection system shall be designed in accordance with the following codes, standards and regulations as applicable:*
    - *American National Standards Institute, Inc. (ANSI)*
    - *Institute of Electrical and Electronics Engineers (IEEE)*
    - *National Electrical Manufacturers Association (NEMA)*
    - *National Electrical Code (2017 NEC) (NFPA No. 70)*
    - *Underwriters' Laboratories, Inc. (UL)*
    - *American Society for Testing and Material (ASTM)*
    - *National Electrical Safety Code (NESC)*
    - *State, County, City, and other local Codes*
    - *Federal Occupational Safety and Health Act (OSHA)*
    - *American Concrete Institute (ACI)*
    - *American Society of Civil Engineers (ASCE)*
    - *InterNational Electrical Testing Association (NETA).*
    - *Insulated Cable Engineers Association (ICEA).*
    - *Other Federal Codes and Regulations*
    - *Interconnecting Utility interconnection requirements and standards as applicable.*
3. *The revision (or edition) of codes, standards and specifications in effect at the inception of the project shall apply for the duration of the work.*
4. *Wherever the project design drawings and/or specifications call for or describe materials or construction of a better grade or larger size than is required by the rules and regulations above, then the provisions of these specifications and drawings shall take precedence.*
5. *Identify testing specifications, including procedures, test equipment, and required information on test forms necessary for confirmation that work performed satisfies design requirements.*

4) Please describe common problems associated with the design of the rock-anchored pile foundations and how are those problems are typically addressed?

<u>RESPONSE</u>: *The advantages of a rock anchor foundation is that generally they will have less concrete and steel than a typical spread footing as well as less blasting for excavation. But rock anchor foundations require specific subgrade conditions to be viable. Subgrade demand is 4 to 5 times higher than a spread footing and therefore cannot be placed on soil and requires shallow competent bedrock. Over blasting can easily occur in weak or fractured rock and results in higher than anticipated lean concrete volumes. Lead times on rock anchors are long and any field changes to anchor lengths affect schedule. Due to congestion from the steel reinforcement in the concrete cap, electrical conduit run is more complicated/ and is commonly run below foundation. Rock anchors require periodic (annual) testing. Replacing or repairing a failed rock anchor bolt is difficult.*

Aviation

5) Regarding turbine #71, the coordinates provided to the FAA (41° 4' 34.58"N 82° 52' 15.22"W) in Aeronautical Study Number 2018-WTE-5606-OE are approximately 200 feet southwest of the location proposed to OPSB staff (41° 4'36.09"N 82°52'13.19"W). Please explain.

<u>RESPONSE</u>: *Turbine 71 was relocated following the submittal to the FAA but prior to the filing of the OPSB application. This relocation was done to ensure compliance with potentially occupied structures south of the turbine. The location submitted to the OPSB is the correct location. The FAA will be provided the updated location prior to construction.*

Setbacks

6) Follow-up to previous data request sent 12/20/2018. OPSB staff received a public comment that indicates turbines 44, 85, and 86 may be close to gas pipelines. Please confirm the distance in feet of these wind turbines to any gas pipeline or gas distribution line.

<u>RESPONSE</u>: *Turbine 44 = 796.4 ft.; Turbine 85 = 1161.7 ft., Turbine 86 = 889.0 ft.*

I. Design References

1. International Code Council Inc., International Building Code, 2015.

    a. American Concrete Institute, ACI 318-14, Building Code Requirements for Structural Concrete, 2014.

    b. American Concrete Institute, ACI 336R.4-XX, "Guide for Analysis of Spread Footings by the Strength Design Method", Draft 2008.

    c. American Institute of Steel Construction Inc., Steel Construction Manual, 13th Edition, 2005.

    d. American Society of Civil Engineers, ASCE 7-10 Minimum Design Loads for Buildings and Other Structures, 2010.

    e. Concrete International, "The Challenge of Predicting the Shear Strength of Very Thick Slabs ", November 2015, Vol. 37, No. 11, pages 29-37.

2. ADD PROJECT GEOTECHNICAL REPORT.

3. ADD TURBINE LOAD DOCUMENT.

4. American Wind Energy Association, American Society of Civil Engineers, ASCE/AWEA RP2011, Recommended Practice for Compliance of Large Land-Based Wind Turbine Support Structures, December 2011.

5. Arya, S. O'Neill, M., Pincus, G., Design of Structures and Foundations for Vibrating Machines, Gulf Publishing Company, 1984.

6. Bowles, Joseph E., Foundation Analysis and Design, 5th Edition, 1996.

7. Det Norske Veritas, Offshore Standard DNV-OS-C502, Offshore Concrete Structures, September 2012.

8. Det Norske Veritas Copenhagen and Wind Energy Department, Riso National Laboratory, Guidelines for Design of Wind Turbines, 2nd Edition, 2002.

9. Fahey, M. "Soil stiffness values for foundation settlement analysis", Pre-failure Deformation Characteristics of Geomaterial, Jamiolkowski, Lancellotta & Lo Presti (eds), 2001 Swets & Zeitlinger, ISBN 90 5909 075 02.

10. Germanischer Lloyd, GL Wind Guidelines 1.1, Edition 2004.

11. International Electrotechnical Commission, Wind Turbine Generator Systems – Part 1: Safety Requirements, 3rd edition, 2005.

12. Potyondy, J.G., "Skin Friction Between Various Soils and Construction Materials", Geotechnique, December 1961.

13. Precast/Prestressed Concrete Institute, PCI Design Handbook, 5th Edition, 1999.

ATTACHMENT B

Prevailing Wind Park

Collection System Design Guide and Cable Ampacity Analysis

Prepared for:

sPower

Thorstad Companies

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September 24, 2018 Revision 4

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Revision Tracking

Revision 0, April 5, 2018, initial release for comment

Revision 1, May 16, 2018, revised per discussion of owner review comments

Revision 2, July 05, 2018, final medium voltage ampacity analysis results added, 35kV switchgear and transformer have been moved outside of turbine – to be addressed in revision 4

Revision 3, August 02, 2018, edited description of cables coming into the substation encased in concrete for clarity

Revision 4, August 24, 2018, 54” references updated to 48”, 35kV switchgear and transformer moved to internal

1. Introduction and Basis of Design

Consulting Engineers Group (CEG) is pleased to provide this collection system basis of design and ampacity analysis for the Prevailing Wind Park Project. The purpose is to summarize key design aspects of the 34.5kV collection system and to show the calculations for the ampacity for cable installed under current specifications of the wind project.

Basis of Design

Material Component General Descriptions

1. Internal Transformers – Refer to GE documentation
2. Internal 35kV Switchgear – Refer to GE documentation
3. Fiber Optic Cable for GE SCADA and Met Towers. 12 fiber pairs (24 fibers) SM, all fiber tested and terminated, one 'loop' per collection circuit – eight loops total.
4. Trench Ground – 7#8 copper clad steel
5. Junction Boxes – Nordic Fiberglass or equal, with installed junctions for 600A Dead Break Elbows and ground sleeve. Spare cable in 'S' outside junction base.
    a. Junction boxes are installed at areas where 3 feeder sections meet.
    b. Junction boxes may be used to replace a splice on home runs, if needed to aid in cable testing.
    c. Junction boxes or other exposed equipment to be protected with 4 bollards, typically 3-4" steel pipes, set in concrete, with yellow HDPE covers. (Other similar construction may be provided.)
6. Fault Indicators used at substation feeder exit, 'output' side of junction boxes (away from substation) and per 3 WTG. Owner to indicate if additional fault indicators to be added at all WTG.
7. Owner to indicate if Fluke IR viewing windows are to be added to junction boxes and, if applicable, turbine switchgear.
8. Power and Fiber to Met Towers to be defined once Met Tower locations are final. Power may be from GE WTG if available. (To be determined.)
9. 34.5kV Terminations, Splices, Elbows, and Arresters - Richards, TYCO (TE), or 3M 600A Dead Break Elbows (compression or shear bolt), 3M or TYCO Cold Shrink Splices (shear bolt, direct buried, marked and GPS located) and 3M Cold Shrink Riser Terminations, Cooper Elbow Arresters and Hubbell (Ohio Brass) Riser Arresters.
10. Low Voltage 690 V Cable and Medium Voltage 6 kV Cable
11. 34.5kV Primary Cable – 345MIL XLPE, General Cable 'EMPOWR' CL-Jacketed Flat Strap Concentric Neutral Aluminum Cable of the following sizes; 4/0 AWG 1/3N, 500 kcmil 9FS N, 750 kcmil 9FSN, 1000 kcmil 9FSN, 1250 kcmil 9 FSN, 1500 kcmil 9 FSN. Refer to attached cut sheets.
    a. CL Jacket allows higher concentric neutral temperatures in fault conditions. All kcmil sizes have neutrals that are sized slightly larger than standard 1000kcmil 1/12N (round wire neutral).
    b. All kcmil sizes except 4/0 cable are using 9-flat strap neutral wires. Refer to the concentric neutral sizing section.

Installation Method – Primary Cable

1. All cable trenched, minimum 48" trench depth

2. All backfill of native soils unless deemed unsuitable – areas with significant rock greater than 1/2" in size to be screened with screen on trencher or other approved method. (Refer to drawing PW-TR-01)
3. Backfill in 2 lifts, 85% compaction as per drawing notes (PW-TR-01 drawing).
4. Areas with significant slopes at risk of water entry / trench erosion to be managed via diverter berms, rip-rap, or other methods as applicable to the particular location.
5. All cable installed in tri-foil configuration (zip tied, taped, placed or by other method).
6. Fiber and trench ground in bottom of trench – no intentional separation.
7. Warning tape in back fill as per drawing notes.
8. Splices to be 3M or TYCO (TE) cold shrink direct buried, minimum practical quantity, by trained and certified electricians, located, marker ball and GPS coordinate on as builts.
9. Installed cable and terminations tested via AC-VLF high-pot & Tan-Delta, per EPC contract.
10. Wetland boring and road crossing locations to be with cable marker ball and above grade marker, spliced locations to be marked with locatable marker ball.

Soils Data – Thermal Resistivity Report

1. Barr Report Dated June 13, 2018, 7 sample locations. Using starting soil temperature of 20C.
    a. Average In Situ Rho Value 73
    b. Average Dry-out Rho Value 164
    c. Average 2% moisture Rho Value 149
    d. Maximum Dry-out Rho Value 194

Design Requirements

1. Primary Cable sizes and routes are based on the shortest practical routes, avoidance of non-participant property and then avoidance of wetlands where practical. Cable ampacity and losses are considered for cable sizing. Cable ampacity calculations are based on the soil thermal resistivity shown in the geotechnical report, and the resulting cable sizes are included in this report, along with the output summary files from CymCap.

2. Primary Cable concentric neutral sizing is based on available fault current at the 34.5kV bus, breaker clearing times, and return of fault current by multiple paths. The cable neutral sizing topic is covered in greater detail following the cable ampacity section of this report.

3. Splice locations to be determined in advance and approved during review of cable management plan. Minimization of splices is desired and splices should be avoided on cable runs shorter than the reel lengths, unless road or wetland borings prevent continuous cable.

4. System designated as 'single point grounded system' (referring to the MPT LV neutral), with concentric wires and trench ground designated as equipment grounding conductors per NEC rule 250.184.B.1.b. Concentric wires are grounded at splices, elbows and terminations per NESC 096C Exception 2.

2. Prevailing Wind Park Site Description

Prevailing Wind Park project consists of 57 x 3.80 MW GE Wind Turbine Generator (WTG). The WTG's output voltage is 6 kV, and a 4779 KVA padmounted transformer converts the 6 kV to the collection system voltage of 34.5 KV. The collection system consists of sizes 4/0, 500 kcmil, 750 kcmil, 1000 kcmil 1250 kcmil and 1500 kcmil aluminum conductors, and the collection system is brought to the substation on eight feeders. The substation is connected to the WAPA 230 kV system through a 135/180/225 MVA, 34.5 KV/115 KV main power transformer, a 28 mile 115kV radial transmission tap, and a 135/180/225 MVA, 230 KV/115 kV autotransformer at the POI.

The site is located north of the town of Avon in Bon Homme, Hutchinson and Charles Mix Counties in South Dakota. The area is primarily agricultural with low rolling hills, some wetlands and field drainage areas, and a mix of tilled land and grazing land.

3. Medium Voltage Assumptions of Ampacity Analysis

CEG uses Cyme's Cymcap software, Version 7.1 Rev 4 to calculate the capacity and temperature rise for electric power cable installed on site. The details for the analysis are the following, and the results are in Figure 1 of the next section:

- The project is designed for 34.5 kV cable using 345 mil insulation (100% insulation level).
- Soil conditions were determined by testing by Barr, and according to the June 2018 report, the tested in situ Rho values and thermal dry-out curves showed a typical peak Rho value of 164 cmC/W (average of 7 samples). The maximum dry out value of Rho 195 is used for direct buried cables.
- The majority of the collection system is direct buried cable. The limiting factor for cable sizing for a given number of turbines was determined by evaluation of areas for wetland, pipeline or road crossings where the cable is in conduit, at Rho 175 cmC/W, 72" deep – road bores are generally deeper than trench depth, as the bore has to be 48" below any road ditch. This value represents a nearly dried out soil condition (2-4%), modeled as a Rho 175 duct bank around the directional bored conduit. A more typical in situ value of Rho 80 cmC/W is used for undisturbed soil away from the conduit. The heat transfer in those areas limits the cable rating to a value lower than that used for the direct buried sections.
    - Note: CymCap does not support 'moisture migration' for cable in conduit, the 'duct bank' model as a partial dry out condition is the closest practical solution and a generally accepted practice. It represents a realistic condition that then limits cable ampacity in the cable in conduit condition.
    - Load Factor is set at 1.0 (fully loaded 24 hrs) as an additional safety factor.
- For the direct buried areas, the soil was assumed to dry by moisture migration from an initial value of Rho 80 cmC/W to a final value of Rho 195 cmC/W, installed at 48" deep, 20 degree C.
- GE 3.8 MW WTG with at 0.9PF max results in 70.66 amps at 34.5kV per WTG.
- At least a 10% cushion is assumed for a safety factor (See column "WTG Allowed".)

- Cases where cables trenches are in parallel (home runs and substation entrance) to be evaluated as a specific case. Generally, parallel trench spacing exceeding 15 feet on center is expected for a safe design margin.
- Directional boring, cable crossing and other cases are evaluated to determine that all installed case scenarios will have a supporting case calculation.
- Cables are General Cable CL Jacket, Flat Strap Neutral on kcmil sizes. All cables are rated MV-105, but evaluated and sized / used based on 90 degree C operation. The 105C rating is an intentional safety factor that is not used as a result of cable sizing for losses.

4. Medium Voltage Ampacity Analysis Results (Preliminary)

Cable Size	Neutral	Direct Bury, 48”, Dry out, Tri-foil, Rho 195	In conduit or duct, 72”, Dry out, Rho 150 Duct Bank	WTG Allowed / Used (based on cable in conduit Amps allowed compared to actual one line diagram WTG used)	Margin > 10%
1/0	2-3N	(not used)			
4/0	1-3N	254 A	218 A	3.08 → 2 WTG	54%
500	9FSN	399 A	355 A	5.02 → 4 WTG	25%
750	9FSN	488 A	436 A	6.17 → 5 WTG	23%
1000	9FSN	564 A	504 A	7.13 → 6 WTG	18%
1250	9FSN	633 A	566 A	8.01 → 7 WTG	14%
1500	9FSN	691 A	618 A	8.74 → 8 WTG	9.2%

Figure 1 Summarizes Cable Loading and Ampacity, based on cable direct bury and in conduit.

The following table has been added to show the operating temperature of the direct buried cable, using the maximum number of turbines on the particular cable size. (The vast majority if the cable is direct buried, not in duct.) For example, 4/0 AL cable is rated for 254 Amps, direct buried, and 90 degree C, but used for a theoretical 142 Amps only results in 65 degree C. The resistances associated with these cable temperatures are used in the operational loss report. All cables can be assumed to be operating below 65C for over 95% of their installed distance.

Cable Size	Neutral	Direct Bury, 48”, Dry out, Tri-foil	WTG USED, Amps	Operating Temp
1/0	2-3N	Not Used		
4/0	1-3N	254 A	2 WTG, 142 A	34.2 C
500	9FSN	399 A	4 WTG, 283 A	43.2 C
750	9FSN	488 A	5 WTG, 354 A	44.1 C
1000	9FSN	564 A	6 WTG, 424 A	46.0 C
1250	9FSN	633 A	7 WTG, 495 A	48.4 C
1500	9FSN	691 A	8 WTG, 566 A	51.4 C

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5. Parallel Cable Ampacity Results and Substation Entry Area

There are several cases of circuits in parallel throughout the project. For circuits in parallel throughout the collection system, the different cases of two or three specific cables in parallel were modeled to determine whether it resulted in a safe operational temperature. In all cases, the scenario of cable in conduit was the limiting case, as opposed to direct buried cable. Model spacing is 8'0" nominal. Expected installation spacing is shown as 15'0" nominal. This provides an additional safety marginal for parallel cables.

Cable Size 1	Neutral	WTG USED, Amps	Operating Temp	Cable Size 2	Neutral	WTG USED, Amps	Operating Temp
500 KCMIL	9FSN	4 WTG, 283 A	66.5 C	1250 KCMIL	9FSN	7 WTG, 495 A	78.1 C
750 KCMIL	9FSN	5 WTG, 354 A	68.8 C	1250 KCMIL	9FSN	7 WTG, 495 A	78.1 C
1250 KCMIL	9FSN	7 WTG, 495 A	78.1 C	1250 KCMIL	9FSN	7 WTG, 495 A	78.1 C
*1250 KCMIL	9FSN	7 WTG, 495 A	80.5 C	1250 KCMIL	9FSN	7 WTG, 495 A	84.8 C
1250 KCMIL	9FSN	7 WTG, 495 A	78.1 C	1500 KCMIL	9FSN	8 WTG, 566 A	84.5 C

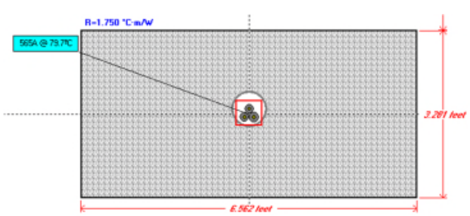
*This represents the case where three 1250 KCMIL cables are in parallel. For conciseness, since the two outside cables have the same temperature, they are represented by cable 1, while the middle cable is represented by cable 2.

The substation entry is modeled as a large concrete duct bank, with cables in conduit in parallel with 8'0" nominal spacing. The entire fill area to 12" below grade is specified as concrete in order to have the best possible heat transfer. Actual circuit configurations of 7-8 turbines (7 turbines on 1250 KCMIL with one 8 turbine circuit on 1500 KCMIL) were used.

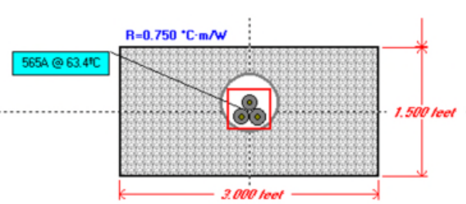
Upon exiting the substation duct bank, the cables are still at 8'0" spacing. This area will require backfill with lean concrete (typical Rho 120 or better) until cables reach 15'0" separation.

The substation entry cables were modeled as cables in conduit at 8'0" separation with a Rho 120 lean concrete backfill. This results in a maximum temperature of 74.5 C, which provides a 29% margin over the cables' 105 C rating.

For clarity, consider the case of a single cable (1500 KCMIL) entering the substation in conduit. Loaded with the full 565 A, the resulting conductor temperature is 79.7 C. The same cable, modeled as if in an area backfilled by 1.5' by 3' of lean concrete, results in a temperature of 63.4 C.



Cable in conduit



Cable in concrete

The cable in concrete results in an approximately 20% decrease in conductor temperature as compared to the cable in conduit. (Note: This aligns with the 74.5 C result reported above when all eight circuits were modeled in parallel with lean concrete backfill.) These results can then be extrapolated to the case where all eight circuits are entering the substation in parallel. When all eight circuits were modeled in parallel at the substation entry, the middle 1500 KCMIL cable reached 97.1 C. If the same 20% decrease was observed, the cable temperature would decrease to 77.68 C, which is well within the cable's 105 C rating. Therefore, at the substation entry, the excavation should be backfilled with lean concrete to deliver better heat transfer.

6. 34.5kV Cable Concentric Neutral Withstand

Fault currents on the 34.5kV cable system return to the substation transformer via the cable concentric neutrals, trench ground, and earth return paths. The concentric neutrals must be size for the available fault current to which the neutrals are exposed during a single line to ground fault and clearing time for that fault condition.

Based on the substation transformer 134/178/222 MVA, Z=11%, and WAPA reported fault current, 10.03kA SLG fault current is available at the substation 34.5kV bus. (Refer to Short Circuit Study.)

Preliminary fault current model shows less than 10,000A SLG fault current on the 34.5kV bus with 1.0 Ohm air core neutral grounding reactor on the main transformer. This is within acceptable limits at 66% of full fault current as described below for the following cable sizes/neutrals:

(Revised from 7 FSN per owner comments. Placeholder note until final report issued after Geotech and initial Short Circuit Study.)

- 1500 kcmil AL, 9 Flat Strap N
- 1250 kcmil AL, 9 Flat Strap N
- 1000 kcmil AL, 9 Flat Strap N
- 750 kcmil AL, 9 Flat Strap N (Refer to Shield Fault Current page of cut sheet)
- 500 kcmil AL, 9 Flat Strap N
- 4/0 AWG AL, 1/3 N (marginal) *(Acceptable based on 7,000A maximum SLG fault current at closest location for 4/0 AWG AL, JB3-1 on Feeder 3.)*

Fault current data from the SKM load flow model indicates less than 10,000A SLG at the 34.5kV bus, and 7,000A SLG at Junction Box JB3-1, the nearest location for 4/0 cable. Fault current data and relaying assumptions are accurate for the purpose of sizing cable concentric neutrals and will be further addressed in other reports.

Method for determining correct neutral wire size for General Cable CL Jacket Flat Strap Neutral product with jacket withstand temperature is 350C.

- For future fault current growth the 34.5kV bus fault current is assumed to be 110% of calculated, or 11kA.
- Fault Currents are to be defined in the fault current report associated with the grounding report. Values shown are based on the preliminary results determined during the loss study.
- A fault exceeding any nominal value will exit the cable jacket and return along the concentric neutrals (both directions, shared on all sets), the trench ground, and ground return paths.
- While it is reasonable to calculate by current division that less than 50% of the fault current will return directly to the substation on one cable neutral, a value over 50% is used to provide a margin of safety.
- For 11kA SLG, with 66% of the available fault current assumed to return by a single set of concentric wires, the withstand fault current is 7.25kA.
- Relay settings are to be defined in the relay coordination report; preliminary clearing times from typical GE projects are used.
    - Primary clearing by the feeder breaker and SEL-351S allows for 6 cycle delay for coordination with the turbine 35kV switch. Breaker operation and pickup time combine for a total clearing time of 12 cycles.
    - Backup breaker failure clearing is assumed to be no greater than 18 cycles.
- Refer to the 750 kcmil General Cable Data Sheet, for 9 flat strap neutrals of 0.193" x 0.025", Cu.
    - The graph crosses 0.3 seconds (18 cycles) the backup clearing time, at 7.25kA
    - Included in that assumption is the initial condition of 105C conductor temperature.

We conclude that 7 flat strap neutral wires are sufficient for future 11kA fault current, allowing 66% return via a single path, for up to 18 cycles, the backup clearing time. *(Final selection of cable is using 9 FSN per owner comments.)*

7. Collection System Studies and Standards

The following studies, reports and calculations are required for the complete collection system design. If so noted, they may be part of the substation engineering scope or part of work by the turbine vendor.

The collection system is designed in accordance with the National Electrical Code (as adopted by the local jurisdiction), and National Electrical Safety Code where applicable. The basic scope of each report is summarized below.

1. Harmonic Analysis Study
    a. Using EMTP-RV or other approved software, a plant specific model will be developed to determine if the project will meet the requirements of IEEE Standard 519 for voltage and current harmonic distortion at the Point of Interconnection.
    b. The turbine vendor may be required to supply additional information regarding turbine controls or other modeling information.
    c. All system configurations and stages of reactive power compensation will be studied.
2. Insulation Coordination and Arrester rating confirmation

   a. Calculate protection margins for electrical equipment based on arrester ratings from IEEE Standard C62.22 and selected arrester data.
3. TOV Study
   a. Using EMTP-RV or other approved software, determine if the project will not experience harmful overvoltage conditions during ground faults.
   b. Confirm rating of arresters relative to energy discharge capability.
   c. Determine if arresters are needed at locations other than end of string and substation riser terminations, or if other equipment is needed to reduce over-voltage issues.
   d. Confirm use of 34.5kV high speed grounding breaker (EMA circuit breaker) or ratings for ground reference transformer (34.5kV grounded wye to 480V delta "grounding transformer" if used.)
   e. Determine if the project meets the definition of "effectively grounded" per IEEE C62.92
4. Load Flow and Loss Study
   a. Using ETAP, SKM or other approved power system load flow software, model the entire project from POI to generator terminals.
   b. Model all system components accurately for distance, resistive and reactive components.
   c. Determine peak power (kW) losses and annual energy (kWh) losses based on wind frequency and turbine power curve 'bin' data provided by owner.
   d. Determine inputs needed for LTC settings or DETC tap selection.
   e. Refer to EPC contract and project Pro-Forma for loss criteria.
5. Reactive Power Study
   a. Using ETAP, SKM or other approved power system load flow software, model the entire project from POI to generator terminals.
   b. Conduct load flow studies at 0, 25%, 50%, 100% output (or as required by Interconnection Agreement).
   c. Confirm that the plant as designed meets the system operator reactive power requirements, or size reactive power compensation equipment (capacitors and/or reactors) as needed to meet the terms of the Interconnection Agreement.
   d. Review WAPA voltage profile for applicable cases.
6. Short Circuit Study
   a. Using ETAP, SKM or other approved power system load flow software, model the entire project from POI to generator terminals.
   b. Conduct short circuit evaluations to determine single line to ground and three phase fault currents at all applicable system bus locations.
   c. Confirm that selected equipment is rated for short circuit interrupting or withstand ratings.
7. Turbine Ground Grid Study
   a. Calculate grid resistance per WTG manufacturer requirements.
   b. Determine if IEEE-80 Step and Touch potentials are met using available fault current and current divider rules.

   c. Determine if additional grounding or 'substation crushed rock' are required.
8. Arc Flash Study
   a. Using ETAP, SKM or other approved power system load flow software, model the entire project from POI to generator terminals.
   b. As required in NFPA 70 and IEEE-1584, determine incident arc flash energy at all operable system bus locations.
   c. After review of the arc flash study report, produced labels for all applicable equipment.
   d. If required by owner's O&M group, include 'arc flash reduction / maintenance mode' setting in Relay and Protection Coordination Report and Arc Flash study.
9. Relay and Protection Coordination Report
   a. Document relay settings and testing requirements.
   b. Provide documentation and graphs as needed to show proper coordination of relay settings and equipment protection (damage curve) coordination.
   c. Explain relay setting and coordination philosophy and methods.
   d. Provide SEL database for testing and commissioning technicians.
10. NERC FAC-008 and Related NERC compliance documents and forms to be completed.
    a. Owner to provide existing compliance template documents.
    b. Engineer to provide documentation as needed to complete forms.

8. Professional Engineer Approval of Report

Signed:

Sincerely,

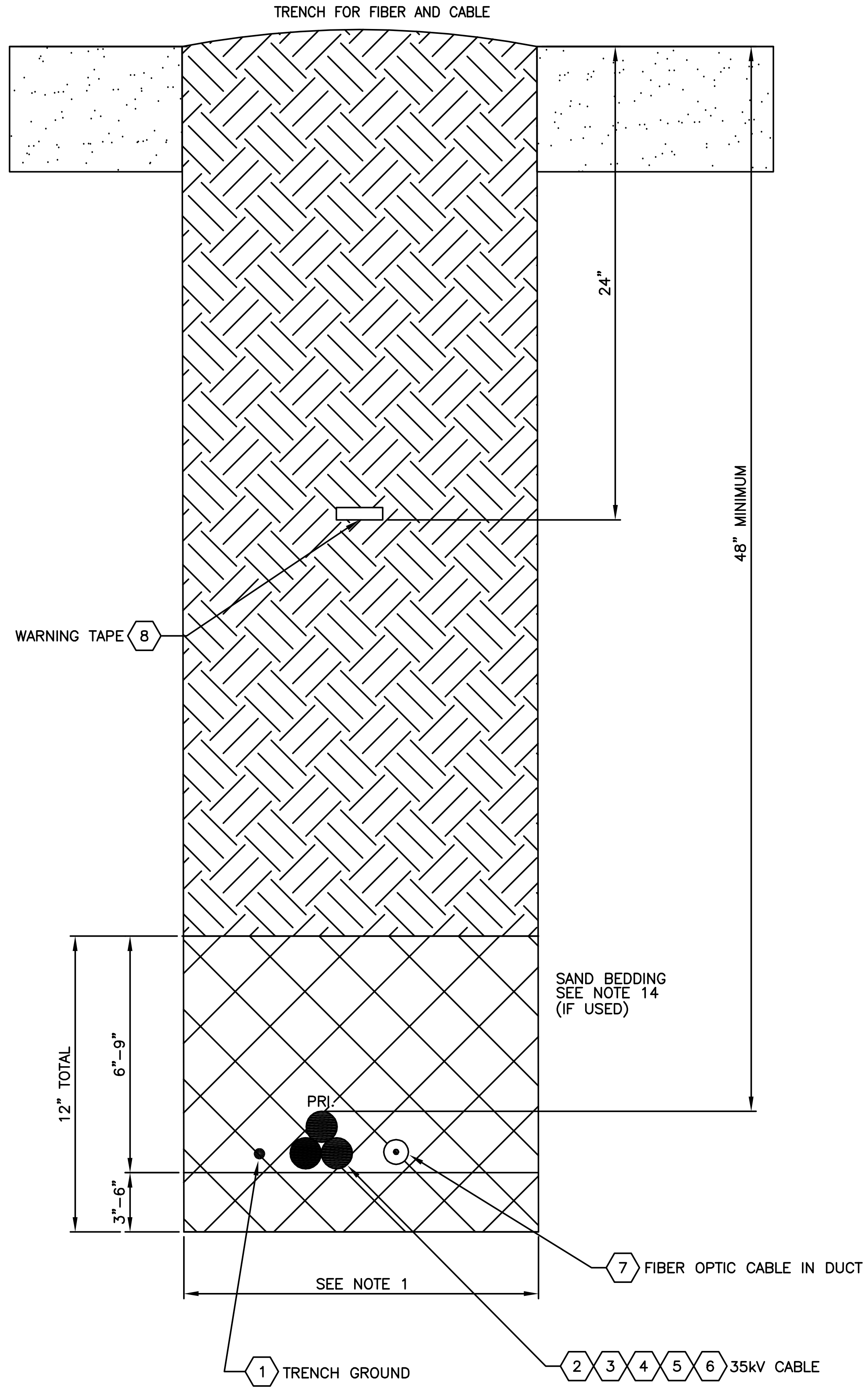
Paul Malamen, Jr.
Vice President
Consulting Engineers Group
Office 651-463-6250

I hereby certify that this plan, specification or report was prepared by me or under my direct supervision and that I am a duly licensed professional engineer under the laws of the state of:
South Dakota
License Number: 6205

Attachments:

Summary Page for CymCap report, all cable sizes, using designed neutrals, direct buried and in conduit
General Cable Data Sheets, all cable sizes
Collection System One Line Diagrams
Thermal Resistivity Results

ATTACHMENT C



NOTES:

1. EXACT TRENCH WIDTH DETERMINED BY EQUIPMENT REQUIRED FOR TERRAIN. CABLE WILL BE BURIED TO MINIMUM DEPTH OF 48".

2. DEPTHS SPECIFIED ARE TO EXISTING GRADE. MINIMUM DEPTHS TO BE FOLLOWED AT ALL TIMES. DEVIATION FROM NOMINAL DEPTHS AT THE DISCRETION OF THE DESIGN ENGINEER AND OWNER BASED ON FIELD CONDITION.

3. BACK FILLING IS PART OF ALL TRENCHING UNITS. BACK FILL WITH SELECT FILL FROM TRENCH. NO ROCKS > 3/8" WITHIN 12" OF CABLE. (SCREEN BACKFILL IF NEEDED.) BED CABLES ON 3" OF SELECT FILL IF BOTTOM OF TRENCH IS ROCK OR SHALE. SELECT FILL MAY BE TRENCHED SOILS OR SIMILAR SOILS FROM TURBINE EXCAVATION. COMPACT TO 85% PER SPECIFICATIONS. FILL/COMPACT IN TWO LIFTS AND COMPACT TOP AFTER RESTORING TOPSOIL. RE-SEED AND RESTORE AS REQUIRED BY OWNER. BACKFILL MAY REQUIRE 3" SAND BEDDING BELOW AND ABOVE CABLE IF TRENCHED SOILS CONTAIN ROCK THAT CANNOT BE SCREENED OUT. CONTRACTOR TO PROVIDE DESCRIPTION OF BACK-FILLING AND COMPACTION PLAN. FIELD TEST COMPACTION IN FIRST 1/4 MILE OF TRENCH AT 2-3 LOCATIONS. IF METHOD PROVES ACCEPTABLE, TEST EVERY 1,500 LF ON ALL HOMERUNS AND CABLES LOADED TO GREATER THE 75%.
   GENERAL INTENT IS TO NOT SCREEN FILL UNLESS AREAS ARE FOUND WHERE SOILS DO NOT CONFORM TO GEOTECH REPORT.

4. WARNING TAPE AT 24" TO BE SPECIFIED ON ALL CIRCUITS. FURNISHED BY TRENCHING CONTRACTOR.

5. MAINTAIN 15' MINIMUM SPACING BETWEEN PARALLEL CIRCUITS.

6. USE HEAVY DUTY TIE WRAPS AS REQUIRED TO MAINTAIN TRIPLEXED BUNDLE CONFIGURATION. ENSURE THAT TIE WRAPS ARE STRONG ENOUGH TO WITHSTAND BACKFILLING.

7. TYPE AND SIZE OF MEDIUM VOLTAGE CABLES TO BE INSTALLED BETWEEN TOWERS IS SPECIFIED IN THE MEDIUM VOLTAGE ONE LINE DIAGRAM.

8. TYPE OF FIBER OPTIC CABLE TO BE INSTALLED BETWEEN TOWERS IS SPECIFIED IN THE FIBER OPTIC ONE LINE DIAGRAM.

9. ANY EXTRA EXCAVATED MATERIAL AND SOIL REMOVED FROM THE TRENCH SHALL BE SPREAD ON SITE.

10. THE LOCATION OF EACH INDIVIDUAL CIRCUIT (CENTER OF TRIPLEXED CABLE) SHALL BE RECORDED IN (WAAS ENABLED) GPS USING A SURVEYING ACCURACY OF +/-7' GPS.

11. ALL SPLICE LOCATIONS, JUNCTION BOXES AND THE EXACT LOCATIONS OF WHERE THE CABLES ENTER AND EXIT THE FOUNDATIONS SHALL BE RECORDED BY GPS AND MARKED IN THE FIELD.

12. ELECTRICAL CONTRACTOR TO TRENCH ACROSS ACCESS ROADS. STRIP ROAD GRAVEL, CUT GEOTECH FABRIC AND RESTORE/REPAIR PER CIVIL PLANS. COORDINATE WORK WITH GENERAL CONTRACTOR.

13. ELECTRICAL CONTRACTOR TO FURNISH AND INSTALL BURIED CABLE MARKERS AT:
    1. BOTH SIDES OF ROAD CROSSINGS.
    2. BOTH SIDES OF WETLAND CROSSINGS.
    3. FENCE CROSSINGS. (IF MORE THE 1,400 LF FROM THE NEAREST WTG OR JUNCTION BOX)
    4. PROPERTY LINE CROSSINGS. (IF MORE THE 1,400 LF FROM THE NEAREST WTG OR JUNCTION BOX)
    5. PIPELINES.

14. SPECIFICATION FOR SAND BEDDING MATERIAL, IF NECESSARY.
    1. FINELY GRADED SAND [100 % PASSING #1/4" SCREEN], NO MORE THAN 35% PASSING THROUGH NO. 200 SIEVE.
    2. THERMAL RESISTIVITY TO MATCH EXISTING GEOTECH. RHO 80 AT 20% MOISTURE, RHO 195 AT DRY OUT. (ENGINEER TO EVALUATE IF RHO VALUE FOR FILL DOES NOT MEET 15.2)
    3. MOISTURE CONTENT >10% WHEN PLACED.
    4. MATERIAL MAY BE SCREENED TRENCH SPOILS OR MATERIAL FROM TURBINE EXCAVATION, OR IMPORTED FILL. REVIEW WITH SITE ELECTRICAL QUALITY CONTROL MANAGER AND ENGINEER.

CABLE PLACEMENT IN TRENCH

TREFOIL (ALL SIZES)
SECURE CABLE EVERY 100' OR
DEMONSTRATE CONSISTENT PLACEMENT.

UNDISTURBED EARTH

COMPACTED BACKFILL
UNLESS OTHERWISE SPECIFIED
SEE NOTE 3

SAND BED CABLE ZONE

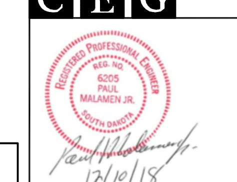
X ITEM NUMBER ON MATERIAL LIST

SCALE: 3" = 1'-0"
0 3' 6' 9' 12'

THIS LINE IS ONE INCH WHEN DRAWING IS FULL SIZE, IF NOT ONE INCH, SCALE ACCORDINGLY.

REV	DATE	DRAWN	DESCRIPTION	WORK ORDER	CHKD	APPD	DATE
0	12/10/18	MAK	ISSUE FOR CONSTRUCTION				

CEG CONSULTING ENGINEERS GROUP
LAKEVILLE, MINNESOTA



PREVAILING WIND PARK LLC
COLLECTION SYSTEM
TRENCHES FOR CABLE INSTALLATION

THORSTAD COMPANIES

CHECKED	CD	SCALE:	AS SHOWN
DATE	12/10/18	PROJECT#	CEGTHR01
DRAWN	MAK	DWG. NO.	PW-TR-02R0
DATE	08/09/18		

ATTACHMENT D

STRUCTURAL NOTES

GENERAL:

1. NOTES AND DETAILS ON THE STRUCTURAL DRAWINGS TAKE PRECEDENCE OVER THESE STANDARD STRUCTURAL NOTES.

2. ALL MATERIAL AND WORKMANSHIP SHALL CONFORM TO THE REQUIREMENTS OF THE FOLLOWING CODES, SPECIFICATIONS, AND DESIGN MANUAL (LATEST EDITION UNLESS NOTED):
   a. ASCE SUBSTATION STRUCTURE DESIGN GUIDE (ASCE MANUAL NO.113-2008)
   b. AMERICAN CONCRETE INSTITUTE (ACI)
   c. CONCRETE REINFORCING STEEL INSTITUTE (CRSI) MANUAL OF STANDARD PRACTICE (FOR PLACING & DETAILING ALL REINFORCING)
   d. AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)
   e. AMERICAN WELDING SOCIETY (AWS) STANDARDS FOR WELDING AS MODIFIED BY A.I.S.C. SPEC.
   f. STATE AND FEDERAL OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA REQUIREMENTS)

3. THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS, ELEVATIONS, AND SITE CONDITIONS BEFORE STARTING WORK; AND THE ENGINEER SHALL BE IMMEDIATELY NOTIFIED, IN WRITING,OF ANY DISCREPANCIES.

4. IN NO CASE SHALL DIMENSIONS BE SCALED FROM PLANS, SECTIONS, OR DETAILS ON THE STRUCTURAL DRAWINGS.

5. ALL OMISSIONS AND CONFLICTS BETWEEN THE VARIOUS ELEMENTS OF THE DRAWINGS SHALL BE BROUGHT TO THE ATTENTION OF, AND RESOLVED WITH THE ENGINEER BEFORE PROCEEDING WITH ANY WORK SO INVOLVED.

6. THE CONTRACTOR SHALL DETERMINE THE LOCATION OF UTILITY SERVICES IN THE AREA TO BE EXCAVATED BEFORE BEGINNING EXCAVATION.

7. UNLESS NOTED OTHERWISE: NO PIPES, DUCTS, SLEEVES, CHASES, ETC., SHALL BE PLACED IN SLABS OR WALLS, NOR SHALL ANY STRUCTURAL MEMBER BE CUT FOR PIPES, DUCTS, ETC.

8. RECESSES, DEPRESSIONS, DIMENSIONS, ELEVATIONS, OPENINGS, EQUIPMENT SUPPORTS, AND DETAILS SHALL BE VERIFIED BY REFERENCE TO OTHER DRAWINGS.

9. TEMPORARY BRACING: PROVIDE TEMPORARY BRACING FOR ALL BUILDING ELEMENTS AND COMPONENTS UNTIL THE STRUCTURE IS SUFFICIENTLY COMPLETE TO PROVIDE PERMANENT BRACING.

FOOTINGS AND FOUNDATIONS

1. NET ALLOWABLE SOIL BEARING PRESSURE:
   a. Fp = 2500 psf

2. FOOTINGS, FOUNDATIONS AND OTHER ITEMS RELATED TO THE SOILS SHALL BE CONSTRUCTED IN ACCORDANCE WITH THE RECOMMENDATIONS IN THE GEOTECHNICAL ENGINEERING REPORT BY BARR.
   a. ROAD RUNNER SUBSTATION
      CHARLES MIX, BON HOMME & HUTCHINSON COUNTY, SD
      PREVAILING WIND PARK GEOTECNICAL REPORT_FINAL_v1 (2)
      REPORTED DATE JULY 12, 2018

3. PLACEMENT OF ENGINEERED FILL SHALL BE OBSERVED & TESTED BY THE SOILS ENGINEER PRIOR TO FOUNDATION PLACEMENT.

4. THE NET ALLOWABLE SOIL BEARING PRESSURE SHALL BE FIELD VERIFIED BY SOILS ENGINEER PRIOR TO PLACING FOOTINGS.

5. ALL SITE SOIL WORK SHALL BE DONE UNDER THE DIRECT OBSERVATION OF A SOILS ENGINEER.

6. ANY CLAY SOILS BELOW MAT/SLAB FOUNDATIONS SHALL BE MOISTURE CONDITIONED TO +/- 2% OF OPTIMUM PRIOR TO CONCRETE PLACEMENT.

7. WATER LEVELS ARE SUBJECT TO SEASONAL AND/OR ANNUAL VARIATIONS. IF NECESSARY A DEWATERING SYSTEM OF SUFFICIENT CAPACITY SHALL BE INSTALLED AND OPERATED TO MAINTAIN THE CONSTRUCTION AREA FREE OF WATER AT ALL TIMES.

8. PROTECT FOUNDATION EXCAVATIONS FROM FROST; DO NOT PLACE CONCRETE ON FROZEN GROUND.

9. FOUNDATION EXCAVATIONS SHALL BE KEPT FREE OF LOOSE MATERIAL AND STANDING WATER AND SHALL BE CHECKED AND APPROVED BY THE SOILS ENGINEER BEFORE THE PLACEMENT OF ANY CONCRETE.

10. UNLESS OTHERWISE NOTED, COLUMN FOOTINGS ARE CENTERED UNDER COLUMNS.

11. CONSTRUCTION OF DRILLED PIER FOUNDATIONS SHALL BE UNDER THE DIRECT OBSERVATION OF A SOILS ENGINEER.

GENERAL NOTES:

1. CONCRETE WORK SHALL CONFORM TO ALL REQUIREMENTS OF ACI 301 (LATEST EDITION) "SPECIFICATIONS FOR STRUCTURAL CONCRETE FOR BUILDINGS", EXCEPT AS MODIFIED BY THESE NOTES.

2. BAR REINFORCEMENT SHALL BE: ASTM A615, GRADE 60.

3. CONTRACTOR SHALL SUBMIT REINFORCING STEEL SHOP DRAWINGS FOR APPROVAL BEFORE FABRICATION AND INSTALLATION.

4. ALL REINFORCING STEEL AND ANCHOR BOLTS SHALL BE SECURED IN POSITION WITH WIRE POSITIONERS BEFORE PLACING CONCRETE.

5. REINFORCING STEEL SHALL BE PROVIDED WITH 3" OF COVER FOR CAST-IN-PLACE CONCRETE UNLESS NOTED OTHERWISE. (TOLERANCE = PLUS 1" / MINUS 1/2")

REINFORCED CONCRETE

CONCRETE SHALL BE AS FOLLOWS:

F'c (P.S.I.) 28 DAYS	MAXIMUM W/C RATIO	MAX. SLUMP (INCHES)	AIR CONTENT	MAX. AGGREGATE SIZE (INCHES)
4,500	0.45	5 +/- 1	6% +/- 1.5%	3/4"

ACI EXPOSURE CLASSES: F2, S0, P0 & C1

1. CONCRETE WORK SHALL CONFORM TO ALL REQUIREMENTS OF ACI 301 (LATEST EDITION) "SPECIFICATIONS FOR STRUCTURAL CONCRETE FOR BUILDINGS", EXCEPT AS MODIFIED BY THESE NOTES.

2. CONTRACTOR SHALL SUBMIT MIX DESIGNS FOR APPROVAL 7 DAYS PRIOR TO FABRICATION AND INSTALLATION. ALL CONCRETE MIXES SHALL BE DESIGNED AND CERTIFIED BY A MATERIALS TESTING LABORATORY.

3. ADMIXTURES MAY BE USED WITH PRIOR APPROVAL OF THE ENGINEER (CALCIUM CHLORIDE SHALL NOT BE USED).

4. ADMIXTURES SHALL COMPLY WITH ASTM C494 AND BE OF A TYPE THAT INCREASES THE WORKABILITY OF THE CONCRETE, BUT SHALL NOT BE CONSIDERED TO REDUCE THE SPECIFIED MINIMUM CEMENT CONTENT.

5. CEMENT SHALL CONFORM TO ASTM C150, TYPE II.

6. READY-MIX CONCRETE SHALL BE MIXED AND DELIVERED IN ACCORDANCE WITH ASTM C94.

7. REFER TO DRAWINGS OF OTHER DISCIPLINES FOR MOLDS, GROOVES, CLIPS, ORNAMENTS, GROUNDS, ETC. REQUIRED TO BE CAST INTO CONCRETE.

8. PROJECTING CORNERS OF SLABS SHALL BE FORMED WITH A 3/4" CHAMFER.

9. UNLESS NOTED OTHERWISE: NO CONDUIT PLACED IN A CONCRETE SLAB SHALL HAVE AN OUTSIDE DIAMETER GREATER THAN 1/3 THE THICKNESS OF THE SLAB. EXCEPT FOR LOCAL OFFSETS, MINIMUM CLEAR DISTANCE BETWEEN CONDUITS SHALL BE 6".

10. FINISH: TOP SURFACE OF PIERS TO BE PERFECTLY LEVEL, SCREEDED AND TROWELLED. OUTDOOR EQUIPMENT SLABS WOOD FLOATED, LIGHTLY TROWELLED AND THEN BROOMED.

11. REINFORCING STEEL IS CONTRACTOR FURNISHED.

12. CONCRETE TEMPERATURES DURING COLD WEATHER SHALL COMPLY WITH ASTM C-94.

13. CONCRETE PLACEMENT: NO CONSTRUCTION JOINTS PERMITTED UNLESS NOTED.

14. CONCRETE PLACEMENT: NO CONSTRUCTION JOINTS PERMITTED UNLESS NOTED. TEMPERATURE & COMPRESSIVE STRENGTH SHALL BE PERFORMED AS FOLLOWS: ONE (1) COMPOSITE SET FOR EACH DAY'S POUR LESS THAN 25 CUBIC YARDS PLUS ONE (1) SET FOR EACH ADDITIONAL 50 CUBIC YARDS OF FRACTION THEREOF.

REV.	DATE	DRAWN	DESCRIPTION	WORK ORDER	CHKD	APPD	DATE
0	12/10/18	RMB	ISSUE FOR CONSTRUCTION				

CEG CONSULTING ENGINEERS GROUP
LAKEVILLE, MINNESOTA

REGISTERED PROFESSIONAL ENGINEER
REG. NO. 6205
PAUL MALAMEN JR.
SOUTH DAKOTA

Paul Malamen Jr.
12/10/18

PREVAILING WIND PARK LLC
230kV/115kV
ROAD RUNNER SUBSTATION
FOUNDATION DETAILS
GENERAL NOTES

CHECKED VG
DATE 09/10/18
DRAWN RMB
DATE 08/15/18

SCALE: AS SHOWN
PROJECT# CEGTHR01
DWG. NO. ROAD-FD-02R0

THORSTAD COMPANIES