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Boise, Idaho 83702
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www.geopier.com

April 21, 2023

TO: Matt Van Goethem and Jason Gamache
MCG Explore Design

SUBJECT: Design Submittal - Geopier Soil Reinforcement
FedEx Sorting Facility – Foundation and Slab Support
Anchorage, Alaska

Introduction

This letter and the attached documents represent our design submittal for Geopier® soil reinforcement to support the foundations and slab-on-grade for the FedEx Sorting Facility and vehicle wash, as well as the loading dock and generator slabs in Anchorage, Alaska. The following paragraphs document our project understanding and design of the Geopier Armorpact reinforcement system for support of the facility foundation and slab and other structures.

We understand that the development will consist of a warehouse building with a footprint of 180,860 square feet and associated improvements, including a vehicle wash, and asphalt paved surface parking on a 21.9-acre site. Additional work includes supporting canopy structure, loading dock, and generator pad. Due to the presence of a highly organic and compressible peat layer over a majority of the site the warehouse building foundations, slab-on-grade, as well as other structures will be supported on Geopier's Armorpact piers.

Geopier Reinforcement Design

Our subsurface soil and groundwater understanding is based on the geotechnical report prepared by CRW Engineering Group dated December 2022. The subsurface profile generally consists of 1 to 10 feet of peat within the building footprint which is underlain by medium dense to very dense silty sand or sand with silt except for borings BH-2 and BH-4. These borings and the sand layer are underlain by stiff to hard silt and/or clay which extends to depths explored. The groundwater is at or near the ground surface in many locations. Geopier Armorpact piers are designed to mitigate static settlement due to the compressibility of the organic layer only. We understand that seismic induced liquefaction settlement at this site is minimal, as such is not included as a part of the ground improvement design.

A structural plan for the sorting facility was provided and is dated April 21, 2023. Foundations supported on Geopier rammed aggregate piers maybe designed for an allowable bearing pressure of 4,000 pounds per square feet (psf). This value can be increased by one third for short-term, transient loads (wind and seismic). We also understand that the uniform slab load over a majority of the site of 250 pounds per square foot (psf) with a small portion on the order of 500 psf. There is about 10,000 square feet of office space as part of the project with a slab loading of 80 psf. We understand that column loads can range from 60 to 325 kips and that settlement criteria are 1-inch total and ½-inch differential, post-construction.

In view of the organic soils coupled with the water table depth, the Geopier-Armorpact system is recommended. The Geopier-Armorpact system which we propose to utilize consists of a robust HDPE sleeve that fits around a specially designed mandrel. The mandrel acts as an internal compaction surface which is driven into the ground using a powerful static down force augmented by dynamic vertical impact energy. After driving the Armorpact shell to the design depth, the hollow mandrel serves as a conduit for aggregate placement. As the mandrel is raised and re-driven downward, thin lifts of compacted aggregate are formed. The compaction procedure densifies aggregate vertically and forces the aggregate and confining sleeve laterally, expanding into the soft matrix soil resulting in a high stiffness element. The process is repeated until the rammed aggregate pier is constructed.

We would envision that the Geopier-Armorpact soil reinforcement would be installed following the placement of the geofabric and structural fill working pad, to be coordinated with the project team. We recommend that the structural fill consist of a granular material that is drillable and can hold an open hole. Following Geopier installation, foundation and slab preparation can begin. We envision installing Geopier elements that would extend to depths of 9 to 20 feet. The top of the Armorpact shell shall be embedded a minimum of 6 inches within the structural fill pad. Furthermore, a minimum thickness of 6 inches and 4 feet of structural fill is required between the top of the Armorpact shell and bottom of the footing and slab, respectively.

Any structural fill shall be placed in accordance with the geotechnical engineer's recommendations. In addition, the slab is required to be designed to be able to span between the Armorpact locations and below slab utilities shall be suspended from the slab. Coordination of the building utilities and Geopier-Armorpact locations is required.

The layout of the Geopier reinforcement for the development are shown on the Geopier Foundation Plan, Sheets GP100 and GP204.

Settlement

Our analysis indicates that Geopier-Armorpact elements installed within the organic peat soil and tipping into the underlying silty sand, sand with silt or silt and clay layer or practical refusal will meet the performance criteria. For our analysis, settlements are first calculated for a zone extending from the bottom of the footing to the depth of the reinforcement. The weighted modulus method (Bowles 1988) is used to estimate settlement in the reinforced zone. This method is described in the Geotechnical Engineering Division/ASCE publication "Control of Settlement and Uplift of Structures Using Short Aggregate Piers) by Dr. Evert C. Lawton, Dr. Nathanial Fox, and Dr. Richard L. Handy.

Additional settlement may occur in the "lower zone" or in the unimproved soil beneath the reinforced zone. The lower zone settlement is calculated using an elastic or consolidation approaches. Based on our analyses, we estimate that total settlement (static) will be less than 1-inch and differential settlement will be less than half an inch where foundations are supported by Geopier's Armorpact piers.

Settlement Monitoring

It will be important to place the top of the Armorpact shell at the appropriate elevation, as such we require that a topographic survey be completed after stripping of the building pad and prior to the placement of the structural fill. The topographic survey, and if required, settlement monitoring program shall be the responsibility of other members of the project team in coordination with the geotechnical engineer of record.

Geopier Installation

A stable subgrade will be required to support our Geopier installation equipment (130,000 pile-driving rig) and to allow access for rock trucks (truck and transfer) to the immediate work area. The fill for the working pad shall consist of material that is drillable and can hold and open hole.

Geopier Quality Control

The installation of the Geopier reinforcement, including a downward modulus test(s), will be completed in general accordance with the specifications. The installation and the modulus test(s) will be conducted under the supervision of an experienced geotechnical engineer from Geopier Northwest. The modulus test will consist of loading the Geopier element in increments to 150% of the design load while measuring deflections to verify the design parameters. The modulus test will also incorporate a creep test at 115% of the design load.

The test will load the Geopier element to 150% of its design load in increments and include a creep test. During the installation of the test Geopier element, the QC and QA personnel will be able to observe and document the Geopier-Armorpact installation process including mandrel pattern to confirm that the same installation procedure is being utilized on the production Geopier elements. If differing conditions are encountered at the site, we will conduct additional modulus/load tests to document the Geopier element performance under differing conditions. The modulus/load test is a direct measurement of the performance of the Geopier element and will provide increased quality control over indirectly measuring the Geopier element performance through the energy input.

Additionally, we will be conducting Crowd Stabilization Tests on at least 10% of all production Geopier elements.

A crowd stabilization test (CST) shall be performed on the first five (5) installed piers to establish acceptance criteria for the maximum allowable deflection of the mandrel under the full-static crowd pressure of the closed-ended mandrel. The CST should be performed in accordance with the following guidelines:

- CST should be performed by shutting the hammer energy off at the top of a compacted lift in the bottom one-half of the pier.
- Once the hammer energy is off and the mandrel is resting on top of the last compacted lift, static crowd pressure should be applied to the pier for a period of ten seconds. The corresponding deflection of the mandrel is then noted and recorded.
- Results of the initial CST should be provided to the designer for review and establishment of acceptance criteria and frequency of CST. The frequency of CST may vary depending on the soil conditions; however, CST shall be performed on no less than 10% of the production piers.

Through our testing we will be able to document the performance of the Geopier elements through direct measurements and will also be able to document and determine when differing soil conditions are encountered. Also, we will have a full-time QC technician onsite during installation documenting all applicable measurements.

We appreciate the opportunity to work with you on this project. If you have any questions or require further information, please call.

Sincerely,
Geopier Northwest Inc.

David M. Plehn, PE

Attachments: Geopier Foundation Plan and Construction Notes (Sheets GP100 and GP204), Geopier Calculations, Aggregate Gradation, and Geopier-Armorpact System Flyer

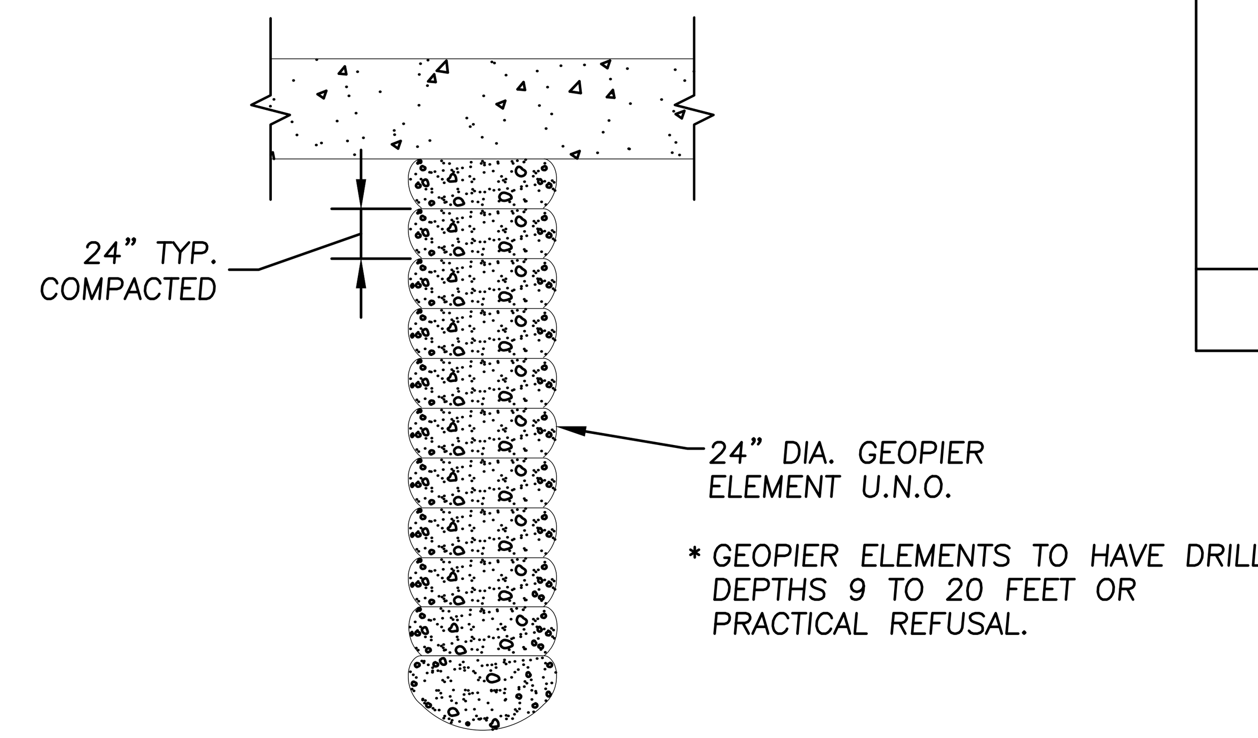
Cc: Gianni Martinez, PE, Geopier Foundation Company

RAP ELEMENT FOUNDATION CONSTRUCTION NOTES

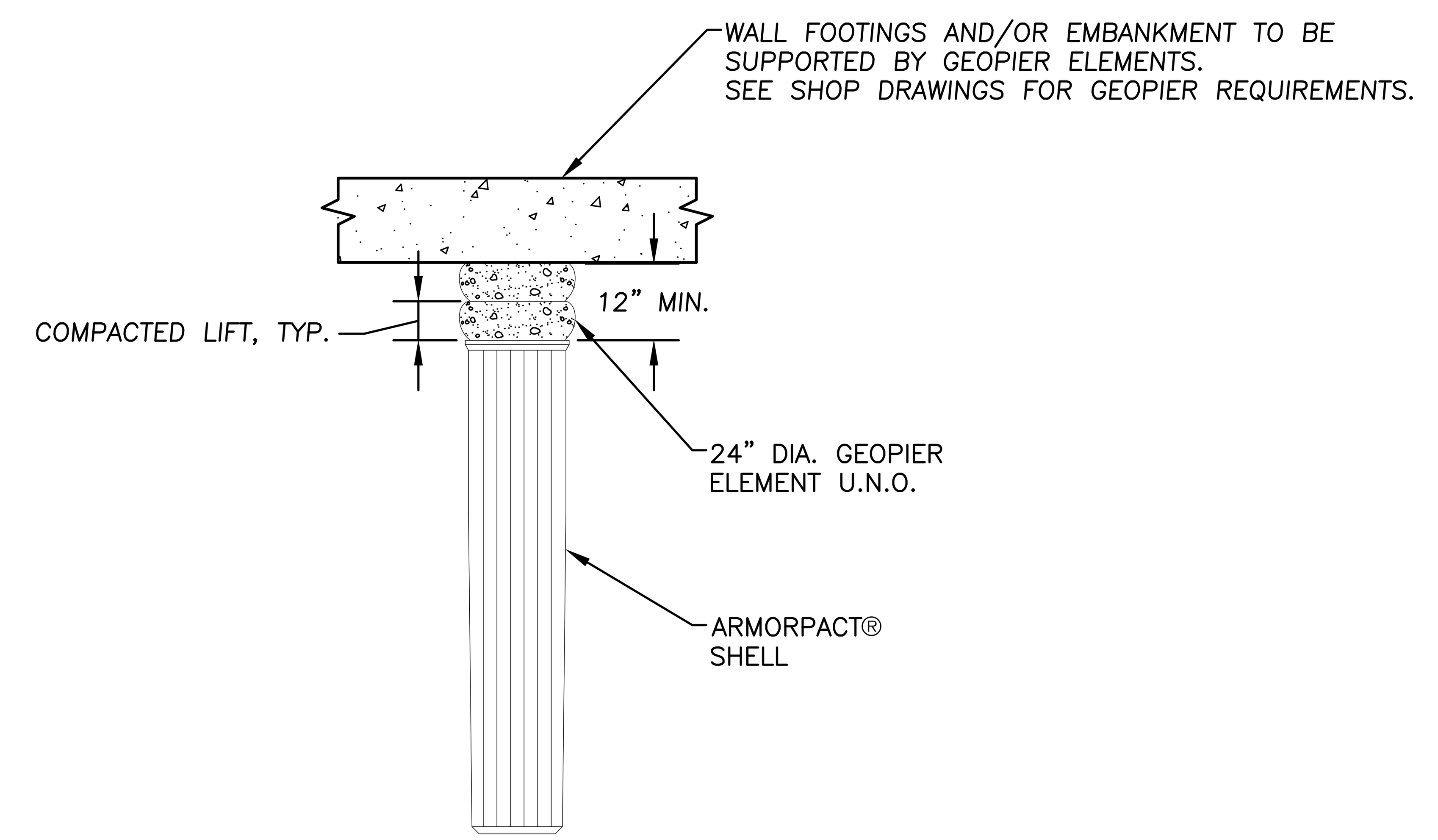
1. RAMMED AGGREGATE PIER (RAP) ELEMENT LAYOUT IS THE RESPONSIBILITY OF THE GENERAL CONTRACTOR (GC). GEOPIER ELEMENT SHALL BE INSTALLED IN THE FIELD WITHIN 6-INCHES OF LOCATION SHOWN ON THESE PLANS.
2. A QUALIFIED, FULL-TIME QUALITY CONTROL (QC) REPRESENTATIVE PROVIDED BY THE RAP INSTALLER (THE INSTALLER) SHALL BE RESPONSIBLE FOR INSTALLATION OF THE RAP ELEMENTS IN ACCORDANCE WITH THE DESIGN, AND SHALL REPORT ALL GEOPIER FOUNDATION CONSTRUCTION ACTIVITIES TO THE DESIGNER. IF AUTHORIZED BY THE OWNER, THE QC REPRESENTATIVE SHALL COORDINATE QC ACTIVITIES WITH THE TESTING AGENCY HIRED BY THE OWNER. UNDER NO CIRCUMSTANCES SHALL THE TESTING AGENCY DIRECT RAP INSTALLATION PROCEDURES.
3. RAP ELEMENTS SHALL BE BASED ON THE FOLLOWING CRITERIA UNLESS OTHERWISE APPROVED IN WRITING BY THE DESIGNER:
   A. RAP ELEMENTS SHALL BE WITHIN 3 INCHES OR DEEPER THAN THE DEPTHS SHOWN ON THE PLANS.
   B. AVERAGE COMPACTED LIFT THICKNESS DURING EACH DAYS PRODUCTION SHALL BE APPROXIMATELY 18 INCHES.
   C. A BASE STABILIZATION TEST (BST) SHALL BE PERFORMED ON THE FIRST FIVE RAP INSTALLED. RESULTS OF THE INITIAL BST SHOULD BE PROVIDED TO THE DESIGNER (GEOPIER NORTHWEST) FOR REVIEW AND ESTABLISHMENT OF ACCEPTANCE CRITERIA AND FREQUENCY OF BST. THE FREQUENCY OF BST MAY VARY DEPENDING ON THE SOIL CONDITIONS; HOWEVER, BST SHALL BE PERFORMED ON NO LESS THAN 10% OF PRODUCTION RAP.
   D. RAP ELEMENT AGGREGATE SHALL CONSIST OF TYPE I GRADE B IN GENERAL ACCORDANCE WITH ASTM D-1241-68, OR APPROVED BY GEOPIER DESIGNER AND SUCCESSFULLY USED IN THE MODULUS TEST.
4. WHEN OBSTRUCTIONS ARE ENCOUNTERED THAT CANNOT BE REMOVED WITH CONVENTIONAL RAP INSTALLATION EQUIPMENT, THE GC SHALL BE RESPONSIBLE FOR REMOVING THE OBSTRUCTIONS. IF THE GC DOES NOT DO SO IN A TIMELY MANNER THAT DOES NOT INTERRUPT RAP PRODUCTION, THE INSTALLER MAY REMOVE OBSTRUCTION(S) AND SHALL BE REIMBURSED FOR COSTS INCURRED, INCLUDING LABOR, EQUIPMENT, AND MATERIALS. IN THE EVENT OBSTRUCTIONS ARE ENCOUNTERED BELOW THE DESIGN BOTTOM OF FOOTING ELEVATION THE OBSTRUCTION SHALL BE REMOVED AS OUTLINED ABOVE. THE RESULTING EXCAVATION SHALL THEN BE BACKFILLED AND COMPACTED IN ACCORDANCE WITH THE PROJECT SPECIFICATIONS. THE AREA SHALL BE TESTED BY THE OWNER'S TESTING AGENCY AND THE COMPACTION TEST RESULTS SHALL BE SUBMITTED TO THE INSTALLER AND THE DESIGNER.
5. RAP ELEMENTS NOT MEETING THE REQUIREMENTS DEFINED IN THE DESIGN AND MODULUS TEST SHALL BE RE-INSTALLED TO MEET PROJECT REQUIREMENTS UNLESS OTHERWISE APPROVED IN WRITING BY THE DESIGNER.
6. FOOTING ELEVATIONS ARE THE RESPONSIBILITY OF THE CONTRACTOR AND SHALL BE REPORTED IN WRITING TO THE INSTALLER'S QC REPRESENTATIVE PRIOR TO INSTALLING RAP ELEMENTS.
7. UTILITY LOCATIONS ARE THE RESPONSIBILITY OF THE GC. THE DESIGNER SHALL BE NOTIFIED OF ANY CONFLICTS WITH RAP LOCATIONS SHOWN ON THE PLANS. NEW UTILITIES EXCAVATIONS SHALL BE LIMITED TO THE ZONE DEPICTING ON DETAIL 1 ON THIS SHEET. IF EXCAVATIONS ARE PLANNED WITHIN THE RAP "NO DIG" ZONE, THE DESIGNER SHOULD BE NOTIFIED IMMEDIATELY TO DISCUSS EXCAVATION OPTIONS.
8. RAP ELEMENTS ARE LOCATED AT THE INTERSECTION OF REFERENCE GRID LINES OR AT THE CENTERLINE OF STRIP FOOTINGS UNLESS DIMENSIONED OTHERWISE.
9. AFTER COMPLETION OF RAP INSTALLATIONS, THE GC IS RESPONSIBLE FOR PROTECTION OF THE WORK. THIS INCLUDES, BUT IS NOT LIMITED TO, PROPER SITE DRAINAGE TO PREVENT PONDING OF WATER ABOVE THE RAP ELEMENTS AND APPROPRIATE CONTROL AND COORDINATION OF EARTHWORK AND ANY SUBSEQUENT DRILL ACTIVITIES SUCH AS ELEVATOR SHAFT CONSTRUCTION, TO PREVENT DAMAGE TO INSTALLED RAP ELEMENTS.
10. ALL RAP ELEMENTS HAVE A MINIMUM NOMINAL TOP DIAMETER OF 24 INCHES WITH COMPACTED 24 INCH LIFTS. GEOPIER ELEMENTS TO HAVE DRILL DEPTHS 9 TO 20 FEET.
11. THESE DRAWINGS ARE BASED ON THE STRUCTURAL DRAWINGS PROVIDED BY SNYDER AND BBFM ENGINEERS, INC. THE RAP ELEMENT LAYOUT LOCATION PLAN AND FOOTING DETAILS PLAN ARE FOR RAP ELEMENT NUMBER, LOCATION, AND LAYOUT ONLY. FOOTING LOCATIONS, SIZES, AND ORIENTATION SHOWN ON THESE PLANS ARE FOR INFORMATION ONLY. PLEASE REFER TO STRUCTURAL PLANS FOR SPECIFIC FOUNDATION DIMENSIONS AND LOCATION. THE DESIGNER ACCEPTS NO RESPONSIBILITY FOR LOCATION OF FOOTINGS SHOWN ON THESE PLANS. THE DESIGNER SHALL BE NOTIFIED IMMEDIATELY IF INFORMATION ON THESE PLANS CONFLICTS WITH STRUCTURAL OR ARCHITECTURAL DRAWINGS.
12. THE RAP FOUNDATION DESIGN IS BASED ON THE GEOTECHNICAL INFORMATION PROVIDED BY CRW ENGINEERING GROUP, INC., REPORT DATE DECEMBER 1, 2022. GEOPIER FOUNDATION COMPANY, INC., HAS RELIED ON THIS INFORMATION AND WE HAVE NO REASON TO SUSPECT ANY OF THE INFORMATION IN THE REPORT IS IN ERROR. GEOPIER FOUNDATION COMPANY, INC. IS NOT RESPONSIBLE FOR ERRORS OR OMISSIONS IN THE REPORT THAT MAY AFFECT THE PARAMETER VALUES IN OUR DESIGN. IF THE SUBSURFACE OR SITE CONDITIONS DIFFER FROM THOSE UTILIZED IN THE DESIGN THE DESIGNER SHALL BE NOTIFIED IMMEDIATELY.
13. RAP FOUNDATION DESIGN LOADS ARE BASED ON THE DESIGN INFORMATION PROVIDED TO US BY STRUCTURAL ENGINEER. IN THE EVENT THE STRUCTURAL LOADS VARY THE DESIGNER SHALL BE NOTIFIED.

CONCRETE FOOTING CONSTRUCTION SUPPORTED BY RAP NOTES

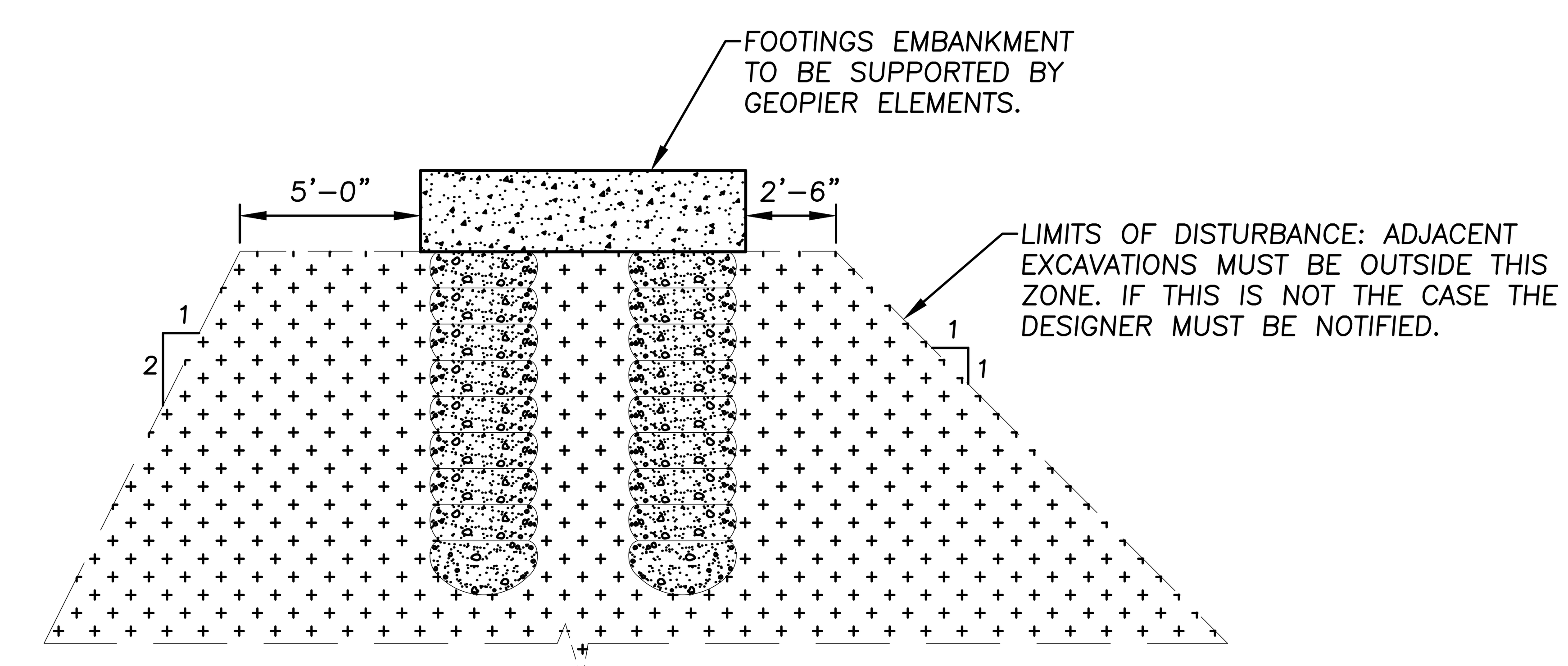
1. ALL EXCAVATIONS FOR FOOTINGS SUPPORTED BY RAMMED AGGREGATE PIERS SHALL BE PREPARED IN THE FOLLOWING MANNER BY THE GC: OVEREXCAVATION BELOW THE BOTTOM OF FOOTING SHALL BE LIMITED TO THREE INCHES. THIS INCLUDES LIMITING THE TEETH OF EXCAVATORS FROM OVEREXCAVATION BEYOND THREE INCHES BELOW THE FOOTING ELEVATION.
2. FOOTINGS SHALL BE POURED AS SOON AS POSSIBLE FOLLOWING FOOTING EXCAVATIONS. IT IS THE CONTRACTORS RESPONSIBILITY TO PROTECT FOOTING BEARING SURFACES FROM WET WEATHER AND DISTURBANCE. A "MUD MAT" (3 INCH THICKNESS OF LEAN CONCRETE) OR COMPACTED CRUSHED ROCK SURFACE IS RECOMMENDED TO PROTECT BEARING SURFACES.
3. PRIOR TO CONCRETE OR MUD MAT PLACEMENT, THE TOP OF THE EXCAVATED SOIL AND RAMMED AGGREGATE PIERS SHALL BE COMPACTED WITH A STANDARD, HAND-OPERATED IMPACT COMPACTOR (I.E. JUMPING JACK COMPACTOR). COMPACTION SHALL BE PERFORMED OVER THE ENTIRE FOOTING SUBGRADE TO COMPACT ANY LOOSE SURFACE SOIL AND LOOSE SURFACE PIER AGGREGATE.
4. WATER SHALL NOT BE ALLOWED TO ACCUMULATE IN THE FOOTING EXCAVATIONS PRIOR TO CONCRETE PLACEMENT OR ALLOWED TO ACCUMULATE OVER THE POURED FOOTING.
5. EXCAVATION AND SURFACE COMPACTION OF ALL FOOTING SUBGRADES SHALL BE THE RESPONSIBILITY OF THE GC.
6. THE TESTING AGENCY SHALL INSPECT EACH FOOTING AND APPROVE IT IN WRITING ON THE SAME DAY THAT THE CONCRETE OR MUD MAT IS PLACED IN THE FOOTING EXCAVATION. THE APPROVAL SHALL STATE THAT ALL FOOTING BOTTOMS INCLUDING MATRIX SOILS AND RAP TOPS HAVE NOT BEEN OVEREXCAVATED MORE THAN THREE-INCHES BELOW THE BOTTOM OF THE FOOTING, HAVE BEEN KEPT FREE OF WATER ACCUMULATION, AND HAVE BEEN REASONABLY DENSIFIED WITH A HAND-HELD MECHANICAL IMPACT COMPACTOR ON THE SAME DAY THAT THE CONCRETE WAS PLACED.
7. THE GC IS RESPONSIBLE FOR MEASURING TOP OF FOOTING ELEVATIONS TO ACCURACY OF 0.01 FEET. MEASUREMENTS SHALL BE TAKEN BY A LICENSED PROFESSIONAL SURVEYOR BEFORE LOADS ARE APPLIED TO THE FOOTINGS.
8. IN THE EVENT THAT FOOTING BOTTOM PREPARATIONS, AS DESCRIBED ABOVE, ARE NOT PERFORMED OR DOCUMENTED IN ACCORDANCE WITH THIS SECTION, ANY WRITTEN OR IMPLIED WARRANTY WITH RESPECT TO GEOPIER FOUNDATION PERFORMANCE CAN BE CONSIDERED VOID.



(1) TYPICAL GEOPIER ELEMENT
NOT TO SCALE



(2) TYPICAL GEOPIER ELEMENT
NOT TO SCALE



(3) ADJACENT EXCAVATION DETAIL
NOT TO SCALE

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GEOPIER NORTHWEST
800 W. MAIN ST., STE 1460
BOISE, IDAHO 83702
ph: (208) 401.9567

STATE OF ALASKA 49 TH
DAVID M. PLEHN
No. CE11956
REGISTERED PROFESSIONAL ENGINEER
4/21/2023

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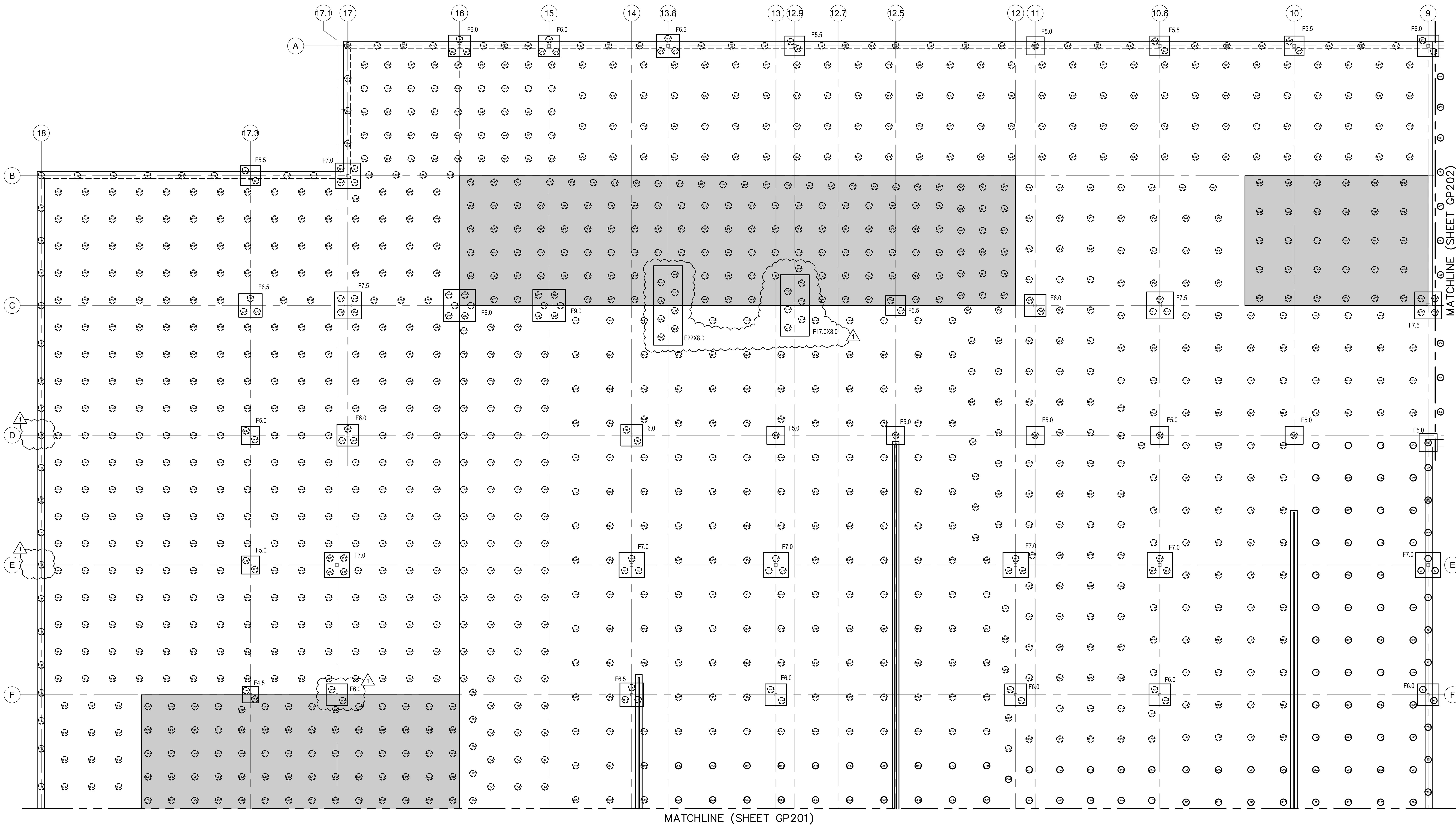
GEOPIER CONSTRUCTION NOTES & DETAILS

SHEET NO.
GP100



FOUNDATION PLAN - SORTING FACILITY

1/16" = 1'-0"

NORTH

GEOPIER LEGEND

○	NUMBERED 24" GEOPIER – 9.5' ARMORPACT
◌	NUMBERED 24" GEOPIER – 14.5' ARMORPACT

GEOPIER PLAN NOTES:

1. THIS DRAWING IS BASED ON STRUCTURAL DRAWINGS PROVIDED BY BBFM ENGINEERS, INC.
2. FOOTING OUTLINES ARE FOR INFORMATION ONLY. SEE STRUCTURAL AND/OR ARCHITECTURAL PLANS FOR FOOTING DIMENSIONS AND DETAILS.
3. FOOTING LOCATIONS SHALL BE IN ACCORDANCE WITH STRUCTURAL AND/OR ARCHITECTURAL DRAWINGS, DIMENSIONS, AND DETAILS.
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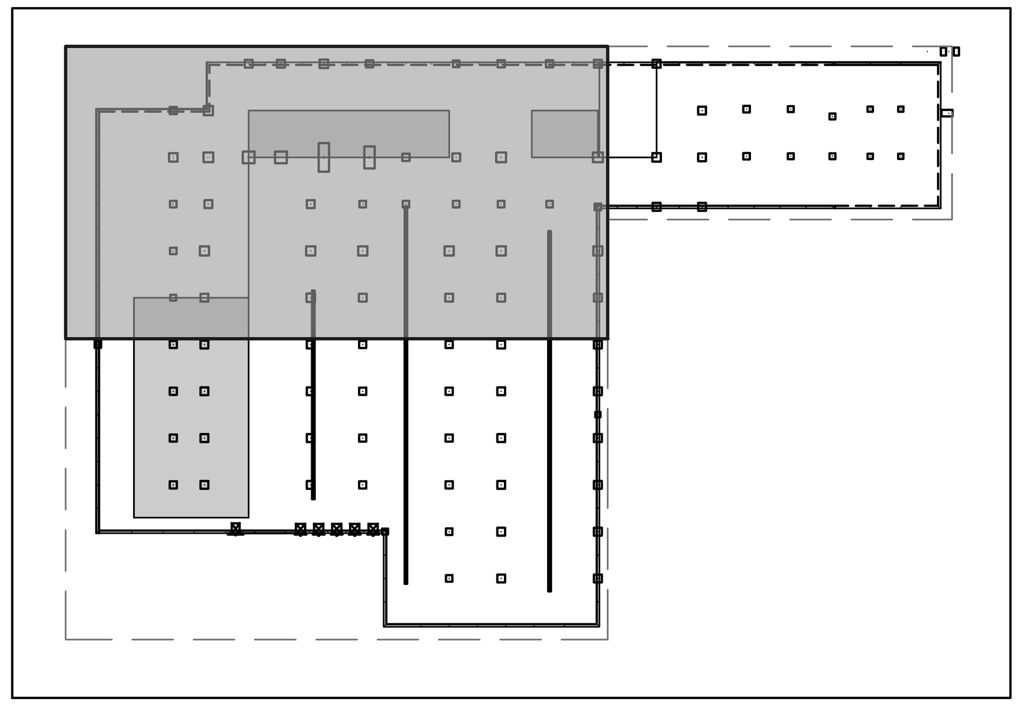

KEY PLAN

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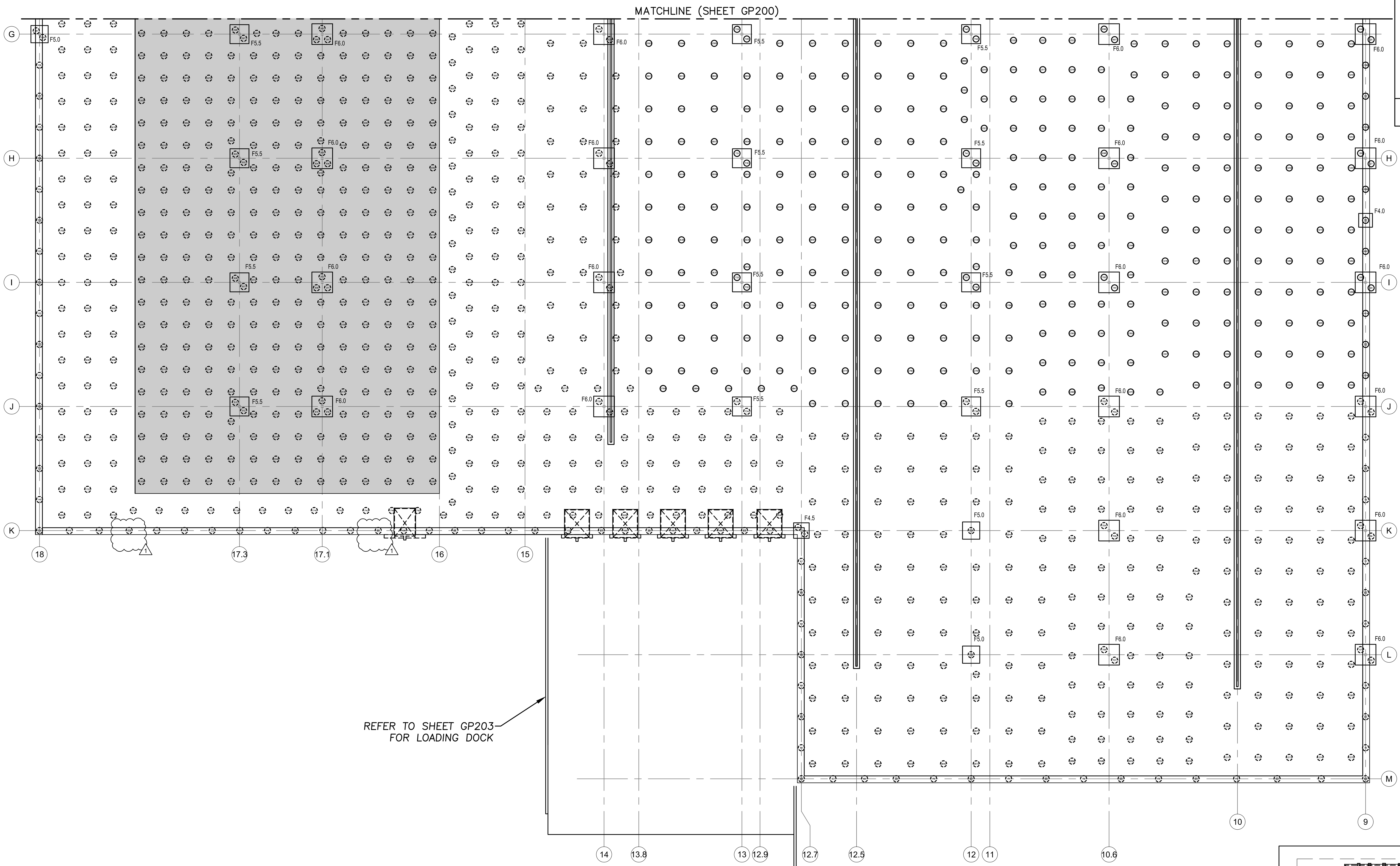
GEOPIER FOUNDATION PLAN - SORTING FACILITY (1 OF 3)

SHEET NO.

GP200



FOUNDATION PLAN - SORTING FACILITY

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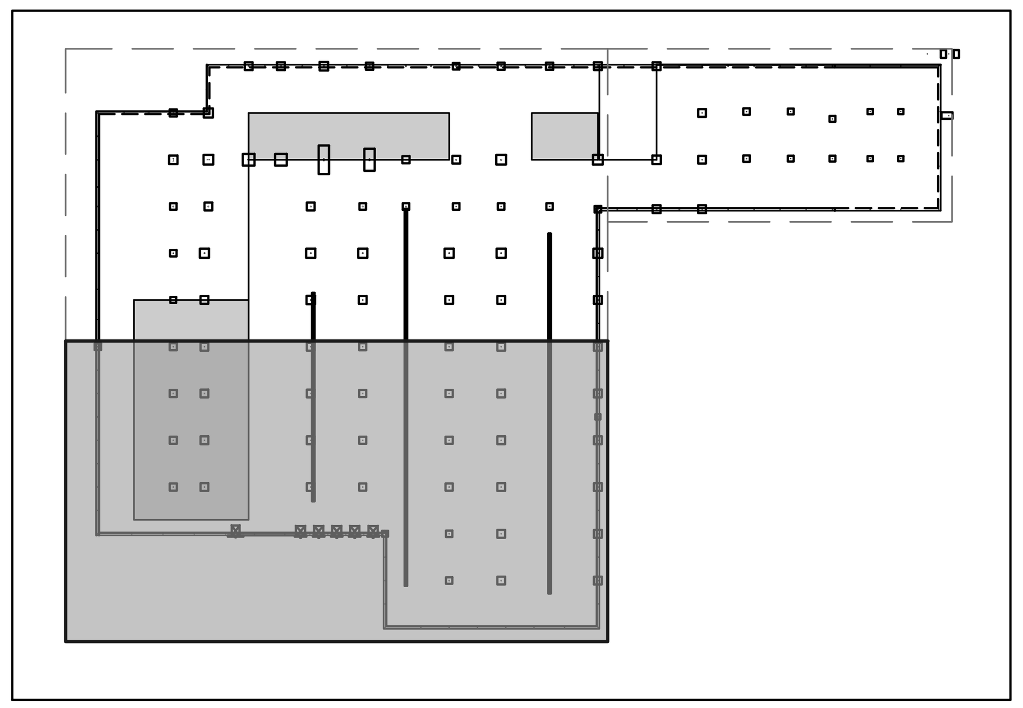

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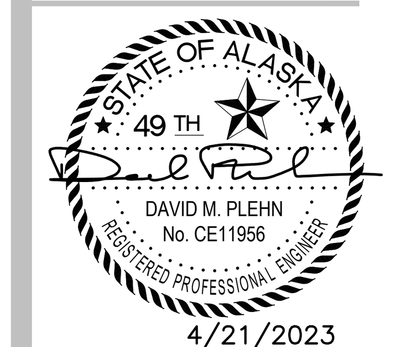

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GEOPIER FOUNDATION PLAN - SORTING FACILITY (2 OF 3)

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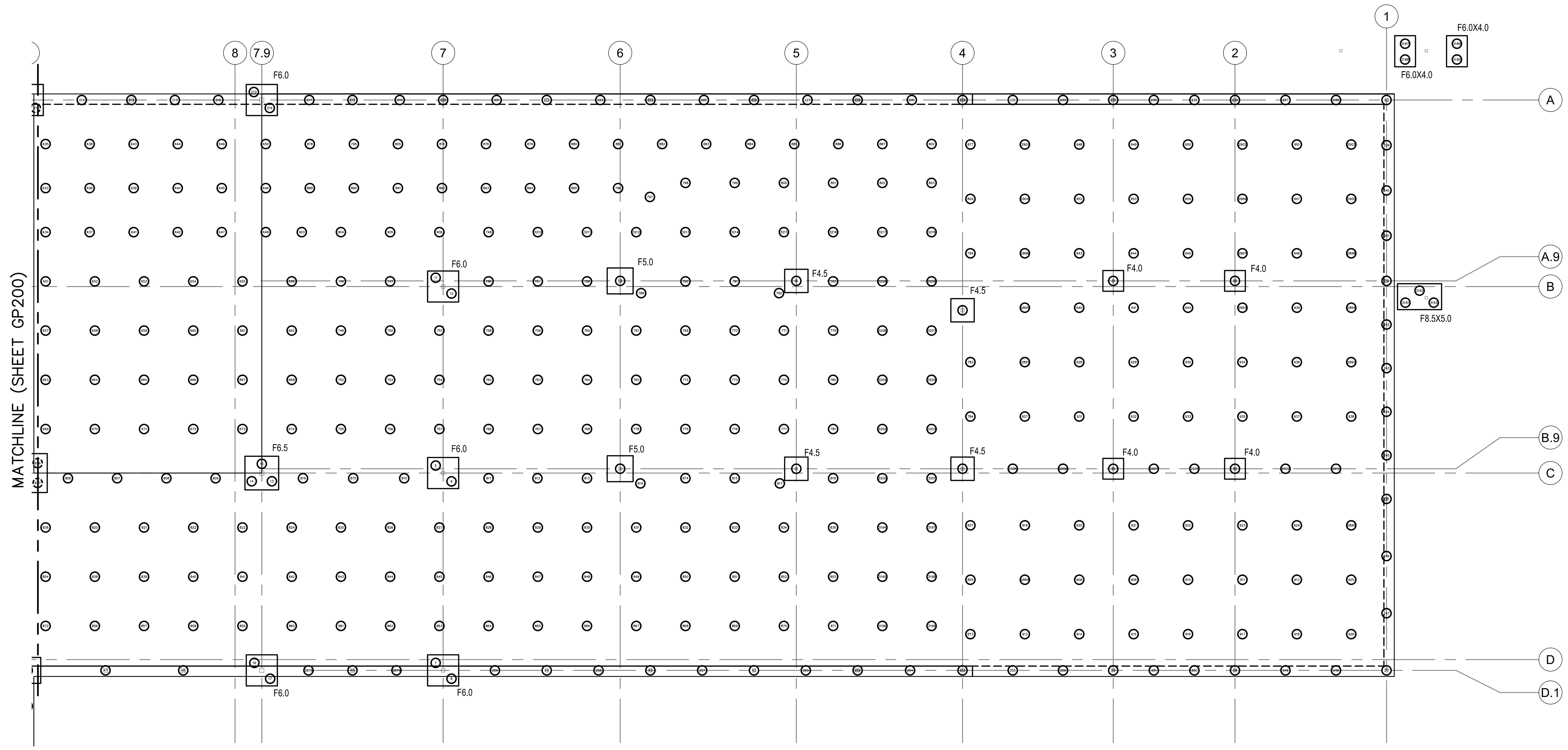

FOUNDATION PLAN - SORTING FACILITY

1/16" = 1'-0"

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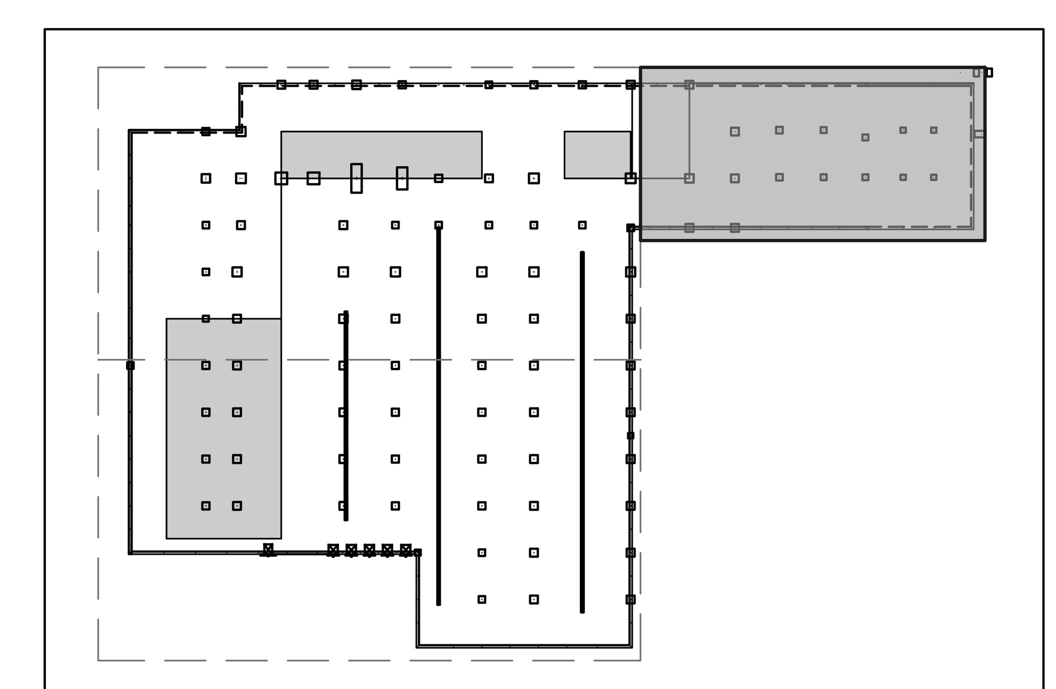

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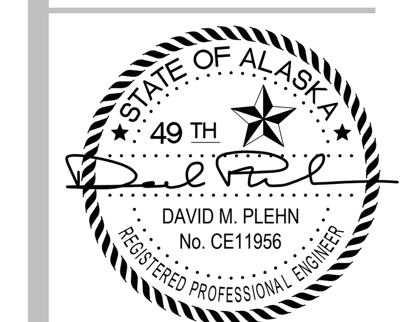

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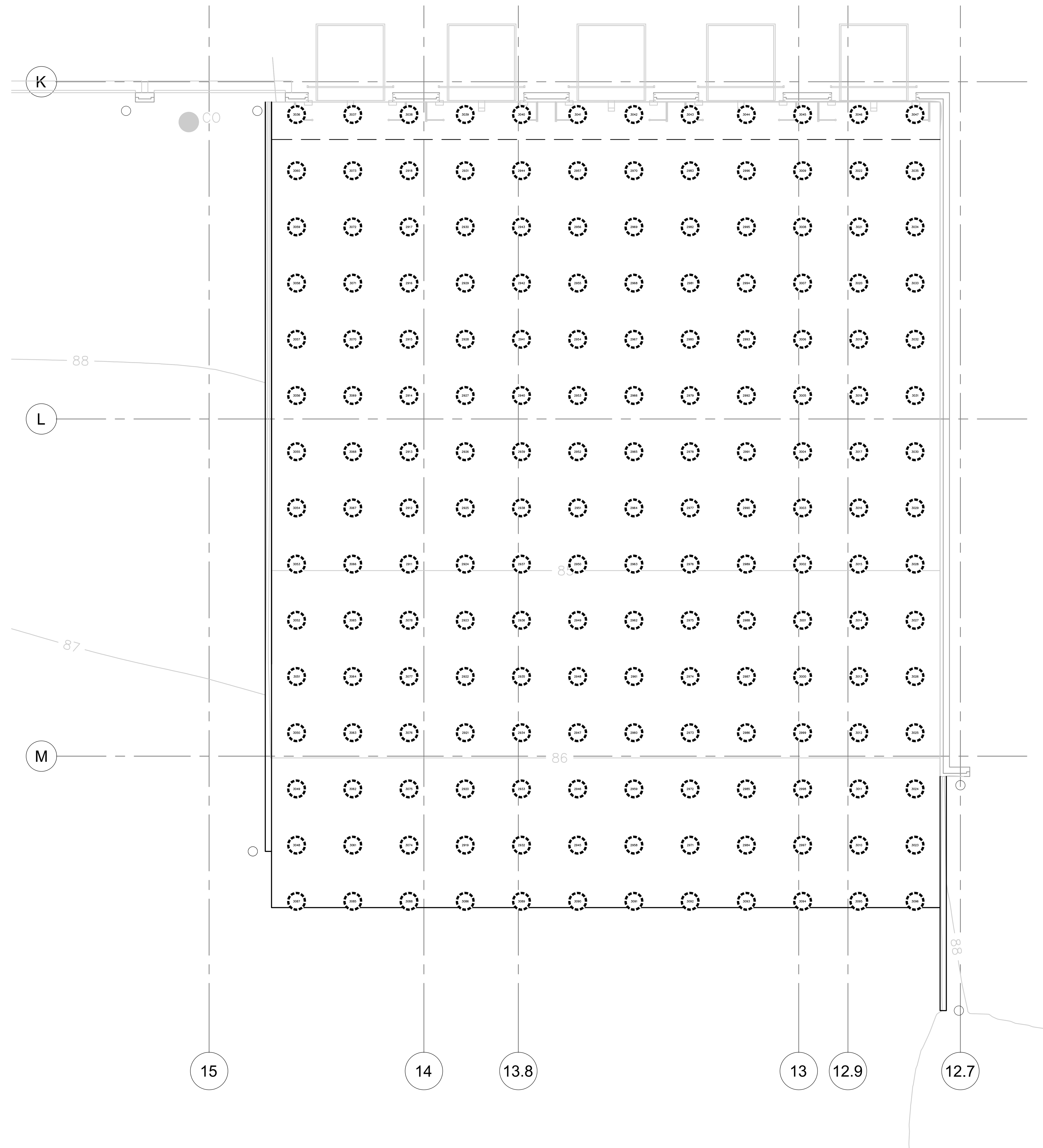
GEOPIER FOUNDATION PLAN - SORTING FACILITY (3 OF 3)

SHEET NO.

GP202



FOUNDATION PLAN - LOADING DOCK
1/8" = 1'-0"
NORTH

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4. GEOPIER ELEMENTS UNDER WALLS AND COLUMNS SHALL BE CENTERED UNDER FOOTINGS AS SHOWN, DIMENSIONED FROM CONTROL POINTS ESTABLISHED FROM STRUCTURAL AND/OR ARCHITECTURAL PLANS.

DATE: Apr 21, 2023 – 3:26pm DRAWING: ANCA FedEx Geopier.dwg

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NOTE: GEOPIER DESIGN DOCUMENTS AND PLANS ARE ONLY VALID IF INSTALLED BY A LICENSED GEOPIER INSTALLER.

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GEOPIER NORTHWEST
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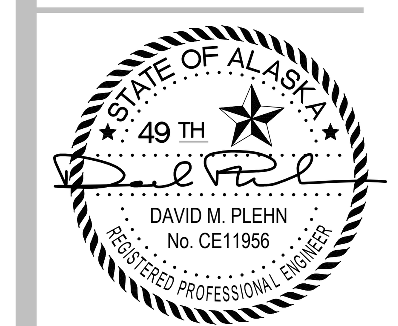

4/21/2023

FEDEX EXPRESS

ANCA FACILITY RELOCATION

POSTMARK DRIVE,
ANCHORAGE, ALASKA

PERMIT SET

JOB NO.	2022001
DATE:	04.21.23
PROJ. MGR.:	DMP
DRAWN BY:	CNT
REVIEWED BY:	DPC
REVISIONS:	

GEOPIER FOUNDATION PLAN - LOADING DOCK

SHEET NO.
GP203

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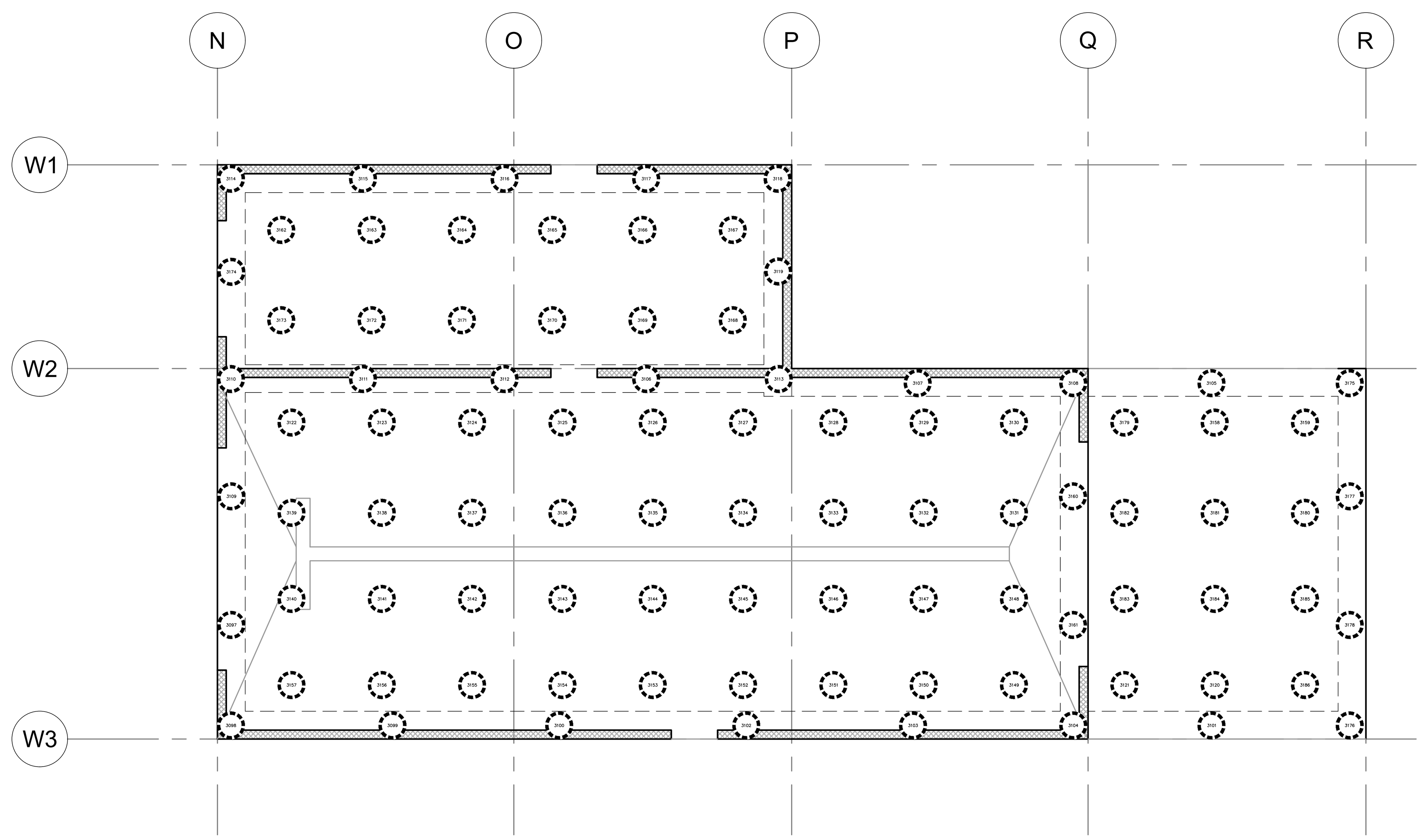
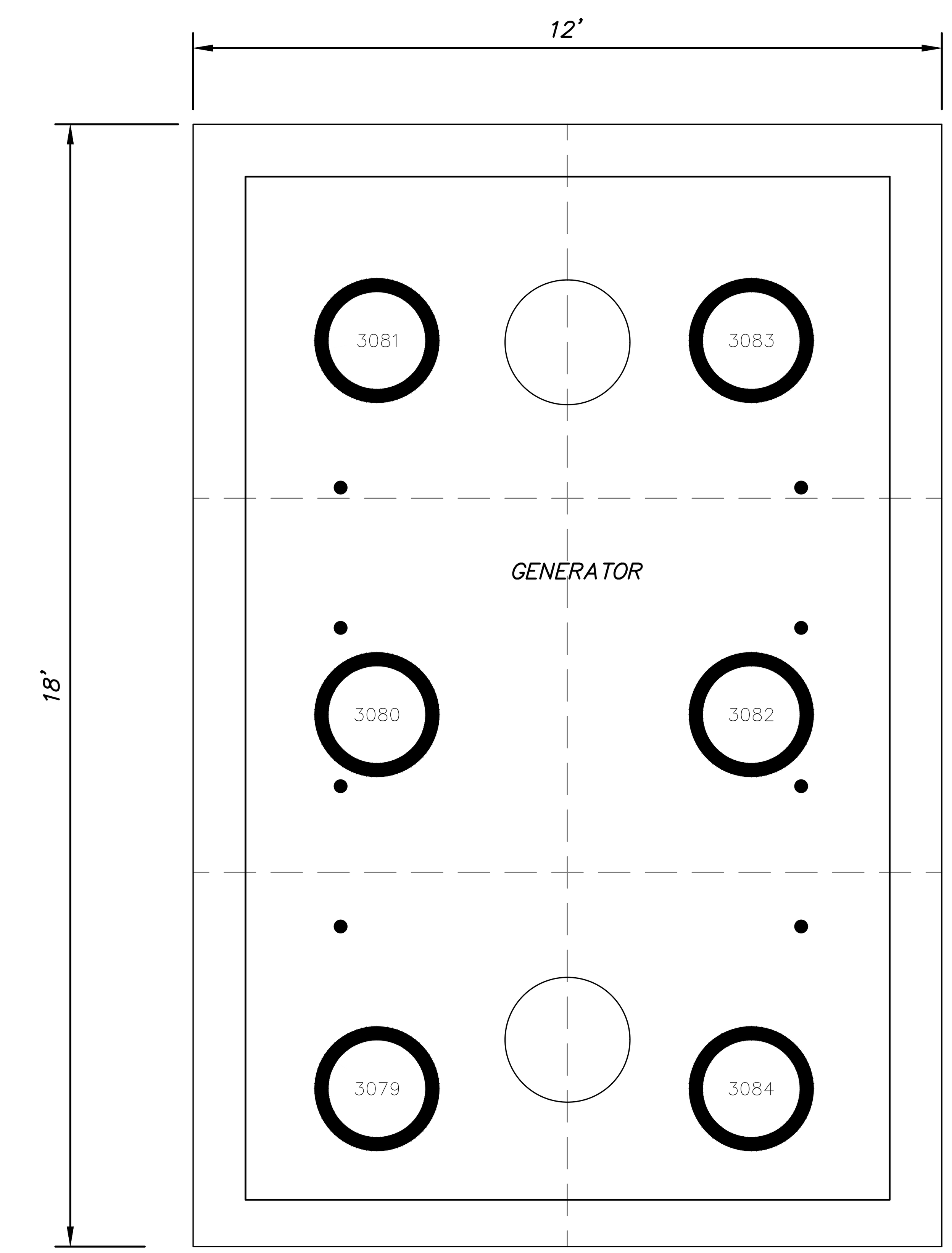
800 W. MAIN ST., STE 1460
BOISE, IDAHO 83702
ph: (208) 401.9567



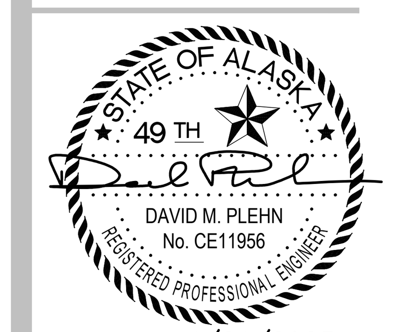
FOUNDATION PLAN - VEHICLE WASH
1/8" = 1'-0"

GEOPIER LEGEND
NUMBERED 24" GEOPIER – 14.5' ARMORPACT



FOUNDATION PLAN - GENERATOR PAD
1/2" = 1'-0"

GEOPIER LEGEND
NUMBERED 24" GEOPIER – 9.5' ARMORPACT



4/21/2023

FEDEX EXPRESS

ANCA FACILITY RELOCATION

POSTMARK DRIVE,
ANCHORAGE, ALASKA

PERMIT SET

JOB NO.	2022001
DATE:	04.21.23
PROJ. MGR.:	DMP
DRAWN BY:	CNT
REVIEWED BY:	DPC
REVISIONS:	

GEOPIER PLAN NOTES:

1. THIS DRAWING IS BASED ON STRUCTURAL DRAWINGS PROVIDED BY BBFM ENGINEERS, INC.
2. FOOTING OUTLINES ARE FOR INFORMATION ONLY. SEE STRUCTURAL AND/OR ARCHITECTURAL PLANS FOR FOOTING DIMENSIONS AND DETAILS.
3. FOOTING LOCATIONS SHALL BE IN ACCORDANCE WITH STRUCTURAL AND/OR ARCHITECTURAL DRAWINGS, DIMENSIONS, AND DETAILS.
4. GEOPIER ELEMENTS UNDER WALLS AND COLUMNS SHALL BE CENTERED UNDER FOOTINGS AS SHOWN, DIMENSIONED FROM CONTROL POINTS ESTABLISHED FROM STRUCTURAL AND/OR ARCHITECTURAL PLANS.

DATE: Apr 21, 2023 – 3:26pm DRAWING: ANCA FedEx Geopier.dwg

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NOTE: GEOPIER DESIGN DOCUMENTS AND PLANS ARE ONLY VALID IF INSTALLED BY A LICENSED GEOPIER INSTALLER.

GEOPIER FOUNDATION PLAN - GENERATOR PAD AND VEHICLE WASH

SHEET NO.
GP204

***GEOPIER®* Foundation Company**

Project: **FedEx Sorting Facility**
No.: GIM-264
Engnr: DPC
Date: 3/31/2023

GEOPIER®

SQUARE FOOTINGS

Version 3.0.6 August 2013

*** Geopier makes no warranties for errors or omissions**
Spreadsheets to be used at own risk

INPUT PARAMETER VALUES:

Parameter	Symb	Val.
RAP diameter (in)	d	24
Depth to groundwater (ft)	dgw	2
Total unit weight of soil (pcf)	g	110
Soil frict. angle (degr)	f	24
Max. hor. pressure (psf)	pmax	2500
From Table 4.2:		
RAP cell cap. (kips)	Qcell	80
Footing bearing press. (ksf)	qall	4
RAP stiffn. modulus (pci)	kg	250
Soil stiffness modulus (pci)	km	27.5

TOP OF PIER STRESS - SQUARE FOOTINGS

Parameter	Symb	Equation	F4/4.5/5	F5.5/6	F6.5/7/7.	F9			
Column load (kips)	P		100	169	225	324			
Required footing width (ft)	Br	sqrt(P/qall)	5.00	6.50	7.50	9.00			
Selected footing width (ft)	B		5	6.5	7.5	9			
Footing bearing pressure	q	P/(B*B)	4.00	4.00	4.00	4.00			
Required No. RAP elems	Nr	P/Qcell	1.3	2.1	2.8	4.1			
Selected No. RAP elems	N		1	2	3	4			
Area replacement ratio	Ra	N*Ag/(B*B)	0.126	0.149	0.168	0.155			
Stiffness ratio	Rs	kg/km	9.1	9.1	9.1	9.1			
Stress at top of GP (ksf)	qg	q*Rs/(Rs*Ra-Ra+1)	18.03	16.50	15.44	16.12			
Load at top of GP (kips)	Qg	qg*Ag	56.6	51.9	48.5	50.7			

SHAFT LENGTH REQUIREMENTS

Depth of Embedment	Df		4.0	4.0	4.0	4.0			
Trial shaft length (ft)	Hs		11.0	11.0	11.0	11.0			
Drill depth (ft)	Hdrill	Df+Hs	15	15	15	15			
Frictional resistance force (kips)	Qs	fs*pi*d*Hs	42	42	42	42			
Allowable tensile resistance (kips)	Qsall	Qs/2	21	21	21	21			
Allowable end-bearing rest. (kips)	Qeb	Qeb	15	15	15	15			
Is shaft long enough?		Qs+Qeb>Pcdem?	**ok**	**ok**	**ok**	**ok**			

INPUT PARAMETER VALUES:

Upper Zone Elastic Parameters		
Parameter	Sym	Val
Pier Modulus Layer 1 (ksf)	Eg1	3500
Pier Modulus Layer 2 (ksf)	Eg2	3000
Pier Modulus Layer 3 (ksf)	Eg3	3000
Pier Modulus Layer 4 (ksf)	Eg4	3000
Pier Modulus Layer 5 (ksf)	Eg5	3000
Soil Modulus Layer 1 (ksf)	Em1	10
Soil Modulus Layer 2 (ksf)	Em2	10
Soil Modulus Layer 3 (ksf)	Em3	10
Soil Modulus Layer 4 (ksf)	Em4	10
Soil Modulus Layer 5 (ksf)	Em5	10

UPPER ZONE SETTLEMENT - SQUARE FOOTINGS

Parameter	**Symb**	Equation							
UZ Settlement Approach		1-Stiffness, 2-Modulus	2	2	2	2	2	2	2
Thickness of UZ sublayer 1(ft)	H_{uz1}		5.0	5.0	5.0	5.0			
Thickness of UZ sublayer 2 (ft)	H_{uz2}		5.0	5.0	5.0	5.0			
Thickness of UZ sublayer 3 (ft)	H_{uz3}		3.0	3.0	3.0	3.0			
Thickness of UZ sublayer 4 (ft)	H_{uz4}		0.0						
Thickness of UZ sublayer 5 (ft)	H_{uz5}		0.0						
Total UZ Thickness OK?		Huz = Hs + d	**ok**	**ok**	**ok**	**ok**			
Composite Modulus Layer 1 (ksf)	E_{comp1}	Eg1Ra + Em1(1-Ra)	449	529	595	551			
Composite Modulus Layer 2 (ksf)	E_{comp2}	Eg2Ra + Em2(1-Ra)	386	455	511	474			
Composite Modulus Layer 3 (ksf)	E_{comp3}	Eg3Ra + Em3(1-Ra)	386	455	511	474			
Composite Modulus Layer 4 (ksf)	E_{comp4}	Eg4Ra + Em4(1-Ra)	386	455	511	474			
Composite Modulus Layer 5 (ksf)	E_{comp5}	Eg5Ra + Em5(1-Ra)	386	455	511	474			
Sett. of LZ sublayer 1 (in)	s_{uz1}	qg/kg or q*Iσ-vag*H/Ecomp	0.37	0.36	0.34	0.38			
Sett. of LZ sublayer 2 (in)	s_{uz2}	$q*I\sigma\text{-}2*H_{uz2}/E_{comp2}$	0.11	0.14	0.16	0.22			
Sett. of LZ sublayer 3 (in)	s_{uz3}	$q*I\sigma\text{-}3*H_{uz3}/E_{comp3}$	0.03	0.04	0.05	0.07			
Sett. of LZ sublayer 4 (in)	s_{uz4}	$q*I\sigma\text{-}4*H_{uz4}/E_{comp4}$	0.00	0.00	0.00	0.00			
Sett. of LZ sublayer 5 (in)	s_{uz5}	$q*I\sigma\text{-}5*H_{uz5}/E_{comp5}$	0.00	0.00	0.00	0.00			
Total Upper Zone Settlement (in)	s_{uz}	$s_{uz1}+s_{uz2}+s_{uz3}+s_{uz4}+s_{uz5}$	0.52	0.55	0.54	0.67			

INPUT PARAMETER VALUES:

Parameter	Symb	Val.
Allowable end-bearing (kips)	Qeb	15
E or c_ε for LZ sublyr 1	E_1 / $c_{\varepsilon1}$	0.02
E or c_ε for LZ sublyr 2	E_2 / $c_{\varepsilon2}$	
E or c_ε for LZ sublyr 3	E_3 / $c_{\varepsilon3}$	
E or c_ε for LZ sublyr 4	E_4 / $c_{\varepsilon4}$	
E or c_ε for LZ sublyr 5	E_5 / $c_{\varepsilon5}$	
Calc. settlement to X*B	X	2

LOWER ZONE SETTLEMENTS - SQUARE FOOTINGS

Parameter	Symb	Equation	F4/4.5/5	F5.5/6	F6.5/7/7.	F9			
Dpth to bottm of LZ from ftg (ft)	X*B	X*B	10	13	15	18			
Upper zone thickness (ft)	H_{uz}	Hs+d	13	13	13	13			
Lower zone thickness (ft)	H_{lz}	H2b-Hlz	-3	0	2	5			
Thickness of LZ sublayer 1(ft)	H_{lz1}				2	5			
Thickness of LZ sublayer 2 (ft)	H_{lz2}								
Thickness of LZ sublayer 3 (ft)	H_{lz3}								
Thickness of LZ sublayer 4 (ft)	H_{lz4}								
Thickness of LZ sublayer 5 (ft)	H_{lz5}								
Total LZ thickness ok?			**No LZ**	**ok**	**ok**	**ok**			
E or c_ε for LZ sublyr 1	E_1 / $c_{\varepsilon1}$	E (ksf) or c_ε	0.015	0.015	0.015	0.015			
E or c_ε for LZ sublyr 2	E_2 / $c_{\varepsilon2}$	E (ksf) or c_ε	0	0	0	0			
E or c_ε for LZ sublyr 3	E_3 / $c_{\varepsilon3}$	E (ksf) or c_ε	0	0	0	0			
E or c_ε for LZ sublyr 4	E_4 / $c_{\varepsilon4}$	E (ksf) or c_ε	0	0	0	0			
E or c_ε for LZ sublyr 5	E_5 / $c_{\varepsilon5}$	E (ksf) or c_ε	0	0	0	0			
Initial stress for sublyr 1 (ksf)	P'_{o1}		0.934	0.934	0.982	1.053			
Initial stress for sublyr 2 (ksf)	P'_{o2}		0.934	0.934	1.029	1.172			
Initial stress for sublyr 3 (ksf)	P'_{o3}		0.934	0.934	1.029	1.172			
Initial stress for sublyr 4 (ksf)	P'_{o4}		0.934	0.934	1.029	1.172			
Initial stress for sublyr 5 (ksf)	P'_{o5}		0.934	0.934	1.029	1.172			
Ftg stress on sublyr 1 (ksf)	ΔP1	q*I	0.27	0.43	0.49	0.57			
Ftg stress on sublyr 2 (ksf)	ΔP2	q*I	0.27	0.43	0.43	0.43			
Ftg stress on sublyr 3 (ksf)	ΔP3	q*I	0.27	0.43	0.43	0.43			
Ftg stress on sublyr 4 (ksf)	ΔP4	q*I	0.27	0.43	0.43	0.43			
Ftg stress on sublyr 5 (ksf)	ΔP5	q*I	0.27	0.43	0.43	0.43			
Sett. of LZ sublayer 1 (in)	s_{lz1}	ce1*Hlz1*log((Po1+DP1)/Po1)	0.00	0.00	0.06	0.17			
Sett. of LZ sublayer 2 (in)	s_{lz2}	ce2*Hlz2*log((Po2+DP2)/Po2)	0.00	0.00	0.00	0.00			
Sett. of LZ sublayer 3 (in)	s_{lz3}	ce3*Hlz3*log((Po3+DP3)/Po3)	0.00	0.00	0.00	0.00			
Sett. of LZ sublayer 4 (in)	s_{lz4}	ce4*Hlz4*log((Po4+DP4)/Po4)	0.00	0.00	0.00	0.00			
Sett. of LZ sublayer 5 (in)	s_{lz5}	ce5*Hlz5*log((Po5+DP5)/Po5)	0.00	0.00	0.00	0.00			
Total lower zone sett. (in)	s_{lz}	$s_{lz1}+s_{lz2}+s_{lz3}+s_{lz4}+s_{lz5}$	0.0	0.0	0.1	0.2			
Total UZ + LZ settlement (in)	s		0.5	0.5	0.6	0.8			

Note: When "No LZ" is displayed, thicknesses of lower zone should equal 0

GEOPIER® **Foundation Company**

Project: **FedEx Sorting Facility**
No.: GIM-264
Engnr: DPC
Date: 3/31/2023

GEOPIER®

SQUARE FOOTINGS

Version 3.0.6 August 2013

*** Geopier makes no warranties for errors or omissions**
Spreadsheets to be used at own risk

INPUT PARAMETER VALUES:

Parameter	Symb	Val.
RAP diameter (in)	d	24
Depth to groundwater (ft)	dgw	2
Total unit weight of soil (pcf)	g	110
Soil frict. angle (degr)	f	24
Max. hor. pressure (psf)	pmax	2500
From Table 4.2:		
RAP cell cap. (kips)	Qcell	50
Footing bearing press. (ksf)	qall	4
RAP stiffn. modulus (pci)	kg	250
Soil stiffness modulus (pci)	km	27.8

TOP OF PIER STRESS - SQUARE FOOTINGS

Parameter	Symb	Equation	F4	F5/5.5	F6/6.5	F7/7.5	F9		
Column load (kips)	P		60	121	169	225	324		
Required footing width (ft)	Br	sqrt(P/qall)	3.87	5.50	6.50	7.50	9.00		
Selected footing width (ft)	B		4	5.5	6.5	7.5	9		
Footing bearing pressure	q	P/(B*B)	3.75	4.00	4.00	4.00	4.00		
Required No. RAP elems	Nr	P/Qcell	1.2	2.4	3.4	4.5	6.5		
Selected No. RAP elems	N		1	2	3	4	6		
Area replacement ratio	Ra	N*Ag/(B*B)	0.196	0.208	0.223	0.223	0.233		
Stiffness ratio	Rs	kg/km	9.0	9.0	9.0	9.0	9.0		
Stress at top of GP (ksf)	qg	q*Rs/(Rs*Ra-Ra+1)	13.12	13.52	12.93	12.91	12.58		
Load at top of GP (kips)	Qg	qg*Ag	41.2	42.5	40.6	40.6	39.5		

SHAFT LENGTH REQUIREMENTS

Parameter	Symb	Equation	F4	F5/5.5	F6/6.5	F7/7.5	F9		
Depth of Embedment	Df		4.0	4.0	4.0	4.0	4.0		
Trial shaft length (ft)	Hs		11.0	11.0	11.0	11.0	11.0		
Drill depth (ft)	Hdrill	Df+Hs	15	15	15	15	15		
Frictional resistance force (kips)	Qs	fs*pi*d*Hs	42	42	42	42	42		
Allowable tensile resistance (kips)	Qsall	Qs/2	21	21	21	21	21		
Allowable end-bearing rest. (kips)	Qeb	Qeb	2	2	2	2	2		
Is shaft long enough?		Qs+Qeb>Pcdem?	**ok**	**ok**	**ok**	**ok**	**ok**		

INPUT PARAMETER VALUES:

Upper Zone Elastic Parameters		
Parameter	Sym	Val
Pier Modulus Layer 1 (ksf)	Eg1	3500
Pier Modulus Layer 2 (ksf)	Eg2	3000
Pier Modulus Layer 3 (ksf)	Eg3	3000
Pier Modulus Layer 4 (ksf)	Eg4	3000
Pier Modulus Layer 5 (ksf)	Eg5	3000
Soil Modulus Layer 1 (ksf)	Em1	10
Soil Modulus Layer 2 (ksf)	Em2	10
Soil Modulus Layer 3 (ksf)	Em3	10
Soil Modulus Layer 4 (ksf)	Em4	10
Soil Modulus Layer 5 (ksf)	Em5	10

UPPER ZONE SETTLEMENT - SQUARE FOOTINGS

Parameter	**Symb**	Equation							
UZ Settlement Approach		1-Stiffness, 2-Modulus	2	2	2	2	2	2	2
Thickness of UZ sublayer 1(ft)	H_{uz1}		5.0	5.0	5.0	5.0	5.0		
Thickness of UZ sublayer 2 (ft)	H_{uz2}		5.0	5.0	5.0	5.0	5.0		
Thickness of UZ sublayer 3 (ft)	H_{uz3}		3.0	3.0	3.0	3.0	3.0		
Thickness of UZ sublayer 4 (ft)	H_{uz4}		0.0						
Thickness of UZ sublayer 5 (ft)	H_{uz5}		0.0						
Total UZ Thickness OK?		Huz = Hs + d	**ok**	**ok**	**ok**	**ok**	**ok**		
Composite Modulus Layer 1 (ksf)	E_{comp1}	Eg1Ra + Em1(1-Ra)	695	735	789	790	822		
Composite Modulus Layer 2 (ksf)	E_{comp2}	Eg2Ra + Em2(1-Ra)	597	631	677	678	706		
Composite Modulus Layer 3 (ksf)	E_{comp3}	Eg3Ra + Em3(1-Ra)	597	631	677	678	706		
Composite Modulus Layer 4 (ksf)	E_{comp4}	Eg4Ra + Em4(1-Ra)	597	631	677	678	706		
Composite Modulus Layer 5 (ksf)	E_{comp5}	Eg5Ra + Em5(1-Ra)	597	631	677	678	706		
Sett. of LZ sublayer 1 (in)	s_{uz1}	qg/kg or q*Iσ-vag*H/Ecomp	0.20	0.24	0.24	0.25	0.26		
Sett. of LZ sublayer 2 (in)	s_{uz2}	$q*I\sigma\text{-}2*H_{uz2}/E_{comp2}$	0.05	0.08	0.10	0.12	0.15		
Sett. of LZ sublayer 3 (in)	s_{uz3}	$q*I\sigma\text{-}3*H_{uz3}/E_{comp3}$	0.01	0.02	0.03	0.04	0.05		
Sett. of LZ sublayer 4 (in)	s_{uz4}	$q*I\sigma\text{-}4*H_{uz4}/E_{comp4}$	0.00	0.00	0.00	0.00	0.00		
Sett. of LZ sublayer 5 (in)	s_{uz5}	$q*I\sigma\text{-}5*H_{uz5}/E_{comp5}$	0.00	0.00	0.00	0.00	0.00		
Total Upper Zone Settlement (in)	s_{uz}	$s_{uz1}+s_{uz2}+s_{uz3}+s_{uz4}+s_{uz5}$	0.26	0.34	0.37	0.41	0.45		

INPUT PARAMETER VALUES:

Parameter	Symb	Val.
Allowable end-bearing (kips)	Qeb	2
E or c_ε for LZ sublyr 1	E_1 / $c_{\varepsilon 1}$	0.02
E or c_ε for LZ sublyr 2	E_2 / $c_{\varepsilon 2}$	
E or c_ε for LZ sublyr 3	E_3 / $c_{\varepsilon 3}$	
E or c_ε for LZ sublyr 4	E_4 / $c_{\varepsilon 4}$	
E or c_ε for LZ sublyr 5	E_5 / $c_{\varepsilon 5}$	
Calc. settlement to X*B	X	2

LOWER ZONE SETTLEMENTS - SQUARE FOOTINGS

Parameter	Symb	Equation	F4	F5/5.5	F6/6.5	F7/7.5	F9		
Dpth to bottm of LZ from ftg (ft)	X*B	X*B	8	11	13	15	18		
Upper zone thickness (ft)	H_{uz}	Hs+d	13	13	13	13	13		
Lower zone thickness (ft)	H_{lz}	H2b-Hlz	-5	-2	0	2	5		
Thickness of LZ sublayer 1(ft)	H_{lz1}					2	5		
Thickness of LZ sublayer 2 (ft)	H_{lz2}								
Thickness of LZ sublayer 3 (ft)	H_{lz3}								
Thickness of LZ sublayer 4 (ft)	H_{lz4}								
Thickness of LZ sublayer 5 (ft)	H_{lz5}								
Total LZ thickness ok?			**No LZ**	**No LZ**	**ok**	**ok**	**ok**		
E or c_ε for LZ sublyr 1	E_1 / $c_{\varepsilon 1}$	E (ksf) or c_ε	0.015	0.015	0.015	0.015	0.015		
E or c_ε for LZ sublyr 2	E_2 / $c_{\varepsilon 2}$	E (ksf) or c_ε	0	0	0	0	0		
E or c_ε for LZ sublyr 3	E_3 / $c_{\varepsilon 3}$	E (ksf) or c_ε	0	0	0	0	0		
E or c_ε for LZ sublyr 4	E_4 / $c_{\varepsilon 4}$	E (ksf) or c_ε	0	0	0	0	0		
E or c_ε for LZ sublyr 5	E_5 / $c_{\varepsilon 5}$	E (ksf) or c_ε	0	0	0	0	0		
Initial stress for sublyr 1 (ksf)	P'_{o1}		0.934	0.934	0.934	0.982	1.053		
Initial stress for sublyr 2 (ksf)	P'_{o2}		0.934	0.934	0.934	1.029	1.172		
Initial stress for sublyr 3 (ksf)	P'_{o3}		0.934	0.934	0.934	1.029	1.172		
Initial stress for sublyr 4 (ksf)	P'_{o4}		0.934	0.934	0.934	1.029	1.172		
Initial stress for sublyr 5 (ksf)	P'_{o5}		0.934	0.934	0.934	1.029	1.172		
Ftg stress on sublyr 1 (ksf)	ΔP1	q*I	0.16	0.32	0.43	0.49	0.57		
Ftg stress on sublyr 2 (ksf)	ΔP2	q*I	0.16	0.32	0.43	0.43	0.43		
Ftg stress on sublyr 3 (ksf)	ΔP3	q*I	0.16	0.32	0.43	0.43	0.43		
Ftg stress on sublyr 4 (ksf)	ΔP4	q*I	0.16	0.32	0.43	0.43	0.43		
Ftg stress on sublyr 5 (ksf)	ΔP5	q*I	0.16	0.32	0.43	0.43	0.43		
Sett. of LZ sublayer 1 (in)	s_{lz1}	ce1*Hlz1*log((Po1+DP1)/Po1)	0.00	0.00	0.00	0.06	0.17		
Sett. of LZ sublayer 2 (in)	s_{lz2}	ce2*Hlz2*log((Po2+DP2)/Po2)	0.00	0.00	0.00	0.00	0.00		
Sett. of LZ sublayer 3 (in)	s_{lz3}	ce3*Hlz3*log((Po3+DP3)/Po3)	0.00	0.00	0.00	0.00	0.00		
Sett. of LZ sublayer 4 (in)	s_{lz4}	ce4*Hlz4*log((Po4+DP4)/Po4)	0.00	0.00	0.00	0.00	0.00		
Sett. of LZ sublayer 5 (in)	s_{lz5}	ce5*Hlz5*log((Po5+DP5)/Po5)	0.00	0.00	0.00	0.00	0.00		
Total lower zone sett. (in)	s_{lz}	$s_{lz1}+s_{lz2}+s_{lz3}+s_{lz4}+s_{lz5}$	0.0	0.0	0.0	0.1	0.2		
Total UZ + LZ settlement (in)	s		0.3	0.3	0.4	0.5	0.6		

Note: When "No LZ" is displayed, thicknesses of lower zone should equal 0

***GEOPIER®* Foundation Company**

GEOPIER®

RECTANGULAR FOOTINGS

Version 3.0.6 August 2013

Project:	**FedEx Sorting Facility**
No.:	GIM-264
Engnr:	DPC
Date:	#######

*** Geopier makes no warranties for errors or omissions**
Spreadsheets to be used at own risk

INPUT PARAMETER VALUES:

Parameter	Symb	Val.
RAP diameter (in)	d	24
Depth to groundwater (ft)	dgw	2
Total unit weight of soil (pcf)	g	110
Soil frict. angle (degr)	f	24
Max. hor. pressure (psf)	pmax	2500
From Table 4.2:		
RAP cell cap. (kips)	Qcell	80
Footing bearing press. (ksf)	qall	4
RAP stiffn. modulus (pci)	kg	250
Soil stiffness modulus (pci)	km	27.8

TOP OF PIER STRESS - RECTANGULAR FOOTINGS

Parameter	Symb	Equation	F12x8						
Column load (kips)	P		345						
Selected footing width (ft)	B		8.00						
Required footing length (ft)	Lr		10.78						
Selected footing length (ft)	L		12.00						
Footing bearing pressure	q	P/(B*L)	3.59						
Required No. RAP elems	Nr	P/Qcell	4.3						
Selected No. RAP elems	N		4						
Area replacement ratio	Ra	N*Ag/(B*L)	0.131						
Stiffness ratio	Rs	kg/km	9.0						
Stress at top of GP (ksf)	qg	q*Rs/(Rs*Ra-Ra+1)	15.79						
Load at top of GP (kips)	Qg	qg*Ag	49.6						

SHAFT LENGTH REQUIREMENTS

Depth of Embedment	Df		4.0						
Trial shaft length (ft)	Hs		11.0						
Drill depth (ft)	Hdrill	Df+Hs	15						
Frictional resistance force (kips)	Qs	fs*pi*d*Hs	42						
Allowable tensile resistance (kips)	Qsall	Qs/2	21						
Allowable end-bearing rest. (kips)	Qeb	Qeb	14						
Is shaft long enough?		Qs+Qeb>Pcdem?	**ok**						

INPUT PARAMETER VALUES:

Upper Zone Elastic Parameters		
Parameter	Sym	Val
Pier Modulus Layer 1 (ksf)	Eg1	3500
Pier Modulus Layer 2 (ksf)	Eg2	3000
Pier Modulus Layer 3 (ksf)	Eg3	3000
Pier Modulus Layer 4 (ksf)	Eg4	3000
Pier Modulus Layer 5 (ksf)	Eg5	3000
Soil Modulus Layer 1 (ksf)	Em1	10
Soil Modulus Layer 2 (ksf)	Em2	10
Soil Modulus Layer 3 (ksf)	Em3	10
Soil Modulus Layer 4 (ksf)	Em4	10
Soil Modulus Layer 5 (ksf)	Em5	10

UPPER ZONE SETTLEMENT - RECTANGULAR FOOTINGS

Parameter	**Symb**	Equation							
UZ Settlement Approach		1-Stiffness, 2-Modulus	2	2	2	1	1	1	1
Thickness of UZ sublayer 1(ft)	H_{uz1}		5.0						
Thickness of UZ sublayer 2 (ft)	H_{uz2}		5.0						
Thickness of UZ sublayer 3 (ft)	H_{uz3}		3.0						
Thickness of UZ sublayer 4 (ft)	H_{uz4}								
Thickness of UZ sublayer 5 (ft)	H_{uz5}								
Total UZ Thickness OK?		Huz = Hs +d	**ok**						
Composite Modulus Layer 1 (ksf)	E_{comp1}	Eg1Ra + Em1(1-Ra)	467						
Composite Modulus Layer 2 (ksf)	E_{comp2}	Eg2Ra + Em2(1-Ra)	401						
Composite Modulus Layer 3 (ksf)	E_{comp3}	Eg3Ra + Em3(1-Ra)	401						
Composite Modulus Layer 4 (ksf)	E_{comp4}	Eg4Ra + Em4(1-Ra)	401						
Composite Modulus Layer 5 (ksf)	E_{comp5}	Eg5Ra + Em5(1-Ra)	401						
Sett. of LZ sublayer 1 (in)	s_{uz1}	qg/kg or q*Iσ-vag*H/Ecomp	0.41						
Sett. of LZ sublayer 2 (in)	s_{uz2}	$q*I\sigma\text{-}2*H_{uz2}/E_{comp2}$	0.25						
Sett. of LZ sublayer 3 (in)	s_{uz3}	$q*I\sigma\text{-}3*H_{uz3}/E_{comp3}$	0.09						
Sett. of LZ sublayer 4 (in)	s_{uz4}	$q*I\sigma\text{-}4*H_{uz4}/E_{comp4}$	0.00						
Sett. of LZ sublayer 5 (in)	s_{uz5}	$q*I\sigma\text{-}5*H_{uz5}/E_{comp5}$	0.00						
Total Upper Zone Settlement (in)	s_{uz}	$s_{uz1}+s_{uz2}+s_{uz3}+s_{uz4}+s_{uz5}$	0.75						

INPUT PARAMETER VALUES:

Parameter	Symb	Val.
Allowable end-bearing (kips)	Qeb	14
E or c_ε for LZ sublyr 1	E_1 / $c_{\varepsilon1}$	0.02
E or c_ε for LZ sublyr 2	E_2 / $c_{\varepsilon2}$	0.02
E or c_ε for LZ sublyr 3	E_3 / $c_{\varepsilon3}$	
E or c_ε for LZ sublyr 4	E_4 / $c_{\varepsilon4}$	
E or c_ε for LZ sublyr 5	E_5 / $c_{\varepsilon5}$	
Calc. settlement to X*B	X	2

LOWER ZONE SETTLEMENTS

Parameter	Symb	Equation	F12x8						
Dpth to bottm of LZ from ftg (ft)	X*B	X*Beq	19.6						
Upper zone thickness (ft)	H_{uz}	Hs+d	13						
Lower zone thickness (ft)	H_{lz}	H2b-Hlz	6.6						
Thickness of LZ sublayer 1(ft)	H_{lz1}		5.00						
Thickness of LZ sublayer 2 (ft)	H_{lz2}		1.60						
Thickness of LZ sublayer 3 (ft)	H_{lz3}								
Thickness of LZ sublayer 4 (ft)	H_{lz4}								
Thickness of LZ sublayer 5 (ft)	H_{lz5}								
Total thickness ok?			**ok**						
E or c_ε for LZ sublyr 1	E_1 / $c_{\varepsilon1}$	E (ksf) or c_ε	0.015						
E or c_ε for LZ sublyr 2	E_2 / $c_{\varepsilon2}$	E (ksf) or c_ε	0.015						
E or c_ε for LZ sublyr 3	E_3 / $c_{\varepsilon3}$	E (ksf) or c_ε	0						
E or c_ε for LZ sublyr 4	E_4 / $c_{\varepsilon4}$	E (ksf) or c_ε	0						
E or c_ε for LZ sublyr 5	E_5 / $c_{\varepsilon5}$	E (ksf) or c_ε	0						
Initial stress for sublyr 1 (ksf)	P'_{o1}		1.053						
Initial stress for sublyr 2 (ksf)	P'_{o2}		1.210						
Initial stress for sublyr 3 (ksf)	P'_{o3}		1.248						
Initial stress for sublyr 4 (ksf)	P'_{o4}		1.248						
Initial stress for sublyr 5 (ksf)	P'_{o5}		1.248						
Ftg stress on sublyr 1 (ksf)	ΔP1	q*I	0.59						
Ftg stress on sublyr 2 (ksf)	ΔP2	q*I	0.42						
Ftg stress on sublyr 3 (ksf)	ΔP3	q*I	0.39						
Ftg stress on sublyr 4 (ksf)	ΔP4	q*I	0.39						
Ftg stress on sublyr 5 (ksf)	ΔP5	q*I	0.39						
Sett. of LZ sublayer 1 (in)	s_{lz1}	ce1*Hlz1*log((Po1+DP1)/Po1)	0.17						
Sett. of LZ sublayer 2 (in)	s_{lz2}	ce2*Hlz2*log((Po2+DP2)/Po2)	0.04						
Sett. of LZ sublayer 3 (in)	s_{lz3}	ce3*Hlz3*log((Po3+DP3)/Po3)	0.00						
Sett. of LZ sublayer 4 (in)	s_{lz4}	ce4*Hlz4*log((Po4+DP4)/Po4)	0.00						
Sett. of LZ sublayer 5 (in)	s_{lz5}	ce5*Hlz5*log((Po5+DP5)/Po5)	0.00						
Total lower zone sett. (in)	s_{lz}	$s_{lz1}+s_{lz2}+s_{lz3}+s_{lz4}+s_{lz5}$	0.2						
Total UZ + LZ settlement (in)	s		1.0						

Note: When "No LZ" is displayed, thicknesses of lower zone should equal 0
Note: For large rectangular footings where L/B>4, consideration to using alternative lowerzone calculations (i.e. continuous footing, ZSTRESS, Settle3D, etc) is recommended.

***GEOPIER*® Foundation Company**

Project:	**FedEx Sorting Facility**
No.:	GIM-264
Engnr:	DPC
Date:	3/31/2023

GEOPIER®
CONTINUOUS FOOTINGS
Version 3.0.6 August 2013

*** Geopier makes no warranties for errors or omissions**
Spreadsheets to be used at own risk

INPUT PARAMETER VALUES:

Parameter	Symb	Val.
RAP diameter (in)	d	24
Depth to groundwater (ft)	dgw	2
Total unit weight of soil (pcf)	g	110
Soil frict. angle (degr)	f	24
Max. hor. pressure (psf)	pmax	2500
From Table 4.2:		
RAP cell cap. (kips)	Qcell	50
Footing bearing press. (ksf)	qall	4
RAP stiffn. modulus (pci)	kg	250
Soil stiffness modulus (pci)	km	27.8

TOP OF PIER STRESS - CONTINUOUS FOOTINGS

Parameter	Symb	Equation						
Wall Load (kips/ft)	p		6	3				
Required Geopier spacing (ft)	sreq	Qcell/p	8.33	16.67				
Selected Geopier spacing (ft)	s		10	12				
Required footing width (ft)	Breq	p/qall	1.50	0.75				
Selected footing width (ft)	B		2	2				
Bearing pressure (ksf)	q	p/B	3.00	1.50				
Area replacement ratio	Ra	Ag/(B*s)	0.157	0.131				
Stiffness ratio	Rs	kg/km	9.0	9.0				
Stress at top of GP (ksf)	qg	q*Rs/(Rs*Ra-Ra+1)	11.96	6.59				
Load at top of GP (kips)	Qg	qg*Ag	37.6	20.7				

SHAFT LENGTH REQUIREMENTS

Parameter	Symb	Equation						
Depth of Embedment	Df		4.0	4.0				
Trial shaft length (ft)	Hs		11.0	11.0				
Drill depth (ft)	Hdrill	Df+Hs	15	15				
Frictional resistance force (kips)	Qs	fs*pi*d*Hs	42	42				
Allowable tensile resistance (kips)	Qsall	Qs/2	21	21				
Allowable end-bearing rest. (kips)	Qeb	Qeb	0	0				
Is shaft long enough?		Qs+Qeb>Pcdem?	**ok**	**ok**				

INPUT PARAMETER VALUES:

Upper Zone Elastic Parameters		
Parameter	Sym	Val
Pier Modulus Layer 1 (ksf)	Eg1	3500
Pier Modulus Layer 2 (ksf)	Eg2	3000
Pier Modulus Layer 3 (ksf)	Eg3	3000
Pier Modulus Layer 4 (ksf)	Eg4	3000
Pier Modulus Layer 5 (ksf)	Eg5	3000
Soil Modulus Layer 1 (ksf)	Em1	10
Soil Modulus Layer 2 (ksf)	Em2	10
Soil Modulus Layer 3 (ksf)	Em3	10
Soil Modulus Layer 4 (ksf)	Em4	10
Soil Modulus Layer 5 (ksf)	Em5	10

UPPER ZONE SETTLEMENT - CONTINUOUS FOOTINGS

Parameter	**Symb**	Equation						
UZ Settlement Approach		1-Stiffness, 2-Modulus	2	2	2	2	2	2
Thickness of UZ sublayer 1(ft)	H_{uz1}		5.0	5.0				
Thickness of UZ sublayer 2 (ft)	H_{uz2}		5.0	5.0				
Thickness of UZ sublayer 3 (ft)	H_{uz3}		3.0	3.0				
Thickness of UZ sublayer 4 (ft)	H_{uz4}							
Thickness of UZ sublayer 5 (ft)	H_{uz5}							
Total UZ Thickness OK?		Huz = Hs +d	**ok**	**ok**				
Composite Modulus Layer 1 (ksf)	E_{comp1}	Eg1Ra + Em1(1-Ra)	558	467				
Composite Modulus Layer 2 (ksf)	E_{comp2}	Eg2Ra + Em2(1-Ra)	480	401				
Composite Modulus Layer 3 (ksf)	E_{comp3}	Eg3Ra + Em3(1-Ra)	480	401				
Composite Modulus Layer 4 (ksf)	E_{comp4}	Eg4Ra + Em4(1-Ra)	480	401				
Composite Modulus Layer 5 (ksf)	E_{comp5}	Eg5Ra + Em5(1-Ra)	480	401				
Sett. of LZ sublayer 1 (in)	s_{uz1}	qg/kg or q*Iσ-vag*H/Ecomp	0.17	0.10				
Sett. of LZ sublayer 2 (in)	s_{uz2}	$q*I\sigma\text{-}2*H_{uz2}/E_{comp2}$	0.06	0.04				
Sett. of LZ sublayer 3 (in)	s_{uz3}	$q*I\sigma\text{-}3*H_{uz3}/E_{comp3}$	0.02	0.01				
Sett. of LZ sublayer 4 (in)	s_{uz4}	$q*I\sigma\text{-}4*H_{uz4}/E_{comp4}$	0.00	0.00				
Sett. of LZ sublayer 5 (in)	s_{uz5}	$q*I\sigma\text{-}5*H_{uz5}/E_{comp5}$	0.00	0.00				
Total Upper Zone Settlement (in)	s_{uz}	$s_{uz1}+s_{uz2}+s_{uz3}+s_{uz4}+s_{uz5}$	0.26	0.16				

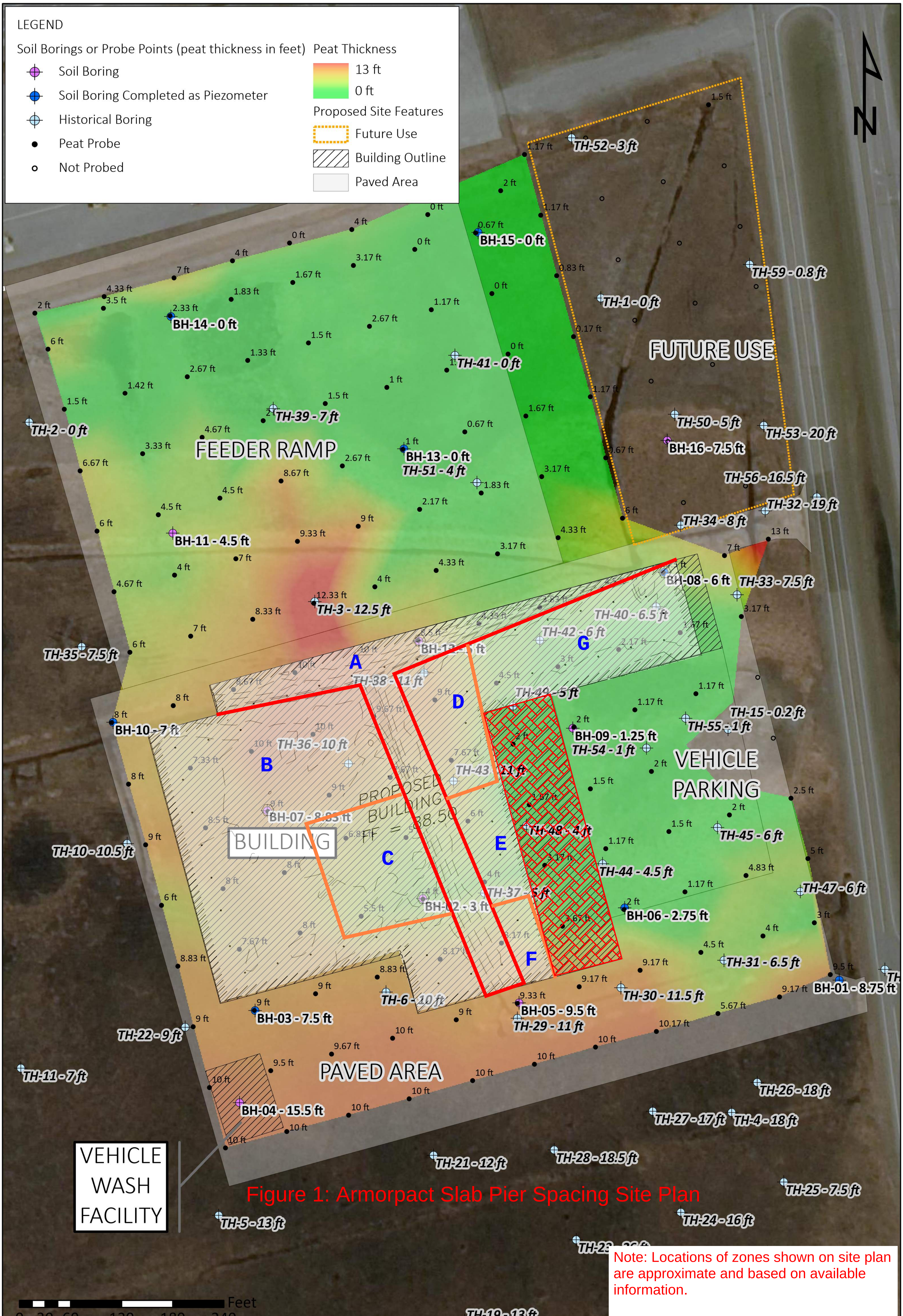
INPUT PARAMETER VALUES:

Parameter	Symb	Val.
Allowable end-bearing (kips)	Qeb	0
E or c_ε for LZ sublyr 1	E_1 / $c_{\varepsilon 1}$	
E or c_ε for LZ sublyr 2	E_2 / $c_{\varepsilon 2}$	
E or c_ε for LZ sublyr 3	E_3 / $c_{\varepsilon 3}$	
E or c_ε for LZ sublyr 4	E_4 / $c_{\varepsilon 4}$	
E or c_ε for LZ sublyr 5	E_5 / $c_{\varepsilon 5}$	
Calc. settlement to X*B	X	5

LOWER ZONE SETTLEMENTS

Parameter	Symb	Equation	0	0				
Dpth to bottm of LZ from ftg (ft)	X*B	X*B	10	10				
Upper zone thickness (ft)	H_{uz}	Hs+d	13	13				
Lower zone thickness (ft)	H_{lz}	H2b-Hlz	-3	-3				
Thickness of LZ sublayer 1(ft)	H_{lz1}							
Thickness of LZ sublayer 2 (ft)	H_{lz2}							
Thickness of LZ sublayer 3 (ft)	H_{lz3}							
Thickness of LZ sublayer 4 (ft)	H_{lz4}							
Thickness of LZ sublayer 5 (ft)	H_{lz5}							
Total thickness ok?			**No LZ**	**No LZ**				
E or c_ε for LZ sublyr 1	E_1 / $c_{\varepsilon 1}$	E (ksf) or c_ε	0	0				
E or c_ε for LZ sublyr 2	E_2 / $c_{\varepsilon 2}$	E (ksf) or c_ε	0	0				
E or c_ε for LZ sublyr 3	E_3 / $c_{\varepsilon 3}$	E (ksf) or c_ε	0	0				
E or c_ε for LZ sublyr 4	E_4 / $c_{\varepsilon 4}$	E (ksf) or c_ε	0	0				
E or c_ε for LZ sublyr 5	E_5 / $c_{\varepsilon 5}$	E (ksf) or c_ε	0	0				
Initial stress for sublyr 1 (ksf)	P'_{o1}		0.934	0.934				
Initial stress for sublyr 2 (ksf)	P'_{o2}		0.934	0.934				
Initial stress for sublyr 3 (ksf)	P'_{o3}		0.934	0.934				
Initial stress for sublyr 4 (ksf)	P'_{o4}		0.934	0.934				
Initial stress for sublyr 5 (ksf)	P'_{o5}		0.934	0.934				
Ftg stress on sublyr 1 (ksf)	ΔP1	q*I	0.28	0.14				
Ftg stress on sublyr 2 (ksf)	ΔP2	q*I	0.28	0.14				
Ftg stress on sublyr 3 (ksf)	ΔP3	q*I	0.28	0.14				
Ftg stress on sublyr 4 (ksf)	ΔP4	q*I	0.28	0.14				
Ftg stress on sublyr 5 (ksf)	ΔP5	q*I	0.28	0.14				
Sett. of LZ sublayer 1 (in)	s_{lz1}	ce1*Hlz1*log((Po1+DP1)/Po1)	0.00	0.00				
Sett. of LZ sublayer 2 (in)	s_{lz2}	ce2*Hlz2*log((Po2+DP2)/Po2)	0.00	0.00				
Sett. of LZ sublayer 3 (in)	s_{lz3}	ce3*Hlz3*log((Po3+DP3)/Po3)	0.00	0.00				
Sett. of LZ sublayer 4 (in)	s_{lz4}	ce4*Hlz4*log((Po4+DP4)/Po4)	0.00	0.00				
Sett. of LZ sublayer 5 (in)	s_{lz5}	ce5*Hlz5*log((Po5+DP5)/Po5)	0.00	0.00				
Total lower zone sett. (in)	s_{lz}	$s_{lz1}+s_{lz2}+s_{lz3}+s_{lz4}+s_{lz5}$	0.0	0.0				
Total UZ + LZ settlement (in)	s		0.3	0.2				

Note: When "No LZ" is displayed, thicknesses of lower zone should equal 0



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CRW ENGINEERING GROUP, LLC
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SITE MAP: PEAT THICKNESS AT CURRENT AND HISTORICAL BOREHOLE LOCATIONS

ANC FEDEX SORTING FACILITY GEOTECHNICAL REPORT
TED STEVENS ANCHORAGE INTERNATIONAL AIRPORT
ANCHORAGE, ALASKA

Project:	73138
Drawn By:	AFS
Scale:	Graphical
Date:	8/11/2022
Figure:	1

Section	Existing Grade (ft)	FFE (ft)	Net Fill Thickness (ft)	Max Peat Thickness (ft)	Fill Load psf	Slab Load+Wt of Slab psf	80 kip Armorpact		50 kip Armorpact	
							Req'd Spacing (ft)	Selected Spacing (ft)	Req'd Spacing (ft)	Selected Spacing (ft)
A	81	88.5	6.8	10	821	575	7.6	**7.5**	6.0	**6.0**
B	83	88.5	4.8	10	581	575	8.3	**8.5**	6.6	**6.5**
C	83	88.5	4.8	7	581	575	8.3	**8.5**	6.6	
D	82	88.5	5.8	9	701	575	7.9	**8.0**	6.3	
E	82.5	88.5	5.3	6	641	575	8.1	**8.0**	6.4	
F	82.5	88.5	5.3	9	641	575	8.1	**8.0**	6.4	**6.5**
G	83	88.5	4.8	4.5	581	575	8.3	**8.5**	6.6	
A	81	88.5	6.8	10	821	325	8.4	**8.5**	6.6	**6.5**
B	83	88.5	4.8	10	581	325	9.4	**9.5**	7.4	**7.5**
C	83	88.5	4.8	7	581	325	9.4	**9.5**	7.4	
D	82	88.5	5.8	9	701	325	8.8	**9.0**	7.0	
E	82.5	88.5	5.3	6	641	325	9.1	**9.0**	7.2	
F	82.5	88.5	5.3	9	641	325	9.1	**9.0**	7.2	**7.0**
G	83	88.5	4.8	4.5	581	325	9.4	**9.5**	7.4	
A office	81	88.5	6.8	10	821	130	9.2	**9.0**	7.3	
G office	83	88.5	4.8	4.5	581	130	10.6	**10.5**	8.4	

Basic Quality Statistical Summary Report

Plant 132110-Anchorage Sand & Gravel (Palmer)
Product D03-3/4" Minus (Coarse Asphalt)
Specification 3/4" Minus
Period 01/01/2022 - 11/29/2022

Sieve/Test	Tests	Average	St Dev	Target	Specification
3/4" (19mm)	514	100.0	0.13	100	100-100
1/2" (12.5mm)	515	34.3	5.09	36	27-45
3/8" (9.5mm)	515	4.2	1.31	4	0-8
#4 (4.75mm)	515	1.0	0.28	1	0-2
#8 (2.36mm)	515	0.7	0.22	0.8	0-2
#200 (75µm)	515	0.25	0.123		
Pan	515	0.00	0.000		

Basic Quality Statistical Summary Report

Plant 132110-Anchorage Sand & Gravel (Palmer)
Product W02-3/4" Concrete Rock
Specification 3/4" Course Concrete Aggregate
Period 01/01/2022 - 11/29/2022

Sieve/Test	Tests	Average	St Dev	Target	Specification
1" (25mm)	377	100.0	0.00		100-100
3/4" (19mm)	377	94.5	2.92	92	90-100
1/2" (12.5mm)	377	59.7	7.06		
3/8" (9.5mm)	377	39.3	6.93		20-50
#4 (4.75mm)	377	3.5	2.73		0-10
#8 (2.36mm)	377	0.7	1.30		0-5
#200 (75µm)	377	0.04	0.021		
Pan	377	0.00	0.000		

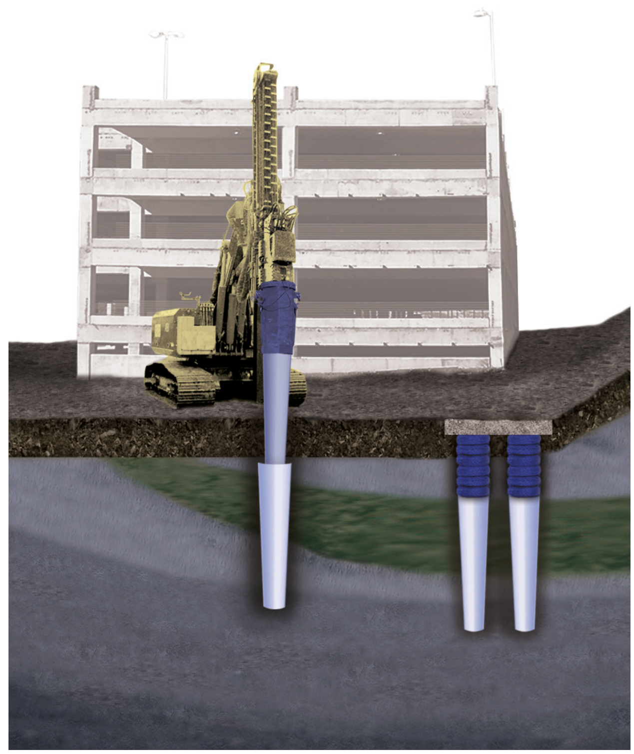
THE GEOPIER ARMORPACT® SYSTEM

INTERMEDIATE FOUNDATION® SOLUTIONS

ARMORPACT®

The Geopier Armorpact® system creates strong and stiff Rammed Aggregate Pier® (RAP) elements in weak soils. The patented system is a cost effective solution for supporting buildings and structures in soft clay and organic soils. Construction begins by inserting a driving mandrel within the patented Armorpact sleeve and driving the sleeve to the design depth. Aggregate is then placed within the confining sleeve and compacted with the mandrel. Applied loads are supported by the densely compacted aggregate that is laterally confined by the sleeve.

The Geopier Armorpact system provides high stiffness and resistance to bulging in soft and organic soils to deliver excellent settlement control and support capacity in soft and organic soils. The displacement method is ideal for contaminated sites where spoils or over-excavation is cost prohibitive or not an option. The Armorpact system also provides cost-effective solutions for soils where temporary casing may increase construction costs or low design capacities for other systems yield expensive solutions. The Armorpact system provides unsurpassed strength, stiffness and superior levels of performance for foundation settlement control and support at challenging soft or organic soil sites.



ADVANTAGES OF THE ARMORPACT® SYSTEM

- **PRACTICAL** Vertically ramming thin lifts of aggregate within the patented Armorpact sleeve is the key to providing strength and stiffness. The Armorpact system eliminates casing and allows for displacement RAP construction in soft and organic soils.
- **ECONOMICAL** Often results in cost savings compared to traditional deep foundation alternatives.
- **EFFICIENT** The patented displacement installation eliminates casing risk in soft and organic soils and accelerates installation rates.
- **STRONG AND STIFF** Vertical impact ramming within a stiff confining sleeve results in high stiffness and high strength RAP elements that provide support capacity and settlement control even in very soft soils.
- **FAST** Rapid installation process means shorter construction schedules.
- **ENGINEERED** Projects are engineered in-house by Geopier Professional Engineers, allowing for rapid response when design or construction changes arise.

THE CONSTRUCTION PROCESS

The patented Geopier Armorpact™ installation process displaces soil during installation and utilizes vertical impact ramming energy to construct Rammed Aggregate Pier® elements that exhibit unsurpassed strength and stiffness in soft soils. RAP solutions are designed to provide total and differential settlement control and increase bearing support to meet project requirements.

1. The Armorpact sleeve is placed on the specially designed tapered mandrel and is driven into the ground using a strong static force augmented by high frequency vertical impact energy. Depths normally range from about 10 to 20 feet, depending on design requirements. The displacement process eliminates spoils.
2. After driving to design depth, the confining sleeve remains in place. Aggregate is placed and densified inside the sleeve. Compaction is achieved through static down force and dynamic vertical ramming from the hammer and mandrel. The process densifies aggregate vertically and forces the aggregate and confining sleeve laterally, expanding into the soft matrix soil. This results in lateral stress increase that, combined with the high stiffness element, provides excellent settlement control with superior strength and stiffness in soft clay and organic soils.
3. Following installation, RAP elements support shallow foundations, floor slabs and mats; reduce liquefaction potential; and improve stability support of embankments, walls and tank pads. The applied stresses are attracted to the stiff RAP elements, resulting in engineered settlement control.

APPLICATIONS

Geopier systems have become preferred replacements for massive over-excavation and replacement or deep foundations, including driven piles, drilled shafts or augered cast-in-place piles. Local Geopier engineers and representatives work with you and your specific soil conditions and loads to engineer a project-specific practical solution to improve your ground. With multiple systems we are able to engineer support for virtually any soil type and groundwater condition across many applications, including:

- ▹ Foundations
- ▹ Floor Slabs
- ▹ Industrial Facilities
- ▹ Storage Tanks
- ▹ Liquefaction Mitigation
- ▹ MSE Walls/Embankment Support
- ▹ Slope Stabilization
- ▹ Transportation
- ▹ Wind Turbines
- ▹ Uplift & Lateral Load Resistance

Driving to design depth

Vertical ramming to compact into thin lifts

JBS Automated Freezer Warehouse
Marshalltown, Iowa

Elven Sted Development
Stoughton, Wisconsin

Geopier Foundation Company developed the Rammed Aggregate Pier® (RAP) system to provide an efficient and cost effective Intermediate Foundation® solution for the support of settlement sensitive structures. Through continual research and development, we've expanded our system capabilities to offer you more. Our design-build engineering support and site specific modulus testing combined with the experience of providing settlement control for thousands of projects provides an unmatched level of support and reliability to meet virtually all of your ground improvement challenges.

Work with regional engineers worldwide to solve your ground improvement challenges.

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