AP Consulting Engineers PLLC

Civil Engineering

PRMH20260510

These calculations must be on site and made available by the Permittee for all inspections.

City of Puyallup
Development & Permitting Services
ISSUED PERMIT

Building	Planning
Engineering	Public Works
Fire	Traffic

Tank Foundation Analysis

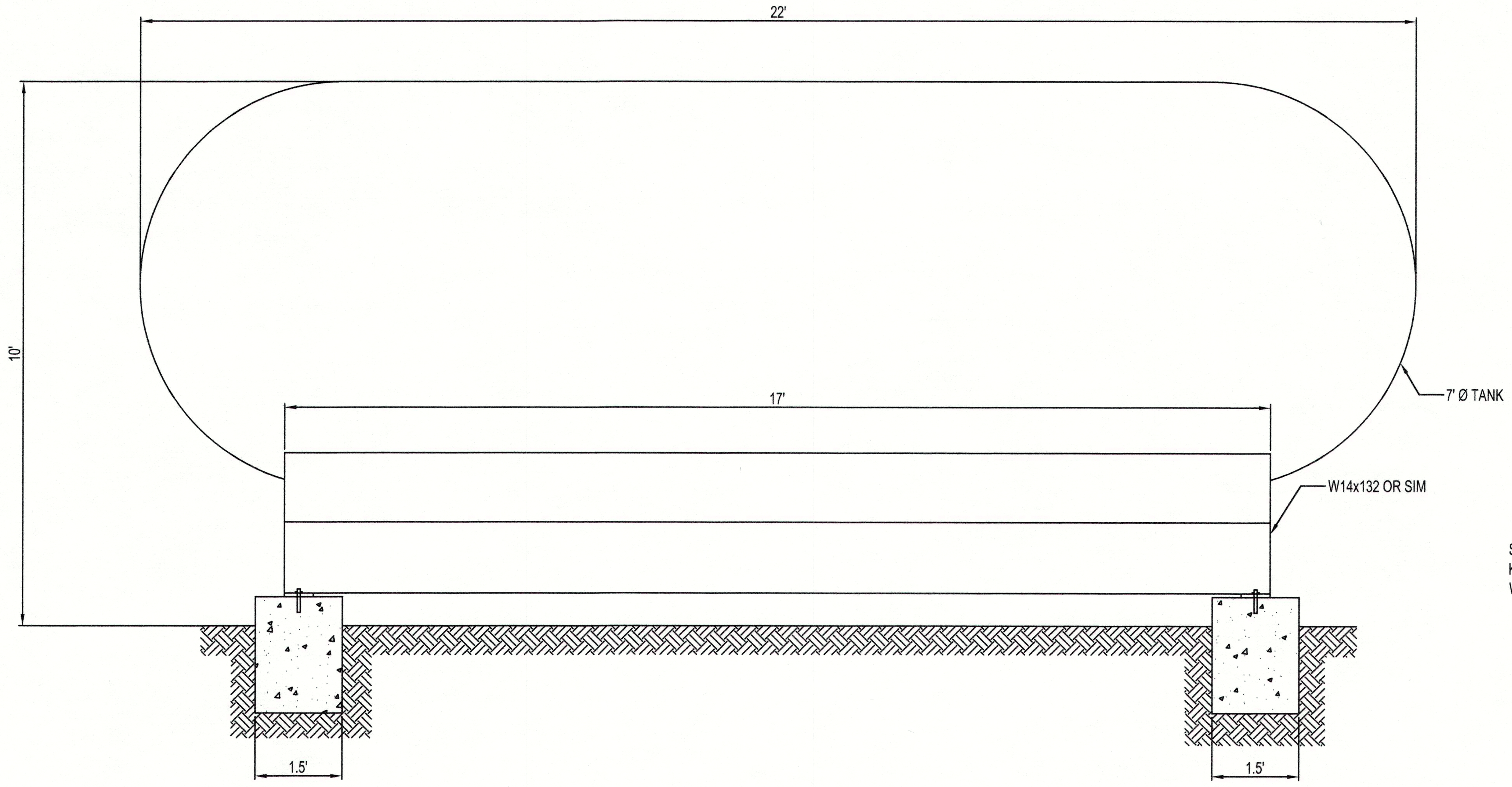
City of Puyallup
Building
REVIEWED FOR COMPLIANCE
BSnowden
05/11/2026
7:51:55 AM

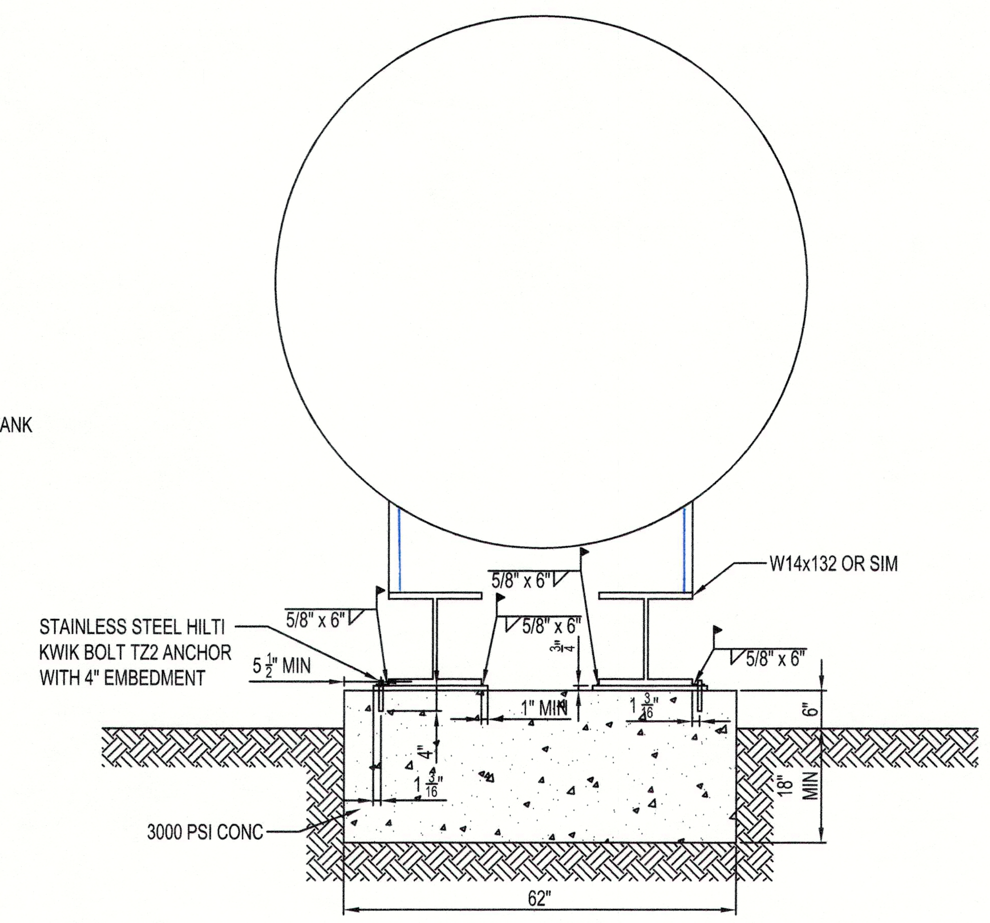
April 6th, 2026
APCE Project #2026005

Prepared for:
Puyallup SD Bus Yard Propane Tank Foundation
1501 39th Avenue SW
Puyallup, WA 98373

At the Request of:
Ferrell Gass
3611 A Street SE
Auburn, WA 98002

Adam E. Paul
State of Washington
43211
Registered Professional Engineer
4/6/26

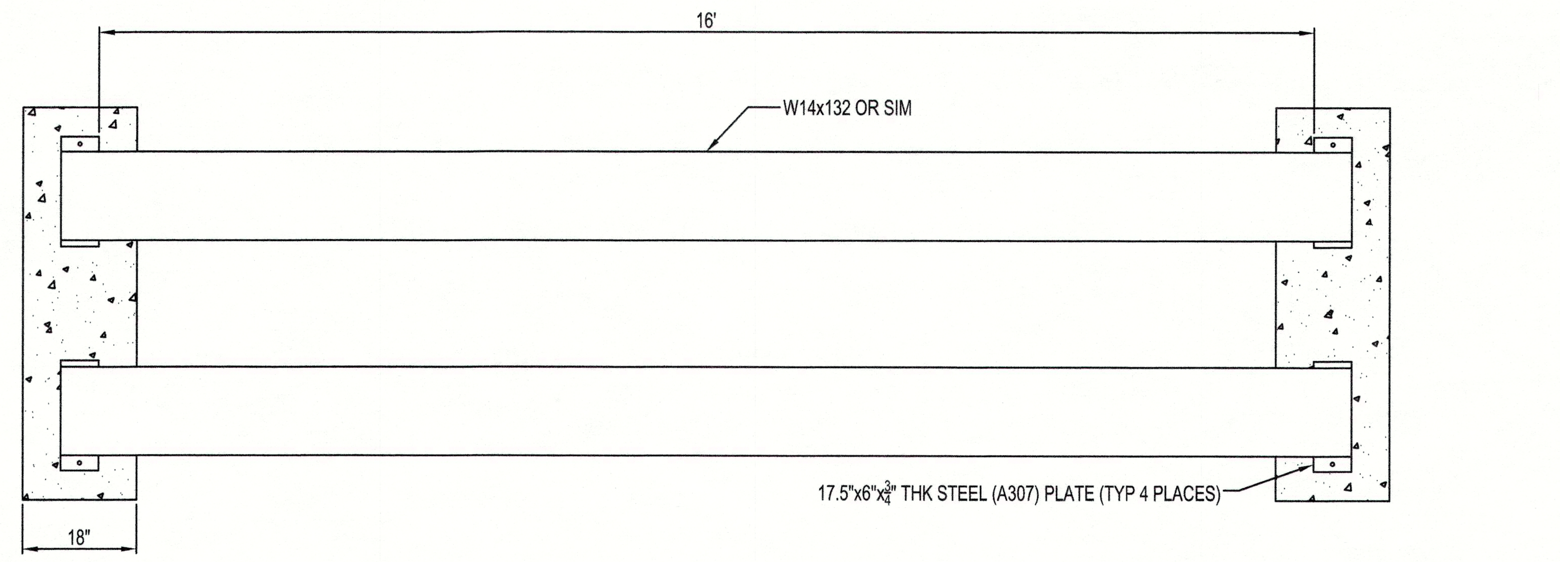


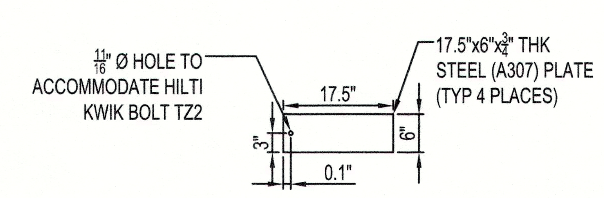


PLAN VIEW

THIS TANK FOUNDATION ANALYSIS IS BASED ON SOIL BEARING PRESSURES TAKEN FROM TABLE 1806.2 OF THE 2021 IBC AND SOIL TYPES BASED ON THE PIERCE COUNTY SOIL SURVEY. IF SITE CONDITIONS DIFFER FROM THESE ASSUMPTIONS, THE ENGINEER MUST BE NOTIFIED SO THAT THE ANALYSIS MAY BE UPDATED TO REFLECT ACTUAL SITE CONDITIONS.

Welding to be completed by an individual or fabricator who is WABO certified or approved by the Building Official to perform the work. All welds must be inspected and approved by a WABO certified special inspector.





Prior to installation:
Review anchor product's ICC-ES Report and install the product per the report. If the report states special inspection(s) are required - the final special inspection report must be on site during City inspections.

1/C1 TANK FOUNDATION DETAIL

NTS

AP CONSULTING ENGINEERS PLLC
CIVIL ENGINEERING
APCE@APConsultingEngineers.com (253) 737-4173 PO BOX 162, AUBURN, WA 98071

JOB TITLE
PUYALLUP SCHOOL BUS YARD PROPANE TANK
3607 17TH STREET SW PUYALLUP, WA

SHEET TITLE
DETAILS AND STRUCTURAL NOTES

REVISIONS

SYM.	DESCRIPTION	DATE

ADAM E. PAUL, STATE OF WASHINGTON, 43211, REGISTERED PROFESSIONAL ENGINEER

DATE	3/12/26
DRAWN	RJK
CHECKED	AEP
JOB NO.	2026005
SHEET NO.	C1

AP CONSULTING ENGINEERS PLLC
PO Box 162, Auburn, WA 98071

Job No. 2026005
4/6/2026

PROJECT NAME: **Puyallup SD Bus Yard Propane Tank Foundation**
3607 17th Street SW, Puyallup, WA

SCOPE OF WORK:

Determine the column and footing requirements for the propane tank subject to static wind loading per the 2024 International Building Code and ASCE 7-16.
All sign material and connections to column by others.

DESIGN CRITERIA:

Per City of Puyallup Standards

Basic Wind Speed:	V =	110	MPH	~~Per Auburn Building Standards~~
Exposure Category:		B		ASCE 7-16 SECTION 26.7.3
Total Height of Sign:		10.06	FT	*Sum of 9.5' + 0.75" plate + 6" found*
Nominal Height of Atmospheric Boundary layer:	z_g =	1200	FT	ASCE 7-16 TABLE 26.11-1
Power Law Exponent:	a =	7		ASCE 7-16 TABLE 26.11-1
Exposure Constant:	z_{min} =	30	FT	ASCE 7-16 TABLE 26.11-1
Turbulence Factor:	c =	0.3		ASCE 7-16 TABLE 26.11-1
Integral Length Scale Factor:	l =	320	FT	ASCE 7-16 TABLE 26.11-1
Integral Length Scale Exponent:	e_{ave} =	0.33		ASCE 7-16 TABLE 26.11-1
Mean Hourly Wind Exponent:	a_{ave} =	0.25		ASCE 7-16 TABLE 26.11-1
Mean Hourly Wind Factor:	b_{ave} =	0.45		ASCE 7-16 TABLE 26.11-1
Period Coefficient:	C_t =	0.02		ASCE 7-16 TABLE 12.8-2
Period Coefficient:	x =	0.75		ASCE 7-16 TABLE 12.8-2
Approximate Fundamental Period:	T_a =	0.11	SEC	ASCE 7-16 Eqn. 12.8-7

DESIGN LOADS A:

Propane tank

Height of tank		7	FT	*7' tank*
Height above grade:		10.06	FT	*6"footing+ 0.75" plate+ 30" rail and I beam+ 7' tank*
Height above footing:		9.56	FT	*0.75" plate+ 30" rail and I beam + 7' tank*
Width:		22.00	FT	
Point of Wind Load Application:		6.06	FT	*(@ top of foundation) 0.75" plate+ 30" rail and I beam+ 3.5' tank*
Loading area	$A_{S\text{-}top}$ =	154.0	FT^2	
Velocity Pressure:	$q_h = 0.00256K_hK_{zt}K_dK_eV^2$			ASCE 7-16 Eqn. 26.10-1
Exposure Coefficient:	K_h =	0.57		ASCE 7-16 TABLE 26.10-1
	K_{zt} =	1.0		ASCE 7-16 SECTION 26.8.2 & FIGURE 26.8-1
	K_d =	0.85		ASCE 7-16 TABLE 26.6-1
	K_e =	1		ASCE 7-16 TABLE 26.9-1, NOTE 1
	q_h =	15.1	LB/FT^2	
Gust Factor:	$G = 0.925(1+0.7g_QI_zQ)/(1+0.7g_vI_z)$			ASCE 7-16 Eqn. 26.11-6
Intensity of Turbulence:	I_z =	0.305		ASCE 7-16 Eqn. 26.11-7
	g_Q =	3.40		ASCE 7-16 SECTION 26.11.4
	g_v =	3.40		ASCE 7-16 SECTION 26.11.4
Equivalent height of structure:	z_{ave} =	30.0		ASCE 7-16 SECTION 26.11.4
Background Response:	Q =	0.932		ASCE 7-16 Eqn. 26.11-8
	$L_{z\,ave}$ =	310.0		ASCE 7-16 Eqn. 26.11-9
Rigid Gust Factor:	G =	0.899		
Clearance Ratio:	$Height_{sign}/Height_{total}$ =	1.000		ASCE 7-16 FIGURE 29.3-1
Aspect Ratio:	$Width_{sign}/Height_{sign}$ =	2.187		ASCE 7-16 FIGURE 29.3-1
Net Force Coefficient:	C_f =	1.40		ASCE 7-16 FIGURE 29.3-1
Design Wind Force:	$F = q_hGC_fA_S$ =	**2921.9**	**LB**	ASCE 7-16 Eqn. 29.3-1
Overturning Moment @ Top of Fndn:		**19177**	**LB-FT**	ASCE 7-16 FIGURE 29.3-1

Rails + I beam

Height of rails and I beam		**2.50**	FT	*14.7" I beam + 15.3" rails*
Height above grade:		**3.06**	FT	*6" footing+0.75" plate+14.7" I Beam+15.3" rail*
Height above footing:		**2.6**	FT	*0.75" plate+14.7" I Beam+15.3" rail*
Width:		**17.00**	FT	
Point of Wind Load Application:		**1.31**	FT	*(@ top of foundation) 0.75"plate +15" I beam and rail*
Loading Area	$A_{s\text{-bottom}}$ =	42.50	FT^2	
Velocity Pressure:	$q_h = 0.00256K_hK_{zt}K_dK_eV^2$			ASCE 7-16 Eqn. 26.10-1
Exposure Coefficient:	K_h =	0.575		ASCE 7-16 TABLE 26.10-1
	K_{zt} =	**1**		ASCE 7-16 SECTION 26.8.2 & FIGURE 26.8-1
	K_d =	0.85		ASCE 7-16 TABLE 26.6-1
	K_e =	1		ASCE 7-16 TABLE 26.9-1, NOTE 1
	q_h =	15.1	LB/FT^2	
Gust Factor:	$G = 0.925(1+0.7g_QI_zQ)/(1+0.7g_vI_z)$			ASCE 7-16 Eqn. 26.11-6
Intensity of Turbulence:	I_z =	0.305		ASCE 7-16 Eqn. 26.11-7
	g_Q =	3.40		ASCE 7-16 SECTION 26.11.4
	g_v =	3.40		ASCE 7-16 SECTION 26.11.4
Equivalent height of structure:	z_{ave} =	30		ASCE 7-16 SECTION 26.11.4
Background Response:	Q =	0.949		ASCE 7-16 Eqn. 26.11-8
	$L_{z\,ave}$ =	310.0		ASCE 7-16 Eqn. 26.11-9
Rigid Gust Factor:	G =	0.905		
Clearance Ratio:	$Height_{sign}/Height_{total}$ =	0.304		ASCE 7-16 FIGURE 29.3-1
Aspect Ratio:	$Width_{sign}/Height_{sign}$ =	5.551		ASCE 7-16 FIGURE 29.3-1
Net Force Coefficient:	C_f =	1.80		ASCE 7-16 FIGURE 29.3-1
Design Wind Force:	$F = q_hGC_fA_s$ =	**1046.3**	**LB**	ASCE 7-16 Eqn. 29.3-1
Overturning Moment @ Top of Fndn:		**1371**	**LB-FT**	ASCE 7-16 FIGURE 29.3-1

Plates

Height of plate		**0.06**	FT	*0.75"*
Height above grade:		**0.56**	FT	*0.75" plate + 6"*
Height above footing:		**0.06**	FT	*0.75"*
Width:		**0.50**	FT	*6"*
Point of Wind Load Application:		**0.03**	FT	*(@top of foundation) 0.375"*
Loading Area	$A_{s\text{-bottom}}$ =	0.03	FT^2	
Velocity Pressure:	$q_h = 0.00256K_hK_{zt}K_dK_eV^2$			ASCE 7-16 Eqn. 26.10-1
Exposure Coefficient:	K_h =	0.575		ASCE 7-16 TABLE 26.10-1
	K_{zt} =	**1**		ASCE 7-16 SECTION 26.8.2 & FIGURE 26.8-1
	K_d =	0.85		ASCE 7-16 TABLE 26.6-1
	K_e =	1		ASCE 7-16 TABLE 26.9-1, NOTE 1
	q_h =	15.1	LB/FT^2	
Gust Factor:	$G = 0.925(1+0.7g_QI_zQ)/(1+0.7g_vI_z)$			ASCE 7-16 Eqn. 26.11-6
Intensity of Turbulence:	I_z =	0.305		ASCE 7-16 Eqn. 26.11-7
	g_Q =	3.40		ASCE 7-16 SECTION 26.11.4
	g_v =	3.40		ASCE 7-16 SECTION 26.11.4
Equivalent height of structure:	z_{ave} =	30		ASCE 7-16 SECTION 26.11.4
Background Response:	Q =	0.993		ASCE 7-16 Eqn. 26.11-8
	$L_{z\,ave}$ =	310.0		ASCE 7-16 Eqn. 26.11-9
Rigid Gust Factor:	G =	0.922		
Clearance Ratio:	$Height_{sign}/Height_{total}$ =	0.056		ASCE 7-16 FIGURE 29.3-1
Aspect Ratio:	$Width_{sign}/Height_{sign}$ =	0.893		ASCE 7-16 FIGURE 29.3-1
Net Force Coefficient:	C_f =	1.95		ASCE 7-16 FIGURE 29.3-1
Design Wind Force:	$F = q_hGC_fA_s$ =	**0.816**	**LB**	ASCE 7-16 Eqn. 29.3-1
Overturning Moment @ Top of Fndn:		**0.024**	**LB-FT**	ASCE 7-16 FIGURE 29.3-1

TOTAL OVERTURNING MOMENT:	**20547**	**LB-FT**
TOTAL WIND FORCE:	**3969**	**LB**
HEIGHT OF RESULTANT FORCE:	**5.18**	**FT**

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PO Box 162, Auburn, WA 98071

DESIGN LOADS B:

Footing

Height:		**0.5**	FT	
Width:		**2.75**	FT	
Point of Wind Load Application:		**0.25**	FT	
Loading Area:	$A_{S\text{-}top}$ =	1.4	FT^2	
Velocity Pressure:	$q_h = 0.00256K_hK_{zt}K_dK_eV^2$			ASCE 7-16 Eqn. 26.10-1
Exposure Coefficient:	K_h =	0.57		ASCE 7-16 TABLE 26.10-1
	K_{zt} =	**1.0**		ASCE 7-16 SECTION 26.8.2 & FIGURE 26.8-1
	K_d =	0.85		ASCE 7-16 TABLE 26.6-1
	K_e =	1		ASCE 7-16 TABLE 26.9-1, NOTE 1
	q_h =	15.1	LB/FT^2	
Gust Factor:	$G = 0.925(1+0.7g_QI_zQ)/(1+0.7g_vI_z)$			ASCE 7-16 Eqn. 26.11-6
Intensity of Turbulence:	I_z =	0.305		ASCE 7-16 Eqn. 26.11-7
	g_Q =	3.40		ASCE 7-16 SECTION 26.11.4
	g_v =	3.40		ASCE 7-16 SECTION 26.11.4
Equivalent height of structure:	z_{ave} =	30.0		ASCE 7-16 SECTION 26.11.4
Background Response:	Q =	0.932		ASCE 7-16 Eqn. 26.11-8
	$L_{z\ ave}$ =	310.0		ASCE 7-16 Eqn. 26.11-9
Rigid Gust Factor:	G =	0.899		
Clearance Ratio:	$Height_{sign}/Height_{total}$ =	1.640		ASCE 7-16 FIGURE 29.3-1
Aspect Ratio:	$Width_{sign}/Height_{sign}$ =	5.500		ASCE 7-16 FIGURE 29.3-1
Net Force Coefficient:	C_f =	1.38		ASCE 7-16 FIGURE 29.3-1
Design Wind Force:	$F = q_hGC_fA_S$ =	**25.8**	**LB**	ASCE 7-16 Eqn. 29.3-1
Overturning Moment:		**6**	**LB-FT**	ASCE 7-16 FIGURE 29.3-1

Tank

Point of Application	6.56	FT	*(@ top of grade) 6" foundation+ 0.75" plate+ 30" rail and I beam+ 3.5' tank*
Tank Overturning Moment @ Grade	19168	LB-FT	

Rails

Point of Application	1.81	FT	*(@ top of foundation) 6" foundation+ 0.75"plate +15" I beam and rail*
Tank Overturning Moment @ Grade	1894	LB-FT	

Plate

Point of Application	0.53	FT	
Tank Overturning Moment @ Grade	0.433	LB-FT	*(@top of foundation) 6" foundation+ 0.375"*

TOTAL OVERTURNING MOMENT:	**21069**	**LB-FT**
TOTAL WIND FORCE:	**3995**	**LB**
HEIGHT OF RESULTANT FORCE:	**5.27**	**FT**

LOAD COMBINATIONS

Calculated By: CPA Date: 4/2/2024

DESIGN WIND FORCE		
Design Wind Force, Fw	4699	lb

WIND @ TOP OF PEDESTAL		
Force, Fw	4699	lb
OTM Arm	3.58	ft
OTM, Mu (@ Top of Pedestal)	**16,822**	lb·ft

WIND @ GROUND		
Force, Fw	4799	lb
OTM, Mu (@ Ground)	21989	lb·ft

DEAD LOADS		
Weight of Tank, D_tank	26000	lb
Foundation Thickness	2.5	ft
Foundation Length	6.5	ft
Foundation Width	5.75	ft
Number of Foundations	2	each
Unit Weight of Concrete	145	pcf
Weight of Foundation	**27,097**	lb
Total Dead Load	**53,097**	lb
Base Shear, V	1200	lb

LOAD COMBINATIONS	
Combinations Considered:	D + 0.6W
	D + 0.7E

0.7E	**840**	lb
0.6W	**2,819.4**	lb

∴ D + 0.6W is Controlling Combination

Foundation & Maximum Soil Pressure —

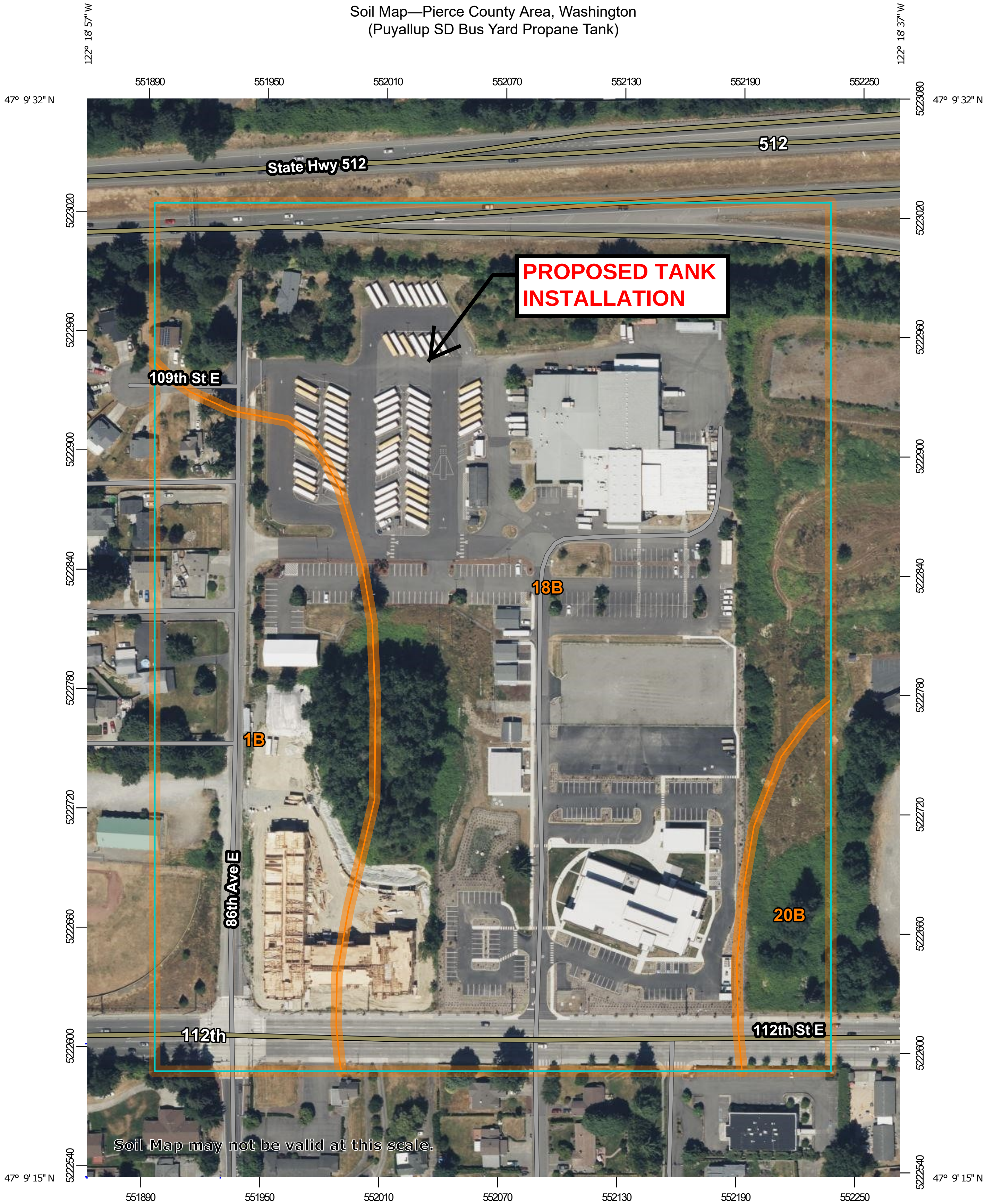
Calculated by: RJK | Dat

INPUTS		
Number of Footings	2.00	Count
Foundation Width, B (ft)	2.75	ft
Foundation Length, L (ft)	5.17	ft
Foundation Depth, Df (ft)	2.00	ft
Concrete Density (pcf)	145.00	PCF

CALCULATED VALUES		
Foundation Area per Footing (ft²)	14.22	
Foundation Volume per Footing (ft³)	28.44	
Foundation Weight — both footings (lb)	8,246.2	*Qty x L*

LOADS		
Tank Weight (lb)	20,374	
Dead Load = Foundation Weight + Tank Weight (lb)	28,620.2	
Wind Overturning Moment, OTM (lb-ft)	21,069	

ECCENTRICITY & SOIL PRESSURE		
Eccentricity, e = OTM / Dead Load (ft)	0.74	
Kern Distance = L / 6 (ft)	0.86	
Within Kern? (e ≤ L/6)	**YES**	
Max Soil Pressure (psf)	**1,866.4**	*q = P/*



Map Scale: 1:2,640 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 35, 70, 140, 210

Feet: 0, 100, 200, 400, 600

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Pierce County Area, Washington
Survey Area Data: Version 21, Aug 28, 2025

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 31, 2022—Aug 8, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
1B	Alderwood gravelly sandy loam, 0 to 8 percent slopes	8.3	22.6%
18B	Indianola loamy sand, 0 to 5 percent slopes	26.8	72.7%
20B	Kitsap silt loam, 2 to 8 percent slopes	1.7	4.7%
Totals for Area of Interest		**36.9**	**100.0%**

Engineering Properties

This table gives the engineering classifications and the range of engineering properties for the layers of each soil in the survey area.

Hydrologic soil group is a group of soils having similar runoff potential under similar storm and cover conditions. The criteria for determining Hydrologic soil group is found in the National Engineering Handbook, Chapter 7 issued May 2007(http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba). Listing HSGs by soil map unit component and not by soil series is a new concept for the engineers. Past engineering references contained lists of HSGs by soil series. Soil series are continually being defined and redefined, and the list of soil series names changes so frequently as to make the task of maintaining a single national list virtually impossible. Therefore, the criteria is now used to calculate the HSG using the component soil properties and no such national series lists will be maintained. All such references are obsolete and their use should be discontinued. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to a seasonal high water table, saturated hydraulic conductivity after prolonged wetting, and depth to a layer with a very slow water transmission rate. Changes in soil properties caused by land management or climate changes also cause the hydrologic soil group to change. The influence of ground cover is treated independently. There are four hydrologic soil groups, A, B, C, and D, and three dual groups, A/D, B/D, and C/D. In the dual groups, the first letter is for drained areas and the second letter is for undrained areas.

The four hydrologic soil groups are described in the following paragraphs:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Depth to the upper and lower boundaries of each layer is indicated.

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is 15 percent or more, an appropriate modifier is added, for example, "gravelly."

Classification of the soils is determined according to the Unified soil classification system (ASTM, 2005) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO, 2004).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to particle-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of particle-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

Percentage of rock fragments larger than 10 inches in diameter and 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

References:

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Report—Engineering Properties

Absence of an entry indicates that the data were not estimated. The asterisk '*' denotes the representative texture; other possible textures follow the dash. The criteria for determining the hydrologic soil group for individual soil components is found in the National Engineering Handbook, Chapter 7 issued May 2007(http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba). Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Engineering Properties–Pierce County Area, Washington														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
1B—Alderwood gravelly sandy loam, 0 to 8 percent slopes														
Alderwood	85	B	0-7	Gravelly sandy loam	SM, GM	A-2, A-1	0- 0- 10	0- 0- 10	50-70-75	45-64-75	35-52-60	20-29-35	30-35-45	NP-2 -5
			7-21	Very gravelly sandy loam, very gravelly coarse sandy loam, gravelly loam	GP-GM, GM, SM	A-1, A-2	0- 0- 10	0- 0- 20	25-50-75	20-45-75	15-34-60	5-16- 30	15-26-35	NP-0 -5
			21-30	Very gravelly sandy loam, very gravelly coarse sandy loam, gravelly loam	GP-GM, GM	A-1, A-2	0- 0- 10	0- 0- 20	25-45-75	20-40-75	15-29-60	5-14- 35	15-24-30	NP-0 -5
			30-35	Very gravelly sandy loam, extremely gravelly loam, extremely gravelly coarse sandy loam	GP-GM, GC-GM	A-1	0- 0- 5	0- 0- 25	15-43-50	10-37-50	5-26- 40	5-12- 20	15-17-25	NP-0 -5
			35-43	Very gravelly sandy loam, very gravelly coarse sandy loam, gravelly fine sandy loam, very gravelly loamy sand	GM, SC-SM	A-1, A-2	0- 0- 5	0- 0- 10	50-55-80	45-51-80	35-39-65	15-19-35	15-17-25	NP-0 -5

Engineering Properties–Pierce County Area, Washington														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
			43-59	Very gravelly sandy loam, very gravelly coarse sandy loam, gravelly fine sandy loam, very gravelly loamy sand	GM, SC-SM	A-1, A-2	0- 0- 5	0- 0- 10	50-56-80	45-51-80	35-39-65	15-19-35	15-17 -25	NP-0 -5
18B—Indianola loamy sand, 0 to 5 percent slopes														
Indianola	85	A	0-1	Slightly decomposed plant material	PT	A-8	0- 0- 0	0- 0- 0	100-100 -100	100-100 -100	60-75-100	50-65-90	—	—
			1-6	Loamy sand	SM	A-2	0- 0- 0	0- 0- 0	90-100-100	90-100-100	65-75-80	20-25-30	0-20 -30	NP-0 -5
			6-17	Loamy sand, loamy fine sand	SM	A-2	0- 0- 0	0- 0- 0	90-100-100	90-100-100	65-75-80	20-25-30	0-0 -30	NP-0 -5
			17-27	Loamy fine sand, sand	SM, SP-SM, SC-SM	A-2, A-3	0- 0- 0	0- 0- 0	85-100-100	85-100-100	65-80-85	10-15-20	0-0 -25	NP-0 -5
			27-37	Loamy sand, sand	SP-SM, SM, SC-SM	A-2, A-3	0- 0- 0	0- 0- 0	85-100-100	85-100-100	65-80-85	10-15-20	0-0 -20	NP-0 -5
			37-60	Loamy sand, sand	SC-SM, SM, SP-SM	A-2, A-3	0- 0- 0	0- 0- 0	85-100-100	85-100-100	65-80-85	10-15-20	0-0 -20	NP-0 -5

Data Source Information

Soil Survey Area: Pierce County Area, Washington
Survey Area Data: Version 21, Aug 28, 2025

Physical Soil Properties

This table shows estimates of some physical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3- or 1/10-bar (33kPa or 10kPa) moisture tension. Weight is determined after the soil is dried at 105 degrees C. In the table, the estimated moist bulk density of each soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute linear extensibility, shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. Depending on soil texture, a bulk density of more than 1.4 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Saturated hydraulic conductivity (Ksat) refers to the ease with which pores in a saturated soil transmit water. The estimates in the table are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity (Ksat) is considered in the design of soil drainage systems and septic tank absorption fields.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3- or 1/10-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported in the table as percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special design commonly is needed.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In this table, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The content of organic matter in a soil can be maintained by returning crop residue to the soil.

Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth. It is a source of nitrogen and other nutrients for crops and soil organisms.

Erosion factors are shown in the table as the K factor (Kw and Kf) and the T factor. Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and Ksat. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor Kw indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Erosion factor Kf indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their susceptibility to wind erosion in cultivated areas. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible. The groups are described in the "National Soil Survey Handbook."

Wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Reference:

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Report—Physical Soil Properties

Physical Soil Properties–Pierce County Area, Washington														
Map symbol and soil name	**Depth**	**Sand**	**Silt**	**Clay**	**Moist bulk density**	**Saturated hydraulic conductivity**	**Available water capacity**	**Linear extensibility**	**Organic matter**	**Erosion factors**			**Wind erodibility group**	**Wind erodibility index**
										Kw	**Kf**	**T**		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
1B—Alderwood gravelly sandy loam, 0 to 8 percent slopes														
Alderwood	0-7	45-65- 70	20-27- 45	5- 8- 10	1.10-1.25	14.00-42.00	0.08-0.10	0.3-0.7	7.0-12.0	.10	.17	3	5	56
	7-21	45-70- 75	10-22- 42	5- 8- 15	1.10-1.25	14.00-42.00	0.05-0.08	0.2-0.8	1.0-4.0	.10	.24			
	21-30	45-65- 80	5-27- 50	5- 8- 15	1.10-1.25	14.00-42.00	0.05-0.08	0.2-0.8	1.0-4.0	.15	.32			
	30-35	45-65- 80	5-27- 50	5- 8- 15	1.10-1.30	14.00-42.00	0.03-0.05	0.2-0.8	0.3-1.0	.15	.43			
	35-43	50-70- 74	16-25- 40	5- 5- 10	1.70-2.00	0.42-1.40	0.00	0.2-0.8	0.0-0.1	.17	.43			
	43-59	50-70- 74	16-25- 40	5- 5- 10	1.70-2.00	0.01-0.42	0.00	0.2-0.8	0.0-0.1	.17	.43			
18B—Indianola loamy sand, 0 to 5 percent slopes														
Indianola	0-1	75-85- 95	5-11- 20	0- 4- 8	0.10-0.30	42.00-705.00	0.30-0.60	—	60.0-90.0			5	2	134
	1-6	75-85- 95	5-11- 20	0- 4- 8	1.00-1.30	42.00-705.00	0.10-0.14	0.1-0.7	5.0-12.0	.05	.05			
	6-17	75-85- 95	5-13- 20	0- 2- 8	1.30-1.50	42.00-705.00	0.06-0.10	0.0-0.6	1.0-4.0	.10	.10			
	17-27	75-90- 95	5- 8- 20	0- 2- 8	1.30-1.70	42.00-705.00	0.04-0.08	0.0-0.5	0.5-2.0	.02	.02			
	27-37	75-90- 95	5- 8- 20	0- 2- 8	1.50-1.70	42.00-705.00	0.02-0.06	0.0-0.4	0.3-1.0	.02	.02			
	37-60	75-90- 95	5- 8- 20	0- 2- 8	1.50-1.70	42.00-705.00	0.02-0.06	0.0-0.4	0.3-1.0	.02	.02			

Data Source Information

Soil Survey Area: Pierce County Area, Washington
Survey Area Data: Version 21, Aug 28, 2025

Foundation Strength Calculation — Aero Controls Tank (20260

Calculated by: RJK | Date: 4/3/2026 | Reference: ACI 318-19

INPUTS

λ (Lambda) — Normal Weight Concrete	1.0	*ACI 318-19 §14.5.2.1a*
f'c — Concrete Compressive Strength (psi)	3,000	*Design Input*
b — Foundation Width (in)	33	
d — Effective Depth (in)	24	

SECTION MODULUS

Sm = b·d² / 6 (in³)	3,168.00	*ACI 318-19 §14.5.1.7*

NOMINAL MOMENT STRENGTH

Mn = 5·λ·√f'c·Sm (lb-in)	867,593	*ACI 318-19 Eqn. 14.5.2.1a*
Mn (lb-ft)	72,299	
Mn = 0.85·f'c·Sm (lb-in) [Upper Limit]	8,078,400	*ACI 318-19 Eqn. 14.5.2.1b*
Mn upper limit (lb-ft)	673,200	
Mn (governing, lb-ft) = MIN of above	72,299	*Use lesser value*

DESIGN MOMENT STRENGTH

φ (phi) — Strength Reduction Factor	0.6	*ACI 318-19*
φMn (lb-ft)	43,380	*Design Moment Capacity*

DEMAND

Mu — Applied Factored Moment (lb-ft)	21,069	*From analysis*

FLEXURE CHECK

φMn ≥ Mu ?	**OK ✓**
Utilization Ratio (Mu / φMn)	48.6%

AP Consulting Engineers PLLC
PO Box 162
Auburn, WA 98071

04/06/2026

Anchorage Strength Design Calculations:

Project: Puyallup School Bus Yard Propane Tank
APCE Job #2026005

Given:

Bolt Type: HILTI KWIK BOLT TZ2 ANCHOR

Outside Diameter of Anchor: $d_a := \left(\frac{5}{8}\right) \cdot in$

Effective Anchor Embedment Depth: $h_{ef} := 4 \cdot in$ ICC ESR-4266, Table 1

Smallest Edge Distance: $c_{a.min} := 5.50 \cdot in$

Number of Bolts Resisting Tension Force: $n_{tension} := 2$

Number of Bolts Resisting Shear Force: $n_{shear} := 4$

Effective Cross-sectional Area of Bolt: $A_{se} := 0.307\ in^2$ $A_{se} = 0.307\ in^2$

Specified Tensile Strength of Anchor Steel: $f_{uta} := 106700 \cdot psi$

Specified Compressive Strength of Concrete: $f_{prime.c} := 3000 \cdot \frac{lbf}{in^2}$

Factored Tension Load: $N_u := 1.6 \cdot \frac{20547}{(4)} \cdot lbf$

Numerator is the overturning moment caused by the wind force. The denominator is the distance between the bolts.

Factored Shear Load: $V_u := 1.6 \cdot 3969 \cdot lbf$

Wind load applied on the tank.

Tensile Strength:

ϕNn = minimum calculated value of ϕNs, ϕNcb or ϕNcbg, & ϕNpn

Nominal Anchor Strength, Ns:

$N_s := n_{tension} \cdot 18835 \cdot lbf$ Table 5, ICC ES-4266

$N_{s.max} := n_{tension} \cdot A_{se} \cdot f_{uta}$ ACI 318-19 17.6.1.2

$N_{s.max} = 65513.8\ lbf$

$N_s := min(N_s, N_{s.max})$

$N_s = 1.4\ 27600 \cdot lbf$

$\phi_{Ns} := 0.75$

$\phi_{Ns} \cdot N_s = 28252.5\ lbf$

Nominal Concrete Breakout Strength, Ncb or Ncbg:

Nominal Strength = $\frac{A_{Nc}}{A_{Nco}} \cdot \psi_{ec.N} \cdot \psi_{ed.N} \cdot \psi_{c.N} \cdot \psi_{cp.N} \cdot N_b$ ACI 318-19 Eq. 17.6.2.1b

Projected Failure Surface Area: $A_{Nc} := 138\ in^2$ ACI 318-19 17.6.2.1.1

$A_{Nc} = 1\ ft^2$

Projected Failure Surface Area of a Single Anchor: $A_{Nco} := 9 \cdot h_{ef}^2$ ACI 318-19 17.6.2.1.1

$A_{Nco} = 144\ in^2$

(The base of the rectilinear geometrical figure that results from projecting the failure surface outward 1.5hef from the centerlines of the anchor)

Coefficient for Basic Breakout Strength in Tension: $k_c := 24$ ACI 318-19 17.6.2.2.1

(**24** for cast-in anchors; **17** for post-installed anchors)

Lightweight Concrete Modification Factor: $\lambda_a := 1.0$ ACI 318-19 Table 19.2.4.1(b)

(1.0 for normalweight concrete;
0.85, for sand-lightweight concrete;
0.75 for all-lightweight concrete)

Basic Concrete Breakout Strength in Tension: $N_b = k_c \cdot \lambda_a \cdot \sqrt{f_{prime.c}} \cdot h_{ef}^{1.5}$

ACI 318-19 Eq 17.6.2.2.1

$N_b := k_c \cdot \lambda_a \cdot \sqrt{3000} \cdot 4^{1.5}$ $N_b = 10516.3$

Eccentricity of normal force on a group of anchors: $e_{prime.N} := 0$ (valid for e'N ≤ s/2)

Eccentricity Modification Factor: $\psi_{ec.N} := \mathbf{if}\left(e_{prime.N} > 0, \frac{1}{\left(1 + \frac{e_{prime.N}}{1.5 \cdot h_{ef}}\right)}, 1\right)$

$\psi_{ec.N} = 1$ ACI 318-19 Eq 17.6.2.3.1

Edge Distance Modification Factor: $\psi_{ed.N} := \mathbf{if}\left(c_{a.min} < 1.5 \cdot h_{ef}, \left(0.7 + 0.3 \cdot \frac{c_{a.min}}{1.5 \cdot h_{ef}}\right), 1\right)$

$\psi_{ed.N} = 1$ ACI 318-19 17.6.2.4

Cracking Modification Factor: $\psi_{c.N} := 1.4$ ACI 318-19 17.6.2.5

(**1.25** for cast-in anchors; **1.4** for post-installed anchors; **1.0** where analysis indicates cracking at service load levels)

Breakout Splitting Factor: $\psi_{cp.N} := 1$ ACI 318-19 17.6.2.6

(**1.0** for cast-in anchors)

Nominal Concrete Breakout Strength:

$$N_{cb} := \frac{A_{Nc}}{A_{Nco}} \cdot \psi_{ec.N} \cdot \psi_{ed.N} \cdot \psi_{c.N} \cdot \psi_{cp.N} \cdot N_b$$

$N_{cb} = 13756.6$

$\phi_{Ncb} := 0.70$

$\phi_{Ncb} \cdot N_{cb} \cdot lbf = 9629.6\ lbf$

$\phi N_n := min\left(\phi_{Ns} \cdot N_s , \phi_{Ncb} \cdot N_{cb} \cdot lbf\right)$

$\phi N_n = 9629.6\ lbf$ > N_u, therefore OK

$N_u = 8218.8\ lbf$

Shear Strength:

ϕVn = minimum calculated value of ϕVs, ϕVcb or ϕVcbg, & ϕVcp

Nominal Anchor Strength, Vs:

$V_s := n_{shear} \cdot 12355 \cdot lbf$ Table 7, ICC ESR-4266

$V_{smax} := n_{shear} \cdot 0.65 \cdot A_{se} \cdot f_{uta}$ ACI 318-19 Eq 17.7.12b

$V_s := min\left(V_s , V_{smax}\right)$

$V_s = 49420\ lbf$

$\phi_{Vs} := 0.65$

$\phi_{Vs} \cdot V_s = 32123\ lbf$

Nominal Concrete Breakout Strength, Vcb or Vcbg:

Distance from the center of an anchor shaft to the edge of concrete in the direction of the shear force: $c_{a1} := 5.5 \cdot in$ Limited per ACI 318-19 17.7.2.1.2

Distance from the center of an anchor shaft to the edge of concrete in the direction perpendicular to c_{a1}: $c_{a2} := 9 \cdot in$

Thickness of member in which an anchor is located, measured parallel to anchor axis:

$h_a := 24 \cdot in$

Maximum center to center distance between anchors perpendicular to shear:

$s_V := 61 \cdot in$

$c_{a1} := \text{if}\left(c_{a1} > \max\left(\frac{c_{a2}}{1.5}, \frac{h_a}{1.5}, \frac{s_V}{3}\right), \max\left(\frac{c_{a2}}{1.5}, \frac{h_a}{1.5}, \frac{s_V}{3}\right), c_{a1}\right)$

$c_{a1} = 5.5\ in$

Projected Concrete Failure Area of an Anchor or Group of Anchors:

$A_{Vc} := 4.5 \cdot c_{a1} \cdot c_{a1}$

$A_{Vc} = 136.1\ in^2$ ACI 318-19 17.7.2.1.1

Projected Concrete Failure Area of One Anchor When Not Limited by Corner Influences, Spacing, or Member Thickness:

$A_{Vco} := 4.5 \cdot c_{a1}^2$ ACI 318-19 17.7.2.1.3

$A_{Vco} = 136.1\ in^2$

Load Bearing Length of Anchor for Shear:

$l_e := 4\ in$ Table 7, ICC ESR-4266

$l_e = 4\ in$

Basic Concrete Shear Breakout Strength:

$V_{b.a} = 7 \cdot \left(\frac{l_e}{d_a}\right)^{0.2} \cdot \sqrt{d_a} \cdot \lambda_a \cdot \sqrt{f_{prime.c}} \cdot c_{a1}^{1.5}$

ACI 318-19 17.7.2.2.1a

$V_{b.a} := 7 \cdot \left(\frac{10}{\left(\frac{5}{4}\right)}\right)^{0.2} \cdot \sqrt{\frac{5}{4}} \cdot \sqrt{2500} \cdot 11.25^{1.5}$

$V_{b.b} = 9 \cdot \lambda \cdot \sqrt{f_{prime.c}} \cdot c_{a1}^{1.5}$

ACI 318-19 17.7.2.2.1b

$V_{b.b} := 9 \cdot 1 \cdot \sqrt{2500} \cdot 11.25^{1.5}$

$V_b := min\left(V_{b.a}, V_{b.b}\right)$

$V_b = 16980.1$

Eccentricity of Shear Force on a Group of Anchors; the Distance Between the Point of Shear Force Application and the Centroid of the Group of Anchors Resisting Shear in the Direction of the Applied Shear:

$e_{prime.V} := 0 \cdot in$

Eccentricity Modification Factor:

$$\psi_{ec.V} := \text{if}\left(e_{prime.V} > 0, \frac{1}{1 + \frac{e_{prime.V}}{1.5 \cdot c_{a1}}}, 1\right)$$

$\psi_{ec.V} = 1.00$ ACI 318-19 17.7.2.3.1

Distance from Center of an Anchor Shaft to the Edge of Concrete in the Direction Orthogonal to c1:

$c_{a2} = 9\ in$

Edge Distance Modification Factor:

$$\psi_{ed.V} := \text{if}\left(c_{a2} < 1.5 \cdot c_{a1}, 0.7 + 0.3 \cdot \frac{c_{a2}}{1.5 \cdot c_{a1}}, 1.0\right)$$

$\psi_{ed.V} = 1.00$ ACI 318-19 17.7.2.4.1

Cracking Modification Factor:

$\psi_{c.V} := 1.0$ ACI 318-19 Table 17.7.2.5.1

(**1.0** for anchors in cracked concrete with no supplementary reinforcement or edge reinforcement smaller than a no. 4 bar; **1.2** for anchors in cracked concrete with supplementary reinforcement of a no. 4 bar or greater between the anchor and the edge; **1.4** for anchors in cracked concrete with supplementary reinforcement of a no. 4 bar or greater between the anchor and the edge, and with the supplementary reinforcement enclosed within stirrups spaced at not more than 4 in.)

Depth of Member:

$h_a := 24 \cdot in$

Member Height Modification Factor:

$$\psi_{h.V} := \text{if}\left(h_a < 1.5 \cdot c_{a1}, \sqrt{\frac{1.5 \cdot c_{a1}}{h_a}}, 1\right)$$

$\psi_{h.V} = 1.00$ ACI 318-19 17.7.2.6.1

Nominal Concrete Breakout Strength in Shear of an anchor group:

$$V_{cb} := \frac{A_{Vc}}{A_{Vco}} \cdot \psi_{ec.V} \cdot \psi_{ed.V} \cdot \psi_{c.V} \cdot \psi_{h.V} \cdot V_b$$

$V_{cb} = 16980.1$ ACI 318-19 17.7.2.1b

$\phi_{Vcb} := 0.70$

Shear Strength of Group of Anchors:

$\phi_{Vcb} \cdot V_{cb} \cdot lbf = 11886.1\ lbf$

Concrete Pryout Strength, Vcp:

Pryout Strength Coefficient:

$k_{cp} := 1$ Table 7, ICC ESR-4266

Nominal Concrete Pryout Strength:

$$V_{cp} := k_{cp} \cdot N_{cb} \cdot \frac{n_{shear}}{n_{tension}}$$

$V_{cp} = 27513.2$ ACI 318-19 Eq 17.7.3.1b

$\phi_{Vcp} := 0.70$

Total Factored Pryout Strength for Anchor Group:

$\phi_{Vcp} \cdot V_{cp} \cdot lbf = 19259.2\ lbf$

$\phi V_n := min\left(\phi_{Vs} \cdot V_s, \phi_{Vcb} \cdot V_{cb} \cdot \mathbf{lbf}, \phi_{Vcp} \cdot V_{cp} \cdot \mathbf{lbf}\right)$

$\phi V_n = 11886.1\ \mathbf{lbf}$ > V_u, therefore OK

$V_u = 6350.4\ \mathbf{lbf}$

Tensile and Shear Force Interaction:

$V_u = 6350.4\ \mathbf{lbf}$ **>** $0.2 \cdot \phi V_n = 2377.2\ \mathbf{lbf}$

$N_u = 8218.8\ \mathbf{lbf}$ **>** $0.2 \cdot \phi N_n = 1925.9\ \mathbf{lbf}$

$\frac{N_u}{\phi N_n} + \frac{V_u}{\phi V_n} = 1.388$ **< 1.2**

STRUCTURAL NOTES

00700 GENERAL CONDITIONS

All materials and construction shall conform to the drawings, these notes, and any specifications for this project.

During the construction period, the Contractor shall be responsible for the safety of the construction project, including all excavation procedures. The Contractor shall provide adequate lagging, shoring, bracing, guys and protection of adjacent property, structures, streets, and utilities in accordance with all national, state, and local safety ordinances.

All information shown on the drawings relative to existing conditions is given as the best present knowledge, but without guarantee of accuracy. Where actual conditions conflict with the drawings they shall be reported to the Engineer so that the proper revisions may be made. Modification of design drawing details shall not be made without written approval of the Engineer.

Provide vertical support and lateral bracing for electrical and mechanical equipment per the applicable code requirements.

DIVISION 1 - GENERAL REQUIREMENTS

01412 BUILDING CODES

International Building Code (IBC) 2021 Edition.
Washington State Building Code
(Washington Administrative Code (WAC) Chapter 51-30)

01415 DESIGN LOADS AND CRITERIA

WIND:	
Basic Wind Speed:	110 mph
Exposure:	B
FOUNDATION:	
Soil Vertical Foundation Pressure:	2,000 PSF

01455 TESTING AND INSPECTION

All special inspection and testing shall comply with IBC Sections 1701, 1702, 1703, 1704, and other applicable building code sections and are in addition to the inspections made by the Building Official under Section 110.

Special inspections are required for the following work:

Earthwork:
- During excavation, grading, and filling
- Construction of drilled piles or caissons

Concrete:
- Placement of reinforcing steel, concrete placement and taking of concrete cylinders, where inspection is required by Section 03300
- Placement of anchor bolts, where noted on plans

Installation of adhesive anchors

Field Welding:
- Reinforcing steel
- Structural and miscellaneous steel

Installation of high-strength bolts

Special inspectors and testing laboratories shall be PROVIDED BY THE OWNER. The Contractor shall coordinate special inspections as well as standard building inspections with the construction schedule and is responsible for facilitating access to areas to be inspected. Special inspectors and testing laboratories shall be approved by the Building Official, and shall be certified by the Washington Association of Building Officials (WABO), if required by the Building Official.

The special inspector shall observe the work for conformance with the design drawings and specifications. The special inspector shall furnish inspection reports to the Building Official and the Engineer. All discrepancies shall be brought to the immediate attention of the Contractor for correction and also to the Building Official and the Engineer. The special inspector shall submit a final signed report stating whether the inspected work was in conformance with the design drawings and specifications and the applicable provisions of the building code.

Special inspections per IBC Section 1703.6 are required unless fabricator is approved per Section 1704.2.

DIVISION 2 - SITEWORK

02315 EXCAVATION AND FILL

All footings shall bear on undisturbed ground or structural fill and shall be a minimum of 18 inches below grade unless noted otherwise on the drawings.

Foundation excavations shall be examined and approved by the Engineer – or a testing laboratory approved by the owner – and the Building Official prior to the placement of any reinforcing steel or concrete.

Material for filling and backfilling shall consist of the excavated material and/or imported borrow and shall be free of organic material, construction debris, cobbles, or other debris.

Fill and backfill shall be deposited in layers not to exceed 8 inches thick for heavy equipment and 4" thick for hand operated equipment. The fill shall be properly moistened to approximate optimum requirements and thoroughly rolled or compacted with approved equipment in such a manner and extent as to produce a relative compaction of 95% of maximum dry density for optimum moisture content as determined by ASTM D 1557. Each lift shall be tested for compliance with compaction requirements by an approved laboratory. See Section 01455.

Hand tampers shall weigh at least 50 lbs. each and shall have a face area not in excess of 64 square inches. Hand tamper may be operated either manually or mechanically and shall be used only where larger power driven compaction equipment cannot be used.

DIVISION 3 - CONCRETE

03152 ANCHOR BOLTS

Materials, fabrication and erection shall conform to IBC Chapter 22, IBC Standard Section 2205, and the AISC 360-16 Specification for Structural Steel Buildings. Galvanize threaded parts, bolts, nuts, and washers exposed to weather unless noted otherwise per ASTM A 153.

Material specifications, unless noted otherwise:

Anchor Bolts:	ASTM A 307
Threaded Rod:	ASTM A 36
High-Strength Bolts:	ASTM A 325, where noted
Nuts:	ASTM A 563
Washers:	ASTM F 436
HILTI KWIK Bolt TZ2	ICC-ES ESR-3265

Substitution of other materials requires approval of the Engineer.

Provide anchor bolt configuration as shown including diameter, spacing, projection, embedment, and end configuration. Substitution of another type of anchor requires approval of the Engineer.

03210 REINFORCING STEEL

Concrete reinforcing steel shall be deformed bars conforming to ASTM A 615, Grade 60 (or A 615M-96a, Grade 420), made from new billets. Reinforcing to be welded shall be Grade 60 (Grade 420) with a Carbon Equivalent (CE) of 0.55 or less, or ASTM A 706 (or A 706M-96b). Do not use epoxy-coated reinforcing unless noted.

Bars marked with metric sizes as shown below conforming to the metric specifications and grades shown above may be substituted for the bars shown on the drawings. Bar spacing, embedment and lap lengths, reinforcing cover, bends, and hooks remain the same.

Fabrication and placement of reinforcing in concrete shall conform to ACI 318-19 as modified by IBC section 1905. Lap all reinforcing bars at all splices, corners, and intersecting walls per table below (unless noted otherwise):

	Concrete Strength (PSI)									
	2,000		3,000		4,000		5,000		6,000	
	Top	Other	Top	Other	Top	Other	Top	Other	Top	Other
#3 (#10)	27	21	22	17	19	15	17	13	15	12
#4 (#13)	35	27	29	22	25	19	22	17	20	16
#5 (#16)	44	34	36	28	31	24	28	22	25	20
#6 (#19)	53	41	43	33	37	29	34	26	31	24
#7 (#22)	77	59	63	48	55	42	49	38	45	34
#8 (#25)	87	67	72	55	63	48	56	43	55	43
#9 (#29)	98	76	81	62	71	54	63	49	57	44

Use "TOP" reinforcing values for horizontal bars with more than 12" of concrete below them in the casting position. Lap lengths (in inches) are based on normal weight concrete (in PSI) and a minimum 2 db spacing and 1 db cover (per ACI 318-19). The sizes shown (#xx) are the corresponding metric bar sizes.

Minimum cover over reinforcement, unless noted otherwise:

Concrete placed on earth:	3 inches
Concrete exposed to earth or weather:	2 inches
Other conditions (UNO):	1-1/2 inches

Reinforcing steel welding shall be performed by WABO certified welders and shall conform to IBC Sections 1901.2 and AWS Welding Code D1.4-2018 with modifications.

Reinforcing shall be securely tied in position prior to concrete placement. Reinforcing shall be supported on chairs or slab bolsters (with distribution plates if required) or concrete dobies prior to concrete placement. Support spacing shall not exceed 10 feet in each direction.

03300 CAST-IN-PLACE CONCRETE

All cast-in-place concrete shall meet the following requirements: Quality of concrete shall be determined by IBC Section 19. Minimum 28 day compressive strength shall be 2,500 PSI unless noted otherwise on the drawings or these notes. Use 5-1/2 94 LB sacks per yard of Type I cement with 6.6 gallons of water per sack of cement or submit mix design to the Engineer for review. See Section 01330. Slump shall be 4 inches plus or minus 1 inch. Use Type I-A cement where air entrainment is required. All methods and materials per IBC Chapter 19.

Water-reducing admixtures conforming to ASTM C 150 may be incorporated in the concrete design mixes and be used in strict accordance with the manufacturer's recommendations, subject to Engineer's approval.

An air-entraining agent conforming to ASTM C 150 shall be used in all concrete mixes for slabs and other flatwork to be exposed to weather. The amount of entrained air shall be 5% plus or minus 1% by volume.

Calcium chloride or other water-soluble chloride ion admixtures conforming to ASTM C 1218/C may be used in concrete not exposed to the weather and in unreinforced concrete. In any case the maximum chloride content of the concrete may not exceed the limits specified in ASTM C 318. Other types of accelerating admixtures may also be used. All admixtures shall conform to ASTM C 618 Type C or F.

Special inspection and testing is required for all reinforced concrete except for foundation concrete with a designated compressive strength not exceeding 2500 PSI and nonstructural slabs on grade.

For each class of concrete where testing is required, the special inspector shall take not less than one set of three cylinders for each day of concrete placement, or for each pour, or not less than one set for each 150 cubic yards of concrete, or not less than one set for each 5,000 square feet of surface area for slabs or walls.

Anchor bolts, dowels, and other embedded items shall be securely tied in position prior to concrete placement.

Do not add water at site. Maximum drop during placement is three feet. Consolidate concrete with a mechanical vibrator as required.

All exposed surfaces shall receive a steel trowel finish unless noted otherwise. Do not dust surfaces with dry cement to remove water.

Concrete shall be maintained in a moist condition for a minimum of five days after placement or sealed with a curing compound applied in two coats at right angles.

Follow manufacturer's application instructions and do not exceed recommended coverage.

Keyed construction joints shall be used in all cases except slabs on grade. All construction joints shall be thoroughly cleaned and all laitance shall be removed. All vertical joints shall be thoroughly wetted and slushed with a coat of neat cement immediately before placing new concrete.

Pipes other than electrical conduits shall not be embedded in structural concrete except where specifically approved. Do not embed aluminum conduits and sleeves in concrete.

03605 NON-SHRINK GROUT

Non-shrink grout shall have a minimum compressive strength of 5,000 PSI. Use non-metallic type in exposed conditions. Install per manufacturer's recommended procedure.

DIVISION 5 - METALS

05120 STRUCTURAL STEEL

Materials, fabrication and erection of structural steel shall conform to IBC Chapter 22 and the AISC 360-16 Specification for Structural Steel Buildings. Paint all structural steel exposed to weather unless noted otherwise on drawings.

Material specifications, unless noted otherwise:

Structural shapes:	ASTM A 36
Bars and plates:	ASTM A 36
Pipe:	ASTM A 500, Grade B, Standard Weight
Structural tubing/HSS:	ASTM A 500, Grade B
Bolts:	ASTM A 307
High-Strength Bolts:	ASTM A 325, where noted
Nuts:	ASTM A 563
Washers:	ASTM F 436
Filler metal:	E70XX

Substitution of other materials requires approval of the Engineer.

Galvanizing of structural shapes and fabricated parts shall be done in accordance with ASTM A 123, after fabrication. Galvanizing of threaded parts, bolts, nuts, and washers shall be done in accordance with ASTM A 153.

Welding shall be performed only by WABO certified welders and shall conform to AWS D1.1 and AISC specifications. E70T-4 weld material is not permitted. Minimum fillet weld size shall be 3/16" unless noted otherwise. Field welds shall have special inspection per IBC section 1705.2.

Reinforcing steel welding to structural steel shall conform to AWS Welding Code D1.4-2018 with modifications.

Provide 3/4" diameter air relief holes @ 12" OC each way in the horizontal surfaces of all embedded bearing plates and angles over 6" in width, when they are above the bottom of the concrete member in the casting position.