

Matchison, Darren

From: Voegele, Douglas M.
Sent: Thursday, February 12, 2026 12:03 PM
To: Matchison, Darren
Subject: FW: PID 123191 - LAW-243-11.28 - Question

Darren,

I have a task related to the LAW-243-11.28 project for ODOT District 9. The center to center spacing for a small section of the wall needs to increase to 6'-4" (see email chain below). Would you please run a supplementary analyses to see what the new deflection would be at this spacing?

[ODT D9 TO 3- JAC-327-14.99](#)

We can discuss after I return from my walk if you have any questions.

Douglas M. Voegele, P.E.
D 513.984.7567 M 513.304.2733

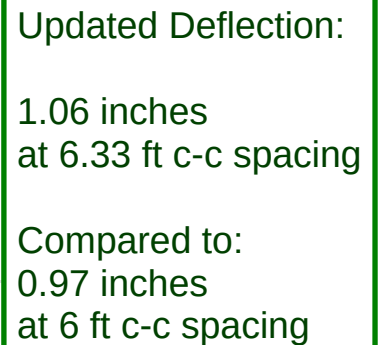
hdrinc.com/follow-us

From: Keith, Shelly <Shelly.Keith@arcadis.com>
Sent: Wednesday, February 11, 2026 11:07 AM
To: Voegele, Douglas M. <doug.voegele@hdrinc.com>; Matthew.Hurst@dot.ohio.gov
Cc: Kehres, Kevin <Kevin.Kehres@arcadis.com>; Boyer, Michael <Michael.Boyer@arcadis.com>
Subject: RE: PID 123191 - LAW-243-11.28 - Question

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Doug,

See below – the minimum king pile spacing that we need is 6'-4" c/c, and this works with a 42" plug pile. Please let us know if this will be acceptable. Thank you!

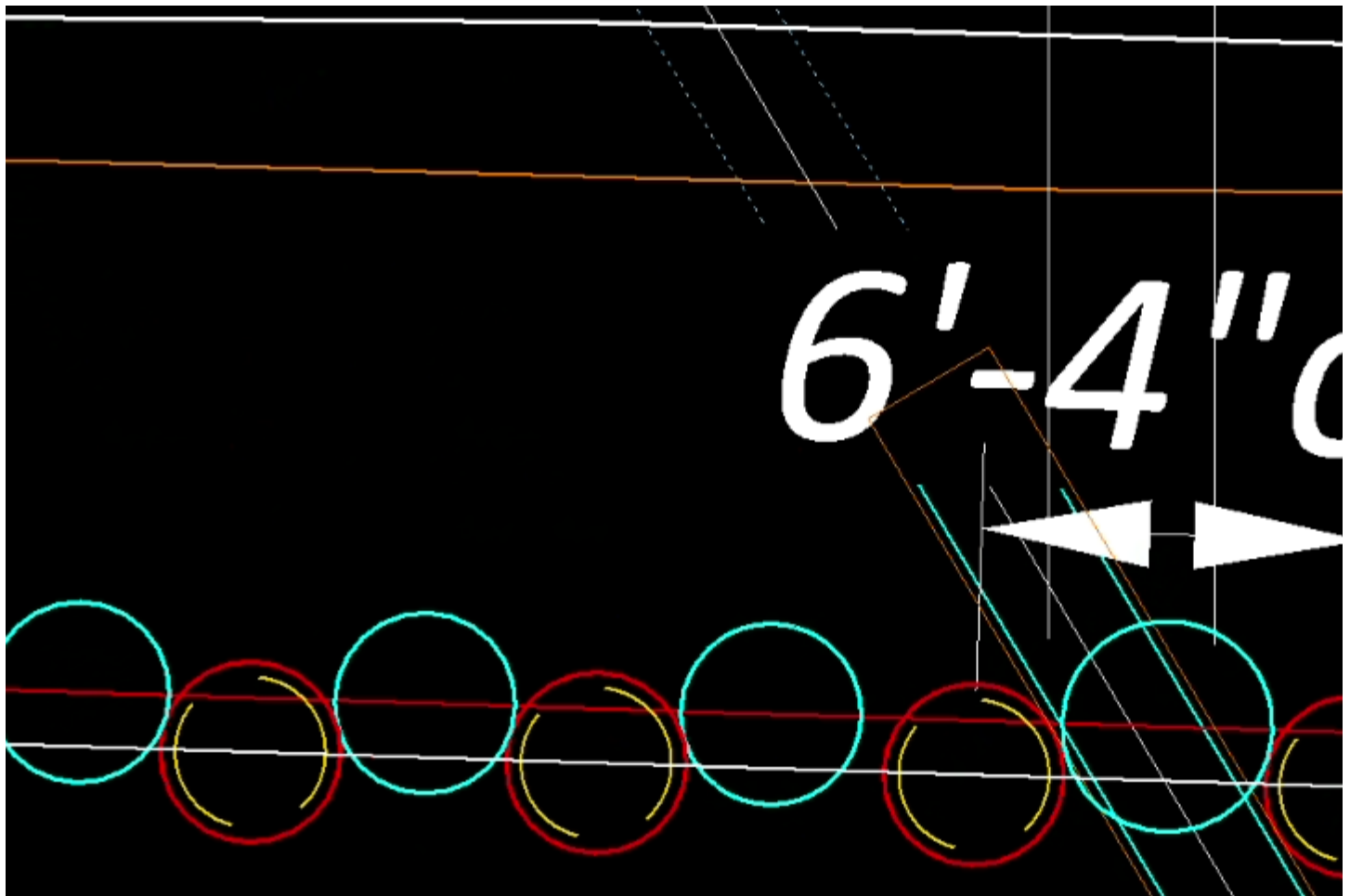


Updated Deflection:

1.06 inches
at 6.33 ft c-c spacing

Compared to:

0.97 inches
at 6 ft c-c spacing



Shelly

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From: Voegele, Douglas M. <doug.voegele@hdrinc.com>
Sent: Tuesday, February 10, 2026 4:54 PM
To: Keith, Shelly <Shelly.Keith@arcadis.com>; Matthew.Hurst@dot.ohio.gov
Cc: Kehres, Kevin <Kevin.Kehres@arcadis.com>; Boyer, Michael <Michael.Boyer@arcadis.com>
Subject: RE: PID 123191 - LAW-243-11.28 - Question

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Hi Shelly,

What is the minimum opening (center to center spacing) that is required for the pipe to fit comfortably between the two king shafts? Your initial email indicated that the 24" culvert was on such a high skew that, with the pipe thickness, it measures almost 36" along the wall. We will need this center to center spacing to check our analyses as although I suspect it will not be an issue, the wall was designed for a center to center spacing of 6 feet.

Also, the diameter of the plug pile is somewhat irrelevant provided the required opening between the king piles is met. This single plug pile can be set in front of or behind the centerline of the 36" plug piles. If the needed center to center spacing between the plug piles is equal to or greater than 42 inches, then the next available diameter for the plug pile will be 48" as the augers for the excavation or drilling of the plug pile typically come in 6" increments.

Thanks!

Doug

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D 513.984.7567 M 513.304.2733

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From: Keith, Shelly <Shelly.Keith@arcadis.com>
Sent: Tuesday, February 10, 2026 12:15 PM
To: Voegele, Douglas M. <doug.voegele@hdrinc.com>; Matthew.Hurst@dot.ohio.gov
Cc: Kehres, Kevin <Kevin.Kehres@arcadis.com>; Boyer, Michael <Michael.Boyer@arcadis.com>
Subject: RE: PID 123191 - LAW-243-11.28 - Question

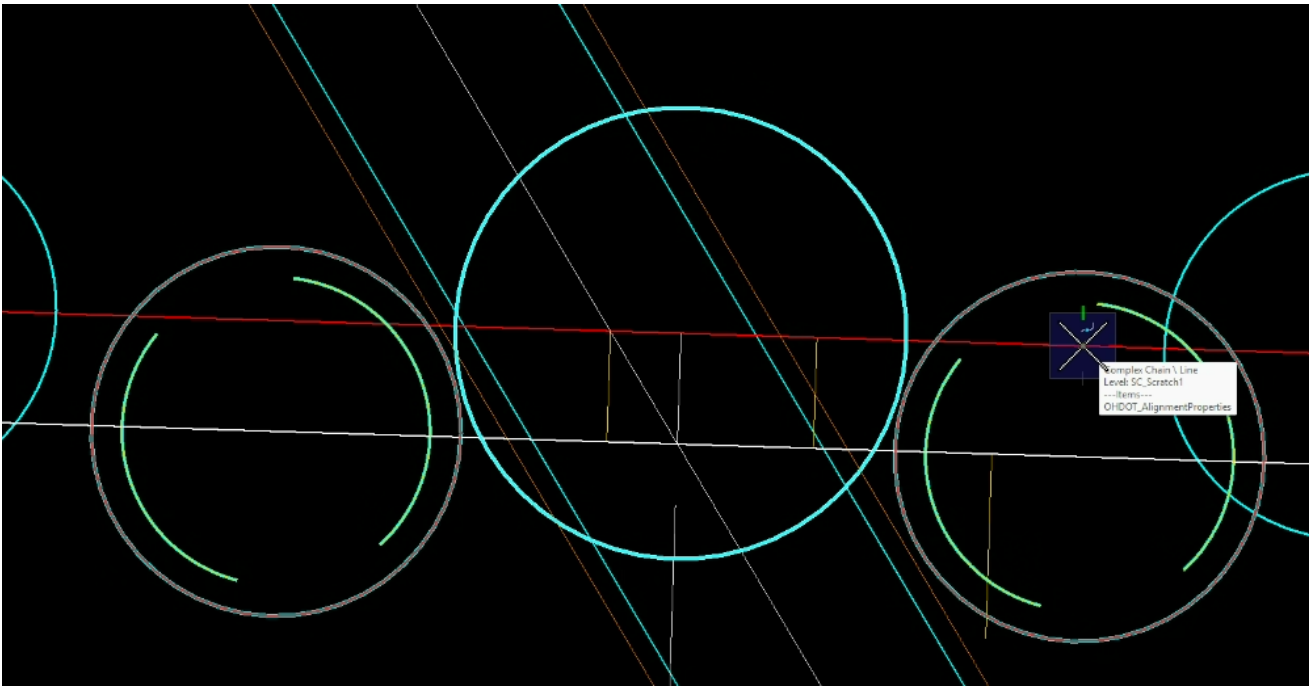
You don't often get email from shelly.keith@arcadis.com. [Learn why this is important](#)

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Doug,

A 42" plug pile still does not give us enough room. Below screenshot shows a 44" plug pile provides just barely enough room for the 24" CPP with 2" wall thickness. Would HDR accept a 44" or 46" plug pile?

Matt – Below screenshot shows 44" plug pile – this still seems like a tight fit. Depending on Doug's response, would you prefer to go with a slightly larger pile diameter or stick with the 42"? Adjusting the wall alignment would also help but I wasn't sure if that is really feasible. Please let me know what you think.



Thank you,

Shelly

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From: Voegelé, Douglas M. <doug.voegelé@hdrinc.com>
Sent: Wednesday, February 4, 2026 5:35 PM
To: Keith, Shelly <Shelly.Keith@arcadis.com>
Cc: Matthew.Hurst@dot.ohio.gov; Kehres, Kevin <Kevin.Kehres@arcadis.com>; Boyer, Michael <Michael.Boyer@arcadis.com>
Subject: RE: PID 123191 - LAW-243-11.28 - Question

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Good afternoon Shelly,

We (HDR) would recommend Option 1 in reviewing the details and options provided below in conjunction with our wall design. As you mention, this option would require slightly shifting the location of one (or both) of the adjacent king piles to allow for a 36-inch opening in the wall and passage of the heavily skewed 24-inch pipe. The diameter of the plug pile at this location would need to be increased to account for this wider opening. It may be possible to increase the diameter of the 36-inch diameter plug pile during construction without changing the auger, but I would suggest increasing the diameter of plug pile to 42 inches on paper at this one location. A precast panel similar to that which you presented should be utilized above the top of the plug pile.

Feel free to reach out with any further questions or to discuss.

Thanks,

Doug

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From: Keith, Shelly <Shelly.Keith@arcadis.com>
Sent: Tuesday, February 3, 2026 3:39 PM
To: Voegele, Douglas M. <doug.voegele@hdrinc.com>
Cc: Matthew.Hurst@dot.ohio.gov; Kehres, Kevin <Kevin.Kehres@arcadis.com>; Boyer, Michael <Michael.Boyer@arcadis.com>
Subject: PID 123191 - LAW-243-11.28 - Question

You don't often get email from shelly.keith@arcadis.com. [Learn why this is important](#)

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Good Afternoon Doug,

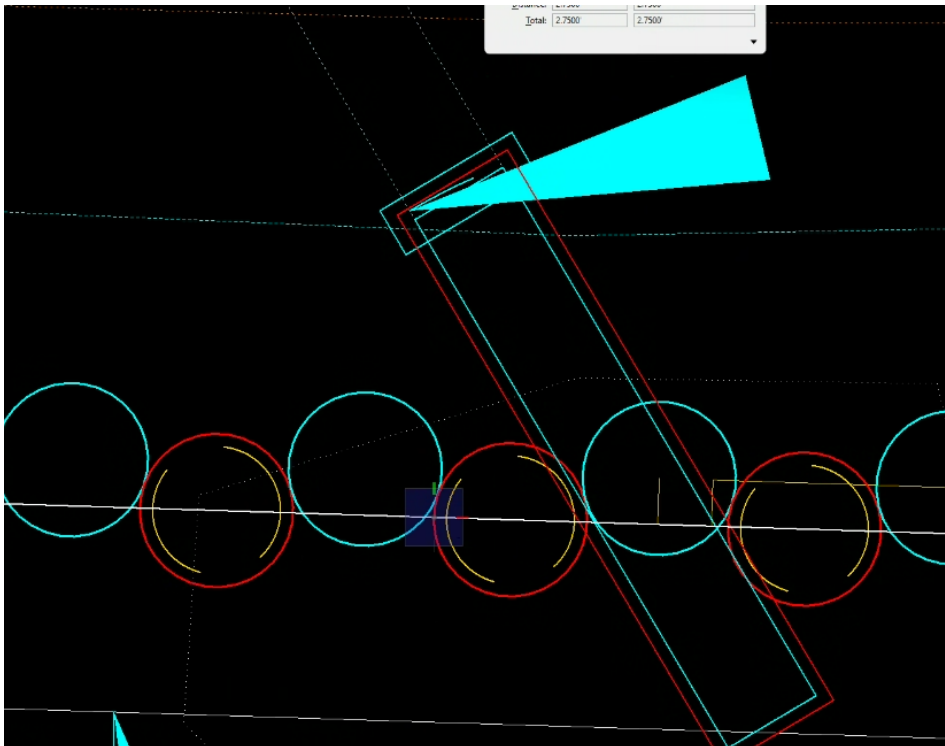
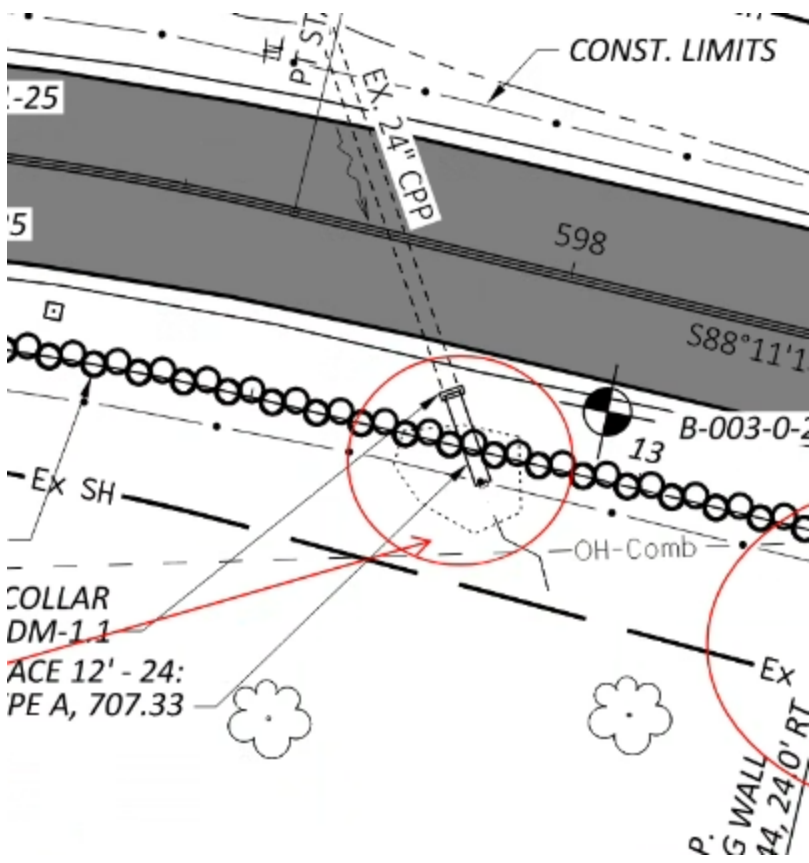
We are working on the Stage 3 plans for this project and having an issue trying to extend the existing 24" culvert over/through the proposed plug pile wall (see below). The 24" culvert is on such a high skew that with the pipe thickness, it measures almost 36" along the wall, while the max spacing between king piles is only 33". We were hoping to just take the culvert overtop of the plug pile and maybe provide a precast panel spanning between the king piles, similar to the attached.

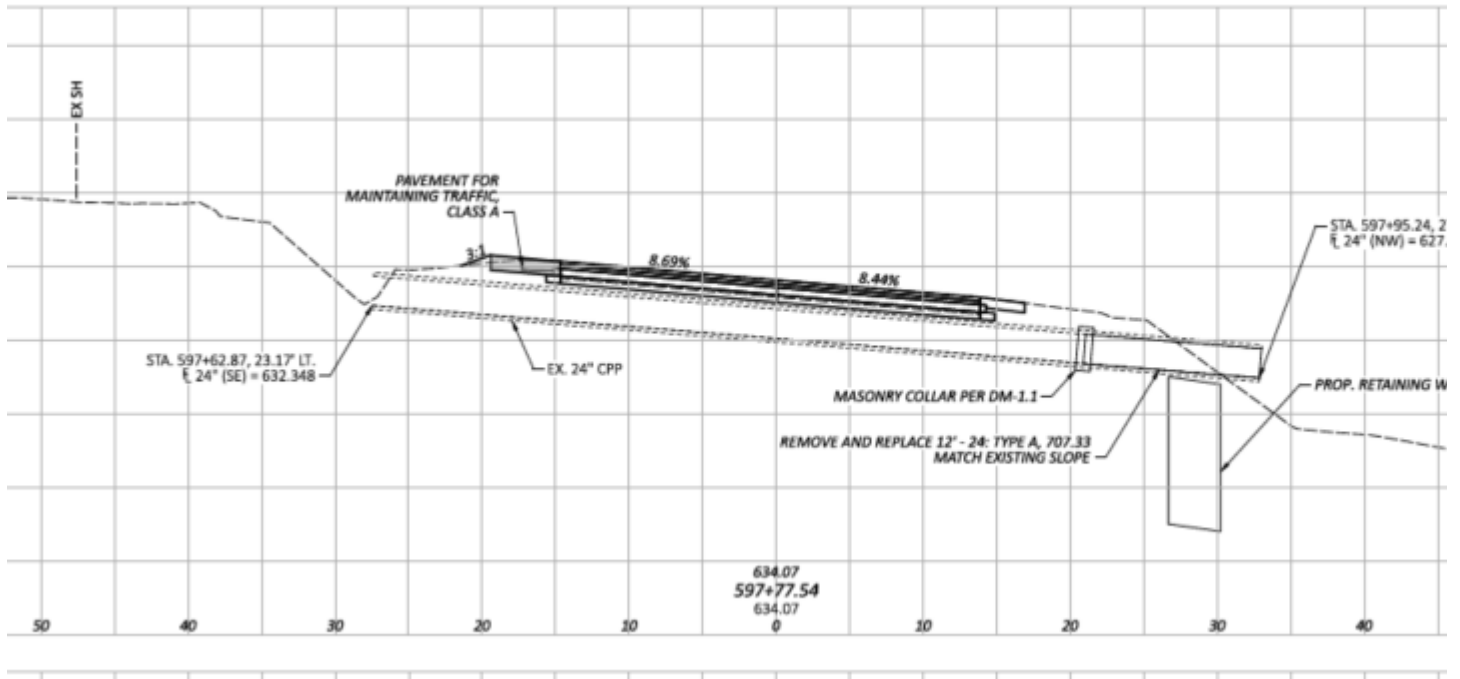
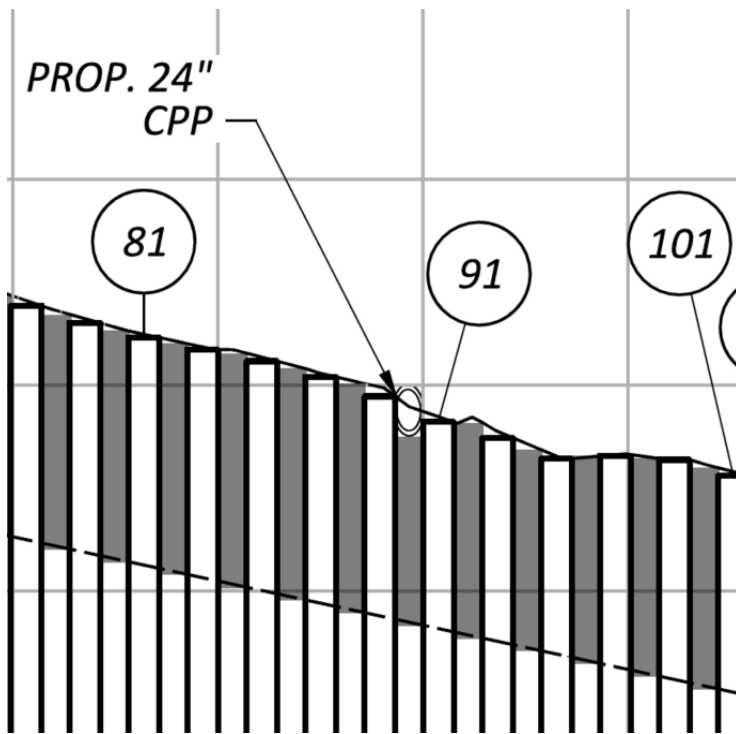
We propose one of the two following options. Would HDR agree with either of these? ODOT will require HDR's approval of the wall modification(s).

1. Slightly shift the location of one or two adjacent king piles and/or adjustment with adding an additional plug pile where the culvert is going.

OR

2. Adjust the rebar cage in the impacted king pile or starting the rebar cage lower.





Thank you,

Shelly

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Be green, leave it on the screen.

Option 1: Buried Drilled Shaft Wall

ORIGINAL Loading Calculations

Oct 2025 - HDR Geohazard Report

(6 ft c-c spacing)

Traffic surcharge omitted as it is accounted for in the wall loading calculations.

FileRunOptionsHelp

Calculated Results

Factor of Safety: 55.84

Force per Shaft: 63167.990 lb

Acting Point X: 26.400 ft Y: 19.475 ft

Analysis Unit System

English

Metric

Number of Vertical Sections and Soil Layers

Vertical Section Num: 13

Soil Layer Num: 8

Analysis Method

Total Stress

Effective Stress

Soil Properties

	Cohesion (psf)	Friction Angle	Total Unit Weight (pcf)
Layer1	0.1	0.0	250.0
Layer2	200.0	26.0	115.0
Layer3	60.0	20.0	120.0
Layer4	80.0	21.0	115.0
Layer5	160.0	23.0	115.0
Layer6	25.0	12.0	130.0
Layer7	350.0	27.0	130.0
Layer8	4000.0	45.0	140.0

Surcharge

New Fill

Soft to M.S. Cohesive

M.S. to S. Cohesive

S. to V.S. Cohesive

Soft Rock

Hard Cohesive

Bedrock

Parameter adjusted to match FS of existing condition in Slope/W.

Drilled Shaft Information

Calculate without Drilled Shaft

Automatic Load Transfer Factor

Manually Defined Load Transfer Factor

Anchor (On/Off)

Anchor force: 0.00 lb

Anchor angle: 0.00

Anchor spacing: 0.00 ft

Auto On Off 0.000 (ft)

Xmin 0.00 Diameter: 3.00 ft

Xmax 0.00 CTC Spacing: 6.00 ft

XDelta 0.00 X Coordinate: 26.40 ft

Auto Save Data

Run

Chart (Double-Click for More Options)

Slope Profile Vertical Sections

	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8	Section 9	Section 10	Section 11	Section 12	Section 13
X (ft)	-12.50	-9.30	-7.30	14.30	14.30	19.10	22.50	26.40	26.40	30.80	32.20	45.80	53.70
Y1 (ft)	7.40	7.40	7.50	8.90	8.90	9.70	10.40	11.60	11.60	12.90	13.30	20.50	19.80
Y2 (ft)	7.40	7.40	7.50	8.90	8.90	9.70	10.40	11.60	11.60	12.90	13.30	20.50	19.80
Y3 (ft)	7.40	7.40	7.50	8.90	8.90	9.70	10.40	11.60	11.60	12.90	13.30	20.50	19.80
Y4 (ft)	13.20	13.30	13.30	13.10	13.10	13.10	14.00	15.10	15.10	16.30	16.70	20.50	19.80
Y5 (ft)	18.00	18.20	18.30	19.40	19.40	19.60	19.80	19.90	19.90	20.10	20.20	20.80	21.20
Y6 (ft)	20.00	20.20	20.30	21.00	21.00	21.10	21.30	21.40	21.40	21.60	21.70	22.30	22.70
Y7 (ft)	23.00	23.20	23.30	24.00	24.00	24.10	24.30	24.40	24.40	24.60	24.70	25.30	25.70
Y8 (ft)	30.90	30.90	30.80	30.20	30.20	30.10	30.00	29.90	29.90	29.80	29.80	29.40	29.20
Y9 (ft)	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00

Coordinates of Crest X: 14.30 ft Y: 8.90 ft

Coordinates of Toe X: 45.80 ft Y: 20.50 ft

Pore Water Pressure

Pore Pressure Options:

No Pore Pressure

Constant Ratio

Specified phreatic surface

	Point 1	Point 2	Point 3	Point 4	Point 5
X (ft)	-12.50	-7.30	19.30	45.80	53.70
Y (ft)	11.60	12.30	15.10	20.50	19.80

Slip Surface

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 9	Point 10	Point 11	Point 12	Point 13	Point 14	Point 15	Point 16	Point 17	Point 18
X (ft)	-6.73	-6.05	-4.41	-2.24	-0.08	1.10	2.45	3.92	4.72	6.04	7.53	9.03	10.54	11.77	13.27	14.42	15.68	18.00
Y (ft)	7.47	7.81	8.66	9.82	10.98	11.61	12.44	13.36	13.86	14.75	15.81	16.87	17.94	18.87	20.12	21.07	21.41	21.90

Corresponds to 24' offset perpendicular to the roadway centerline.

REVISED ORIGINAL Loading Calculations

(6.33 ft c-c spacing)

UA Slope Program Version 2.3 - J:\ODOT-D9 GES\Task 1_LAW-243-11.28\20260212_Revised Spacing_6.33cc\Sta. 597+11.99 (Skew) Wall.ua3*

FileRunOptionsHelp

Calculated Results

Factor of Safety: 55.84

Force per Shaft: 66642.229 lb

Acting Point X: 26.400 ft Y: 19.475 ft

Analysis Unit System

English

Metric

Number of Vertical Sections and Soil Layers

Vertical Section Num: 13 Soil Layer Num: 8

Analysis Method

Total Stress

Effective Stress

Soil Properties

	Cohesion (psf)	Friction Angle	Total Unit Weight (pcf)
Layer1	0.1	0.0	250.0
Layer2	200.0	26.0	115.0
Layer3	60.0	20.0	120.0
Layer4	80.0	21.0	115.0
Layer5	160.0	23.0	115.0
Layer6	25.0	12.0	130.0
Layer7	350.0	27.0	130.0
Layer8	4000.0	45.0	140.0

Drilled Shaft Information

Calculate without Drilled Shaft

Automatic Load Transfer Factor

Manually Defined Load Transfer Factor

Anchor (On/Off)

Anchor force: 0.00 lb

Anchor angle: 0.00

Anchor spacing: 0.00 ft

Auto

OnOff

 0.000 (ft)

Xmin 0.00 Xmax 0.00 XDelta 0.00

Diameter: 3.00 ft

CTC Spacing: 6.33 ft

X Coordinate: 26.40 ft

Run

Chart (Double-Click for More Options)

Slope Profile Vertical Sections

	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8	Section 9	Section 10	Section 11	Section 12	Section 13
X (ft)	-12.50	-9.30	-7.30	14.30	14.30	19.10	22.50	26.40	26.40	30.80	32.20	45.80	53.70
Y1 (ft)	7.40	7.40	7.50	8.90	8.90	9.70	10.40	11.60	11.60	12.90	13.30	20.50	19.80
Y2 (ft)	7.40	7.40	7.50	8.90	8.90	9.70	10.40	11.60	11.60	12.90	13.30	20.50	19.80
Y3 (ft)	7.40	7.40	7.50	8.90	8.90	9.70	10.40	11.60	11.60	12.90	13.30	20.50	19.80
Y4 (ft)	13.20	13.30	13.30	13.10	13.10	13.10	14.00	15.10	15.10	16.30	16.70	20.50	19.80
Y5 (ft)	18.00	18.20	18.30	19.40	19.40	19.60	19.80	19.90	19.90	20.10	20.20	20.80	21.20
Y6 (ft)	20.00	20.20	20.30	21.00	21.00	21.10	21.30	21.40	21.40	21.60	21.70	22.30	22.70
Y7 (ft)	23.00	23.20	23.30	24.00	24.00	24.10	24.30	24.40	24.40	24.60	24.70	25.30	25.70
Y8 (ft)	30.90	30.90	30.80	30.20	30.20	30.10	30.00	29.90	29.90	29.80	29.80	29.40	29.20
Y9 (ft)	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00

Coordinates of Crest X: 14.30 ft Y: 8.90 ft

Coordinates of Toe X: 45.80 ft Y: 20.50 ft

Pore Water Pressure

Pore Pressure Options: No Pore PressureConstant RatioSpecified phreatic surface

	Point 1	Point 2	Point 3	Point 4	Point 5
X (ft)	-12.50	-7.30	19.30	45.80	53.70
Y (ft)	11.60	12.30	15.10	20.50	19.80

Slip Surface

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 9	Point 10	Point 11	Point 12	Point 13	Point 14	Point 15	Point 16	Point 17	Point 18
X (ft)	-6.73	-6.05	-4.41	-2.24	-0.08	1.10	2.45	3.92	4.72	6.04	7.53	9.03	10.54	11.77	13.27	14.42	15.68	18.00
Y (ft)	7.47	7.81	8.66	9.82	10.98	11.61	12.44	13.36	13.86	14.75	15.81	16.87	17.94	18.87	20.12	21.07	21.41	21.90



LPile

Geometry

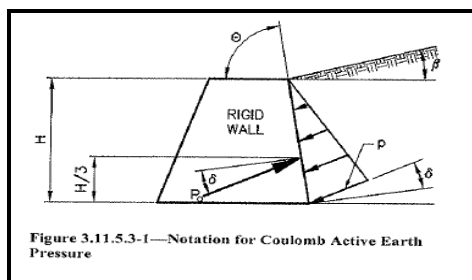
Elevation (ft)			Horiz. Distance from C/L (ft)		
Top of Slope =	641.1	at Outside Edge of Shoulder	Start of Wall Backfill =	14.3	at Outside Edge of Shoulder
Top of Wall =	638.4	at C/L of Wall	Wall =	26.4	at C/L of Wall
Existing Ground Surface =	638.4	at C/L of Wall			
Slip Plane =	626.6	at C/L of Wall	Backfill Slope Angle =	4.4	H:1V

Wall Loading Profile

	Top Elev.		Cohesion (psf)	Phi (deg)	Unit Wt (pcf)
Soft to Medium Stiff Cohesive	638.4	3.5	60	20	120
Medium Stiff to Stiff Cohesive	634.9	3.0	80	21	115
Lowered Ground Surface	631.9				
Weighted Value		6.5	70	20	120

Earth Pressure Coefficients

	Deg	
Shear Resistance, Φ =	21	
Wall Friction, δ^A =	0.0	
Wall Slope, θ =	90	
Backfill Slope, β =	12.80	
Revised Backfill Slope, β =	12.80	
Backfill Condition	INFINITE	
Horz. Backslope Dist.	12.1	feet (C/L of Wall - Edge of Shoulder)
Wall Height (H)	0.0	feet (Top of Wall - Maintenance Bench)
Slope Height (h)	2.7	feet (Top of Backfill - Top of Wall)
I =		degrees



Active Earth Coefficient

$$K_a = \frac{\sin^2(\theta + \Phi)}{(\sin^2(\theta) * \sin(\theta - \delta) * [1 + \sqrt{(\sin(\Phi + \delta) * \sin(\Phi - \beta)) / (\sin(\theta - \delta) * \sin(\theta + \beta))}]^2)}$$

$$K_a = 0.566$$

At-Rest Earth Coefficient

$$K_0 = (1 - \sin(\phi))^* (1 + \sin(\beta))$$

$$K_0 = 0.775$$

Notes:

- A. Wall friction neglected
- B. Figure and Equation for Active Earth Pressure from AASHTO 3.11.5.3 (LRFD Design Manual).
- C. The wall is designed to be completely buried. The soil parameters as determined by backcalculation in SlopeW ($c' = 70$ psf and $\phi' = 20^\circ$, per backcalculated UA Slope Values), were converted to equivalent soil strength parameters $c' = 0$ psf and $\phi' = 21^\circ$ for computing earth pressures based on a 1 degree increase in friction angle for every 50 psf decrease in cohesion up to 150 psf (Ref: Hall's Thesis).

Soil Lateral Design Profile

	Top Elev	Depth (ft)	Cohesion (psf)	Phi (deg)	Unit Wt (pcf)	ε50	k
Medium Stiff to Stiff Cohesive	631.9	6.5	900	0	52.6	0.01	N/A
Stiff to Very Stiff Cohesive	630.1	8.3	2600	0	52.6	0.005	N/A
Hard Cohesive (Residual Claystone)	628.1	10.3	4000	0	67.6	0.005	N/A
Bedrock	620.1	18.3	N/A	N/A	N/A	N/A	N/A

Bedrock Lateral Design Profile

	Top Elev	Depth (ft)	qu (psi)	Em (psi)	Unit Wt (pcf)	RQD (%)	krm
Weathered Claystone (SPT Refusal)	620.1	18.3	75	18,000	145	20	0.0005
Claystone	612.6	25.8	150	51,400	145	20	0.0005
Siltstone	611.9	26.5	850	386,300	160	60	0.0005
Claystone	601.6	36.8	150	51,400	145	20	0.0005

Depths referenced below the top of wall, starting at the lowered ground surface. ϵ_{50} and k values per LPile Technical Manual.

Wall Loading Computations

Earth Pressure Model = **CONVENTIONAL** (Conventional or UA SLOPE)

UA SLOPE

1) Soil Unit Weight = **120** pcf Unit Weight Behind the Wall in the Lowered Ground Surface Zone

2) Determine Coefficient of Earth Pressure (K)

Restraint Condition = **ACTIVE** (Active or At-Rest)

Ka = **0.566**

3) Determine Equivalent Fluid Weight (G_H)

G_H = (γ_m) * (K_a)

G_H = **68** For application to CONVENTIONAL Earth Pressure Model

4) Artificially Lowered Ground Surface (ODOT GDM Section 903.3.2, pg. 9-14) for FS_{dh} < 1.30

Consider Lowered G. S.? **YES**

Lowered Ground Surface (ft) = **6.5** = dt (tan(β_{dh}))

β_{dh} = **28.74** = steepness of the slope downhill of the drilled shaft

FS_{dh} = **1.05** = Factor of Safety down slope of the proposed wall

d_t = **11.8** = depth below top of wall to the shear surface at the location of the drilled shaft

5) Modification of p-y curves (ODOT GDM Section 903.2, pg. 9-13)

P_m = 0.64*(S/D)^{0.34} (Ref: Reese, Isenhower, & Wang - 2006)

D = **3** feet (shaft diameter or pile flange width)

Assumed Shaft Spacing = **6.33** feet (center-to-center pile spacing)

P_m = **0.82** For retaining wall, applies from top of wall to top of rock/bottom of drilled shafts

For a row of drilled shafts, applies below shear plane to top of rock/bottom of drilled shafts

Reduce p-multiplier? **YES** For application above shear plane if using a row of spaced drilled shafts instead of a retaining wall

FS_{UAS} = **2.72** = Factor of Safety from UASlope including shafts

p-multiplier = **0.52** = (P_m - P_m/FS_{UAS}) From top of wall to bottom of shear plane

6) Determine Lateral Thrust

Conventional Earth Pressure Theory

Exposed Wall Height (H) = **0.0** feet

Wall Height (H) + GS_{AL} = **6.5**

P = 1/2 * G_H * H²

P = **1421** lbs/foot

P_{SH} = P*(Shaft Spacing) (earth loading)

P_{SH} = **8994** lbs/shaft

UA SLOPE

Depth from T/Wall to Slip Plane = **11.8** feet

Force Per Shaft = **66642** lbs/shaft

7) Resolve horizontal earth force to distributed triangular load (for LPILE)

w = 2*P_{SH}/H

w = **2780** lbs/foot per shaft (Earth - Service Limit)

11295 lbs/foot per shaft

w = **232** lbs/inch per shaft (Earth - Service Limit)

941 lbs/inch per shaft

γ_E = **1.5** Earth Load Factor

w = (2*P_{SH}/H)*γ_E

w = **347** lbs/inch per shaft (Earth - Strength Limit)

1412 lbs/inch per shaft

8) Determine live-load traffic surcharge force (P_s)

Include traffic surcharge? **YES**

Surcharge Pressure (q_s) = **250** psf

P_s = Ka * q_s * H

P_s = **915** lbs/foot

(surcharge resolved to distributed load)

1668 lbs/foot

P_s = **5791** lbs/shaft

10560 lbs/shaft

9) Resolve surcharge to distributed rectangular load (for LPILE)

w = P_s/H

w = **895** lbs/foot per shaft (surcharge - unfactored)

895 lbs/foot per shaft

w = **75** lbs/inch per shaft (surcharge - unfactored)

75 lbs/inch per shaft

γ_s = **1.75** Surcharge Load Factor - Strength I

w = (P_s/L)*γ_s

w = **131** lbs/inch per shaft (Surcharge - Strength I)

131 lbs/inch per shaft

Distributed Lateral Loads for LPILE

CONVENTIONAL

Depth (ft.)	Service (lb/in)	Strength-I (lb/in)
0	75	131
6.5	306	478

Distributed Lateral Loads for LPILE

UA SLOPE

Depth (ft.)	Service (lb/in)	Strength-I (lb/in)
0	75	131
11.8	1016	1542

Shear, Moment, and Deflection Results

Shear and Moment capacity will need to be confirmed in the final analyses.

Shaft Geometry

Shaft Diameter

36

in

Rebar Cover

3

in

Steel Reinforcing

Assumed Bar No.

8

No. of Bars

13

Percent Steel

1.01%

Yield Strength of Steel

60

ksi

Modulus of Elasticity of Steel (E_s)

29000000

psi

Concrete Properties

Concrete Compressive Strength (f'_c)

4000

psi

Modulus of Elasticity of Concrete (E_c)

3604997

psi

Maximum Shear and Moment (from LPile)

V_u =

121.2

kip

M_u =

7001.2

in*kip

Deflection Criteria

Pile Length Above Rock =

18.3

ft

Pile Length Above Rock =

219.6

in

Exposed Wall Height =

0

ft

Exposed Wall Height =

in

1.)

Per the ODOT GDM, pile-head deflection in the service limit state limited to 1% or less of the shaft length above bedrock, or 1% of total drilled shaft length if not embedded in bedrock.

2.)

Following industry acceptance criteria, limit wall deflection to 1% of exposed wall height where ODOT landslide criteria does not govern. Alternatively, limit wall deflection to 1.5% of the exposed wall height in accordance with NCDOT guidelines. Use 1.5% wall deflection for PYWALL software.

ODOT Landslide Criteria Governs

YES

1% Wall Height OR 2 inches- LPILE

0

in

δ =

1.062

in

(from LPILE)

1.5% Wall Height - PYWALL

in

δ =

in

(from PYWALL)

Drilled Shafts Located Within 10 feet of Edge of Pavement

YES

=====

LPile for Windows, Version 2022-12.009

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method
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Files Used for Analysis

Path to file locations:
\ODOT-D9 GES\Task 1_LAW-243-11.28\20260212_Revised Spacing_6.33cc\

Name of input data file:
LAW-243-11.28 Wall Design.lp12d

Name of output report file:
LAW-243-11.28 Wall Design.lp12o

Name of plot output file:
LAW-243-11.28 Wall Design.lp12p

Name of runtime message file:
LAW-243-11.28 Wall Design.lp12r

Date and Time of Analysis

Date: February 12, 2026

Time: 16:18:19

Problem Title

Project Name: LAW-243-11.28

Job Number:

Client: ODOT

Engineer: HDR

Description: Buried Drilled Shaft Wall -6 ft 4 inch c-c spacing

Program Options and Settings

Computational Options:

- Conventional Analysis

Engineering Units Used for Data Input and Computations:

- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

- | | | |
|--|---|---------------|
| - Maximum number of iterations allowed | = | 500 |
| - Deflection tolerance for convergence | = | 1.0000E-05 in |
| - Maximum allowable deflection | = | 100.0000 in |
| - Number of pile increments | = | 100 |

Loading Type and Number of Cycles of Loading:

- Static loading specified
- Analysis uses p-y modification factors for p-y curves
- Analysis uses layering correction (Method of Georgiadis)
- Analysis includes loading by multiple distributed lateral loads acting on pile

- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:

- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

----- Pile Structural Properties and Geometry -----

Number of pile sections defined	=	1
Total length of pile	=	25.300 ft
Depth of ground surface below top of pile	=	6.5000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	36.0000
2	25.300	36.0000

Input Structural Properties for Pile Sections: -----

Pile Section No. 1:

Section 1 is a round drilled shaft, bored pile, or CIDH pile	
Length of section	= 25.300000 ft
Shaft Diameter	= 36.000000 in

Soil and Rock Layering Information

The soil profile is modelled using 7 layers

Layer 1 is stiff clay without free water

Distance from top of pile to top of layer	=	6.500000 ft
Distance from top of pile to bottom of layer	=	8.300000 ft
Effective unit weight at top of layer	=	52.600000 pcf
Effective unit weight at bottom of layer	=	52.600000 pcf
Undrained cohesion at top of layer	=	900.000000 psf
Undrained cohesion at bottom of layer	=	900.000000 psf
Epsilon-50 at top of layer	=	0.010000
Epsilon-50 at bottom of layer	=	0.010000

Layer 2 is stiff clay without free water

Distance from top of pile to top of layer	=	8.300000 ft
Distance from top of pile to bottom of layer	=	10.300000 ft
Effective unit weight at top of layer	=	52.600000 pcf
Effective unit weight at bottom of layer	=	52.600000 pcf
Undrained cohesion at top of layer	=	2600. psf
Undrained cohesion at bottom of layer	=	2600. psf
Epsilon-50 at top of layer	=	0.005000
Epsilon-50 at bottom of layer	=	0.005000

Layer 3 is stiff clay without free water

Distance from top of pile to top of layer	=	10.300000 ft
Distance from top of pile to bottom of layer	=	18.300000 ft
Effective unit weight at top of layer	=	67.600000 pcf
Effective unit weight at bottom of layer	=	67.600000 pcf
Undrained cohesion at top of layer	=	4000. psf
Undrained cohesion at bottom of layer	=	4000. psf
Epsilon-50 at top of layer	=	0.005000
Epsilon-50 at bottom of layer	=	0.005000

Layer 4 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	18.300000 ft
Distance from top of pile to bottom of layer	=	25.800000 ft
Effective unit weight at top of layer	=	145.000000 pcf
Effective unit weight at bottom of layer	=	145.000000 pcf
Uniaxial compressive strength at top of layer	=	75.000000 psi
Uniaxial compressive strength at bottom of layer	=	75.000000 psi
Initial modulus of rock at top of layer	=	18000. psi
Initial modulus of rock at bottom of layer	=	18000. psi
RQD of rock at top of layer	=	20.000000 %
RQD of rock at bottom of layer	=	20.000000 %
k _{rm} of rock at top of layer	=	0.0005000
k _{rm} of rock at bottom of layer	=	0.0005000

Layer 5 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	25.800000 ft
Distance from top of pile to bottom of layer	=	26.500000 ft
Effective unit weight at top of layer	=	145.000000 pcf
Effective unit weight at bottom of layer	=	145.000000 pcf
Uniaxial compressive strength at top of layer	=	150.000000 psi
Uniaxial compressive strength at bottom of layer	=	150.000000 psi
Initial modulus of rock at top of layer	=	51400. psi
Initial modulus of rock at bottom of layer	=	51400. psi
RQD of rock at top of layer	=	20.000000 %
RQD of rock at bottom of layer	=	20.000000 %
k _{rm} of rock at top of layer	=	0.0005000
k _{rm} of rock at bottom of layer	=	0.0005000

Layer 6 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	26.500000 ft
Distance from top of pile to bottom of layer	=	36.800000 ft
Effective unit weight at top of layer	=	160.000000 pcf
Effective unit weight at bottom of layer	=	160.000000 pcf
Uniaxial compressive strength at top of layer	=	850.000000 psi
Uniaxial compressive strength at bottom of layer	=	850.000000 psi
Initial modulus of rock at top of layer	=	386300. psi
Initial modulus of rock at bottom of layer	=	386300. psi
RQD of rock at top of layer	=	60.000000 %
RQD of rock at bottom of layer	=	60.000000 %
k _{rm} of rock at top of layer	=	0.0005000
k _{rm} of rock at bottom of layer	=	0.0005000

Layer 7 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	36.800000 ft
Distance from top of pile to bottom of layer	=	39.000000 ft
Effective unit weight at top of layer	=	145.000000 pcf
Effective unit weight at bottom of layer	=	145.000000 pcf
Uniaxial compressive strength at top of layer	=	150.000000 psi
Uniaxial compressive strength at bottom of layer	=	150.000000 psi
Initial modulus of rock at top of layer	=	51400. psi
Initial modulus of rock at bottom of layer	=	51400. psi
RQD of rock at top of layer	=	20.000000 %
RQD of rock at bottom of layer	=	20.000000 %
k _{rm} of rock at top of layer	=	0.0005000
k _{rm} of rock at bottom of layer	=	0.0005000

(Depth of the lowest soil layer extends 13.700 ft below the pile tip)

**** Warning - Possible Input Data Error ****

Values entered for effective unit weight of rock were outside the limits of 50 pcf to 150 pcf.

The maximum input value, in layer 7, for effective unit weight = 160.00 pcf

This data may be erroneous. Please check your data.

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Cohesion psf	Uniaxial qu psi	RQD %	E50 or krm	Rock Mass Modulus psi
1	Stiff Clay	6.5000	52.6000	900.0000	--	--	0.01000	--
	w/o Free Water	8.3000	52.6000	900.0000	--	--	0.01000	--
2	Stiff Clay	8.3000	52.6000	2600.	--	--	0.00500	--
	w/o Free Water	10.3000	52.6000	2600.	--	--	0.00500	--
3	Stiff Clay	10.3000	67.6000	4000.	--	--	0.00500	--
	w/o Free Water	18.3000	67.6000	4000.	--	--	0.00500	--
4	Weak Rock	18.3000	145.0000	--	75.0000	20.0000	5.00E-04	18000.
		25.8000	145.0000	--	75.0000	20.0000	5.00E-04	18000.
5	Weak Rock	25.8000	145.0000	--	150.0000	20.0000	5.00E-04	51400.
		26.5000	145.0000	--	150.0000	20.0000	5.00E-04	51400.

6	Weak	26.5000	160.0000	--	850.0000	60.0000	5.00E-04	386300.
	Rock	36.8000	160.0000	--	850.0000	60.0000	5.00E-04	386300.
7	Weak	36.8000	145.0000	--	150.0000	20.0000	5.00E-04	51400.
	Rock	39.0000	145.0000	--	150.0000	20.0000	5.00E-04	51400.

Modification Factors for p-y Curves

Distribution of p-y modifiers with depth defined using 4 points

Point No.	Depth X ft	p-mult	y-mult
1	6.500	0.5200	1.0000
2	11.800	0.5200	1.0000
3	11.800	0.8200	1.0000
4	18.300	0.8200	1.0000

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Distributed Lateral Loading for Individual Load Cases

Distributed lateral load intensity for Load Case 1 defined using 2 points

Point No.	Depth X ft	Dist. Load lb/in
1	0.000	75.000
2	11.800	1016.000

Distributed lateral load intensity for Load Case 2 defined using 2 points

Point	Depth X	Dist. Load
-------	---------	------------

No.	ft	lb/in
1	0.000	131.000
2	11.800	1542.000

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 2

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 0.0000 lbs	M = 0.0000 in-lbs	0.000000	Yes	Yes
2	1	V = 0.0000 lbs	M = 0.0000 in-lbs	0.000000	Yes	Yes

V = shear force applied normal to pile axis

M = bending moment applied to pile head

y = lateral deflection normal to pile axis

S = pile slope relative to original pile batter angle

R = rotational stiffness applied to pile head

Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).

Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Drilled Shaft (Bored Pile):

Length of Section = 25.300000 ft

Shaft Diameter	=	36.000000 in
Concrete Cover Thickness (to edge of long. rebar)	=	3.000000 in
Number of Reinforcing Bars	=	13 bars
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Shaft	=	1018. sq. in.
Total Area of Reinforcing Steel	=	10.270000 sq. in.
Area Ratio of Steel Reinforcement	=	1.01 percent
Edge-to-Edge Bar Spacing	=	5.940154 in
Maximum Concrete Aggregate Size	=	0.750000 in
Ratio of Bar Spacing to Aggregate Size	=	7.92
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in

Axial Structural Capacities:

Nom. Axial Structural Capacity = $0.85 F_c A_c + F_y A_s$	=	4042.060 kips
Tensile Load for Cracking of Concrete	=	-453.434 kips
Nominal Axial Tensile Capacity	=	-616.200 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
-----	-----	-----	-----	-----
1	1.000000	0.790000	14.500000	0.000000
2	1.000000	0.790000	12.839112	6.738486
3	1.000000	0.790000	8.236939	11.933266
4	1.000000	0.790000	1.747782	14.394279
5	1.000000	0.790000	-5.14177	13.557736
6	1.000000	0.790000	-10.85341	9.615279
7	1.000000	0.790000	-14.07866	3.470077
8	1.000000	0.790000	-14.07866	-3.47008
9	1.000000	0.790000	-10.85341	-9.61528
10	1.000000	0.790000	-5.14177	-13.55774
11	1.000000	0.790000	1.747782	-14.39428
12	1.000000	0.790000	8.236939	-11.93327
13	1.000000	0.790000	12.839112	-6.73849

NOTE: The positions of the above rebars were computed by LPile

Minimum spacing between any two bars not equal to zero = 5.940 inches
between bars 10 and 11.

Ratio of bar spacing to maximum aggregate size = 7.92

Concrete Properties:

Compressive Strength of Concrete = 4000. psi
 Modulus of Elasticity of Concrete = 3604997. psi
 Modulus of Rupture of Concrete = -474.34165 psi
 Compression Strain at Peak Stress = 0.001886
 Tensile Strain at Fracture of Concrete = -0.0001154
 Maximum Coarse Aggregate Size = 0.750000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
-----	-----
1	0.000

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
 Y = stress in reinforcing steel has reached yield stress.
 T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318-14, Section 21.2.3.
 Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
 Position of neutral axis is measured from edge of compression side of pile.
 Compressive stresses and strains are positive in sign.
 Tensile stresses and strains are negative in sign.

Axial Thrust Force = 0.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Run Msg
-----	-----	-----	-----	-----	-----	-----	-----	-----
6.25000E-07	234.8458740	375753398.	18.0000836	0.00001125	-0.00001125	0.0470968	0.2707890	
0.00000125	468.8181144	375054491.	18.0000839	0.00002250	-0.00002250	0.0939147	0.5415780	
0.00000188	701.9167212	374355585.	18.0000841	0.00003375	-0.00003375	0.1404538	0.8123671	

0.00000250	934.1416945	373656678.	18.0000843	0.00004500	-0.00004500	0.1867139	1.0831561
0.00000313	1165.	372957771.	18.0000846	0.00005625	-0.00005625	0.2326951	1.3539452
0.00000375	1396.	372258864.	18.0000848	0.00006750	-0.00006750	0.2783973	1.6247342
0.00000438	1626.	371559957.	18.0000851	0.00007875	-0.00007875	0.3238207	1.8955233
0.00000500	1854.	370861050.	18.0000853	0.00009000	-0.00009000	0.3689652	2.1663124
0.00000563	2082.	370162144.	18.0000856	0.0001013	-0.000101	0.4138308	2.4371015
0.00000625	2309.	369463237.	18.0000858	0.0001125	-0.000112	0.4584174	2.7078906
0.00000688	2309.	335875670.	8.6711586	0.00005961	-0.000188	0.2437545	-4.838600 C
0.00000750	2309.	307886031.	8.6733423	0.00006505	-0.000205	0.2656012	-5.277998 C
0.00000813	2309.	284202490.	8.6755298	0.00007049	-0.000222	0.2873954	-5.717316 C
0.00000875	2309.	263902312.	8.6777212	0.00007593	-0.000239	0.3091372	-6.156553 C
0.00000938	2309.	246308824.	8.6799163	0.00008137	-0.000256	0.3308263	-6.595710 C
0.00001000	2309.	230914523.	8.6821154	0.00008682	-0.000273	0.3524628	-7.034787 C
0.00001063	2309.	217331316.	8.6843182	0.00009227	-0.000290	0.3740466	-7.473782 C
0.00001125	2309.	205257354.	8.6865250	0.00009772	-0.000307	0.3955776	-7.912696 C
0.00001188	2309.	194454335.	8.6887357	0.0001032	-0.000324	0.4170558	-8.351529 C
0.00001250	2309.	184731618.	8.6909503	0.0001086	-0.000341	0.4384810	-8.790281 C
0.00001313	2309.	175934875.	8.6931687	0.0001141	-0.000358	0.4598532	-9.228950 C
0.00001375	2309.	167937835.	8.6953912	0.0001196	-0.000375	0.4811723	-9.667538 C
0.00001438	2309.	160636190.	8.6976175	0.0001250	-0.000392	0.5024383	-10.106043 C
0.00001500	2309.	153943015.	8.6998479	0.0001305	-0.000410	0.5236511	-10.544466 C
0.00001563	2309.	147785295.	8.7020822	0.0001360	-0.000427	0.5448106	-10.982806 C
0.00001625	2309.	142101245.	8.7043205	0.0001414	-0.000444	0.5659167	-11.421064 C
0.00001688	2309.	136838236.	8.7065628	0.0001469	-0.000461	0.5869694	-11.859238 C
0.00001750	2309.	131951156.	8.7088091	0.0001524	-0.000478	0.6079686	-12.297329 C
0.00001813	2309.	127401116.	8.7110595	0.0001579	-0.000495	0.6289142	-12.735337 C
0.00001875	2309.	123154412.	8.7133139	0.0001634	-0.000512	0.6498061	-13.173261 C
0.00001938	2309.	119181689.	8.7155724	0.0001689	-0.000529	0.6706443	-13.611100 C
0.00002000	2309.	115457261.	8.7178350	0.0001744	-0.000546	0.6914287	-14.048856 C
0.00002063	2309.	111958557.	8.7201016	0.0001799	-0.000563	0.7121592	-14.486527 C
0.00002125	2309.	108665658.	8.7223724	0.0001854	-0.000580	0.7328358	-14.924113 C
0.00002188	2309.	105560925.	8.7246473	0.0001909	-0.000597	0.7534584	-15.361614 C
0.00002250	2309.	102628677.	8.7269263	0.0001964	-0.000614	0.7740268	-15.799031 C
0.00002313	2309.	99854929.	8.7292095	0.0002019	-0.000631	0.7945410	-16.236361 C
0.00002375	2309.	97227168.	8.7314969	0.0002074	-0.000648	0.8150010	-16.673606 C
0.00002438	2309.	94734163.	8.7337884	0.0002129	-0.000665	0.8354067	-17.110766 C
0.00002563	2309.	90112985.	8.7383842	0.0002239	-0.000699	0.8760547	-17.984826 C
0.00002688	2309.	85921683.	8.7429968	0.0002350	-0.000733	0.9164845	-18.858539 C
0.00002813	2309.	82102941.	8.7476265	0.0002460	-0.000766	0.9566953	-19.731905 C
0.00002938	2309.	78609199.	8.7522734	0.0002571	-0.000800	0.9966866	-20.604920 C
0.00003063	2309.	75400661.	8.7569376	0.0002682	-0.000834	1.0364578	-21.477582 C
0.00003188	2309.	72443772.	8.7616193	0.0002793	-0.000868	1.0760082	-22.349891 C
0.00003313	2339.	70607879.	8.7663186	0.0002904	-0.000902	1.1153372	-23.221843 C
0.00003438	2426.	70578531.	8.7710355	0.0003015	-0.000936	1.1544440	-24.093436 C
0.00003563	2513.	70549088.	8.7757704	0.0003126	-0.000970	1.1933281	-24.964670 C
0.00003688	2600.	70519549.	8.7805232	0.0003238	-0.001004	1.2319889	-25.835540 C
0.00003813	2687.	70489912.	8.7852942	0.0003349	-0.001038	1.2704255	-26.706047 C

0.00003938	2774.	70460179.	8.7900834	0.0003461	-0.001071	1.3086375	-27.576186 C
0.00004063	2861.	70430347.	8.7948910	0.0003573	-0.001105	1.3466240	-28.445956 C
0.00004188	2948.	70400416.	8.7997172	0.0003685	-0.001139	1.3843844	-29.315356 C
0.00004313	3035.	70370385.	8.8045621	0.0003797	-0.001173	1.4219180	-30.184382 C
0.00004438	3121.	70340253.	8.8094259	0.0003909	-0.001207	1.4592241	-31.053032 C
0.00004563	3208.	70310021.	8.8143086	0.0004022	-0.001240	1.4963021	-31.921305 C
0.00004688	3294.	70279686.	8.8192105	0.0004134	-0.001274	1.5331512	-32.789198 C
0.00004813	3381.	70249285.	8.8239489	0.0004247	-0.001308	1.5697415	-33.656964 C
0.00004938	3467.	70218791.	8.8286702	0.0004359	-0.001342	1.6060946	-34.524410 C
0.00005063	3553.	70188198.	8.8334094	0.0004472	-0.001375	1.6422151	-35.391488 C
0.00005188	3639.	70157505.	8.8381666	0.0004585	-0.001409	1.6781024	-36.258195 C
0.00005313	3725.	70126711.	8.8429421	0.0004698	-0.001443	1.7137557	-37.124530 C
0.00005438	3811.	70095816.	8.8477359	0.0004811	-0.001476	1.7491742	-37.990489 C
0.00005563	3897.	70064818.	8.8525482	0.0004924	-0.001510	1.7843574	-38.856071 C
0.00005688	3983.	70033717.	8.8573791	0.0005038	-0.001544	1.8193044	-39.721273 C
0.00005813	4069.	70002512.	8.8622288	0.0005151	-0.001577	1.8540145	-40.586093 C
0.00005938	4155.	69971203.	8.8670975	0.0005265	-0.001611	1.8884870	-41.450529 C
0.00006063	4240.	69939789.	8.8719852	0.0005379	-0.001645	1.9227211	-42.314578 C
0.00006188	4326.	69908268.	8.8768922	0.0005493	-0.001678	1.9567160	-43.178239 C
0.00006313	4411.	69876641.	8.8818186	0.0005607	-0.001712	1.9904710	-44.041508 C
0.00006438	4496.	69844905.	8.8867646	0.0005721	-0.001745	2.0239854	-44.904384 C
0.00006563	4581.	69813062.	8.8917302	0.0005835	-0.001779	2.0572583	-45.766863 C
0.00006688	4667.	69781108.	8.8967158	0.0005950	-0.001813	2.0902890	-46.628944 C
0.00006813	4752.	69749045.	8.9017214	0.0006064	-0.001846	2.1230766	-47.490624 C
0.00006938	4837.	69716871.	8.9067472	0.0006179	-0.001880	2.1556204	-48.351900 C
0.00007063	4921.	69684584.	8.9117934	0.0006294	-0.001913	2.1879196	-49.212771 C
0.00007188	5006.	69652185.	8.9168601	0.0006409	-0.001947	2.2199733	-50.073232 C
0.00007313	5091.	69619673.	8.9219476	0.0006524	-0.001980	2.2517808	-50.933282 C
0.00007438	5176.	69587046.	8.9270559	0.0006639	-0.002014	2.2833411	-51.792919 C
0.00007563	5261.	69554537.	8.9321642	0.0006754	-0.002047	2.3149014	-52.652490 C
0.00007688	5346.	69522028.	8.9372725	0.0006869	-0.002081	2.3464617	-53.512061 C
0.00007813	5431.	69489519.	8.9423808	0.0006984	-0.002114	2.3780220	-54.371632 C
0.00007938	5513.	69455373.	8.9477019	0.0007102	-0.002147	2.4070948	-55.227271 C
0.00008063	5595.	69421227.	8.9530230	0.0007217	-0.002181	2.4361676	-56.082910 C
0.00008188	5677.	69387081.	8.9583441	0.0007332	-0.002214	2.4652404	-56.938549 C
0.00008313	5760.	69352935.	8.9636652	0.0007447	-0.002248	2.4943132	-57.794188 C
0.00008438	5849.	69321795.	8.9686969	0.0007567	-0.002281	2.5268266	-58.654782 C
0.00008563	5938.	69290655.	8.9738286	0.0007682	-0.002315	2.5593400	-59.515376 C
0.00008688	6027.	69259515.	8.9789603	0.0007797	-0.002348	2.5918534	-60.375970 C
0.00008813	6116.	69228375.	8.9840920	0.0007912	-0.002382	2.6243668	-61.236564 C
0.00008938	6205.	69197235.	8.9892237	0.0008027	-0.002415	2.6568802	-62.097158 C
0.00009063	6294.	69166095.	8.9943554	0.0008142	-0.002449	2.6893936	-62.957752 C
0.00009188	6383.	69134955.	8.9994871	0.0008257	-0.002482	2.7219070	-63.818346 C
0.00009313	6472.	69103815.	9.0046188	0.0008372	-0.002516	2.7544204	-64.678940 C
0.00009438	6561.	69072675.	9.0097505	0.0008487	-0.002549	2.7869338	-65.539534 C
0.00009563	6650.	69041535.	9.0148822	0.0008602	-0.002583	2.8194472	-66.400128 C
0.00009688	6739.	69010395.	9.0200139	0.0008717	-0.002616	2.8519606	-67.260722 C
0.00009813	6828.	68979255.	9.0251456	0.0008832	-0.002650	2.8844740	-68.121316 C
0.00009938	6917.	68948115.	9.0302773	0.0008947	-0.002683	2.9169874	-68.981910 C
0.00010063	7006.	68916975.	9.0354090	0.0009062	-0.002717	2.9495008	-69.842504 C
0.00010188	7095.	68885835.	9.0405407	0.0009177	-0.002750	2.9820142	-70.703098 C
0.00010313	7184.	68854695.	9.0456724	0.0009292	-0.002784	3.0145276	-71.563692 C
0.00010438	7273.	68823555.	9.0508041	0.0009407	-0.002817	3.0470410	-72.424286 C
0.00010563	7362.	68792415.	9.0559358	0.0009522	-0.002851	3.0795544	-73.284880 C
0.00010688	7451.	68761275.	9.0610675	0.0009637	-0.002884	3.1120678	-74.145474 C
0.00010813	7540.	68730135.	9.0661992	0.0009752	-0.002918	3.1445812	-75.006068 C
0.00010938	7629.	68698995.	9.0713309	0.0009867	-0.002951	3.1770946	-75.866662 C
0.00011063	7718.	68667855.	9.0764626	0.0009982	-0.002985	3.2096080	-76.727256 C
0.00011188	7807.	68636715.	9.0815943	0.0010097	-0.003018	3.2421214	-77.587850 C
0.00011313	7896.	68605575.	9.0867260	0.0010212	-0.003052	3.2746348	-78.448444 C
0.00011438	7985.	68574435.	9.0918577	0.0010327	-0.003085	3.3071482	-79.309038 C
0.00011563	8074.	68543295.	9.0969894	0.0010442	-0.003119	3.3396616	-80.169632 C
0.00011688	8163.	68512155.	9.1021211	0.0010557	-0.003152	3.3721750	-81.030226 C
0.00011813	8252.	68481015.	9.1072528	0.0010672	-0.003186	3.4046884	-81.890820 C
0.00011938	8341.	68449875.	9.1123845	0.0010787	-0.003219	3.4372018	-82.751414 C
0.00012063	8430.	68418735.	9.1175162	0.0010902	-0.003253	3.4697152	-83.612008 C
0.00012188	8519.	68387595.	9.1226479	0.0011017	-0.003286	3.5022286	-84.472602 C
0.00012313	8608.	68356455.	9.1277796	0.0011132	-0.003320	3.5347420	-85.333196 C
0.00012438	8697.	68325315.	9.1329113	0.0011247	-0.003353	3.5672554	-86.193790 C
0.00012563	8786.	68294175.	9.1380430	0.0011362	-0.003387	3.5997688	-87.054384 C
0.00012688	8875.	68263035.	9.1431747	0.0011477	-0.003420	3.6322822	-87.914978 C
0.00012813	8964.	68231895.	9.1483064	0.0011592	-0.003454	3.6647956	-88.775572 C
0.00012938	9053.	68200755.	9.1534381	0.0011707	-0.003487	3.6973090	-89.636166 C
0.00013063	9142.	68169615.	9.1585698	0.0011822	-0.003521	3.7298224	-90.496760 C
0.00013188	9231.	68138475.	9.1637015	0.0011937	-0.003554	3.7623358	-91.357354 C
0.00013313	9320.	68107335.	9.1688332	0.0012052	-0.003588	3.7948492	-92.217948 C
0.00013438	9409.	68076195.	9.1739649	0.0012167	-0.003621	3.8273626	-93.078542 C
0.00013563	9498.	68045055.	9.1790966	0.0012282	-0.003655	3.8598760	-93.939136 C
0.00013688	9587.	68013915.	9.1842283	0.0012397	-0.003688	3.8923894	-94.800000 CY
0.00013813	9676.	67982775.	9.1893600	0.0012512	-0.003722	3.9249028	-95.660000 CY
0.00013938	9765.	67951635.	9.1944917	0.0012627	-0.003755	3.9574162	-96.520000 CY
0.00014063	9854.	67920495.	9.1996234	0.0012742	-0.003789	3.9899296	-97.380000 CY
0.00014188	9943.	67889355.	9.2047551	0.0012857	-0.003822	4.0224430	-98.240000 CY
0.00014313	10032.	67858215.	9.2098868	0.0012972	-0.003856	4.0549564	-99.100000 CY
0.00014438	10121.	67827075.	9.2150185	0.0013087	-0.003889	4.0874698	-100.000000 CY
0.00014563	10210.	67795935.	9.2201502	0.0013202	-0.003923	4.1199832	-100.000000 CY
0.00014688	10299.	67764795.	9.2252819	0.0013317	-0.003956	4.1524966	-100.000000 CY
0.00014813	10388.	67733655.	9.2304136	0.0013432	-0.003990	4.1850100	-100.000000 CY
0.00014938	10477.	67702515.	9.2355453	0.0013547	-0.004023	4.2175234	-100.000000 CY
0.00015063	10566.	67671375.	9.2406770	0.0013662	-0.004057	4.2500368	-100.000000 CY
0.00015188	10655.	67640235.	9.2458087	0.0013777	-0.004090	4.2825502	-100.000000 CY
0.00015313	10744.	67609095.	9.2509404	0.0013892	-0.004124	4.3150636	-100.000000 CY
0.00015438	10833.	67577955.	9.2560721	0.0014007	-0.004157	4.3475770	-100.000000 CY
0.00015563	10922.	67546815.	9.2612038	0.0014122	-0.004191	4.3800904	-100.000000 CY
0.00015688	11011.	67515675.	9.2663355	0.0014237	-0.004224	4.4126038	-100.000000 CY
0.00015813	11100.	67484535.	9.2714672	0.0014352	-0.004258	4.4451172	-100.000000 CY
0.00015938	11189.	67453395.	9.2765989	0.0014467	-0.004291	4.4776306	-100.000000 CY
0.00016063	11278.	67422255.	9.2817306	0.0014582	-0.004325	4.5101440	-100.000000 CY
0.00016188	11367.	67391115.	9.2868623	0.0014697	-0.004358	4.5426574	-100.000000 CY
0.00016313	11456.	67359975.	9.2919940	0.0014812	-0.004392	4.5751708	-100.000000 CY
0.00016438	11545.	67328835.	9.2971257	0.0014927	-0.004425	4.6076842	-100.000000 CY
0.00016563	11634.	67297695.	9.3022574	0.0015042	-0.004459	4.6401976	-100.000000 CY
0.00016688	11723.	67266555.	9.3073891	0.0015157	-0.004492	4.6727110	-100.000000 CY
0.00016813	11812.	67235415.	9.3125208	0.0015272	-0.004526	4.7052244	-100.000000 CY
0.00016938	11901.	67204275.	9.3176525	0.0015387	-0.004559	4.7377378	-100.000000 CY
0.00017063	11990.	67173135.	9.3227842	0.0015502	-0.004593	4.7702512	-100.000000 CY
0.00017188	12079.	67141995.	9.3279159	0.0015617	-0.004626	4.8027646	-100.000000 CY
0.00017313	12168.	67110855.	9.3330476	0.0015732	-0.004660	4.8352780	-100.000000 CY
0.00017438	12257.	67079715.	9.3381793	0.0015847	-0.004693	4.8677914	-100.000000 CY
0.00017563	12346.	67048575.	9.3433110	0.0015962	-0.004727	4.9003048	

0.0001694	7808.	46100044.	8.1401868	0.0013787	-0.004719	3.6745836	-60.000000 CY
0.0001744	7848.	45007261.	8.0908087	0.0014108	-0.004867	3.7112211	-60.000000 CY
0.0001794	7887.	43970883.	8.0421062	0.0014426	-0.005015	3.7452725	-60.000000 CY
0.0001844	7926.	42989243.	7.9966119	0.0014744	-0.005163	3.7772930	-60.000000 CY
0.0001894	7965.	42057984.	7.9540799	0.0015063	-0.005311	3.8072622	-60.000000 CY
0.0001944	8003.	41173194.	7.9142898	0.0015383	-0.005459	3.8351594	-60.000000 CY
0.0001994	8040.	40324416.	7.8761188	0.0015703	-0.005607	3.8608174	-60.000000 CY
0.0002044	8071.	39490836.	7.8369008	0.0016017	-0.005756	3.8838761	-60.000000 CY
0.0002094	8097.	38672432.	7.7967341	0.0016324	-0.005905	3.9044611	-60.000000 CY
0.0002144	8119.	37875124.	7.7566019	0.0016628	-0.006055	3.9228073	-60.000000 CY
0.0002194	8140.	37106762.	7.7162307	0.0016927	-0.006205	3.9389617	-60.000000 CY
0.0002244	8161.	36370452.	7.6767795	0.0017225	-0.006355	3.9531313	-60.000000 CY
0.0002294	8181.	35665365.	7.6394803	0.0017523	-0.006505	3.9654712	-60.000000 CY
0.0002344	8201.	34989484.	7.6042015	0.0017822	-0.006655	3.9759626	-60.000000 CY
0.0002394	8220.	34340962.	7.5708227	0.0018123	-0.006805	3.9845861	-60.000000 CY
0.0002444	8240.	33718102.	7.5392336	0.0018424	-0.006955	3.9913220	-60.000000 CY
0.0002494	8259.	33119365.	7.5093329	0.0018726	-0.007105	3.9961502	-60.000000 CY
0.0002544	8278.	32543297.	7.4810274	0.0019030	-0.007255	3.9990498	-60.000000 CY
0.0002594	8297.	31988573.	7.4542334	0.0019334	-0.007404	3.9998484	-60.000000 CY
0.0002644	8316.	31453657.	7.4289724	0.0019640	-0.007553	3.9952503	-60.000000 CY
0.0002694	8334.	30937816.	7.4050419	0.0019947	-0.007703	3.9984609	-60.000000 CY
0.0002744	8352.	30439234.	7.3822062	0.0020255	-0.007852	3.9999101	-60.000000 CY
0.0003044	8423.	27674597.	7.2338285	0.0022018	-0.008756	3.9948036	-60.000000 CY
0.0003344	8469.	25327089.	7.1057264	0.0023760	-0.009662	3.9969623	-60.000000 CY
0.0003644	8510.	23353711.	7.0058284	0.0025527	-0.010565	3.9966011	-60.000000 CY
0.0003944	8545.	21668453.	6.9199808	0.0027291	-0.011468	3.9927976	-60.000000 CY
0.0004244	8579.	20215343.	6.8523038	0.0029079	-0.012370	3.9910213	-60.000000 CY
0.0004544	8606.	18940606.	6.7941459	0.0030871	-0.013270	3.9992404	-60.000000 CYT
0.0004844	8623.	17801649.	6.7367928	0.0032631	-0.014174	3.9875287	-60.000000 CYT
0.0005144	8632.	16781743.	6.6813287	0.0034367	-0.015081	3.9993765	-60.000000 CYT
0.0005444	8639.	15869978.	6.6295496	0.0036090	-0.015989	3.9821596	-60.000000 CYT
0.0005744	8645.	15051624.	6.5818131	0.0037804	-0.016897	3.9944591	-60.000000 CYT
0.0006044	8645.	14304491.	6.5825817	0.0039783	-0.017779	3.9921260	60.000000 CYT

Summary of Results for Nominal Moment Capacity for Section 1

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain	Max. Tens. Strain
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1	0.000	8592.889	0.00300000	-0.01283246

Note that the values of moment capacity in the table above are not factored by a strength reduction factor (ϕ -factor).

In ACI 318, the value of the strength reduction factor depends on whether the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318, or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding bending stiffnesses computed for common resistance factor values used for reinforced concrete sections.

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in ²
1	0.65	0.0000	8593.	0.0000	5585.	69426608.
1	0.75	0.0000	8593.	0.0000	6445.	67654421.
1	0.90	0.0000	8593.	0.0000	7734.	48233943.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	6.5000	0.00	N.A.	No	0.00	15615.
2	8.3000	0.6540	Yes	No	15615.	51618.
3	10.3000	1.7733	Yes	No	67233.	390580.
4	18.3000	11.8000	No	Yes	N.A.	N.A.
5	25.8000	19.3000	No	Yes	N.A.	N.A.
6	26.5000	20.0000	No	Yes	N.A.	N.A.
7	36.8000	30.3000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for

peak lateral load transfer. These soil types are soft and stiff clays,
non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 0.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	1.0620	-3.62E-05	1.49E-06	-0.00595	0.00	3.76E+11	0.00	0.00	80.0439
0.2530	1.0439	368.8941	265.9833	-0.00595	0.00	3.76E+11	0.00	0.00	95.1757
0.5060	1.0259	1615.	585.5634	-0.00595	0.00	3.76E+11	0.00	0.00	115.3514
0.7590	1.0078	3924.	966.3968	-0.00595	0.00	3.76E+11	0.00	0.00	135.5270
1.0120	0.9898	7483.	1408.	-0.00595	0.00	3.76E+11	0.00	0.00	155.7027
1.2650	0.9717	12477.	1912.	-0.00595	0.00	3.76E+11	0.00	0.00	175.8784
1.5180	0.9537	19092.	2476.	-0.00594	0.00	3.76E+11	0.00	0.00	196.0541
1.7710	0.9356	27514.	3102.	-0.00594	0.00	3.76E+11	0.00	0.00	216.2297
2.0240	0.9176	37929.	3789.	-0.00594	0.00	3.76E+11	0.00	0.00	236.4054
2.2770	0.8995	50523.	4538.	-0.00594	0.00	3.76E+11	0.00	0.00	256.5811
2.5300	0.8815	65482.	5347.	-0.00594	0.00	3.76E+11	0.00	0.00	276.7568
2.7830	0.8634	82992.	6218.	-0.00594	0.00	3.76E+11	0.00	0.00	296.9325
3.0360	0.8454	103238.	7150.	-0.00594	0.00	3.76E+11	0.00	0.00	317.1081
3.2890	0.8273	126408.	8144.	-0.00594	0.00	3.76E+11	0.00	0.00	337.2838
3.5420	0.8093	152687.	9198.	-0.00594	0.00	3.76E+11	0.00	0.00	357.4595
3.7950	0.7913	182260.	10314.	-0.00594	0.00	3.76E+11	0.00	0.00	377.6352
4.0480	0.7732	215314.	11491.	-0.00594	0.00	3.76E+11	0.00	0.00	397.8108
4.3010	0.7552	252035.	12730.	-0.00594	0.00	3.76E+11	0.00	0.00	417.9865
4.5540	0.7372	292609.	14029.	-0.00593	0.00	3.75E+11	0.00	0.00	438.1622
4.8070	0.7192	337221.	15390.	-0.00593	0.00	3.75E+11	0.00	0.00	458.3379
5.0600	0.7012	386058.	16812.	-0.00593	0.00	3.75E+11	0.00	0.00	478.5136
5.3130	0.6832	439306.	18296.	-0.00592	0.00	3.75E+11	0.00	0.00	498.6892
5.5660	0.6652	497150.	19840.	-0.00592	0.00	3.75E+11	0.00	0.00	518.8649
5.8190	0.6473	559776.	21446.	-0.00592	0.00	3.75E+11	0.00	0.00	539.0406
6.0720	0.6293	627371.	23113.	-0.00591	0.00	3.75E+11	0.00	0.00	559.2163
6.3250	0.6114	700121.	24842.	-0.00591	0.00	3.74E+11	0.00	0.00	579.3919

6.5780	0.5934	778211.	26390.	-0.00590	0.00	3.74E+11	-159.073	813.8113	599.5676
6.8310	0.5755	860361.	27755.	-0.00589	0.00	3.74E+11	-160.839	848.4418	619.7433
7.0840	0.5577	946741.	29177.	-0.00589	0.00	3.74E+11	-162.531	884.8594	639.9190
7.3370	0.5398	1037522.	30654.	-0.00588	0.00	3.73E+11	-164.146	923.2171	660.0947
7.5900	0.5220	1132873.	32188.	-0.00587	0.00	3.73E+11	-165.681	963.6860	680.2703
7.8430	0.5042	1232968.	33779.	-0.00586	0.00	3.73E+11	-167.132	1006.	700.4460
8.0960	0.4864	1337978.	35427.	-0.00585	0.00	3.72E+11	-168.495	1052.	720.6217
8.3490	0.4686	1448078.	36578.	-0.00584	0.00	3.72E+11	-534.604	3463.	740.7974
8.6020	0.4509	1560078.	37230.	-0.00583	0.00	3.72E+11	-537.477	3619.	760.9731
8.8550	0.4333	1674138.	37935.	-0.00581	0.00	3.71E+11	-540.050	3784.	781.1487
9.1080	0.4156	1790420.	38694.	-0.00580	0.00	3.71E+11	-542.306	3961.	801.3244
9.3610	0.3981	1909090.	39508.	-0.00578	0.00	3.71E+11	-544.228	4151.	821.5001
9.6140	0.3805	2030316.	40379.	-0.00577	0.00	3.70E+11	-545.796	4355.	841.6758
9.8670	0.3630	2154268.	41306.	-0.00575	0.00	3.70E+11	-546.990	4574.	861.8514
10.1200	0.3456	2281123.	42291.	-0.00573	0.00	3.70E+11	-547.784	4812.	882.0271
10.3730	0.3282	2411059.	42952.	-0.00567	0.00	7.06E+10	-800.652	7405.	902.2028
10.6260	0.3112	2541931.	43291.	-0.00556	0.00	7.05E+10	-800.945	7814.	922.3785
10.8790	0.2945	2673922.	43691.	-0.00545	0.00	7.05E+10	-800.724	8256.	942.5542
11.1320	0.2781	2807220.	44153.	-0.00533	0.00	7.04E+10	-799.975	8734.	962.7298
11.3850	0.2621	2942019.	44680.	-0.00521	0.00	7.04E+10	-798.680	9252.	982.9055
11.6380	0.2465	3078515.	45272.	-0.00508	0.00	7.04E+10	-796.824	9816.	1003.
11.8910	0.2312	3216913.	43900.	-0.00494	0.00	7.03E+10	-1253.	16447.	142.3626
12.1440	0.2164	3345076.	40320.	-0.00480	0.00	7.03E+10	-1248.	17505.	0.00
12.3970	0.2021	3461737.	36540.	-0.00465	0.00	7.02E+10	-1242.	18663.	0.00
12.6500	0.1882	3566948.	32779.	-0.00450	0.00	7.02E+10	-1236.	19934.	0.00
12.9030	0.1747	3660771.	29040.	-0.00435	0.00	7.01E+10	-1228.	21333.	0.00
13.1560	0.1618	3743277.	25325.	-0.00419	0.00	7.01E+10	-1219.	22878.	0.00
13.4090	0.1493	3814547.	21639.	-0.00402	0.00	7.01E+10	-1209.	24588.	0.00
13.6620	0.1374	3874669.	17984.	-0.00386	0.00	7.01E+10	-1198.	26489.	0.00
13.9150	0.1259	3923746.	14364.	-0.00369	0.00	7.01E+10	-1186.	28610.	0.00
14.1680	0.1150	3961887.	10782.	-0.00352	0.00	7.00E+10	-1173.	30984.	0.00
14.4210	0.1045	3989214.	7242.	-0.00334	0.00	7.00E+10	-1159.	33654.	0.00
14.6740	0.09466	4005859.	3747.	-0.00317	0.00	7.00E+10	-1143.	36671.	0.00
14.9270	0.08530	4011964.	301.0464	-0.00300	0.00	7.00E+10	-1127.	40096.	0.00
15.1800	0.07646	4007686.	-3091.	-0.00282	0.00	7.00E+10	-1108.	44007.	0.00
15.4330	0.06816	3993193.	-6427.	-0.00265	0.00	7.00E+10	-1089.	48499.	0.00
15.6860	0.06038	3968663.	-9700.	-0.00248	0.00	7.00E+10	-1068.	53693.	0.00
15.9390	0.05312	3934292.	-12908.	-0.00231	0.00	7.01E+10	-1045.	59744.	0.00
16.1920	0.04638	3890286.	-16045.	-0.00214	0.00	7.01E+10	-1021.	66851.	0.00
16.4450	0.04015	3836867.	-19106.	-0.00197	0.00	7.01E+10	-995.404	75274.	0.00
16.6980	0.03442	3774274.	-22086.	-0.00180	0.00	7.01E+10	-967.847	85362.	0.00
16.9510	0.02919	3702759.	-24980.	-0.00164	0.00	7.01E+10	-938.392	97587.	0.00
17.2040	0.02445	3622595.	-27781.	-0.00148	0.00	7.02E+10	-906.901	112601.	0.00
17.4570	0.02019	3534072.	-30483.	-0.00133	0.00	7.02E+10	-873.212	131330.	0.00
17.7100	0.01638	3437500.	-33080.	-0.00118	0.00	7.02E+10	-837.135	155119.	0.00
17.9630	0.01303	3333212.	-35562.	-0.00103	0.00	7.03E+10	-798.444	185985.	0.00
18.2160	0.01012	3221565.	-37923.	-8.90E-04	0.00	7.03E+10	-756.874	227057.	0.00

18.4690	0.00763	3102941.	-40618.	-7.54E-04	0.00	7.03E+10	-1019.	405320.	0.00
18.7220	0.00554	2974929.	-43748.	-6.22E-04	0.00	7.04E+10	-1043.	571294.	0.00
18.9750	0.00385	2837301.	-46920.	-4.97E-04	0.00	7.04E+10	-1046.	825209.	0.00
19.2280	0.00253	2690028.	-50067.	-3.78E-04	0.00	7.05E+10	-1026.	1233589.	0.00
19.4810	0.00155	2533296.	-53118.	-2.66E-04	0.00	7.05E+10	-983.808	1922282.	0.00
19.7340	9.13E-04	2367495.	-56019.	-1.60E-04	0.00	7.06E+10	-926.916	3082861.	0.00
19.9870	5.81E-04	2193151.	-58771.	-1.00E-04	0.00	3.70E+11	-886.516	4632835.	0.00
20.2400	3.04E-04	2010636.	-61337.	-8.31E-05	0.00	3.70E+11	-803.758	8033746.	0.00
20.4930	7.66E-05	1820712.	-62970.	-6.74E-05	0.00	3.71E+11	-272.179	1.08E+07	0.00
20.7460	-1.05E-04	1628280.	-62783.	-5.33E-05	0.00	3.72E+11	395.7949	1.14E+07	0.00
20.9990	-2.47E-04	1439496.	-60809.	-4.07E-05	0.00	3.72E+11	904.4444	1.11E+07	0.00
21.2520	-3.53E-04	1259048.	-57856.	-2.97E-05	0.00	3.73E+11	1041.	8955967.	0.00
21.5050	-4.28E-04	1088192.	-54537.	-2.02E-05	0.00	3.73E+11	1146.	8139455.	0.00
21.7580	-4.75E-04	927900.	-50926.	-1.20E-05	0.00	3.74E+11	1233.	7872650.	0.00
22.0110	-5.00E-04	778970.	-47074.	-5.06E-06	0.00	3.74E+11	1305.	7918502.	0.00
22.2640	-5.06E-04	642068.	-43020.	7.01E-07	0.00	3.74E+11	1365.	8190063.	0.00
22.5170	-4.96E-04	517751.	-38800.	5.40E-06	0.00	3.75E+11	1415.	8658467.	0.00
22.7700	-4.73E-04	406474.	-34445.	9.14E-06	0.00	3.75E+11	1454.	9325767.	0.00
23.0230	-4.41E-04	308598.	-29988.	1.20E-05	0.00	3.75E+11	1483.	1.02E+07	0.00
23.2760	-4.00E-04	224389.	-25458.	1.42E-05	0.00	3.76E+11	1501.	1.14E+07	0.00
23.5290	-3.54E-04	154014.	-20891.	1.57E-05	0.00	3.76E+11	1508.	1.29E+07	0.00
23.7820	-3.05E-04	97537.	-16323.	1.67E-05	0.00	3.76E+11	1502.	1.50E+07	0.00
24.0350	-2.53E-04	54902.	-11795.	1.73E-05	0.00	3.76E+11	1481.	1.78E+07	0.00
24.2880	-1.99E-04	25916.	-7552.	1.77E-05	0.00	3.76E+11	1315.	2.00E+07	0.00
24.5410	-1.45E-04	9047.	-4056.	1.78E-05	0.00	3.76E+11	988.3074	2.06E+07	0.00
24.7940	-9.13E-05	1288.	-1586.	1.79E-05	0.00	3.76E+11	638.6003	2.12E+07	0.00
25.0470	-3.71E-05	-585.291	-212.104	1.79E-05	0.00	3.76E+11	266.7247	2.19E+07	0.00
25.3000	1.72E-05	0.00	0.00	1.79E-05	0.00	3.76E+11	-126.998	1.12E+07	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

Pile-head deflection	=	1.06195905 inches
Computed slope at pile head	=	-0.0059453 radians
Maximum bending moment	=	4011964. inch-lbs
Maximum shear force	=	-62970. lbs
Depth of maximum bending moment	=	14.92700000 feet below pile head
Depth of maximum shear force	=	20.49300000 feet below pile head
Number of iterations	=	58
Number of zero deflection points	=	2

Pile deflection at ground = 0.59896328 inches

Pile-head Deflection vs. Pile Length for Load Case 1

Boundary Condition Type 1, Shear and Moment

Shear = 0. lbs
Moment = 0. in-lbs
Axial Load = 0. lbs

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
25.30000	1.06195905	4011964.	-62970.
24.03500	1.08949637	4063618.	-68737.
22.77000	1.16567081	3950810.	-77781.
21.50500	1.51219075	3693384.	-76671.
20.24000	2.74136480	3394295.	-73775.
18.97500	7.43024608	2880430.	-69112.
17.71000	16.17967085	2517552.	-69188.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 0.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	2.5433	-3.08E-04	-2.98E-06	-0.01358	0.00	3.76E+11	0.00	0.00	138.5632
0.2530	2.5021	638.5895	455.1208	-0.01358	0.00	3.76E+11	0.00	0.00	161.2528
0.5060	2.4608	2763.	990.6079	-0.01358	0.00	3.76E+11	0.00	0.00	191.5056
0.7590	2.4196	6654.	1618.	-0.01358	0.00	3.76E+11	0.00	0.00	221.7584

1.0120	2.3784	12588.	2337.	-0.01358	0.00	3.76E+11	0.00	0.00	252.0112
1.2650	2.3372	20845.	3148.	-0.01358	0.00	3.76E+11	0.00	0.00	282.2640
1.5180	2.2959	31703.	4051.	-0.01358	0.00	3.76E+11	0.00	0.00	312.5168
1.7710	2.2547	45442.	5046.	-0.01358	0.00	3.76E+11	0.00	0.00	342.7696
2.0240	2.2135	62341.	6132.	-0.01358	0.00	3.76E+11	0.00	0.00	373.0224
2.2770	2.1722	82678.	7311.	-0.01358	0.00	3.76E+11	0.00	0.00	403.2752
2.5300	2.1310	106732.	8581.	-0.01358	0.00	3.76E+11	0.00	0.00	433.5280
2.7830	2.0898	134782.	9943.	-0.01358	0.00	3.76E+11	0.00	0.00	463.7808
3.0360	2.0486	167107.	11397.	-0.01358	0.00	3.76E+11	0.00	0.00	494.0336
3.2890	2.0074	203985.	12943.	-0.01357	0.00	3.76E+11	0.00	0.00	524.2864
3.5420	1.9662	245696.	14581.	-0.01357	0.00	3.76E+11	0.00	0.00	554.5392
3.7950	1.9250	292518.	16310.	-0.01357	0.00	3.75E+11	0.00	0.00	584.7919
4.0480	1.8838	344731.	18131.	-0.01357	0.00	3.75E+11	0.00	0.00	615.0447
4.3010	1.8426	402612.	20045.	-0.01356	0.00	3.75E+11	0.00	0.00	645.2975
4.5540	1.8014	466442.	22050.	-0.01356	0.00	3.75E+11	0.00	0.00	675.5503
4.8070	1.7602	536498.	24147.	-0.01356	0.00	3.75E+11	0.00	0.00	705.8031
5.0600	1.7191	613059.	26335.	-0.01355	0.00	3.75E+11	0.00	0.00	736.0559
5.3130	1.6779	696406.	28616.	-0.01355	0.00	3.74E+11	0.00	0.00	766.3087
5.5660	1.6368	786815.	30988.	-0.01354	0.00	3.74E+11	0.00	0.00	796.5615
5.8190	1.5957	884567.	33453.	-0.01353	0.00	3.74E+11	0.00	0.00	826.8143
6.0720	1.5546	989939.	36009.	-0.01353	0.00	3.73E+11	0.00	0.00	857.0671
6.3250	1.5136	1103212.	38657.	-0.01352	0.00	3.73E+11	0.00	0.00	887.3199
6.5780	1.4726	1224663.	41093.	-0.01351	0.00	3.73E+11	-199.651	411.6236	917.5727
6.8310	1.4316	1352731.	43315.	-0.01350	0.00	3.72E+11	-201.988	428.3687	947.8255
7.0840	1.3906	1487674.	45622.	-0.01349	0.00	3.72E+11	-204.242	445.9082	978.0783
7.3370	1.3497	1629750.	48014.	-0.01347	0.00	3.72E+11	-206.409	464.3051	1008.
7.5900	1.3088	1779218.	50492.	-0.01346	0.00	3.71E+11	-208.487	483.6291	1039.
7.8430	1.2679	1936336.	53055.	-0.01344	0.00	3.71E+11	-210.471	503.9579	1069.
8.0960	1.2271	2101366.	55704.	-0.01343	0.00	3.70E+11	-212.357	525.3785	1099.
8.3490	1.1864	2274570.	57741.	-0.01341	0.00	3.70E+11	-674.342	1726.	1129.
8.6020	1.1457	2451968.	59162.	-0.01335	0.00	7.06E+10	-678.580	1798.	1160.
8.8550	1.1054	2633799.	60662.	-0.01324	0.00	7.05E+10	-682.527	1875.	1190.
9.1080	1.0653	2820306.	62242.	-0.01312	0.00	7.04E+10	-686.176	1955.	1220.
9.3610	1.0257	3011735.	63904.	-0.01300	0.00	7.04E+10	-689.519	2041.	1250.
9.6140	0.9864	3208333.	65648.	-0.01286	0.00	7.03E+10	-692.548	2132.	1281.
9.8670	0.9476	3410351.	67475.	-0.01272	0.00	7.02E+10	-695.255	2228.	1311.
10.1200	0.9092	3618043.	69387.	-0.01257	0.00	7.02E+10	-697.631	2330.	1341.
10.3730	0.8713	3831667.	70894.	-0.01241	0.00	7.01E+10	-1022.	3561.	1371.
10.6260	0.8339	4048511.	71996.	-0.01223	0.00	7.00E+10	-1025.	3731.	1402.
10.8790	0.7970	4268829.	73183.	-0.01205	0.00	6.99E+10	-1027.	3912.	1432.
11.1320	0.7607	4492878.	74455.	-0.01186	0.00	6.98E+10	-1029.	4106.	1462.
11.3850	0.7250	4720922.	75815.	-0.01166	0.00	6.98E+10	-1030.	4313.	1492.
11.6380	0.6899	4953227.	77264.	-0.01145	0.00	6.97E+10	-1031.	4536.	1523.
11.8910	0.6554	5190066.	75871.	-0.01123	0.00	6.96E+10	-1625.	7529.	216.0698
12.1440	0.6217	5413915.	71265.	-0.01100	0.00	6.95E+10	-1625.	7934.	0.00
12.3970	0.5886	5622790.	66336.	-0.01076	0.00	6.94E+10	-1623.	8370.	0.00
12.6500	0.5563	5816706.	61413.	-0.01051	0.00	6.93E+10	-1620.	8841.	0.00

12.9030	0.5248	5995689.	56500.	-0.01025	0.00	6.92E+10	-1616.	9350.	0.00
13.1560	0.4941	6159774.	51600.	-0.00998	0.00	6.90E+10	-1612.	9902.	0.00
13.4090	0.4642	6309004.	46716.	-0.00971	0.00	6.84E+10	-1606.	10502.	0.00
13.6620	0.4352	6443433.	41851.	-0.00942	0.00	6.77E+10	-1599.	11155.	0.00
13.9150	0.4070	6563125.	37009.	-0.00913	0.00	6.68E+10	-1591.	11867.	0.00
14.1680	0.3797	6668153.	32193.	-0.00883	0.00	6.58E+10	-1582.	12646.	0.00
14.4210	0.3534	6758602.	27407.	-0.00851	0.00	6.48E+10	-1571.	13499.	0.00
14.6740	0.3281	6834567.	22653.	-0.00819	0.00	6.40E+10	-1560.	14437.	0.00
14.9270	0.3037	6896153.	17936.	-0.00787	0.00	6.34E+10	-1547.	15470.	0.00
15.1800	0.2803	6943475.	13259.	-0.00753	0.00	6.27E+10	-1534.	16611.	0.00
15.4330	0.2579	6976662.	8626.	-0.00719	0.00	6.22E+10	-1519.	17875.	0.00
15.6860	0.2366	6995852.	4040.	-0.00685	0.00	6.19E+10	-1502.	19277.	0.00
15.9390	0.2163	7001194.	-494.530	-0.00651	0.00	6.19E+10	-1485.	20840.	0.00
16.1920	0.1971	6992849.	-4974.	-0.00617	0.00	6.20E+10	-1466.	22586.	0.00
16.4450	0.1789	6970990.	-9395.	-0.00583	0.00	6.23E+10	-1446.	24545.	0.00
16.6980	0.1617	6935801.	-13754.	-0.00549	0.00	6.28E+10	-1425.	26751.	0.00
16.9510	0.1456	6887479.	-18045.	-0.00516	0.00	6.35E+10	-1402.	29247.	0.00
17.2040	0.1304	6826231.	-22266.	-0.00483	0.00	6.41E+10	-1378.	32085.	0.00
17.4570	0.1162	6752281.	-26411.	-0.00451	0.00	6.49E+10	-1353.	35330.	0.00
17.7100	0.1030	6665862.	-30477.	-0.00420	0.00	6.58E+10	-1326.	39064.	0.00
17.9630	0.09075	6567225.	-34458.	-0.00389	0.00	6.68E+10	-1297.	43391.	0.00
18.2160	0.07938	6456634.	-38349.	-0.00360	0.00	6.76E+10	-1267.	48446.	0.00
18.4690	0.06888	6334367.	-42952.	-0.00331	0.00	6.82E+10	-1766.	77814.	0.00
18.7220	0.05925	6195827.	-48496.	-0.00304	0.00	6.89E+10	-1886.	96658.	0.00
18.9750	0.05044	6039900.	-54381.	-0.00277	0.00	6.91E+10	-1991.	119813.	0.00
19.2280	0.04244	5865625.	-60557.	-0.00251	0.00	6.93E+10	-2078.	148627.	0.00
19.4810	0.03522	5672197.	-66970.	-0.00225	0.00	6.94E+10	-2147.	185024.	0.00
19.7340	0.02875	5458985.	-73561.	-0.00201	0.00	6.95E+10	-2196.	231830.	0.00
19.9870	0.02301	5225534.	-80270.	-0.00178	0.00	6.96E+10	-2224.	293378.	0.00
20.2400	0.01796	4971588.	-87027.	-0.00156	0.00	6.97E+10	-2228.	376645.	0.00
20.4930	0.01357	4697104.	-93758.	-0.00134	0.00	6.98E+10	-2206.	493644.	0.00
20.7460	0.00979	4402288.	-100374.	-0.00115	0.00	6.99E+10	-2152.	667076.	0.00
20.9990	0.00660	4087636.	-106764.	-9.63E-04	0.00	7.00E+10	-2057.	946102.	0.00
21.2520	0.00395	3754020.	-112777.	-7.93E-04	0.00	7.01E+10	-1904.	1463818.	0.00
21.5050	0.00179	3402855.	-118156.	-6.38E-04	0.00	7.02E+10	-1639.	2782778.	0.00
21.7580	7.50E-05	3036579.	-121164.	-4.99E-04	0.00	7.04E+10	-342.589	1.39E+07	0.00
22.0110	-0.00124	2667144.	-119198.	-3.76E-04	0.00	7.05E+10	1638.	4008130.	0.00
22.2640	-0.00221	2312810.	-113715.	-2.75E-04	0.00	7.99E+10	1974.	2713924.	0.00
22.5170	-0.00291	1976667.	-107376.	-2.23E-04	0.00	3.70E+11	2202.	2298499.	0.00
22.7700	-0.00356	1660820.	-100379.	-2.08E-04	0.00	3.71E+11	2408.	2053758.	0.00
23.0230	-0.00417	1367167.	-92776.	-1.95E-04	0.00	3.72E+11	2601.	1893729.	0.00
23.2760	-0.00475	1097486.	-84600.	-1.85E-04	0.00	3.73E+11	2785.	1781815.	0.00
23.5290	-0.00529	853477.	-75872.	-1.77E-04	0.00	3.74E+11	2964.	1699657.	0.00
23.7820	-0.00582	636789.	-66607.	-1.71E-04	0.00	3.74E+11	3140.	1636990.	0.00
24.0350	-0.00633	449040.	-56812.	-1.67E-04	0.00	3.75E+11	3313.	1587625.	0.00
24.2880	-0.00684	291825.	-46494.	-1.64E-04	0.00	3.75E+11	3485.	1547624.	0.00
24.5410	-0.00733	166731.	-35653.	-1.62E-04	0.00	3.76E+11	3656.	1514388.	0.00

24.7940	-0.00782	75339.	-24291.	-1.61E-04	0.00	3.76E+11	3828.	1486166.	0.00
25.0470	-0.00831	19233.	-12408.	-1.61E-04	0.00	3.76E+11	4000.	1461771.	0.00
25.3000	-0.00880	0.00	0.00	-1.61E-04	0.00	3.76E+11	4173.	720201.	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 2:

Pile-head deflection	=	2.54330603 inches
Computed slope at pile head	=	-0.0135805 radians
Maximum bending moment	=	7001194. inch-lbs
Maximum shear force	=	-121164. lbs
Depth of maximum bending moment	=	15.93900000 feet below pile head
Depth of maximum shear force	=	21.75800000 feet below pile head
Number of iterations	=	231
Number of zero deflection points	=	1
Pile deflection at ground	=	1.48520596 inches

----- Pile-head Deflection vs. Pile Length for Load Case 2 -----

Boundary Condition Type 1, Shear and Moment

Shear	=	0. lbs
Moment	=	0. in-lbs
Axial Load	=	0. lbs

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
25.30000	2.54330603	7001194.	-121164.
24.03500	2.88872051	6865618.	-135716.
22.77000	3.90669392	6379315.	-132616.
21.50500	6.88482957	5752881.	-120063.
20.24000	21.15003642	5074524.	-107703.

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	0.00	M, in-lb	0.00	0.00	1.0620	-0.00595	-62970.	4011964.
2	V, lb	0.00	M, in-lb	0.00	0.00	2.5433	-0.01358	-121164.	7001194.

Maximum pile-head deflection = 2.5433060322 inches

Maximum pile-head rotation = -0.0135804862 radians = -0.778105 deg.

Summary of Warning Messages

The following warning was reported 10000 times

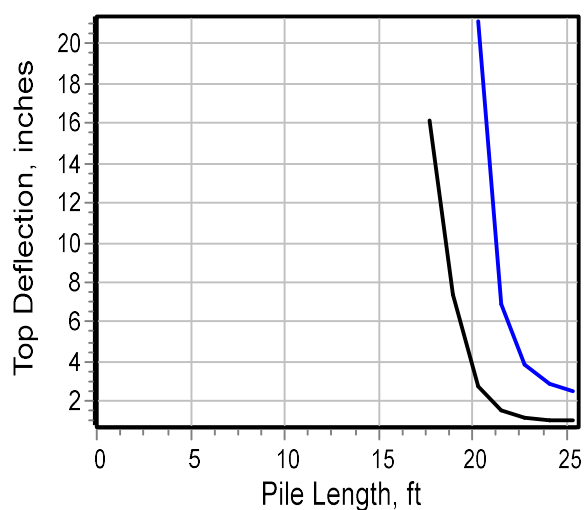
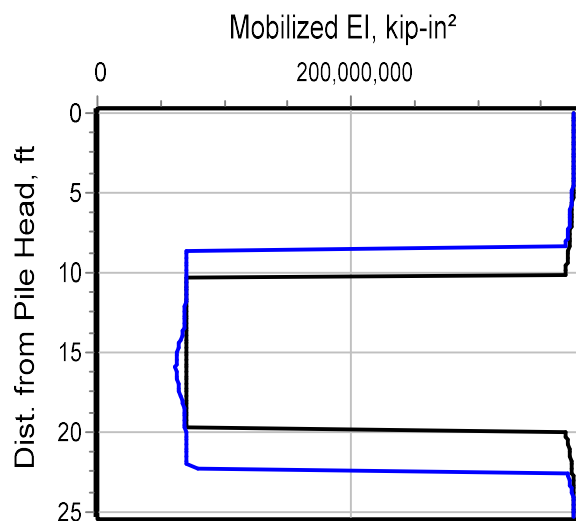
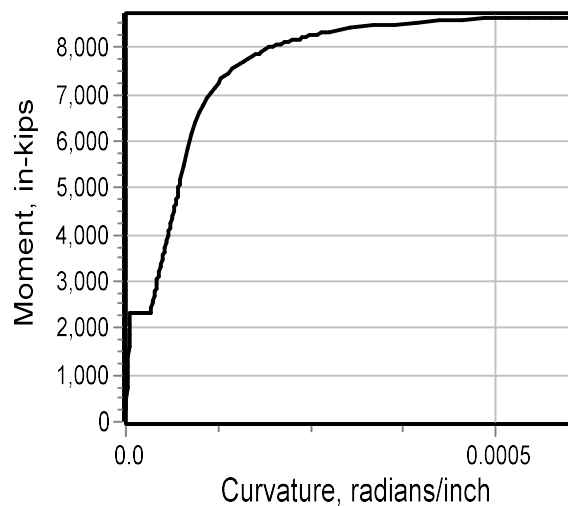
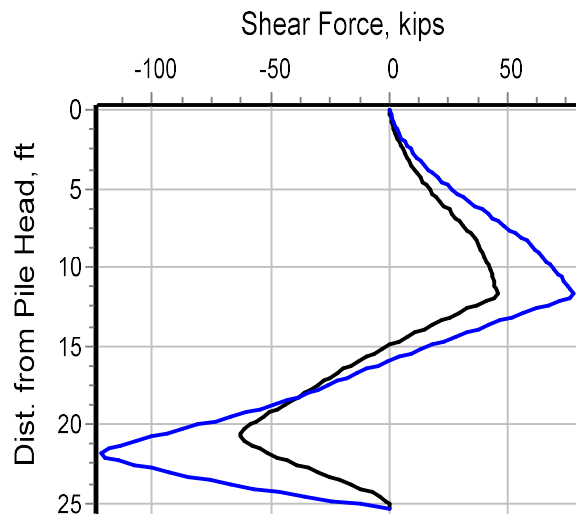
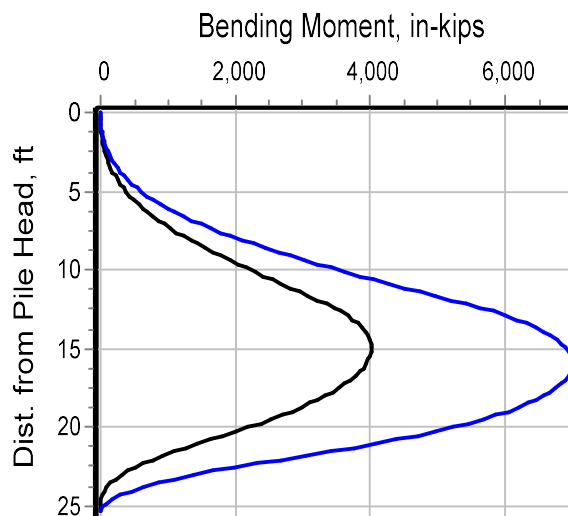
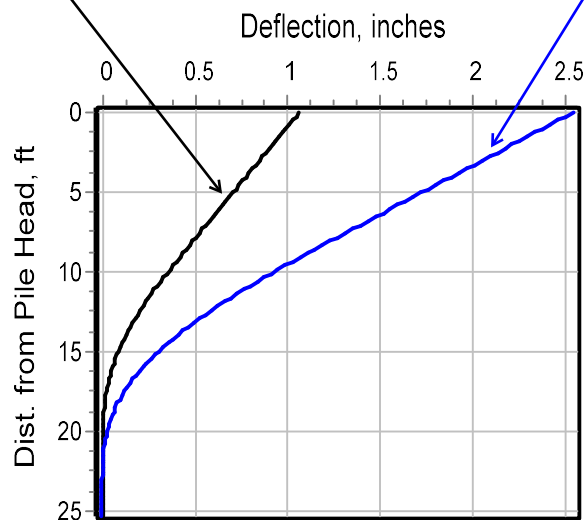
**** Warning ****

An unreasonable input value for compressive strength has been specified for a soil defined using the weak rock criteria. The input value is less than 100 psi. Please check your input data for correctness.

The analysis ended normally.

Case 1 = Service Limit Case

Case 2 = Strength Limit Case





Project: ODOT
Subject: Drilled Shaft Analysis
Task: Drilled Shaft Analysis Overview

Computed: MAW

Checked: BJH

Updated: BJH

Checked: JAS

Date: 10/2/2025

Date: 10/2/2025

Date: 2/13/2026

Date: 2/13/26

ODOT Drilled Shaft Analysis Overview

Drilled Shaft Analysis and Background Information

Background Information

- Analyze the drilled shafts for a drilled shaft wall for remediation of a landslide for ODOT. Use max moment and shear from provided LPile run to check the longitudinal and transverse shear reinforcement required. Use provided drilled shaft dimensions and assumed reinforcement.
- $f'_c = 4.0$ ksi for concrete strength
- $F_y = 60$ ksi steel strength
- Drilled Shaft diameter = 3'-0"
- Assumed longitudinal reinforcement = 13 - #8 bars (Provides 1.01% steel)
- Assumed transverse spiral reinforcement = #5 bars at 5" pitch (See ODOT BDM Section 305.4.4.3 Table 305-3)
- Clear cover to #5 transverse bar = 3" (See ODOT BDM Section 305.4.4.3 Table 305-3)

Loads from LPile

- Min Axial Load = 0 kips (See email reference provided - loads start below the top of drilled shaft)
- Max Factored Moment = 583.43 k-ft (7001.2 in-kips)
- Max Factored Shear = 121.2 k

Analysis Results

- Based on analysis results, for the 3'-0" diameter drilled shaft and provided loading: Use 13 - #8 longitudinal bars and #5 at 5" pitch transverse spiral bars with a 3" clear cover to the transverse bars.

ODOT DRILLED SHAFT FLEXURAL ANALYSIS

BY: MAW DATE: 10/2/2025

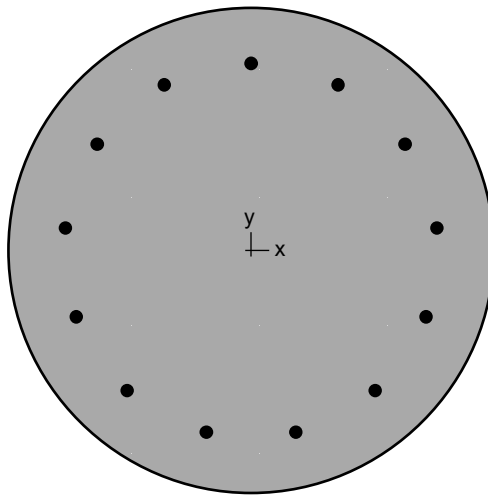
CHK: BJH DATE: 10/2/2025

Updated: BJH DATE: 2/13/2026

Checked: JAS DATE: 2/13/26



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Computer program for the Strength Design of Reinforced Concrete Sections
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1. General Information

File Name	...\ODOT Drilled Shaft Design - 3.0' Drilled S...
Project	---
Column	---
Engineer	---
Code	ACI 318-14
Bar Set	ASTM A615
Units	English
Run Option	Investigation
Run Axis	X - axis
Slenderness	Not Considered
Column Type	Structural
Capacity Method	Critical capacity

2. Material Properties

2.1. Concrete

Type	Standard
f'_c	4 ksi
E_c	3605 ksi
f_c	3.4 ksi
ϵ_u	0.003 in/in
β_1	0.85

2.2. Steel

Type	Standard
f_y	60 ksi
E_s	29000 ksi
ϵ_{ty}	0.00206897 in/in

3. Section

3.1. Shape and Properties

Type	Circular
Diameter	36 in
A_g	1017.88 in ²
I_x	82448 in ⁴
I_y	82448 in ⁴
r_x	9 in
r_y	9 in
X_o	0 in
Y_o	0 in

3.2. Section Figure

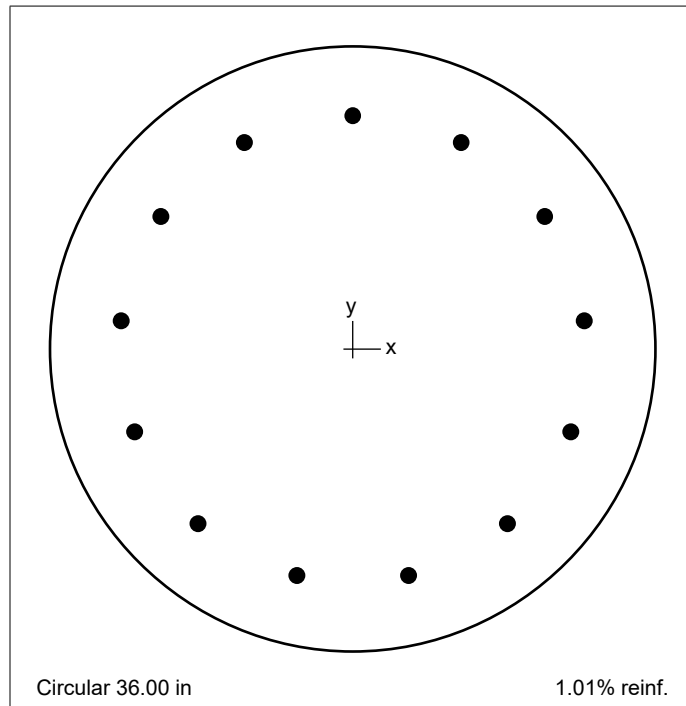


Figure 1: Column section

4. Reinforcement

4.1. Bar Set: ASTM A615

Bar	Diameter in	Area in ²	Bar	Diameter in	Area in ²	Bar	Diameter in	Area in ²
#3	0.38	0.11	#4	0.50	0.20	#5	0.63	0.31
#6	0.75	0.44	#7	0.88	0.60	#8	1.00	0.79
#9	1.13	1.00	#10	1.27	1.27	#11	1.41	1.56
#14	1.69	2.25	#18	2.26	4.00			

4.2. Confinement and Factors

Confinement type	Other
For #8 bars or less	#5 ties
For larger bars	#5 ties
Capacity Reduction Factors	
Axial compression, (a)	0.8
Tension controlled ϕ , (b)	0.9
Compression controlled ϕ , (c)	0.75

4.3. Arrangement

Pattern	All sides equal
Bar layout	Circular
Cover to	Transverse bars
Clear cover	3 in
Bars	13 #8

Total steel area, A_s	10.27 in ²
Rho	1.01 %
Minimum clear spacing	5.64 in

5. Control Points

About Point	P kip	X-Moment k-ft	Y-Moment k-ft	NA Depth in	d_t Depth in	ϵ_t	ϕ
X @ Max compression	3031.5	0.00	0.00	102.71	31.88	-0.00207	0.75000
X @ Allowable comp.	2425.2	603.52	0.00	32.96	31.88	-0.00010	0.75000
X @ $f_s = 0.0$	2342.4	667.35	0.00	31.88	31.88	0.00000	0.75000
X @ $f_s = 0.5 f_y$	1627.2	1012.52	0.00	23.70	31.88	0.00103	0.75000
X @ Balanced point	1129.2	1078.62	0.00	18.86	31.88	0.00207	0.75000
X @ Tension control	529.1	1037.76	0.00	11.95	31.88	0.00500	0.90000
X @ Pure bending	0.0	628.86	0.00	7.19	31.88	0.01030	0.90000
X @ Max tension	-554.6	0.00	0.00	0.00	31.88	9.99999	0.90000
-X @ Max compression	3031.5	0.00	0.00	101.41	31.47	-0.00207	0.75000
-X @ Allowable comp.	2425.2	-606.60	0.00	32.91	31.47	-0.00013	0.75000
-X @ $f_s = 0.0$	2314.5	-689.85	0.00	31.47	31.47	0.00000	0.75000
-X @ $f_s = 0.5 f_y$	1598.0	-1017.61	0.00	23.40	31.47	0.00103	0.75000
-X @ Balanced point	1106.8	-1082.11	0.00	18.63	31.47	0.00207	0.75000
-X @ Tension control	520.2	-1028.48	0.00	11.80	31.47	0.00500	0.90000
-X @ Pure bending	0.0	-625.02	0.00	7.16	31.47	0.01018	0.90000
-X @ Max tension	-554.6	0.00	0.00	0.00	31.47	9.99999	0.90000

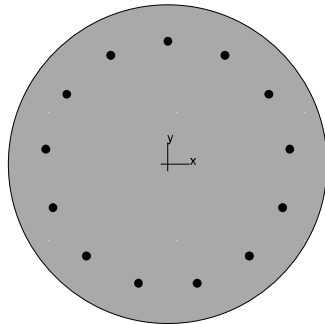
6. Factored Loads and Moments with Corresponding Capacity Ratios

NOTE: Calculations are based on "Critical Capacity" Method.

No.	Demand		Capacity		Parameters at Capacity			Capacity Ratio
	P_u kip	M_{ux} k-ft	ϕP_n kip	ϕM_{nx} k-ft	NA Depth in	ϵ_t	ϕ	
1	0.00	583.43	0.00	628.86	7.19	0.01030	0.900	0.96

7. Diagrams

7.1. PM at $\theta=0$ [deg]



Circular 36.00 in

General Information

Project	---
Column	---
Engineer	---
Code	ACI 318-14
Bar Set	ASTM A615
Units	English
Run Option	Investigation
Run Axis	X - axis
Slenderness	Not Considered
Column Type	Structural
Capacity Method	Critical capacity

Materials

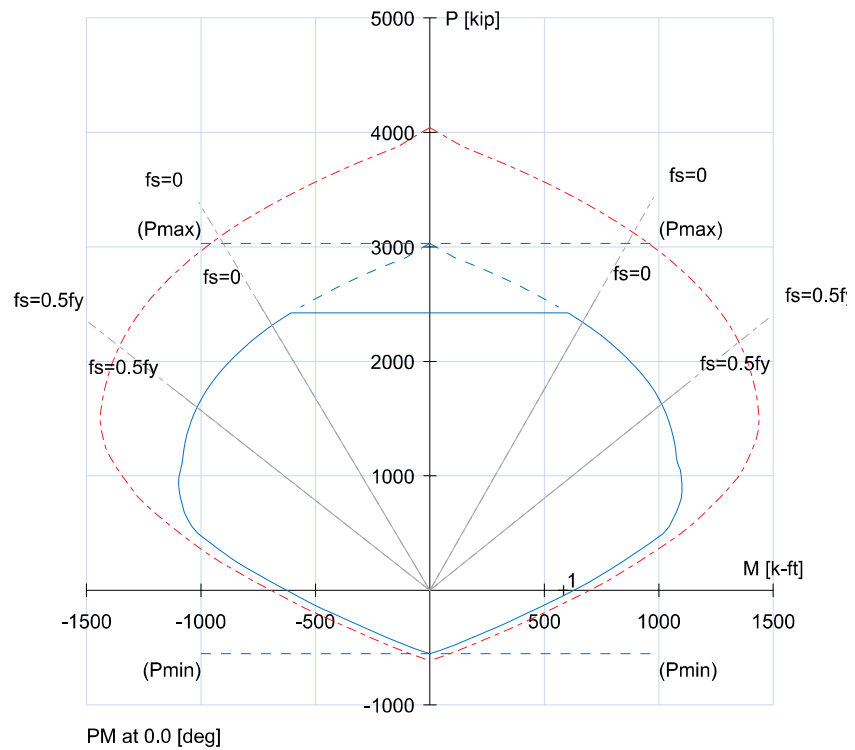
f'_c	4 ksi
E_c	3605 ksi
f_y	60 ksi
E_s	29000 ksi

Section

Type	Circular
Diameter	36 in
A_g	1017.88 in ²
I_x	82448 in ⁴
I_y	82448 in ⁴

Reinforcement

Pattern	All sides equal
Bar layout	Circular
Cover to	Transverse bars
Clear cover	3 in
Bars	13 #8
Confinement type	Other
Total steel area, A_s	10.27 in ²
Rho	1.01 %
Min. clear spacing	5.64 in



No.	P_u kip	M_{ux} k-ft	ϕP_n kip	ϕM_{nx} k-ft	Capacity Ratio
1	0.0	583.4	0.00	628.86	0.96

Max. Capacity Ratio: 0.96



Project:	ODOT	Computed:	MAW	Date:	10-2-25
Subject:	Drilled Shaft Check	Checked:	BJH	Date:	10/2/2025
Task:	Drilled Caisson Shear Design	Page:		of:	
Job #:		No:			

Updated: BJH Date: 2/13/2026
Checked: JAS Date: 2/13/2026

DRILLED CAISSON SHEAR CHECK - DRILLED SHAFT

Determine Shear Capacity of Section

- Use Simplified Procedure as drilled shaft contains minimum transverse reinforcement and is not in axial tension (A5.7.3.4.1)

Drilled Caisson section:

Drilled Caisson Diameter =	36.0	in
Cover to shear reinforcing =	3.0	in
Shear Reinforcing bar size =	5	bar
Longitudinal Reinforcing bar size =	8	bar
Shear Reinforcing spacing =	5.0	in
Concrete Strength, f'_c =	4.0	ksi
Reinforcing Steel, f_y =	60	ksi

Nominal Shear Resistance is the lesser of:

$$V_n = V_c + V_s \quad (\text{A5.7.3.3-1})$$

$$V_n = 0.25 f'_c b_v d_v \quad (\text{A5.7.3.3-2})$$

$$V_c = 0.0316 \beta \lambda (f'_c)^{0.5} b_v d_v \quad (\text{A5.7.3.3-3})$$

β =	2.0	(A5.7.3.4.1)
λ =	1.0	(A5.4.2.8 - normal weight concrete)
b_v =	36.0	in (C5.7.2.8)
D_r =	27.8	in (Figure C5.7.8-2)
d_e =	26.8	in (C5.7.2.8-2)
d_v =	24.1	in (C5.7.2.8)

$$V_c = 109.9 \text{ k}$$

$$V_s = A_v f_y d_v (\cot \theta) / s \quad (\text{C5.7.3.3-1})$$

θ =	45	degrees (A5.7.3.4.1)
V_s =	179.7	k

$$\phi = 0.9 \quad (\text{A5.5.4.2})$$
$$\phi V_n = \phi (V_c + V_s) = 260.6 \text{ k} \quad (\text{A5.7.2.1-1})$$
$$\phi V_{n \max} = \phi (0.25 f'_c b_v d_v) = 782.5 \text{ k} \quad (\text{A5.7.2.1-1})$$

$$\phi V_n = \min \text{ of } \phi (V_c + V_s) \text{ and } \phi V_{n \max} = 260.6 \text{ k}$$

For circular members, such as reinforced concrete columns or prestressed concrete piles, d_v can be determined from Eq. C5.7.2.8-1 provided that M_n is calculated ignoring the effects of axial load and that the reinforcement areas, A_s and A_{ps} , are taken as the reinforcement in one-half of the section. Alternatively, d_v can be taken as $0.9d_e$, where:

$$d_e = \frac{D}{2} + \frac{D_r}{\pi} \quad (\text{C5.7.2.8-2})$$

where:

D = external diameter of the circular member (in.)
 D_r = diameter of the circle passing through the centers of the longitudinal reinforcement (in.)

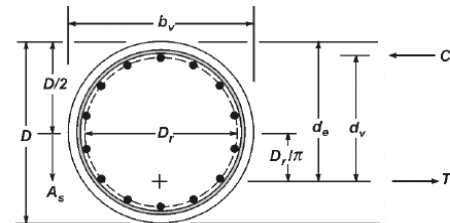


Figure C5.7.2.8-2—Illustration of Terms b_v , d_e , and d_v for Circular Sections

Circular members usually have the longitudinal reinforcement uniformly distributed around the perimeter of the section. When the member cracks, the highest shear stresses typically occur near the middepth of the section. This is also true when the section is not cracked. It is for this reason that the effective web width can be taken as the diameter of the section.

Shear Capacity Checks			
Shear Load Case	Resultant Shear (kips)	D/C	Section okay for Shear?
Max STR	121.2	0.47	YES

Max D/C = 0.47 < 1.0 : Okay for Shear

REFERENCE

Hixson, Brooke

From: Voegele, Douglas M.
Sent: Friday, February 13, 2026 9:09 AM
To: Werner, Melissa A.; Hixson, Brooke
Cc: Baratta, Alma
Subject: RE: Caisson Reinforcement Design
Attachments: ODOT Drilled Shaft Analysis_CD01.pdf; ODOT Drilled Shaft Analysis_CP01.pdf; Drilled Shaft Shear Design.xlsx; ODOT Drilled Shaft Design - 3.0' Drilled Shaft.colx

Good morning Melissa and Brooke.

A modification was required to the drilled shaft wall that we designed for the LAW-247-11.28 project in ODOT District 9. Long story short, the center to center spacing for two of the shafts needed to be widened from 5'-9" to 6'-4" due to a drainage pipe needing to pass through the wall on a heavy skew. Our original design was for a maximum spacing of 6'-0". Would one of you have an opportunity to check that our current steel reinforcing remains valid? The new loading from our Lpile analyses are:

- Maximum shear and moment values (provided for the Strength I case, which incorporate a load factor of 1.5 for the active earth pressure loading, and 1.75 for the traffic surcharge):
 - **Maximum shear: 121.2 kips**
 - **Maximum moment: 7001.2 in-kips**

It seems like it should be fine, but I would like to confirm. And of course, this was a last-minute request from the consultant developing the plan set for District 9, which are due today.

I have attached your original design files for reference/use.

The project number is 10429951. Please use task 004.

Thanks in advance.

Doug

Douglas M. Voegele, P.E.
D 513.984.7567 M 513.304.2733

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From: Baratta, Alma <Alma.Baratta@hdrinc.com>
Sent: Friday, October 3, 2025 8:28 AM
To: Werner, Melissa A. <melissa.werner@hdrinc.com>
Cc: Voegele, Douglas M. <doug.voegele@hdrinc.com>; Pike, Joshua <joshua.pike@hdrinc.com>; Hixson, Brooke <Brooke.Hixson@hdrinc.com>
Subject: RE: Caisson Reinforcement Design

Thank you Melissa, the quick turnaround is greatly appreciated!

Ms. Alma K. Baratta, P.E.
D 513.984.7619 M 513.418.8912

REFERENCE

hdrinc.com/follow-us

From: Werner, Melissa A. <melissa.werner@hdrinc.com>

Sent: Thursday, October 2, 2025 5:05 PM

To: Baratta, Alma <Alma.Baratta@hdrinc.com>

Cc: Voegele, Douglas M. <doug.voegele@hdrinc.com>; Pike, Joshua <joshua.pike@hdrinc.com>; Hixson, Brooke <Brooke.Hixson@hdrinc.com>

Subject: RE: Caisson Reinforcement Design

Alma,

We have completed the drilled shaft structural analysis using the drilled shaft information and loads provided in previous emails. Based on the analysis, the use of a 36 inch diameter drilled shaft with longitudinal steel of 13 - #8 bars and transverse spiral reinforcement using #5 bars at 5" pitch is okay for the loads provided.

Please see the attached calculations, including a checked PDF and the design files.

Let me know if you need any additional information or need anything clarified or changed.

Thanks,

Melissa Werner, PE
Structural Engineer

 412.497.6018

hdrinc.com/follow-us

From: Baratta, Alma <Alma.Baratta@hdrinc.com>

Sent: Wednesday, October 1, 2025 2:56 PM

To: Werner, Melissa A. <melissa.werner@hdrinc.com>

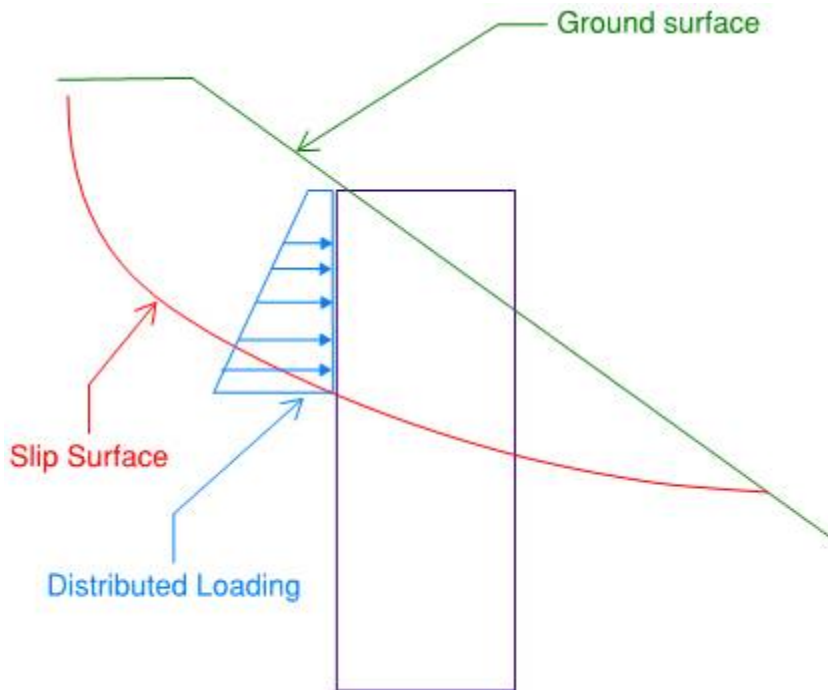
Cc: Voegele, Douglas M. <doug.voegele@hdrinc.com>; Pike, Joshua <joshua.pike@hdrinc.com>

Subject: RE: Caisson Reinforcement Design

There is not. For clarification, the bending moment and shear provided below are the maximum resultant values determined from LPile (shown on PDF pages 28/29), not the applied loading.

For the applied loading, we convert the landslide loading to a distributed lateral load in LPile, applied from the top of the shaft to the depth where the slide plane intersects the shaft. There is a triangular component from the earth loading plus a rectangular component from the traffic surcharge, resulting in a trapezoidal distribution, something like this:

REFERENCE



The values are presented in the lower right box on PDF page 9 for the Service and Strength-I cases (snipped below), and entered into LPILE as shown on PDF page 17. We do not have any concentrated loading applied to the pile head.

Distributed Lateral Loads for LPILE

UA SLOPE		
Depth (ft.)	Service (lb/in)	Strength-I (lb/in)
0	71	124
11.8	963	1462

Ms. Alma K. Baratta, P.E.
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From: Werner, Melissa A. <melissa.werner@hdrinc.com>
Sent: Wednesday, October 1, 2025 2:41 PM
To: Baratta, Alma <Alma.Baratta@hdrinc.com>
Cc: Voegelé, Douglas M. <doug.voegelé@hdrinc.com>; Pike, Joshua <joshua.pike@hdrinc.com>
Subject: RE: Caisson Reinforcement Design

Alma,

Thanks for the information, I will be working on it first thing tomorrow. One question, is there an axial load to apply to the drilled shaft? I see the bending moment and shear in the email below.

Thanks,

Melissa Werner, PE
Structural Engineer

REFERENCE

D 412.497.6018

hdrinc.com/follow-us

From: Baratta, Alma <Alma.Baratta@hdrinc.com>

Sent: Wednesday, October 1, 2025 1:23 PM

To: Werner, Melissa A. <melissa.werner@hdrinc.com>

Cc: Voegelé, Douglas M. <doug.voegele@hdrinc.com>; Pike, Joshua <joshua.pike@hdrinc.com>

Subject: RE: Caisson Reinforcement Design

Melissa,

As an additional reference, concrete reinforcing for drilled shafts is discussed in Section 305.4.4.3 of the ODOT BDM (PDF page 135): [Bridge Design Manual - July 2025](#) It has a table discussing the spiral pitch and bar size for each drilled shaft diameter:

Table 305-3

Column/Shaft Diameter	Column/Shaft Reinforcing			
	Cover	Bar	Pitch	Clear
30"	3"	#4	4.00"	3.50"
36"	3"	#5	5.00"	4.38"
42"	4"	#5	4.50"	3.88"
48"	4"	#5	3.75"	3.13"
54"	4"	#5	3.25"	2.63"
60"	6"	#5	3.13"	2.50"
66"	6"	#5	2.88"	2.25"
72"	6"	#5	2.50"	1.875"
84"	6"	#6	3.00"	2.25"
96"	6"	#6	2.63"	1.875"

Ms. Alma K. Baratta, P.E.

D 513.984.7619 M 513.418.8912

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From: Baratta, Alma

Sent: Wednesday, October 1, 2025 12:41 PM

To: Werner, Melissa A. <melissa.werner@hdrinc.com>

REFERENCE

Cc: Voegelé, Douglas M. <doug.voegelé@hdrinc.com>; Pike, Joshua <joshua.pike@hdrinc.com>

Subject: RE: Caisson Reinforcement Design

Melissa,

Thank you for your willingness to assist on this project. We are designing a buried drilled shaft wall for remediation of a landslide for ODOT. We have already performed the LPile analyses to check deflections and determine the maximum shear and moment values, but need to verify the longitudinal and transverse rebar required to satisfy the shear and moment requirements. I have attached the LPile analyses for your reference. As a general summary:

- Drilled shaft diameter: 36"
- Assumed longitudinal reinforcing for LPile: 13 No. 8 bars (1.01% steel). No transverse reinforcing has been modeled.
- Assumed rebar cover: 3" (This is an ODOT requirement from section 305.4.4.2 of the Bridge Design Manual.)
- Exposed wall height: 6.5 feet (The drilled shafts will be completely buried at completion of construction. However, as this is a landslide, it is anticipated that the soil material in front of the wall may continue to move. As such, our LPile analyses consider the ground surface to be 6.5' below the top of shaft to account for future movement.)
- Drilled shaft length: 25.3 feet (based on an embedment length of 15 feet into residual/weathered claystone materials)
- Maximum shear and moment values (provided for the Strength I case, which incorporate a load factor of 1.5 for the active earth pressure loading, and 1.75 for the traffic surcharge):
 - Maximum shear: 112.9 kips
 - Maximum moment: 6600.2 in-kips
- Schedule: We are looking to submit the final report this Friday, October 3. As such, we would like to have analyses performed/checked by mid-day Friday or so for inclusion. **If the longitudinal reinforcing needs to change, please let us know ASAP so we can update the LPile analyses.**
- Budget: No more than a day (8 hours) for analysis and checking/review.
- Charge number:

10429951 - ODT_D9_TO1 LAW-243-11.28

004-Geotechnical Analyse

Please let me know if you anticipate any issues, have any questions, or need any additional information.

Thanks,
Alma

Ms. Alma K. Baratta, P.E.
D 513.984.7619 M 513.418.8912

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From: Baratta, Alma <Alma.Baratta@hdrinc.com>

Sent: Wednesday, October 1, 2025 12:02 PM

To: Pike, Joshua <joshua.pike@hdrinc.com>

Cc: Werner, Melissa A. <melissa.werner@hdrinc.com>; Voegelé, Douglas M. <doug.voegelé@hdrinc.com>

Subject: RE: Caisson Reinforcement Design

Thank you Josh, I'll get this pulled together ASAP.

Ms. Alma K. Baratta, P.E.
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REFERENCE

From: Pike, Joshua <Joshua.Pike@hdrinc.com>
Sent: Wednesday, October 1, 2025 11:26 AM
To: Baratta, Alma <Alma.Baratta@hdrinc.com>
Cc: Werner, Melissa A. <melissa.werner@hdrinc.com>
Subject: Caisson Reinforcement Design

Alma,

Melissa is available to run an analysis for the reinforcement design of the caisson that we talked about this morning. Please provide her with the information she will need to run the calculation including LPILE results. Also let her know schedule and budget.

Joshua D. Pike, PE (PA,WV)
Geotechnical Engineer

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