LPB™

A FORTE COMPANY

ENGINEERING REFERENCE MANUAL

The Future of Precast Light Pole Bases

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A FORTE COMPANY

Produced by The Precast Forte Group

Version 3.0 - December 2024

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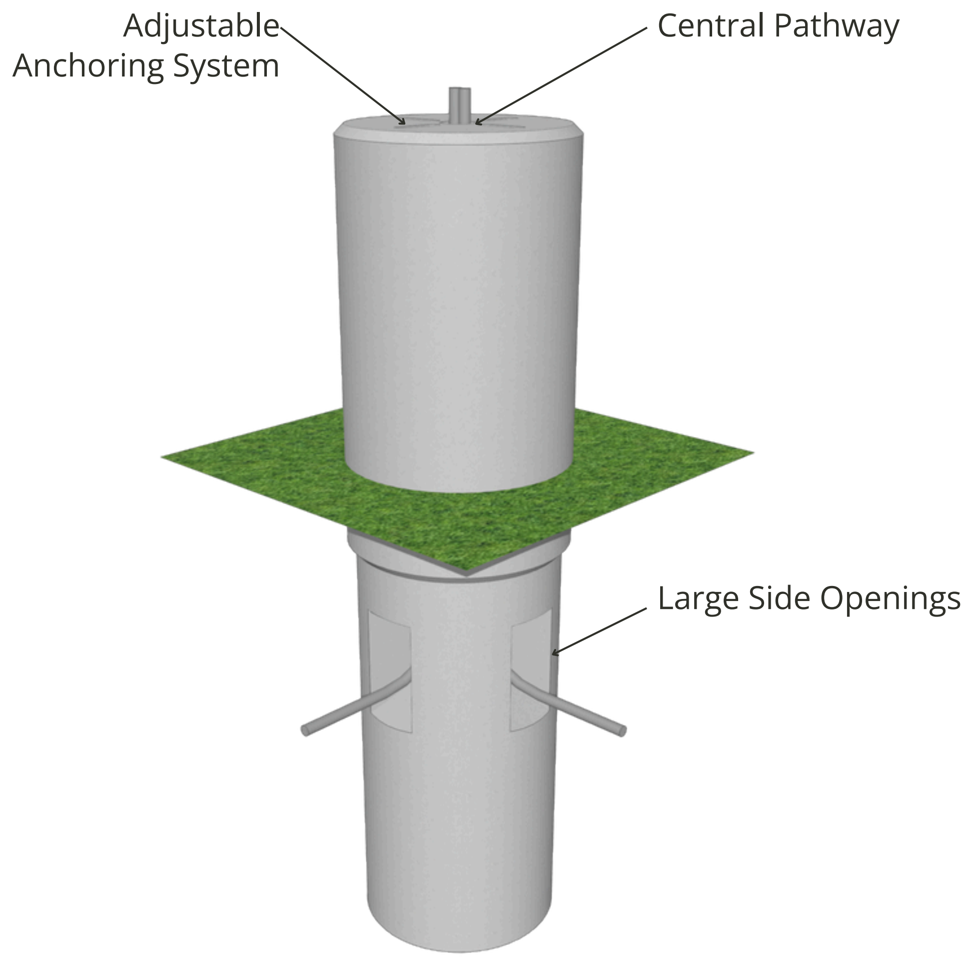
THE LPB

The LPB is a universal precast concrete light pole foundation that offers several distinct advantages over other precast pole foundations as well as cast-in-place concrete foundations.



ADJUSTABLE ANCHORING SYSTEM

The slotted Anchoring System, which is embedded into the top of the LPB, accepts four ¾-inch or 1-inch diameter bolts and can accommodate bolt circle diameters as small as 7-½-inches and as large as 13-½-inches. This allows for the installation of a variety pole sizes and shapes, sure to fit most commercial light pole base plate configurations.

LARGE SIDE OPENINGS AND CENTRAL PATHWAY

The LPB contains four large side openings that lead to a central vertical pathway sleeve. The size and location of the openings along with the pathway sleeve allow for flexibility and ease of electrical conduit installation from multiple directions.

THE LPB

IN STOCK AND AVAILABLE

The standardized size and configuration of the LPB, designed to fit a variety of pole sizes and shapes, enables it to be produced ahead of time without requiring specific project details. This reduces lead times and provides flexibility to adapt to changing project requirements.

INSTALLATION EFFICIENCY

The LPB arrives at the jobsite fully cured and ready for immediate installation. Once the base is set and backfilled, light poles can be installed within hours instead of days. With no need for onsite formwork or rebar tying, the LPB minimizes construction effort and reduces coordination between the installer and electrician.

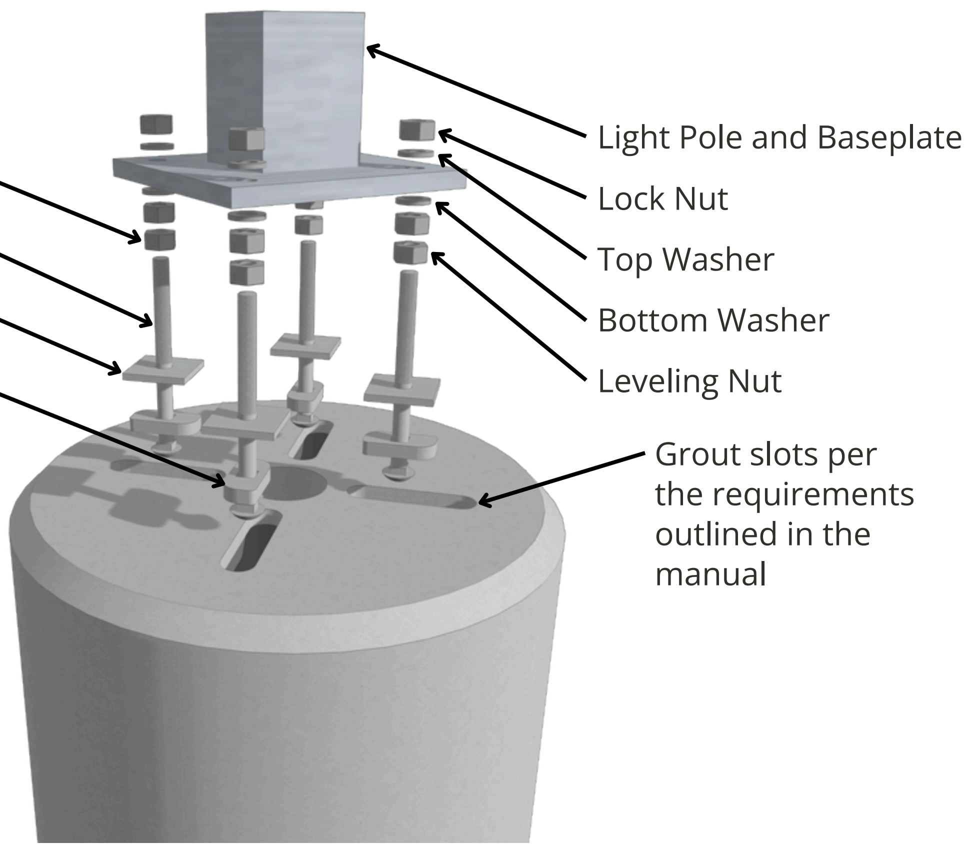
QUALITY

The LPB is manufactured by trained personnel in a controlled environment, ensuring consistent high quality. Documented mix designs and rigorous quality assurance programs result in a reliable and uniform product every time.

DESIGN APROACH OVERVIEW

DESIGN APPROACH OVERVIEW

The review of an LPB foundation involves the analysis of two distinct components: the proprietary Anchoring System integrated into the top portion of the foundation and the concrete foundation itself. The Anchoring System is comprised of four slots formed by plastic inserts, each designed to accept a carriage bolt and anchoring plate, secured with a nut and bearing plate washer (refer to the bolting diagram below).



Note 1: The LPB Lock Nut, LPB Anchor Rod, and LPB Bearing Plate shall be installed as shown and as noted in Step 6 of the General Installation Recommendations, without exception.

Recommended LPB Bolting Diagram

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DESIGN APPROACH OVERVIEW

Prior to beginning the analysis process, a number of site and project parameters must be collected. These include the following:

Pole & Luminaire Info:

- Pole Height
- Pole Shape
- Pole Width or Diameter
- Bolt Circle Diameter
- Required Bolt Size (must be between 7-½-inches and 13-½-inches)
- Fixture Effective Projected Area (EPA)

Site Conditions:

- Basic Design Wind Speed
- Exposure Category
- Soil Type (i.e. Cohesionless or Cohesive)
- Soil Unit Weight
- Cohesion

Foundation:

- Specified above grade exposure
- Required bury depth (or can be calculated)
- Foundation type (i.e. Classic, Flare, or Legacy)
- Note: All LPB foundations utilize 5,000 psi concrete, 60ksi steel reinforcing, (4) #6 vertical bars, and #3 hoops at 12" O.C. If something other than this is required based upon the analysis, contact the producer for product availability.

With this information, you can accurately analyze an the LPB Anchoring System and the concrete foundation for your site specific conditions.

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ANCHORING SYSTEM ANALYSIS

ANCHORING SYSTEM ANALYSIS

STEP 1

The initial step in analyzing the Anchoring System is to determine the maximum wind pressures acting on the pole and luminaires. This process is guided by the *American Association of State Highway and Transportation Officials (AASHTO) publication: LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, First Edition, 2015 (LRFDLTS-1)*. The wind pressure is calculated using the basic wind speed, wind exposure category, and several additional coefficients and factors. Detailed information on the wind pressure calculation methodology is provided in Chapter 3 of the referenced AASHTO manual.

AASHTO Manual

A key consideration in this step is the selection of the Basic Wind Speed, which is determined based on the Mean Recurrence Interval, Risk Category, and project location, as specified by the designer. This selection is critical, as the Basic Wind Speed significantly influences the loads transferred to the LPB Anchoring System. Additionally, per AASHTO LRFDLTS-1, wind is classified as an extreme event with a Load Factor of 1.0, meaning the wind pressures calculated in this step will not be further amplified in subsequent steps.

STEP 2

The next step in the process involves calculating the base reactions, specifically the moment and shear at the base of the pole. This is achieved by multiplying the effective area of the pole and luminaires by the corresponding wind pressures determined in Step 1. Since this is an LRFD design, the resulting moment and shear are further multiplied by a Load Factor. As wind is classified as an Extreme Load, the applicable Load Factor is 1.0, as specified in AASHTO Table 3.4-1.

ANCHORING SYSTEM ANALYSIS

STEP 3

After determining the base reactions, the tensile force in each individual bolt is calculated based on the specified bolt circle diameter. As previously noted, LPB allows for bolt circle diameters ranging from 7-½-inches up to 13-½-inches.

The Total Tensile Load within a given bolt is based upon the following:

- Moment at the base of the pole
- The centroid distance to each bolt
- The moment of inertia of the bolt group
- And the stress area of the bolts

An example and accompanying Figure 1, shown below, illustrate the calculation process for determining the tensile force in the bolts.

$$Centroid\ Distance\ to\ Bolts = c = \frac{d}{2} \cdot \cos 45$$

$$Tensile\ Stress\ Area\ of\ Each\ Bolt = A_T = \frac{\pi}{4} \cdot \left[d_b - \frac{0.9743}{n}\right]^2$$

$$Tensile\ Stress\ Area\ of\ Each\ Bolt = A_T = \frac{\pi}{4} \cdot \left[d_b - \frac{0.9743}{n}\right]^2$$

$$n = threads\ per\ inch = 10$$

$$A_T = 0.334\ in^2$$

$$Moment\ of\ Inertia\ of\ Bolts = I = \sum A_T \cdot c^2 = 4 \cdot A_T \cdot c^2$$

$$Bolt\ Stress = \frac{Moment \cdot c}{I}$$

$$Bolt\ Tension = T_u = \frac{Bolt\ Stress}{A_T}$$

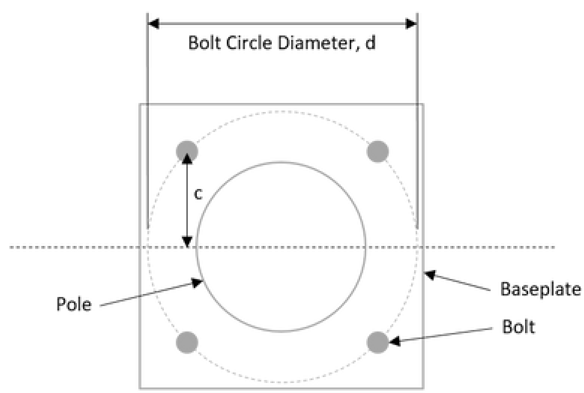

Figure 1

ANCHORING SYSTEM ANALYSIS

For additional information regarding the procedure outlined above, refer to the National Cooperative Highway Research Program document NCHRP Report 412.

NCHRP Report 412

STEP 4

The next step in the analysis process is to evaluate the adequacy of the Anchoring System. To verify its performance, load testing was conducted to determine the nominal tensile capacity, given the proprietary nature of the system. Detailed documentation of the testing procedures and results is provided in Appendix A.

Load Testing Report

A total of 12 tests were performed using three different bolt circle diameters: 14 inches, 10 inches, and 7-½ inches. Each anchor was subjected to a load of 18,500 pounds, a value derived from the actual anticipated loads. In all 12 tests, the Anchoring System successfully withstood the applied load without failure. Based on these results, LPB recommends a nominal tensile capacity of 18,500 pounds for each individual anchor bolt within the system.

According to the Chapter 5 Section 5.16.3 of the *AASHTO LRFDLTS-1* manual, resistance factors for concrete anchorages shall be as specified in *ACI 318*, Appendix D. Section D.4.3 of *ACI 318* specifies that for anchors governed by concrete breakout, side-face blow-out, pullout, or pryout (which is typically how the LPB Anchoring System performed) a reduction factor of 0.7 should be used for tension loads.

ANCHORING SYSTEM ANALYSIS

The final check within this step compares the reduced nominal tensile to the applied load that was calculated in Step 3. If the applied load exceeds the reduced nominal tensile capacity, an alternative pole and bolt circle configuration must be selected to lower the applied load.

STEP 5

In accordance with the *AASHTO LRFDLTS-1* manual and *National Cooperative Highway Research Program (NCHRP) Report 469*, anchor rods subjected to more than 20,000 repeated axial tension cycles must be assessed for fatigue limit state. This step initiates the fatigue loading analysis. In Step 1, the wind pressure calculated is considered the ultimate design load. In addition to evaluating for this condition, fatigue loading must also be considered using a reduced wind pressure.

Report 469

Step 5 involves determining the resulting bolt stress due to the pressure from natural wind gusts. The natural wind gust pressure is calculated using the Yearly Mean Wind Velocity, drag coefficients for the pole and luminaires, and an Importance Factor based on a designated Fatigue Category. The calculation for the natural wind gust is based on a Yearly Mean Wind Velocity of 11.2 miles per hour, though an alternate velocity may be used if known. For guidance on selecting the Fatigue Category and determining the Importance Factor, refer to Section 11.6 of the *AASHTO LRFDLTS-1*.

For this analysis, truck-induced gusts and galloping effects are neglected, given the expected installation locations and pole/luminaires configurations used with the LPB. If either of these conditions is anticipated based on actual site conditions, further analysis is recommended.

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ANCHORING SYSTEM ANALYSIS

STEP 6

The final step in the Anchoring System analysis is to evaluate the anchor rods with respect to the fatigue bolt stress calculated in Step 5. The *NCHRP Report 469* defines the stress range as the magnitude of the change in nominal stress due to the application or removal of the unfactored live load. The S-N curve for galvanized non-pretensioned anchor rods corresponds to Detail Category E', though the fatigue threshold for anchor rods is significantly higher than for other Category E' details. As such, a threshold of 7,000 psi is recommended for anchor rods, as specified in the *NCHRP Report 469*. This value is compared to the fatigue stress calculated in Step 5.

The *NCHRP Report 469* states that if the calculated stress remains below the threshold, no further fatigue evaluation is necessary. However, we recommend an additional check, which compares the combined fatigue tension and ultimate design tension to the reduced nominal capacity of the Anchoring System. While this additional check is not required by Code or industry standards, it is offered as a recommendation and can be used at the Designer's discretion.

It is important to note that the NCHRP Report 469 also asserts that “in steel-to-concrete joints subject to fatigue, the anchor rod will fail before the concrete reaches its fatigue strength”. Therefore, no further fatigue analysis of the concrete Anchoring System has been performed.

Finally, it is possible to meet the requirements of Step 4, based upon the specified pole and bolt circle diameter, but not meet the requirements of Step 6. If this is the case, an alternative pole and bolt circle configuration must be selected, if possible, and then re-analyzed.

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FOUNDATION ANALYSIS

FOUNDATION ANALYSIS

STEP 7

The first step in the foundation analysis process involves calculating the ground line reactions based on the specified site-specific soil conditions. The total unfactored moment and shear at the base of the foundation are determined by multiplying the surface area of the foundation, pole, and luminaire by the wind pressures specific to each component. These wind pressures are calculated in the same manner as outlined in Step 1 of the Anchoring System Analysis, in accordance with the *AASHTO LRFDLTS-1* guidelines.

AASHTO Manual

It is important to note that properly defining the soil type as either cohesive or cohesionless is critical to the analysis process. The primary distinction between these soil types lies in how the shear strength of the soil is determined. For cohesive soils, shear strength is based on cohesion, which refers to the attractive forces between soil particles. For cohesionless soils, shear strength depends on the internal friction angle of the soil particles. Cohesive soils are typically fine-grained materials such as clays and silts, while cohesionless soils are generally sands and gravels.

Once the unfactored moment and shear at the base have been calculated, a factor of safety is applied to each value. It is at this point where LPB's analysis procedure varies from that which is outlined in AASHTO LRFDLTS-1. In the commentary portion of Section 13.6.1.1 (C13.6.1.1), equations are given to determine the required embedment based upon an analysis method developed by Broms (1964a and 1964b). The equations are based upon the ultimate load of the soils and utilize a factored moment and shear at the groundline.

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FOUNDATION ANALYSIS

The commentary, however, does not clearly state the factor that should be applied to the shear and moment. Previous versions of the AASHTO manual, using an Allowable Stress Design (ASD), show the same procedure for calculating the required embedment depth but clearly state the factors that should be applied to the moment and shear. In AASHTO LTS-6, the commentary references a paper written by Broms where he suggests using an undercapacity factor of 0.7 and an overload factor of 2 to 3. The value for the factor of safety is then determined by dividing the overload factor by the undercapacity factor. Based upon this information, it is LPB's recommendation, that this type of factor of safety should be used when utilizing Broms' approach. The inclusion of this factor can be seen in the analysis process and example calculation.

STEP 8

In this step, the required foundation embedment is determined based on the soil type and the factored shear and moment. The equations used in this calculation process are outlined in the example and follow the method developed by Broms. This step may be iterative, as adjustments to the overall foundation length or the reduction of the above-grade foundation may be necessary to achieve the required embedment.

FOUNDATION ANALYSIS

STEP 9

This step calculates the ultimate moment in the foundation shaft for the purpose of verifying the adequacy of the reinforcement. The equations used to determine the maximum moment are based on Broms' approach, with the exception that Broms' recommended factor of safety has been omitted. Instead, an AASHTO LRFD load factor has been applied. This adjustment is necessary because the reinforcement check performed in the subsequent step follows an LRFD approach, and the maximum moment must be factored accordingly.

STEP 10

The typical LPB is constructed with a minimum of 5,000 psi concrete and reinforced with (4) #6 vertical bars and #3 stirrups spaced approximately 12 inches on center. Step 10 evaluates whether this standard reinforcement is sufficient to resist the applied moment in the foundation shaft. The check is performed at two locations: the solid portion of the foundation and the knockout section where the universal pathway openings are located. In the first location, the entire cross-sectional area of concrete and all four vertical bars are considered. In the second location, the section is modeled as a 6-inch wide by 24-inch deep beam with a single #6 bar. Based on LPB's experience, the typical reinforcement is generally adequate, with the prior steps in the analysis typically governing the design.

DESIGN EXAMPLE

DESIGN EXAMPLE

DESIGN EXAMPLE

The following example outlines the calculation process for the LPB foundation design based on the general analysis steps described above. It is important to note that this example uses standard assumptions and simplified conditions for illustrative purposes. Designers are advised to input their own site-specific conditions, such as local soil properties, wind speed, and load factors, to ensure an accurate and tailored design for their project.

For more detailed assistance or specific inquiries, please feel free to contact us directly. Additionally, our BaseCalc PRO tool, which is explained further in the manual, is available to help designers complete the full analysis process. This tool can streamline the design process and provide accurate calculations based on the unique parameters of your project.

Pole & Luminaires

Height	30	ft
Width/Diameter	6	in
Pole Shape	◉ Round ○ Square	
Bolt Circle Diameter	10	in
Required Bolt Size	0.75	in
Total Fixture EPA	4	ft²

Foundation

Specified Exposure	3	ft
Bury Depth	○ Specified ◉ Calculate	
Specified Bury Depth		ft
Foundation Type	Classic	
Above Grade Diameter	26	in
Below Grade Diameter	24	in

Site Conditions

Basic Wind Speed	105	mph
Exposure Category	C	
Soil Type	Cohesionless	
Internal Angle of Friction, φ	30	deg
Soil Unit Weight, γ	120	pcf
Cohesion, c	0	psf

Foundation Material Properties

Concrete Strength, f'c	5000	psi
Reinforcing Yield Strength, fy	60000	psi
Concrete Unit Weight	145	pcf
Vertical Rebar Size	6	
Hoop Rebar Size	3	

Fatigue Analysis

V_{mean}	11.2	mph (typical)
Fatigue Category	Category III	(typical)

Summary Results

Bolt and Anchoring System Check	OK	**Specified Foundation Exposure**	3.00 ft
Fatigue Loading Check	OK	**Calculated Min. Bury Depth**	4.64 ft
Combined Tension & Fatigue	OK	**Minimum Rec'd Foundation Length**	8.00 ft
Standard Reinforcing Check	OK		

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STEP 1 - DETERMINE WIND PRESSURE

$$\text{Wind Pressure} = P_Z = 0.00256 \cdot K_Z \cdot K_D \cdot G \cdot V^2 \cdot C_D$$

Basic Wind Speed, V	**105 mph**
Wind Exposure Category	**C**
K_z	**0.98**
K_d	**0.95**
G	**1.14**
C_d Pole	**0.7488245196493876**
C_d Lum	**1.00**
Pressure on Pole, P_z Pole	**22.4 lb/ft^2**
Pressure on Luminaires, P_z Lum	**29.9 lb/ft^2**

STEP 2 - DETERMINE POLE BASE REACTIONS

Pole Area	**15.00 ft^2**
Luminaire Area	**4.00 ft^2**
Total Moment at Base, M_u	**8618 ft·lb**
Total Shear at Base, V_u	**455 lb**

STEP 3 - DETERMINE TENSILE LOAD ON ANCHORS

Bolt Circle Diameter	**10**
Number of Bolts	**4**
Bolt Diameter	**0.75 in**
Bolt Stress Area	**0.334 in^2**
c	**3.54 in**
$I_{Bolt\ Group}$	**16.72 in^4**
Bolt Stress, S_u	**21865 in^4**
Total Tensile Load, T_u	**7313 lb**

STEP 4 - DETERMINE BOLT AND ANCHORING SYSTEM ADEQUACY

Nominal Tensile Capacity, T_n	**18500 lb**
Strength Reduction Factor, φ	**0.70**

Adequacy Check

Applied Load T_u(lb)	Allowable Load φT_n (lb)	Result
7313	12950	OK

STEP 5 - FATIGUE ANALYSIS - NATURAL WIND GUST PRESSURE, POLE BASE REASTION AND BOLT STRESS

Wind Pressure Due To Natural Wind Gusts = $P_{NW} = 5.2 \cdot C_D \cdot (V_{Mean}/11.2)^2 \cdot I_F$

V_{mean}	**11.2 mph**
C_d Pole	**1.1**
C_d Lum	**1.00**
Fatigue Category	**Category III**
I_F	**0.55**
P_{NW} Pole	**3.1 lb/ft^2**
P_{NW} Lum	**2.9 lb/ft^2**
Pole Area	**15.00 ft^2**
Luminaire Area	**4.00 ft^2**
Moment, M_F	**1051 ft·lb**
Shear, V_F	**59 lb**
Fatigue Bolt Stress, S_F	**2666 lb/in^2**

STEP 6 - ANCHOR BOLT ADEQUACY WITH FATIGUE LOADING

Adequacy Check

Applied Maximum Stress Range (lb/in^2)	Threshold Stress Range (lb/in^2)	Result
2666	7000	OK

Additional Check

Combined Fatigue and Ultimate Tension $T_F + T_u$(lb)	Allowable Load φT_n (lb)	Result
892 + 7313 = 8205	12950	OK

STEP 7 - DETERMINE GROUND LINE REACTIONS

Section	Wind Pressure P_z (psf)	Surface Area A (sf)	Force ($P_z \cdot A$) (lb)	Moment Arm (ft)	Moment (ft·lb)
Foundation	11.8	6.5	76.6	1.5	114.8
Pole	22.4	15.0	335.6	18.0	6040.2
Luminaire	29.9	4.0	119.5	33.0	3943.5
			531.6		10098.5

Undercapacity Factor	**0.7**
Overload Factor	**2.0**
Factor of Safety	**2.9**
M_F	**28852.8**
V_F	**1518.9**

STEP 8 - DETERMINE REQUIRED FOUNDATION EMBEDMENT

Cohesionless Soils (C13.6.1.1-5)

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

$$K_p = tan^2(45 + \frac{\phi}{2})$$ K_p = **3.00**

Required Embedment = **4.64 ft**

Cohesive Soils (C13.6.1.1-1)

$$L = 1.5D + q\left(1 + \sqrt{2 + \frac{4H + 6D}{q}}\right)$$

$$H = \frac{M_F}{V_F}$$ **H = 19.0** $$q = \frac{V_F}{9cD}$$ **q = na**

Required Embedment =

STEP 9 - DETERMINE ULTIMATE MOMENT IN FOUNDATION SHAFT

Total Applied Moment, M_{Tot}	**10098.5 ft·lb**
Total Applied Shear, V_{Tot}	**531.6 lb**
Load Factor	**1.0**
Factored Moment, M_{max}	**10098.5 ft.lb**
Factored Shear, V_{max}	**531.6 lb**

H =	**19.0**
q =	**na**
K_p =	**3.00**

Cohesionless Soils (C13.6.1.1-7)

$$M_u = V_{max}\left(H + 0.54\sqrt{\frac{V_{max}}{\gamma D K_p}}\right) \quad Location = 0.82\sqrt{\frac{V_{max}}{\gamma D K_p}}$$

Max Moment in Shaft, M_u	**10345.1 ft.lb**
Location Below Groundline	**0.7 ft**

Cohesive Soils (C13.6.1.1-4)

$$M_u = V_{max}(H + 1.5D + 0.5q)$$

$$Location = 1.5D + q$$

Based upon the equations for Cohesionless soils

STEP 10 - CHECK REINFORCING IN FOUNDATION SHAFT

Reduction Factor, φ	**0.9**
Typ Bar Cover	**3 in**
# of Vert Bars	**4**

Check Within The Soild Portion Of The Foundation Shaft:

Gross Area of Total Section, A_g	**452.4 in^2**
Dist between Bar Centers, z	**16.5 in**
Area Steel Provided, A_{sg}	**1.77 in^2**

$$\rho_{req} = \left[1 - \left(\sqrt{1 - \frac{2 \cdot M_u}{\phi \cdot A_g \cdot z \cdot 0.85 f'_c}}\right)\right] \cdot \frac{0.85 f'_c}{f_y} \geq 0.0033$$

ρreq	**0.0033**
ρprov = A_{sg} / A_g	**0.00391**

Check Within The Knockout Portion Of The Foundation Shaft - Treat As 24" Deep By 6" Wide Beam:

Beam Width, b	**6.0 in**
Dist Outer Edge to Bar Center, d	**20.3 in**
Beam Area (b·d), A_b	**121.5 in^2**
Area Steel Provided, A_{sb}	**0.44 in^2**

$$\rho_{req} = \left[1 - \left(\sqrt{1 - \frac{2 \cdot M_u}{\phi \cdot bd^2 \cdot 0.85 f'_c}}\right)\right] \cdot \frac{0.85 f'_c}{f_y} \geq 0.0033$$

ρreq	**0.0033**
ρprov = A_{sg} / A_g	**0.00364**

References And Tables

Wind Exposure Categories (ASCE 07)

Category	Description
B	Urban and suburban areas, wooded areas, or other terrain with numerous closely spaced obstructions having the size of a single-family dwelling or larger, prevailing for a distance greater than 1500 feet in any direction from the installation
C	Open terrain with scattered obstructions having heights generally less than 30 feet. (Commonly associated with flat open areas and areas not meeting the requirements of Categories B or D)
D	Areas located a close distance (typically within 600 feet) from an "open waterway" one mile or more across. This category is readily distinguishable, where the locally enforced Code very likely has this listed in the requirements.

Height And Exposure Factor, K_Z

Exposure Category	α	Z_g
B	7	1200
C	9.5	900
D	11.5	700

From Inputs:	
α	9.5
Z_g	900

Directionality Factor, K_D

Support Type/Pole	Factor
Round	0.95
Square	0.90

Notes Regarding Nominal Anchor Capcity And Reduction Factor

Given the proprietary use of the inserts and anchoring nuts, load testing of the anchoring system was completed in order to determine the nominal tensile capacity. A full write-up of the testing completed is contained in Appendix A. In total, 12 tests were completed at three different bolt circle diameters; 14-inches, 10-inches, and 7-½-inches. In each test, the anchor was loaded to 18,500 pounds which was a predetermined value based upon the actual anticipated loads. In all 12 tests, the anchoring system held the applied load without failure. Based upon these results, ReCon recommends using 18,500 pounds as the nominal tensile capacity of an individual anchor bolt within the anchoring system. This value may be modified by the Designer, per their review of the testing information, but should not exceed 18,500 pounds

According to the Chapter 5 Section 5.16.3 of the AASHTO LRFDLTS-1 manual, resistance factors for concrete anchorages shall be as specified in ACI 318, Appendix D. Section D.4.3 of ACI 318 specifies that for anchors governed by concrete breakout, side-face blow-out, pullout, or pryout (which is typically how the LPB anchoring system performed) a reduction factor of 0.7 should be used for tension loads. This value may be modified by the Designer but should not exceed 0.7.

Drag Coefficients, C_D (Non-Extreme Limit State C_V = 1.0)

Luminaire Shape	Coefficient	
Rounded	0.50	
Flat Sides	1.20	
Pole Shape	**Coefficient**	
Round	$C_V d \le 39$ mph·ft	
	1.10	
Square	2.0 - 6rs [for $r_s < 0.125$]	1.183
	1.25 [for $r_s \ge 0.125$]	

Fatigue Importance Factors, I_F

Fatigue Category	Fatigue Importance Factor
	Natural Wind Gusts
Category I	1.00
Category II	0.80
Category III	0.55

Note: Importance Factors Shown Are From AASHTO Table 11.6-1 For Noncantilevered Traffic Signals.

Notes Regarding Fatigue

According to Chapter 4 of the National Cooperative Highway Research Program (NCHRP) Report 469, anchor rods subject to more than 20,000 repeated applications of significant axial tension shall be checked for the fatigue limit state. The stress range is defined as the magnitude of the change in nominal stress due to the application or removal of the unfactored live load (4.6). The S-N curve for galvanized non-pretensioned anchor rods corresponds to detail Category E', however the fatigue threshold is much greater than other Category E' details. In the case of anchor rods a threshold of 7000 psi should be used (4.6 and C-4.6)No further evaluation of fatigue resistance is required if the stress in the anchor rod remains below the threshold stress range (4.6). Finally, in steel-to-concrete joints subject to fatigue, the anchor rod will fail before the concrete fatigue strength is reached. Therefore, it is not necessary to consider the fatigue strength of the concrete (C-4.6).

Foundation Details Table

Foundation Type	Above Grade Dia. (in)
Classic	26
Flare	26
Legacy	24

Wind Pressure On Foundation

Shape =	Round
K_z =	0.86
K_d =	0.95
G	1.14
C_d =	0.45
P_z =	11.78

DESIGN CALCULATION RESOURCES

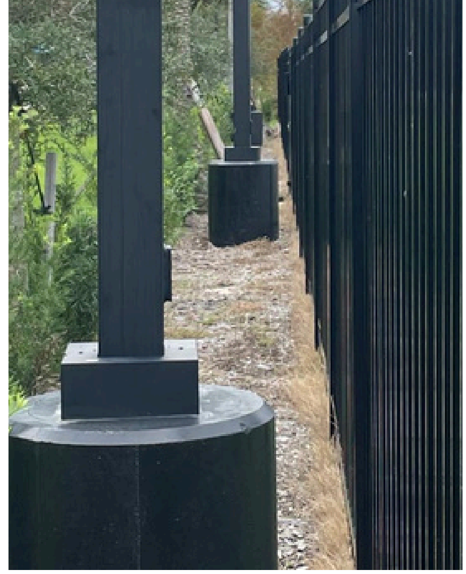
DESIGN CALCULATION RESOURCES

The design calculation resources, BaseCalc LT and BaseCalc PRO, have been developed to support the analysis of the LPB foundation system. The analysis method of these resources is in general accordance with the guidelines outlined in the Design Approach section of this manual and the requirements specified in the LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, First Edition, 2015 (LRFDLTS-1), published by the American Association of State Highway and Transportation Officials (AASHTO).

Users should thoroughly review and understand the Design Approach section and the stated assumptions associated with BaseCalc LT and BaseCalc PRO. These tools have been created by The Precast Forte Group and, to the best of its knowledge, accurately reflect the intended application of the product. However, users of these resources do so at their own risk and assume all associated liability.

It is essential to note that final design for construction purposes must be performed by a licensed Professional Engineer who is familiar with the project requirements and has accounted for specific site conditions.

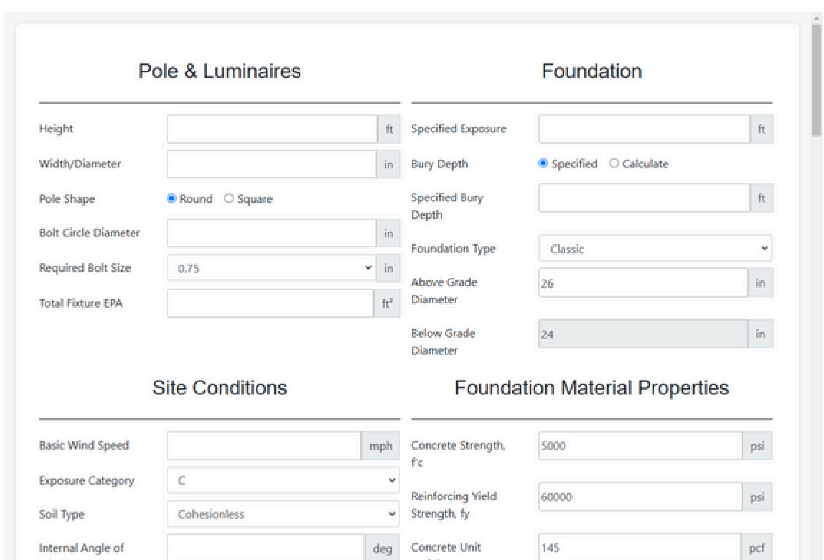
DESIGN CALCULATION RESOURCES



BASECALC PRO

BaseCalc PRO is a comprehensive design and analysis tool developed to provide engineers with full control over all variables affecting the performance of an LPB foundation. Tailored to accommodate site-specific conditions, BaseCalc PRO allows users to input detailed parameters such as soil properties, pole height, loading conditions, wind speeds, and other critical factors, ensuring an accurate and reliable analysis in accordance with industry standards. This advanced resource is designed to support designers in the engineering process, ensuring that LPB meets their project-specific requirements while adhering to the AASHTO LRFD specifications for structural supports. To request access to BaseCalc PRO, visit lightpolebase.com/light-pole-base-technical-resources/ today.

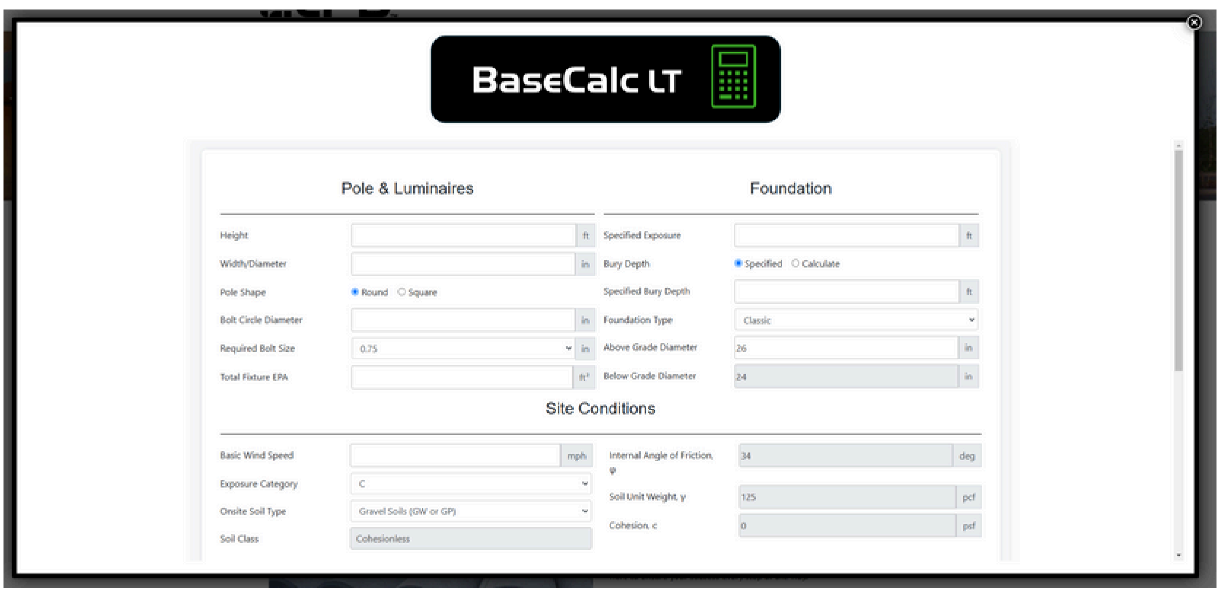
BaseCalc PRO



DESIGN CALCULATION RESOURCES

BASECALC LT

BaseCalc LT is a streamlined design and analysis tool created for quick and efficient evaluation of LPB foundations. By limiting the number of user-controlled variables, BaseCalc LT simplifies the process while maintaining the same overall analytical approach as BaseCalc PRO. This version is ideal for users seeking a faster, more accessible solution for preliminary assessments or standard applications. It is crucial, however, for users to review the assumptions outlined in the BaseCalc LT printout to confirm alignment with the specific site conditions of their project.



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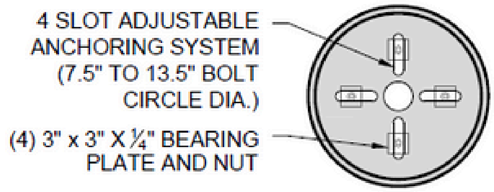
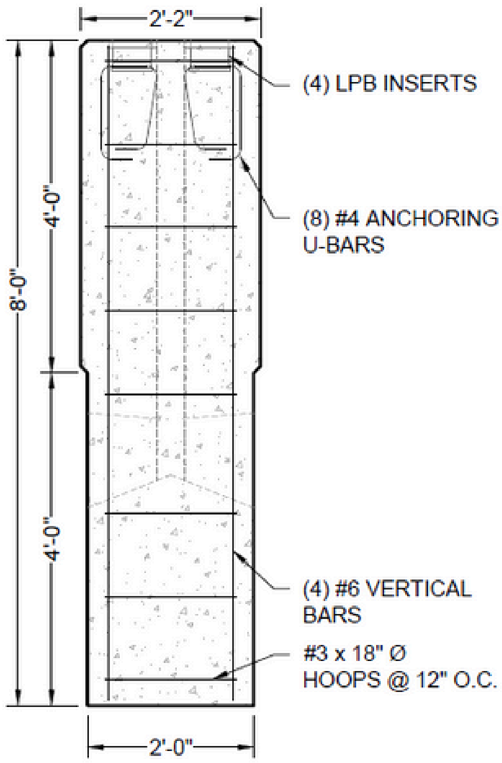
PRODUCT DRAWINGS

MATERIALS:

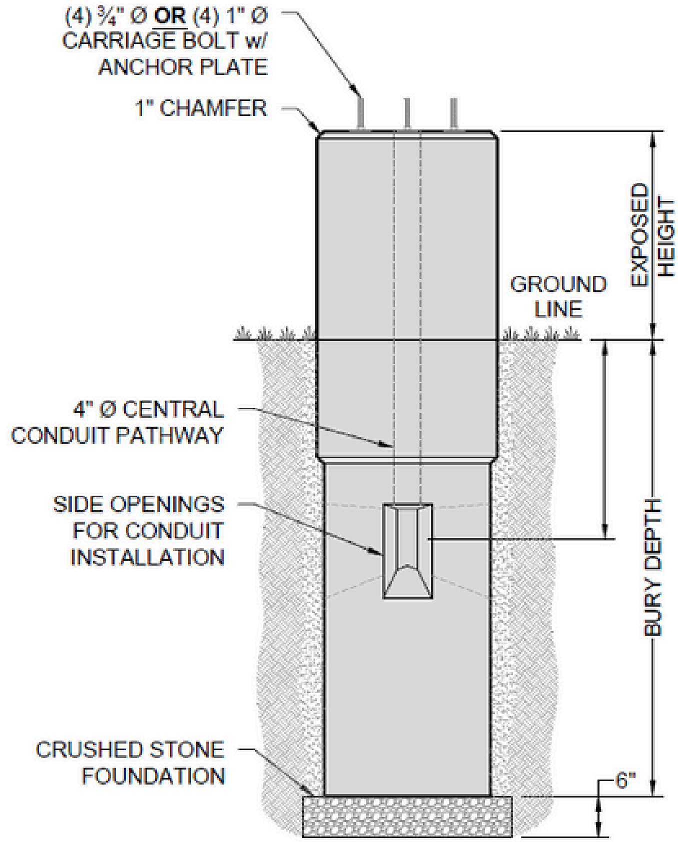
1. CONCRETE: MIN. 5000 psi @ 28 DAYS
2. REBAR: ASTM A615 GRADE 60
3. CARRIAGE BOLTS: ASTM F1554 GRADE 55
4. ANCHOR PLATES: ASTM A514
5. BEARING PLATES: ASTM A36
6. NUTS: ASTM A194 GRADE 2H
7. WASHERS: ASTM F436



TOP VIEW
SCALE: ½" = 1'-0"



PRODUCT SECTION VIEW
SCALE: ½" = 1'-0"



INSTALLED PRODUCT VIEW
SCALE: ½" = 1'-0"

Disclaimer: This drawing has been prepared by LPB, A Forte Company, and to the best of its knowledge, accurately represents the product use in the application that it is illustrated. This drawing is intended for conceptual purposes only. Anyone making use of this drawing does so at their own risk and assumes all liability for such use. Final design for construction purposes must be completed by a Registered Professional Engineer who is familiar with the product and who has taken into account specific site conditions.

LPB
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LPB CLASSIC

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MATERIALS:

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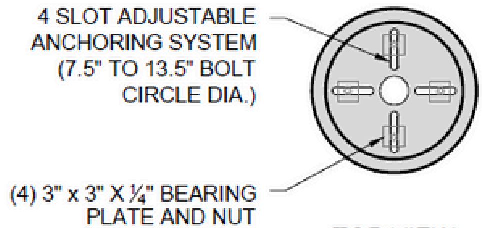

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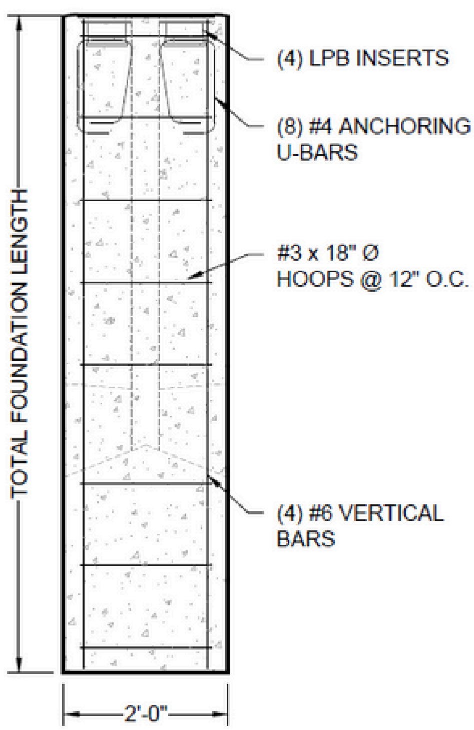

PRODUCT SECTION VIEW
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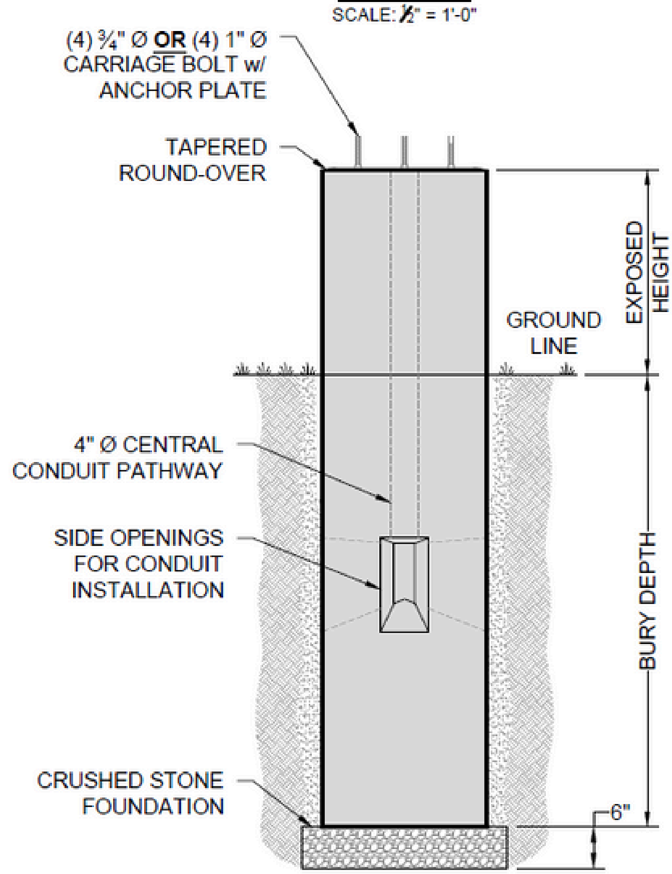

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LPB
LEGACY

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Table of Contents

MATERIALS:
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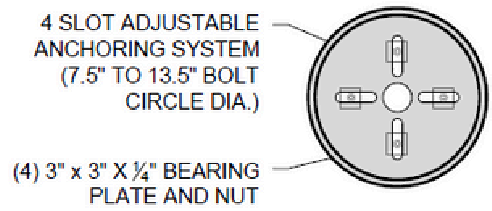

TOP VIEW
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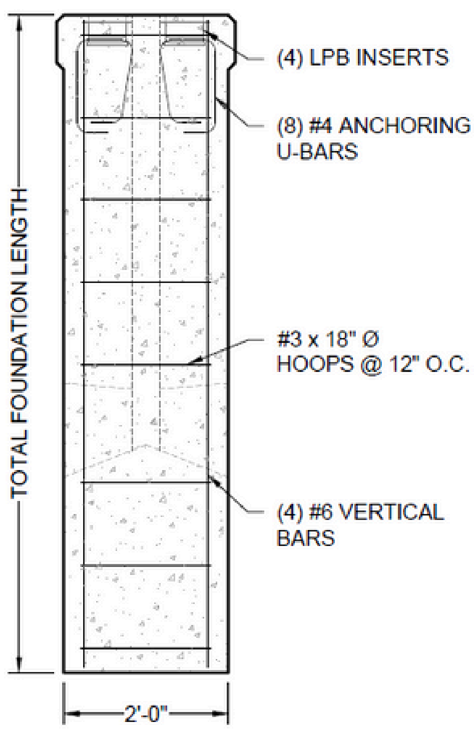
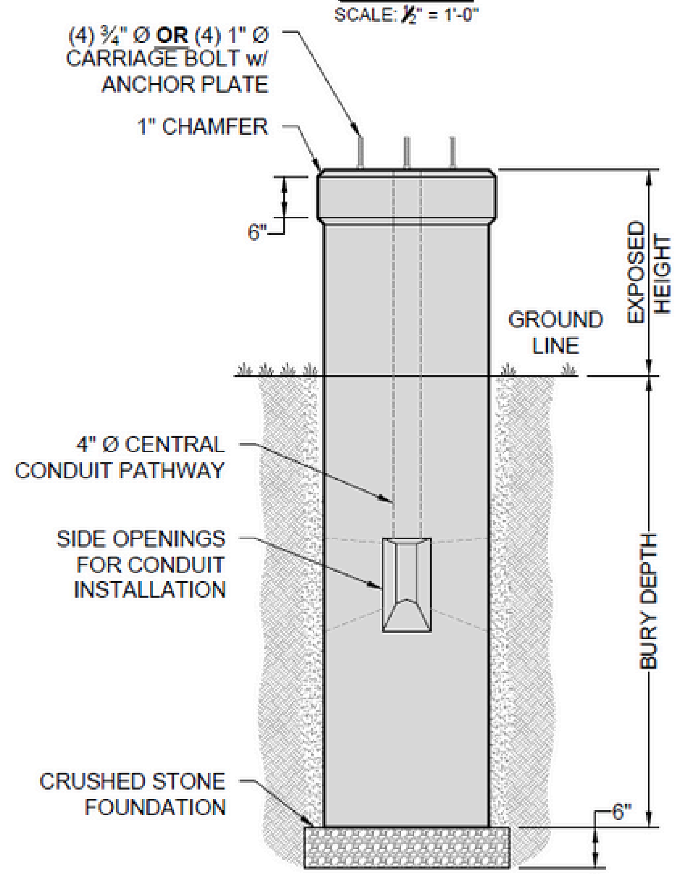


PRODUCT SECTION VIEW
SCALE: ½" = 1'-0"



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APPENDIX A

BRAUN INTERTEC
The Science You Build On.

Braun Intertec Corporation
11001 Hampshire Avenue S
Minneapolis, MN 55438

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Fax: 952.995.2020
Web: braunintertec.com

January 30, 2023

Project B2203870

ReCon Wall Systems, Inc.
7600 West 27th St. #229
St. Louis Park, MN 55426

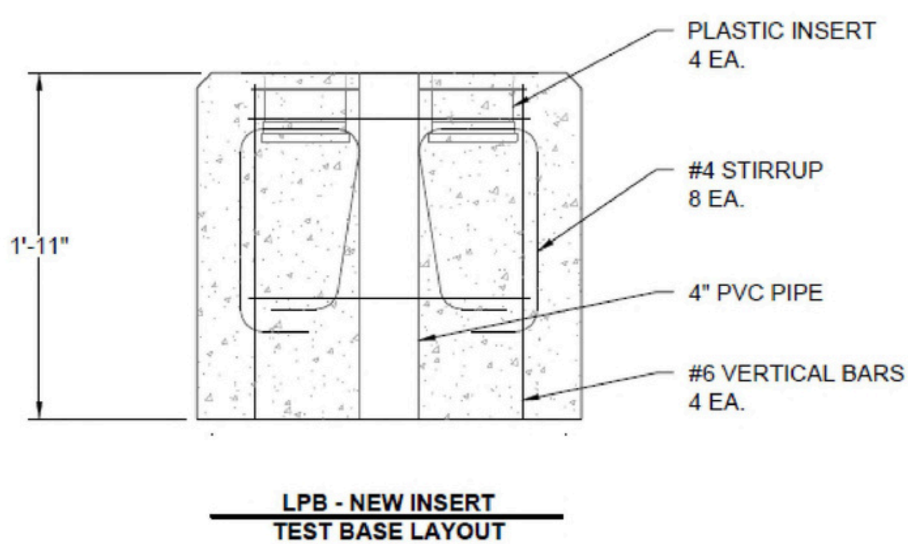
Re: Universal Precast Light Pole Foundation Testing

This report is a summary of load testing performed on ReCon light pole foundations. The purpose of the testing was to verify the anchorage could withstand a test load of 18,250 lbf.

Test Samples

Three 26" and one 24" diameter foundation samples were supplied for testing. The reinforcing layout and plastic insert is shown in figures 1 and 2 below.

Figure 1: Reinforcing Layout



AA/EOE

Figure 2: Plastic Insert

Concrete Strength Verification

Each of the samples was cast using a concrete mix with a specified minimum compressive strength of 5,000 psi. Concrete test cylinders were cast alongside the foundations and cured in the same environment. The cylinders were tested in accordance with ASTM C39, "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens" the same day as the anchor tests on the foundations were performed. The test results are shown in table 1 below.

Table 1: Concrete Compressive Strength Results

Cylinder Specimen Age (days)	Compressive Strength (psi)	Average Compressive Strength (psi)
3	5,234	5,119
3	4,952	
3	5,172	

BRAUN INTERTEC

Load Test Procedure

Two of the four anchor pockets in each foundation were load tested in tension. The samples were restrained by placing them in a load frame with steel tubes bearing on the top face. The load was applied to a single galvanized ¾”-16 bolt and t-nut inserted into the channel using a calibrated hydraulic ram. The general test setup is shown in figure 3 below.

Figure 3: Test Setup

Load tests were performed with the threaded rod located either 4” or 7” from the center of the foundation. These locations were selected to cover the full range of bolt circle diameters allowed by Recon Wall Systems, Inc. A test load of 18,250 lbf was applied during each test and any visible cracks that appeared prior to that load were noted.

Test Results.

The test results are shown in table 2 below.

Table 2: Load Test Results

14" Bolt Spacing					
Test Number	**Foundation Number**	**Foundation Diameter (in)**	**Load Applied (lbf)**	**Load at First Crack (lbf)**	**Test Result**
1	1	26	18,250	16,800	Pass
2	1	26	18,250	17,100	Pass
3	3	26	18,250	NA	Pass
4	3	26	18,250	NA	Pass
8" Bolt Spacing					
Test Number	**Foundation Number**	**Foundation Diameter (in)**	**Load Applied (lbf)**	**Load at First Crack (lbf)**	**Test Result**
1	3	26	18,250	NA	Pass
2	3	26	18,250	NA	Pass
3	2	24	18,250	NA	Pass
4	2	24	18,250	NA	Pass

The cracks occurring prior to reaching the test load appeared in a typical fashion. A vertical crack would start at the outside of the anchor and extend to the edge of the foundation and down the outside face to the approximate elevation of the first stirrup. The crack would then extend radially at around the circumference of the sample. An example of the cracks noted is shown in figure 4 below.

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The test results are shown in table 2 below.

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REFERENCES

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Dexter, R., and M. Ricker. 2002. Fatigue-Resistant Design of Cantilever Signal, Sign, and Light Supports, NCHRP Report 469. Transportation Research Board, National Research Council, Washington, DC.

Kaczinski, M. R., R. J. Dexter, and J. P. Van Dien. 1998. Fatigue Resistant Design of Cantilever Signal, Sign, and Light Supports, NCHRP Report 412. Transportation Research Board, National Research Council, Washington, DC.

DISCLAIMER

This reference manual has been created as a tool to assist in the analysis process of the LPB. The user must read the entire contents of the manual as well as the applicable portions of the referenced materials. By using this manual, the user acknowledges and agrees that an understanding of the concepts contained in this manual are essential to the proper design of an LPB.

Final design and construction, for a specific application of an LPB, are the sole responsibility of the user. Anyone making use of this manual and its calculations does so at his or her own risk and assumes any and all liability resulting from such use.

The calculations shown within the manual are for preliminary use only and shall not be relied upon prior to review by a qualified Professional Engineer. A qualified Engineer is one that is familiar with the site conditions, project conditions, soil mechanics and the design theory as described in this manual. A final site and project specific design must be prepared by a registered Professional Engineer who is licensed in the state of the project.

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11521 Eagle St NW, Ste 3
Coon Rapids, MN 55448

Patents Issued: US 8,991,122 and US 9,624,640

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