3.1.1.1.3 Base plates

PLS-POLE can check the design of a doubly symmetric steel base plate welded at the base of a tubular pole. The plate is supported by anchor bolts. While **PLS-POLE** checks the design of the plate, it does not check the design of the bolts. Like pole cross sections, base plates can have any shape. The plates can be hollowed inside the pole (the size of the hole is only used to determine the weight of the plate and it is assumed that it does not affect its strength).

If you input a thickness for the base plate it's weight will be calculated and printed in the base plate section of the input echo in the analysis report. The weight of the base plate will also be included in the weight of the steel pole when it is reported. The weight of just the tubes can be determined by subtracting the base plate weight from the steel pole weight or by summing the weights printed in the tubes summary.

The program will always calculate the minimum required thickness for your plate, but will not change the input thickness (even if it is zero). After reviewing the calculated minimum thickness you will need to round this number up to the next largest plate thickness that your manufacturer can procure and input it in the dialog shown in Figure 3.1.1-7.

You may choose to override the effective bend line length used by the program. When you do this the program does not make any check to ensure that your length is correct or even reasonable. With an appropriate override, you should be able to match results from most base plate design methods.

You can control whether a base plate drawing (like that in Fig 3.1.1-5) will be included in your analysis report and/or in a separate window through the output options available in General/Output Options.

Fig. 3.1.1.5 shows the outline of an 8-sided plate at the base of a 12-side pole. The six small squares show the locations of the anchor bolts. The circle shows the portion of the plate hollowed-out inside the pole.

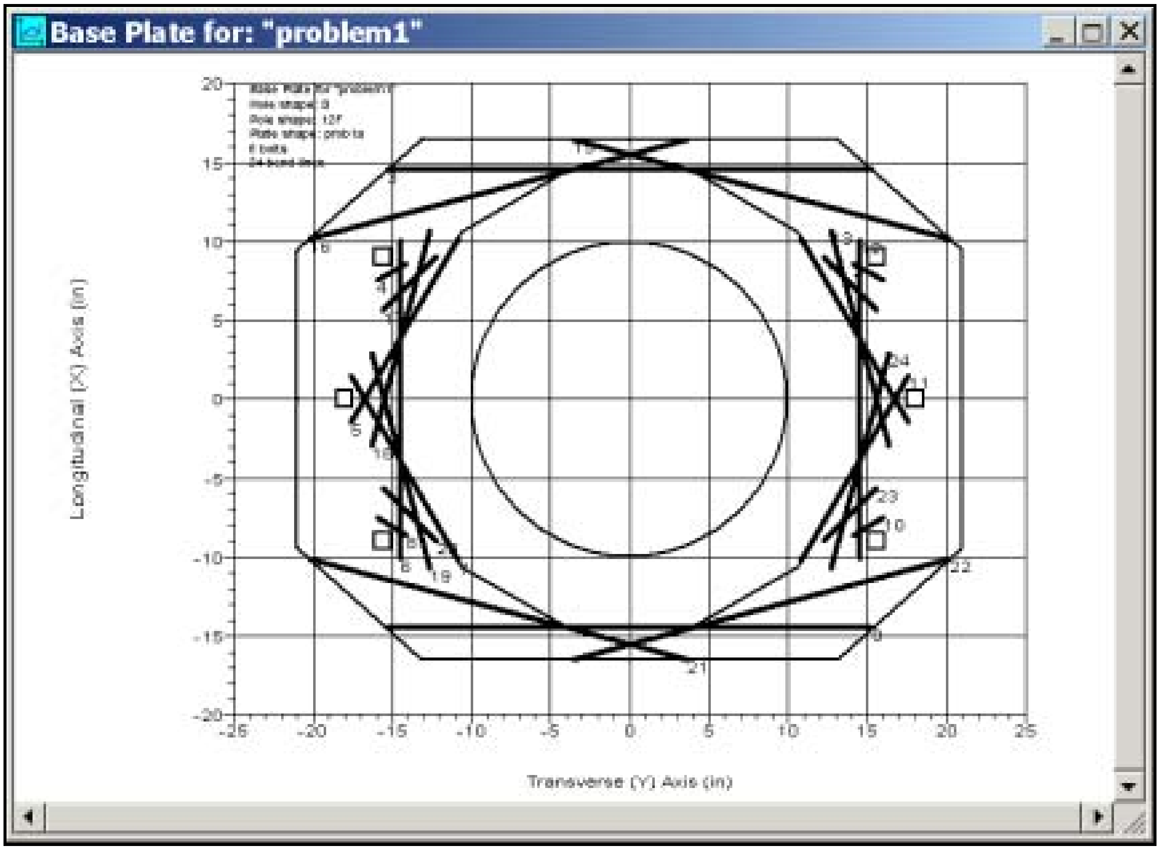
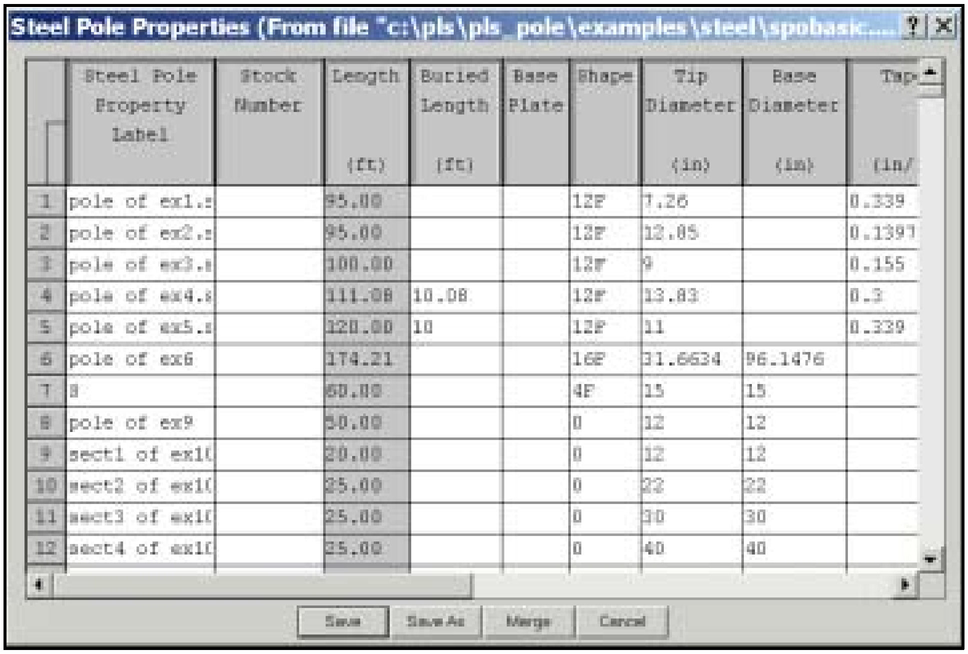


Fig. 3.1.1-5 Base plate and effective bend lines

The twenty four straight lines shown between the pole and the plate ouside boundary are effective bend lines as discussed in Section 3.1.1.3.6.

3.1.1.2 Properties

Fig. 3.1.1-6 shows the pole properties table accessed via **Components/ Steel Pole**.



Steel Pole Properties (From file "c:\pls\pls_pole\examples\steel\spobasic....

	Steel Pole Property Label	Stock Number	Length (ft)	Buried Length (ft)	Base Plate	Shape	Tip Diameter (in)	Base Diameter (in)	Tap (in/
1	pole of ex1.s		95.00			12F	7.26		0.339
2	pole of ex2.s		95.00			12F	12.05		0.1397
3	pole of ex3.s		100.00			12F	9		0.155
4	pole of ex4.s		111.08	10.08		12F	13.83		0.3
5	pole of ex5.s		120.00	10		12F	11		0.339
6	pole of ex6		174.21			16F	31.6634	96.1476	
7	8		60.00			4F	15	15	
8	pole of ex9		50.00			0	12	12	
9	sect1 of ex10		20.00			0	12	12	
10	sect2 of ex10		25.00			0	22	22	
11	sect3 of ex10		25.00			0	30	30	
12	sect4 of ex10		25.00			0	40	40	

Save | Save As | Merge | Cancel

Fig. 3.1.1-6 Main pole properties table

The data are:

Pole property label:

Alphanumeric identifier

Stock Number:

Optional stock number

Length, L:

Total pole length calculated as the sum of the lengths of individual tubes minus the overlaps, as defined in the last field of the table. This is a derived quantity which you cannot change

Buried length, BL:

For direct embedded poles, this is the distance between the lower end (base) of the manufactured pole and the ground. This is a default value that can be overriden by the data in the last two columns of the **Steel Pole Connectivity** table which is opened with **Geometry/ Steel Poles**.

Base Plate:

For poles supported by a base plate, you click in this column to access the **Base Plate** properties table of Fig. 3.1.1-7. Base plate data include:

Plate shape: Code for exterior shape of plate. Selected from same list of available shapes as that developed for the poles (either standard or custom shape in the table of Fig. 3.1.1-4).

Plate diameter: Plate outside diameter (see Sections 3.1.1.1.1 and 3.1.1.1.2 as well as Fig. 3.1.1-3 for effect of this value on actual exterior dimensions of plate

Hole shape and diameters:

Quantities similar to the *Plate shape* and *Plate diameter* described above, except that these define the shape and size of the hole.

Steel density:

Density of plate material

Bolt pattern diam.:

Diameter of circle along which bolts are located or multiplier of bolt coordinates X and Y as defined in table in lower part of dialog box

Bolt diameter:

Bolt diameter

Steel yield stress, F_{yPL}:

Yield stress of plate material

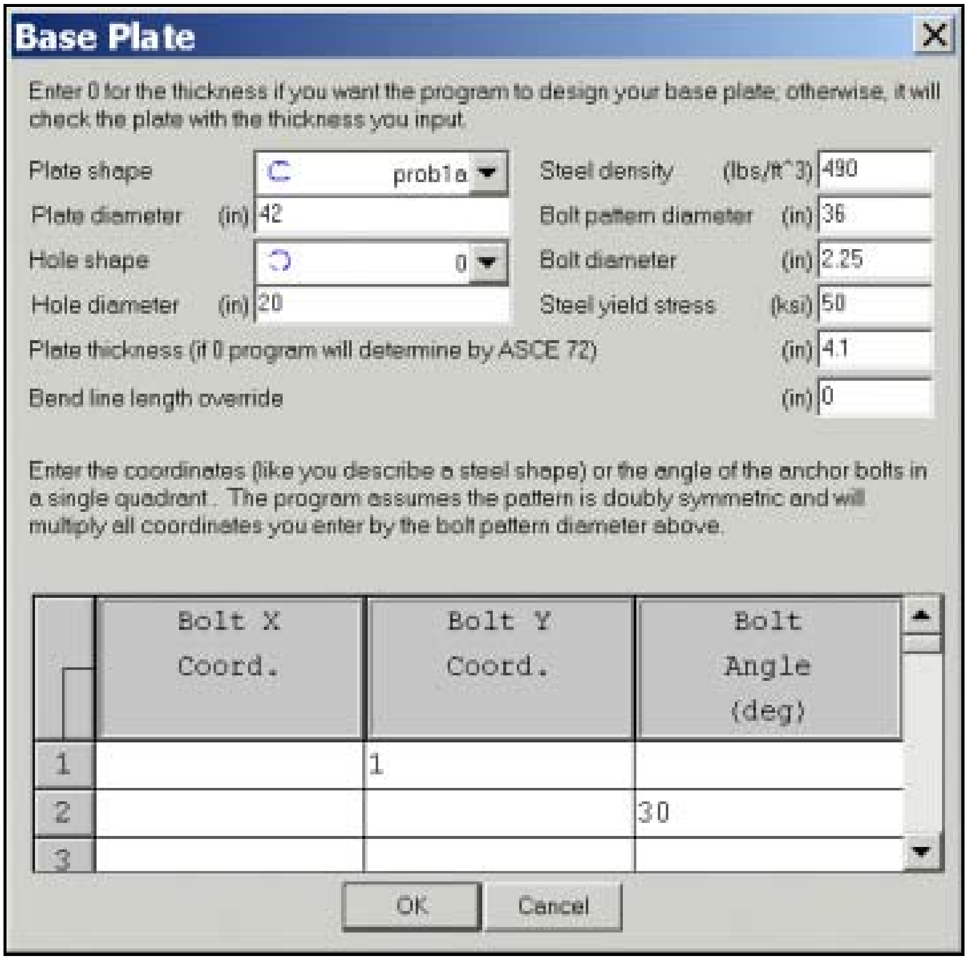


Fig. 3.1.1-7 Base plate properties table

Plate thickness, T_{PL}
:

Plate thickness. If you enter zero, **PLS-POLE** will determine the minimum thickness required

Bend line length override, B_{EFF}:

Effective length of bend line if you enter a nonzero value (see Section 3.1.1.3.6)

Bolt coordinates or bolt angle:

For each bolt, you enter either the normalized coordinates of that bolt (which will be mutliplied by the *Bolt pattern diameter*) or the azimuth of that bolt measured clockwise from the pole transverse axis.

Shape: Code for shape of pole tubular cross section. Selected from list of available shapes (either standard or custom shape in the table of Fig. 3.1.1-4). If the shape at the base does not have the same proportions as the shape at the top (see *Shape at Base* information below), this shape is that at the top of the pole.

<u>NOTE</u>: the program only allows two (2) out of the following three (3) parameters to be input with the third quantity being always calculated.

Tip diameter, TD: Outside diameter at tip (see Sections 3.1.1.1.1 and 3.1.1.1.2 as well as Fig. 3.1.1.-3 for effect of this value on actual dimensions of cross section)

Base diameter, BD: Outside diameter at base (see Sections 3.1.1.1 and 3.1.1.2 as well as Fig. 3.1.1-3 for effect of this value on actual dimensions of cross section)

Taper, TAP: Tube taper. The taper is the rate of change of diameter per unit length of tube (twice the slope of the face of each tube), and therefore is not necessarily equal to difference between the base and top diameters divided by the pole length.

Drag coefficient, CD: Pole drag coefficient

Tubes: Clicking in this field opens the tube geometry table shown in Fig. 3.1.1-8. Tubes are described from pole tip to base. For each tube, the data include:

Length, L:

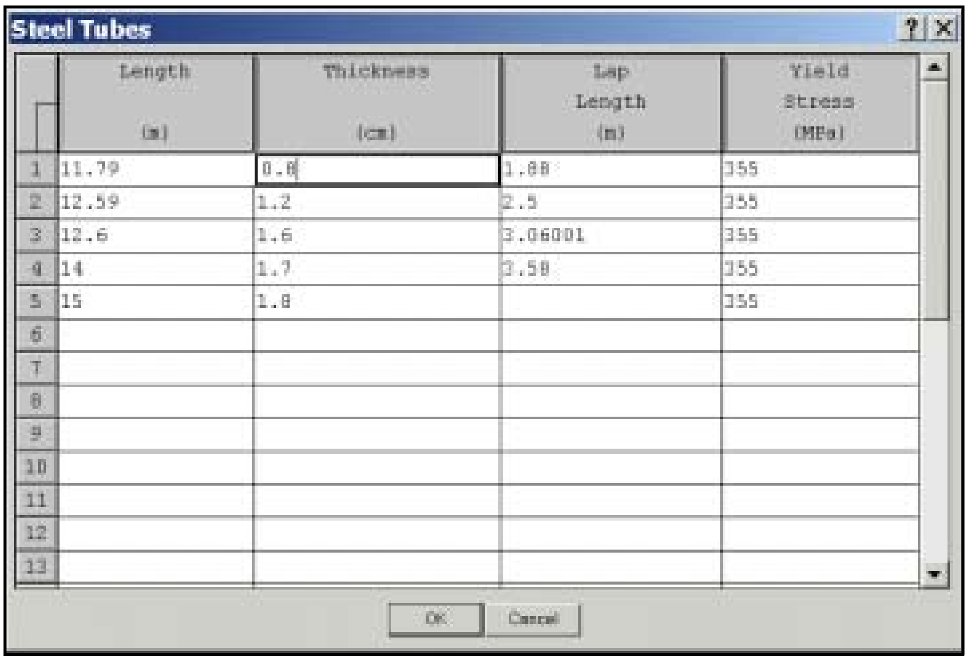
Total tube length

Thickness, t:

Tube Thickness

Lap, LAP:

Lap length at base of tube. Enter a zero value if tube is welded to tube below or if there is no tube below. Enter -1 if you want the default overlap value of 1.5 times the tube diameter to be used



	Length (m)	Thickness (cm)	Lap Length (m)	Yield Stress (MPa)
1	11.79	0.8	1.88	355
2	12.59	1.2	2.5	355
3	12.6	1.6	3.06001	355
4	14	1.7	3.58	355
5	15	1.8		355
6				
7				
8				
9				
10				
11				
12				
13				

Fig. 3.1.1-8 Steel tubes properties table

Yield stress, FY:

Steel yield stress for particular tube

Modulus of Elasticity Override:

This optional value will replace the default value used internally for the modulus of elasticity of steel (default = 29,000 ksi)

Weight Density Override:

This optional value will replace the default value used internally for the density of steel (default = 490 lbs/cubic foot)

Shape at Base: This optional value lets you select a shape of different proportions at the base of the pole as that selected at the top, with the restriction that the shapes at the top and base have the same number of faces (i.e. the same number of defining points and number of faces perpendicular to the axes in the shape definition table of Fig. 3.1.1.4)

Strength Check Type: If you select *Calculated*, the pole strength will be checked according to the method selected in the *Strength Check For Steel Poles* pick box of the **General Data** dialog of Fig. 4.2-1. The calculated strength methods are described in Sections 3.1.1.3.1 to 3.1.1.3.4.
If you select *Nominal - Circular* or *Nominal - Triangular*, the pole will be checked as described in Section 3.1.1.3.5.

The data in the last three columns of the table are only needed if you select *Nominal - Circular* or *Nominal - Triangular* as the *Strength Check Type*:

Distance From Tip, D: Distance below top of nominal *Ultimate Transverse* and *Ultimate Longitudinal Loads*.

Ultimate Transverse Load, T_n: Nominal ultimate transverse capacity of the pole measured by a single transverse load applied at a distance D below its top.

Ultimate Longitudinal Load, L_n: Nominal ultimate longitudinal capacity of the pole measured by a single longitudinal load applied at a distance D below its top. This value is not used if you select the *Nominal - Circular* method.

3.1.1.3 Design checks

For each design load case, the analysis produces axial, bending, shear, and torsional stresses at the ends of each tubular element. If you select the *Calculated* strength method in the table of Fig. 3.1.1-6, these stresses (or the corresponding forces and moments) are the basis for computing the element strength usage as described in Sections 3.1.1.3.1 to 3.1.1.3.4. The type of calculated strength check to be made for tubular elements is specified in the *Strength Check for Steel Poles* pick box of the **General Data** dialog (see Fig. 4.2-1).

3.1.1.3.1 ASCE strength check

The strength usage of a tubular element is determined as the largest stress usage at N points in the most highly stressed quadrant of each end of the element. The N points are located on the outer face of the tube wall as shown in Fig. 3.1.1-3.

For transmission poles designed according to ASCE Manual 72 (ASCE, 1990) the strength usage is calculated at each of the N points as:

$$\mathrm{SQRT}\ \{ (f_a + f_b)^2 + 3\,(f_v + f_t)^2 \ \} \ / \ (f_{all} \times \mathrm{S.F.})$$

where:

f_a	=	normal stress due to axial load
f_b	=	normal stress due to bending
f_v	=	shear stress due to shear force
f_t	=	shear stress due to torsion
f_{all}	=	allowable combined stress defined in ASCE Manual 72. It is based on D/t (circular section) or w/t (multiple flats). To calculate the unsupported flat width "w", it is assumed that a steel plate bending radius of 4 times the plate thickness is used. For a corner point, w/t is the largest of the values for the two adjacent flat faces.
S.F.	=	Strength Factor for steel poles (see Figs. 5.3-1 or 5.4-1)

3.1.1.3.2 EIA Rev F strength check

For communication poles designed according to Revision F of the EIA/TIA code (ANSI/ EIA/ TIA, 1996), the strength check is made exactly as described in Section 3.1.1.3.1 except that f_{all} is obtained from Table 5 of the EIA/TIA document and is then adjusted by the " *Allowable stress increase factor, ASI* " defined for each EIA load case (see Fig. 5.6-1). The value of f_{all} for EIA designs is about 40 percent smaller than for ASCE designs to account for the fact that the EIA code is an allowable stress code wherein the basic allowable stress is only about 60 percent of the yield value.

3.1.1.3.3 EIA Rev G strength check

For communication poles designed according to Revision G of the EIA/TIA code (ANSI/ EIA/ TIA, 2002), the strength check is made with the following equation (note that this is a single equation and not a check at N points as described in Sections 3.1.1.3.1 and 3.1.1.3.2):

$$[\ P / 0.85P_n + M / 0.9M_n + (\ V / 0.9V_n + T / 0.9T_n)^2 \ ] \ / \ \mathrm{S.F.}$$

where:

P, M, V and T	=	axial force, moment, shear and torsional moment due to design loads
P_n, M_n, V_n and T_n	=	design axial, bending, shear and torsion capacities as defined by EIA Rev G

3.1.1.3.4 RTE-ASCE strength check

For the RTE variation of the ASCE strength check, the equations shown in Section 3.1.1.3.1 are used except that the calculations of f_v, f_t and f_{all} are made according to the RTE specification.

3.1.1.3.5 Strength check when capacity defined by nominal top load

In some rare cases, the capacity of a tubular steel pole is given by the manufacturer as a single nominal horizontal load T_n (*Circular interaction)*, or a combination of transverse and longitudinal loads T_n and L_n ,where $L_n = k \times T_n$ (*Triangular Interaction*), applied at a given distance D from the top of the pole. It is then assumed that the transverse moment capacity MTCAP of a section located a distance Z below T_n is equal to T_n x Z and that the longitudinal moment capacity MLCAP of that section is equal to L_n x Z. It is further assumed that these moment capacities never get smaller than their value for Z = 5 ft.

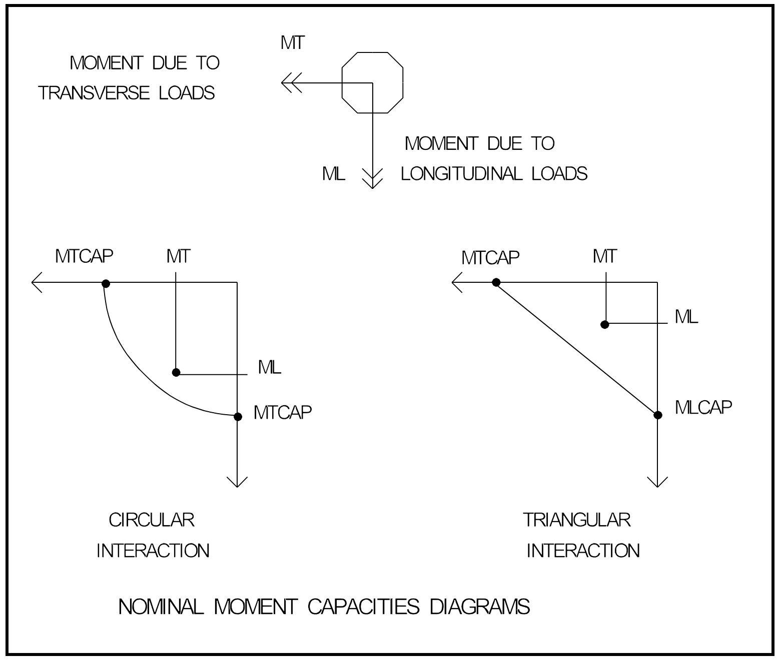


Fig. 3.1.1-9 Nominal strength checks

In such cases, the strength usage for a pole cross section where the transverse and longitudinal moments caused by the loads are MT and ML, respectively, depend on whether you select *Nominal - Circular* or *Nominal - Triangular* in the **Steel Pole Properties** table of Fig. 3.1.1-6.

If you select *Nominal - Circular* (see lower left part of Fig. 3.1.1-9), the strength usage of a section is given by:

SQRT (MT x MT + ML x ML) / (MTCAP x S.F.)

If you select *Nominal - Triangular* (see lower right part of Fig. 3.1.1-9), the strength usage is given by:

(MT + ML / k) / (MTCAP x S.F.)

where

$$k = L_n / T_n$$

3.1.1.3.6 Base plates

The strength usage of a base plate is calculated by the following process.

First, assuming that the base plate behaves as an infinitely rigid body, the axial force in bolt " i " , BL_i, is calculated by the following formula:

$$BL_i = P / n + MT\ x_i / IBC_T + ML\ y_i / IBC_L$$

where:

P = total vertical load at the base of the pole

n = total number of anchor bolts
M_T = transverse base moment
M_L = longitudinal base moment
x_i, y_i = transverse and longitudinal distances of bolt from section reference axes
IBC_T = anchor bolt cage transverse moment of inertia for unit area bolts
= $x_1^2 + x_2^2 ... + x_n^2$

IBC_L = anchor bolt cage longitudinal moment of inertia for unit area bolts
= $y_1^2 + y_2^2 ... + y_n^2$

Then, for an m-sided pole, a bending stress is calculated along the effective length, B_{EFF} , of each of 2 x m bend lines. Bend lines are straight lines which are either lined up with a face (parallel bend lines) or are perpendicular to the line going from the center of the pole to a coner (tangential bend lines), as shown in Fig. 3.1.1-10.

For a circular pole, a bending stress is calculated along two bend lines which are the two straight lines tangent to the surface of the pole and parallel to the direction of the resultant base moment.

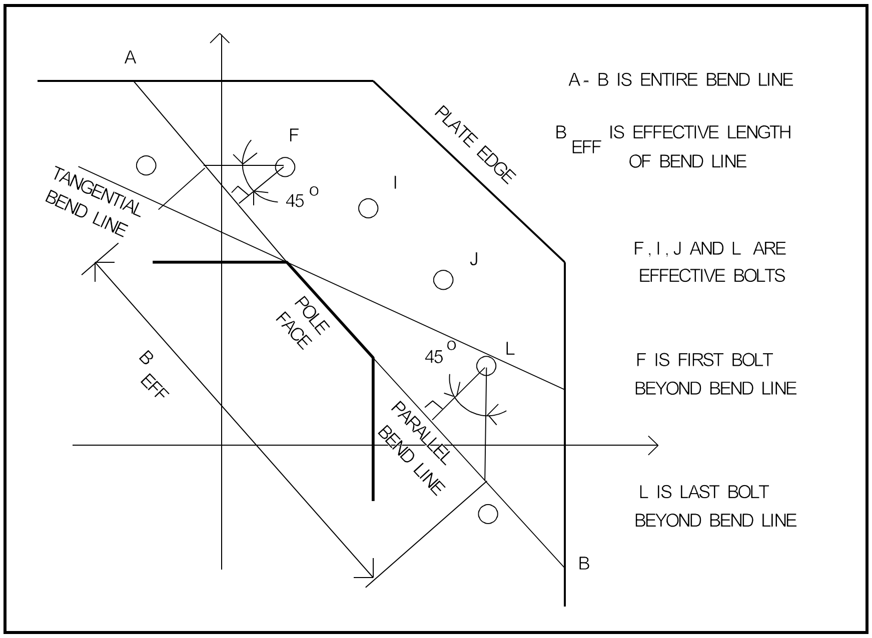


Fig. 3.1.1-10 Effective length of bend line

Assuming that the axial loads of all bolts on the outside of a bend line (total of k contributing bolts) contribute to the moment along that line and that the bending stress is uniform and limited to the effective length of the line, a design bending stress is calculated by the formula:

$$F_{bPL} = (6 / B_{EFF} \times T_{PL}^2) (BL_1 \times c_1 + BL_2 \times c_2 .... + BL_k \times c_k)$$

where:

B_{EFF} = effective length of bend line which is equal to either: 1) the length of the bend line between the projections of the first and the last contributing bolts plus the shortest distances of the first and last contributing bolts to the bend line as shown in Fig. 3.1.1-10, or 2) the *Bend line length override* in the dialog box of Fig. 3.1.1-7 if you enter a nonzero value in that box

T_{PL} = plate thickness

c_i = shortest distance from anchor bolt " i " to the bend line

Finally, the base plate strength usage is calculated by the largest of the ratios below, considering all bend lines:

$$(F_{bPL}) / (F_{yPL} \times S.F.)$$

where:

F_{yPL} = yield stress of plate steel

S.F. = Strength Factor for steel poles (see Figs. 5.3-1 or 5.4-1)

The example in Fig. 3.1.1-5 shows the 24 effective bend lines from which its base plate strength usage was calculated.