

Hand Calculation

Problem Statement 1:

Analyze reaction force for a bolt group using Elastic Method

Applied Load	$P := 335 \text{ lb}$
Applied Load Angle	$\theta_P := 0 \text{ deg}$
X axis from bolt group centroid to the center of the bolt	$e_x := -17 \text{ in}$
Y axis from bolt group centroid to the center of the bolt	$e_y := 0 \text{ in}$

4 bolts, 2 horizontal rows spaced 2 1/2" o.c , 2 vertical rows spaced 5 1/2" o.c

Bolt 1

$$x_1 := 0 \text{ in} \quad y_1 := 0 \text{ in}$$

Bolt 2

$$x_2 := 0 \text{ in} \quad y_2 := 2.5 \text{ in}$$

Bolt 3

$$x_3 := 5.5 \text{ in} \quad y_3 := 0 \text{ in}$$

Bolt 4

$$x_4 := 5.5 \text{ in} \quad y_4 := 2.5 \text{ in}$$

Solution:

Step 1: Calculate coordinate of the bolt group centroid

Applied Load X axis
Applied Load Y axis

$$X_{centroid} := \frac{x_1 + x_2 + x_3 + x_4}{4} = 2.75 \text{ in}$$

$$Y_{centroid} := \frac{y_1 + y_2 + y_3 + y_4}{4} = 1.25 \text{ in}$$

Step 2: Calculate applied load moment about the bolt group centroid

$$\begin{aligned} \text{Applied load X axis ,} \quad P_x &:= -P \cdot \sin(\theta_P) = 0 \text{ lb} \\ \text{Applied load Y axis ,} \quad P_y &:= -P \cdot \cos(\theta_P) = -335 \text{ lb} \end{aligned}$$

Moment from applied load about the bolt group centroid

$$M_{centroid} := (-P_x) \cdot (e_y) + (P_y) \cdot (e_x) = 5695 \text{ lb} \cdot \text{in}$$

Step 3: Calculate the X and Y distances from the bolt group centroid to each bolt.

Bolt 1:

$$c_{x_1} := x_1 - X_{centroid} = -2.75 \text{ in}$$

$$c_{y_1} := y_1 - Y_{centroid} = -1.25 \text{ in}$$

Bolt 2:

$$c_{x_2} := x_2 - X_{centroid} = -2.75 \text{ in}$$

$$c_{y_2} := y_2 - Y_{centroid} = 1.25 \text{ in}$$

Bolt 3:

$$c_{x_3} := x_3 - X_{centroid} = 2.75 \text{ in}$$

$$c_{y_3} := y_3 - Y_{centroid} = -1.25 \text{ in}$$

Bolt 4:

$$c_{x_4} := x_4 - X_{centroid} = 2.75 \text{ in}$$

$$c_{y_4} := y_4 - Y_{centroid} = 1.25 \text{ in}$$

Step 4: Calculate radial distance from the bolt group centroid to the center of each bolt, and Calculate the polar moment of inertia of each bolt about the about the bolt group centroid

Bolt 1:

$$c_1 := \sqrt{c_{x_1}^2 + c_{y_1}^2} = 3.02 \text{ in}$$

$$I_{p_1} := c_1^2 = 9.13 \text{ in}^2$$

Bolt 2:

$$c_2 := \sqrt{c_{x_2}^2 + c_{y_2}^2} = 3.02 \text{ in}$$

$$I_{p_2} := c_2^2 = 9.13 \text{ in}^2$$

Bolt 3:

$$c_3 := \sqrt{c_{x_3}^2 + c_{y_3}^2} = 3.02 \text{ in}$$

$$I_{p_3} := c_3^2 = 9.13 \text{ in}^2$$

Bolt 4:

$$c_4 := \sqrt{c_{x_4}^2 + c_{y_4}^2} = 3.02 \text{ in}$$

$$I_{p_4} := c_4^2 = 9.13 \text{ in}^2$$

Combined polar moment of inertia

$$I_p := I_{p_1} + I_{p_2} + I_{p_3} + I_{p_4} = 36.5 \text{ in}^2$$

Step 5: Calculate shear and torsional shear for each bolt in X and Y axis.

Bolt 1: Direct Shear

$$r_{px_1} := \frac{-P_x}{4} = 0 \text{ lb}$$

$$r_{py_1} := \frac{-P_y}{4} = 83.8 \text{ lb}$$

Torsional Shear

$$r_{mx_1} := \frac{M_{centroid} \cdot c_{y_1}}{I_p} = -195 \text{ lb}$$

$$r_{my_1} := \frac{-M_{centroid} \cdot c_{x_1}}{I_p} = 429.1 \text{ lb}$$

Bolt 2:

$$r_{px_2} := \frac{-P_x}{4} = 0 \text{ lb}$$

$$r_{py_2} := \frac{-P_y}{4} = 83.8 \text{ lb}$$

$$r_{mx_2} := \frac{M_{centroid} \cdot c_{y_2}}{I_p} = 195 \text{ lb}$$

$$r_{my_2} := \frac{-M_{centroid} \cdot c_{x_2}}{I_p} = 429.1 \text{ lb}$$

Bolt 3:

$$r_{px_3} := \frac{-P_x}{4} = 0 \text{ lb}$$

$$r_{py_3} := \frac{-P_y}{4} = 83.8 \text{ lb}$$

$$r_{mx_3} := \frac{M_{centroid} \cdot c_{y_3}}{I_p} = -195 \text{ lb}$$

$$r_{my_3} := \frac{-M_{centroid} \cdot c_{x_3}}{I_p} = -429.1 \text{ lb}$$

Bolt 4:

$$r_{px_4} := \frac{-P_x}{4} = 0 \text{ lb}$$

$$r_{py_4} := \frac{-P_y}{4} = 83.8 \text{ lb}$$

$$r_{mx_4} := \frac{M_{centroid} \cdot c_{y_4}}{I_p} = 195 \text{ lb}$$

$$r_{my_4} := \frac{-M_{centroid} \cdot c_{x_4}}{I_p} = -429.1 \text{ lb}$$

Step 6: Calculate total direct and torsional shear for each bolt in X and Y axis.

Bolt 1:

$$r_{x_1} := r_{px_1} + r_{mx_1} = -195 \text{ lb}$$

$$r_{y_1} := r_{py_1} + r_{my_1} = 512.8 \text{ lb}$$

Bolt 2:

$$r_{x_2} := r_{px_2} + r_{mx_2} = 195 \text{ lb}$$

$$r_{y_2} := r_{py_2} + r_{my_2} = 512.8 \text{ lb}$$

Bolt 3:

$$r_{x_3} := r_{px_3} + r_{mx_3} = -195 \text{ lb}$$

$$r_{y_3} := r_{py_3} + r_{my_3} = -345.3 \text{ lb}$$

Bolt 4:

$$r_{x_4} := r_{px_4} + r_{mx_4} = 195 \text{ lb}$$

$$r_{y_4} := r_{py_4} + r_{my_4} = -345.3 \text{ lb}$$

Step 6: Calculate resultant shear for each bolt in the bolt group.

Bolt 1:

$$r_1 := \sqrt{r_{x_1}^2 + r_{y_1}^2} = 549 \text{ lb}$$

Bolt 2:

$$r_2 := \sqrt{r_{x_2}^2 + r_{y_2}^2} = 549 \text{ lb}$$

Bolt 3:

$$r_3 := \sqrt{r_{x_3}^2 + r_{y_3}^2} = 397 \text{ lb}$$

Bolt 4:

$$r_4 := \sqrt{r_{x_4}^2 + r_{y_4}^2} = 397 \text{ lb}$$

See the following ENERCALC printed calculation report for comparison

Steel Bolt Group Analysis

Project File: Bolt Group Analysis.ec6

LIC# : KW-06000215, Build:20.26.02.18

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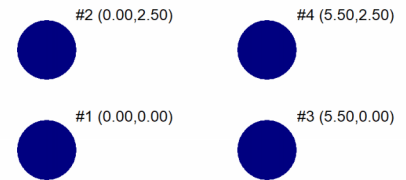
DESCRIPTION: Steel Bolt Group Analysis
Code References

 Governing Code : IBC 2024
 Load Combination Set : IBC 2018

Centroid & Eccentricity
Bolt Group Centroid...

 X Distance 2.750 in
 Y Distance 1.250 in

Load Eccentricity from C.

 Y Distance 0.000 in
 X Distance -17.000 in
 Total Moment 0.00k-in

Bolt Locations

Bolt #	X Location =	Y Location =
Bolt #1	0.00 in	0.00 in
Bolt #2	0.00 in	2.50 in
Bolt #3	5.50 in	0.00 in
Bolt #4	5.50 in	2.50 in

Applied Loads

	Dead Load	L : Live Load	Lr : Roof Live	S : Snow	W : Wind	E : Seismic	H : Earth
Load Magnitude	0.335			0.000	0.000	0.000	0.000 k
Application Angle	270.00	0.00	0.00	0.00	0.00	0.00	0.00 deg CCW
Horiz Dist from Datur	-14.25 in						
Vert Dist from Datum	1.25 in						

Maximum Bolt Shear Forces

Bolt #	Load Combination	Bolt Dist. From C.B.G		Direct Shear Force		Moment	Torsional Shear Force		Final Shear
		X	Y	X	Y		X	Y	
1	D Only	-2.750 in	-1.250 in	-0.000k	-0.084 k	0.47 k-ft	0.195 k	-0.429 k	0.549k
2	D Only	-2.750 in	1.250 in	-0.000k	-0.084 k	0.47 k-ft	-0.195 k	-0.429 k	0.549k
3	D Only	2.750 in	-1.250 in	-0.000k	-0.084 k	0.47 k-ft	0.195 k	0.429 k	0.397k
4	D Only	2.750 in	1.250 in	-0.000k	-0.084 k	0.47 k-ft	-0.195 k	0.429 k	0.397k

Detailed Analysis Results

Bolt #	Load Combination	Bolt Dist. From C.B.G		Direct Shear Force		Moment	Torsional Shear Force		Final Shear
		X	Y	X	Y		X	Y	
1	D Only	-2.750 in	-1.250 in	-0.000k	-0.084 k	0.47 k-ft	0.195 k	-0.429 k	0.549k
2	D Only	-2.750 in	1.250 in	-0.000k	-0.084 k	0.47 k-ft	-0.195 k	-0.429 k	0.549k
3	D Only	2.750 in	-1.250 in	-0.000k	-0.084 k	0.47 k-ft	0.195 k	0.429 k	0.397k
4	D Only	2.750 in	1.250 in	-0.000k	-0.084 k	0.47 k-ft	-0.195 k	0.429 k	0.397k