

DESIGN OF LIFTING LUGS

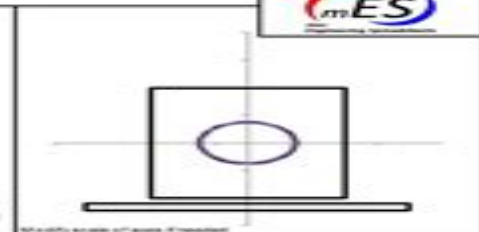
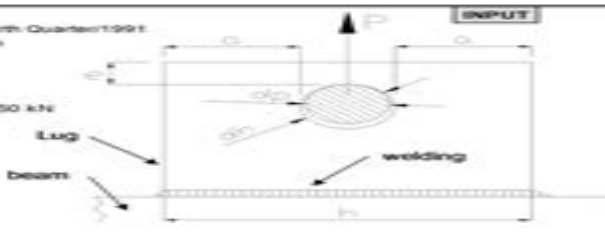
Reference: Design and Construction of Lifting Beams
David T. Ricker, PE, ASCE Engineering Journal, Fourth Quarter 1991
Updated to 2005 ASCE Manual of Steel Construction
2nd ed 2005

Date and project ref.:
Designed by: XXXXXX
Company: XXXXXX

Select Units System: S.I.

Unfactored lifting load, $P = 50$ kN
Safety Factor, $S.F. = 1$
Pin diameter, $d_p = 29$ mm
Lug hole diameter, $d_h = 30$ mm
 $a = 15$ mm
 $e = 25$ mm
Lug plate Thickness, $t = 20$ mm
Lug yield stress, $F_y = 235$ MPa
Lug ultimate stress, $F_u = 360$ MPa
Welding length $h = 60,00$ mm

$P = 11,24$ kips.
 $P \cdot S.F. = 11,24$ kips = 50 kN
 $d_p = 1,14$ in.
 $d_h = 1,18$ in.
 $a = 0,59$ in.
 $e = 0,98$ in.
 $t = 0,79$ in.
 $F_y = 34,06$ ksi.
 $F_u = 52,21$ ksi.
 $h = 2,36$ in.



Geometry Checks:
 $d_p < d_h - 1/16"$? No Pin is considered fitting the hole.
 $a \geq 2t$? No Increase a or decrease t.
 $a \leq 2t + 63"$? Yes Use full value of a.
 $a \geq d_h/27$? Yes Plate proportions are correct.
 $t \geq 1/2"$? Yes Plate proportions are correct.
 $e \geq 0,67d_h$? Yes Plate proportions are correct.
 $t \geq 0,25d_h$? Yes Plate proportions are correct.
 $h \geq 2a + d_h$? Yes Welding length is correct.

Capacity Checks (capacity values without S.F.):
Failure mode 1 $P_t = 48,56$ kips = 216,0 kN, Tensile Rupture of Lug.
Failure mode 2 $P_p = 27,58$ kips = 122,7 kN, Bearing Capacity of Pin on Hole.
Failure mode 3 $P_s = 21,13$ kips = 94,0 kN, Shear Yielding to Edge of Plate.
Failure mode 4 $P_e = N/A$ kips = N/A, Tension Tear Out to Edge of Plate

Verification
Failure mode 1 O.K. $SF = 4,32$ 2"MPa(29+63")/F_u Pg. 151 of Reference, Equation (D5-1) of Manual.
Failure mode 2 O.K. $SF = 2,45$ 2"MPa(29+63")/F_y Pg. 152 of Reference, Equation (D7-1) of Manual.
Failure mode 3 O.K. $SF = 1,38$ 2"MPa(29+63")/F_y Pg. 152 of Reference, Equation (D3-1) of Manual.
Failure mode 4 N/A. $SF = 1,67$ 2"MPa(29+63")/F_y Pg. 152 of Reference, with $P_t = 0,67 F_y$.

Checks of lug bottom section:
 $F_{u2} = h \cdot t \cdot f_y = 282$ kN Tension resistance of the section
Verification O.K. $P \cdot S.F. = F_{u2}$

Welding verification

Material of bottom beam

Yield of bottom beam, $f_y = 355$ MPa
Ultimate stress of bottom beam, $f_u = 555$ MPa



Welding verification (type 1, fillet welding)

Geometry
Welding length, $h = 60,00$ mm
Number of welding chord, $n_w = 2$
Welding
Welding throat, $a_w = 5$ mm
Side t_w of weld, $t_w = a_w \cdot \sqrt{2} = 7,07$ mm
Load
Load, $N_{u2} = P \cdot S.F. = 50,00$ kN



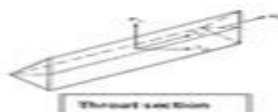
Materials

Yield of the lug, $f_{y1} = 235,00$ MPa
Ultimate stress of lug, $f_{u1} = 360,00$ MPa
Yield of bottom beam, $f_{y2} = 355,00$ MPa
Ultimate stress of bottom beam, $f_{u2} = 555,00$ MPa
Yield of the weakest component, $f_y = f_{y1} = 235,00$ MPa
Ultimate stress weakest component, $f_u = 360,00$ MPa

$\gamma_{M2} = 1,25$
 $\phi_1 = 0,5$
 $\phi_2 = 0,8$
☒ User value

Stresses on the throat section

Verification as per method of Eurocode 3 EN 1993 1-8:2005
 $\sigma_{t1} = N_{u2} / (n_w \cdot h \cdot a_w) = 58,93$ MPa
 $\sigma_{t2} = N_{u2} / (n_w \cdot h \cdot a_w) = 58,93$ MPa
 $\tau_w = 0$
 $\sigma_{w1} = (\sigma_{t1}^2 + 3 \cdot (\tau_w^2 + \sigma_{t2}^2))^{1/2} = 117,85$ MPa
 $\sigma_w = f_y / (\phi_w \cdot \gamma_{M2}) = 576,00$ MPa
 $\sigma_w^* = 0,9 \cdot f_y / \gamma_{M2} = 259,20$ MPa



Stresses on the overturned throat section

Verification as per alternative method in EN 1993 1-8:2005
 $\sigma_{t1} = \sigma_{t2} = N_{u2} / (n_w \cdot h \cdot a_w) = 83,33$ MPa
 $\tau_w \cdot \phi_1 = 188,00$ MPa
 $\tau_w \cdot \phi_2 = 235,00$ MPa
 $\sigma_{w1} = (\sigma_{t1}^2 + \tau_w^2)^{1/2} = 83,33$ MPa
 $[\sigma_{t1} + \tau_w] = 83,33$ MPa



$\sigma_w \leq \sigma_w^*$ OK VERIFIED $SF^* = 4,89$, ratio* = 0,205
 $\sigma_w \leq \sigma_w^*$ OK VERIFIED $SF^* = 4,4$, ratio* = 0,227

$\sqrt{(\sigma_{w1}^2 + \tau_w^2) \leq \sigma_{w1} \cdot \phi_1}$ OK VERIFIED $SF^* = 2,26$, ratio* = 0,443
 $[\sigma_{t1} + \tau_w] \leq \sigma_{w1} \cdot \phi_2$ OK VERIFIED $SF^* = 2,82$, ratio* = 0,355

Simplified method

Tension resistance of the welding:
 $F_{w2} = f_y \cdot l \cdot (\sqrt{3} \cdot \phi_w \cdot \gamma_{M2}) = 332,55$ MPa
 $F_{w2} = a_w \cdot h \cdot f_{w2} \cdot \gamma_{M2} = 199,53$ kN
 $F_{w2} \geq N_{u2}$ OK VERIFIED $SF^* = 3,99$, ratio* = 0,251

(*) additional safety factor with respect to the S.F. already considered above in the load (N_{u2})

Welding verification (type 2, full penetration)

(Eurocode 3 EN 1993 1-8:2005)
Joint resistance is equal to the weakest material component

Data
Lug plate thickness, $t = 20,00$ (mm)
Welding length, $h = 60,00$ (mm)
dimension c ($c \leq 3$ mm) $c = 3$ (mm)
Known values
Welding side, $t_1 = 8$ (mm)
Welding height, $h_1 = 10$ (mm)
Welding throat, $a_1 = 12,81$ (mm)
Welding angle 1, $\alpha_1 = 51,34$ (deg)
Welding side, $t_2 = 9,00$ (mm)
Welding height, $h_2 = 10$ (mm)
Welding throat, $a_2 = 13,45$ (mm)
Welding angle 2, $\alpha_2 = 48,01$ (deg)

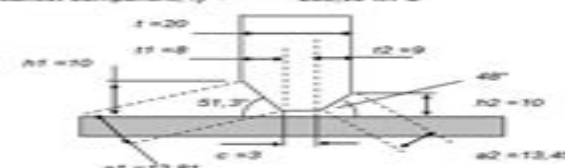
$a_1 + a_2 \geq t$ OK VERIFIED

Tension resistance of the welding:
 $F_{w2} = h \cdot t \cdot f_y = 282,00$ kN
 $F_{w2} \geq N_{u2}$ OK VERIFIED $SF^* = 5,64$, ratio* = 0,177

Materials

Yield of the lug, $f_{y1} = 235,00$ MPa
Yield of bottom beam, $f_{y2} = 355,00$ MPa
Yield of the weakest component, $f_y = 235,00$ MPa

Load
Load, $N_{u2} = P \cdot S.F. = 50,00$ kN



(*) additional safety factor with respect to the S.F. already considered above in the load (N_{u2})

Lifting Lug Design Manual

JS Bruner



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