3-3.3 PINNED CONNECTION

LUG PLATE DESIGN CHECK

Reference 1 : ASME BTH-1-2005: Design of Below-the hook lifting devices, Chapter 3, Structural Design

Reference 2 : Work Safe BC, Part 15 Rigging

3-3.3.1 STATIC STRENGTH OF THE PLATES

PLATE MATERIAL

Fy=	300 mPa
Fu=	450 mPa

ALLOWABLE TENSILE STRENGTH THROUGH THE PIN HOLE Pt SHALL BE:

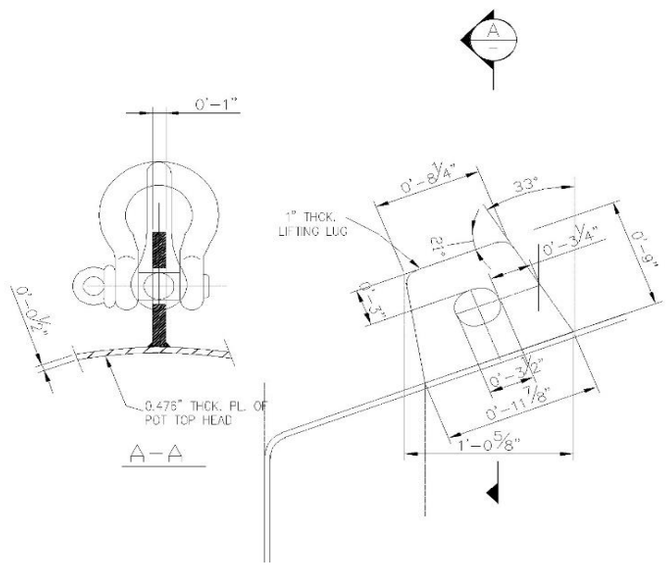
$$Pt = \frac{Fu}{1.20 * Nd} * 2 * t * beff$$ (3-45), ref 1

As per Table C3-3 Design Category B Static Load Spectrum ref 1

Nd= 3.6 FOR CONNECTION (LUG PLATE)

$b_{eff=}$ effective width of each side of the pin hole

$b_{eff} \leq 4t \leq$



b_e	=	3.25 inch	=	82.55 mm	
t	=	1 inch	=	25.4 mm	
Dh	=	3 inch	=	76.2 mm	
b_{eff}	=	82.55 mm	=	3.25 inch	(3-46), ref 1

$$b_{eff} \leq be * 0.6 * \frac{Fu}{Fy} * \sqrt{(\frac{Dh}{be})} \leq be$$ (3-47)

b_{eff} = 71.38 mm = 2.81 inch (3-47)

b_{eff} = 71.38 mm = 2.81 inch

Pt = 377.72 kN = 38503.66 kg = 38.50 T

ALLOWABLE SINGLE PLANE FRACTURE STRENGTH BEYOND THE PIN HOLE Pb IS:

Nd_fract= Nd 3.60 § 3-1.3. (b)

$$Pb = \frac{Fu}{1.20*Nd\_fract} * \left[1.13 * \left(R - \frac{Dh}{2}\right) + 0.92 * be/(1 + \frac{be}{Dh})\right]*t$$ (3-48)

R= 114 mm = 4.488188976 inch distance from the center of the hole to the edge of the plate

Pb= 316.64 kN 32277.08 kg = 32.28 T

The allowable double plane shear strength beyond the pin hole Pv is

$$Pv = 0.70 * \frac{Fu}{1.20*Nd}*Av$$ (3-49)

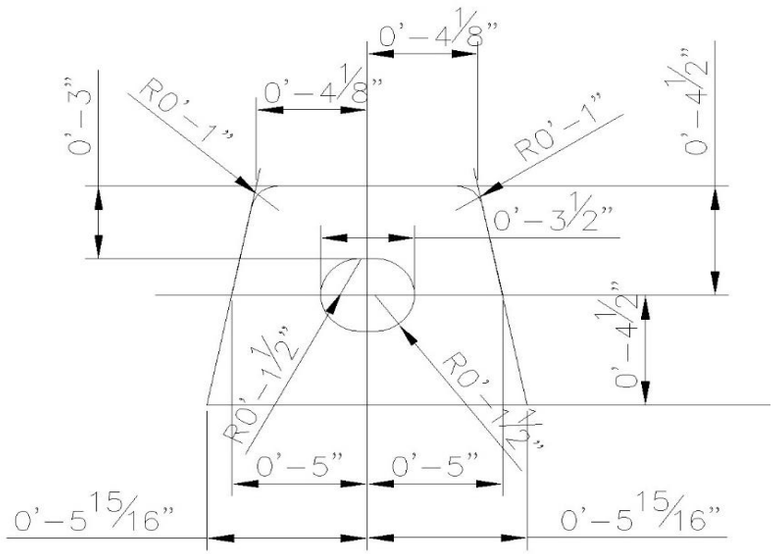
Av= total area of the two shear planes beyond the pin hole

$$Av = 2 * \left(R - \frac{Dh}{2} * \cos 45\ deg \right) * t \quad \text{(3-50)}$$

∏= 3.141593

Av= 4422.61 mm2

Pv= 322.48 kN = 32872.77 kg = 32.87 T



OVERALL CAPACITY OF ONE LUG-PLATE BASED ON 4 MODES OF FAILURE: WORKING LOAD LIMIT, WLL (PER ONE 1 LUG PLATE)

angle: VERTICAL

WLL(1)=	316.64 kN	=	32277.08 kg	= 32.28 T

BELOW THE HOOK WLL (TOTAL FOR BOTH LUGS)

WLL, vert=	633.28	=	64554.17 kg	= 64.55 T

LIFTING OF THE LOAD-OTHER THEN VERTICAL

3-3.3.2 COMBINED STRESSES

SLING ANGLE

Θ= angle in between sling and the horizontal line connecting the c/c of lifting lugs

DISTANCE C/C OF LUG PLATES, dist_lugs	58 INCH	1473.2 mm
LENGTH OF THE SLING (ALONG THE ANGLE), sling_lngth	243.5 INCH	6184.9 mm

$$\theta = \operatorname{acos}\left(\frac{dist_{lugs}}{2*sling_{lngth}}\right)$$

Θ= 83.16 deg

PLATE ANGLE

α angle in between the horizontal and the centerline of the hole parallel to the base line

α= 21 deg

angle in between the sling line and the c.l. thru hole parallel to base line of the lifting lug, ψ

ψ=Θ-α

ψ= 62.16003756 deg

angle in between the vertical c.l. thru the hook and sling line, ω

ω= 6.839962441 deg

Based on Table 15-3 : WLL-reduction for slings at an angle ref 2

reduction= 90.00%

nominal S(WLL) on one sling (for vertical sling line)	19 T	=	186.39 kN
reduced S(WLL)_ω	17.1 T	=	167.751 kN

S(WLL) is axial tension force in one sling for total WLL under the hook

$$S(WLL) = \frac{WLL}{2COS(\omega)}$$

F norm (WLL) IS THE TENSION ON THE LIFTING LUG (direction normal to base line of the plate)

F tang (WLL) IS THE SHEAR/TANGENTIAL FORCE ON THE LIFTING LUG (direction PARALLEL to base line of the plate)

$$Fnorm(WLL) = S(WLL) * \cos(90 - \psi)$$

$$Ftang(WLL) = S(WLL) * \cos(\psi)$$

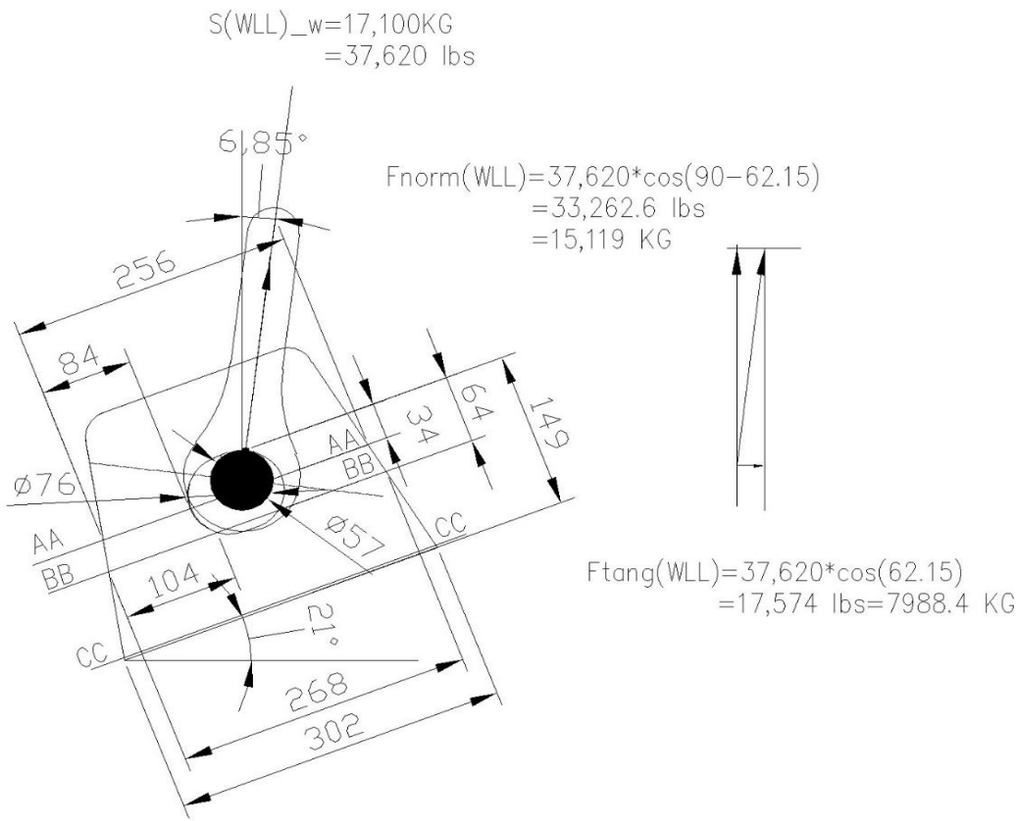
assume WLL to be reduced by sin of angle ψ

WLL_ψ=WLL_vert*cos ψ

WLL_ψ=

S(WLL)_ψ= 167.75 kN

Fnorm(WLL)=	148.33 kN	15120.76848 KG
Ftang(WLL)=	78.34 kN	7985.759867 KG



SECTIONAL FORCES AT SECTION BB-BB

Fnorm=	15119	148.32	kN
Ftang=	7988.4	78.37	kN
lever arm=	64	0.064	m
M(BB)=Ftang*lever arm=		5.01543706	kN-m

length of gross section at the section BB-BB

ls=	268	0.268	m
length of one side (half) of netsection at the section BB-BB, leff	104	0.104	m
		60	
		164	lever arm for moment

stresses:

normal stresses

normal stress from Fn

$$ft(N) = Fn/(2 * leff * t)$$

ft(N)= 28.0734 mPa

normal stress from moment

M= 5.02 kN-m

Vertical force from moment resolution

lever arm= 164 mm

Vl=-Vr 30.58 kN

stress

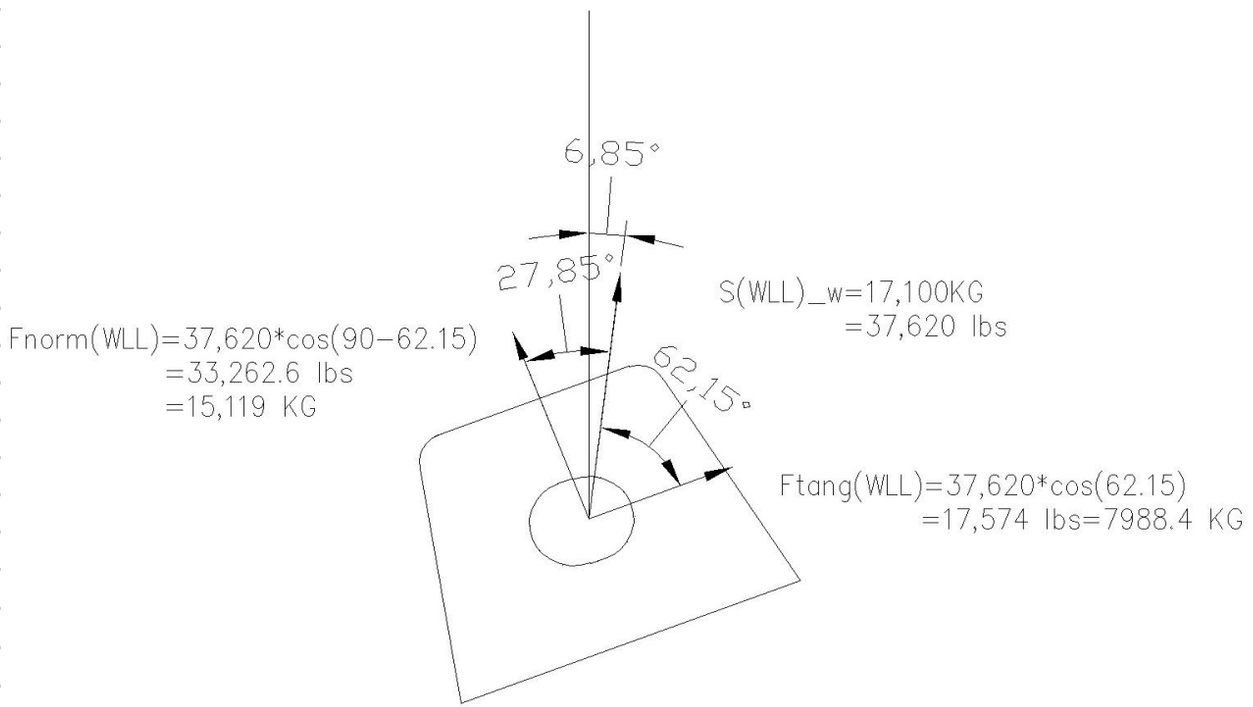
ftb=Vr/(0.7*leff*t)

ftb= 16.54 mPa

total normal stress

ft,total=ft(N)+ftb

ft,total= 44.61 mPa



(1) COMBO AXIAL TENSION+ TENSION (BENDING)

$$\frac{ft}{Ft}+\frac{fbt}{Fb}\leq 1.0$$

$$Ft=\frac{Fu}{1.20*Nd_{fract}}$$

$$Fb=Fy*\frac{1.25}{Nd}$$

Ft= 104.17 mPa

Fb= 104.17 mPa

SHEAR STRESS

$$fv = \frac{Ft}{leff * t * 2}$$

fv= 14.83 mPa

TOTAL NORMAL STRESS:

Ftn/Ft= 0.269505

ftb/Fb= 0.158771

SUM 0.4283 ok

NORMAL+

allowable stress Fv

$$Fv = 0.70 * \frac{Fu}{1.20 * Nd_{fract}}$$

Fv= 72.92 mPa

$$\frac{fv}{Fv} \leq 1.0$$

0.20 ok

(2) COMBINED NORMAL AND SHEAR STRESSES

$$fcr = \sqrt{(fx^2 - fx * fy + 3 * fv^2)} <= Fcr$$

fxtotal= 44.61 mPa fy= 0

fv= 14.83 mPa

fcr= 51.48 mPa

$$Fcr = \frac{Fy}{Nd}$$

Fcr= 83.33 mPa

$$\frac{fcr}{Fcr} = \quad 0.62 \text{ ok}$$

Since all checks are passed we can adopt:
WLL_ψ=2*S(WLL)_ ψ*cos(ω)

WLL_ψ=	333.11 kN	33.96 T

WLL BASED ON CAPACITY OF THE LIFTING LUGS, ONLY=

WLL_ψ=	539.22 kN	54.97 T