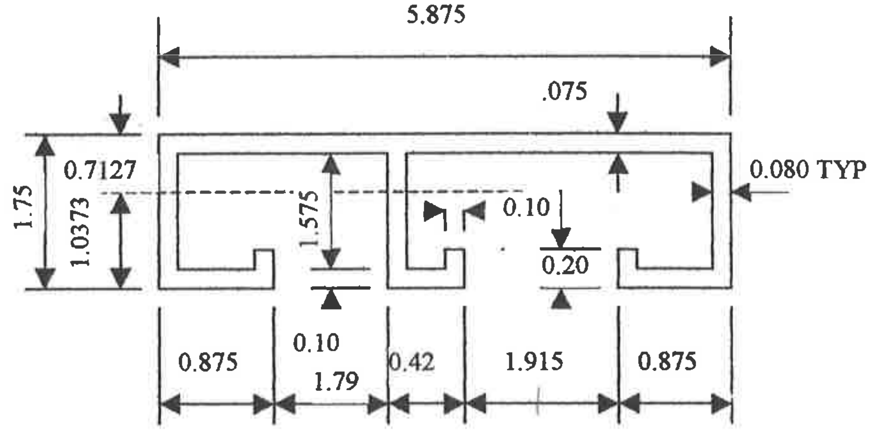
LOAD CALCULATIONS FOR 2x6 ALUMINUM PLANK

A = 0.075 (5.875) = 0.4406 in^2
A = 0.10 (0.875)(2)+
0.10(0.42) = 0.2170 in^2
A= 0.08 (1.575)(3) = 0.3780 in^2
A = 3 (0.10)(0.10) = 0.0300 in^2
A total = 1.0656 in^2



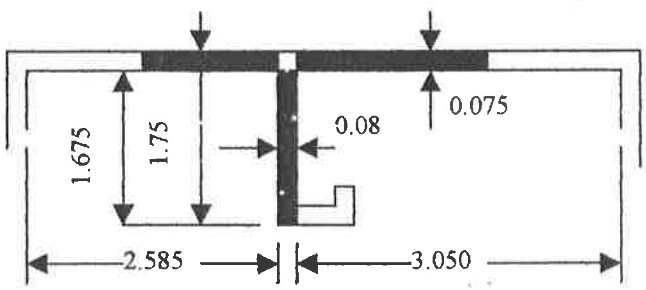
$$N.A. = \frac{0.4406\,(1.7125) + 0.2170\,(0.050) + 0.3780\,(0.8875) + 0.0300\,(0.15)}{1.0656} = 1.0373 \text{ in}$$

$I = 5.875\,(0.075)^3/12 + 0.4406\,(0.6752)^2 + 2.17\,(0.10)^3/12 + 0.2170(0.9873)^2 +$

$3(0.080)(1.575)^3/12 + 0.3780(0.1498)^2 + 3\,(0.10)(0.10)^3/12 + 0.03(0.8873)^2 = 0.5231 \text{ in-4}$

Sx top = 0.5231 / 0.7127 = 0.7339 in^3

Sx bottom = 0.5231 / 1.0373 = 0.5043 in^3 $r = \sqrt{0.5231 / 1.0656} = 0.7006$ in



Reference: Allowable compressive stress in plank in accordance with Section 3.4.1 of the *Aluminum Design Manual*; The Aluminum Association 900 19th Street N.W. Washington D. C. © 1994

Fcy = Compressive Yield Stress = 25 ksi
Bc = Buckling Formula Constant – Compression
Dc = Buckling Formula Constant – Compression
Cc = 0.41 x Bc/Dc *Table 3.3-4*

kc = 1.12 *Table 3.4-2*
ny = 1.65 *Table 3.4-1*
nu = 1.95 *Table 3.4-1*

$Bc = Fcy\,(1 + \sqrt{Fcy/2250})$ *Table 3.3-4* $Bc = 25\,(1 + \sqrt{25/2250}) = 27.64$ ksi

$Dc = Bc/10\sqrt{Bc/E}$ *Table 3.3-4* $Dc = 27.64/10\sqrt{27.64/10100} = 0.1445$

Cc = 0.41 (27.64/0.1445) = 78.42

Fc = 25 ksi for 6063-T6 *Table 3.3-1*

S1 = [Bc – (nu Fcy) / (kc ny)] / Dc *Eq. 3.4.9.2-4*

S1 = [27.64 – (1.95x25 / 1.12 x 1.65)] / 0.1445 = 8.72

S2 = Cc = 78.42 *Eq. 4.4.9.2-5* b = (2.585 + 3.050)/2 = 2.8175

Fc = Fcy / kc ny = 25 / 1.12 x 1.65 = 13.53 If λ < S1 *Eq. 3.4.9.2-1*

A stem = 1.675 (0.080) = 0.1340 in^2
A flange = 2.8175 (0.075) = 0.2113 in^2
Area total = 0.3453 in^2

$$N.A. = \frac{0.080\,(1.675)(0.8375) + 2.8175\,(0.075)(1.7125)}{0.3453} = 1.373 \text{ in}$$

$$Io = 0.080\,(1.675)^3/12 + 0.134(0.5351)^2 + 2.818\,(0.075)^3/12 + 0.2113\,(0.3399)^2$$

Io = 0.0942 in-4

$$\lambda = 4.62(b/t)\sqrt{\frac{1 + As/bt}{1 + \sqrt{1 + (10.67\ Io)/(bt)}}} = 4.62(2.8175/0.075)\sqrt{\frac{1 + 0.134/(2.8175)(0.075)}{1 + \sqrt{1 + \frac{10.67(0.0942)}{2.8175(0.075)^3}}}}$$

λ = 40.442

Fc = (1/nu)(Bc - Dcλ) = (1/1.95)[27.64 – 0.1445(40.442)] *Eq. 3.4.9.2-2*

Fc = 11.18 ksi If λ is between S1 and S2 ⟵ Use this one

Fc = π^2 E / nu λ^2 = π^2 (10100) / 1.95 $(40.442)^2$ = 31.26 ksi If λ is > S2 *Eq 3.4.9.2-3*

Fty = 25 ksi *Table 3.3-1*

Foot and seat planks must be capable of supporting 120 plf. NRS uses a 2 x 10 (9 ½") as our narrowest seat or foot board. Review the 2 x 6 plank based on the same area load as a 120 plf on a 9 ½" plank.

Load per inch of width = 120 / 9.5 = 12.63 lbs. per in

12.63 (5.875) = 74.20 plf

Maximum frame spacing 6'-0"

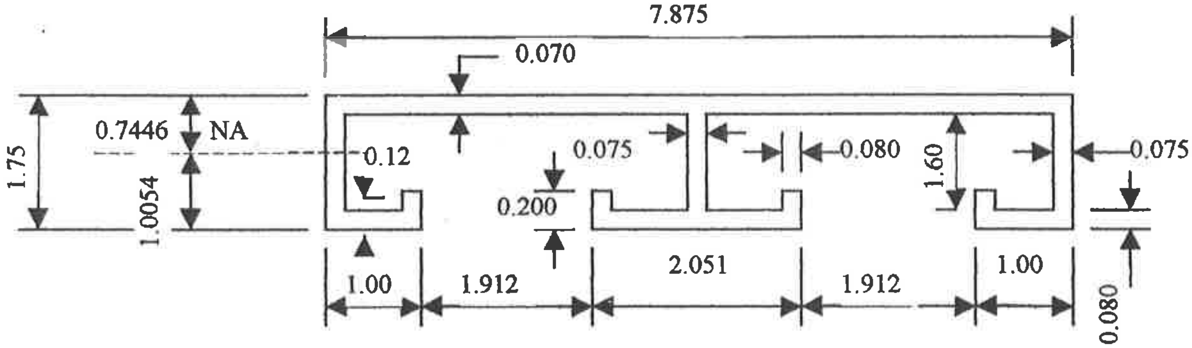
M = 74.20 x 6^2 / 8 = 333.91 ft-lbs.

fb compression = 333.91 x 12/ 0.7339 = 5460 psi < 11.18 ksi

fb tension = 333.91 x 12 / 0.5043 = 7946 psi < 25 ksi

<u>The 2 x 6 plank is adequate for National Recreation Systems' applications.</u>

LOAD CALCULATIONS FOR MEDIUM DUTY 2 X 8 ALUMINUM PLANK



Area = 7.875 x 0.070 = 0.5513 in^2
= (2 x 1.00 + 2.051) x 0.080 = 0.3241 in^2
= 1.600 x 0.075 x 3 = 0.3600 in^2
= 4 x 0.080 x 0.120 = 0.0384 in^2
Total Area = 1.2738 in^2

$$N.A. = \frac{0.5513 \times 1.715 + 0.3241 \times 0.04 + 0.36 \times 0.88 + 0.0384 \times 0.14}{1.2738} = 1.0054 \text{ in}$$

$$I = 7.875(0.070^3)/12 + 0.5513(0.7096^2) + 4.051\,(0.080^3)/12 + 0.3241\,(0.9654^2) +$$

$$3\,(0.075)(1.6^3)/12 + 0.36\,(0.1254)^2 + 4\,(0.08)(0.12^3)/12 + 0.0384\,(0.8654^2) =$$

I = 0.6913 in-4

S_x top = 0.6913/0.7446 = 0.9284 in^3

S_x bottom = 0.6913 / 1.0054 = 0.6876 in^3

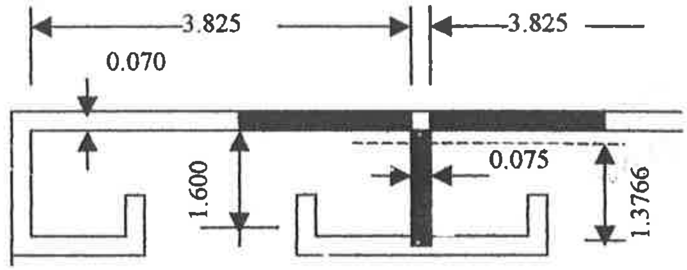
$$r_x = \sqrt{0.6913 / 1.2738} = 0.7367 \text{ in}$$

Reference: Allowable compressive stress in plank in accordance with Section 3.4.9.2 and allowable tension stress in accordance with Section 3.4.1 of the Aluminum Design Manual; The Aluminum Association 900 19th Street N.W. Washington D.C. 20006 © 1994.

F_{cy} = Compressive Yield Strength = 25 ksi**	n_y = 1.65	*Table 3.4-1*
B_c = Buckling Formula Constant – Compression	n_u = 1.95	*Table 3.4-1*
D_c = Buckling Formula Constant – Compression	k_c = 1.12	*Table 3.4-2*
C_c = 0.41 x B_c/D_c		*Table 3.3-4*

** F_{cy} = 25 ksi and F_{ty} = 25 ksi for 6063-T6 *Table 3.3-1*

$B_c = F_{cy}\ 1 + \sqrt{F_{cy} / 2250}$ $\quad D_c = B_c/10 \sqrt{B_c / E}$ → *Table 3.3-4*



$$Bc = 25 \left(1 + \sqrt{25/2250} \right)$$

$$Bc = 27.64$$

$$Dc = 27.64/10 \sqrt{\frac{27.64}{10100}} = 0.1445$$

$$Cc = 0.41\ (27.64)/0.1445 = 78.42$$

S1 = [Bc – (nu x Fcy) /(kc x ny)] / Dc *Eq. 3.4.9.2-4*

S1 = [27.64 – (1.95 x 25)/(1.12 x 1.65)] / 0.1445 = 8.72

S2 = Cc = 78.42 *Eq. 3.4.9.2-5*

A stem = 1.600 (0.075) = 0.12000 in^2
A flange = 3.825 (0.07) = 0.26775 in^2
A total = 0.38775 in^2

$$N.A. = \frac{0.26775\ (1.6350) + 0.12\ (0.80)}{0.38775} = 1.3766 \text{ in}$$

$$Io = 0.075\ (1.600)^3/12 + 0.12\ (0.5766^2) + 3.825\ (0.07)^3/12 + 0.26775\ (0.2584)^2 = 0.08348 \text{ in-4}$$

$$\lambda = 4.62\ (b/t) \sqrt{\frac{1 + As/bt}{1 + \sqrt{1 + 10.67\ Io/bt^3}}}$$. *Eq. 3.4.9.2-6*

$$\lambda = 4.62\ (3.825/0.070) \sqrt{\frac{1 + 0.1200/0.070\ (3.825)}{1 + \sqrt{1 + 10.67\ (0.08348)/3.825\ (0.07)^3}}} = 58.385$$

Fc = Fcy / kc ny = 25 / 1.12 x 1.65 = 13.52 ksi *Eq. 3.4.9.2-1*

If λ < S!

Fc = 1/nu[Bc - Dcλ] = 1/1.95 [27.64 - 0.1445(58.385)] = 9.847 *Eq. 3.4.9.2-2*

Use This One

If λ is between S1 and S2.

Fc = π^2 E / nu λ^2 = π^2 10100 / 1.95 $(58.385)^2$ = 14.996 ksi *Eq. 3.4.9.2-3*

If λ > S2

Foot and seat planks must be capable of supporting 120 plf. NRS uses a 2x10 (9 ½") as our narrowest seat or foot board. Review the 2x8 plank based on the same area load.

Load per inch of width = 120 / 9.5 = 12.63 lbs/inch

12.63 (7.875) = 99.5 plf

Maximum frame spacing = 6' – 0"

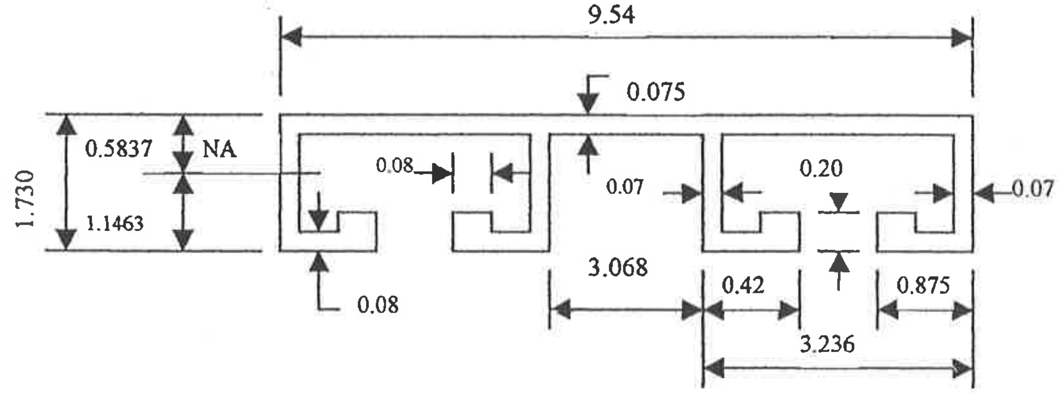
$M = 99.5 (6^2) / 8 = 448$ ft-lbs

f_b tension = 448 (12) /0.6876 = 7818 psi < 25 ksi

f_b compression = 448(12) /0.9284 = 5791 psi < 9.847 ksi

<u>The 2x8 plank is adequate for National Recreation Systems' applications.</u>

LOAD CALCULATIONS FOR MEDIUM DUTY 2 x 10 ALUMINUM PLANK



Area =	9.540×0.075 =	$0.7155\ in^2$
Area =	$[2(0.875) + 2(0.420)](0.080)$ =	$0.2072\ in^2$
Area =	$4(1.575)(0.070)$ =	$0.4410\ in^2$
Area =	$4(0.080)(0.120)$ =	$0.0384\ in^2$
	Total Area =	$1.4021\ in^2$

$$NA = \frac{0.7155(1.6925) + 0.2072(0.04) + 0.441(0.8675) + 0.0384(0.140)}{1.4021} = 1.1463\ in$$

$$I = 9.540(0.075)^3/12 + 0.7155(0.5462)^2 + 2.59(0.080)^3/12 + 0.2072(1.1063)^2 +$$

$$4(0.070)(1.575)^3/12 + 0.441(0.2788)^2 + 4(0.080)(0.12)^3/12 + 0.0384(1.0063)^2 = 0.6319\ in^4$$

$$S_{x\text{-top}} = 0.6319/0.5837 = 1.0826\ in^3$$

$$S_{x\text{-bottom}} = 0.6319/1.1463 = 0.5513\ in^3$$

$$r_x = \sqrt{0.6319/1.4021} = 0.6713\ in$$

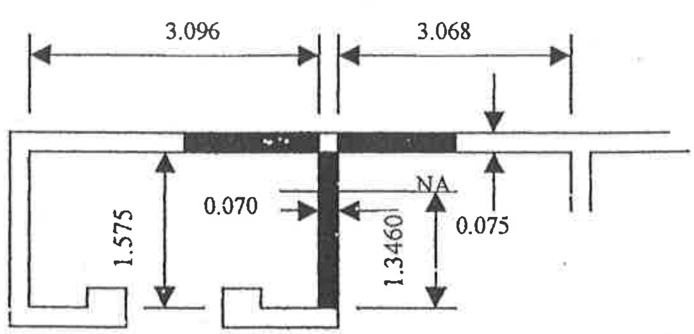
Reference: Allowable compressive stress in plank in accordance with Section 3.4.9.2 and allowable tension stress in accordance with Section 3.4.1 of the *Aluminum Design Manual*; The Aluminum Association 900 19th Street, N.W. Washington D.C. 20006 © 1994.

Fcy = Compressive Yield Strength = 25 ksi**
Bc = Buckling Formula Constant - Compression
Dc = Buckling Formula Constant – Compression
Cc = 0.41 x Bc/Dc *Table 3.3-4*

$B_c = F_{cy}\{1 + (F_{cy}/2250)^{1/2}\}$ *Table 3.3-4*

$B_c = 25\{1 + (25/2250)^{1/2}\} = 27.64$ ksi

$D_c = (B_c/10)\{(B_c/E)^{1/2}\}$ *Table 3.3-4*



Dc = 27.64/10 [(27.64/10100)½] = 0.1445 b = $\frac{3.096 + 3.068}{2}$ = 3.082

Cc = 0.41 (27.64/0.1445) = 78.42

** Fc=25 ksi for 6063-T6 *Table 3.3-1*
S1 = [Bc – (nu Fcy/kc ny)] / Dc = [27.64 – (1.95 x 25 / 1.12 x 1.65)] / 0.1445 = 8.719 *Eq. 3.4.9.2-4*

S2 = Cc = 78.42 *Eq. 3.4.9.2-5*

Fc = Fcy / kc ny = 25 / (1.12)(1.65) = 13.53 *Eq. 3.4.9.2-1*

Area stem = 1.575(0.070) = 0.1103 in^2
Area flange = 3.082(0.075) = 0.2312 in^2
Area Total = 0.3415 in^2

NA = $\frac{0.1103(0.7875) + 0.2312(1.6125)}{0.3415}$ = 1.3460 in

$Io = 0.070(1.575)^3/12 + 0.1103(0.5585)^2 + 3.082(0.075)^3/12 + 0.2312(0.2665)^2 = 0.07372\ in^4$

$$\lambda = 4.62(b/t)\sqrt{\frac{1 + As/bt}{1 + \sqrt{1 + (10.67\ Io)/bt^3}}} = 4.62(3.082/0.075)\sqrt{\frac{1 + 0.1103/0.075(3.082)}{1 + \sqrt{1 + 10.67(0.07372)/3.082(0.075)^3}}}$$

λ = 45.59 *Eq. 3.4.9.2-6*

Fbc = $\frac{27.64 - 0.1445(45.59)}{1.95}$ = 10.796 ksi Fbt = 20 ksi

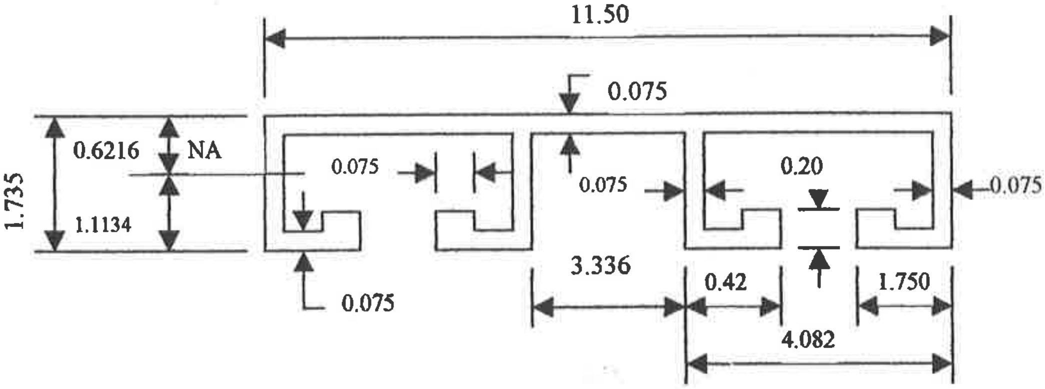
M = δ S M-compression = 10.796 (1.0826)/12 = 0.97 ft.-kips

M-tension = 20 (0.5513)/12 = 0.92 ft.-kips

Moment (120 lbs./ln. ft) = 120 x 6^2/8 x 1000 = 0.54 ft. kips < 0.92 ft. kips.

Plank is satisfactory for the maximum standard six (6) foot frame spacing.

LOAD CALCULATIONS FOR 2 x 12 ALUMINUM PLANK



Area = 11.50 x 0.075 = 0.8625 in²
Area = [2(1.750) + 2(0.420)](0.075) = 0.3255 in²
Area = 4(1.585)(0.075 = 0.4755 in²
Area = 4(0.075)(0.125) = 0.0375 in²
Total Area = 1.7010 in²

$$NA = \frac{0.8625(1.6975) + 0.3255(0.0375) + 0.4755(0.8675) + 0.0375(0.1375)}{1.7010} = 1.1134 \text{ in}$$

$I = 11.50(0.075)^3/12 + 0.8625(0.5841)^2 + 4.34(0.075)^3/12 + 0.3255(1.0759)^2 +$

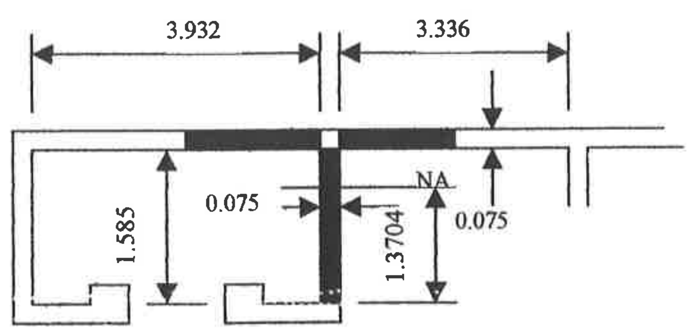
$4(0.075)(1.585)^3/12 + 0.4755(0.2459)^2 + 4(0.075)(0.125)^3/12 + 0.0375(0.9759)^2 = 0.8357 \text{ in}^4$

Sx-top = 0.8357/0.6216 = 1.3444 in³

Sx-bottom = 0.8357/1.1134 = 0.7506 in³

$rx = \sqrt{0.8357/1.7010} = 0.7009$ in

Reference: Allowable compressive stress in plank in accordance with Section 3.4.9.2 and allowable tension stress in accordance with Section 3.4.1 of the *Aluminum Design Manual*; The Aluminum Association 900 19th Street, N.W. Washington D.C. 20006 © 1994.



Fcy = Compressive Yield Strength = 25 ksi**
Bc = Buckling Formula Constant - Compression
Dc = Buckling Formula Constant – Compression
Cc = 0.41 x Bc/Dc *Table 3.3-4*

Bc = Fcy { 1 + (Fcy/2250)½} *Table 3.3-4*

Bc = 25 { 1 + (25/2250)½} = 27.64 ksi

Dc = (Bc/10){(Bc/E)½} *Table 3.3-4*

Dc = 27.64/10 [(27.64/10100)½] = 0.1445   b = $\frac{3.096 + 3.068}{2}$ = 3.082

Cc = 0.41 (27.64/0.1445) = 78.42

** Fc=25 ksi for 6063-T6 *Table 3.3-1*
S1 = [Bc – (nu Fcy/kc ny)] / Dc = [27.64 – (1.95 x 25 / 1.12 x 1.65)] / 0.1445 = 8.719   *Eq. 3.4.9.2-4*

S2 = Cc = 78.42   *Eq. 3.4.9.2-5*

Fc = Fcy / kc ny = 25 / (1.12)(1.65) = 13.53   *Eq. 3.4.9.2-1*

Area stem =	1.585(0.075) =	0.1189 in^2
Area flange =	3.634(0.075) =	0.2726 in^2
Area Total =		0.3915 in^2

NA = $\frac{0.1189(0.7925) + 0.2726(1.6225)}{0.3915}$ = 1.3704in

Io = $0.075(1.585)^3/12 + 0.1189(0.5779)^2 + 3.634(0.075)^3/12 + 0.2726(0.2521)^2$ = 0.0820 in^4

$$\lambda = 4.62(b/t)\sqrt{\frac{1 + As/bt}{1 + \sqrt{1 + (10.67\ Io)/bt^3}}} = 4.62(3.634/0.075)\sqrt{\frac{1 + 0.1189/0.075(3.634)}{1 + \sqrt{1 + 10.67(0.0820)/3.634(0.075)^3}}}$$

λ = 53.75`   *Eq. 3.4.9.2-6*

Fbc = $\frac{27.64 - 0.1445(53.75)}{1.65}$ = 12.044 ksi   Fbt = 20 ksi

M = δ S   M-compression = 12.044 (1.3444)/12 = 1.35 ft.-kips

M-tension = 20 (0.7506)/12 = 1.251 ft.-kips

Moment (120 lbs./ln. ft) = 100 x 6^2/8 x 1000 = 0.45 ft. kips < 1.251 ft. kips.

Moment = (200 lbs.)(6 ft) / 4 x 1000 = 0.30 ft. kips < 1.251 ft. kips

Plank is satisfactory for the maximum standard six (6) foot wide stair tread.

Michael R. Foster, P.E.

January 11, 1999

Bleacher Plank Clip Analysis

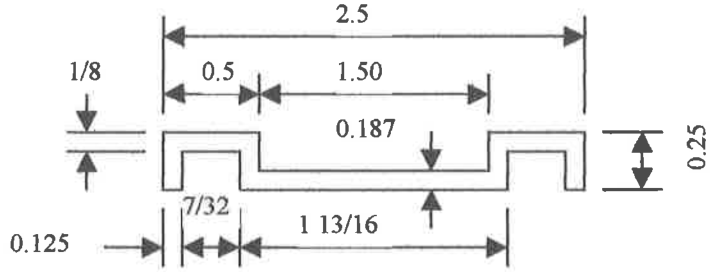
Check clip in bending for wind uplift and check the clip for shear using 5% of the live load or the side sway for the lateral load.

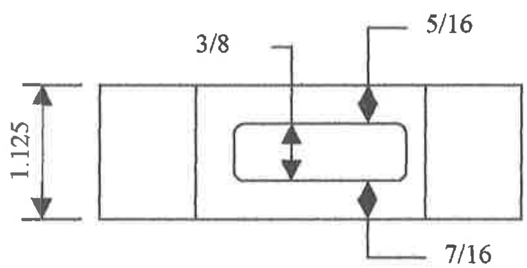
Wind Uplift 149 lbs. per plank attachment. 149 lbs./ 2 clips = 74.5 lbs. per clip uplift

Lateral load

24 lbs./ft. x 6 ft. = 144 lbs. 144 lbs. / 2 clips = 72 lbs. per clip ← Use this one.

720 lbs. x 0.05 = 36 lbs. 36 lbs./ 2 = 18 lbs. per clip





Minimum Side Shear Resistance

2 x 5/16 x 3/16 = 0.1172 in^2

0.1172 in^2 x 8.5 ksi = 996 lbs > 72 lbs

Bending Due to Wind Uplift

Moment Arm = l = $\frac{1\ 13/16 - 7/32}{2}$ =

l = 0.797 in

M = 0.797 x 74.5/2 = 29.7 in-lbs.

S = bd^2/6 = 0.75 x 0.1875^2/ 6 =

S = 0.0044 in^3

Fb = 18.00 ksi > fb = 29.7 in-lbs / 0.0044 in^3 = 6750 psi

The standard plank clip is adequate.

Aluminum alloy 6063-T6. Allowable stresses based on the *Aluminum Design Manual* published by the Aluminum Association.