Fermi National Accelerator Laboratory

D0 ENGINEERING NOTE
3823.130-EN-556

5/21/00

A LAYER DRAWBRIDGE ACCESS PLATFORMS
CALCULATIONS AND ANALYSIS

Brent Anderson

Approved By:

Summary

The calculations in this engineering note are to check the design of the A layer drawbridge access platforms. There are a total of four platforms, with two different types of construction. The platforms in the Northwest and Northeast locations are supported on one side only. The platforms in the Southwest and Southeast locations extend over to the cryogenic support bridge and are supported on two sides.

All calculations are based on a combination of directly measured and estimated platform element sizes. A point load of 500 lb is used to determine the platform performance. The only exception to this is a 1000 lb point load applied in the examination of the main beams in the South platforms. This was done to provide larger reaction forces in the beam, than what would be caused by eccentric loading of 500 lb and still account for a more centrally located load.

Tables 1 and 2 summarize the stresses in platform members for the North and South A layer drawbridge access platforms, respectively.

The only stress calculation exceeding the allowable stress is found in the North platform upper right support bracket. The stress is considered acceptable in this case since it is within rounding error of the allowable stress.

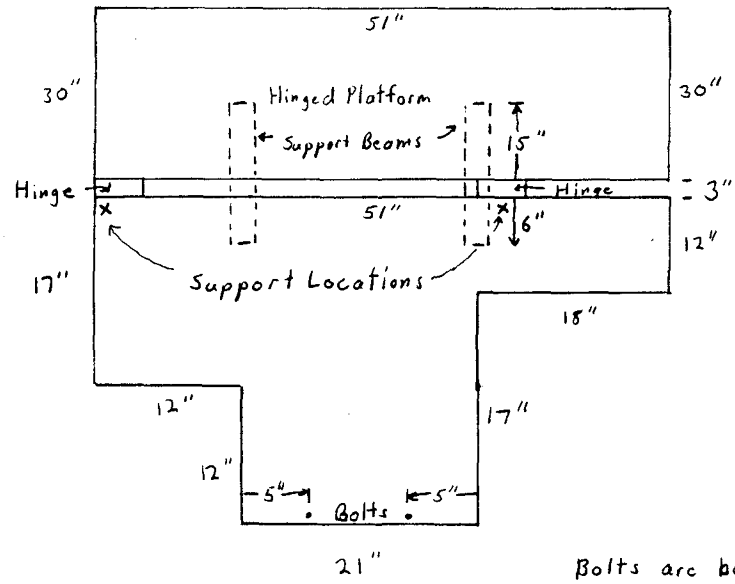
Based upon these results, the platforms can be used by personnel as long as a body harness is worn.

Table 1: North Platform Stresses

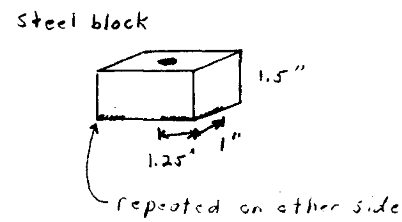
Part	Location	Page	Stresses				Allowable Stresses			Critical Stress
			Tensile lb/in^2	Compressive lb/in^2	Shear lb/in^2	Bending lb/in^2	Tensile lb/in^2	Shear lb/in^2	Bending lb/in^2	Buckling lb/in^2
Hinge	Welds	7	1,710	1,710			21,600			
	Pins	7			3,890			25,500		
Hinged Platform Support	Welds on Bracket	8	1,408				21,600			
	Bracket	8	1,300				21,600			
	Beam	9			1,520	20,000		14,400	32,400	
Platform	2 Members	10			421	27,500		14,400	32,400	
	Plating Support Welds	11	88				21,600			
Left Platform Support	Upper Left Bracket Welds	14		1,050	610		21,600	14,400		
	Upper Left Bracket	12	12,340	21,580			21,600			
	Bolt In Upper/Lower Left Bracket	15			3,212			25,500		
	Left Support Column	18		776						4,590
	Lower Left Bracket	20		1,500	862		21,600	14,400		
	Lower Left Support Anchor Bolt	22	7,754		2,780		43,000	25,500		
Right Platform Support	Upper Right Bracket Welds	16		2,820	2,820		21,600	14,400		
	Upper Right Bracket	13	22,000	38,500			21,600			
	Bolt In Upper/Lower Right Bracket	17			7,020			25,500		
	Right Support Column	19		1,700						33,700
	Lower Right Bracket	21		2,700	2,700		21,600	14,400		
	Lower Right Support Anchor Bolt	23	24,000		5,000		43,000	25,500		
Platform Anchor	Platform Anchor Bolts	24	3,800		15,900		43,000	25,500		
	Platform Anchor Welds	25	672		2,493		21,600	14,400		

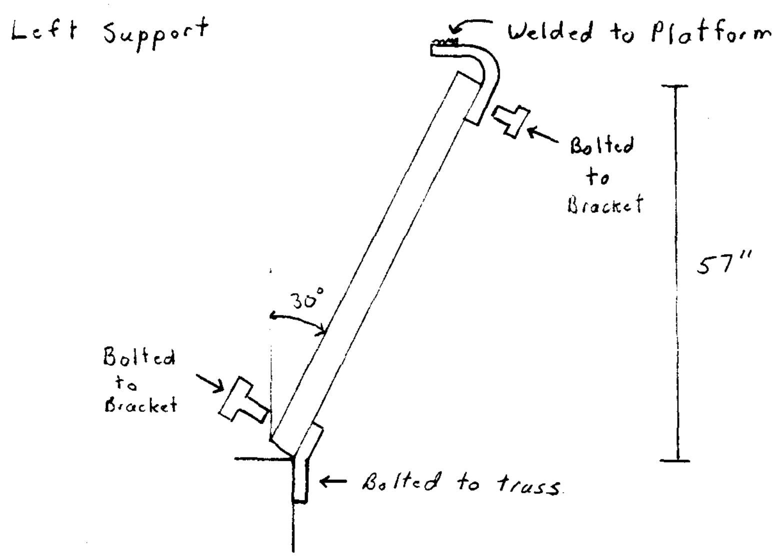
FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE
			EN-556	1a

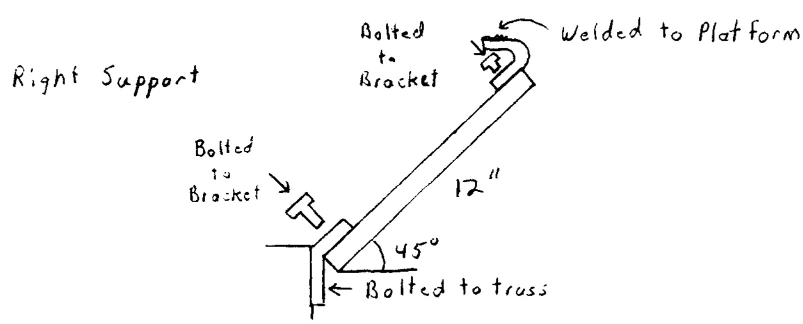
SUBJECT	NAME	
North A Layer Drawbridge Access Platforms (East & West) Basic Dimensions	Brent J. Anderson	
	DATE: 5/11/01	REVISION DATE:



Bolts are bolted into steel blocks welded to the truss.

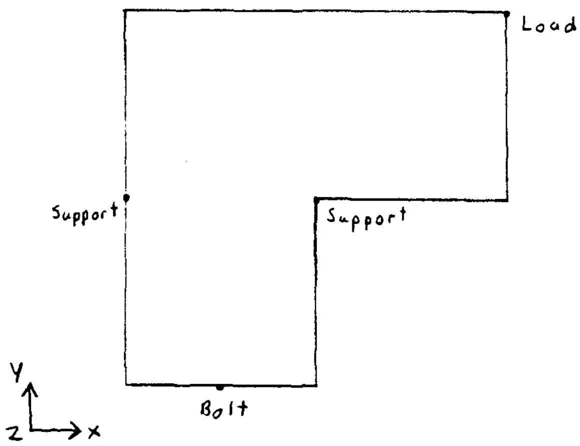


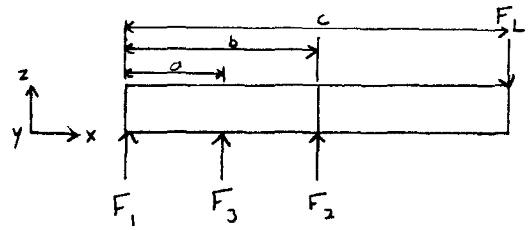


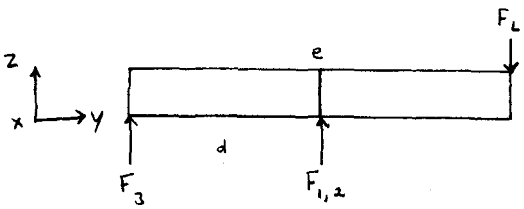


FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE
			EN-556	2

SUBJECT	NAME
North A Layer Drawbridge Access Platforms Loading Conditions Type #1	Brent J. Anderson
	DATE: 5/10/01 REVISION DATE:







$\circlearrowleft + \Sigma M_{F_1} = 0 = F_3(d) + F_L(e)$

$F_3 = \frac{-F_L e}{d}$

$a = 22.5''$

$b = 33.0''$

$c = 51.0''$

$d = 29.0''$

$e = 62.0''$

$F_L = 500\ lb$

$\rightarrow + \Sigma F_x = 0$

$\uparrow + \Sigma F_y = 0 = F_1 + F_2 + F_3 - F_L$

$\circlearrowleft + \Sigma M_{F_1} = 0 = -F_3(a) - F_2(b) + F_L(c)$

$F_2 = -F_3(a) + F_L(c)$

$F_2 = \frac{F_L e a}{b d} + F_L \frac{c}{b}$

$F_2 = F_L \left(\frac{ae}{bd} + \frac{c}{b} \right)$

$F_1 = -F_2 - F_3 + F_L$

$F_1 = -F_L \left(\frac{ae}{bd} + \frac{c}{b} \right) + F_L \left(\frac{e}{d} \right) + F_L$

$F_1 = F_L \left[-\frac{ae}{bd} - \frac{c}{b} + \frac{e}{d} + 1 \right]$

$F_1 = 500\ lb \left[-\frac{(22.5)(62.0)}{(33.0)(29.0)} - \frac{51.0}{33.0} + \frac{62.0}{29.0} + 1 \right]$

$F_1 = 67\ lb$

$F_2 = 500\ lb \left(\frac{(22.5)(62.0)}{(33.0)(29.0)} + \frac{51.0}{33.0} \right)$

$F_2 = 1500\ lb$ (Max Force)

$F_3 = \frac{-500\ lb\ (62.0)}{29.0}$

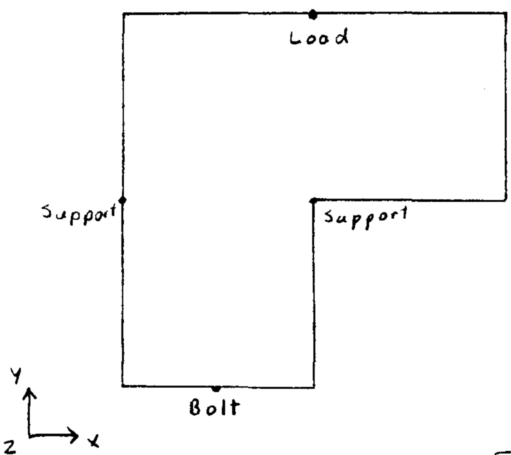
$F_3 = -1070\ lb$ (Max Force)

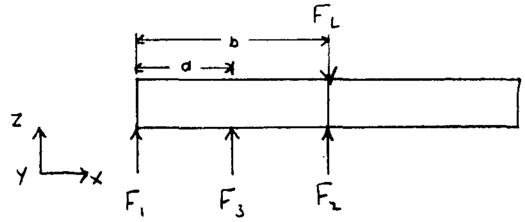
FERMILAB ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE
		EN-556	3

SUBJECT: North A Layer Drawbridge Access Platforms
Loading Conditions Type # 2

NAME: Brent J. Anderson
DATE: 5/10/01
REVISION DATE:





$\rightarrow \Sigma F_x = 0$

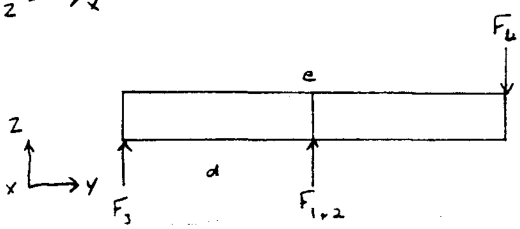
$\uparrow \Sigma F_Z = 0 = F_1 + F_2 + F_3 - F_L$

$\curvearrowleft + \Sigma M_{F_1} = 0 = -F_3(a) - F_2(b) + F_L(b)$

$$F_2 = -F_3 \frac{a}{b} + F_L$$

$$F_2 = F_L\left(\frac{ae}{bd}\right) + F_L$$

$$F_2 = F_L\left[\frac{ae}{bd} + 1\right]$$



$\curvearrowleft + \Sigma M_{F_1} = 0 = F_3(d) + F_L(e)$

$$F_3 = -\frac{F_L e}{d}$$

$a = 22.5''$
$b = 33.0''$
$c = 51.0''$
$d = 29.0''$
$e = 62.0''$

$F_L = 500 lb$

$$F_1 = -F_2 - F_3 + F_L$$

$$F_1 = -F_L\left[\frac{ae}{bd} + 1\right] + F_L\left(\frac{e}{d}\right) + F_L$$

$$F_1 = F_L\left[-\frac{ae}{bd} - 1 + \frac{e}{d} + 1\right]$$

$$F_1 = F_L\left[-\frac{ae}{bd} + \frac{e}{d}\right]$$

$$F_1 = 500 lb\left[-\frac{(22.5)(62.0)}{(33.0)(29.0)} + \frac{62.0}{29.0}\right]$$

$F_1 = 340 lb$

$$F_2 = 500 lb\left[\frac{(22.5)(62.0)}{(33.0)(29.0)} + 1\right]$$

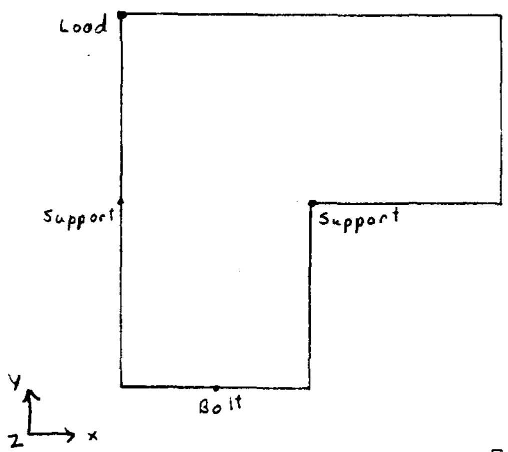
$F_2 = 1230 lb$

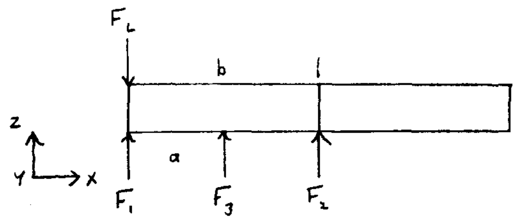
$$F_3 = -500 lb \ \frac{62.0}{29.0}$$

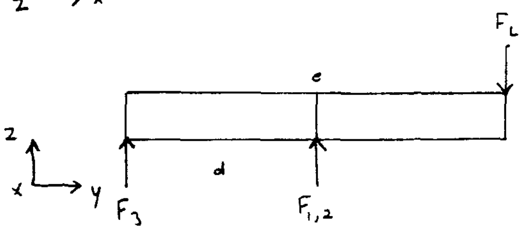
$F_3 = -1070 lb$

FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE
			EN-556	4

SUBJECT	NAME
North A Layer Drawbridge Access Platforms Loading Conditions Type # 3	Brent J. Anderson
	DATE: 5/10/01 — REVISION DATE:







$\rightarrow \Sigma F_x = 0$

$\uparrow \Sigma F_z = 0 = F_1 + F_2 + F_3 - F_L$

$\curvearrowleft + \Sigma M_{F_1} = 0 = -F_3(a) - F_2(b)$

$F_2 = -F_3\left(\frac{a}{b}\right)$

$F_2 = F_L\left(\frac{ae}{bd}\right)$

$\curvearrowleft + \Sigma M_{F_1} = 0 = F_3(d) + F_L(e)$

$F_3 = \frac{-F_L e}{d}$

$F_1 = -F_2 - F_3 + F_L$

$F_1 = -F_L\left(\frac{ae}{bd}\right) + F_L \frac{e}{d} + F_L$

$F_1 = F_L\left[-\frac{ae}{bd} + \frac{e}{d} + 1\right]$

$a = 22.5''$

$b = 33.0''$

$c = 51.0''$

$d = 29.0''$

$e = 62.0''$

$F_L = 500 lb$

$F_1 = 500 lb\left[-\frac{(22.5)(62.0)}{(33.0)(29.0)} + \frac{62.0}{29.0} + 1\right]$

$F_1 = 840 lb$ (Max Force)

$F_2 = 500 lb\left(\frac{(22.5)(62.0)}{(33.0)(29.0)}\right)$

$F_2 = 729 lb$

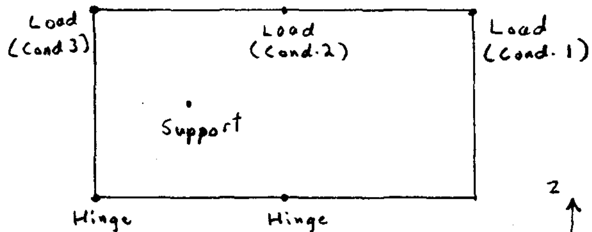
$F_3 = -500 lb \ \frac{62.0}{29.0}$

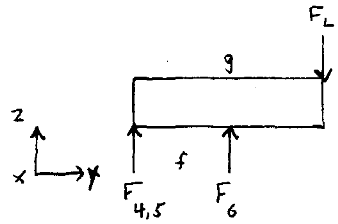
$F_3 = -1070 lb$

FERMILAB
ENGINEERING NOTE

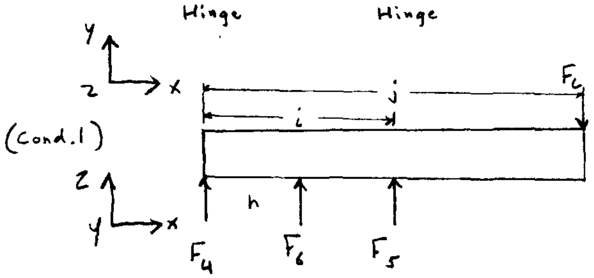
SECTION	PROJECT	SERIAL-CATEGORY	PAGE
		EN-556	5

SUBJECT	NAME
North A Layer Drawbridge Access Platforms 3 Loading Conditions on Hinged Portion of Platform	Brent J. Anderson
	DATE: 5/10/01 — REVISION DATE:





$F_L = 500\,lb$
$f = 15.0''$
$g = 30.0''$
$h = 22.5''$
$i = 33.0''$
$j = 51.0''$



$\rightarrow \Sigma F_y = 0$

$\uparrow \Sigma F_z = 0 = F_4 + F_5 + F_6 - F_L$

$\circlearrowleft \Sigma M_{F_4} = 0 = -F_6(f) + F_L(g)$

$F_6 = F_L\left(\frac{g}{f}\right)$ (For all 3 loading conditions)

$F_6 = 500\,lb\left(\frac{30}{15}\right)$

$\boxed{F_6 = 1000\,lb}$ (For all 3 loading cond.)

$\rightarrow \Sigma F_x = 0$

$\uparrow \Sigma F_z = 0 = F_4 + F_5 + F_6 - F_L$

$\circlearrowleft \Sigma M_{F_4} = 0 = -F_6(h) - F_5(i) + F_L(j)$

$F_5 = -F_6\left(\frac{h}{i}\right) + F_L\left(\frac{j}{i}\right)$

$F_5 = -F_L\left(\frac{gh}{fi}\right) + F_L\left(\frac{j}{i}\right)$

$F_5 = F_L\left[-\frac{gh}{fi} + \frac{j}{i}\right]$

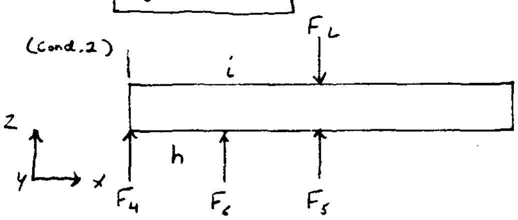
$F_5 = 500\,lb\left[-\frac{(30.0)(22.5)}{(15.0)(33.0)} + \frac{51.0}{33.0}\right]$

$F_5 = 91\,lb$

$F_4 = -F_5 - F_6 + F_L$

$F_4 = -91\,lb - 1000\,lb + 500\,lb$

$F_4 = -591\,lb$



$\rightarrow \Sigma F_x = 0$

$\uparrow \Sigma F_z = 0 = F_4 + F_5 + F_6 - F_L$

$\circlearrowleft \Sigma M_{F_5} = 0 = F_4(i) + F_6(i-h)$

$F_4 = -F_6\left(\frac{i-h}{i}\right)$

$F_4 = -1000\,lb\left(\frac{33.0-22.5}{33.0}\right)$

$F_4 = -318\,lb$

$F_5 = -F_4 - F_6 + F_L$

$F_5 = 318\,lb - 1000\,lb + 500\,lb$

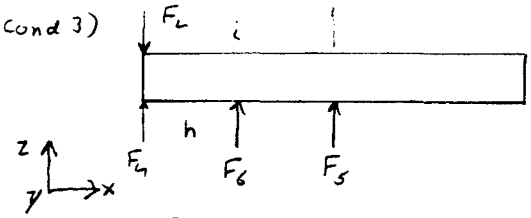
$F_5 = -182\,lb$

SUBJECT: North A Layer Drawbridge Access Platforms
3 Loading Conditions on Hinged Platform Cont.

NAME: Brent J. Anderson

DATE: 5/10/01 | REVISION DATE

(cond 3)



$\rightarrow \Sigma F_x = 0$

$\uparrow \Sigma F_z = 0 = F_4 + F_5 + F_6 - F_L$

$\circlearrowleft \Sigma M_{F_4} = 0 = -F_6(h) - F_5(i)$

$F_5 = -F_6\left(\frac{h}{i}\right)$

$F_5 = -1000 lb\left(\frac{22.5}{33.0}\right)$

$F_5 = -682 lb$

$F_4 = -F_5 - F_6 + F_L$

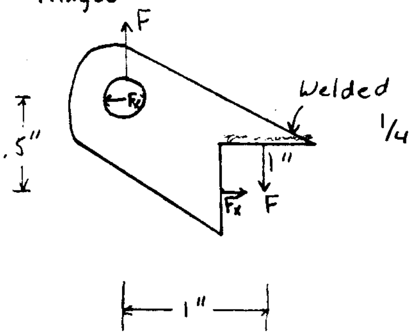
$F_4 = 682 lb - 1000 lb + 500 lb$

$F_4 = 182 lb$

FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE
			EN-556	7

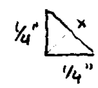
SUBJECT	NAME	
North A Layer Drawbridge Access Platforms Stresses in Hinges	Brent J. Anderson	
	DATE: 5/10/01	REVISION DATE

Hinges



1/4 in thick

$F = 68\ 2\ lb$ (from pg. 6)

Weld Area 

$x = .177\ in$

$L = (1'')2 + 1/4'' = 2.25\ in$

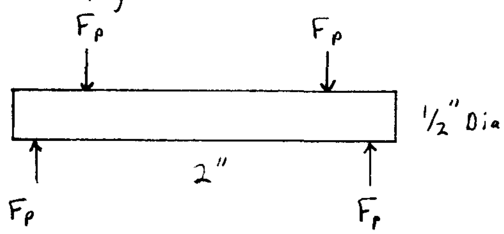
$A = .177\ in \times 2.25\ in = .398\ in^2$

$\circlearrowright + \Sigma M_{Hole} = 0 = F(1\ in) - F_x(.5\ in)$

$F_x = \frac{682\ lb\ (1\ in)}{.5\ in} = 1364\ lb$

$\sigma_w = \frac{F}{A} = \frac{682\ lb}{.398\ in^2} = \boxed{1710\ lb/in^2}$ (tension)

Pins In Hinges



$F_s = -682\ lb$

$F_x = 364\ lb$

$F_p = \frac{1}{2}\sqrt{(682\ lb)^2 + (1364\ lb)^2} = 762\ lb$

$\tau = \frac{F}{A_{//}}$

$A = \pi r^2 = \frac{\pi d^2}{4} = \frac{\pi(.5\ in)^2}{4} = .196\ in^2$

$\tau = \frac{762\ lb}{.196\ in^2} = \boxed{3890\ lb/in^2}$

FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE
			EN-556	8

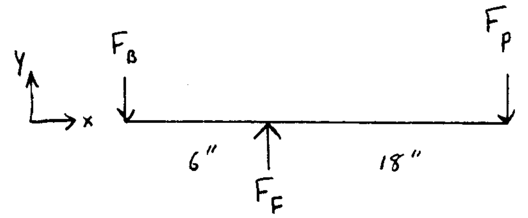
SUBJECT: North A Layer Drawbridge Access Platforms — Stresses in Hinged Platform Support Beam Brackets

NAME: Brent J. Anderson

DATE: 5/10/01

REVISION DATE:

F.B.D. of Under Side Beam For Hinged Platform Support



$F_6 = 1000\,lb$ 2 beams share the load.

$F_p = \frac{1}{2} F_6 = 500\,lb$ (from pg. 5)

$\rightarrow \Sigma F_x = 0$

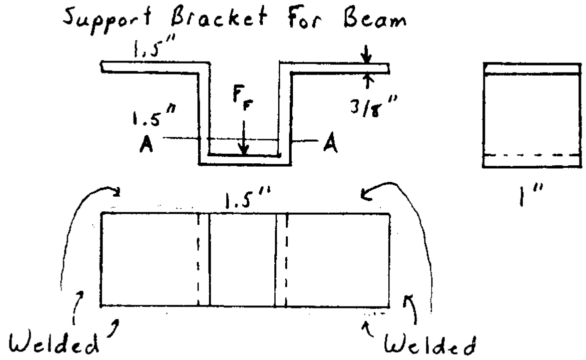
$\uparrow \Sigma F_y = 0 = -F_B + F_F - F_p$

$\circlearrowleft \Sigma M_{F_B} = 0 = -F_F\,(6\,in) + F_p\,(6\,in + 18\,in)$

$$F_F = \frac{F_p\,(24\,in)}{6\,in} = F_p\,(4)$$

$$F_F = 500\,lb\,(4) = 2000\,lb$$

Support Bracket For Beam



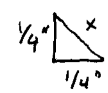
Stress On Cross-Section AA

$$Area = (3/8\,in \times 1\,in)\,2 = .75\,in^2$$

$$F = \frac{2000\,lb}{2} = 1000\,lb$$

$$\sigma = \frac{F}{A} = \frac{1000\,lb}{.75\,in^2} = \boxed{1300\,lb/in^2}\ \text{(tension)}$$

Weld Area Stress



$x = .177\,in$

$$x = \left(\sqrt{.25^2 + .25^2}\right)/2 = .177''$$

Length $L = 1.5''(4) + 1''(2) = 8\,in$

$$Area = (.177\,in)(8\,in) = 1.42\,in^2$$

$$\sigma_w = \frac{F}{A} = \frac{2000\,lb}{1.42\,in^2} = \boxed{1408\,lb/in^2}\ \text{(tension)}$$

FERMILAB
ENGINEERING NOTE

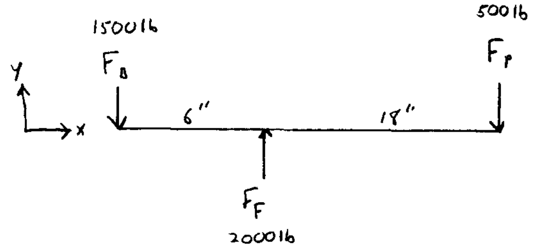
SECTION	PROJECT	SERIAL-CATEGORY	PAGE
		EN-556	9

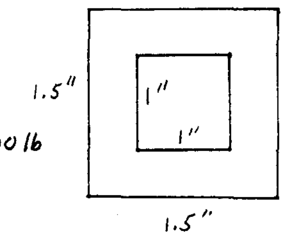
SUBJECT: North A Layer Drawbridge Access Platforms
Stresses on Hinged Platform Support Beams

NAME: Brent J. Anderson

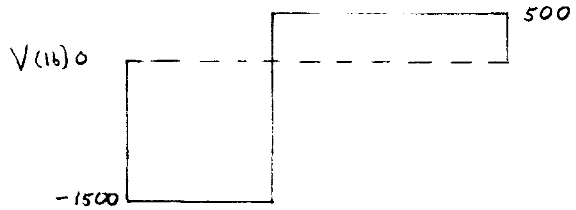
DATE: 5/10/01 REVISION DATE:

Stresses on Under Side Support Beam





F_B = 2000 lb − 500 lb = 1500 lb



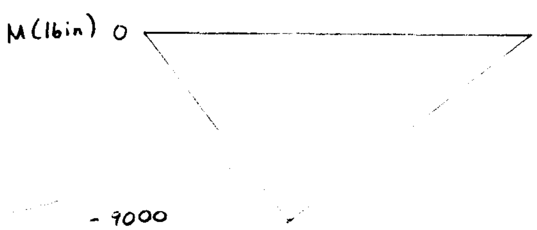
$$\sigma_{Bend} = \frac{Mc}{I}$$

M = 9000 lb in

$c = \frac{1.5\text{ in}}{2} = .75\text{ in}$

$I = \frac{b_1 h_1^3}{12} - \frac{b_2 h_2^3}{12} = \frac{(1.5)^4}{12} - \frac{(1)^4}{12} = .339\text{ in}^4$

$$\sigma_{Bend} = \frac{9000\text{ lbin}\cdot .75\text{ in}}{.339\text{ in}^4} = \boxed{20{,}000\text{ lb/in}^2}$$



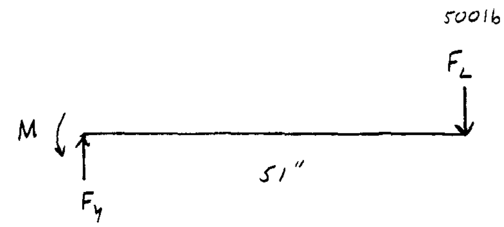
$$\tau = \frac{VQ}{Ib}$$ (shear due to bending)

$Q = \frac{.75''}{2}\left[(1.5\text{ in})^2/2\right] - \left[(1\text{ in})^2/2\right]\frac{1''}{2}$

$Q = .172\text{ in}^3$

$b = 1.5'' - 1'' = .5''$

$$\tau = \frac{1500\text{ lb }(.172\text{ in}^3)}{(.339\text{ in}^4)(.5\text{ in})} = \boxed{1520\text{ lb/in}^2}$$



$F_y = F_L = 500\,lb$

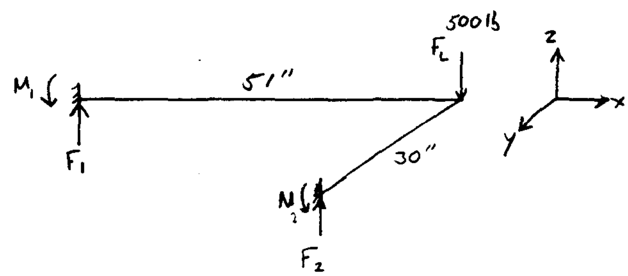
$M = F_L(51") = 500\,lb(51\,in) = 25500\,lb\,in$

$\sigma_{Bend} = \frac{Mc}{I} = \frac{25500\,lb\,in\,(.75\,in)}{.339\,in^4}$

$\sigma_{Bend} = 56400\,lb/in^2 > \sigma_{allow}$ (look at 2 member support)

$\tau = \frac{VQ}{Ib} = \frac{500\,lb\,(.172\,in^3)}{(.339\,in^4)(.5\,in)}$

$\tau = 507\,lb/in^2$



$\Sigma F_z = F_1 + F_2 - F_L = 0$

$\curvearrowleft + \Sigma M_{F_{L\,xz}} = -M_1 + F_1(51\,in) = 0$

$\curvearrowleft + \Sigma M_{F_{L\,yz}} = -M_2 + F_2(30\,in) = 0$

$\delta_1 = \delta_2$

$\frac{F_1 \ell_1^3}{3EI} = \frac{F_2 \ell_2^3}{3EI}$

$F_1 \ell_1^3 = F_2 \ell_2^3$

$F_1 = F_2 \frac{\ell_2^3}{\ell_1^3}$

$F_2\left(1 + \frac{\ell_2^3}{\ell_1^3}\right) = F_L$

$F_2 = F_L / \left(1 + \frac{\ell_2^3}{\ell_1^3}\right)$

$F_2 = 500\,lb / \left(1 + \frac{(30\,in)^3}{(51\,in)^3}\right)$

$F_2 = 415\,lb$

$F_1 = -415\,lb + 500\,lb = 85\,lb$

$M_1 = 85\,lb(51\,in)$

$M_1 = 4340\,lb\,in$

$M_2 = 415(30\,in)$

$M_2 = 12450\,lb\,in$

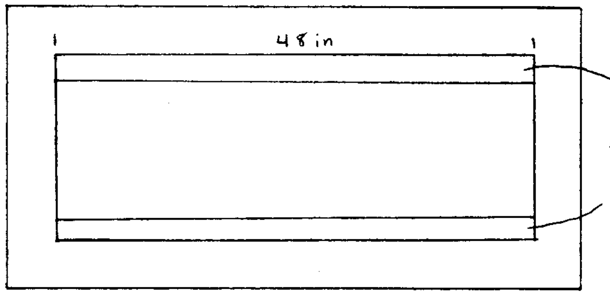
$\sigma_{Bend} = \frac{Mc}{I} = \frac{12450\,lb\,in\,(.75\,in)}{.339\,in^4} = \boxed{27500\,lb/in^2}$

$\tau = \frac{VQ}{Ib} = \frac{415\,lb\,(.172\,in^3)}{(.339\,in^4)(.5\,in)} = \boxed{421\,lb/in^2}$

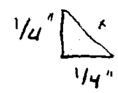
SUBJECT
North A Layer Drawbridge Access Platforms
Stresses in Platform Plating Supports

NAME Brent J. Anderson

DATE 5/11/01 REVISION DATE



Plates To Support Platform Floor
1 in welds with 2 in spacing.



$x = .177\,in$

1 in of weld for 3 in length

$\frac{48\,in}{3} = 16\,in$ of weld

$$\text{Weld Area} = 2\left[(16\,in)(.177\,in)\right] = 5.66\,in^2$$

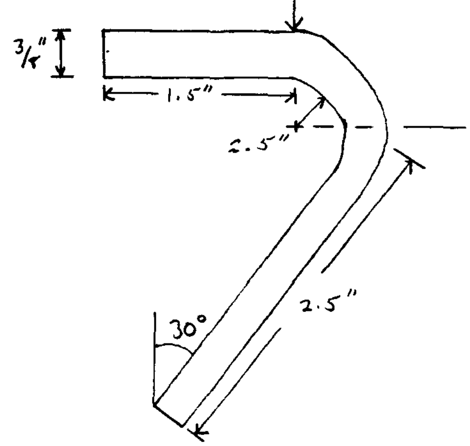
$$\sigma = \frac{F}{A} = \frac{500\,lb}{5.66\,in^2} = \boxed{88\ lb/in^2}\ \text{(tension)}$$

SUBJECT: North A Layer Drawbridge Access Platforms
Stresses in Upper Left Bracket for Platform Support

NAME: Brent J. Anderson

DATE: 5/15/01 | REVISION DATE:

$F_1 = 840$ lb (from pg. 4)



Outer Radius $r_o = 0.5'' + 3/8'' = 0.875''$

Inner Radius $r_i = 0.5''$

Width $h = 0.375''$

Centrodial Axis Radius $R = (0.5'' + 0.875'')\frac{1}{2} = 0.6875''$

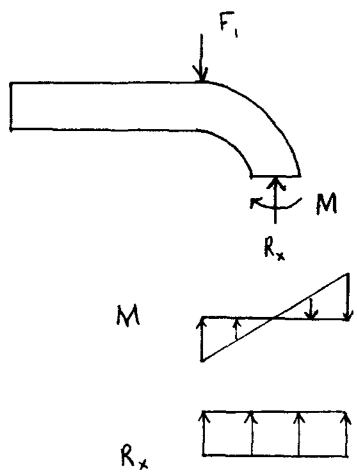
Neutral Axis Radius $r_n = \frac{h}{\ln(r_o/r_i)} = \frac{0.375''}{\ln(0.875/.5)} = 0.6701''$

Dist. from C.A. to N.A. $e = R - r_n = 0.6875'' - 0.6701'' = 0.0174''$

$c_o = r_o - r_n = 0.875'' - 0.6701'' = 0.2049''$

$c_i = r_n - r_i = 0.6701'' - 0.5'' = 0.1701''$

Area of X-Section $A = (0.375'')(1.5'') = 0.5625\,in^2$



$R_x = F_1 = 840$ lb

$M = F_1(R) = 840\text{ lb}(0.6875'')$

$M = 578$ lb·in

$$\sigma_i = \frac{Mc_i}{Aer_i} + \frac{F}{A} = \frac{578\text{ lb in}(.1701\text{ in})}{(0.5625\text{ in}^2)(.0174\text{ in})(0.5\text{ in})} + \frac{840\text{ lb}}{.5625\text{ in}^2}$$

$\sigma_i = \boxed{21580\text{ lb/in}^2}$ (comp.)

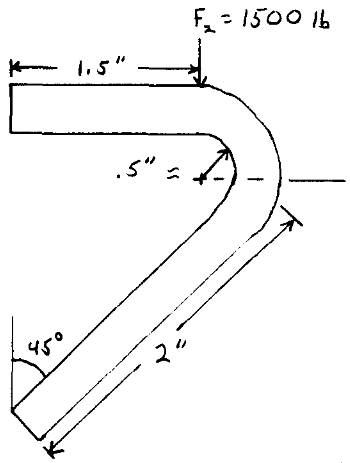
$$\sigma_o = \frac{Mc_o}{Aer_o} - \frac{F}{A} = \frac{578\text{ lb in}(0.2049)}{(0.5625\text{ in}^2)(0.0174\text{ in})(0.875\text{ in})} - \frac{840\text{ lb}}{.5625\text{ in}^2}$$

$\sigma_o = \boxed{12340\text{ lb/in}^2}$ (tension)

SUBJECT: North A Layer Drawbridge Access Platforms
Stresses in Upper Right Bracket for Platform Support

NAME: Brent J. Anderson

DATE: 5/15/01 | REVISION DATE



$r_o = 0.875''$

$r_i = 0.5''$

$h = 0.375''$

$R = 0.6875''$

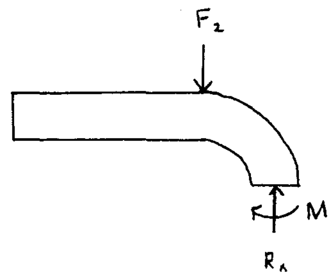
$r_n = 0.6701''$

$e = 0.0174''$

$c_o = 0.2049''$

$c_i = 0.1701''$

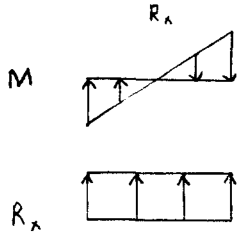
$A = 0.5625\ in^2$



$R_x = F_z = 1500\ lb$

$M = F_z(R) = 1500\ lb(0.6875\ in)$

$M = 1031\ lb\ in$



$$\sigma_i = \frac{Mc_i}{Aer_i} + \frac{F}{A} = \frac{1031\ lb\ in\ (.1701\ in)}{(.5625\ in^2)(.0174\ in)(0.5\ in)} + \frac{1500\ lb}{(.5625\ in^2)}$$

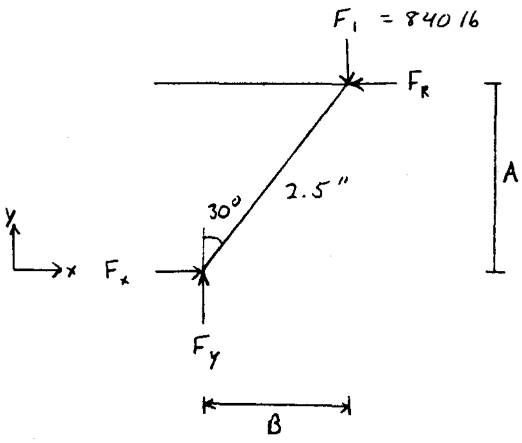
$\sigma_i =$ **38500 lb/in²** (comp.)

$$\sigma_o = \frac{Mc_o}{Aer_o} - \frac{F}{A} = \frac{1031\ lb\ in\ (.2049\ in)}{(.5625\ in^2)(.0174\ in)(0.875\ in)} - \frac{1500\ lb}{(.5625\ in^2)}$$

$\sigma_o =$ **22000 lb/in²** (tension)

FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE
			EN-556	14

SUBJECT	NAME
North A Layer Drowbridge Access Platforms Stresses in Welds between Upper Left Bracket and Platform	Brent J. Anderson
	DATE: 5/15/01 REVISION DATE:



$\rightarrow \Sigma F_x = 0 = -F_R + F_x$

$F_x = F_R$

$\uparrow \Sigma F_y = 0 = -F_1 + F_y$

$F_y = F_1$

$A = 2.5'' \sin 60° = 2.16$ in

$B = 2.5'' \cos 60° = 1.25$ in

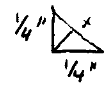
$\circlearrowright \Sigma M_{F_1} = 0 = -F_x A + F_y B$

$F_x = F_y \frac{B}{A} = 840\text{ lb}\ \frac{1.25\text{ in}}{2.16\text{ in}} = 486\text{ lb}$

$F_R = 486$ lb

$F_y = 840$ lb

Stress In Weld   1.5" welds on 3 sides of bracket

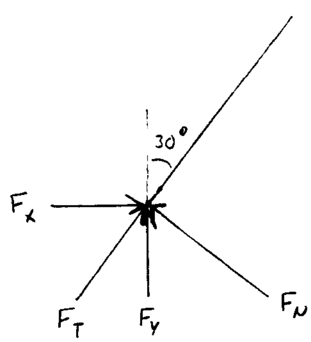


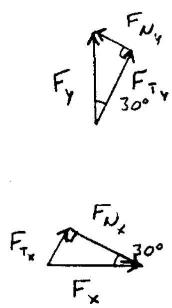
$x = .177$ in

$\sigma = \frac{F}{A} = \frac{840\text{ lb}}{(1.5\text{in})(.177\text{in})3} = \boxed{1050\text{ lb/in}^2}$ (comp.)

$\tau = \frac{F}{A} = \frac{486\text{ lb}}{(1.5\text{in})(.177\text{in})3} = \boxed{610\text{ lb/in}^2}$

Find Normal & Tangential Forces





$F_{N_y} = F_y \sin 30° = 840\text{ lb} \sin 30° = 420\text{ lb}$

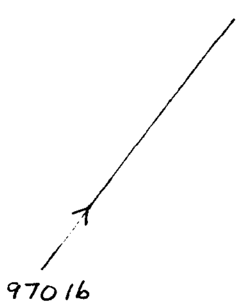
$F_{T_y} = F_y \cos 30° = 840\text{ lb} \cos 30° = 727\text{ lb}$

$F_{N_x} = F_x \cos 30° = 486\text{ lb} \cos 30° = 420\text{ lb}$

$F_{T_x} = F_x \sin 30° = 486\text{ lb} \sin 30° = 243\text{ lb}$

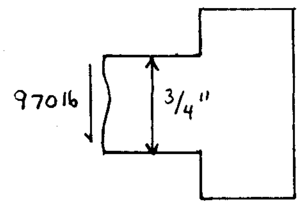
$F_N = F_{N_x} - F_{N_y} = 420\text{ lb} - 420\text{ lb} = 0\text{ lb}$

$F_T = F_{T_x} + F_{T_y} = 243\text{ lb} + 727\text{ lb} = 970\text{ lb}$



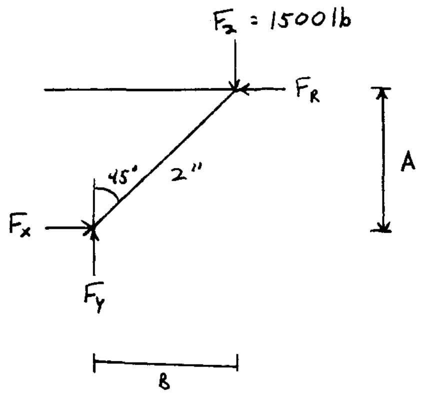
SUBJECT: North A Layer Drawbridge Access Platforms
Stresses in Bolt in Upper Left Bracket

NAME: Brent J. Anderson
DATE: 5/11/01
REVISION DATE



A_r = .302 in² (Table 8-2 Mech. Eng. Design 5th Ed. Shigley & Mischke pg. 328)

$$\tau = \frac{F}{A_r} = \frac{970\ \text{lb}}{.302\ \text{in}^2} = \boxed{3212\ \text{lb/in}^2}$$



$\rightarrow \Sigma F_x = 0 = -F_R + F_x$

$F_x = F_R$

$A = 2''\sin 45° = 1.41\,in$

$B = 2''\cos 45° = 1.41\,in$

$\uparrow \Sigma F_y = 0 = F_y - F_2$

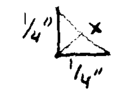
$F_y = F_2 = 1500\,lb$

$\circlearrowleft \Sigma M_{F_2} = 0 = -F_x A + F_y B$

$F_x = F_y \frac{B}{A} = 1500\,lb \, \frac{1.41\,in}{1.41\,in} = 1500\,lb$

$F_R = 1500\,lb$

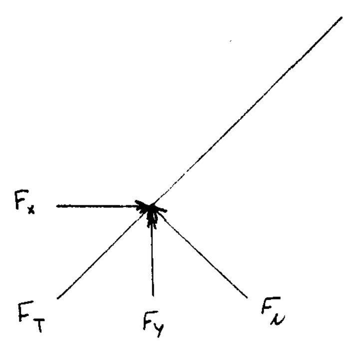
Stress In Weld   1.5" Welds on 2 sides of bracket



$X = .177\,in$

$\sigma = \frac{F}{A} = \frac{1500\,lb}{(1.5\,in)(.177\,in)2} = \boxed{2820\,lb/in^2}$ (comp.)

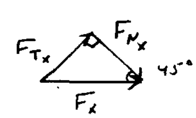
$\tau = \frac{F}{A} = \frac{1500\,lb}{(1.5\,in)(.177\,in)2} = \boxed{2820\,lb/in^2}$



Find Normal & Tangential Forces

$F_{N_y} = F_y \sin 45° = 1500\,lb \sin 45° = 1060\,lb$

$F_{T_y} = F_y \cos 45° = 1500\,lb \cos 45° = 1060\,lb$



$F_{N_x} = F_x \cos 45° = 1500\,lb \cos 45° = 1060\,lb$

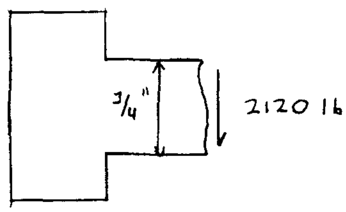
$F_{T_y} = F_x \sin 45° = 1500\,lb \sin 45° = 1060\,lb$

$F_N = F_{N_x} - F_{N_y} = 1060\,lb - 1060\,lb = 0\,lb$

$F_T = F_{T_x} + F_{T_y} = 1060\,lb + 1060\,lb = 2120\,lb$

SUBJECT
North A Layer Drawbridge Access Platforms
Stresses in Bolt in Upper Right Bracket

NAME: Brent J. Anderson
DATE: 5/11/01
REVISION DATE:



$A_r = 0.302\ in^2$ (Table 8-2 pg. 328 M.E. Design)

$$\tau = \frac{F}{A_r} = \frac{2120\,lb}{.302\,in^2} = \boxed{7020\ lb/in^2}$$

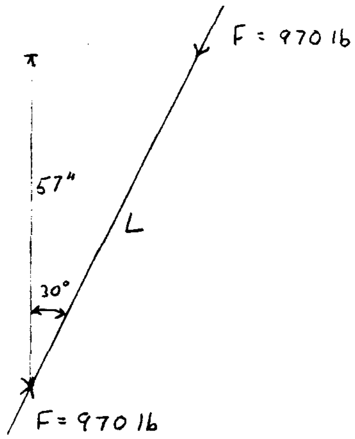
FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE
			EN-556	18

SUBJECT: North A Layer Drawbridge Access Platforms
Stresses in Left Support Column

NAME: Brent J. Anderson

DATE: 5/16/01

REVISION DATE:



$$L = \frac{57''}{\cos 30^\circ} = 65.8 \text{ in}$$

$$\sigma = \frac{F}{A} = \frac{970 \text{ lb}}{(1.5\text{in})^2 - (1\text{in})^2} = \frac{970 \text{ lb}}{1.25 \text{in}^2} = \boxed{776 \text{ lb/in}^2} \text{ (comp.)}$$

Check buckling stress. $I = .339 \text{ in}^4$ (from pg. 9)

radius of gyration $K = \sqrt{\frac{I}{A}} = \sqrt{\frac{.339 \text{in}^4}{1.25 \text{in}^2}} = .52 \text{ in}$

$$\ell/k = \frac{65.8 \text{in}}{.52 \text{in}} = 127$$

$$\left(\ell/k\right)_1 = \left(\frac{2\pi^2 cE}{S_y}\right)^{1/2}$$

c - end condition constant (Fixed-Free)
$c = \frac{1}{4}$ (pg. 123 M.E. Design)
$E = 30.0 \times 10^6 \text{ lb/in}^2$ (pg. 729 M.E. Design)
$S_y = 36 \times 10^3 \text{ lb/in}^2$ (pg. 12 M.E. Design)

$$\left(\ell/k\right)_1 = \left(\frac{2\pi^2 (1/4)(30.0 \times 10^6 \text{ lb/in}^2)}{36 \times 10^3 \text{ lb/in}^2}\right)^{1/2}$$

$$\left(\ell/k\right)_1 = 64$$

$127 > 64$ $\quad \ell/k > (\ell/k)_1$ Use Euler's Eq.
(pg. 124 M.E. Design)

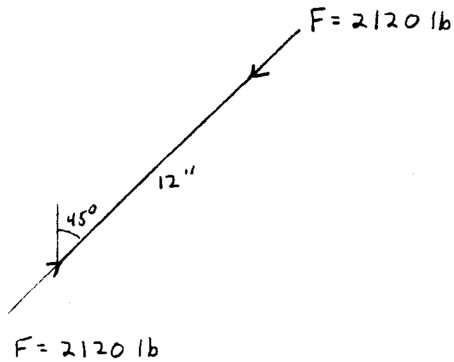
Euler's Eq.

$$\frac{P_{cr}}{A} = \frac{c\pi^2 E}{(\ell/k)^2} = \frac{(1/4)\pi^2 \, 30.0 \times 10^6 \text{ lb/in}^2}{(127)^2} = 4590 \text{ lb/in}^2 \text{ (comp.)}$$

SUBJECT: North A Layer Drawbridge Access Platforms
Stresses in Right Support Column

NAME: Brent J. Anderson

DATE: 5/16/01 | REVISION DATE



$\sigma = \frac{F}{A} = \frac{2120 \text{ lb}}{1.25 \text{ in}^2} = \boxed{1700 \text{ lb/in}^2}$ (comp.)

Check buckling stress

radius of gyration $k = .52 \text{ in}$ (from pg. 18)

$l/k = 12 \text{ in} / .52 \text{ in} = 23$

$(l/k)_1 = 64$ (conditions are the same as the other support beam)

$23 < 64 \qquad l/k < (l/k)_1$ Use J. B. Johnson Eq. (pg. 125 M.E. Design)

J. B. Johnson Eq.

$$\frac{P_{CR}}{A} = S_y - \left(\frac{S_y l}{2\pi k}\right)^2 \frac{1}{cE}$$

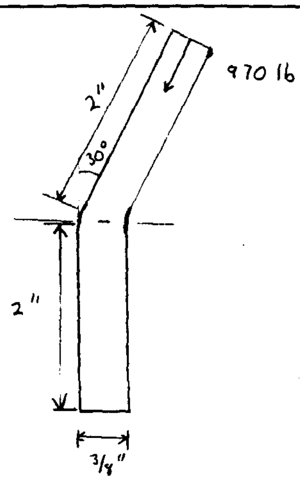
$$\frac{P_{CR}}{A} = 36.0\times10^3 \text{ lb/in}^2 - \left(\frac{36.0\times10^3 \text{ lb/in}^2 \ 12 \text{ in}}{2\pi \ (.52 \text{ in})}\right)^2 \frac{1}{(1/4)(30.0\times10^6 \text{ lb/in}^2)}$$

$$\frac{P_{CR}}{A} = 33700 \text{ lb/in}^2$$

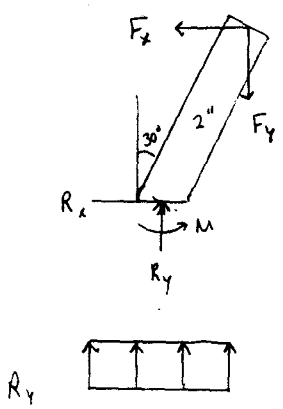
SUBJECT: North A Layer Drawbridge Access Platforms
Stresses in Lower Left Support Bracket

NAME: Brent J. Anderson

DATE: 5/16/01 | REVISION DATE



$A = 0.5625\ in^2$ (from pg. 12)



$F_y = 970\ lb\ \cos 30° = 840\ lb$ $\qquad R_y = 840\ lb$

$F_x = 970\ lb\ \sin 30° = 485\ lb$ $\qquad R_x = 485\ lb$

$\circlearrowleft + \Sigma M_R = 0 = -M + F_y(2in \sin 30°) - F_x(2in \cos 30°)$

$M = 840lb(2in \sin 30°) - 485lb(2in \cos 30°)$

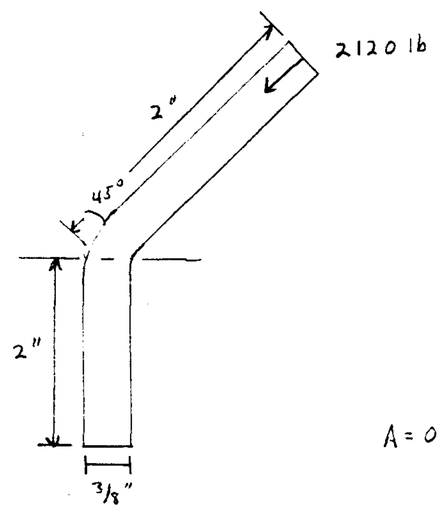
$M = 0\ lb\ in$

$\sigma = \frac{F}{A} = \frac{840\ lb}{.5625 in^2} = \boxed{1500\ lb/in^2}$ (comp.)

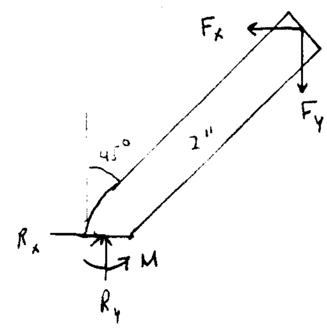
$\tau = \frac{F}{A} = \frac{485\ lb}{.5625 in^2} = \boxed{862\ lb/in^2}$

FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE
			EN-556	21

SUBJECT	NAME
North A Layer Drawbridge Access Platforms Stresses in Lower Right Support Bracket	Brent J. Anderson
	DATE: 5/16/01



$A = 0.5625\ in^2$ (from pg. 12)



$F_y = 2120\,lb(\cos 45°) = 1500\,lb$ $R_y = 1500\,lb$

$F_x = 2120\,lb(\sin 45°) = 1500\,lb$ $R_x = 1500\,lb$

$\circlearrowleft + \Sigma M_R = 0 = -M + F_y(2in \sin 45°) - F_x(2in \cos 45°)$

$M = 1500\,lb(2in \sin 45°) - 1500\,lb(2in \cos 45°)$

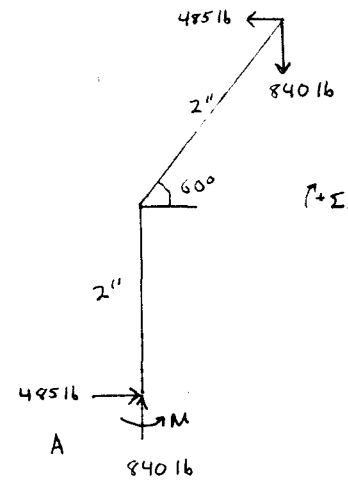
$M = 0\ lb\ in$

$\sigma = \frac{F}{A} = \frac{1500\,lb}{.5625\,in^2} =$ **$2700\ lb/in^2$** (comp.)

$\tau = \frac{F}{A} = \frac{1500\,lb}{.5625\,in^2} =$ **$2700\ lb/in^2$**

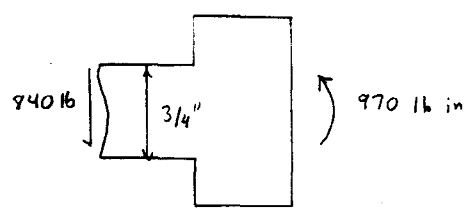
FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE
			EN-556	22

SUBJECT	NAME	
North A Layer Drawbridge Access Platforms Stresses in Lower Left Support Bracket Anchor Bolt	Brent J. Anderson	
	DATE: 5/16/01	REVISION DATE:



$$\circlearrowleft + \Sigma M_A = 0 = -M + 840\,lb(2\,in\,\cos 60°) - 485\,lb(2\,in\,\sin 60° + 2\,in)$$

$$M = -970\ lb\,in$$



$$\tau = \frac{F}{A_r} = \frac{840\,lb}{.302\,in^2} = \boxed{2780\ lb/in^2}$$

$$M = F_x$$

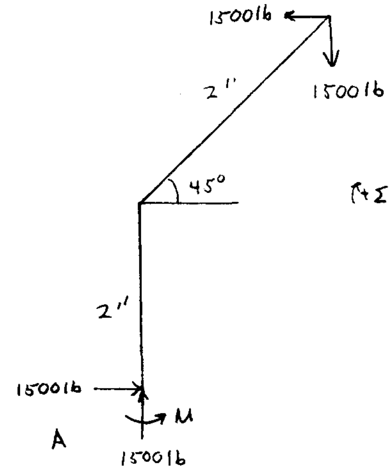
$$F = \frac{M}{x} = \frac{970\,lb\,in}{.375\,in} = 2590\,lb$$

$A_t = .334\ in^2$ (Table 8-2 pg. 328 M.E. Design)

$$\sigma = \frac{F}{A_t} = \frac{2590\,lb}{.334\,in^2} = \boxed{7754\ lb/in^2}$$ (tension)

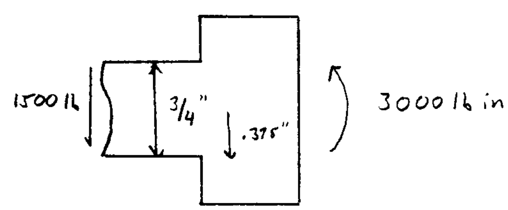
FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE
			EN-556	23

SUBJECT	NAME	
North A Layer Drawbridge Access Platforms Stresses in Lower Right Support Bracket Anchor Bolt	Brent J. Anderson	
	DATE: 5/16/01	REVISION DATE



$\curvearrowleft + \Sigma M_A = 0 = -M + 1500\,lb(2in\cos 45°) - 1500\,lb(2in + 2in\sin 45°)$

$M = -3000\ lb\ in$



$\tau = \frac{F}{A_r} = \frac{1500\,lb}{.302} = \boxed{5000\ lb/in^2}$

$M = Fx$

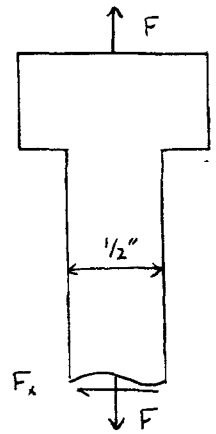
$F = \frac{M}{x} = \frac{3000\ lb\ in}{.375\ in} = 8000\ lb$

$\sigma = \frac{F}{A_t} = \frac{8000\ lb}{.334\ in^2} = \boxed{24000\ lb/in^2}$ (tension)

FERMILAB ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE
		EN-556	24

SUBJECT	NAME
North A Layer Drawbridge Access Platforms Stresses in Platform Anchor Bolts	Brent J. Anderson
	DATE: 5/14/01 REVISION DATE:



2 Bolts

$F = \frac{1}{2} F_3 = \frac{1}{2}(1070\ lb) = 535\ lb$

$F_x = 486\ lb + 1500\ lb = 1986\ lb$

$\sigma = \frac{F}{A_t} = \frac{535\ lb}{.141\ in^2} = \boxed{3800\ lb/in^2}$ (tension)

$A_t = .141\ in^2$ (Table 8-2 M.E. Design pg. 328)

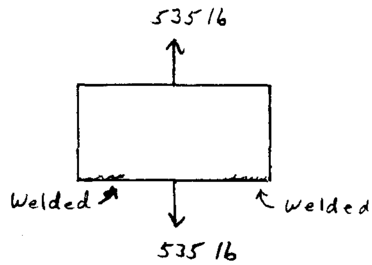
$\tau = \frac{F}{A_r} = \frac{1986\ lb}{.125\ in^2} = \boxed{15900\ lb/in^2}$

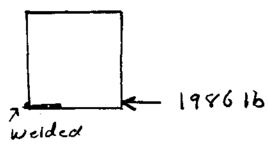
$A_r = .125\ in^2$ (Table 8-2 M.E. Design pg. 328)

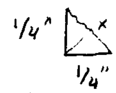
SUBJECT: North A Layer Drawbridge Access Platforms
Stresses in Steel Blocks for Anchoring the Platform

NAME: Brent J. Anderson

DATE: 5/14/01 | REVISION DATE







$x = .177$ in

Total Length of welds $1'' + 1'' + 1.25'' + 1.25'' = 4.5''$

$A = (.177\,in)(4.5\,in) = .7965\,in^2$

$\sigma = \frac{F}{A} = \frac{535\,lb}{.7965\,in^2} = \boxed{672\ lb/in^2}$ (tension)

$\tau = \frac{F}{A} = \frac{1986\,lb}{.7965\,in^2} = \boxed{2493\ lb/in^2}$

SUBJECT: North A Layer Drawbridge Access Platforms Allowable Stresses

NAME: Brent J. Anderson

DATE: 5/14/01 | REVISION DATE

Carbon Steel (A36) $S_y = 36 \times 10^3 \ lb/in^2$ (pg. 12 M.E. Design)

Tension $\sigma_{allow} \leq 0.60 \ S_y$ (pg. 12 M.E. Design)

$\sigma_{allow} \leq 0.60 (36 \times 10^3 \ lb/in^2) = 21600 \ lb/in^2$

$\boxed{\sigma_{allow} \leq 21600 \ lb/in^2}$

Shear $\tau_{allow} \leq 0.40 S_y$ (pg. 12 M.E. Design)

$\tau_{allow} \leq 0.40 (36 \times 10^3 \ lb/in^2) = 14400 \ lb/in^2$

$\boxed{\tau_{allow} \leq 14400 \ lb/in^2}$

Bending $\sigma_{allow} \leq 0.90 S_y$ (pg. 12 M.E. Design)

$\sigma_{allow} \leq 0.90 (36 \times 10^3 \ lb/in^2) = 32400 \ lb/in^2$

$\boxed{\sigma_{allow} \leq 32400 \ lb/in^2}$

Bolts (A 354) $S_y = 130 \times 10^3 \ lb/in^2$ (Table 8-5 pg. 342 M.E. Design)
$S_u = 150 \times 10^3 \ lb/in^2$

$\sigma_{allow} \leq \frac{1}{3} S_y = \frac{1}{3} (130 \times 10^3 \ lb/in^2)$

$\boxed{\sigma_{allow} \leq 43000 \ lb/in^2}$

$\tau_{allow} \leq .17 S_u = .17 (150 \times 10^3 \ lb/in^2)$

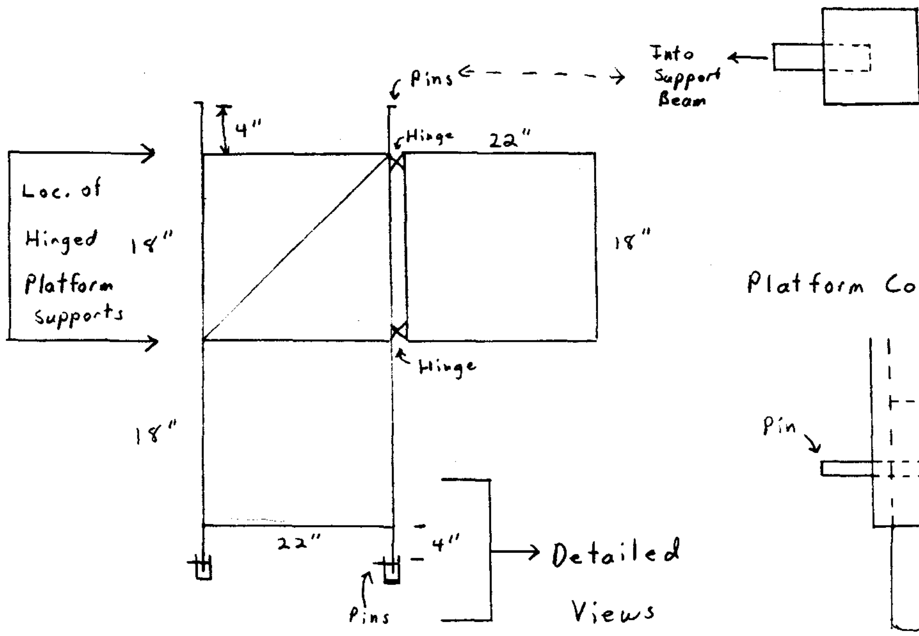
$\boxed{\tau_{allow} \leq 25500 \ lb/in^2}$

Table 2: South Platform Stresses

Part	Location	Page	Stresses				Allowable Stresses		
			Tensile lb/in^2	Compressive lb/in^2	Shear lb/in^2	Bending lb/in^2	Tensile lb/in^2	Shear lb/in^2	Bending lb/in^2
Hinge	Welds	29	314	314			21,600		
	Pins	29			4,150			25,500	
Hinged Platform Support	Welds on Support Blocks	30	148	148	1,520		21,600	14,400	
	Pins	30		32,740		25,420	21,600		32,400
Platform	1.5 in sq. Box Beam	32				19,900			32,400
	1.0 in sq. Beam	32				15,010			32,400
Platform Anchors	Weld Between Flange & Fixture	33			256	2,915		14,400	32,400
	Weld Between Flange & Truss	33		472		13,930	21,600		32,400
	Pins	34		32,740		18,250	21,600		32,400
	Welds on Support Blocks	34	208		1,513	2,270	21,600	14,400	32,400

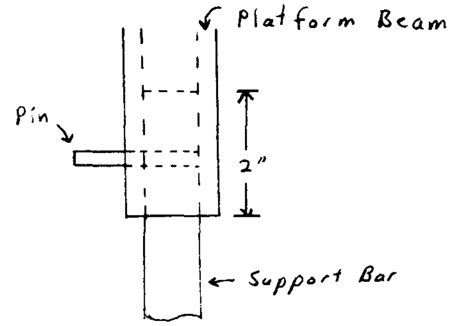
FERMILAB ENGINEERING NOTE	SECTION	PROJECT	SERIAL-CATEGORY	PAGE
			EN-556	27a

SUBJECT	NAME	
South A Layer Drawbridge Access Platforms (East + West) Basic Dimensions	Brent J. Anderson	
	DATE: 5/14/01	REVISION DATE:

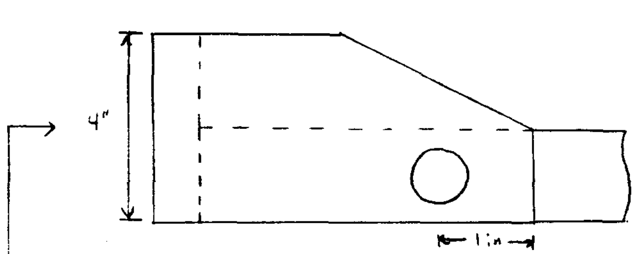


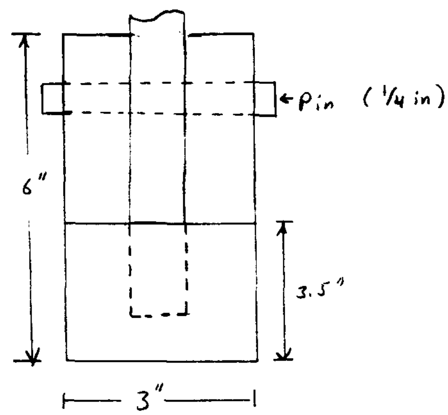
Blocks welded to truss.
1/4" pin used to hold the support beam.
Blocks 1.5" cubed

Platform Connection

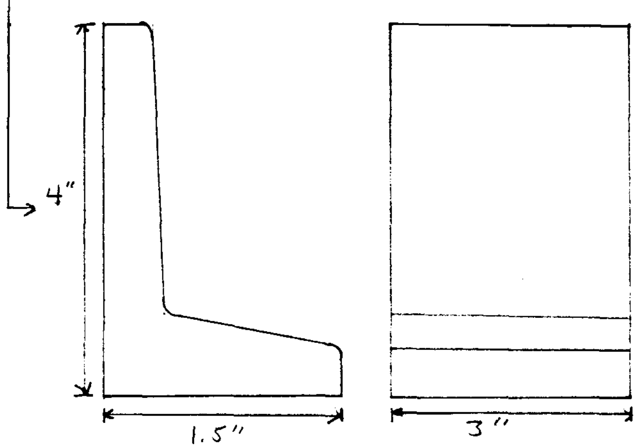


Support Anchors

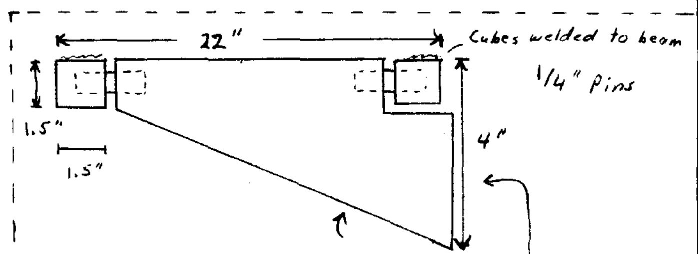




This end is welded to a flange.
(1/4" welds 2 sides + top)



Bottom welded to truss
(1/4" welds 3 sides)



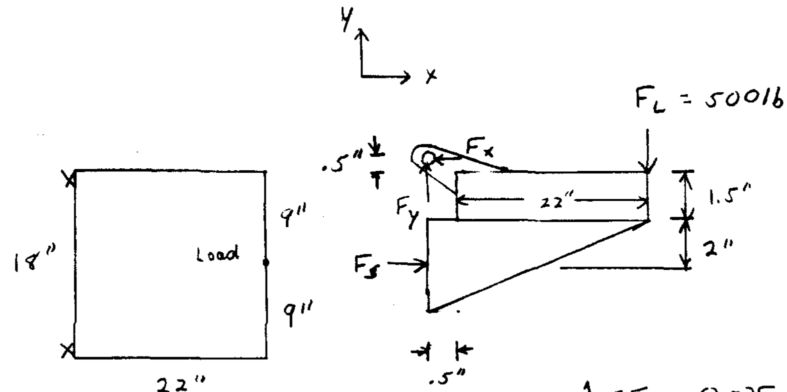
Hinged Platform Supports 1/2" thick
Qty 4
2 - Hinged Platform
2 - Main Platform

This edge rests against matting support

SUBJECT: South A Layer Drawbridge Access Platforms — Resultant Forces on Hinges and Platform Supports

NAME: Brent J. Anderson

DATE: 5/16/01 REVISION DATE:



F_x, F_y, F_s applied equally at each location of X.

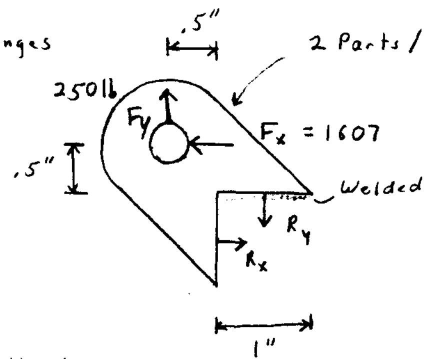
$$+\uparrow \Sigma F_y = 0 = 2F_y - F_L$$
$$F_y = \tfrac{1}{2} F_L = \tfrac{1}{2}\, 500\,lb = 250\,lb$$

$$\rightarrow \Sigma F_x = 0 = -F_x + F_s$$
$$F_x = F_s$$

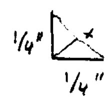
$$\circlearrowleft + \Sigma M_{pin} = 0 = -F_s\,(3.5'')2 + F_L\,(22.5'')$$
$$F_s = F_L\,(22.5'')/[(3.5'')\,2]$$
$$F_s = 500\,lb \left(\frac{22.5''}{3.5''}\right)\frac{1}{2}$$
$$F_s = 1607\ lb$$

$$F_x = 1607\ lb$$

Hinges



1/4" thick



$x = .177\,in$

$R_y = \frac{1}{2}F_y = 250\,lb/2 = 125\,lb$

$R_x = \frac{1}{2}F_x = 1607\,lb/2 = 803.5\,lb$

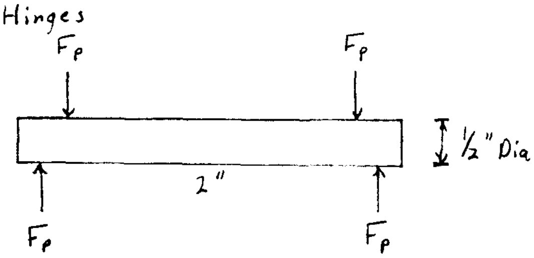
Stress in the Weld

$L = (1'')\,2 + 1/4'' = 2.25\,in$

$A = 2.25\,(.177\,in) = .398\,in^2$

$\sigma_w = \frac{F}{A} = \frac{125\,lb}{.398\,in^2} = \boxed{314\ lb/in^2}$ (tension + comp.)

Pins In Hinges



$F_p = \frac{1}{2}\sqrt{F_y^2 + F_x^2}$

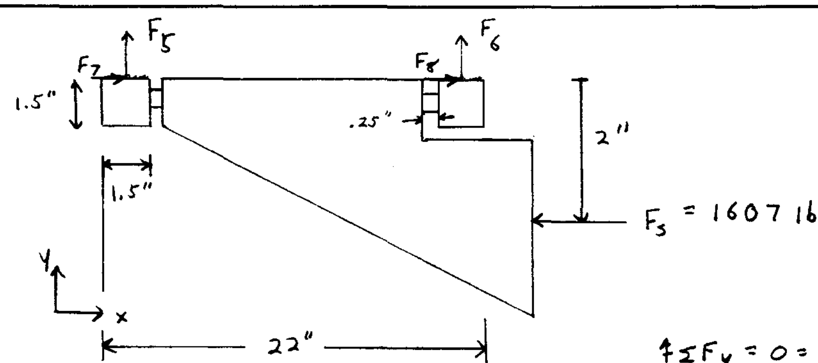
$F_p = \frac{1}{2}\sqrt{(250\,lb)^2 + (1607\,lb)^2}$

$F_p = 813\,lb$

$A = \pi r^2 = \frac{\pi d^2}{4} = \frac{\pi\,(.5\,in)^2}{4} = .196\,in^2$

$\tau = \frac{F}{A} = \frac{813\,lb}{.196\,in^2}$

$\tau = \boxed{4150\ lb/in^2}$



$\uparrow + \Sigma F_y = 0 = F_5 + F_6$

$F_5 = -F_6$

$\rightarrow + \Sigma F_x = 0 = F_7 + F_8 - F_s$

$\circlearrowleft + \Sigma M_{5,7} = 0 = -F_6 (22'' - 1.5'') + F_s (2'')$

$F_6 = F_s \dfrac{2''}{(22'' - 1.5'')}$

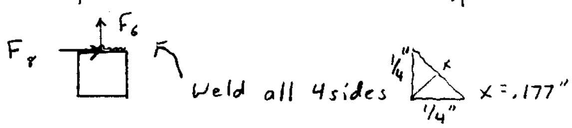
$F_6 = 1607 \dfrac{2''}{(22'' - 1.5'')} = 157 \text{ lb}$

$F_5 = -157 \text{ lb}$

Assume $F_8 = 0$

$F_7 = F_s = 1607 \text{ lb}$

Blocks

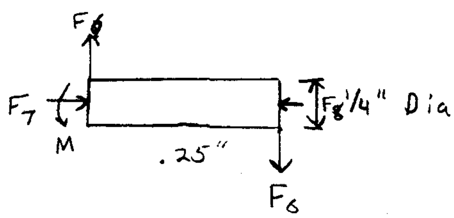


Weld Area = 4(1.5")(.177") = 1.06 in²

$\sigma = \dfrac{F}{A} = \dfrac{157 \text{ lb}}{1.06 \text{ in}^2} = \boxed{148 \text{ lb/in}^2}$ (tension + comp.)

$\tau = \dfrac{F}{A} = \dfrac{1607 \text{ lb}}{1.06 \text{ in}^2} = \boxed{1520 \text{ lb/in}^2}$

Pins



$\circlearrowleft + \Sigma M = 0 = -M + F_6 (.25'')$

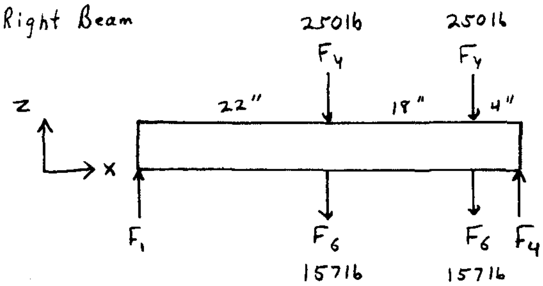
$M = F_6 (.25'')$

$M = 157 \text{ lb} (.25'') = 39 \text{ lb in}$

$\sigma = \dfrac{F}{A} = \dfrac{1607 \text{ lb}}{\pi (.25 \text{ in})^2 / 4} = \boxed{32740 \text{ lb/in}^2}$ (comp.)

$\sigma_{Bend} = \dfrac{Mc}{I} = \dfrac{39 \text{ lb in } (.25 \text{ in}/2)}{\pi (.25 \text{ in})^4 / 64} = \boxed{25420 \text{ lb/in}^2}$

Right Beam



X-Z $\uparrow \Sigma F_z = 0 = F_1 - 2(250\,lb) - 2(157\,lb) + F_4$

$F_1 = 814\ lb - F_4$

$250\ lb + 157\ lb = 407\ lb$

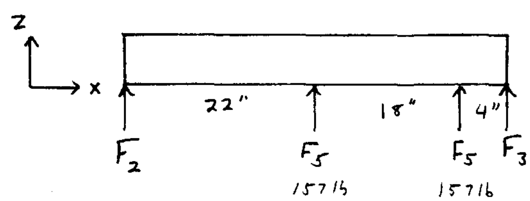
$\circlearrowleft + \Sigma M_{F_1} = 407\,lb(22") + 407\,lb(40") - F_4(44") = 0$

$F_4 = 574\ lb$

$F_1 = 814\,lb - 574\,lb$

$F_1 = 240\ lb$

Left Beam



X-Z $\uparrow \Sigma F_z = 0 = F_2 + 2(157\,lb) + F_3$

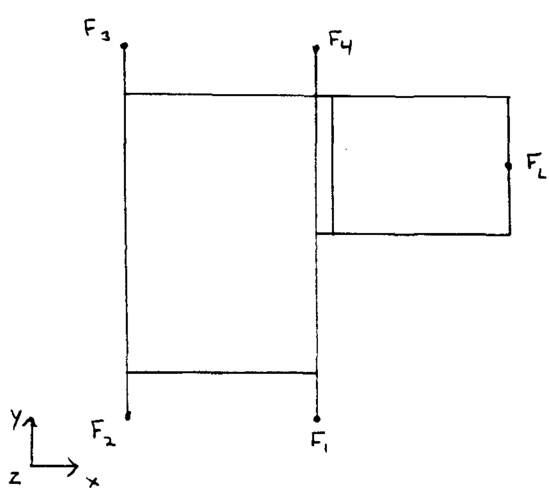
$F_2 = -314\ lb - F_3$

$\circlearrowleft \Sigma M_{F_2} = 0 = -157\,lb(22") - 157\,lb(40") - F_3(44")$

$F_3 = -221\ lb$

$F_2 = -314\,lb + 221\,lb$

$F_2 = -93\,lb$



Check That All Forces in Z-Dir Balance.

$\uparrow \Sigma F_z = F_1 + F_2 + F_3 + F_4 + F_L$

$240\ lb - 93\,lb - 221\,lb + 574\,lb - 500\,lb = 0$

Forces Balance.

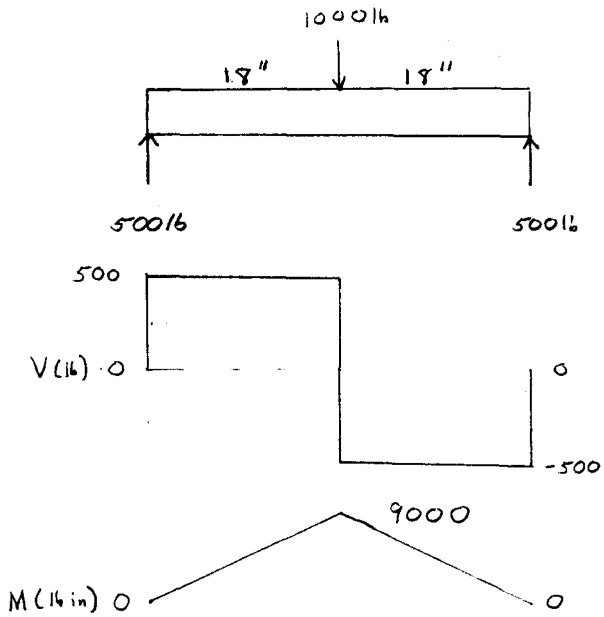
FERMILAB
ENGINEERING NOTE

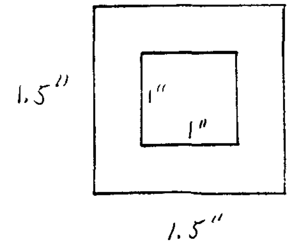
SECTION	PROJECT	SERIAL-CATEGORY	PAGE
		EN-556	32

SUBJECT: South A Layer Drawbridge Access Platforms
Worst Case Stresses In Beams

NAME: Brent J. Anderson

DATE: 5/17/01 **REVISION DATE:**

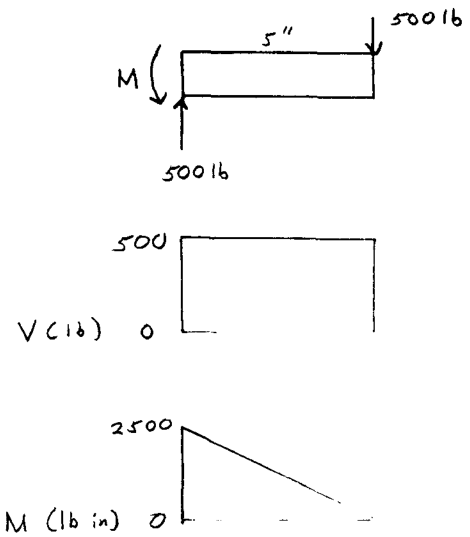




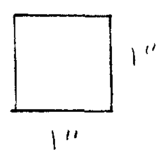
$$I = \frac{b_1 h_1^3}{12} - \frac{b_2 h_2^3}{12} = \frac{(1.5)^4}{12} - \frac{1^4}{12} = .339\ in^4$$

$$\sigma_{Bend} = \frac{Mc}{I} = \frac{9000\ lb\,in\ (.75\ in)}{.339\ in^4}$$

$$\sigma_{Bend} = \boxed{19900\ lb/in^2}$$



$$M = 500\ lb\ (5\ in) = 2500\ lb$$



$$I = \frac{b_1 h_1^3}{12} = \frac{1^4}{12} = .0833\ in^4$$

$$\sigma_{Bend} = \frac{2500\ lb\,in\ (.5\ in)}{.0833\ in^4}$$

$$\sigma_{Bend} = \boxed{15010\ lb/in^2}$$

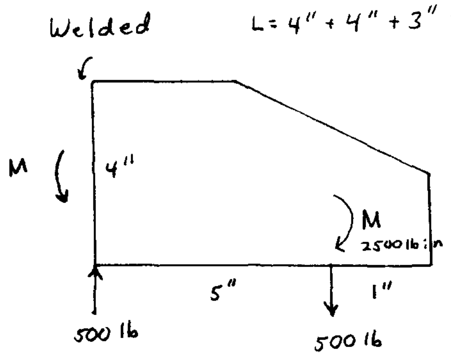
FERMILAB
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE
		EN-556	33

SUBJECT: South A Layer Drawbridge Access Platforms
Stresses in Platform Anchors

NAME: Brent J. Anderson

DATE: 5/17/01 REVISION DATE:



$L = 4" + 4" + 3" = 11"$ $x = .177\,in$ $A = 11"(.177") = 1.95\,in^2$

$$\tau = \frac{F}{A} = \frac{500\,lb}{1.95\,in^2} = \boxed{256\,lb/in^2}$$

(pg. 397 Mech. Eng. Design 5th Ed. Shigley & Mischke)

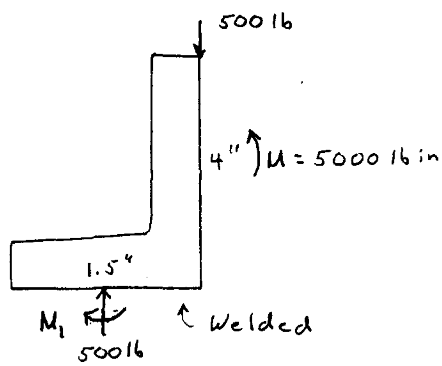
$$I_u = \frac{2d^3}{3} - 2d^2\frac{d^2}{b+2d} + (b+2d)\left(\frac{d^2}{b+2d}\right)^2$$

$$I_u = \frac{2(4")^3}{3} - 2(4")^2\frac{(4")^2}{3"+2(4")} + (3"+2(4"))\left(\frac{(4")^2}{3"+2(4")}\right)^2 = 19.4\,in^3$$

$$I = .707\,h\,I_u = .707(1/4")(19.4\,in^3) = 3.43\,in^4$$

$M = (2500\,lb\,in)\,2 = 5000\,lb\,in$

$$\sigma_{Bend} = \frac{Mc}{I} = \frac{5000\,lb\,in\,(2")}{3.43\,in^4} = \boxed{2915\,lb/in^2}$$



$$M_1 = 5000\,lb\,in - 500\,lb\left(\frac{1.5\,in}{2}\right)$$

$$M_1 = 4625\,lb\,in$$

$L = (1.5" + 1.5" + 3") = 6\,in$

$x = .177\,in$

$A = 6"(.177") = 1.06\,in^2$

$$\sigma = \frac{F}{A} = \frac{500\,lb}{1.06\,in^2} = \boxed{472\,lb/in^2} \text{ (comp.)}$$

$$I_u = \frac{2(1.5")^3}{3} - 2(1.5")^2\frac{(1.5")^2}{3"+2(1.5")} + (3"+2(1.5"))\left(\frac{(1.5")^2}{3"+2(1.5")}\right)^2$$

$$I_u = 1.41\,in^3$$

$$I = .707\,h\,I_u = .707(1/4")(1.41\,in^3) = .249\,in^4$$

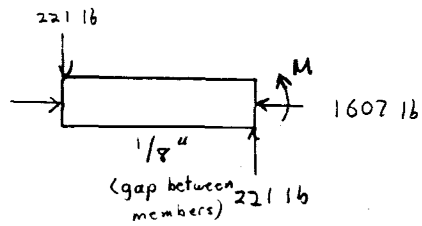
$$\sigma_{Bend} = \frac{Mc}{I} = \frac{4625\,lb\,in\,(.75\,in)}{.249\,in^4} = \boxed{13930\,lb/in^2}$$

SUBJECT: South A Layer Drawbridge Access Platforms
Stresses In Platform Anchors

NAME: Brent J. Anderson

DATE: 5/17/01 | REVISION DATE:

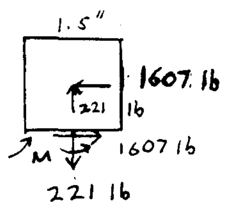
¼" Pins



$\sigma = \frac{F}{A} = \frac{1607\ lb}{\pi(.25in)^2/4} =$ **32740 lb/in²** (comp.)

$M = 221\ lb\ (.125") = 28\ lb\ in$

$\sigma_{Bend} = \frac{Mc}{I} = \frac{28\ lb\ in\ (.25in/2)}{\pi(.25in)^4/64} =$ **18250 lb/in²**



Welded

$\tau = \frac{F}{A} = \frac{1607\ lb}{1.062\ in^2} =$ **1513 lb/in²**

$A = 4(1.5")(.177in) = 1.062\ in^2$

$\sigma = \frac{F}{A} = \frac{221\ lb}{1.062\ in^2} =$ **208 lb/in²** (tension)

$I = .707\ h\ I_u \qquad I_u = \frac{d^2}{6}(3b + d)$ (pg. 397 M.E. Design)

$I_u = \frac{1.5"^2}{6}(3(1.5") + 1.5") = 2.25\ in^3$

$I = .707(¼")\ 2.25 in^3 = .398\ in^4$

$M = 1607\ lb\ \left(\frac{1.5"}{2}\right) = 1205\ lb\ in$

$\sigma_{Bend} = \frac{Mc}{I} = \frac{1205\ lb\ in\ (1.5"/2)}{.398\ in^4} =$ **2270 lb/in²**

SUBJECT: South A Layer Drawbridge Access Platforms Allowable Stresses

NAME: Brent J. Anderson

DATE: 5/17/01 | REVISION DATE

Carbon Steel (A36) $S_y = 36 \times 10^3 \text{ lb/in}^2$ (pg. 12 M.E. Design)

Tension $\sigma_{allow} \leq 0.60\, S_y$ (pg. 12 M.E. Design)

$\sigma_{allow} \leq 0.60(36 \times 10^3 \text{ lb/in}^2) = 21600 \text{ lb/in}^2$

$\boxed{\sigma_{allow} \leq 21600 \text{ lb/in}^2}$

Shear $\tau_{allow} \leq 0.40\, S_y$ (pg. 12 M.E. Design)

$\tau_{allow} \leq 0.40(36 \times 10^3 \text{ lb/in}^2) = 14400 \text{ lb/in}^2$

$\boxed{\tau_{allow} \leq 14400 \text{ lb/in}^2}$

Bending $\sigma_{allow} \leq 0.90\, S_y$ (pg. 12 M.E. Design)

$\sigma_{allow} \leq 0.90(36 \times 10^3 \text{ lb/in}^2) = 32400 \text{ lb/in}^2$

$\boxed{\sigma_{allow} \leq 32400 \text{ lb/in}^2}$

Hinge Pins (A354) $S_y = 130 \times 10^3 \text{ lb/in}^2$ (Table 9-5 pg. 342 M.E. Design)
$S_u = 150 \times 10^3 \text{ lb/in}^2$

$\sigma_{allow} \leq \frac{1}{3} S_y = \frac{1}{3}(130 \times 10^3 \text{ lb/in}^2)$

$\boxed{\sigma_{allow} \leq 43000 \text{ lb/in}^2}$

$\tau_{allow} \leq .17\, S_u = .17(150 \times 10^3 \text{ lb/in}^2)$

$\boxed{\tau_{allow} \leq 25500 \text{ lb/in}^2}$