A5 : Bracket Design

Safety Factor = 4

$200\ lb_f < F < 300\ lb_f$

Assume no failure due to direct shear stress

HDPE, Torlon® PAI, or Nylon

HDPE	Torlon® PAI	Nylon
not enough info	higher E	lower E
	higher Strgth	lower strength
	lower elongation %	higher elongation %

winner

Torlon ® PAI   E = 600,000 psi

Tensile strength = 20,000 psi

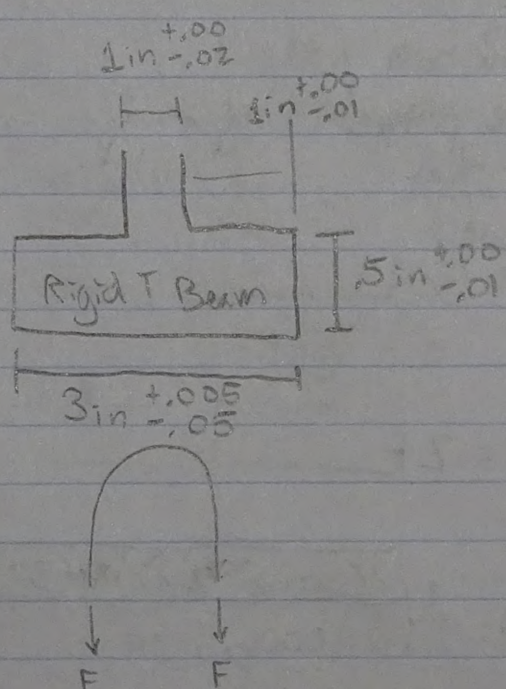


Figure 1)

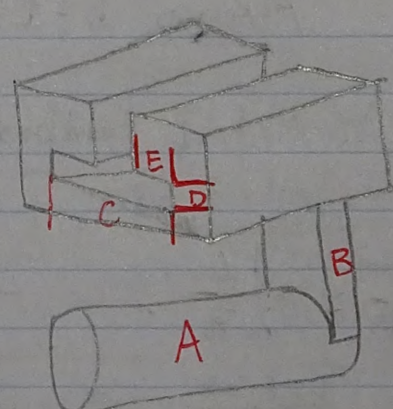
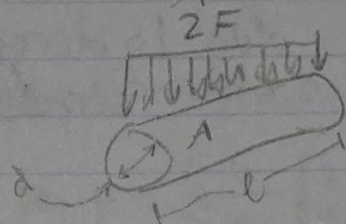
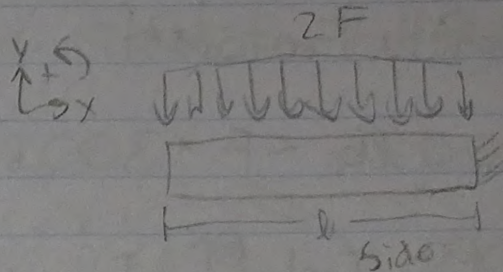


Figure 2) from Appendix C

Stress Analyses

Section A:





Model as cantilever beam

Known	Unknown
$F = 250\,lbf$	l
E 600ksi	Area
$\sigma_{yield} = 20ksi$	
$SF = 4$	

Assume no shear failure
$l >$ width of Uline polyester strap $> 3/4$ in
Assume $l = 1$ in

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Section modulus circle ⌀

$$Z = \frac{\pi d^3}{32}$$

$$\frac{\sigma}{SF} = \frac{Wl}{2Z}$$

$$W = 2F$$

$$Z = \frac{WlSF}{\sigma}$$

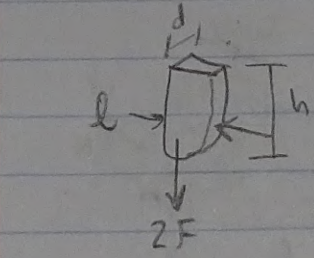
$$\frac{\pi d^3}{32} = \frac{2FlSF}{\sigma}$$

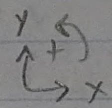
$$\boxed{d = \sqrt[3]{\frac{2Fl\,SF\,32}{\sigma\,\pi}}}$$

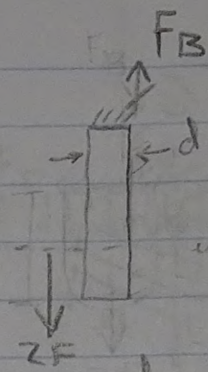
$$d = \sqrt[3]{\frac{2(250\,lbf)(1in)(4)(32)}{(20{,}000psi)\,\pi}}$$

$$\boxed{d = 1.006in}$$

Section B:

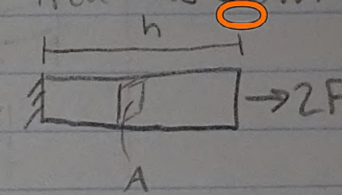






side

treat as beam



<u>known</u>	<u>unknown</u>
$F = 250\,lb_f$	l
$F_B = 2F$	d
$\sigma = 20\,ksi$	h

Assume no shear failure

Model as cantilever beam

Assume $l = \phi_A = 1.006$ in

Assume $A = d \cdot l$

Model as a rod in tension

Assume $h > \phi_A$ Set arbitrary h at 1.25"

Assume

$h = \phi_A$ + clearence

$\therefore h \approx 1.25$ in

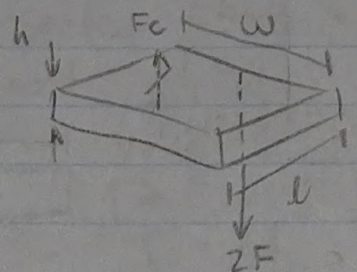
$$\frac{\sigma}{SF} = \frac{F}{A} = \frac{2F}{d\,l}$$

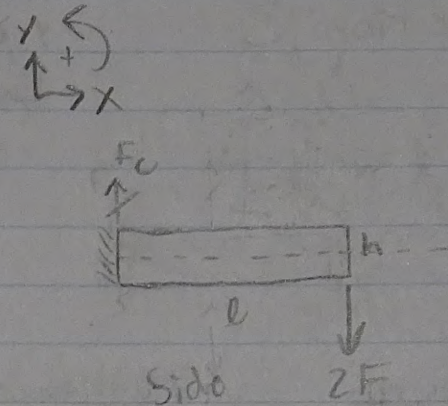
$$\boxed{d = \frac{2F\,SF}{l\,\sigma}}$$

$$d = \frac{2(250\,lb_f)\,4}{(1.006)(20{,}000\,psi)}$$

$$\boxed{d = 0.0994\,in}$$

Section C:





known	unknown
$F = 250\ lbf$	h
$\sigma = 20\ ksi$	w
$SF = 4$	l

Model as cantilever beam
Assume no shear failure
Assume $l \geq$ Section A $= 1$ in
Assume $w >$ width of T-beam $= 3$ in $+ .005$
Assume $w =$ ~~3.50 in (fit .25 on each side~~
4.00 in for 1/2 in on each side for D)

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$$\frac{\sigma}{SF} = \frac{Wl}{Z}$$

$$Z = \frac{bd^2}{6}$$

$d = h$
$b = w$

$$Z = \frac{Wl\,SF}{\sigma}$$

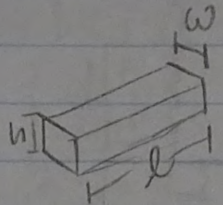
$$\frac{wh^2}{6} = \frac{2F\,l\,SF}{\sigma}$$

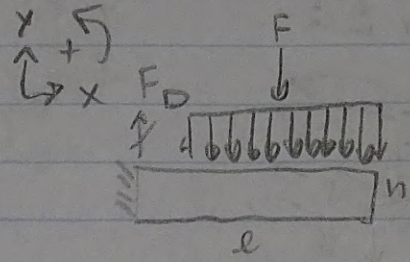
$$\boxed{h = \sqrt{\frac{2F\,l\,SF\,6}{\sigma w}}}$$

$$h = \sqrt{\frac{2(250\ lbf)(1.00\ in)(4)\,6}{(20{,}000\ psi)(4.00\ in)}}$$

$$\boxed{h = 0.387\ in}$$

Section D:





side c

Known	unknown
$F = 250\,lbf$	l
$SF = 4$	h
$\sigma = 20\,ksi$	w

Assume no shear failure
Model as cantilever beam
Assume $l = 1$ in
Assume $h = 0.60$ – flange height + clearence
Target $w < 0.5$ in

$$\frac{\sigma}{SF} = \frac{Wl}{2Z} \qquad Z = \frac{bd^2}{6} \quad \begin{matrix} d = h \\ b = w \end{matrix}$$

$$Z = \frac{F\,l\,SF}{2\sigma} = \frac{wh^2}{6}$$

$$\boxed{w = \frac{F\,l\,SF\,6}{\sigma h^2}}$$

$$w = \frac{(250\,lbf)(1.00\,in)(4)(6)}{2(20{,}000\,psi)(0.60)^2}$$

$$\boxed{w = 0.417\ in}$$

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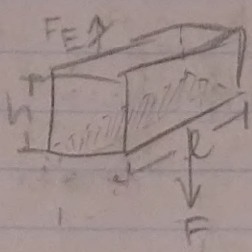
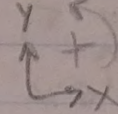
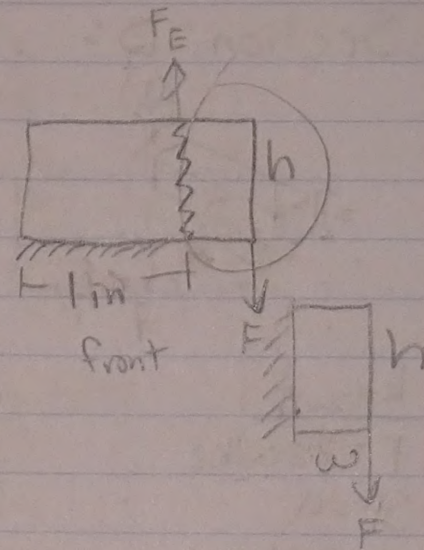
Section E:







known	unknown
$F = 250\,lb_f$	h
$SF = 4$	w
$\sigma = 20ksi$	l

Assume no shear failure
Assume $l = 1.00in$
Assume? $w = 0.417in$ same as width of D
model as cantilever

$$\frac{\sigma}{SF} = \frac{Wl}{Z} \quad l = w \qquad Z = \frac{bd^2}{6} \quad d = h \quad b = l$$

$$W = F$$

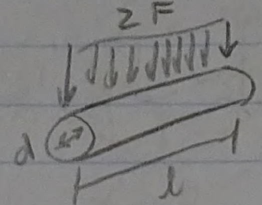
$$\frac{\sigma}{SF} = \frac{Fw}{Z} \qquad Z = \frac{lh^2}{6}$$

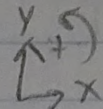
$$\boxed{h = \sqrt{\frac{Fw\,SF\,6}{\sigma\,l}}} \qquad h = \sqrt{\frac{(250\,lbf)(0.417in)(4)6}{(20{,}000psi)(1.00in)}}$$

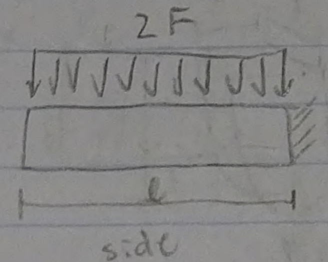
$$\boxed{h = 0.354\ in}$$

Stiffness Analyses $\delta_{max} = 0.005$ in

Section A







Known	unknown
$\delta_{max} = .005''$	l
$E = 600 ksi$	d
$F = 250 lbf$	
$SF = 4$	

Assume shear deflection negligible
Assume $l = 1 in$

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$$\delta = \frac{Wl^3}{8EI}$$

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$$I = \frac{\pi d^4}{64}$$

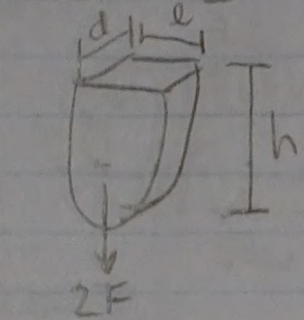
$$I = \frac{Wl^3 SF}{8E\delta} = \frac{\pi d^4}{64}$$

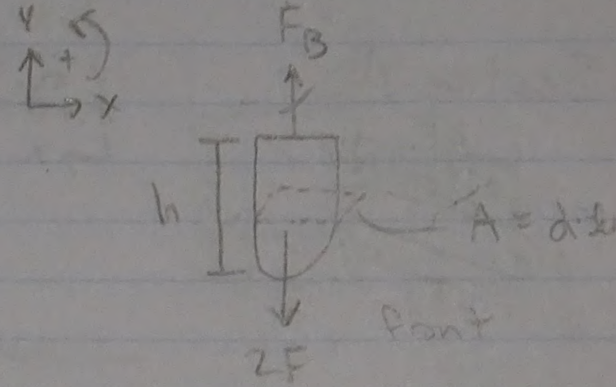
$$\boxed{d = \sqrt[4]{\frac{(2F)l^3\, SF\, 64}{8E\,\delta_{max}\,\pi}}}$$

$$d = \sqrt[4]{\frac{2(250\, lbf)(1)^3(4)(64)}{8(600{,}000 psi)(.005)\pi}}$$

$$\boxed{d = 1.52 \text{ in}}$$

Section B:





known	unknown
$F = 250\,lbf$	d
$SF = 4$	l
$E = 600\,ksi$	h

Assume negligible shear
Model as rod in tension
Assume $l \doteq \phi_A = 1.52\,in$
Assume $h > 1.52\,in$
add ~ 1/4" for clearence say $h = 1.75"$

$\sigma = \frac{F}{A}$

$\sigma = E\varepsilon$

$\varepsilon = \frac{\sigma}{E}$

$\varepsilon = \frac{F}{AE}$

$\varepsilon = \frac{\Delta l}{l}$

$\delta = \frac{FL}{AE}$

$$\delta_{max} = \frac{Pl}{AE} \qquad P = 2F,\; l = h,\; A = d \cdot l$$

$$\frac{\delta}{SF} = \frac{2Fh}{dlE}$$

$$\boxed{d = \frac{2FhSF}{\delta l E}}$$

$$d = \frac{2(250\,lbf)(1.75\,in)(4)}{(0.005\,in)(1.52\,in)(600{,}000\,psi)}$$

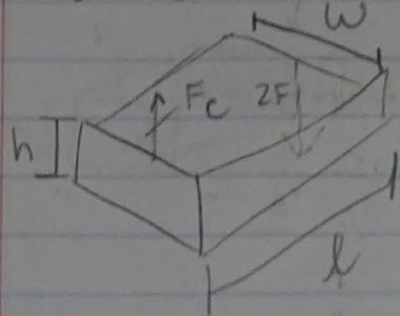
$$\boxed{d = 0.768\,in}$$

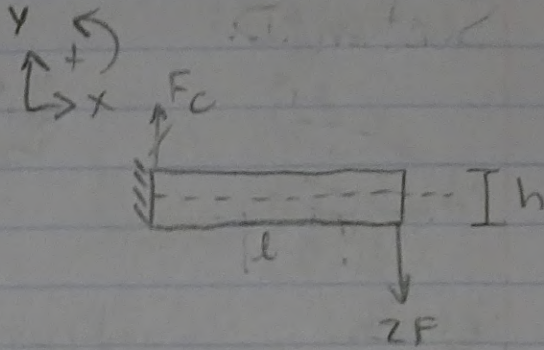
ideally $d \leq 1/4"$
but cannot be done
easily w/ this mode

h is limited by ϕ_A

l should be limited by ϕ_A but mostly by CW

Section C:





Known	Unknown
F = 250 lbf	h
E = 600 ksi	w
SF = 4	l

Assume negligible shear
Model as cantilever beam
Assume $l \approx$ Section A_l = 1 in
Assume $w >$ width of T beam + ½ for each D section
Assume w = 4.00 in

$$\frac{\delta}{SF} = \frac{W l^3}{3EI} \qquad W = 2F \qquad I = \frac{bh^3}{12} \qquad b = w$$

$$I = \frac{(2F) l^3 SF}{3E\delta} = \frac{wh^3}{12}$$

$$h = \sqrt[3]{\frac{2(250\,lbf)(1)^3(4)\,12}{3(600{,}000\,psi)(.005)(4\,in)}}$$

$$\boxed{h = \sqrt[3]{\frac{2F l^3 SF\, 12}{3E\delta w}}}$$

$$\boxed{h = 0.874\ in}$$

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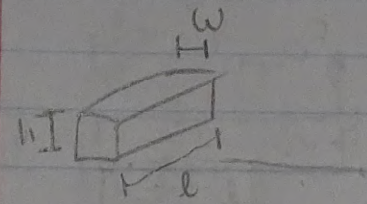
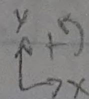
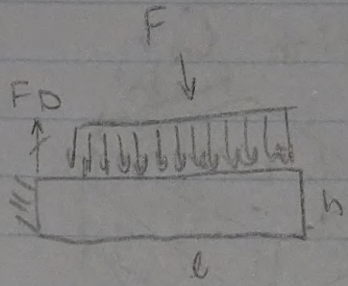
Section D:







Known	unknown
F=250lbf	h
SF=4	w
E=600ksi	l

Assume negligible shear
Model as cant. lever beam
Assume l=1in
Assume h=0.60in
Target w < 0.5in

$$\delta = \frac{Wl^3}{8EI} \qquad I = \frac{bh^3}{12} \quad b=w$$

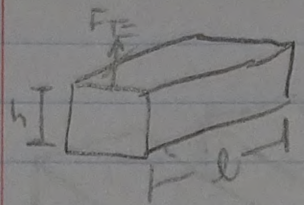
$$I = \frac{Fl^3}{8\delta E} = \frac{wh^2}{12}$$

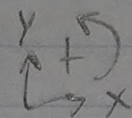
$$\boxed{w = \frac{Fl^3\,12}{8\delta E h^2}}$$

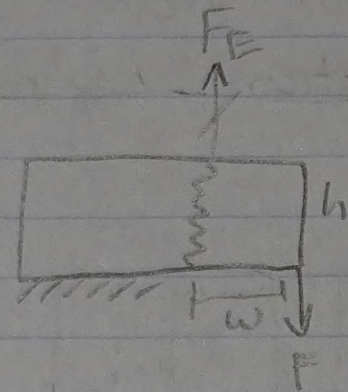
$$w = \frac{(250\,\text{lbs})(1\text{in})^3\,12}{8(.005\text{in})(600{,}000\text{psi})(0.60)^2}$$

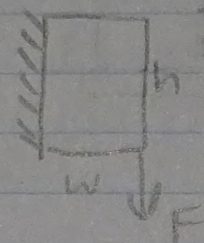
$$\boxed{w = 0.347\text{in}}$$

Section E:









known	uknown
F=250lbf	h
SF=4	w
E=600ksi	l

Assume negligible shear
Model as cantilever
Assume $l = 1 in$
Assume $w = 0.347 in$

$$\frac{\delta}{SF} = \frac{Wl^3}{3EI} \quad W = F \quad l = w$$

$$I = \frac{bh^3}{12} \quad b = l$$

$$I = \frac{Fw^3}{3E\delta} = \frac{lh^3}{12}$$

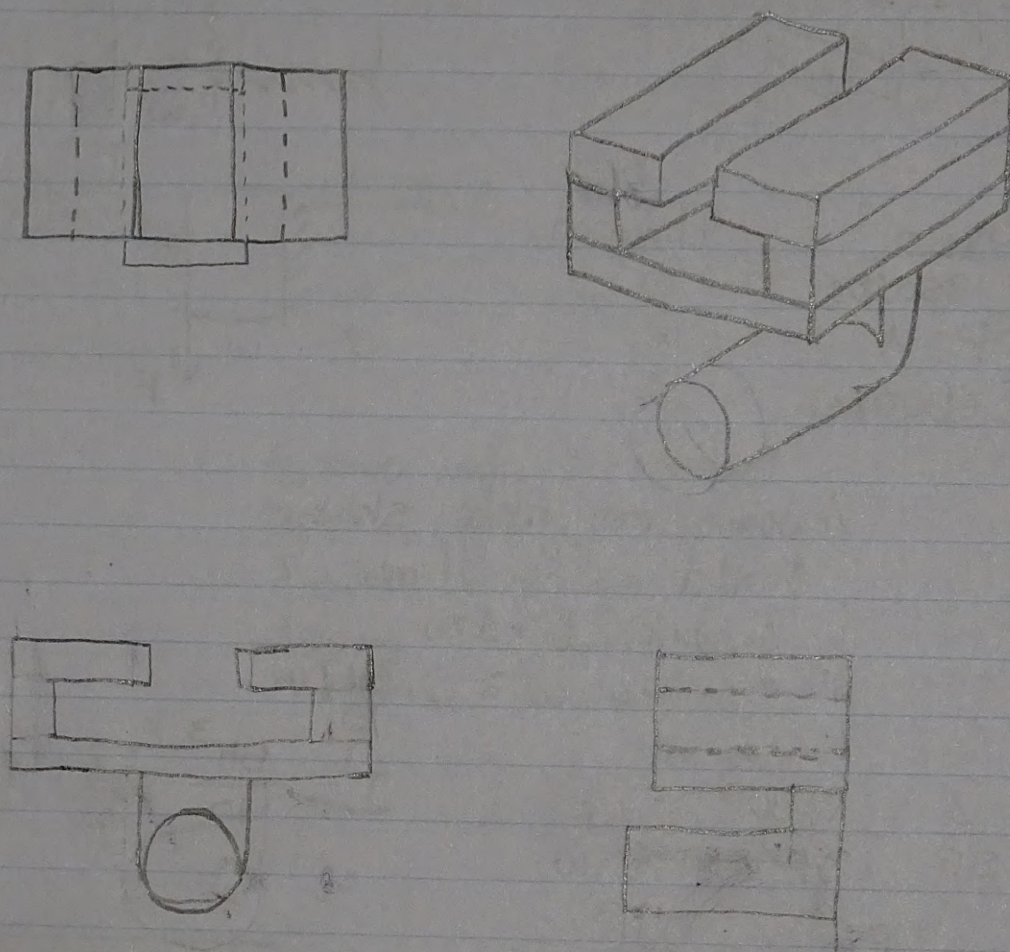
$$\boxed{h = \sqrt[3]{\frac{Fw^3 12}{3E\delta l}}}$$

$$h = \sqrt[3]{\frac{(250\,lbf)(.347in)^3 12}{3(600{,}000psi)(.005in)(1in)}}$$

$$\boxed{h = 0.241\,in}$$

Multiview Sketches

<u>Stress Analysis</u>



Stiffness Analysis