# BEAM CALCULATIONS FOR PARAGON CTD BOOM

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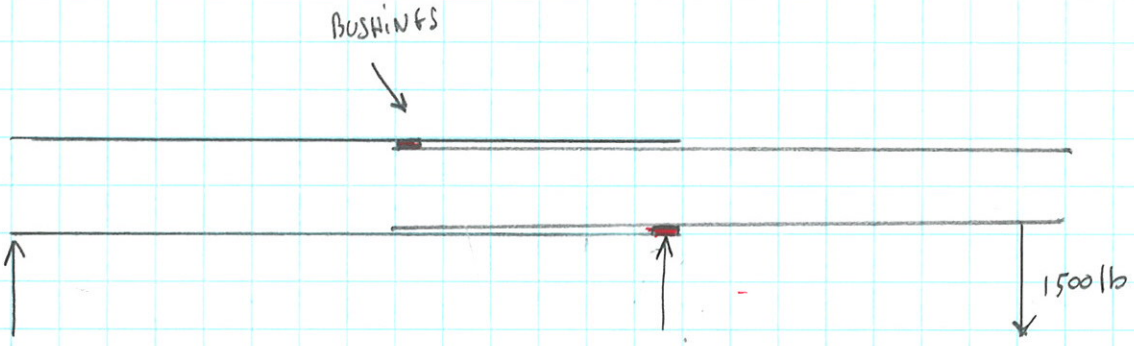
BEAM 1 BEAM 2




BEAM 1 : 3" x 3" x 3/16" x 42"

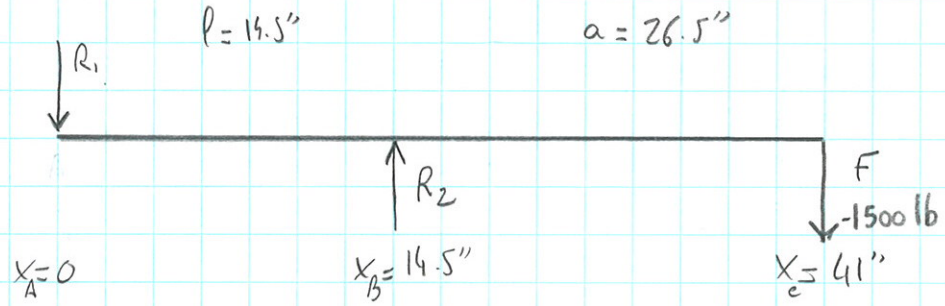
MATERIAL: A36 STEEL, $E = 29 \times 10^6$ PSI
$YS = 36000$ PSI

MOMENT OF INERTIA : $I = 2.6\ in^4$
SECTION MODULUS : $S = 1.73\ in^3$

BEAM 2: 2.5" x 2.5" x 1/4" x 44" $I = 1.69\ in^4$, $S = 1.35\ in^3$

CONSIDERING BEAM 2. WE ASSUME THE BEAMS DO NOT TOUCH EACH OTHER EXCEPT AT BUSHINGS

USING EQUATIONS AND NOTATIONS FROM SHIGLEY'S PAGE 1017




$$R_1 = F \times a / p = -2741\ lb$$

$$R_2 = \frac{F}{p}(p+a) = \frac{1500 \times 41}{14.5} = +4241\ lb$$

SHEAR FORCE

$V_{AB} = 2741\ lb$ $\qquad V_{BC} = -1500\ lb$

MOMENT

$M_{AB} = 2741x \quad x$ $\qquad M_{BC} = -1500 \times (x - l - a)$

$= -1500x + 61500$

DISPLACEMENT:

AT END OF BEAM $\quad y_c = -\frac{F a^2}{3EI}(l + a) = \frac{1500 \times 26.5^2}{3 \times 29 \times 10^6 \times 1.69} \times 41 = 0.29''$

AT $x = 7''$ (WHERE IT IS MOST LIKELY TO INTERFERE WITH OTHE BEAM)

$$y = \frac{F a x\, x}{6EIl}(l^2 - x^2) = \frac{1500 \times 26.5 \times 7}{6 \times 29 \times 10^6 \times 1.69 \times 14.5}(14.5^2 - 7^2)$$

$= 0.01'' \ll 1/16$ GAP

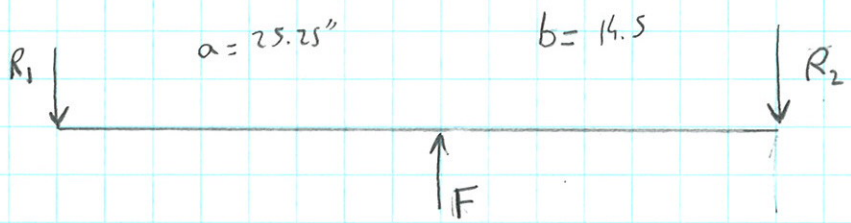
THERE IS NO INTERFERENCE EXCEPT AT BUSHINGS

MAX STRESS IN BEAM (USING EQUATION 3-26B FROM SHIGLEY, PAGE 90)

$$\sigma_{MAX} = \frac{M_B}{S} = \frac{2741 \times 14.5}{1.35} = 29440\ PSI$$

RESULT MATCHES FEA

NOW WE CONSIDER BEAM 1, USING RESULTING FORCE FROM BEAM 2 CALCULATIONS




ASSUMING SIMPLE SUPPORTS

EQUATIONS FROM SHIGLEY'S PAGE 1015

$X_A = 0$ $\quad X_B = 25.25$ $\quad X_C = 39.75" = l$

$F = 4241$ lb (FROM CALCULATIONS ON BEAM 2)

MAXIMUM MOMENT IS AT $X_B$

$$M_B = \frac{F b x}{l} = \frac{4241 \times 14.5 \times 25.25}{39.75} = 39062 \text{ lb.in}$$

MAXIMUM STRESS

$$\sigma_{MAX} = \frac{M_B}{S} = \frac{39062}{1.73} = 22579 \text{ PSI}$$

RESULT MATCHES FEA

CONCLUSION: STRESS IN BEAM 2 IS CLOSE TO YS

STRESS IN BEAM 1 IS MUCH LOWER THAN YS

BEARINGS MUST BE DESIGNED TO HANDLE RESULTING FORCES

ASSUMING LOAD IS APPLIED AT 45° FROM VERTICAL, TOWARD BACK OR FRONT OF BOAT

MOMENT OF INERTIA DOES NOT CHANGE BECAUSE IT'S A SQUARE SECTION

SECTION MODULUS CHANGES:

$$S = \frac{I}{C} \qquad (C \text{ IS MAX DISTANCE FROM CENTER})$$

BEAM 1: - $S = 2.6 / 1.366 = 1.32\ in^3$

BEAM 2 $S = 1.69 / 1.56 = 1.08\ in^3$

C CALCUTED IN SOLIDWORKS SKETCHES

MAX STRESS IN BEAM 2:

FROM PAGE 2

$$\sigma_{MAX} = \frac{M_B}{S} = \frac{2741 \times 14.5}{1.08} = 36800\ PSI$$

RESULT

MAX STRESS IN BEAM 1:

$$\sigma_{MAX} = \frac{M_B}{S} = \frac{39062}{1.32} = 29592\ PSI$$

FROM PAGE 3

CONCLUSION: STRESS IN BEAM2 IS AT YS AT 45° LOAD

POSSIBLE SOLUTIONS: - INCREASE WALL THICKNESS OF BEAM 2 TO 5/16"

- REDUCE MAXIMUM DESIGN LOAD AT 45°
- DETERMINE THAT YS IS GREATER THAN 36800 PSI