NWA MANNED PLATFORM: STRUCTURAL ANALYSIS

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D0 ENGINEERING NOTE

3740.522-EN-400

The manned platform in question was in-house built at DAB. It consists of four 100" channel beams that were welded to make two 4"x3.4" rectangular beams 5/16" thick. The platform is to be attached to an existing building crane and will support a load (person) up to 1000 lbs. (500 lbs. per beam). The platform will be bolted to the crane at four points along the beams length (A_1, A_2, B_1, B_2; refer to calculation pages). Since each beam has four reaction supports which are indeterminate, it is assumed that reaction forces A_1 and B_1 are approximately equal to A_2 and B_2, respectively. Since the two beams, the personal fall arrest bar, the plywood floor, and the bolts which will be used to attach the platform to the crane are the only load carrying members, they will be the only ones analyzed in this note. Reaction forces were found to be (refer to drawing/calculations): $A_1=A_2=456$ lb., $B_1=B_2=207$ lb. As the calculations in the following pages will show, a maximum absolute stress (bending plus shear stress) of 4320 psi. occurs at point A_1 in the beam. The platform was constructed of 6061-T6 aluminum which has a yield stress of 40 ksi (safety factor of 9.25) . The "personal fall arrest" bar was constructed of 6061-T6511 aluminum which also has a yield stress of 40 ksi. The maximum stress found in this member was 9543 psi (safety factor of 4.2). This exceeds the minimum required factor of safety of 2 as stated in OSHA standard 1910.66 App. C. The bolts used were 3/4" dia., grade 8 for points A_1 and A_2 and 3/8" dia., grade 8 for points B_1 and B_2. Both size bolts have a yield stress of 130 ksi. The 3/4" bolts saw a maximum stress of 1035 psi. (safety factor of 126). The 3/8" bolts saw a maximum stress of 1874 psi. (safety factor of 69). The last member analyzed in this note is the 3/4" plywood which will make up the floor of the platform. Maximum stress for the plywood was 220 psi. Since OSHA code states that all timber carrying members of the platform shall have a minimum stress grade of 1500 f., 6.8 is a minimum factor of safety for the plywood floor. According to these calculations, the manned platform is found to be structurally safe, well within the required factors of safety, and in compliance with OSHA standard 1910.28 (ANSI A10.8-1969, Safety Requirements for Scaffolding).

SUMMARY:

YIELD STRESS:
6061-T6,T6511 ALUMINUM= 40 KSI.
1500 f. PLYWOOD= 1500 PSI.

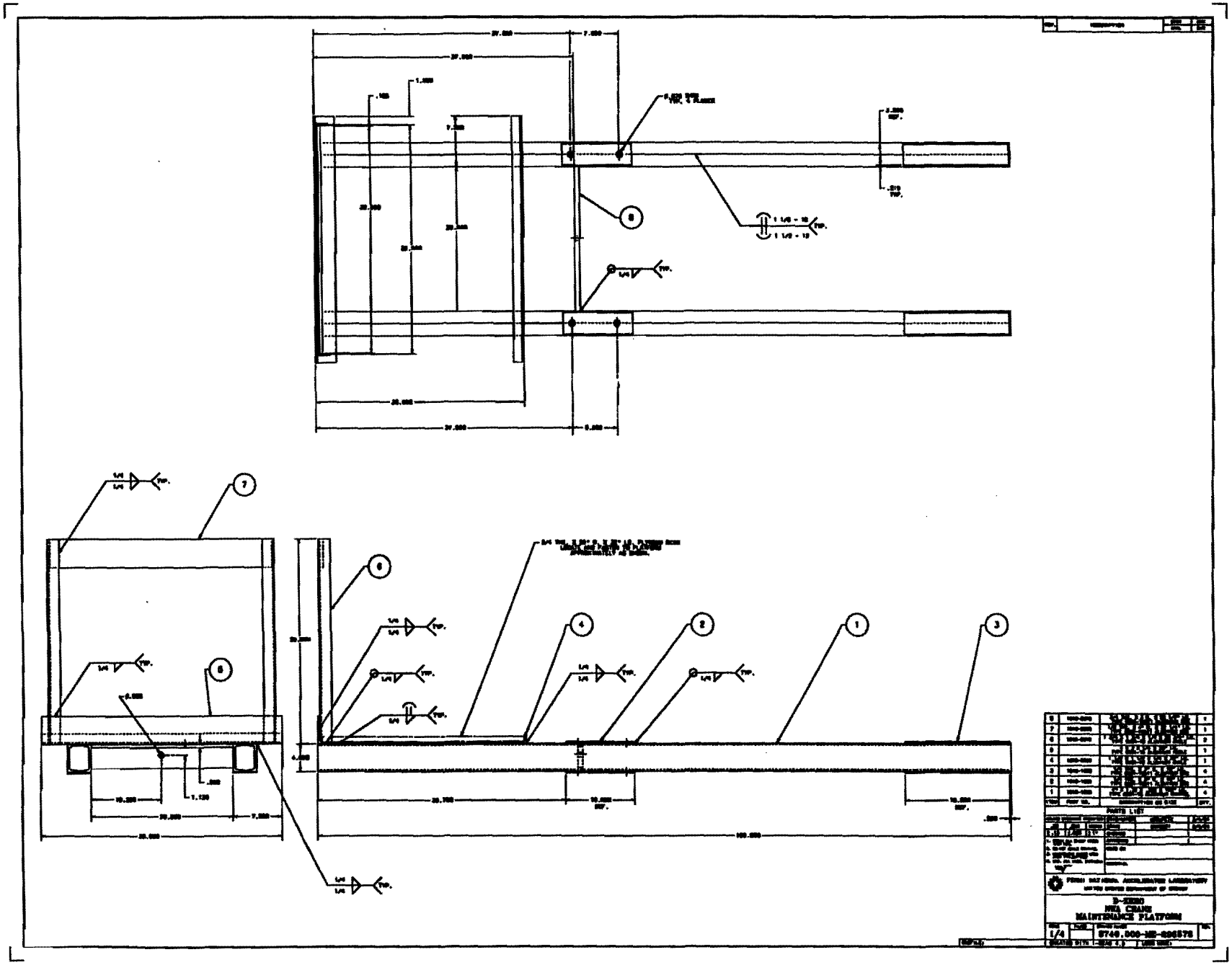
MAX LOAD=1000 LBS (500 LBS. EACH BEAM)
A_1=A_2=456 LB., B_1=B_2=207 LB.

BEAMS:
MAX. STRESS=4320 PSI., FACTOR OF SAFETY= 9.25

PERSONAL FALL ARREST BAR:
MAX. STRESS=9543 PSI, FACTOR OF SAFETY= 4.2

PLYWOOD FLOOR:
MAX. STRESS= 220 PSI., FACTOR OF SAFETY= 6.8 (MIN.)

BOLTS:
MAX. STRESS=1035 PSI., FACTOR OF SAFETY=126 (3/4" BOLTS)
MAX. STRESS=1874 PSI., FACTOR OF SAFETY=69 (3/8" BOLTS)


PARTS LIST
D-ZERO
NMA CRANE
MAINTENANCE PLATFORM
8740.000-MD-000575

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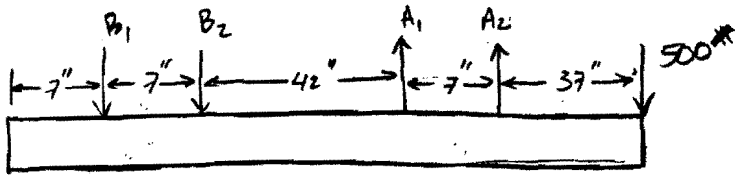
SECTION	PROJECT	SERIAL-CATEGORY	PAGE

SUBJECT

4" x 3.4" BEAMS

NAME

DATE | REVISION DATE



Assume: $A_1 \approx A_2$

$B_1 \approx B_2$

ΣF_y: $A_1 + A_2 - B_1 - B_2 = 500$

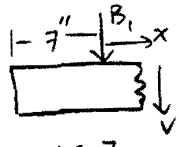
$2A_1 - 2B_1 = 500$

ΣM_{B_1}: $7B_2 + 93(500) - 49A_1 - 56A_2 = 0$

$-105A_1 + 7B_2 = -46{,}500$

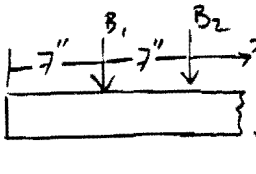
$A_1 = A_2 = 456^{\#}$

$B_1 = B_2 = 207^{\#}$



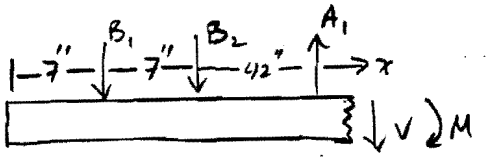
$0 \le x \le 7$

$V = -B_1 = -207^{\#}$ $\quad M = B_1 x^{7} = 207(7) = 1450$ lb-in



$V = -(B_1 + B_2) = -414^{\#}$ $\quad M = B_2 x^{7} + B_1(7 + x)^{7}$

$= 4347$ lb-in

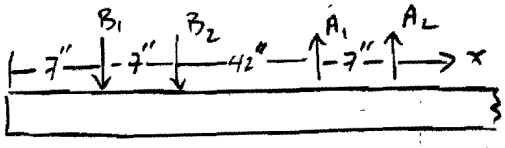


$V = A_1 - B_1 - B_2 = 43^{\#}$

$M = B_1(49 + x) + B_2(42 + x) - A_1 x$

$= 49B_1 + 42B_2 + (B_1 + B_2 - A_1)x^{0}$

$= \underline{18837 \text{ lb-in}}$



$V = A_1 + A_2 - B_1 - B_2 = 500^{\#}$

$M = B_1(56 + x) + B_2(49 + x) - A_1(7 + x) - A_2 x$

$= 56B_1 + 49B_2 - 7A_1 + (B_1 + B_2 - A_1 - A_2)x^{0}$

$= 18543$ lb-in

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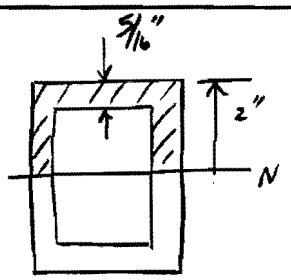
SECTION	PROJECT	SERIAL-CATEGORY	PAGE

SUBJECT: 4" x 3.4" BEAMS

NAME:

DATE:

REVISION DATE:



$$\tau = \frac{VQ}{It} \qquad Q = \bar{y}' A'$$

$$\bar{y}' = \frac{(1.84375)(3.4)(0.3125) + 2[(0.84375)(1.6875)(0.3125)]}{(3.4)(0.3125) + (1.6875)(0.3125)}$$

$\bar{y}' = 1.8\ in$
$A' = 1.59\ in^2$

$Q = (1.8\ in)(1.59\ in^2) = \underline{2.86\ in^3}$

$$\sigma_{MAX} = \frac{(18837\ lb\text{-}in)(2\ in)}{9.25\ in^4} = 4073\ psi$$

$$\tau_{MAX} = \frac{(500\ lb)(2.86\ in^3)}{(9.25\ in^4)(0.625\ in)} = 247\ psi$$

$$\sigma_{MAX_{ABS}} = 4073 + 247 = \underline{4320\ psi}$$

$$F.S. = \frac{40{,}000}{4320} = \underline{9.25}$$

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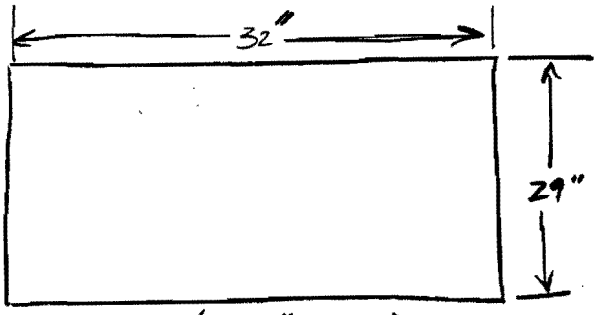
SECTION	PROJECT	SERIAL-CATEGORY	PAGE

SUBJECT: PLYWOOD ANALYSIS

NAME:

DATE: REVISION DATE:

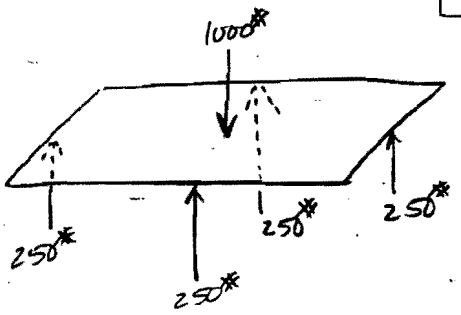


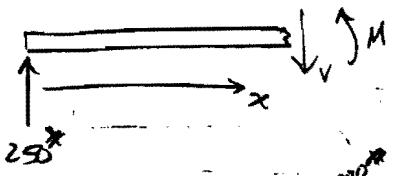
(3/4" THICK)

$\sigma = \frac{Mc}{KI}$ ⟹ FROM MARK'S STANDARD HNDBK. FOR MECHANICAL ENGINEERS (pg. 6-136)

where $K = 1.50$, $I = 4.959\ in^4$, $C = 3/8"$

↑ FROM TABLE 7 OF ABOVE REFERENCE.



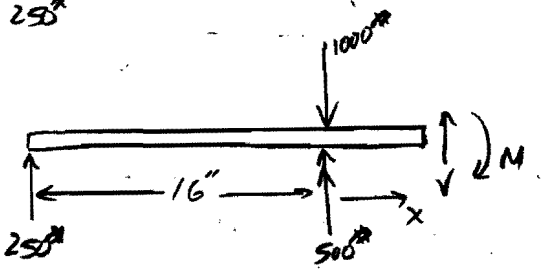


$V = 250\#$

$M = 250(16) = 4000\ lb\text{-}in$

$\sigma = \frac{(4000\ lb\text{-}in)(3/8\ in)}{1.5\,(4.959\ in^4)}$

$\sigma = 200\ psi$



$V = 1000 - 750 = 250\#$

$M = (1000-500)(x) - 250(16+x)$

$= -4000 + 250x$

$\sigma_{max} = \underline{200\ psi}$

$\tau_{max} = 1.5\frac{V}{A} = \frac{1.5(250)}{21.75\ in^2} = \underline{17\ psi}$

FACTOR OF SAFETY $= \frac{1500}{220} = \underline{6.8}$

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SECTION	PROJECT	SERIAL-CATEGORY	PAGE

SUBJECT: "PERSONAL FALL ARREST" BAR ANALYSIS

NAME:

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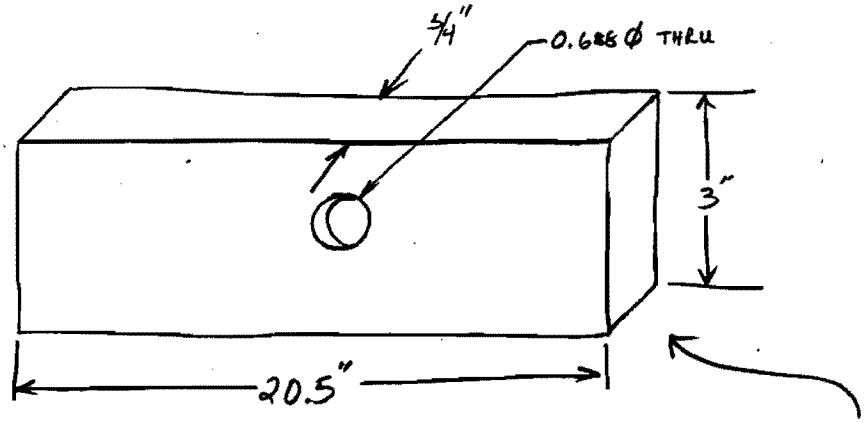
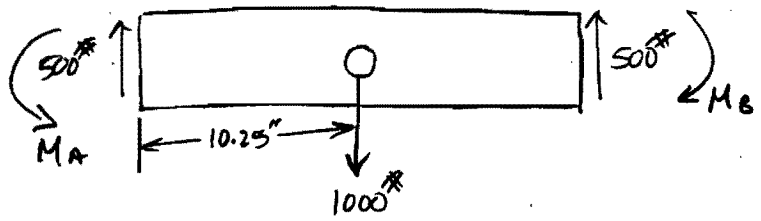
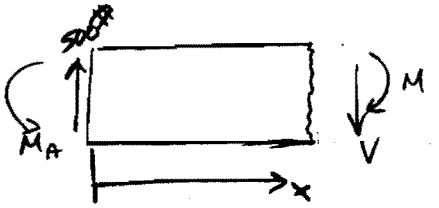


$I = \frac{1}{12}(0.75)(3^3) = 1.6875\ in^4$



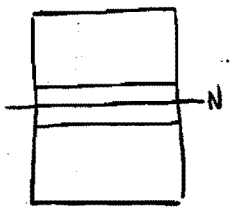
$M_A = M_B = 10250\ lb\text{-}in$



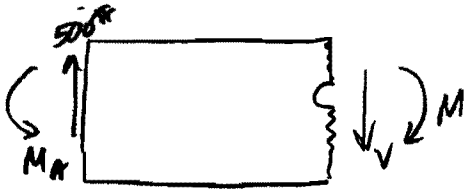
$V = 500\#$

$M = M_A - 500x$

$\sigma_{max} = \frac{(10250\ lb\text{-}in)(1.5\ in)}{1.6875\ in^4} = 9110\ psi$



$I = 1.6875 - \frac{1}{12}(0.75)(0.688^3) = 1.6671\ in^4$



$V = 500\#$

$M = M_A - 500(10.25) = 5125\ lb\text{-}in$

$\sigma = \frac{(5125)(1.5)}{1.6671} = 4610\ psi$

$\tau_{max} = 1.5\frac{V}{A} = \frac{1.5(500)}{3/4(3-0.688)} = 432\ psi$

$\sigma_{max} = 9543\ psi$

FACTOR OF SAFETY $= \frac{40000}{9543} = 4.2$

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SECTION	PROJECT	SERIAL-CATEGORY	PAGE

SUBJECT: 3/4" & 3/8" BOLTS

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3/4" BOLTS (USED AT POINTS A_1 & A_2):

$A = \pi (0.75^2)/4 = 0.4418\ in^2$

$F = 457\#$

$\sigma_{MAX} = \frac{457\ lb}{0.4418\ in^2} = \underline{1035\ psi}$

$F.S. = \frac{130000}{1035} = \underline{126}$

3/8" BOLTS (USED AT POINTS B_1 & B_2):

$F = 207\#$

$A = \pi (0.375^2)/4 = 0.11045\ in^2$

$\sigma_{MAX} = \frac{207\ lb.}{0.1105\ in^2} = \underline{1874\ psi}$

$F.S. = \frac{130000}{1874} = \underline{69}$