Fermilab

Particle Physics Division
Mechanical Department Engineering Note

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Project Internal Reference:

Project: NOVA

Title: IPND Lifting Fixture Stresses-Frame Leg C

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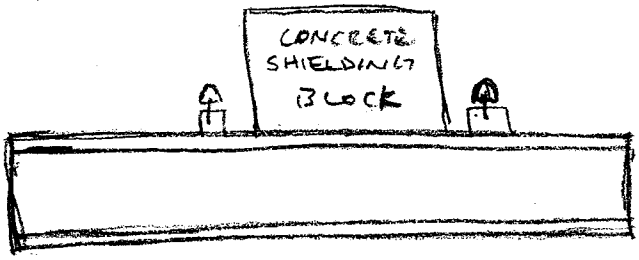
Key Words: IPND, NOVA

Abstract Summary: This engineering note determines the stresses present in Frame Leg C of the NOVA-Detector Prototype IPND Lifting Fixture subassembly. The reactions at each of the lifting points are determined as well as the stresses that are present in the bolts used to lift the fixture.

Applicable Codes:



IN8X10
$I = 30.8\ in^4$

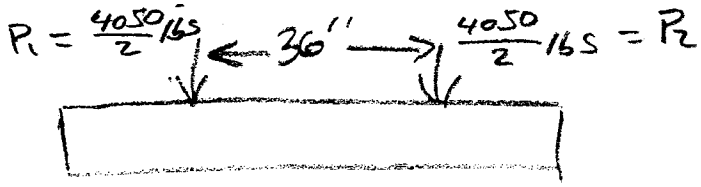
ASTM-A36 STEEL
$E = 29 \times 10^6$ psi

TOTAL WEIGHT OF THE BLOCK
8100 lbs

THE TOTAL WEIGHT OF THE BLOCK IS EVENLY DISTRIBUTED OVER THE TWO BEAMS (LEG FRAME C, LH AND RH)

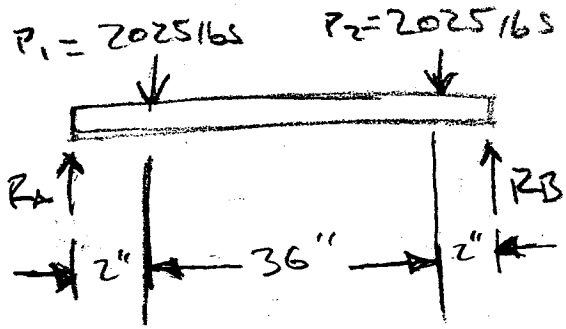
→ WT OF BLOCK PER BEAM:
4050 lbs.

THIS WEIGHT IS SUBSEQUENTLY DIVIDED INTO TWO EQUAL PARTS THAT ARE APPLIED AT THE EDGE OF THE BLOCK.



EACH BEAM IS SUPPORTED ON EACH SIDE BY A SWIVEL EYE/HOIST RING, WITH A ½-13 BOLT SECURING IT TO A BLOCK 2" FROM EACH EDGE OF THE BLOCK.

FREE BODY DIAGRAM OF BEAM:



FOR P_1,

$$R_{A,1} = \frac{W}{L}(L-a_1) = \frac{2025\text{ lbs}}{40''}(40''-2'') = 1923.75\text{ lbs}$$

$$R_{B,1} = \frac{Wa_1}{L} = \frac{(2025\text{ lbs})(2'')}{40''} = 101.25\text{ lbs}$$

FOR P_2

$$R_{A,2} = \frac{W}{L}(L-a_2) = \frac{2025\text{ lbs}}{40''}(40''-38'') = 101.25$$

$$R_{B,2} = \frac{Wa_2}{L} = \frac{(2025\text{ lbs})(38'')}{40''} = 1923.75$$

$$R_A = R_{A,1} + R_{A,2} = 2025\text{ lbs}$$

$$R_B = R_{B,1} + R_{B,2} = 2025\text{ lbs}$$

MAX. DEFLECTION

$$\delta_{MAX} = -\frac{Pa}{24EI}(3L^2-4a^2)$$

$$\delta_{MAX} = -\frac{(2025\text{ lbs})(2'')}{24(29\times10^6\text{ psi})(30.8\text{ in}^4)}(3(40'')^2-4(2'')^2)$$

$$\delta_{MAX} = 0.000904''$$

BEAM ANGLE AT A AND B

$$\theta_A = \theta_B$$

$$\theta_A = \frac{P}{2EI}(aL-a^2-x^2), \text{ WHERE } x=0$$

$$\theta_A = \frac{-2025\text{ lbs}}{2(29\times10^6\text{ psi})(30.8\text{ in}^4)}((2'')(40'')-(2'')^2-(0'')^2)$$

$$\theta_A = -0.000086\text{ rad.}$$

FASTENER SPECIFICATIONS

THE BOLTS USED TO CONNECT THE HOIST RINGS TO THE BLOCKS ON THE BEAM ARE ASSUMED TO BE A325/GRADE 5 BOLTS.

ACCORDING TO THE MANUAL OF STEEL CONSTRUCTION, NINTH ED., THE MAXIMUM ALLOWABLE TENSION FOR A325 BOLTS IS 44.0 ksi.

FOR TENSION IN THE BOLT:

$$\sigma = \frac{P}{A}, \quad \sigma = \text{TENSION}$$

P = FORCE ACTING ON THE BOLT

A = AREA OF THE BOLT

$$\sigma = \frac{2025 \text{ lbs}}{\left(\pi\left(\frac{.5''}{2}\right)^2\right)}$$

$$\sigma = 10{,}313 \text{ lbs/in}^2 \quad \text{OR } 10.313 \text{ ksi}$$

THE VALUE FOR TENSION FALLS WITHIN THE RANGE OF ACCEPTABLE VALUES.

BASED ON THE METHOD USED TO LIFT THE FIXTURE (VERTICAL LIFTING), SHEAR WILL NOT BE A FACTOR.