Fermilab

Particle Physics Division

Mechanical Department Engineering Note

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Title: E-906 Station 1 Support Structure

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Key Words:

Abstract/Summary:
These calculations are to show that the E-906 station 1 support structure meets to AISC code.

Applicable Codes:

AISC, Manual of Steel Construction, 9th Edition

E096 Station 1 Support Structure
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The E906 Station 1 support structure is a pair of cantilevered beams each taking 1/2 of the load. Estimates for the load were not firm, but around 1500 lbs. For these calculations use 4000 lbs. The cantilevered beams are WF 8 by 24 lb/ft. The cantilever length is 72 inches. Assume that in the worst case all of the load is concentrated at the end of the beam 9Case 22, page 2-303 of the AISC Manual of Construction).

$l := 72 \cdot in$ Length of the cantilever

$P := 4000 \cdot \frac{lb}{2}$ Weight of the load divided by two beams

$M := l \cdot P$

$M = 1.44 \times 10^{5}\ in \cdot lb$

For a W8 by 24 beam S=20.9 cubic inches

$S := 20.9 \cdot in^{3}$

$\sigma := \frac{M}{S}$ Bending stress in the beam

$\sigma = 6.89 \times 10^{3}\ \frac{lb}{in^{2}}$

For A-36 steel the allowable stress is 0.66*Fy = 23,800 psi. Since the bending stress in the beams is less the beams are OK.

The beams are seeing a torque about the mounting point nearest the edge of the magnet equal to the moment calculated above The short beam is welded to the long bean with a 1/4inch Vee grove weld on each side of the beams and the weld to the magnet is a 1/4 inch fillet weld on each side of the short beam to the magnet iron. Now find the amount of weld needed.

The upward force on the beam is:

$F := \frac{M}{24 \cdot in}$

$F = 6 \times 10^{3}\ lb$

Use E70 rod and choose the allowable stress in the weld to be only 20,000 psi.

$$psi := \frac{lb}{in^2}$$

$$tw := \frac{.25 \cdot in}{\sqrt{2}}$$ Weld throat measurement

$$Aw := \frac{F}{20000psi}$$

$Aw = 0.3\,in^2$ Area of weld required

$$lw := \frac{Aw}{tw}$$

$lw = 1.697\,in$ Length of weld required

To weld the beams together and to the magnet use a 6 inch long bead across the ends of the two beams and two 3 inch long beads on each side of the beams on each end of the 2 foot long pieces. This is many times the 1.7 inches of weld required.

The last area to check is the bending in one of the aluminum beams. The I-beams are American Standard 8 inches deep by 4 inch flange width, weighing 6.35 lb/in. The beams have a S=14.39 inches cubed. From the drawing we can use Case 9, page 2-298 for a simple beam with two equal concentrated loads symetrically placed.

For this calculation assume that the object to be held weighs 2000 lbs.

$$P := \frac{2000 \cdot lb}{2}$$ The load is supported on the beam with two hangers

$$a := \frac{118 \cdot in - 60 \cdot in}{2}$$

$Mmax := P \cdot a$

$Mmax = 2.9 \times 10^4\,in \cdot lb$

$$\sigma alumbend := \frac{Mmax}{14.39 \cdot in^3}$$

$\sigma alumbend = 2.015 \times 10^3\,psi$

For 6061-T6 material the allowable stress should be 10000 psi. The stress in bending for these beams is less by a factor of five, so the beams are OK.