Title
MAGNET CORE: POLE TIP ASSEMBLY SEISMIC BRACING

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**MAGNET CORE**

**POLE TIP ASSEMBLY SEISMIC BRACING**

The purpose of this note is to determine stresses and safety factors within members of the pole tip assembly seismic bracing under earthquake load conditions. These braces must be able to withstand forces resulting from the horizontal acceleration of the pole tip assembly. Vertical acceleration is taken care of by the pole tip positioning mechanism.

Three horizontal directions of ground acceleration are considered. For each case, resultant loads and safety factors within the members are determined. Page 4 shows the three cases of ground acceleration and the force diagram upon which calculations are based. Detailed calculations for one case are shown. Calculation results for all cases are tabulated on.

**REV A** Added check on brace attachment pages 8-9. For joint "E" have to use socket head shoulder screw. See page 9.
CASE I \( \cdot 7G \rightarrow \) CASE II \( \cdot 7G \uparrow \) CASE III \( \cdot 7G \downarrow \) 

THREE CASES OF GROUND ACCELERATION RELATIVE TO STRUCTURE ABOVE.
POLE TIP ASSY. 131,000 LBS

POLE TIP POSITIONING MECHANISM

SUPPORT STRUCTURE

SUPPORT STRUCTURE AND POLE TIP ASSEMBLY.

SIDE ELEVATION VIEW
**VIEW A - UPPER SEISMIC BRACE**

POLE TIP

SYM. C

131,000 LBS.

SEISMIC BRACE

HEX FRAME

**VIEW B - LOWER SEISMIC BRACE**

51° TYP.

63.94"

47.8" TYP.

44.25" TYP.

82.75" TYP.

40.62" TYP.

49° TYP.

41° TYP.

35.16" TYP.

44° TYP.

44.25° TYP.

51° TYP.

62.75"

82.75" TYP.
CASE I  UPPER BRACE

ON POLE TIP  \[ F_H = MA = 131,000 \text{ lb} \times 0.7 \text{g} = 88 \text{ k} \]

FORCE OF POLE TIP ON BRACE = \[ \frac{88 \text{k}}{2} = 44 \text{ kip} \]

\[ F_3 + F_5 = -44 \text{k} \]

BY COMPARING FORCES AT JOINT A & B,

\[ F_3 = F_5 = \frac{-44}{2} = -22 \text{k} \]

\[ \leq F_V = MA = 0 \quad \therefore F_4 + F_6 = 0 \]

\[ \leq M_{C4} = 0 \quad \therefore F_4 = F_6 = 0 \]

ON BRACE  \[ \leq F_H = 0 \quad \therefore F_1 + F_7 + F_3 + F_5 = 0 \]

\[ F_1 + F_7 = 44 \text{k} \]

\[ \leq F_V = 0 \quad \therefore F_4 + F_6 + F_2 + F_8 = 0 \]

\[ F_2 + F_8 = 0 \]

\[ \leq M_D = 0 \quad \therefore F_2 (82.75 \times 2) = (47.6 \times F_3 + F_5) \]

\[ F_2 = -12.7 \text{k} \]

\[ F_8 = +12.7 \text{k} \]

\[ \leq F_A = 0 \quad \therefore f_{H1} (\cos 44^\circ) + F_4 = (\cos 44\frac{1}{2}^\circ) f_q \]

\[ f_{H1} = 0.719 \quad f_q = 0.992 \quad f_{H1} = 0.713 \quad f_{H2} = 0.992 \]

\[ f_{H1} (\sin 44^\circ) + f_A (\sin 44\frac{1}{2}^\circ) + F_3 = 0 \]

\[ (0.719 \times 0.992) (\sin 44^\circ) f_A = 0.701 \]

\[ f_A = 15.83 \text{k} \]

\[ f_{H2} = 0.992 (15.83 \text{k}) = 15.7 \text{k} \]

\[ \leq F_B = 0 \quad \therefore f_{H1} (\cos 44^\circ) = F_6 + f_{H2} (\cos 44\frac{1}{2}^\circ) \]

\[ f_{H1} = 0.719 \quad f_{H2} = 0.713 \quad f_{H1} (\cos 44\frac{1}{2}^\circ) = 15.83 \text{k} \]

\[ \leq F_E = 0 \quad \therefore f_{H1} (\cos 96^\circ) = F_6 + f_{H2} (\cos 96\frac{1}{2}^\circ) \]

\[ f_{H1} = 0.695 (15.71 \text{k}) = 10.92 \text{k} \]
\[ F_{o} = 0 \quad \therefore F_i = F_{10} + (\cos 45^\circ) F_2 = 10.92 + (0.707) (5.83) \]
\[ F_i = 22.01 \text{ k} \]

\[ F_f = 44 - F_i = 21.99 \text{ k} \]

**ALLOWABLE AXIAL LOADING.**

<table>
<thead>
<tr>
<th>MEMBER</th>
<th>MAX. ALLOWABLE (FROM RYERSON DATA BK, P. 198)</th>
<th>SAFETY FACTOR (OVER ALLOWABLE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AE</td>
<td>136 k</td>
<td>8.7</td>
</tr>
<tr>
<td>AC</td>
<td>122 k</td>
<td>8.3</td>
</tr>
<tr>
<td>EC</td>
<td>127 k</td>
<td>11.6</td>
</tr>
</tbody>
</table>

**WELD STRESSES - ALL WELDED JOINTS CONSIST OF AT LEAST 20" OF 3/8" FILLET WELD.**

\[ \text{MAX. WELD STRESS} = \frac{\text{MAX. LOAD}}{\text{AREA}} = \frac{15.83 \text{ k}}{2.0" \times 3/8"} \]
\[ = 1,260 \text{ psi} \]

\[ \text{SAFETY FACTOR} = \frac{\text{ALLOWABLE}}{\text{MAX. STRESS}} = \frac{9,200}{1,260} = 7.3 \]

**BENDING STRESS - MAX OCCURS AT JOINT OF MEMBERS AC AND EC.**

\[ \sigma_b = \frac{MC}{I} \quad M = 9" (F_1 + F_2) \]
\[ = 9" (22.0 - 12.7) = 83.7 \text{ k-in} \]
\[ = 83.7 \times \frac{12}{12} = 13.95 \text{ ksi} \]

\[ \sigma = 13.95 \text{ ksi} \]

\[ \text{SAFETY FACTOR} = \frac{\text{55 ksi U.L.}}{13.95 \text{ ksi}} = 3.9 \]
<table>
<thead>
<tr>
<th>ITEM</th>
<th>CASE I</th>
<th>CASE II</th>
<th>CASE III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UPPER</td>
<td>LOWER</td>
<td>UPPER</td>
</tr>
<tr>
<td>EXTERNAL FORCES (KIPS)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F1</td>
<td>22.0</td>
<td>22.0</td>
<td>-21.6</td>
</tr>
<tr>
<td>F2</td>
<td>-12.7</td>
<td>-12.7</td>
<td>22.0</td>
</tr>
<tr>
<td>F3</td>
<td>-22.0</td>
<td>-22.0</td>
<td>21.6</td>
</tr>
<tr>
<td>F4</td>
<td>0</td>
<td>0</td>
<td>-22.0</td>
</tr>
<tr>
<td>F5</td>
<td>-22.0</td>
<td>-22.0</td>
<td>-21.6</td>
</tr>
<tr>
<td>F6</td>
<td>0</td>
<td>0</td>
<td>-22.0</td>
</tr>
<tr>
<td>F7</td>
<td>22.0</td>
<td>22.0</td>
<td>21.6</td>
</tr>
<tr>
<td>F8</td>
<td>12.7</td>
<td>12.7</td>
<td>22.0</td>
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<tr>
<td>INTERNAL FORCES (KIPS)</td>
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<tr>
<td>F9</td>
<td>15.8</td>
<td>14.5</td>
<td>-30.9</td>
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<tr>
<td>F10</td>
<td>10.9</td>
<td>12.9</td>
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</tr>
<tr>
<td>F11</td>
<td>15.7</td>
<td>17.1</td>
<td>0</td>
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<tr>
<td>F12</td>
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<td>14.5</td>
<td>-30.9</td>
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<tr>
<td>AXIAL LOAD SAFETY FACTOR</td>
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<tr>
<td>MEMBER AE</td>
<td>8.7</td>
<td>7.7</td>
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<tr>
<td>AC</td>
<td>8.3</td>
<td>9.2</td>
<td>4.3</td>
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<tr>
<td>EC</td>
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<td>9.9</td>
<td>-</td>
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<tr>
<td>WELD STRESS</td>
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</tr>
<tr>
<td>PSI</td>
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<td>13.66</td>
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<tr>
<td>SAFETY FACTOR</td>
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<tr>
<td>BENDING STRESS</td>
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<td></td>
</tr>
<tr>
<td>PSI</td>
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<td>13.950</td>
<td>0</td>
</tr>
<tr>
<td>SAFETY FACTOR</td>
<td>3.9</td>
<td>3.9</td>
<td>-</td>
</tr>
</tbody>
</table>
PINS AT A, B, C, D

CHECK PIN SHEAR WORST CASE III UPPER

\[ F_1 = 32.8 \quad F_2 = 24.5 \quad F = \sqrt{32.8^2 + 24.5^2} = 40.9 \text{ kips} \]

SEISMIC BRACKET

PIN 1/4" DIA. COIL NOUNED 1018

\[ F_u = 69 \text{ kips} \]
\[ F_y = 54 \text{ kips} \]
\[ \tau_u = 0.5 \tau_{u} = 0.5(69) = 41.5 \text{ ksi} \]

\[ A = \frac{\pi d^2}{4} = \frac{3.14(1.5)^2}{4} = 1.76 \text{ in}^2 \]

DOUBLE SHEAR

\[ \tau = \frac{F}{2A} = \frac{40.9}{2(1.76)} = 11.6 \text{ ksi} \]

CHECK BOLTS A 307 1/4" UNC

DISC ALLOWABLE TENSION = \[ 1.33(19.8) = 26.33 \text{ ksi} \]

1/2 ALLOWABLE SHEAR = \[ 1.33(10) = 13.3 \text{ ksi} \]

MAX TENSION = \[ \frac{32.8 \times 3.25}{10} \frac{24.5}{6 \times 2 \text{ bolts}} = 9.7 \text{ kips} \]

OR \[ \frac{9.7 \text{ kips}}{0.606 \text{ in}^2} = 15.3 \text{ ksi} = \tau_u \]

SHEAR = \[ \frac{32.8 \times 3.25}{6 \times (0.55 \text{ in}^2)} = 10 \text{ kips} = F_v \]

COMBINING:

\[ \left( \frac{\tau}{F_v} \right)^2 + \left( \frac{N A}{F_u} \right)^2 \leq 1 \]

\[ \left( \frac{15.3}{26.33} \right)^2 + \left( \frac{10}{13.3} \right)^2 = 0.34 + 0.56 = 0.9 < 1 \text{ kips} \]
CHECK JOINT E  
WORST CASE  
17.1 k = \( f_{11} \)  
12.9 = \( f_{10} \)

20C.29%  
LOWER SEISMIC BRACE  
20C.296C  
UPPER SEISMIC BRACE

1" DIA  1/16 THICK PLATE  A36  
\( F_u = 58 \text{ ksi} \)  
\( F_y = 36 \text{ ksi} \)

For 1-8 UNC BOLT  \( A = 0.55 \text{ in}^2 \)  
Shear Stress = \( \frac{11.5 \text{k}}{0.55 \text{in}^2} = 20.9 \text{ ksi} \)

Allowable for A307 Bolt = 10 ksi  
FS = 4.6

SOCKET HEAD SHOULDER SCREW  
NOM 1" SHOULDER DIA  
Shear Strength [96 ksi]
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