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SUBJ: STAINLESS STEEL SUPPORT RODS
CAPACITY ANALYSIS
TENSION AND COMPRESSION

The support rods are 316 Stainless steel bars with 316 stainless steel clevis ends. The clevis ends are machined in sets with right hand threads on one end and left handed threads on the other end allowing for easy length adjustment by rotating the rod. The support rods may act in compression to resist wind uplift in accordance to the recommendations herein. The compression load capacity of the rods are a function of the rod length measured between rod ends and shall be limited to the loads shown herein for a given rod length.

The bar strength is calculated in accordance with SEI/ASCE 8-02 *Specification for the Design of Cold-Formed Stainless Steel Structural Members*. The rod strengths provided herein are calculated in accordance with the International Building Code, all versions and state buildings codes adopted there from.

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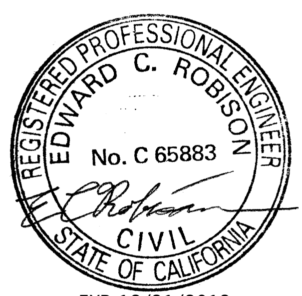

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Material:
316 Stainless steel annealed condition hot rolled bar.
Clevises are machined from solid bar stock

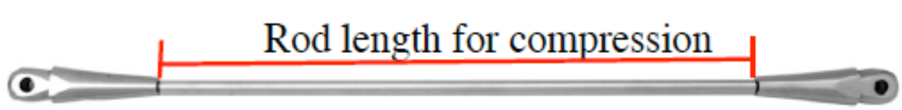
Yield strength of rods:
$F_{yt} \geq 30$ ksi (0.2% offset)
$F_{yc} = 28$ ksi
$E_o = 28.0 \text{ x} 10^3$ ksi

Tension strength in accordance with SEI/ASCE 8-02 section 3.2:
$\phi_t = 0.85$
$T_n = A_n F_y$
$T_u \leq \phi T_n$
A_n = net area at threads

Compression strength in accordance with SEI/ASCE 8-02 section 3.6.2
$\phi_c = 0.80$
$P_n = F_n A_e$
$F_n = \pi^2 E_t/(kL/r)^2 \leq F_y$
$A_e = \{1-[1-(E_t/E_o)2](1-A_o/A)\}A$
$A_o = K_c A = A$ for solid bar
A = area of full, unreduced cross section
Thus simplifying for solid bar:
$P_n = F_n A$

E_t is a function of the bar stress:
From SEI/ASCE 8-02 Table A10b:
<8 ksi: 1.0 E_o
=8 ksi: 0.99 E_o
=12 ksi: 0.97 E_o
=16 ksi: 0.92 E_o
= 20 ksi: 0.83 E_o
= 24 ksi: 0.71 E_o
= 28 ksi: 0.58 E_o

For initial check assume $E_t = 0.9 \, E_o = 0.9*28{,}000$ ksi = 25,200 ksi



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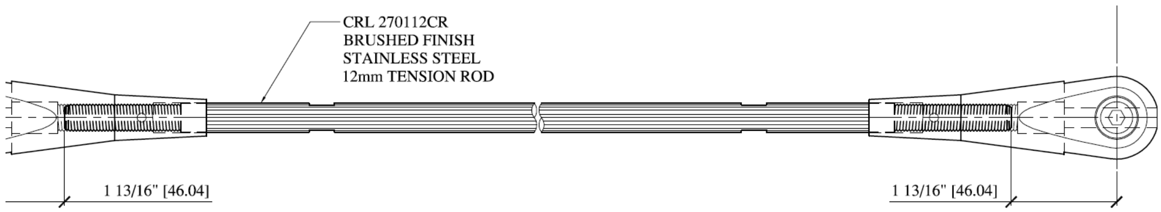
12mm Rod Strength

12mm stainless steel bars, 0.472" diameter.



For Tension strength:

$A_T = 0.1306\ in^2$

$T_u = 0.85*F_{yt}*A_T = 0.85*30ksi*0.1306in^2 = 3{,}330\#$

Tension Service load = $T_s = T_u/1.6$

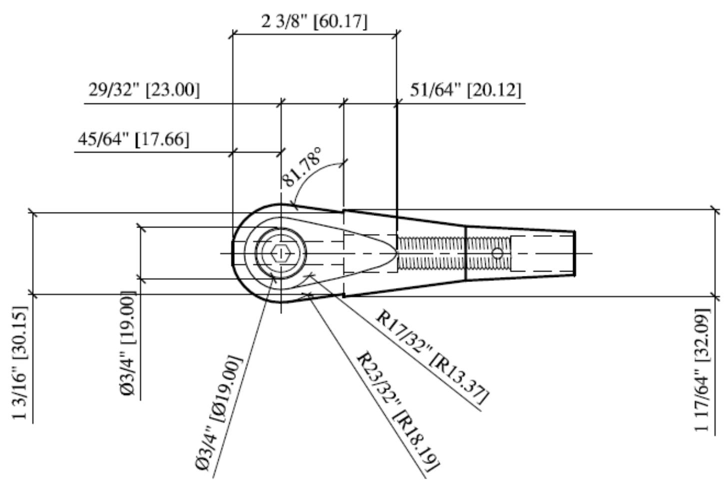
$T_s = 3{,}330/1.6 = 2{,}081\#$ Allowable tension load on 12mm bar

Verify clevis strength:

Tension strength of clevis at hole:

$A_n = 0.580\ in^2$ Total of four sections.

Clevis tension strength will exceed bar at hole.



Block shear at end of clevis:

Based on shear yielding of end at connection pin:

$A = 2*0.703*0.5156 = 0.725in^2$

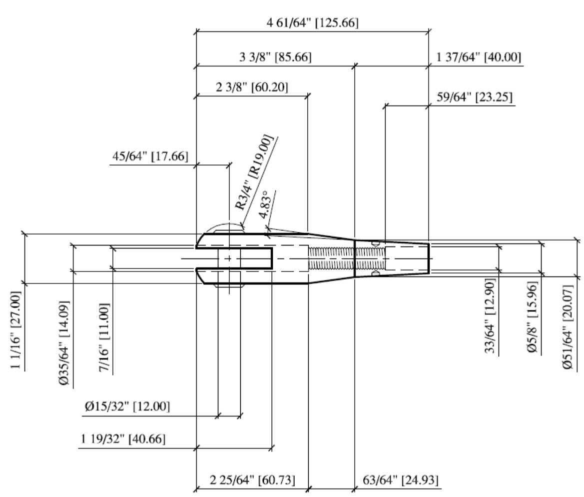
$R_n = 0.6F_yA$

$R_n = 0.6*30ksi*0.725 = 13\ k$

Tension strength of end at taper (minimum thread engagement depth)

$A = [(0.797/2)^2 - (0.472/2)^2]\pi = 0.324\ in^2$

End strength is greater than bar strength



Required thread length into bar end:

$A_{sc} = 0.747\ in^2/in$

$øR_n = 0.65*0.6F_yA_{sc}M$

Setting $øR_n = T_u$ and solving for embed depth M:

$M = 3{,}330/(0.65*.6*30{,}000*0.747) = 0.381"$

Requires a minimum of 6 threads into bar end.

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Strength of bar in compression:
Compression strength is a function of the square of the bar length:

$A_{bar} = (0.472/2)^2*\pi = 0.175$ in^2
r = d/4 = 0.472/4 = 0.118
k = 1.00 (side sway prevented)
kL/r = 1.0*L/0.118" = 8.4746 L
$F_n = \pi^2 E_t/(kL/r)^2$
$F_n = \pi^2 E_t/(8.4746L)^2 = 0.1374 E_t/L^2$

$P_n = A*F_n = 0.175*0.1374 E_t/L^2 = 0.02405*E_t/L^2$

$P_u = øP_n = 0.8* 0.02405*E_t/L^2 = 0.0192*E_t/L^2$

Bar length in	Est F_n ksi	Rev'd E_t	Rev'd F_n	P_u lbs	P_s lbs
20	8.66	28000	9.62	1344	840
30	3.85	28000	4.27	597	373
40	2.16	28000	2.40	336	210
50	1.38	28000	1.54	215	134
60	0.96	28000	1.07	149	93
70	0.707	28000	0.785	110	69
80	0.54	28000	0.60	84	53
90	0.427	28000	0.475	66	41

P_u = maximum factored compression load for the given rod length.
P_s = allowable compression load assuming all uplift is from wind load.
Linear interpolation of the table is allowed.

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16mm Rod Strength
16mm stainless steel bars, 0.630" diameter.

For Tension strength:
$A_T = 0.226\ in^2$
$T_u = 0.85*F_{yt}*A_T = 0.85*30ksi*0.226in^2 = 5{,}763\#$
Tension Service load = $T_s = T_u/1.6$
$T_s = 5{,}763/1.6 = 3{,}602\#$ Allowable tension load on 16mm bar

Clevis strength will exceed bar strength at all sections.

Required thread length into bar end:
$A_{sc} = 1.027\ in^2/in$
$øR_n = 0.65*0.6F_yA_{sc}M$
Setting $øR_n = T_u$ and solving for embed depth M:
M = 5,763/(0.65*.6*30,000*1.027) = 0.479"
Requires a minimum of 7 threads into bar end.

Strength of bar in compression:
Compression strength is a function of the square of the bar length:

$A_{bar} = (0.630/2)^2*\pi = 0.308\ in^2$
r = d/4 = 0.630/4 = 0.1575
k = 1.00 (side sway prevented)
kL/r = 1.0*L/0.1575" = 6.349 L
$F_n = \pi^2E_t/(kL/r)^2$
$F_n = \pi^2E_t/(6.349L)^2 = 0.2448E_t/L^2$

$P_n = A*F_n = 0.308*0.2448E_t/L^2 = 0.07541*E_t/L^2$
$P_u = øP_n = 0.8*0.07541*E_t/L^2 = 0.0603*E_t/L^2$

Bar length in	Est F_n ksi	Rev'd E_t	Rev'd F_n	P_u lbs	P_s lbs
40	3.86	28000	4.28	1055	660
60	1.71	28000	1.90	469	293
70	1.26	28000	1.40	345	215
80	0.96	28000	1.07	264	165
90	0.76	28000	0.85	208	130
100	0.62	28000	0.69	169	106
110	0.51	28000	0.57	140	87
120	0.43	28000	0.48	117	73

P_u = maximum factored compression load for the given rod length.
P_s = allowable compression load assuming all uplift is from wind load.
Linear interpolation of the table is allowed.

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20mm Rod Strength
20mm stainless steel bars, 0.787" diameter.

For Tension strength:
$A_T = 0.379 \text{ in}^2$
$T_u = 0.85*F_{yt}*A_T = 0.85*30\text{ksi}*0.379\text{in}^2 = 9{,}665\#$
Tension Service load = $T_s = T_u/1.6$
$T_s = 9{,}665/1.6 = 6{,}040\#$ Allowable tension load on 20mm bar

Clevis strength will exceed bar strength at all sections.

Required thread length into bar end:
$A_{sc} = 1.310 \text{ in}^2/\text{in}$
$øR_n = 0.65*0.6F_yA_{sc}M$
Setting $øR_n = T_u$ and solving for embed depth M:
$M = 9{,}665/(0.65*.6*30{,}000*1.310) = 0.631"$
Requires a minimum of 7 threads into bar end.

Strength of bar in compression:
Compression strength is a function of the square of the bar length:

$A_{bar} = (0.787/2)^2*\pi = 0.486 \text{ in}^2$
$r = d/4 = 0.787/4 = 0.1968$
k = 1.00 (side sway prevented)
$kL/r = 1.0*L/0.1968" = 5.0826\ L$
$F_n = \pi^2E_t/(kL/r)^2$
$F_n = \pi^2E_t/(5.0826L)^2 = 0.3821E_t/L^2$

$P_n = A*F_n = 0.486*0.3821E_t/L^2 = 0.1857*E_t/L^2$
$P_u = øP_n = 0.8*0.1857*E_t/L^2 = 0.1485*E_t/L^2$

Bar length in	Est F_n ksi	Rev'd E_t	Rev'd F_n	P_u lbs	P_s lbs
40	6.02	28000	6.69	2599	1624
60	2.67	28000	2.97	1155	722
80	1.50	28000	1.67	650	406
100	0.96	28000	1.07	416	260
120	0.67	28000	0.74	289	180
140	0.49	28000	0.55	212	133
160	0.38	28000	0.42	162	102
180	0.30	28000	0.33	128	80

P_u = maximum factored compression load for the given rod length.
P_s = allowable compression load assuming all uplift is from wind load.
Linear interpolation of the table is allowed.

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28mm Rod Strength
28mm stainless steel bars, 1.102" diameter.

For Tension strength:
$A_T = 0.763$ in^2
$T_u = 0.85*F_{yt}*A_T = 0.85*30\text{ksi}*0.763\text{in}^2 = 19{,}456\#$
Tension Service load = $T_s = T_u/1.6$
$T_s = 19{,}456/1.6 = 12{,}160\#$ Allowable tension load on 28mm bar

Clevis strength will exceed bar strength at all sections.

Required thread length into bar end:
$A_{sc} = 1.803$ in^2/in
$øR_n = 0.65*0.6F_yA_{sc}M$
Setting $øR_n = T_u$ and solving for embed depth M:
M = 19,456/(0.65*.6*30,000*1.803) = 0.922"
Requires a minimum of 8 threads into bar end.

Strength of bar in compression:
Compression strength is a function of the square of the bar length:

$A_{bar} = (1.102/2)^2*\pi = 0.9538$ in^2
r = d/4 = 1.102/4 = 0.2755
k = 1.00 (side sway prevented)
kL/r = 1.0*L/0.2755" = 3.630 L
$F_n = \pi^2E_t/(kL/r)^2$
$F_n = \pi^2E_t/(3.630L)^2 = 0.749E_t/L^2$

$P_n = A*F_n = 0.9538*0.749E_t/L^2 = 0.7145*E_t/L^2$
$P_u = øP_n = 0.8*0.7145*E_t/L^2 = 0.5716*E_t/L^2$

Bar length in	Est F_n ksi	Rev'd E_t	Rev'd F_n	P_u lbs	P_s lbs
40	11.80	27,160	12.71	9703	6064
80	2.95	28000	3.28	2501	1563
100	1.89	28000	2.10	1600	1000
125	1.21	28000	1.34	1024	640
150	0.84	28000	0.93	711	445
175	0.62	28000	0.68	523	327
200	0.47	28000	0.52	400	250
225	0.37	28000	0.41	316	198
250	0.30	28000	0.34	256	160

P_u = maximum factored compression load for the given rod length.
P_s = allowable compression load assuming all uplift is from wind load.
Linear interpolation of the table is allowed.

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Strength of bolt attaching clevis to plate:

3/8" bolts in double shear: For 12mm rod
SS bolts ASTM F593 AF
$A_v = 0.110$ in^2
$øV_n = 0.65*0.110*33.7$ksi$*2$ (double shear) = 4.8 k

7/16" bolts in double shear: For 12mm rod
SS bolts ASTM F593 AF
$A_v = 0.150$ in^2
$øV_n = 0.65*0.150*33.7$ksi$*2$ (double shear) = 6.6 k

1/2" bolts in double shear: For 16mm Rods
SS bolts ASTM F593 AF
$A_v = 0.1590$ in^2
$øV_n = 0.65*0.159*33.7$ksi$*2$ (double shear) = 6.97k

5/8" diameter in double shear: For 20mm rod
SS bolts ASTM F593 AF
$A_v = 0.2516$ in^2
$øV_n = 0.65*0.2516*33.7$ksi$*2$ (double shear) = 11k

3/4" diameter in double shear: For 20mm rod
SS bolts ASTM F593 AF
$A_v = 0.44$ in^2
$øV_n = 0.65*0.44*33.7$ksi$*2$ (double shear) = 19.3k

1" diameter in double shear: For 28mm rod
SS bolts ASTM F593 AF
$A_v = 0.785$ in^2
$øV_n = 0.65*0.785*33.7$ksi$*2$ (double shear) = 34.4k

Attachment plate shall be designed for the imposed loads.

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