WEAVER CONSTRUCTION MANAGEMENT, INC.
3679 S. Huron St., Suite 404
Englewood, CO 80110
Phone: (303) 789-4111 FAX: (303) 789-4310

SUBMITTAL TRANSMITAL

December 15, 2011
WCM Submittal No: 05500-005.B

PROJECT: **Harold Thompson Regional WRF**
Birdsall Rd.
Fountain, CO 80817
Job No. 2908

ENGINEER: **GMS, Inc.**
611 No. Weber St., #300
Colorado Springs, CO 80903
719-475-2935 Roger Sams

OWNER: **Lower Fountain Metropolitan Sewage Disposal District**
901 S. Santa Fe Ave.
Fountain, CO 80817
719-382-5303 James Heckman

CONTRACTOR: **Rocky Mountain Railings**
11839 E. 51st Ave.
Denver, CO 80239

SUBJECT: Resubmittal – RMR's letter of response to GMS's review of 05500-001.A – Load Testing and Structural Calculations.
Handrail for the Aeration Basin/Digester Structure, Clarifiers and Pumping and Disinfection Building.

SPEC SECTION: 05500 – Metal Fabrications
PREVIOUS SUBMISSION DATES: 11/28/11

DEVIATIONS FROM SPEC: ____ YES _X_ NO

CONTRACTOR'S STAMP: This submittal has been reviewed by WCM and approved with respect to the means, methods, techniques, & safety precautions & programs incidental thereto. Weaver General Construction also warrants that this submittal complies with contracted documents and comprises on deviations thereto:

Contractor's Stamp:	Engineer's Stamp:
Date: 12/15/11 Reviewed by: H.C. Myers (X) Reviewed Without Comments ( ) Reviewed With Comments	

ROCKY MOUNTAIN RAILINGS

December 15, 2011

Weaver Construction
3679 S. Huron St. Suite 404
Englewood, CO. 80110

Re: Harold D. Thompson R.W.R.F. & Lower Fountain Metro. S.D.D - R2027
Subject: Response Letter

This is Rocky Mountain Railings response to GSM. Inc's review comments,

Comment #1
GMS, Inc. is in receipt of the shop submittal identified as 05500-005 which was followed by Shop Submittal No. 05500-005A. Based upon our review of Submittal No. 05500-005A, this submittal supersedes the initial submittal of 05500-005. Therefore, the comments below apply to Submittal No. 05500-005A.

Response #1
Acknowledged

Comment #2
A certification from ATEC Associates, Inc. was provided for load testing of the aluminum handrail titled, TABCO 2500 CONSTRUCITON. The testing data was provided on February 7, 1986. We question whether the certification provided is applicable to this handrail and if there is data more current than 25-year old data. Several pages following the certification is a letter provided by Rocky Mountain Railings, Inc. stating as of January 1, 2007, they have changed the aluminum alloy being used for the Schedule 40 pipe. Since this change was instituted in January 2007, we question the validity of the certification letter prepared in 1986

Response #2
Attached is test data that was done on 8/12/2009 for another project that we worked on. The loads required per the specification are congruent.

Comment #3
We acknowledge the use of the aluminum alloy 6105-T5 and take no exception to the use of this material.

Response #3
Acknowledged

Comment #4
Reference is made to Marson stainless rivets in the shop submittal. No rivets are to be used in the fabrication and installation of the handrail system proposed for use at the LFMSDD HDTRWRF.

Response #4
No reference was made to said specific company and the mention of a blind rivet has been removed from the submittals.

Comment #5
H.B. Tenemecol: No Exceptions Taken

Response #5
Acknowledged

Comment #6
Hilti HIT-RE 500 epoxy adhesive anchoring system: No Exceptions Taken

Response #6
Acknowledged

Comment #7
Design calculations: No Exceptions Taken

Response #8
Acknowledged

Sincerely,
Danny Brown
Rocky Mountain Railings
dbrown@rockymountainrailings.com

LOADS TESTINGS AND

STRUCTURAL CALCULATIONS

FOR

GUARD RAILINGS

W.P.C.P. PHASE II DIGESTERS 12 13 14 15 & 16
SAN JOSE, CALIFORNIA

ROCKY MOUNTAIN RAILINGS
11939 EAST 51ST AVENUE
DENVER, COLORADO 80239

PROJECT NUMBER
R1376

COLORADO REGISTERED
ROY E. WOOTEN
7232
PROFESSIONAL ENGINEER
8/12/09

ROY E. WOOTEN and ASSOCIATES
• CONSULTING ENGINEERS •

7585 West Arkansas Avenue, Suite 206 - Lakewood, Colorado 80232 - Phone (303)980-8603 Fax (303)980-8647

ROY E. WOOTEN and ASSOCIATES

• Consulting Engineers • **wootenrp@aol.com**

7585 West Arkansas Avenue, Suite 206, Lakewood, CO 80232, Ph. (303)980-8603 Fax (303)980-8647

August 12, 2009

Mr. Scot Hooper
Rocky Mountain Railings
11939 East 51st Avenue
Denver, Colorado 80239

REFERENCE: RMR NO. R1376
SAN JOSE, CALIFORNIA

Dear Mr. Hooper,

At your request, full size tests were conducted on August 7, 2009 as required by the City of San Jose, California. The purpose of the tests is to verify the adequacy of rails, posts, fittings and bases associated with the subject project. The tests were conducted at the facilities of Reliance Industries, LLC, 10790 W. 50th Avenue, Wheat Ridge, Colorado 80033, specifically, lead engineer Daniel Adam in conjunction with you and me as coordinates and observers. The following tests were conducted with results tabulated:

1. **Post and Base Connections** – 1-1/2" Ø schedule 40, 6005-T5 with 12" standard stiffeners in 16E 5"x 5", four (4) hole base mounts with ½" Ø T 316 stainless steel machine bolts anchored to a W10 x 33 steel beam. Posts were spaced 12'-0 apart and loads applied with a calibrated hydraulic ram system. Ram was supported on a pipe to minimize the dead load influence to the system. Deflections were measured to the nearest 1/16" and compared with calculated deflections assuming a fixed base condition. Measure deflections at all loads, i.e., 200 lb., 250 lb., and 300 lb. were 2 + times greater than calculated loads as would be expected due to minor looseness in pipe-to-base mount fitting. Also some rotation of the fitting occurs as load is applied and the base collar and ½" plate deflects due to bolt spacing, 3-1/2" x 3-1/2". See 16E drawing sketches.

2. **Post and Base Connections** – West post is 1-1/2" Ø schedule 80 in 16 H 5" x 8" four (4) bolt base; East post is unstiffened 1-1/2"Ø schedule 40 in 2-5/8" x 7" 2-bolt 11C base. Posts are spaced 12'-6 o.c. and bases anchored to the W10 x 33 beam with 1/2" Ø T 316 stainless steel machine bolts. Anchor bolt spacing of 16H base is 6-1/4" x 3-1/2"; Bolt spacing of 11C base is 4-3/8". Hydraulic ram is supported on pipe to negate dead load influence. Loads of 200 lbs, 250 lbs, and 300 lbs. were applied and overall lengths of deflected posts measured and individual post deflection calculated by inverse I ratio. These proportioned measured deflections were compared to fixed base calculated deflections. Measured proportioned deflections were 2-3/4 + times calculated deflection for Schedule 80 posts, all loads and 2-

3/4 +/- for 200 lb. and 250 lb. load on Schedule 40 post. At 300 lbs., Schedule 40 post measured deflection jumped to 3-3/8 times calculated. The 11C base fitting went from elastic stress range into plastic and ¼" measured permanent base plate deformation was measured. The increased measured deflection of both posts and bases is probably due to the winder bolt spacing allowing more rotation of the ½" thick base plate/collar sections as compared to Test 1.

3. **Continuous Top Rail Splice/Expansion Joint Connection** – Top rail is 1-1/2" Ø Sch 40, 6005 TS connected to four 1-1/2" Ø posts, 3 spaces at 6'-0 o.c. and 8" overhang each end. West rail length is 12"-2 and east rail length is 7'-2. Splice/expansion joint is standard 6" from east mid post. Test loads of 300 plus pounds are applied to middle 6'-0 span at 6", 1'-6, 2'-6, 3'-6, 4'-6 and 5'-6 from west mid post. Center deflection was measured to nearest 1/16" as each load was recorded and visual inspection of the splice/expansion joint to check for displacement. Only visual displacement was observed at 340 lb. load applied just west of joint, i.e., 5'- 5-7/8". Splice joint flat head #20 screws removed from west side to form expansion joint condition then reloaded to 340 lb. Maximum vertical displacement was less than 1/64" visually, approximately the fit differential between the ID of the rail and the OD of the fitting, i.e., 1.610" vs 1.596".

In summary, the results of the tests substantiate the calculated performance of the products, rails, posts, fittings, anchorages, connectors, etc., of the Rocky Mountain Railing System for the San Jose, California W.P.C.P., Phase II Project, Job No. R1376. We did not test post installed concrete anchors since these are special proprietary products requiring ICC testing and approval for each Supplier's systems. Base mount 11C is not part of the San Jose package but was tested to check the calculated performance.

Since both, 16E and 16H, four (4) bolts base mount fittings are being considered for the project and both previously submitted for review and comment, the final acceptance will be by the City of San Jose personnel individual preference. Both are adequate. Actual field deflections will be less than those measured since global geometry, i.e., used on circular tanks, will allow deflections to be resisted by axial tension or compression of the top rail system.

Let me know if any clarification or additional backup data is requested.

Very truly yours,

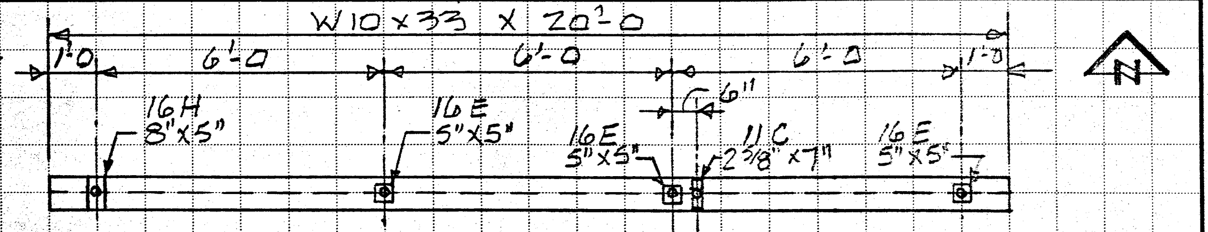
Roy E. Wooten, P.E.

COLORADO REGISTERED
ROY E. WOOTEN
7232
PROFESSIONAL ENGINEER

Attachments

ROY E. WOOTEN AND ASSOCIATES
Consulting Engineers
7585 W. Arkansas Ave., #206
Lakewood, Colorado 80232
(303) 980-8603

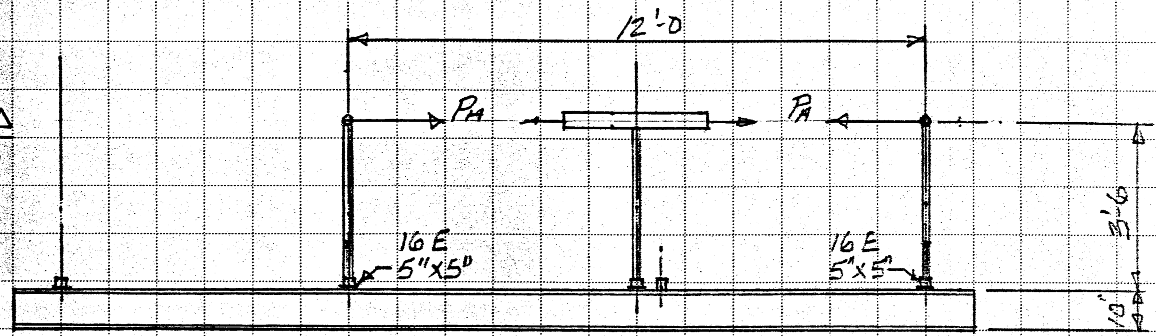
JOB RMR No, R1376, San Jose, CA 20941
SHEET NO. 1 OF 1
CALCULATED BY REW DATE 08/11/09
CHECKED BY DATE
SCALE 1/4" = 1'-0



TOP VIEW

TEST No 1

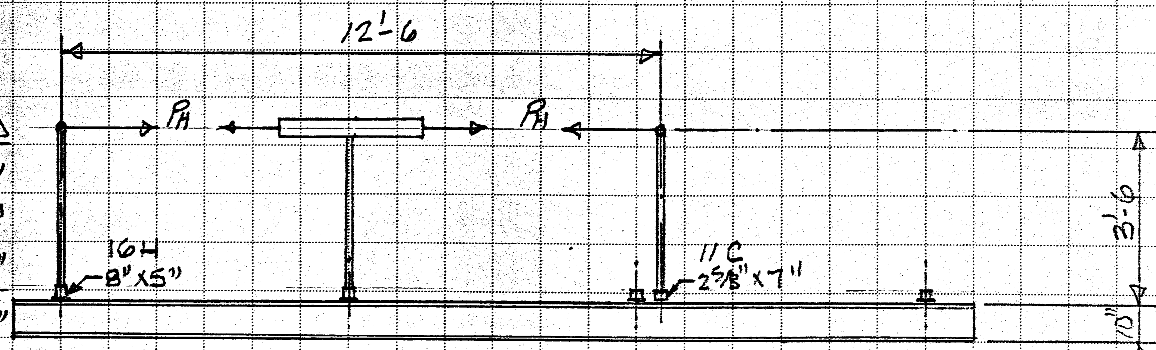
P_H	DEFL Δ	CALC Δ
200 lb	2 1/2"	1.22"
250 lb	3 1/8"	1.53"
300 lb	3 3/4"	1.83"



ELEVATION

TEST No. 2

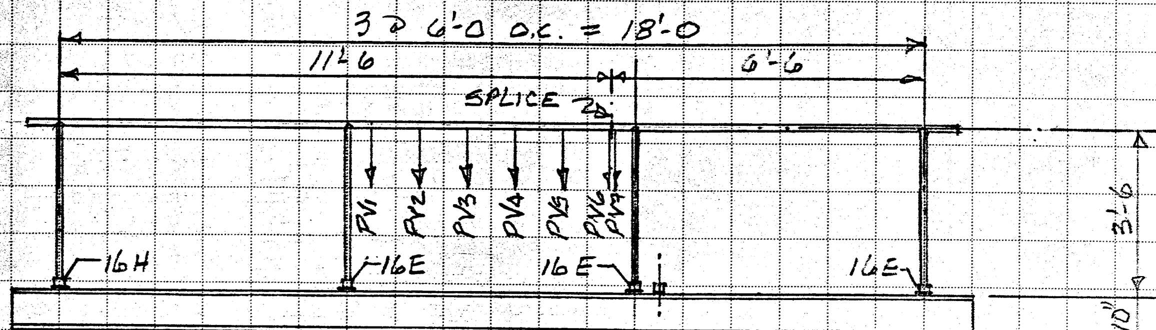
P_H	SCH 80 DEFL Δ	SCH 80 CALC Δ
200 lb	3 7/16"	1.251"
250 lb	4 7/16"	1.563"
300 lb	5 1/4"	1.876"
SCH 40	SCH 40	SCH 40
200 lb	4 5/16"	1.625"
250 lb	5 9/16"	2.030"
300 lb	8 1/4"	2.437"



ELEVATION

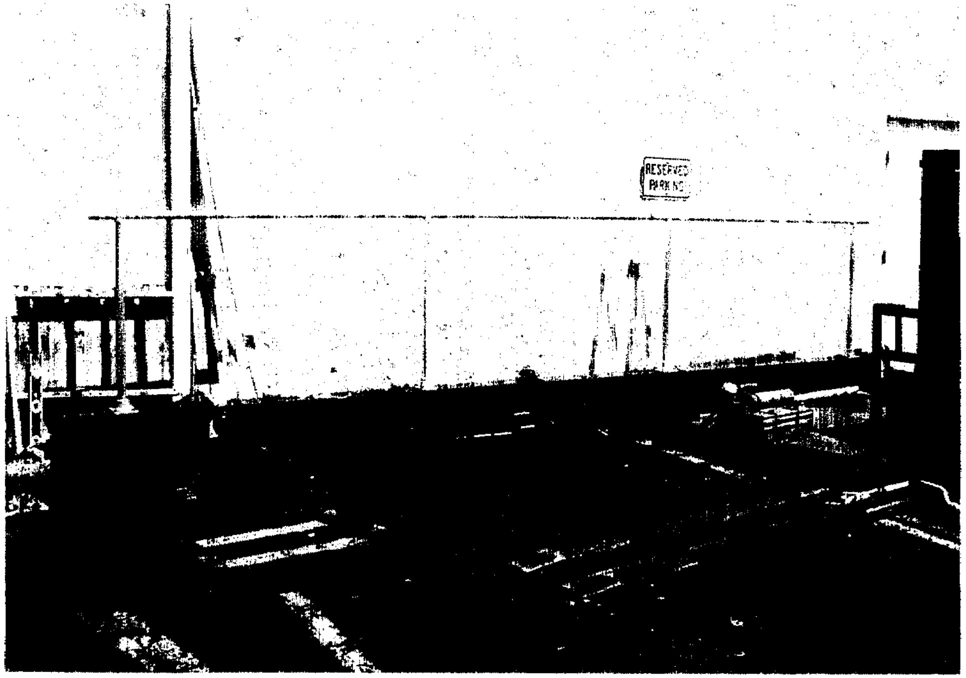
TEST No 3

P_V	LOAD	DEFL. ℄	
1	340 lb	0	
2	320 lb	1/4"	
3	320 lb	3/8"	
4	320 lb	3/8"	
5	350 lb	3/16"	
6	340 lb	0	SPLICE
7	340 lb	0	EXP. JOINT



ELEVATION

TEST No. 3



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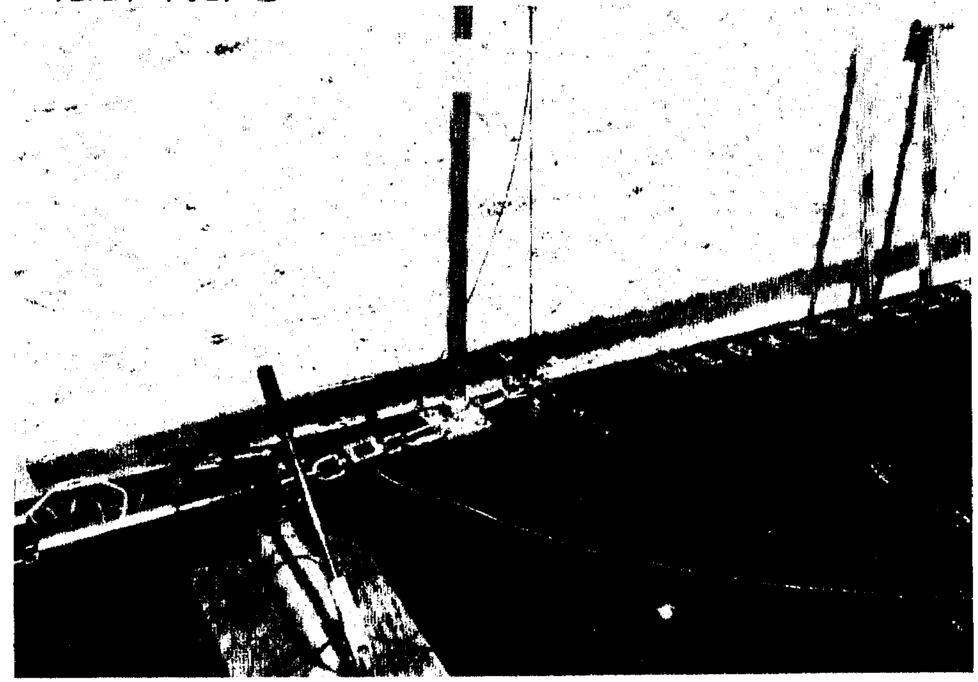

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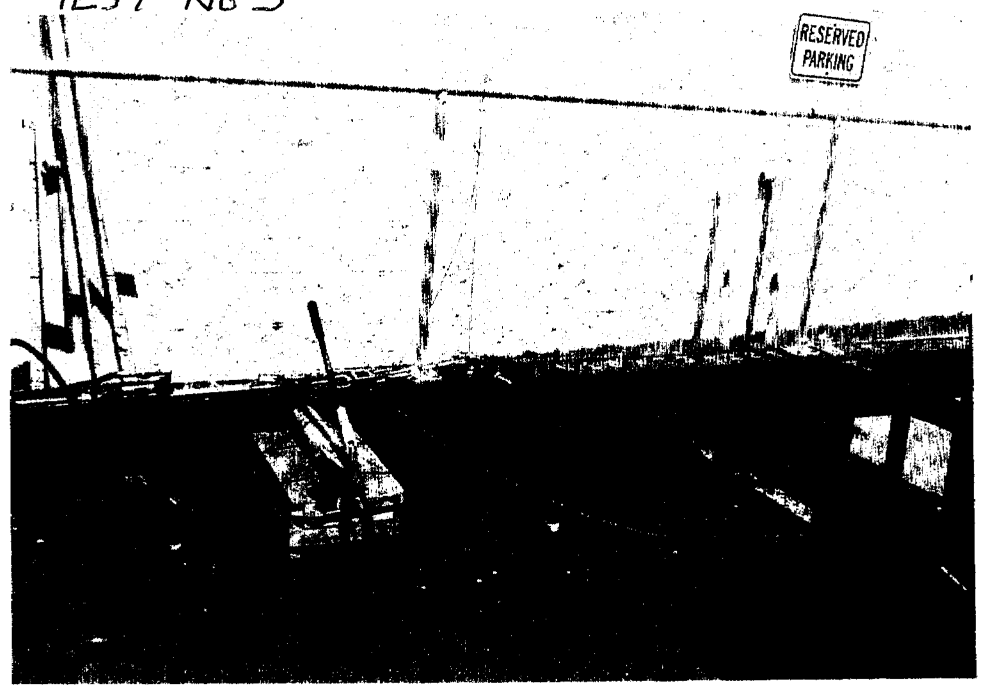

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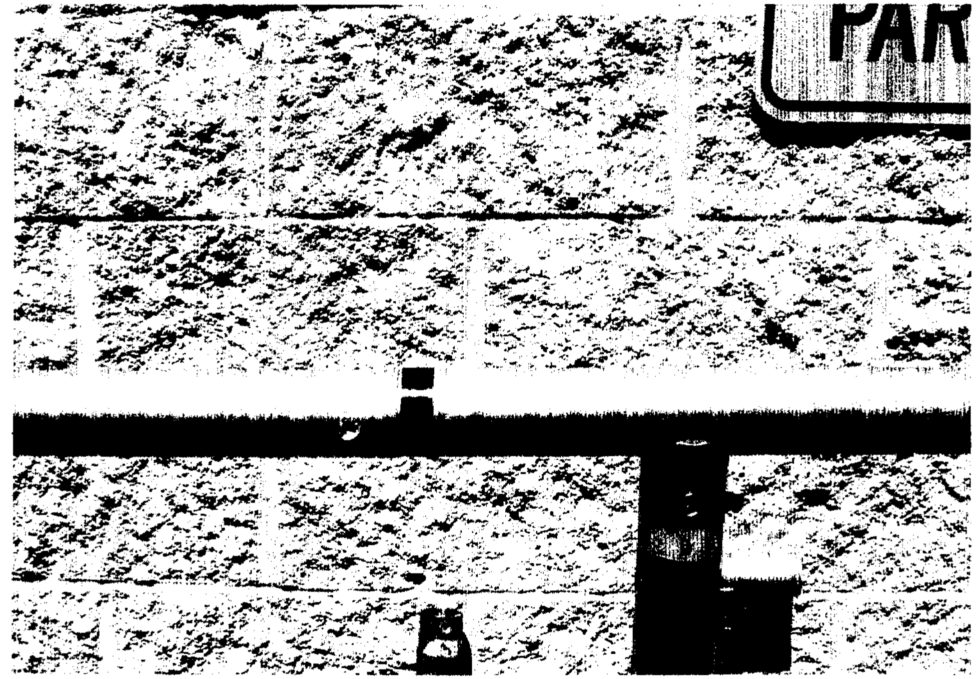

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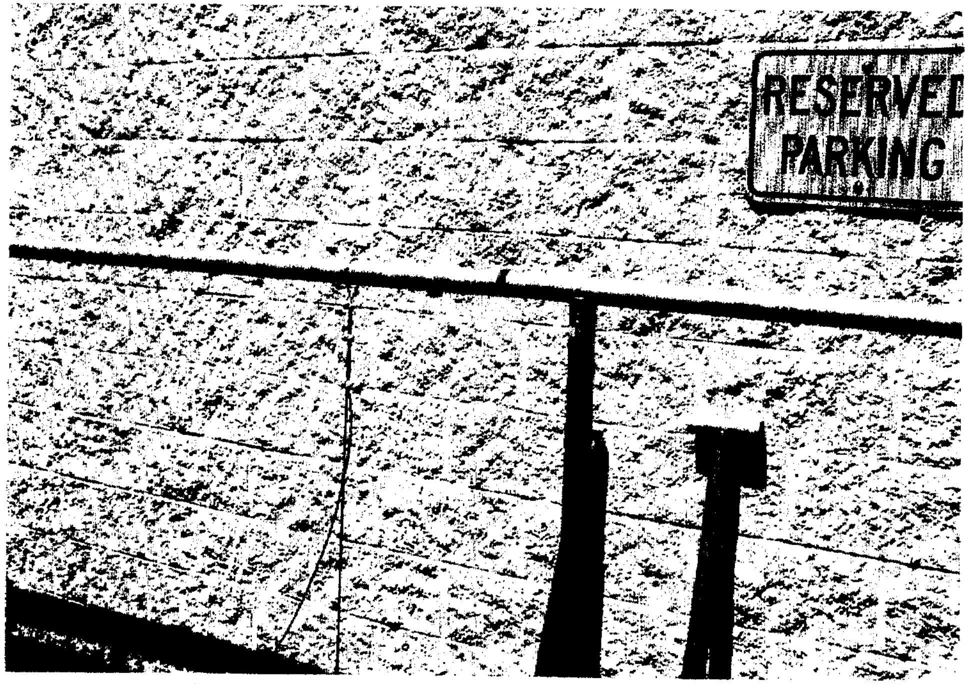

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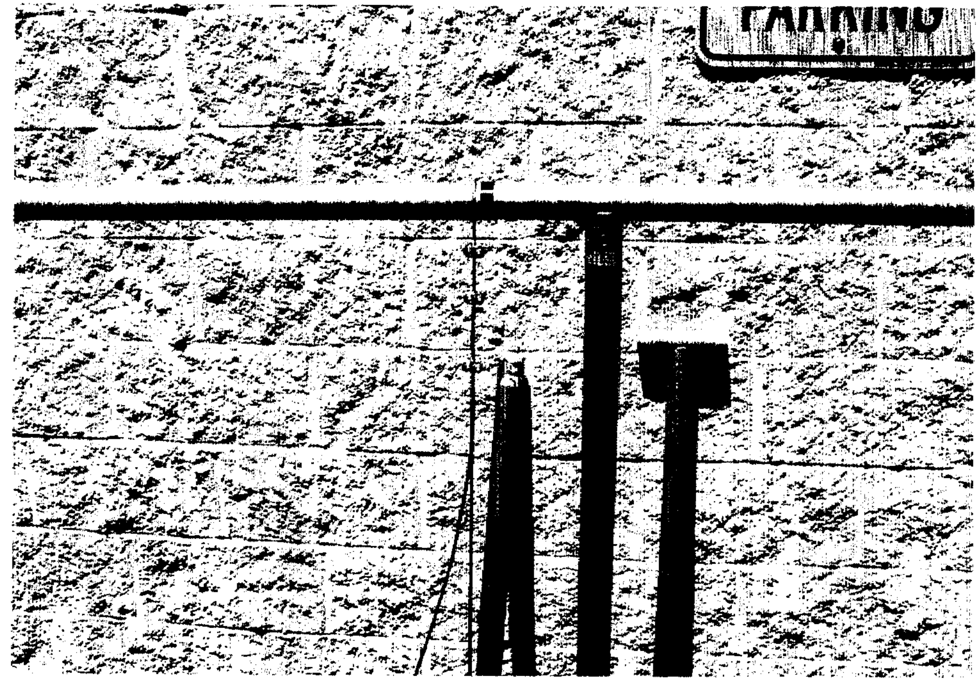

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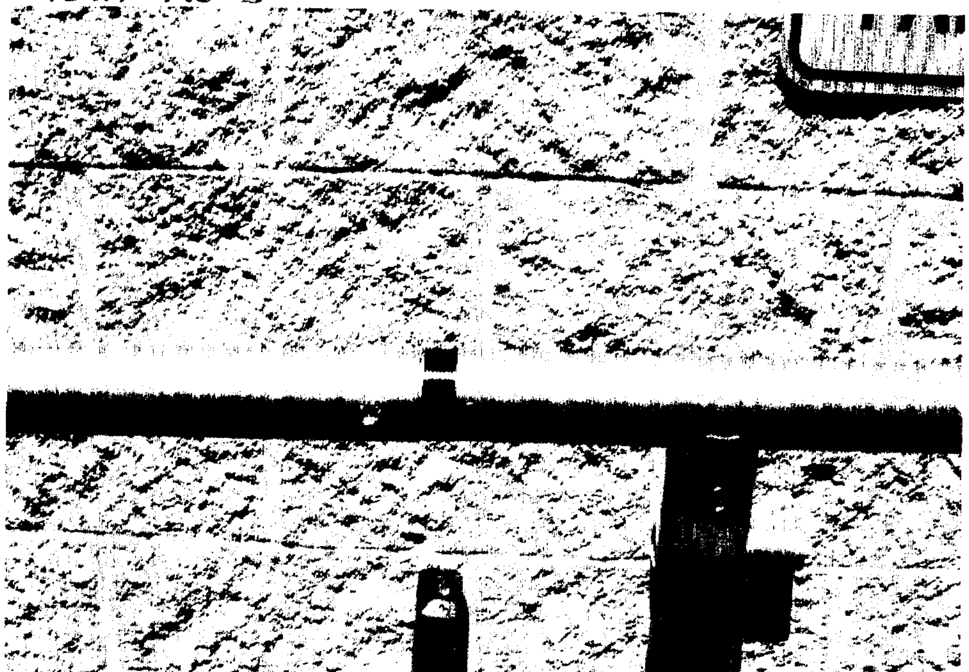

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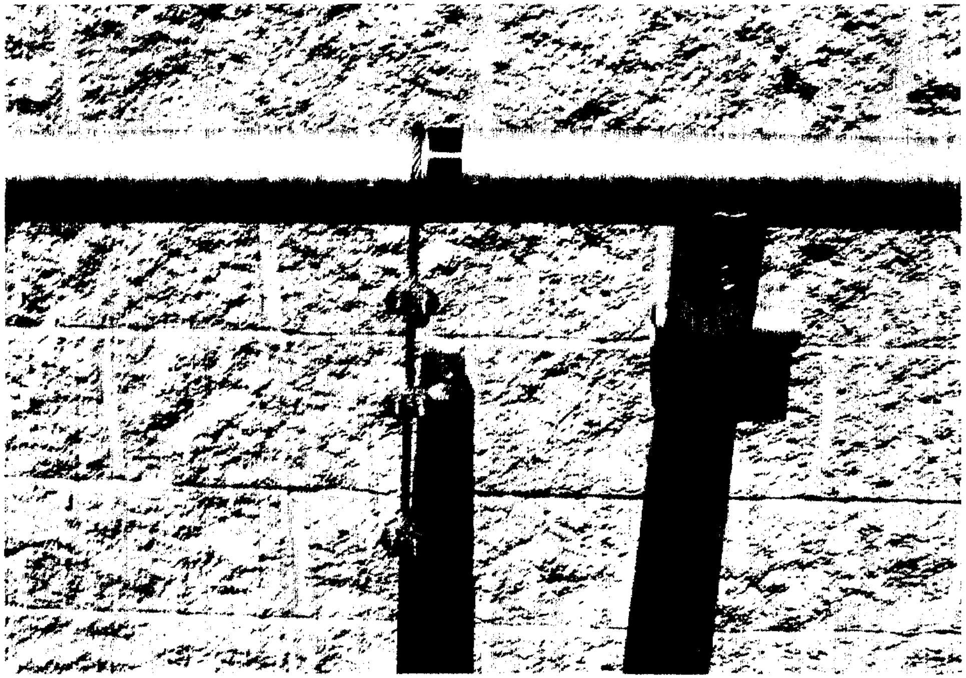

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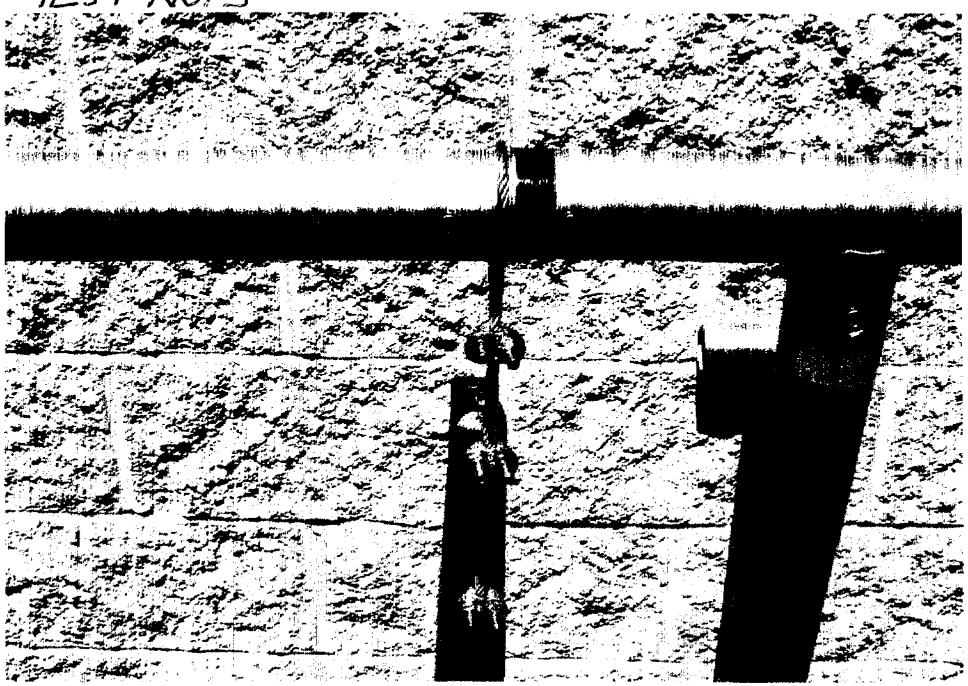
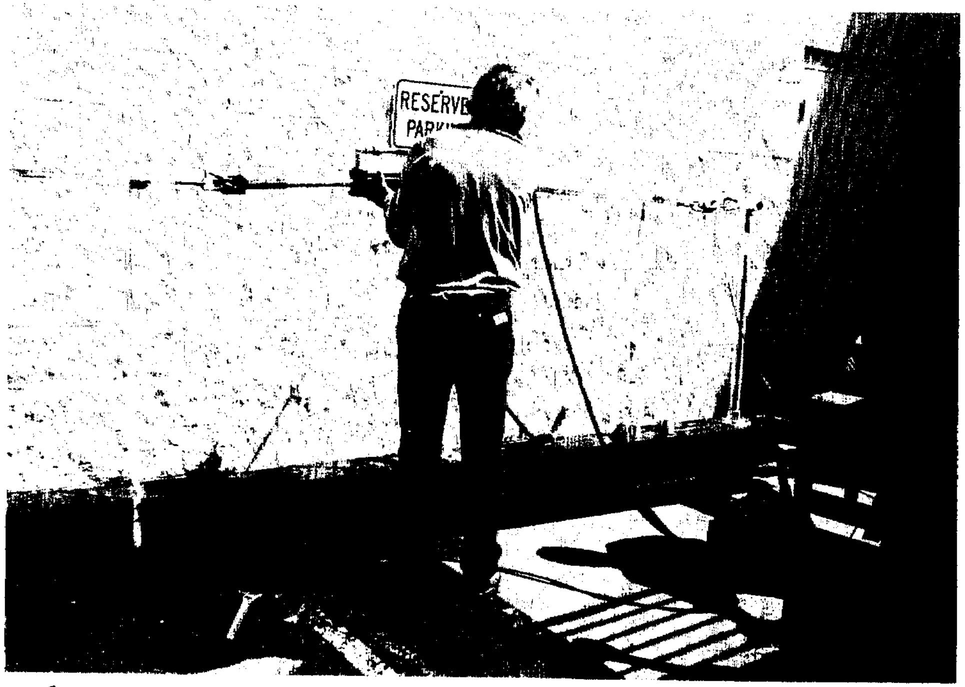


TEST No. 3

TEST No. 1



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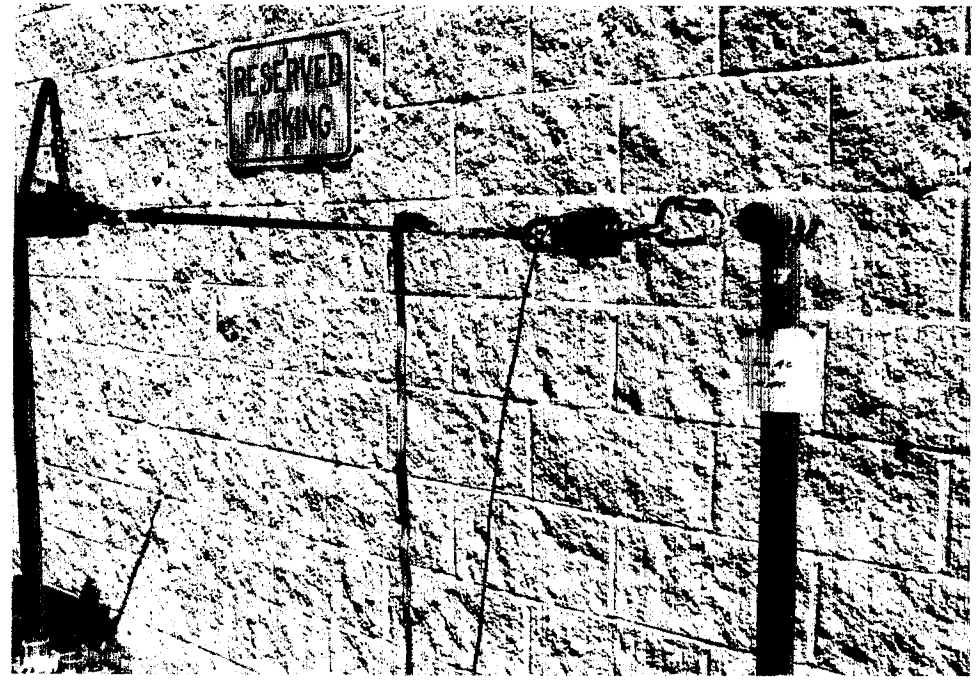

TEST No. 1

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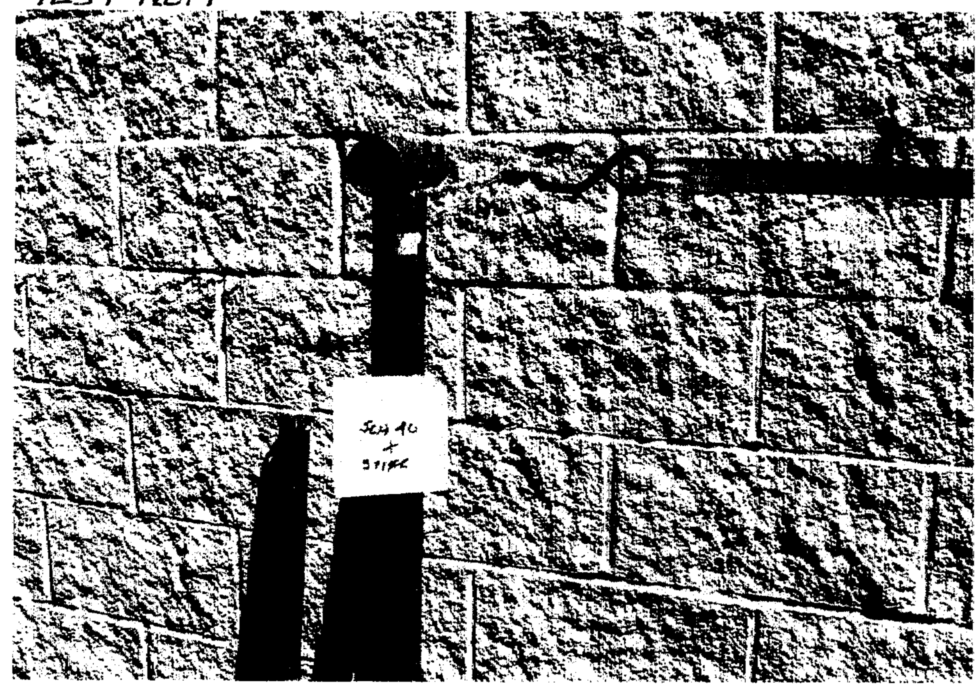

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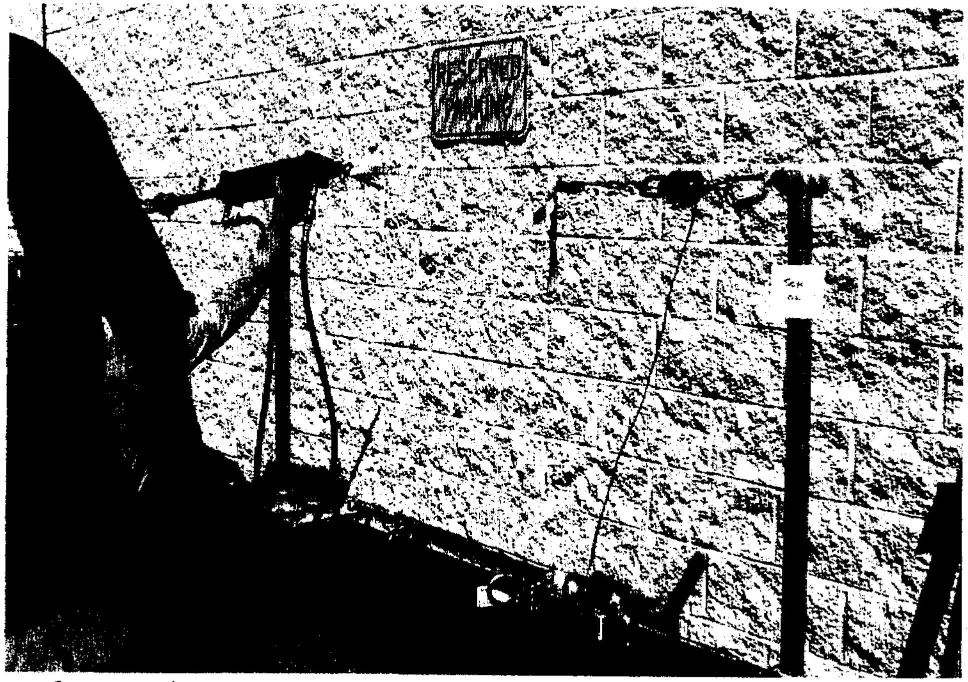

TEST No. 1

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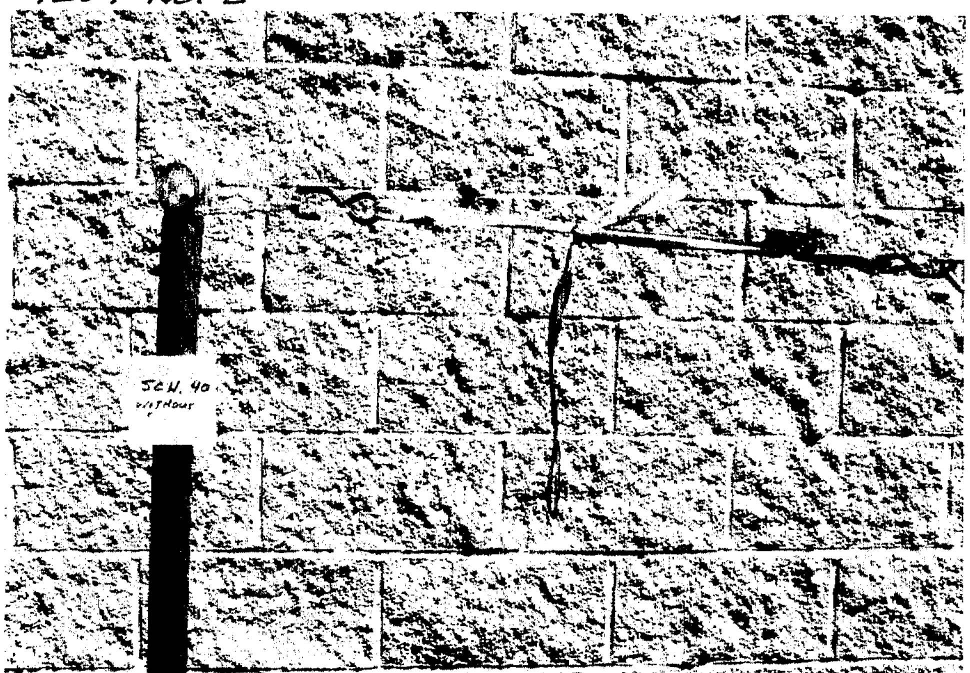

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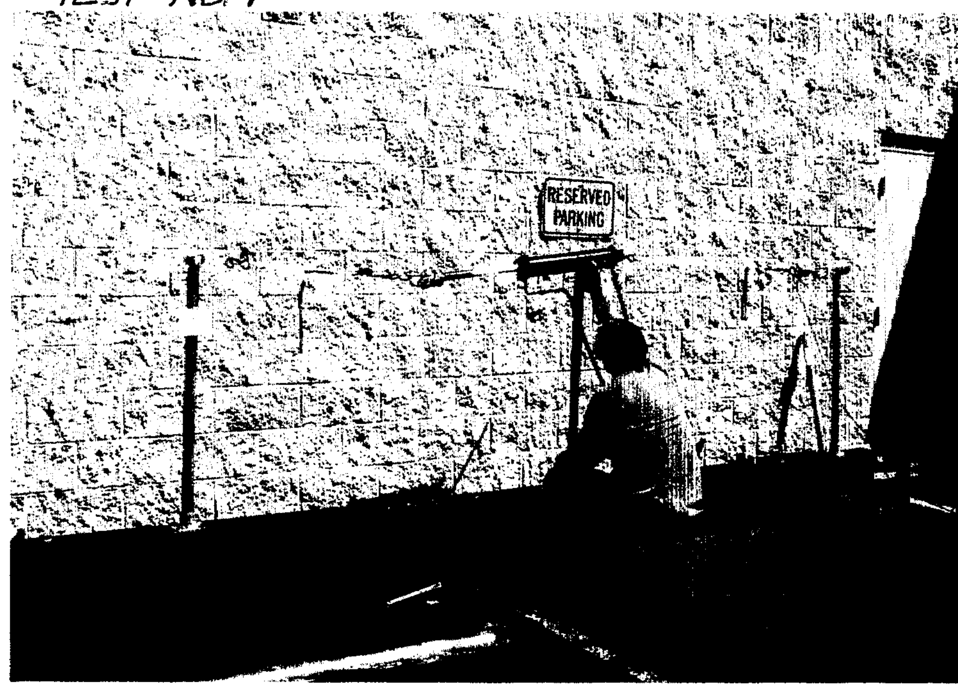

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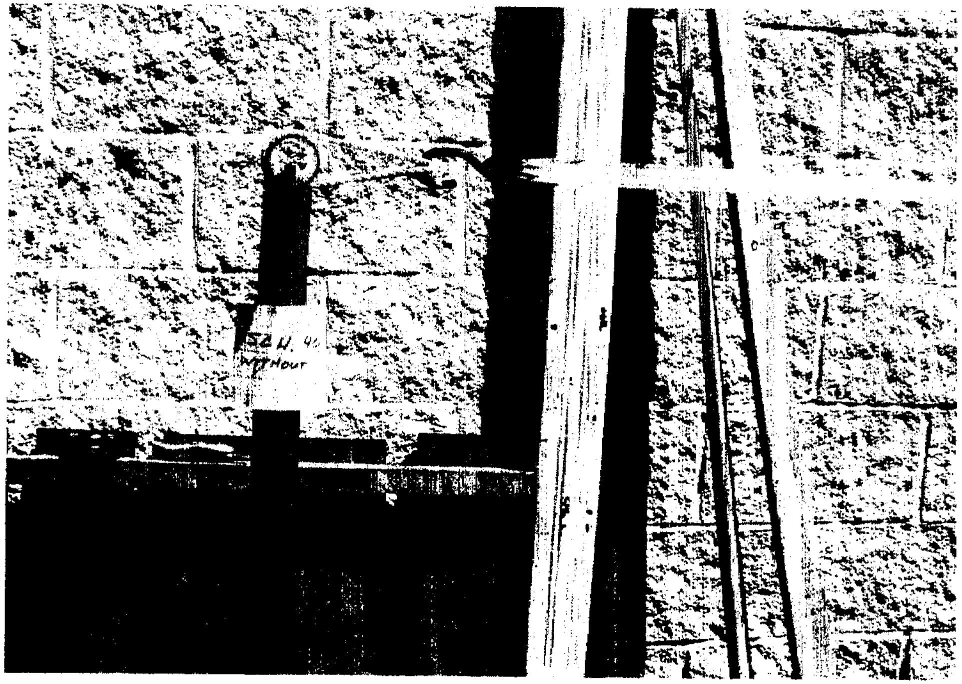

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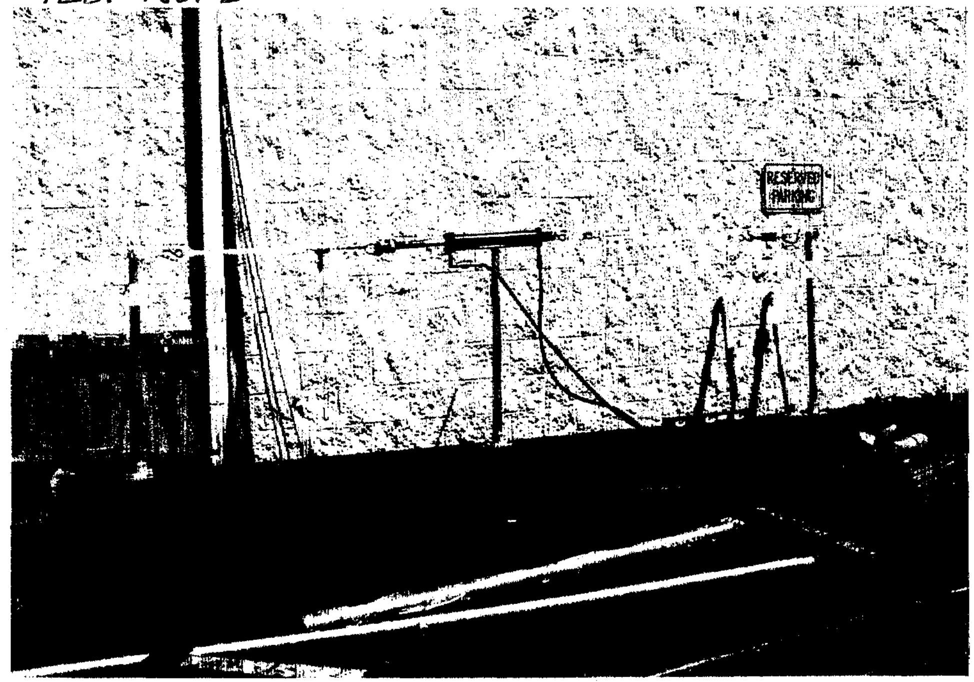

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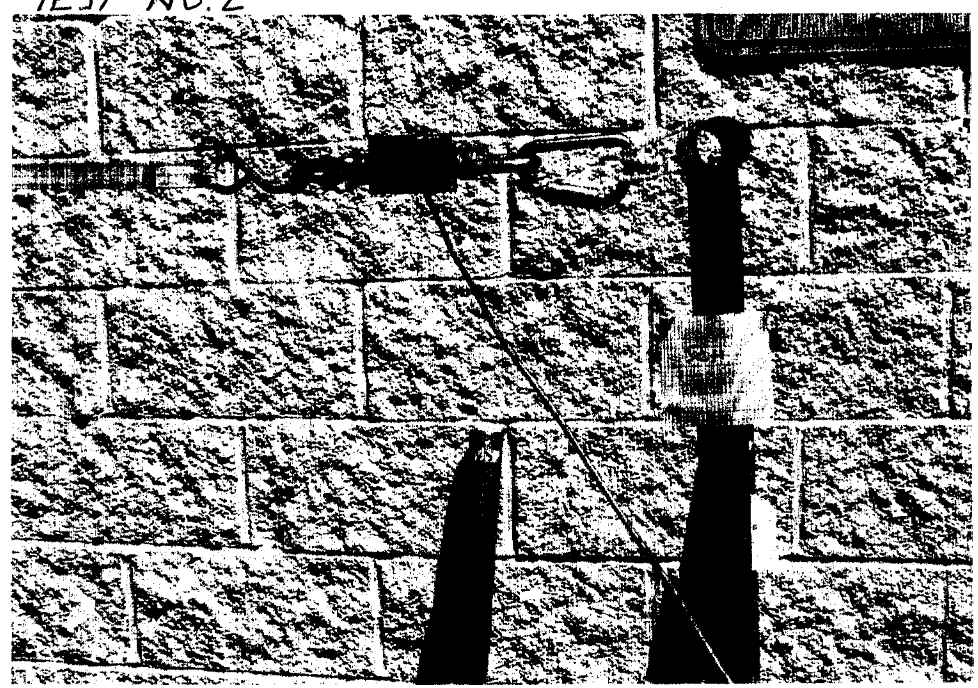

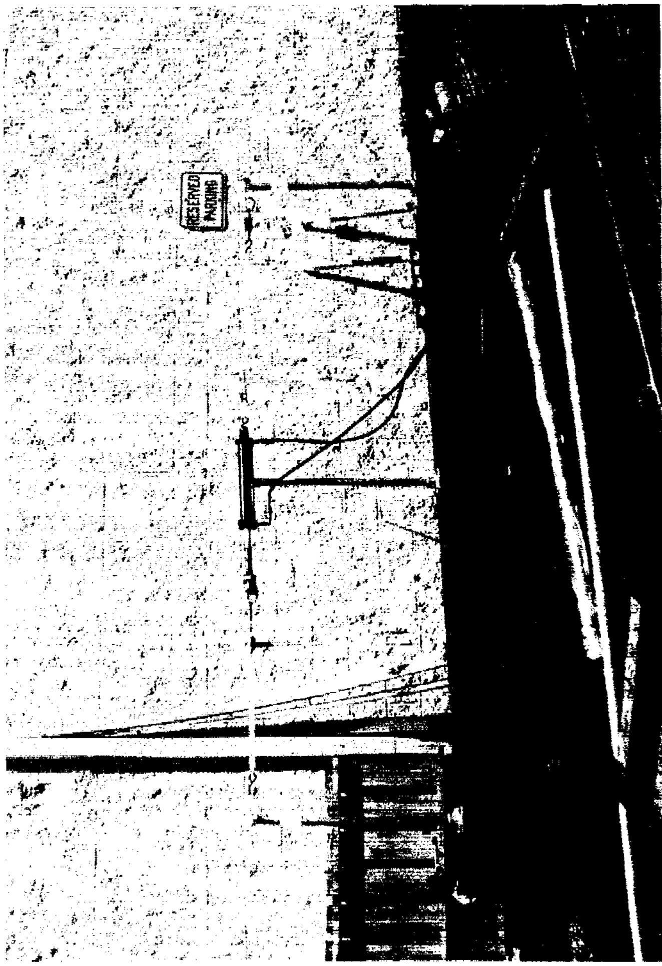

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TEST No. 2

TEST No 1

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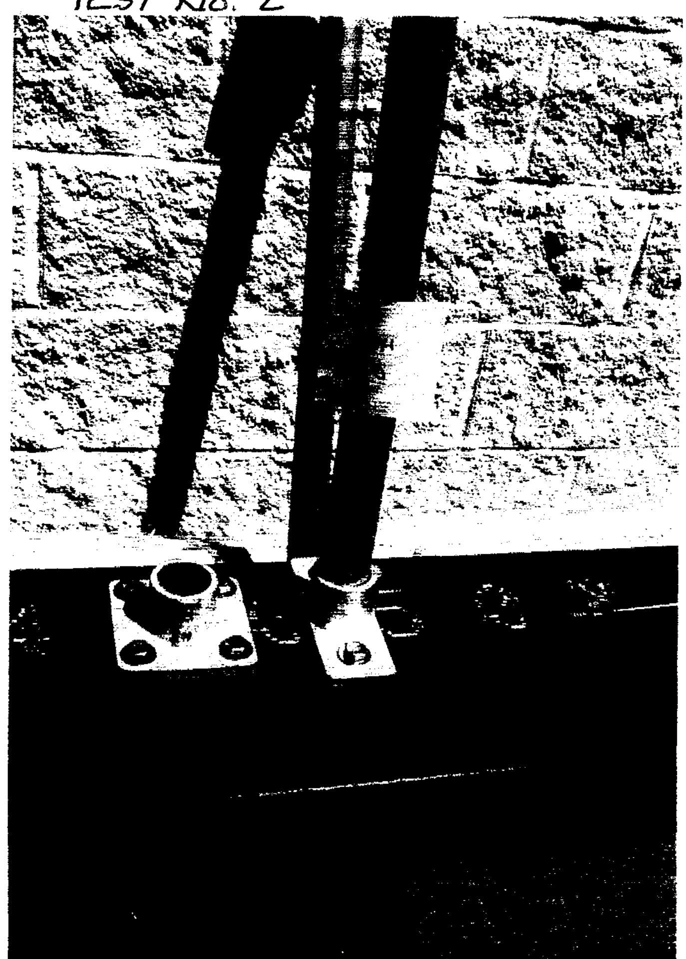

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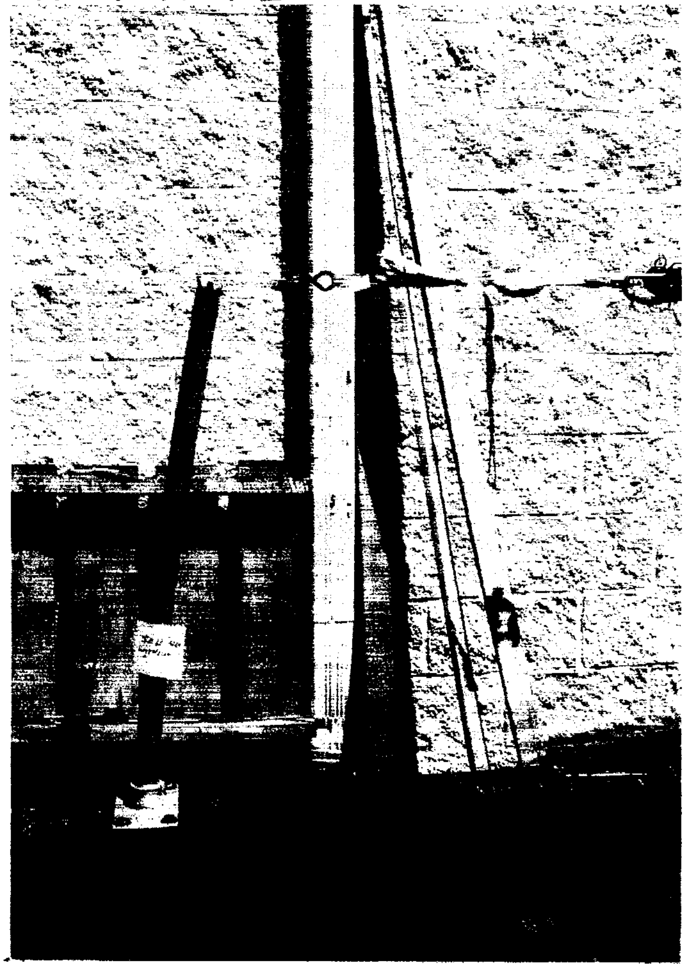

TEST No. 2

TEST No. 2

TEST No 2

ROY E. WOOTEN AND ASSOCIATES
Consulting Engineers
7585 W. Arkansas Ave., #206
Lakewood, Colorado 80232
(303) 980-8603

JOB RMR No. 1376, SAN JOSE, CA 20941

CALCULATED BY REW DATE 8/12/09
CHECKED BY ______ DATE ______
SCALE ______

W.P.C.P. PHASE II DIGESTERS

DESIGN CRITERIA

CODES - IBC 2006/2003, OSHA
ASCE 7-05/02 & CALIFORNIA
BUILD CODE

LOADS
1. TOP RAILS - 50 PLF OR 200 LB.
2. MID RAILS - 200 LB.
3. CORNER RAILS - 200 lb
4. POSTS - MAX. OF 1.

MATERIALS SPECIFICATIONS
1. RAILS, POSTS & FITTINGS - 6005-T5
2. CONNECTORS & ANCHORS - T316 SS
3. CONCRETE - F'c 4000 PSI

MATERIALS PROPERTIES
SEE ATTACHED SHEETS

DESIGN - PER 2005/2000 ALUMINUM DESIGN MANUALS - ALLOWABLE STRESS METHOD

TOP RAILS

1½" ϕ SCH 40 ℓmax = 6'-0
W = 50 PLF Mw = 1/8 (50 PLF) 6'-0² = 225 FT·lb
P = 200 lb Mp = 1/4 (200 lb) 6'-0 = 300 FT·lb
fb = M/S = 300 FT·lb x 12"/1 / 0.326 IN³
= 11043 PSI < 24000 PSI ✓ OK

MID RAILS

1½" ϕ SCH 40 ℓmax = 6'-0
P = 200 lb Mp = 1/4 (200 lb) 6'-0 = 300 FT·lb
fb = 300 FT·lb x 12"/1 / 0.326 IN³
= 11,043 PSI < 24000 PSI ✓ OK

CORNER RAILS

1½" ϕ SCH 40 SEE STANDARDS 25-KD-4

POSTS

1½" ϕ SCH 80 6'-0 MAX SPACING
Ww = 50 PLF x 6'-0 = 300 lb ←
P = 200 lb
(A / D-1) h = 2'-5" - 2½" = 2'-2½" OR 26½"
Mw = 300 lb x 26½" = 7950 IN·lb
fb = 7950 IN·lb / 0.412 IN³
= 19296 PSI < 24000 PSI ✓ OK

ANCHORAGE - 16H 8"x5" 4-½" ϕ TR. RODS
TREQ'D = 300 lb x 2'-5 x 12"/1 / 4⅛"
= 2110 lb OR 1055 lb / TR. ROD
SEE ATTACHED PREVIOUS SUBMITTALS
½" ϕ x 6" EMBED TALLOW = 2633 lb / TR. ROD
F'c = 3000 PSI TALLOW = 2505 lb / TR. ROD
F'c = 2400 PSI TALLOW = 2428 lb / TR. ROD
ALSO (1) 7-28-09 F'c 3000 PSI FOR 4½" & 5" EMBED

- 16E 5"x5" 4-½" ϕ TR RODS
TREQ'D = 300 lb x 2'-5 x 12"/1 / 4"
= 2175 lb OR 1088 lb / TR. ROD
SEE ATTACHED PREVIOUS SUBMITTALS
F'c = 3000 PSI ½" ϕ x 4" EMBED - TALL. = 1897 lb / TR. ROD
½" ϕ x 5" EMBED - TALL. = 1955 lb / TR. ROD

ROY E. WOOTEN AND ASSOCIATES
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7585 W. Arkansas Ave., #206
Lakewood, Colorado 80232
(303) 980-8603

JOB BMR # R1376, SAN JOSE, CA 20941
SHEET NO. 1 OF 1
CALCULATED BY REW DATE 7-17-09
CHECKED BY ____ DATE △1 7-28-09
SCALE 1½" = 1'-0

SECONDARY CALCS FOR BASE MOUNT FITTING 16E, 5"x5" W 4-½"Ø CHEM BOND ANCHORS - W_H = 50 plf x 6'-0 = 300 lb

F'c = 3000 PSI

EMBED 1. 4"
EMBED 2. 5"

M = 300 lb x 42" = 12600 in·lb

---

1. 4" EMBED - TBASIC = 3800 lb
SPACING 3½" → 0.78
EDGE DIST 2¼" → 0.645
TALL = 3800 lb/ROD x .78 x .645
= <u>1897 lb/ROD</u>

TACT = 12600 lb·in ÷ 3.99" = 3158 lb/T
OR 1579 lb/T.ROD
✓ OK

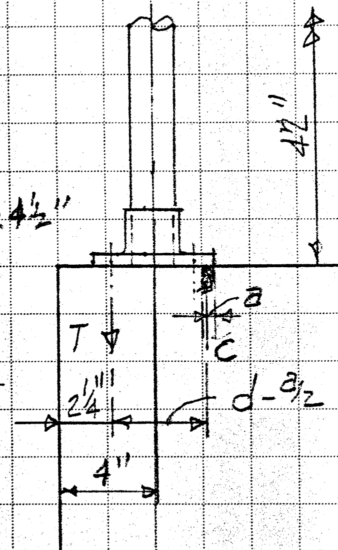
2. 5" EMBED - TBASIC = 4495 lb
SPACING 3½" ~ 0.75
EDGE DIST 2¼" ~ 0.58
TALL = 4495 x .75 x 0.58 = <u>1955 lb/ROD</u> ✓ OK

TACT = 12600 in·lb ÷ 3.99" = 3158 lb
OR 1579 lb/TROD

△1 FOR FITTING 16H 8"x5" W/4-½"Ø CHEM BOND ANCHORS - F_H = 200 lb
1. EMBED 4½"
2. EMBED 5"

ANCHORAGE BASED ON POWERS AC100 PLUS OR POWER AC100+GOLD EPOXY ADHESIVE SYSTEM.

T = C = M/(d-a/2)
= 12600 ÷ 3.99"
= 3158 lb
a = 3158/(.45 x 3000 psi x 4½")
= 0.52"
d - a/2 = 4¼ - 0.52/2
= 3.99"



T△1 = C = M/(d-a/2)
= 42" x 200 lb / 4.15"
= 2024 lb
a = 2024/(.45 x 3000 x 7.5")
= 0.20" d - a/2 = 4.15"

1△1. 4½" EMBED TBASIC = 4235 lb/TR.ROD
SPACING 6¼" - 0.881
EDGE DIST 2¼" 0.589
TALL = 4235 x 0.881 x 0.589 = 2198 lb/T.ROD
TACT = 2024 ÷ 2 = 1012 lb/TR.ROD
<u>S.F = 2198 lb/ROD ÷ 1012 lb/ROD = 2.172</u>

2△1. 5" EMBED TBASIC = 4495 lb/TR.ROD
SPACING 6¼" 0.862
EDGE DIST 2¼" 0.539
TALL = 4495 x 0.862 x 0.539 = 2088 lb/ROD
TACT = 2024 ÷ 2 = 1012 lb/ROD
S.F = 2088 ÷ 1012 = 2.063 ✓ OK

ROY E. WOOTEN AND ASSOCIATES
Consulting Engineers
7585 W. Arkansas Ave., #206
Lakewood, Colorado 80232
(303) 980-8603

JOB RMR No. R1376 SAN JOSE, CA.
SHEET NO. 1 OF 1
CALCULATED BY REW DATE 7/27/09
CHECKED BY ______ DATE ______
SCALE 3/4" = 1'-0

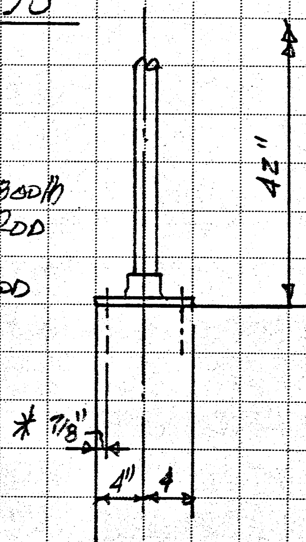
80-16 H TURNED 90°

F'c = 3000psi

1. 1/2"ϕ X 4 1/2" EMBED

2. 1/2"ϕ X 5" EMBED

TREQ'D = 42" X 300 lb ÷ 7" = 1800 lb
OR 900 lb/T. ROD



1. TBASIC = 4235 lb/T ROD
SPACING 3 1/2" · 0.74
EDGE DIST. 7/8" – NO VALUE

TALL = 4235 X 0.74 X 0
= 0

NOT ALLOWED

2. TBASIC = 4495 lb/T. ROD
SPACING = 3 1/2" · 0.70
EDGE DIST = 7/8" – NO VALUE

TALL = 4495 X 0.70 X 0.00 = 0
NOT ALLOWED

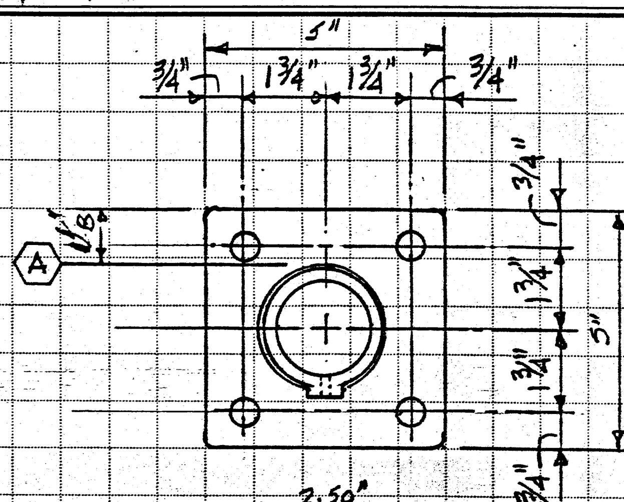
NOTE * NEEDS TO BE MIN. OF 2 1/8"
TO GET VALID CALCULABLE
LOADS.

ROY E. WOOTEN AND ASSOCIATES
Consulting Engineers
7585 W. Arkansas Ave., #206
Lakewood, Colorado 80232
(303) 980-8603

JOB: ROCKY MOUNTAIN RAILINGS STANDARDS
SHEET NO. 1 OF 1
CALCULATED BY: REW DATE: JULY 2008
CHECKED BY: R.B DATE: JAN. 26, 2009
SCALE: 1/4" = 1"

16 E

FOUR (4) HOLE BASE MOUNT 6105-T5



(A) PROPERTIES

AREA = 1/2" x 5" = 2.50 IN²

$I = \frac{1}{12}(5)(\frac{1}{2}")^3 = 0.05208\ IN^4$

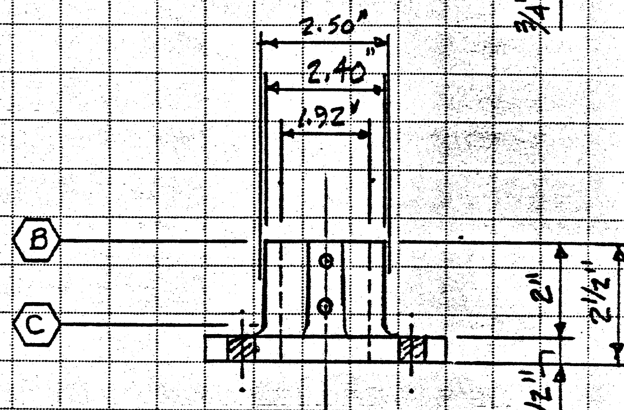
$S = \frac{1}{6}(5)(\frac{1}{2}")^2 = 0.20833\ IN^3$

$M = 0.20833\ IN^3 \times 24000\ PSI = 5000\ IN \cdot lb$

$R_C = 5000 \div 15/16" = 5333\ lb$

$P = W = 5333 \times 4\frac{1}{16}" / 42" = 516\ lb > 300\ lb$

OR 6'-0" @ 50 plf = 300 lb



(B) PROPERTIES

AREA = $\frac{\pi}{4}(2.40^2 - 1.92^2) = 1.6286\ IN^2$

$I = \frac{\pi}{64}(2.40^4 - 1.92^4) = 0.9615\ IN^4$

$S = I/r_{OD} = 0.9615 \div 1.2" = 0.8013\ IN^3$

$M_R = 0.8013\ IN^3 \times 24000 = 19,230\ IN \cdot lb$

$P = W = 19230 / (42" - 2\frac{1}{2}") = 487\ lb > 200\ lb$

OR 6'0 x 50 plf.

(C) PROPERTIES

AREA = $\frac{\pi}{4}(2.50^2 - 1.92^2) = 2.0135\ IN^2$

$I = \frac{\pi}{64}(2.50^4 - 1.92^4) = 1.2504\ IN^4$

$S = I/r_{OD} = 1.2504 / 1.25" = 1.0000\ IN^3$

$M_R = 1.000\ (24000) = 24000\ IN \cdot lb$

$P = W = 24000 \div (42 - 5/8") = 580\ lb > 200\ lb$

OR 6'0 x 50 plf.

STANDARD ANCHORS

4 - 1/2" φ x 3 3/4 "POWERS" WEDGE ANCHORS
PER ICC-ES ESR-1532

SPECIAL ANCHORAGE FOR RMR & R1376

4 - 1/2" φ x 6" EMBED THREADED RODS
EPOXY BOND - POWERS AC 100 PLUS
OR POWERS AC 100 + GOLD; F'C = 4000 PSI

$T_{BASIC} = 5167\ lb/ROD$

SPACING - 3 1/2" 0.70
EDGE DIST. - 2 1/4" 0.60

$= 0.42(5167\ lb) = 2170\ lb/ROD$

$T_{ACT} = 300\ lb \times 42" \div 4\frac{1}{16}" = 3102\ lb$

OR 1551 lb/ROD < 2170 lb/ROD

✓OK

COLORADO REGISTERED PROFESSIONAL ENGINEER ROY E. WOOTEN 7232

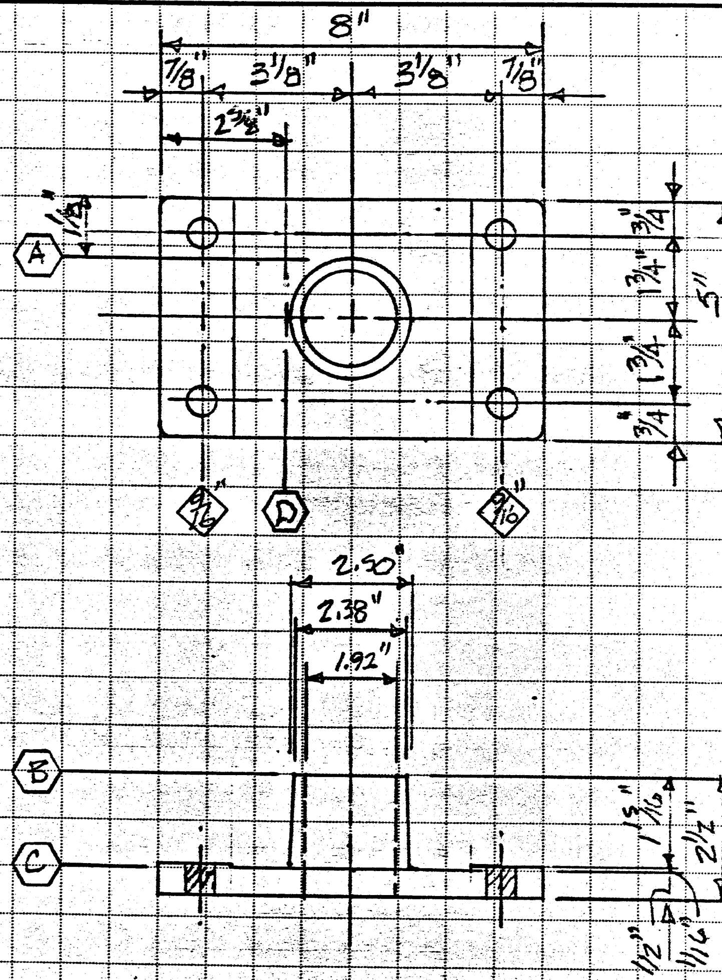
7/15/09

ROY E. WOOTEN AND ASSOCIATES
Consulting Engineers
7585 W. Arkansas Ave., #206
Lakewood, Colorado 80232
(303) 980-8603

JOB: ROCK MOUNTAIN RAILINGS STANDARDS
SHEET NO. 1 OF 1
CALCULATED BY: REW DATE: JUNE 23, 2009
CHECKED BY: RGB DATE: JUNE 29, 2009
SCALE: 1/4" = 1"

8C-16H

FOUR (4) HOLE BASE MOUNT



(A) PROPERTIES

$AREA = 1/2" \times 8" = 4.00\ IN^2$

$I = 1/12 (8")(1/2")^3 = 0.0833\ IN^4$

$S = 1/6 (8")(1/2")^2 = 0.3333\ IN^3$

$M = 0.3333 \times 24000\ PSI = 8000\ IN \cdot lb$

$R_{H\ MAX} = 8000\ IN \cdot lb \div 15/16" = 8533\ lb$

$P_{TOP\ OF\ 42"\ POST} = 8533\ lb \times 4 1/16" \div 42" = 825\ lb$

(B) PROPERTIES

$AREA = \pi/4 (2.38^2 - 1.92^2) = 1.5535\ IN^2$

$I = \pi/64 (2.38^4 - 1.92^4) = 0.9079\ IN^4$

$S = I/r_{OD} = 0.9079 \div 1.19" = 0.7630\ IN^3$

$M = 0.7630\ IN^3 \times 24000\ PSI = 18,310\ IN \cdot lb$

$P_H = W_H = 18310 / (42" - 2 1/2") = 464\ lb$

(C) PROPERTIES

$AREA = \pi/4 (2.50^2 - 1.92^2) = 2.0135\ IN^2$

$I = \pi/64 (2.50^4 - 1.92^4) = 1.2504\ IN^4$

$S = I/r_{OD} = 1.2504/1.25" = 1.0003\ IN^3$

$M = 1.0003\ IN^3 \times 24000 = 24,008\ IN \cdot lb$

$P_H = W_H = 24008 / (42" - 1/2") = 579\ lb$

STANDARD ANCHORS

4 - 1/2" Φ x 3 3/4" "POWERS" WEDGE ANCHORS
PER ICC-ES-ESR-1532

RMR No 1376
SAN JOSE, CA.

(D) PROPERTIES

$AREA = 1/2" \times 5" = 2.00\ IN^2$

$I = 1/12 (5")(1/2")^3 = 0.0528\ IN^4$

$S = 1/6 (5")(1/2")^2 = 0.2083\ IN^3$

$M = 0.2083 \times 24000\ PSI = 5000\ IN \cdot lb$

$R_{MAX} = 5000\ IN \cdot lb \div 2 1/2 = 2000\ lb$

$P_H / W_H = 2000\ lb \times 6.98" \div 42" = 332\ lb$

✓ OK

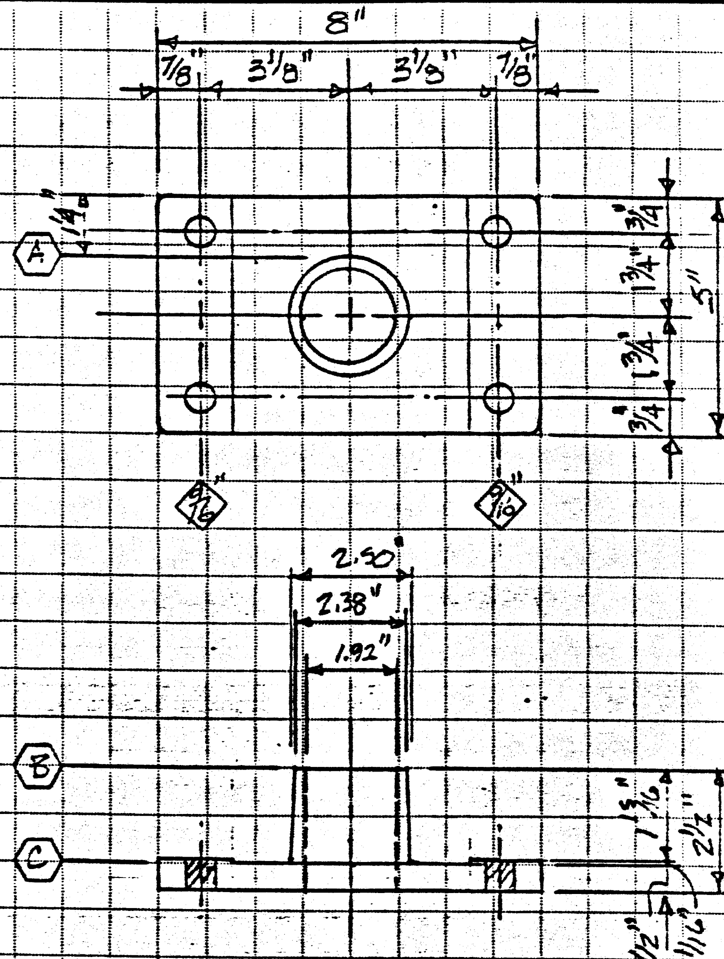
PROBABLY SHOULD BE LOAD TESTED FOR VERIFICATION OF CALC'D VALUES.

ROY E. WOOTEN AND ASSOCIATES
Consulting Engineers
7585 W. Arkansas Ave., #206
Lakewood, Colorado 80232
(303) 980-8603

JOB: ROCK MOUNTAIN RAILINGS STANDARDS
SHEET NO. 1 OF 1
CALCULATED BY: REW DATE: JUNE 23, 2009
CHECKED BY: DATE:
SCALE: 1/4" = 1"

80-16H

FOUR (4) HOLE BASE MOUNT



(A) PROPERTIES

$AREA = 1/2" \times 8" = 4.00\,IN^2$

$I = 1/12\,(8")(1/2")^3 = 0.0833\,IN^4$

$S = 1/6\,(8")(1/2")^2 = 0.3333\,IN^3$

$M = 0.3333 \times 24000\,PSI = 8000\,IN \cdot lb$

$P_{H\,MAX} = 8000\,IN \cdot lb \times 4/3 \div 1\,3/16" = 8982\,lb$

$P_{TOP\ OF\ 42"\ POST} = 8000\,IN\,lb \times 4/3 \div 42" = 254\,lb$

(B) PROPERTIES

$AREA = \pi/4\,(2.38^2 - 1.92^2) = 1.5535\,IN^2$

$I = \pi/64\,(2.38^4 - 1.92^4) = 0.9079\,IN^4$

$S = I/r_{OD} = 0.9079 \div 1.19" = 0.7630\,IN^3$

$M = 0.763\,IN^3 \times 24000\,PSI = 18{,}310\,IN \cdot lb$

$P_H = W_H = 18310/(42" - 2\,1/2") = 464\,lb$

(C) PROPERTIES

$AREA = \pi/4\,(2.50^2 - 1.92^2) = 2.0135\,IN^2$

$I = \pi/64\,(2.50^4 - 1.92^4) = 1.2504\,IN^4$

$S = I/r_{OD} = 1.2504/1.25" = 1.0003\,IN^3$

$M = 1.0003\,IN^3 \times 24000 = 24{,}008\,IN \cdot lb$

$P_H = W_H = 24008/(42" - 1/2") = 579\,lb$

STANDARD ANCHORS

4 - 1/2" Φ x 3 3/4" "POWERS" WEDGE ANCHORS
PER ICC - ES - ESR - 1532

SPECIAL ANCHORAGE FOR RMR # R1376

4 - 1/2" Φ x 6" EMBED THREADED RODS
EPOXY BOND - POWER AC 100 PLUS
OR POWERS AC 100 + GOLD; F'c = 4000 PSI

$T_{BASIC} = 5270\,lb/ROD$

SPACING 6 1/4" : 0.815
EDGE DIST. 2 1/4" : 0.613
} = 0.4996 (5270 lb) = 2633 lb/ROD

$T_{ACT} = 300\,lb \times 42" \div 4\,1/8"$
$= 3054\,lb$ OR $1527\,lb/ROD < 2633\,lb$ ✓ OK

COLORADO REGISTERED
ROY E. WOOTEN
7232
PROFESSIONAL ENGINEER

[signature]
6/23/09

Table 3.3-1
MINIMUM MECHANICAL PROPERTIES FOR ALUMINUM ALLOYS

ALLOY AND TEMPER	PRODUCT	THICKNESS RANGE in.	F_{tu} ksi	F_{ty} ksi	F_{cy} ksi	F_{su} ksi	COMPRESSIVE MODULUS OF ELASTICITY[2] E (ksi)
5052-O	Sheet & Plate	0.006 to 3.000	25	9.5	9.5	16	10,200
-H32	Sheet & Plate	All	31	23	21	19	10,200
-H34	Cold Fin. Rod & Bar	All	34	26	24	20	10,200
-H36	Drawn Tube						
	Sheet	0.006 to 0.162	37	29	26	22	10,200
5083-O	Extrusions	up thru 5.000	39	16	16	24	10,400
-H111	Extrusions	up thru 0.500	40	24	21	24	10,400
-H111	Extrusions	0.501 to 5.000	40	24	21	23	10,400
-O	Sheet & Plate	0.051 to 1.500	40	18	18	25	10,400
-H116	Sheet & Plate	0.188 to 1.500	44	31	26	26	10,400
-H32, H321	Sheet & Plate	0.188 to 1.500	44	31	26	26	10,400
-H116	Plate	1.501 to 3.000	41	29	24	24	10,400
-H32, H321	Plate	1.501 to 3.000	41	29	24	24	10,400
5086-O	Extrusions	up thru 5.000	35	14	14	21	10,400
-H111	Extrusions	up thru 0.500	36	21	18	21	10,400
-H111	Extrusions	0.501 to 5.000	36	21	18	21	10,400
-O	Sheet & Plate	0.020 to 2.000	35	14	14	21	10,400
-H112	Plate	0.025 to 0.499	36	18	17	22	10,400
-H112	Plate	0.500 to 1.000	35	16	16	21	10,400
-H112	Plate	1.001 to 2.000	35	14	15	21	10,400
-H112	Plate	2.001 to 3.000	34	14	15	21	10,400
-H116	Sheet & Plate	All	40	28	26	24	10,400
-H32	Sheet & Plate Drawn Tube	All	40	28	26	24	10,400
-H34	Sheet & Plate Drawn Tube	All	44	34	32	26	10,400
5154-H38	Sheet	0.006 to 0.128	45	35	33	24	10,300
5454-O	Extrusions	up thru 5.000	31	12	12	19	10,400
-H111	Extrusions	up thru 0.500	33	19	16	20	10,400
-H111	Extrusions	0.501 to 5.000	33	19	16	19	10,400
-H112	Extrusions	up thru 5.000	31	12	13	19	10,400
-O	Sheet & Plate	0.020 to 3.000	31	12	12	19	10,400
-H32	Sheet & Plate	0.020 to 2.000	36	26	24	21	10,400
-H34	Sheet & Plate	0.020 to 1.000	39	29	27	23	10,400
5456-O	Sheet & Plate	0.051 to 1.500	42	19	19	26	10,400
-H116	Sheet & Plate	0.188 to 1.250	46	33	27	27	10,400
-H32, H321	Sheet & Plate	0.188 to 1.250	46	33	27	27	10,400
-H116	Plate	1.251 to 1.500	44	31	25	25	10,400
-H32, H321	Plate	1.251 to 1.500	44	31	25	25	10,400
-H116	Plate	1.501 to 3.000	41	29	25	25	10,400
-H32, H321	Plate	1.501 to 3.000	41	29	25	25	10,400
6005-T5	Extrusions	up thru 1.000	38	35	35	24	10,100
6061-T6, T651	Sheet & Plate	0.010 to 4.000	42	35	35	27	10,100
-T6, T6510, T6511	Extrusions	All	38	35	35	24	10,100
-T6, T651	Cold Fin. Rod & Bar	up thru 8.000	42	35	35	25	10,100
-T6	Drawn Tube	0.025 to 0.500	42	35	35	27	10,100
-T6	Pipe	All	38	35	35	24	10,100
6063-T5,	Extrusions	up thru 0.500	22	16	16	13	10,100
-T52	Extrusions	up thru 1.000	22	16	16	13	10,100
-T5	Extrusions	0.500 to 1.000	21	15	15	12	10,100
-T6	Extrusions & Pipe	All	30	25	25	19	10,100
6066-T6, T6510, T6511	Extrusions	All	50	45	45	27	10,100
6070-T6, T62	Extrusions	up thru 2.999	48	45	45	29	10,100
6105-T5	Extrusions	up thru 0.500	38	35	35	24	10,100
6351-T5	Extrusions	up thru 1.000	38	35	35	24	10,100
6351-T6	Extrusions	up thru 0.750	42	37	37	27	10,100
6463-T6	Extrusions	up thru 0.500	30	25	25	19	10,100
7005-T53	Extrusions	up thru 0.750	50	44	43	28	10,500

1. F_{tu} and F_{ty} are minimum specified values (except F_{ty} for 1100-H12, H14 Cold Finished Rod and Bar and Drawn Tube, Alclad 3003-H18 Sheet and 5050-H32, H34 Cold Finished Rod and Bar which are minimum expected values); other strength properties are corresponding minimum expected values.

2. Typical values. For deflection calculations an average modulus of elasticity is used; this is 100 ksi lower than values in this column.

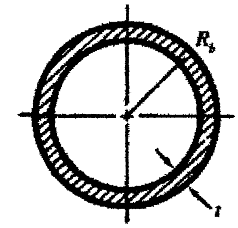


TABLE 22 – PIPES

Nominal Pipe Size	Schedule No.	Outside Diameter OD in.	Inside Diameter ID in.	Wall Thickness t in.	Weight[2] lb/ft	Area A in²	I in⁴	S in³	r in.	R_b/t
1 1/2	5	1.900	1.770	0.065	0.441	0.375	0.158	0.166	0.649	14.1
	10	1.900	1.682	0.109	0.721	0.613	0.247	0.260	0.634	8.2
	40	1.900	1.610	0.145	0.940	0.799	0.310	0.326	0.623	6.1
	80	1.900	1.500	0.200	1.26	1.07	0.391	0.412	0.605	4.3
	160	1.900	1.338	0.281	1.68	1.43	0.482	0.508	0.581	2.9
2	5	2.375	2.245	0.065	0.555	0.472	0.315	0.265	0.817	17.8
	10	2.375	2.157	0.109	0.913	0.776	0.499	0.420	0.802	10.4
	40	2.375	2.067	0.154	1.26	1.07	0.666	0.561	0.787	7.2
	80	2.375	1.939	0.218	1.74	1.48	0.868	0.731	0.766	4.9
	160	2.375	1.687	0.344	2.58	2.19	1.16	0.980	0.728	3.0
2 1/2	5	2.875	2.709	0.083	0.856	0.728	0.710	0.494	0.988	16.8
	10	2.875	2.635	0.120	1.22	1.04	0.987	0.687	0.975	11.5
	40	2.875	2.469	0.203	2.00	1.70	1.53	1.06	0.947	6.6
	80	2.875	2.323	0.276	2.65	2.25	1.92	1.34	0.924	4.7
	160	2.875	2.125	0.375	3.46	2.95	2.35	1.64	0.894	3.3
3	5	3.500	3.334	0.083	1.05	0.891	1.30	0.744	1.21	20.6
	10	3.500	3.260	0.120	1.50	1.27	1.82	1.04	1.20	14.1
	40	3.500	3.068	0.216	2.62	2.23	3.02	1.72	1.16	7.6
	80	3.500	2.900	0.300	3.55	3.02	3.89	2.23	1.14	5.3
	160	3.500	2.624	0.438	4.95	4.21	5.04	2.88	1.09	3.5
3 1/2	5	4.000	3.834	0.083	1.20	1.02	1.96	0.98	1.39	23.6
	10	4.000	3.760	0.120	1.72	1.46	2.76	1.38	1.37	16.2
	40	4.000	3.548	0.226	3.15	2.68	4.79	2.39	1.34	8.3
	80	4.000	3.364	0.318	4.33	3.68	6.28	3.14	1.31	5.8
4	5	4.500	4.334	0.083	1.35	1.15	2.81	1.25	1.56	26.6
	10	4.500	4.260	0.120	1.94	1.65	3.96	1.76	1.55	18.3
	40	4.500	4.026	0.237	3.73	3.17	7.23	3.21	1.51	9.0
	80	4.500	3.826	0.337	5.18	4.41	9.61	4.27	1.48	6.2
	120	4.500	3.624	0.438	6.57	5.59	11.7	5.18	1.44	4.6
	160	4.500	3.438	0.531	7.79	6.62	13.3	5.90	1.42	3.7
5	5	5.563	5.345	0.109	2.20	1.87	6.95	2.50	1.93	25.0
	10	5.563	5.295	0.134	2.69	2.29	8.43	3.03	1.92	20.3
	40	5.563	5.047	0.258	5.06	4.30	15.2	5.45	1.88	10.3
	80	5.563	4.813	0.375	7.19	6.11	20.7	7.43	1.84	6.9
	120	5.563	4.563	0.500	9.35	7.95	25.7	9.25	1.80	5.1
	160	5.563	4.313	0.625	11.4	9.70	30.0	10.8	1.76	4.0
6	5	6.625	6.407	0.109	2.62	2.23	11.8	3.58	2.30	29.9
	10	6.625	6.357	0.134	3.21	2.73	14.4	4.35	2.30	24.2
	40	6.625	6.065	0.280	6.56	5.58	28.1	8.50	2.25	11.3
	80	6.625	5.761	0.432	9.88	8.40	40.5	12.2	2.19	7.2
	120	6.625	5.501	0.562	12.6	10.7	49.6	15.0	2.15	5.4
	160	6.625	5.187	0.719	15.7	13.3	59.0	17.8	2.10	4.1

Table 2-20
ALLOWABLE STRESSES FOR BUILDING TYPE STRUCTURES

6005-T5 Extrusions up through 1.000 in. thick
6105-T5 Extrusions up through 0.500 in. thick

White bars apply to unwelded metal
Shaded bars apply to weld-affected metal

For tubes with circumferential welds, Sections 3.4.10, 3.4.12, and 3.4.16.1 apply for $R_b/t < 20$

Type of Stress	Type of Member or Element		Sec. 3.4.	Allowable Stress	
TENSION, axial	Any tension member	gross section net section	1	21 19	12.5
TENSION IN BEAMS, extreme fiber, net section	Flat elements in uniform tension		2	19	8
	Round or oval tubes		3	24	9
	Flat elements in bending in their own plane, symmetric shapes		4	28	10
BEARING	On rivets and bolts		5	39	25
	On flat surfaces and pins and on bolts in slotted holes		6	26	16

Type of Stress	Type of Member or Element	Sec. 3.4.	Allowable Stress, $S \leq S_1$	S_1	Allowable Stress, $S_1 < S < S_2$	S_2	Allowable Stress, $S \geq S_2$
COMPRESSION IN COLUMNS, axial	All columns	7	–	0	$20.2 - 0.126\ kL/r$	66	$51100\ /(kL/r)^2$
			–	0	$7.4 - 0.034\ kL/r$	144	$51100\ /(kL/r)^2$
COMPRESSION IN COLUMN ELEMENTS, gross section	Flat elements supported on one edge – columns buckling about a symmetry axis	8	21	2.4	$23.1 - 0.787\ b/t$	10	$154\ /(b/t)$
			8	3.8	$8.7 - 0.224\ b/t$	19	$85\ /(b/t)$
	Flat elements supported on one edge – columns not buckling about a symmetry axis	8.1	21	2.4	$23.1 - 0.787\ b/t$	12	$1970\ /(b/t)^2$
			8	3.8	$8.7 - 0.224\ b/t$	26	$1970\ /(b/t)^2$
	Flat elements supported on both edges	9	21	7.6	$23.1 - 0.247\ b/t$	33	$491\ /(b/t)$
			8	12	$8.7 - 0.070\ b/t$	62	$271\ /(b/t)$
	Flat elements supported on one edge and with stiffener on other edge	9.1	see Part IA Section 3.4.9.1				
	Flat elements supported on both edges and with an intermediate stiffener	9.2	see Part IA Section 3.4.9.2				
	Curved elements supported on both edges	10	21	1.4	$22.1 - 0.799\ \sqrt{R_b/t}$	141	$3190\ /\left(\frac{R_b}{t}\right)\left(1 + \frac{\sqrt{R_b/t}}{35}\right)^2$
			8	6.6	$8.6 - 0.275\ \sqrt{R_b/t}$	450	$3190\ /\left(\frac{R_b}{t}\right)\left(1 + \frac{\sqrt{R_b/t}}{35}\right)^2$

COMPRESSION IN BEAMS, extreme fiber, gross section	Single web shapes	11	21	21	$23.9 - 0.124\ L_b/r_y$	79	$87000\ /(L_b/r_y)^2$
			8	26	$8.8 - 0.034\ L_b/r_y$	172	$87000\ /(L_b/r_y)^2$
	Round or oval tubes	12	25	29	$39.3 - 2.70\ \sqrt{R_b/t}$	81	Same as
			9	62	$15.2 - 0.764\ \sqrt{R_b/t}$	184	Section 3.4.10
	Solid rectangular and round sections	13	28	14	$40.5 - 0.927\ \frac{d}{t}\sqrt{\frac{L_b}{d}}$	29	$11400\ /\left(\frac{d}{t}\right)^2\frac{L_b}{d}$
			10	19	$13.7 - 0.182\ \frac{d}{t}\sqrt{\frac{L_b}{d}}$	50	$11400\ /\left(\frac{d}{t}\right)^2\frac{L_b}{d}$
	Tubular shapes	14	21	123	$23.9 - 0.238\ \sqrt{\frac{2L_bS_c}{\sqrt{I_yJ}}}$	1680	$23600\ /\frac{2L_bS_c}{\sqrt{I_yJ}}$
			8	190	$8.8 - 0.065\ \sqrt{\frac{2L_bS_c}{\sqrt{I_yJ}}}$	8070	$23600\ /\frac{2L_bS_c}{\sqrt{I_yJ}}$
COMPRESSION IN BEAM ELEMENTS, (element in uniform compression), gross section	Flat elements supported on one edge	15	21	6.5	$27.3 - 0.930\ b/t$	10	$182\ /(b/t)$
			8	9	$10.3 - 0.265\ b/t$	14	$101\ /(b/t)$
	Flat elements supported on both edges	16	21	21	$27.3 - 0.292\ b/t$	33	$580\ /(b/t)$
			8	29	$10.3 - 0.083\ b/t$	62	$320\ /(b/t)$
	Curved elements supported on both edges	16.1	25	2.1	$26.2 - 0.944\ \sqrt{R_b/t}$	141	$3780\ /\left(\frac{R_b}{t}\right)\left(1 + \frac{\sqrt{R_b/t}}{35}\right)^2$
			9	8.2	$10.1 - 0.325\ \sqrt{R_b/t}$	450	$3780\ /\left(\frac{R_b}{t}\right)\left(1 + \frac{\sqrt{R_b/t}}{35}\right)^2$
	Flat elements supported on one edge and with stiffener on other edge	16.2	see Part IA Section 3.4.16.2				
	Flat elements supported on both edges and with an intermediate stiffener	16.3	see Part IA Section 3.4.16.3				
COMPRESSION IN BEAM ELEMENTS, (element in bending in own plane), gross section	Flat elements supported on tension edge, compression edge free	17	28	9.1	$40.5 - 1.41\ b/t$	19	$4930\ /(b/t)^2$
			10	12	$13.7 - 0.277\ b/t$	33	$4930\ /(b/t)^2$
	Flat elements supported on both edges	18	28	48	$40.5 - 0.270\ h/t$	75	$1520\ /(h/t)$
			10	65	$13.7 - 0.053\ h/t$	129	$881\ /(h/t)$
	Flat elements supported on both edges and with a longitudinal stiffener	19	28	110	$40.5 - 0.117\ h/t$	173	$3500\ /(h/t)$
			10	150	$13.7 - 0.023\ h/t$	300	$2040\ /(h/t)$
SHEAR IN ELEMENTS, gross section	Unstiffened flat elements supported on both edges	20	12	36	$15.8 - 0.101\ h/t$	64	$38700\ /(h/t)^2$
			4.5	50	$6.0 - 0.029\ h/t$	139	$38700\ /(h/t)^2$
	Stiffened flat elements supported on both edges	21	12	–	12	66	$53200\ /(a_e/t)^2$
			4.5	93	$8.2 - 0.039\ a_e/t$	139	$53200\ /(a_e/t)^2$