2

STRUCTURAL CALCULATIONS
Mechanical Unit on Roof

PROJECT:

Atiyeh Bros.
Cleaning Facility
1516 SE Divison Street
Portland, OR 97202

for

Atiyeh Bros.
Rug and Carpet Cleaning

STRUCTURAL
James G. Pierson, Inc.
Since 1945
ENGINEERS

REGISTERED PROFESSIONAL
ENGINEER
18346PE
OREGON
MARCH 19, 1998
PETER R. GOLBERG
…: JUNE. 30, 13

12-216549-MT

James G. Pierson, Inc.
Consulting Structural Engineers
610 S.W. ALDER SUITE 918 PORTLAND, OR. 97205
(503) 226-1286 FAX 226-3130

December 7, 2012

TASK: Add Mech unit on Roof of business.

- Large wood Girder Trusses @ ± 17 ft o/c.

2x 12 framing between.

- make platform on top of roof to support mech.

- Mech. units - 2000# max (985# model used)

1000# per support

trusses - 15 psf DL, 25 psf LL × 17 ft = 680 lbs/ft
50 ft span = 34000#

- Add 1000# mech 35/34 = 2.9% increase.

(E) Large trusses okay for new load.

- Design new beams to carry mech platform to trusses.

- see Enercalc attached. _use (2) 4x10's to make platform.

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Project	Job no.
Location	Date
Client	Sheet no.

James G. Pierson, Inc. — Structural Engineers

Peder Golberg, PE, SE
James G. Pierson, Inc.
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Title :
Dsgnr:
Description :

Scope :

Job #
Date: 8:25AM, 7 DEC 12

General Timber Beam

Description Mech Platform Beam

General Information

Code Ref: 1997/2001 NDS, 2000/2003 IBC, 2003 NFPA 5000. Base allowables are user defined

Section Name	4x10	Center Span	17.00 ft	.....Lu	0.00 ft
Beam Width	3.500 in	Left Cantilever	ft	.....Lu	0.00 ft
Beam Depth	9.250 in	Right Cantilever	ft	.....Lu	0.00 ft
Member Type	Sawn	Douglas Fir - Larch, No.2			
		Fb Base Allow	900.0 psi		
Load Dur. Factor	1.000	Fv Allow	180.0 psi		
Beam End Fixity	Pin-Pin	Fc Allow	625.0 psi		
		E	1,600.0 ksi		

Point Loads

Dead Load	1,000.0 lbs	lbs	lbs	lbs	lbs	lbs	lbs
Live Load	lbs	lbs	lbs	lbs	lbs	lbs	lbs
...distance	8.500 ft	0.000 ft	0.000 ft	0.000 ft	0.000 ft	0.000 ft	0.000 ft

Summary

Beam Design OK

Span= 17.00ft, Beam Width = 3.500in x Depth = 9.25in, Ends are Pin-Pin

Max Stress Ratio 0.946 : 1

Maximum Moment	4.2 k-ft	Maximum Shear * 1.5	0.8 k
Allowable	4.5 k-ft	Allowable	5.8 k

Max. Positive Moment	4.25 k-ft	at	8.500 ft	Shear:		@ Left	0.50 k
Max. Negative Moment	0.00 k-ft	at	17.000 ft			@ Right	0.50 k
Max @ Left Support	0.00 k-ft			Camber:		@ Left	0.000 in
Max @ Right Support	0.00 k-ft					@ Center	0.718 in
Max. M allow	4.49			Reactions...		@ Right	0.000 in
fb	1,021.81 psi	fv	23.17 psi	Left DL	0.50 k	Max	0.50 k
Fb	1,080.00 psi	Fv	180.00 psi	Right DL	0.50 k	Max	0.50 k

Deflections

Center Span...	Dead Load	Total Load	Left Cantilever...	Dead Load	Total Load
Deflection	-0.479 in	-0.479 in	Deflection	0.000 in	0.000 in
...Location	8.500 ft	8.500 ft	...Length/Defl	0.0	0.0
...Length/Defl	426.0	426.01	**Right Cantilever...**		
Camber (using 1.5 * D.L. Defl) ...			Deflection	0.000 in	0.000 in
@ Center	0.718 in		...Length/Defl	0.0	0.0
@ Left	0.000 in				
@ Right	0.000 in				

Stress Calcs

Bending Analysis

Ck	34.195	Le	0.000 ft	Sxx	49.911 in3	Area	32.375 in2
Cf	1.200	Rb	0.000	Cl	500.000		

	Max Moment	Sxx Req'd	Allowable fb
@ Center	4.25 k-ft	47.22 in3	1,080.00 psi
@ Left Support	0.00 k-ft	0.00 in3	1,080.00 psi
@ Right Support	0.00 k-ft	0.00 in3	1,080.00 psi

Shear Analysis	@ Left Support	@ Right Support
Design Shear	0.75 k	0.75 k
Area Required	4.167 in2	4.167 in2
Fv: Allowable	180.00 psi	180.00 psi

Bearing @ Supports

Max. Left Reaction	0.50 k	Bearing Length Req'd	0.229 in
Max. Right Reaction	0.50 k	Bearing Length Req'd	0.229 in

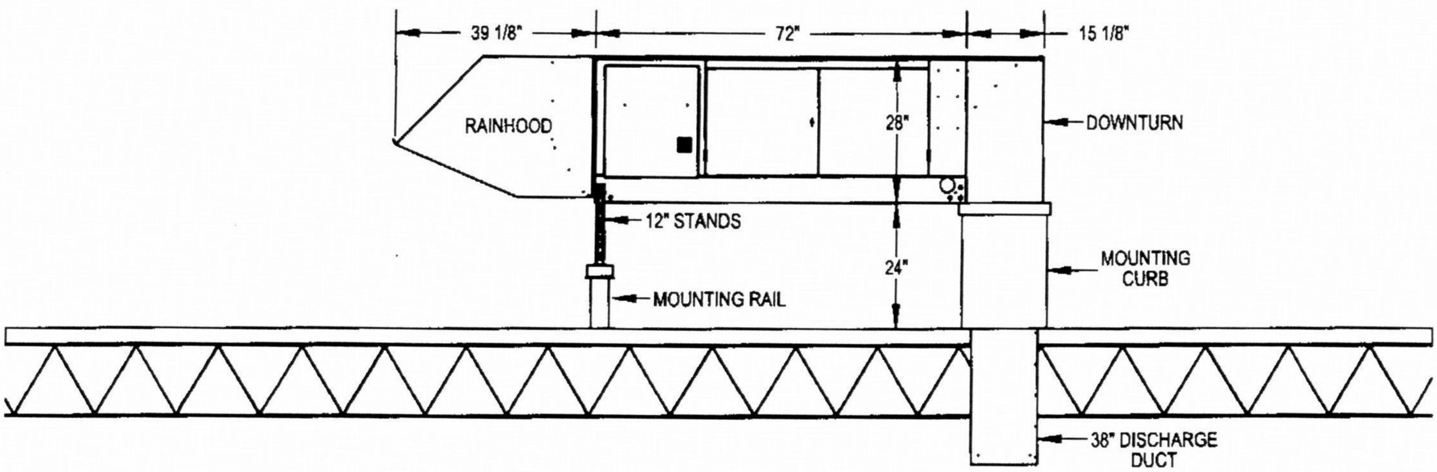
Genuine Cambridge

PROJECT:	Rug Drying Room
LOCATION:	St. Louis, MO
DATE:	02/23/12
QUOTE #:	Q-17833-w

Model S1200 Blow-Thru® Space Heater

Roof Top Configuration

NOTES:
- All mounting hardware by others
- Heater width = 42"
- Recommended roof opening: 16½" L x 43½" W
- 15' - 25' AFF recommended discharge height



Gas Information

Supply	Max Pressure	Inlet Size
Natural Gas	2 psi	1¼" NPT

- Cambridge Engineering stainless steel burner
- High pressure regulator provided
- EDSM Gas Controls
- Space temperature dial on side of remote control
- Intermittent/continuous operating controls

Electric Information

Supply	HP	FLA
460V/3PH/60HZ	3	6

- Integral non-fused disconnect switch
- Premium efficiency ODP motor with adjustable sheaves
- Integral motor starter with thermal overloads
- One exhaust fan interlock (heater slave to exhaust)
- Remote control station including:
  - Electronic operating thermostat

Unit Specifications

Qty	Airflow	TESP	Input	Output	Weight (ea.)
1	5,767 CFM	0.30"WC	1200 MBH	1104 MBH	985 lbs.

- Gray polyester powder coat finish
- Two position motorized discharge damper
- Full 2 year parts warranty / 5 year burner warranty

WARNING

DO NOT ATTEMPT TO SUBSTITUTE

any other heater for a Genuine Cambridge Blow-Thru® Space Heater. The technologies are different. Ability to heat the building will be jeopardized and energy costs will increase.

Seismic Design Forces on Mechanical Units

Task: Determine the lateral forces (seismic) and required connections for roof top mechanical units installed on a wood framed structure. The vertical adequacy of the wood framed structure for the weight of the mechanical unit, resulting snow drift, and other dead and live loads is beyond the scope of this lateral analysis and unless specifically noted in other sections of this calculation package is the responsibility of others.

References: 2009 IBC (2010 OSSC) Section 1613.1

ASCE 7-05 Section 13.6 for mechanical components and systems

Criteria: Seismic Design Category D, Component Importance Factor Ip = 1.00
S_{DS} = 1.1 or less (covers all of Oregon/Washington and will be conservative for most jurisdictions. For instance, for Portland, Oregon Sds = 0.75

Application of OSSC Requirements:

Section 13.3.1 - Seismic Forces

Total design lateral force:

$$F_p = \frac{0.40 a_p S_{DS} I_p}{R_p}\left(1 + 2\frac{z}{h}\right)W_p \qquad \text{Eq. 13.3-1}$$

Except that: $$F_p > 0.3 S_{DS} I_p W_p \quad and \quad F_p \le 1.6 S_{DS} I_p W_p \qquad \text{Eq. 13.3-2, -3}$$

Table 13.6-1 - Horizontal Force Factors, a_p and R_p

HVAC systems. - **a_p = 1.0 and R_p = 2.5**

Load Combinations - Members and the connection design shall use the load combinations and factors specified in Section 2.3.2. The reliability/redundancy factor may be taken as 1.0 and Fp is substituted for Q_E.

Design Lateral Force:

$Fp = 0.40\ a_p\ Sds\ Ip / Rp\ [1 + 2z/h]\ Wp$	=	**0.528 Wp**
Fp need not exceed 1.6 Sds Ip Wp	=	1.76 Wp
Fp shall not be less than 0.3 Sds Ip Wp	=	0.33 Wp

The design will be controlled by Fp = 0.528 Wp

Overturning:

Overturning will be controlled by Equation 2.3.2-7 of the Basic Load Combinations for Strength Design which is:

0.9 D + E

In this equation, according to ASCE 7 the value of E shall include

E = pQe - 0.2 Sds D = 1.0 Qe - [0.2 x 1.1 x D] **= Qe - 0.22 D**

Therefore, when substituting Qe Equation 16-18 becomes <u>**0.68 D + E**</u>

Continue with a generic Working Stress Method overturning analysis using a York unit (Y14AC04N2KDCCB) to illustrate specific aspects of design. This unit may not be used on this particular project but is used to investigate overturning issues.

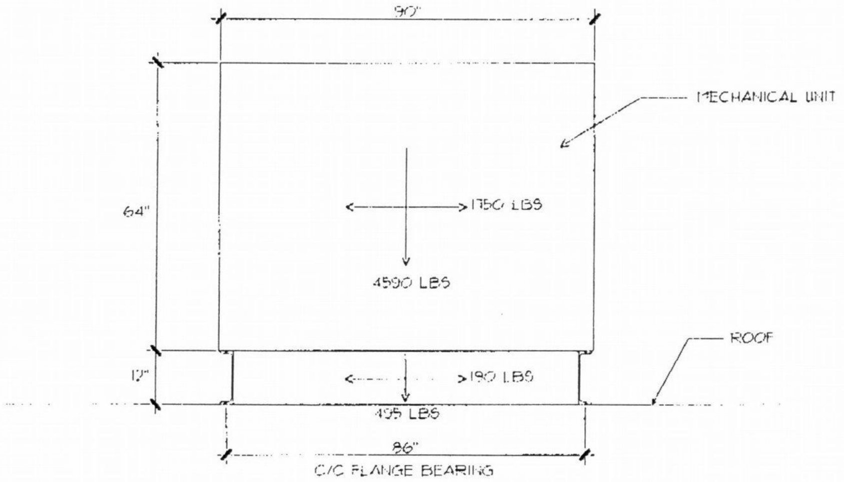
By inspection, overturning is more critical in the width of the unit as the unit is more than twice and long as wide. The design calculations are therefore:

Weight of unit with accessories is	5100 lbs = Wp
Seismic Force of unit Fp = 0.528 Wp	<u>2693 lbs</u>
Weight of standard curb (estimated)	550 lbs = Wp
Seismic Force of curb Fp = 0.528 Wp	<u>290 lbs</u>

Overturning check - continued:

Assume Center of gravity of unit and curb is located at center of height. The following forces apply to allowable stress stability calculations using Equation 16-18 as modified for Qe

Unit -	0.68 D =	.68 (5100) =	3468 lbs
	E =		2695 lbs
Curb -	0.68 D =	.68 (550) =	374 lbs
	E =		290 lbs



Compute Stability about bottom of curb

Overturning Moment = 2695 lbs x 44" = 118,580 in-lbs

290 lbs x 6" = 1,740 in-lbs

Total Overturning Moment = 120,320 in-lbs

Restoring Moment = (3468 lbs + 374 lbs) x 43" = 165,206 in-lbs

Safety Factor Against Overturning = 165,206 / 120,320 = 1.37

From this calculation, it is demonstrated that a typically proportioned mechanical unit is ordinarily stable against overturning without benefit of hold down anchors. Overturning will generally not be a problem unless the height of the unit is greater than two times the width.

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Project: Atiyeh Bros HVAC on roof	Job no.
Location: 1516 SE Division Street, Portland	Date: 12-3-12
Client: Atiyeh Bros	Sheet no.

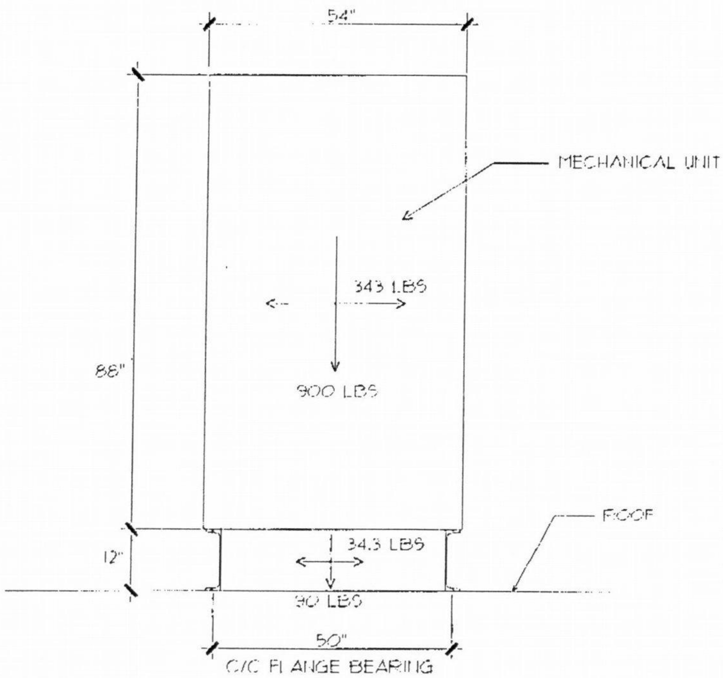
Overturning check - continued:

The prior calculations show appropriate formulas for calculating seismic forces of rigidly attach roof top mechanical units which can be summarized as:

Strength design F_p= 0.528 W_p
Working Stress = E/1.4
Thus, using working stress methods, the horizontal force to be resisted by positive mechanical connections (NO FRICTION) is finally equal to 0.528/1.4 =
37.7% of unit + curb weight.

It has been illustrated that overturn stability is usually not a problem & need not be specifically investigated until the height of the unit exceeds its width by more than two times. Base connections provided for horizontal forces will generally be effective in resisting overturning forces & can add to stability of taller units.

Example of unit with height = 2 times width:
Unit weight = 1000 lbs
Curb weight = 100 lbs



Overturning Moment:
(37.7 lbs)(6")+(377 lbs)(56") = 21,338 in-lbs

Restoring Moment: (using 0.68D)
(680 lbs + 68 lbs)(25") = 18,700 in-lbs

In this example, the unit requires connections to resist overturn moment of:
21,338 - 18,700 = 2,638 in-lbs.
Since the base width is 50 inches, a connector which provides 100 lbs of tensile strength will provide an overturn resistance of:

100 lbs x 50" = 5,000 in-lbs

Thus, a single 100 pound connection is sufficient to provide stability against overturning

Base Connection From Curb to Roof

Diaphragm:

For typical roof top units, seismic attachment becomes a relatively simple matter of making a positive connection from the standard steel channel curb into the roof diaphragm system.

For a wood roof system, it will ordinarily be more convenient to use working stress values for connector designs. Generally it will not be necessary to go beyond the connector (screw or lag) design as the relatively small horizontal forces can be absorbed by the roof diaphragm.

Most mechanical curbs come pre-punched for base screw of lags, and many mechanical subcontractors will habitually use lag screws for this attachment. Often these lag screws are found to be 3/8" diameter, apparently stemming from standard plumbing/mechanical braces & brackets fabricated for "SMACNA" standard applications. The use of 3/8" diameter lags is unnecessary (but certainly acceptable) and smaller connectors are also acceptable.

Examples of Suitable Connectors:

Simpson SDS 1/4 x 2 screw

Shear Capacity in D.F. — 303 lb with 10 gage side plate
327 lb with 3 gage side plate

2002 NDS 1/4" Dia. Lag Screw

$G = 0.49$ D.F. — $Z_{II} = 220$ lb $Z_{PERP.} = 160$ w/10 gage plate
$Z_{II} = 260$ lb $Z_{PERP.} = 190$ w/3 gage plate

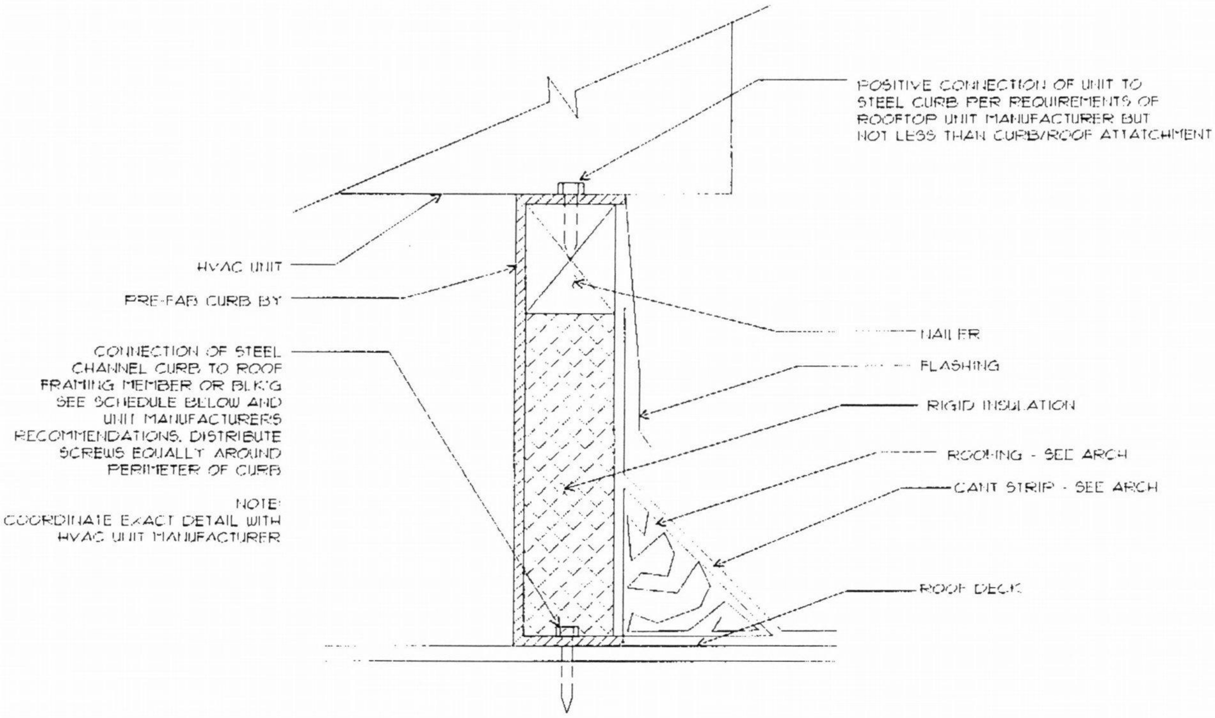
2002 NDS #14 Gage Cut Thread
Wood Screw
$D = 0.242$
$G = 0.49$ D.F. — $Z = 182$ lb w/10 gage plate
$Z = 221$ lb w/3 gage plate

The lowest value found above is 160 lbs for perp. to grain installation of 1/4" diameter lag. For seismic shear this value would be 1.33(160 lbs) = **213 lbs**

Thus it seems prudent to construct a table using a conservative value of 150 lbs per connector, to allow for any imperfections of connection installation such as minimal penetration or edge distances, and base the table on the following screws or lags.

#14 x 2-1/2" Cut Thread Wood Screw
1/4" Dia. x 2-1/2" min. Standard Lag Screw
Simpson SDS 1/4" x 2-1/2" Hex Head Wood Screw

Typical Curb Detail and Connector Table:



MAXIMUM WEIGHT OF MECH. UNIT + CURB (POUNDS)	HORIZONTAL SEISMIC FORCE FORCE GENERATED IN UBC SEISMIC ZONE 3 (POUNDS)	MINIMUM NUMBER OF SCREWS OR LAGS FROM CURB TO ROOF STRUCTURE
1000	343	4
1500	514	6
2000	686	6
2500	857	8
3000	1029	8
4000	1311	10
5000	1714	12
6000	2057	15

CONNECTORS ARE TO BE INSTALLED THROUGH THE BOTTOM FLANGE OF THE STEEL CURB SECTION THROUGH THE ROOF PLYWOOD SHEATHING AND INTO A WOOD FRAMING MEMBER (OR WOOD BLOCKING) BELOW. VERTICAL SUPPORT OF THE WEIGHT OF THE MECHANICAL UNIT IS A SEPARATE CONSIDERATION AND SHALL BE PROVIDED FOR BY ARRANGEMENT OF ROOF STRUCTURAL FRAMING NOT SHOWN SPECIFICALLY BY THIS TABLE OR DETAIL. APPROVED CONNECTORS INCLUDE THE FOLLOWING - LARGER SIZES MAY BE USED.

#14 X 2 1/2" MINIMUM LENGTH CUT THREAD WOOD SCREW
1/4" DIAMETER X 2 1/2" MINIMUM LENGTH STANDARD LAG SCREW
"SIMPSON" SDS1/4 X 2 1/2" MINIMUM LENGTH HEX HEAD WOOD SCREW

James G. Pierson, Inc. Consulting Structural Engineers 610 SW Alder, Suite 918 Portland, Oregon 97205 T: 530-226-1286 F: 503-226-3130 jgpierson.com	Project Atiyeh Bros HVAC on roof	Job no.
	Location 1516 SE Division Street, Portland	Date 12-3-12
	Client Atiyeh Bros	Sheet no.

Base Connection From Curb to Concrete Roof

Diaphragm:
For typical roof top units, seismic attachment becomes a relatively simple matter of making a positive connection from the standard steel channel curb or wood leveling curb to the roof diaphragm system.

For a concrete roof system, it will ordinarily be more convenient to use factored load values for connector designs. Generally it will not be necessary to go beyond the connector (anchor bolt) design as the relatively small horizontal forces can be absorbed by the roof diaphragm.

Most mechanical curbs come pre-punched for the base connection , and many mechanical subcontractors will habitually use lag screws for this attachment. Often these lag screws are found to be 3/8" diameter, apparently stemming from standard plumbing/mechanical braces & brackets fabricated for "SMACNA" standard applications. The use of 3/8" diameter lags is unnecessary (but certainly acceptable) and smaller connectors are also acceptable. To attach curb (steel or wood) to a concrete roof, the 3/8" size of bolt is therefore chosen.

Examples of Suitable Connectors:

Simpson Titen HD 3/8 x 2 1/2" embedment bolt

Shear Capacity in concrete:. Use 500 lb with 10 gage curb

See Simpson Anchor Calculations attached

Thus it seems prudent to construct a table using a conservative value of 250 lbs per connector, to allow for any imperfections of connection installation such as minimal penetration or edge distances, and base the table on the 3/8" Titen HD.