ENGINEERING CALCULATIONS AND ANALYSIS REPORT

ECAR No.: 423 ECAR Rev. No.: 1 Project File No.: N/A Date: 10/30/2008

Title: ANALYSIS OF SUPPLEMENTAL ANCHORAGE FOR PPS CABINETS

1. Index Codes

Building/Type: 670 SSC ID: N/A Site Area: TRA

2. Quality Level: 1

3. Objective/Purpose

The purpose of this calculation is to perform a structural evaluation of the supplemental anchorage for the PPS cabinets in the first basement of TRA-670. The exact configuration and capacity of the existing anchorage are unknown, so supplemental anchorage is being provided. The supplemental anchorage is designed to hold the cabinets fast during a safe shutdown earthquake (SSE).

4. Conclusions/Recommendations

The design documented in Drawing 600848 provides adequate capacity to secure the ATR PPS cabinets against PC-4 level safe shutdown earthquake loading.

Revision 1 of this analysis considers the as-installed condition where a minimum of four (4) Hilti HDA anchors are installed on the side of each long cabinet, and the end anchors of the short cabinet are inset about seventeen (17) inches from the end of the cabinet. This analysis concludes that the as-installed configuration satisfies the applicable seismic requirements.

5. Review (R) and Approval (A) and Acceptance (Ac)[1]:

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Performer/Author		S. R. Jensen / GA00	SR Jensen 10/30/08
Performer/Author		D. J. Stewart / W221	Appendix C N/A No change in Rev. 1
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Technical Checker	R	R. D. McMurtrey / W221	Appendix C N/A No change in Rev 1
Independent Peer Reviewer[3]	R	M. J. Russell / W210	By SR Jensen per e-mail 10/30/08
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1 Review and Approval are required. See LWP-10200 for definitions and responsibilities.
2 An Electronic Change Request (ECR) indicating final review and concurrence by the listed individuals can be used in lieu of signatures.
3 If Required, per LWP-10200.

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Scope and Brief Description

The purpose of this calculation is to perform a structural evaluation of the supplemental anchorage for the Plant Protective System (PPS) cabinets (Ref. 1) in the first basement of TRA-670. The exact configuration and capacity of the existing anchorage are unknown, so supplemental anchorage is being provided. The supplemental anchorage is designed to hold the cabinets fast during a safe shutdown earthquake (SSE).

Design Inputs and Sources

a) Quality Level 1 is defined per QLD RTC-000550, "Seismic Analysis of ATR Seismic Category 1 SSC"
b) ATR SC-1 structures, systems and components (SSC) are analyzed for PC-4 loading, which is the project direction of the ATR Seismic Assessment Project, per PLN-588 (Ref. 2).
c) Seismic inputs are taken from the probabilistic soil-structure interaction analysis (PSSI) (Ref 3).

Results of Literature Searches and Other Background Data

The seismic functionality of the PPS cabinets has been previously evaluated (Ref. 4). This evaluation included consideration of the structural integrity of the rooms, potential interaction hazards, and the operability of the equipment within the cabinets. However, the exact configuration and capacity of the existing anchorage was unknown. Rather than perform destructive testing and examination to determine the existing capacity, it was thought preferable to design and install supplemental anchorage with known capacity. Such anchorage has been designed as shown in Drawing 600848 (Ref. 1).

The seismic input at the PPS room location is based upon a probabilistic soil-structure interaction which produced 80% non-exceedance probability (NEP) in-structure response spectra suitable for evaluation of ATR equipment (Ref. 3). Since these spectra are available for a limited number of points at each floor of TRA-670, the analyst must select the point with reported spectra that is most representative of the location of interest. The selection of spectra is further discussed under "Analysis."

An extensive document search was conducted to determine the weight of the PPS cabinets. No documented weight value was found. Therefore, this analysis will be based upon conservative estimates. This is considered acceptable, as will be demonstrated, because of the overall robustness of the anchorage design.

Revision 1 of this analysis considers the as-installed condition where a minimum of four (4) Hilti HDA anchors are installed on the side of each long cabinet, and the end anchors of the short cabinet are inset about seventeen (17) inches from the end of the cabinet.

Assumptions

Except where field verification is noted, it is assumed that physical materials and configurations conform to the drawings and specifications.

Computer Code Validation

Mathcad versions 13 and 14 are used on Dell desktop computers running Windows XP professional service pack 2. Validation of the calculations is by manual checking performed by the technical checker.

Analysis

The analysis is based upon the in-structure spectra from Reference 3. The map of the first basement, showing points with available spectra, is copied here as Figure 1.

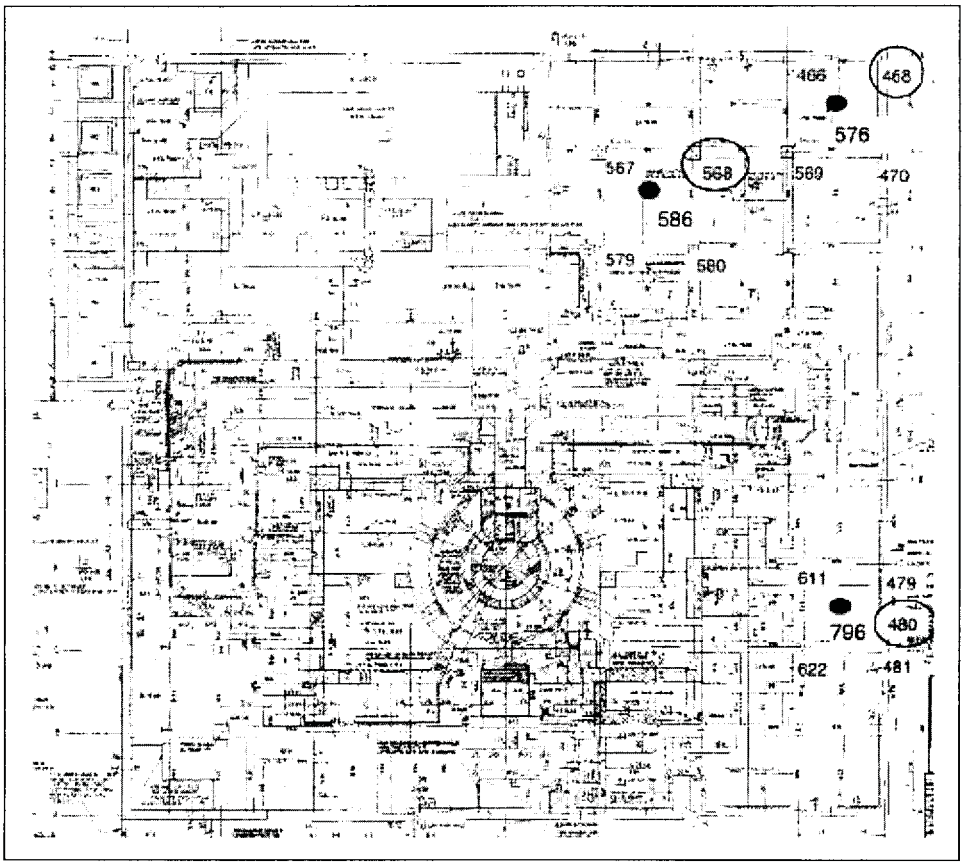


Figure 1: Locations of In-Structure Response Spectra

As can be seen, node 796 is in the center of the PPS rooms, and provides an appropriate input for the PPS room evaluations.

The input is taken as peak of the horizontal 3% damped response spectra, which is conservative, and at the ZPA of the vertical spectra. Using the vertical ZPA is justified by the fact that the cabinets are by inspection rigid in the vertical direction. The input spectra applied are illustrated in Figures 2-4 below.

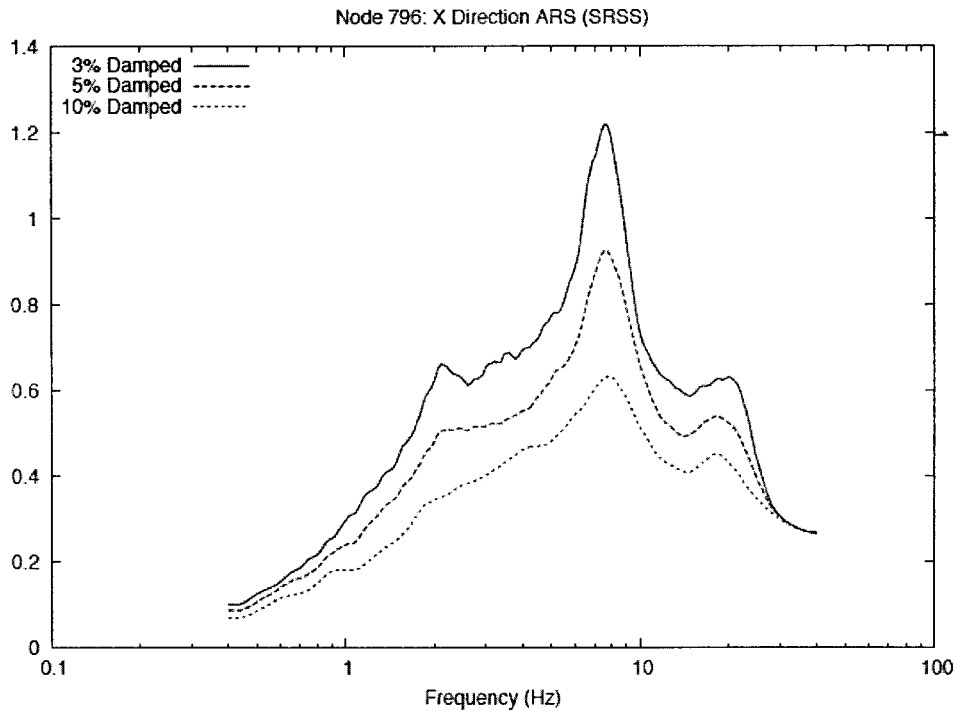


Figure 2: East-West Spectra

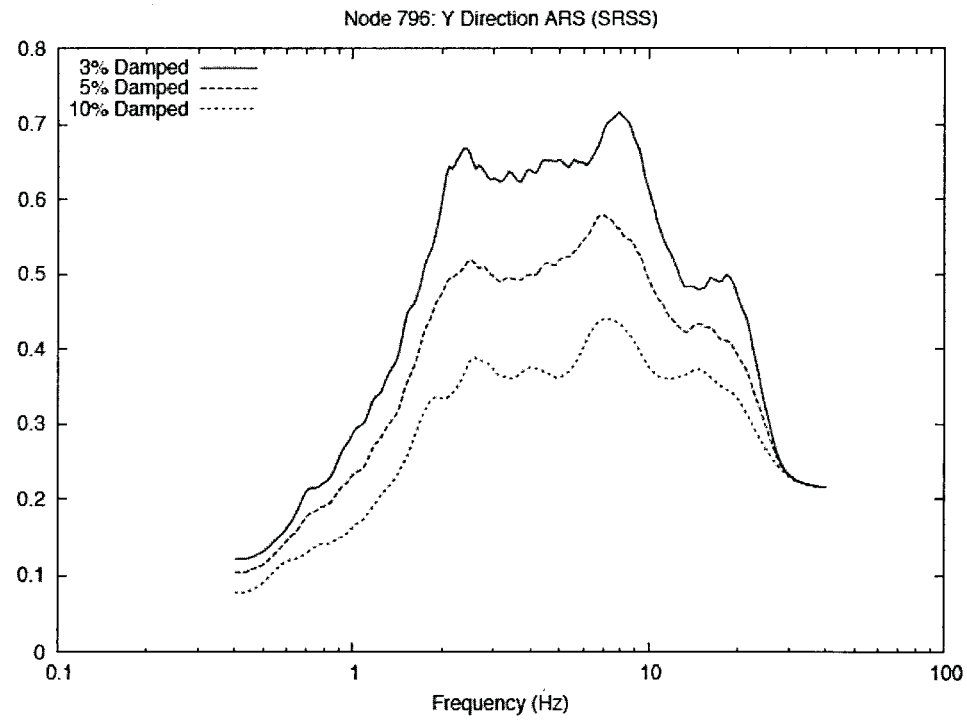


Figure 3: North-South Spectra

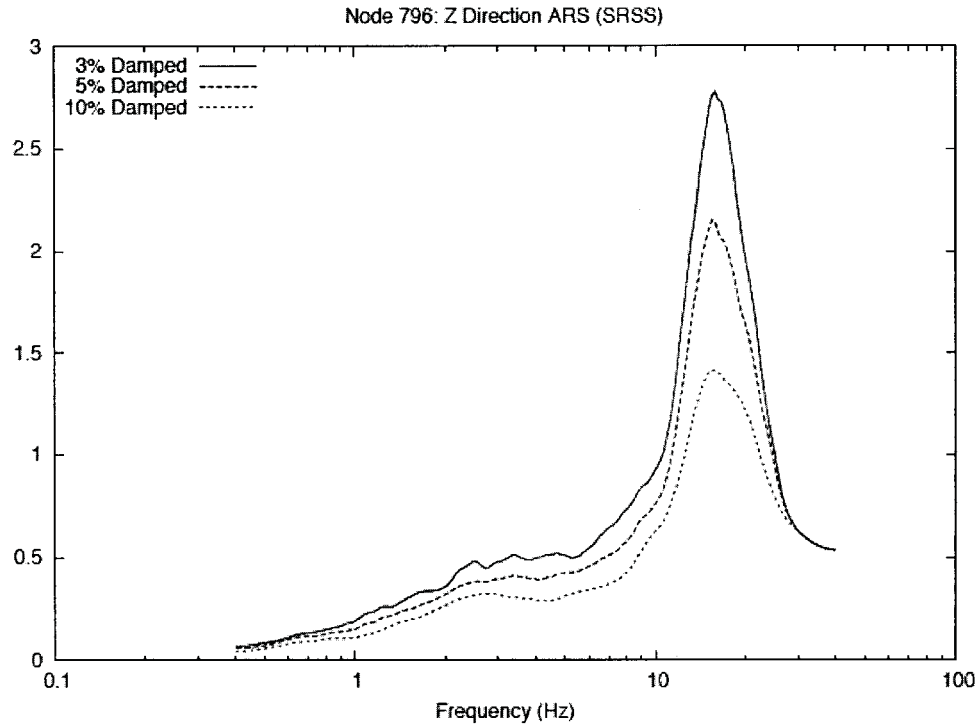


Figure 4: Vertical Spectra

To evaluate the anchorage, the overturning and restoring moments about the short axis of the cabinets are calculated. From these, a required hold-down force at each edge of the cabinets is derived. There is also one short cabinet, for which the long axis is not much longer than the short axis. Because no supplemental anchorage is provided at the short ends of the cabinets, this short cabinet is also evaluated for overturning in the long direction. The required hold-down force on the anchors at the end of the cabinet is calculated, and is less than the per-foot required hold-down force for short axis overturning. Therefore, long-axis overturning is not considered further.

The prying action of the new base angle is considered, and a tensile load on the new anchor bolts is determined. The number of required bolts is calculated from this tensile demand, and compared to the number of bolts provided in the design.

Next the bending in the base angle of the supplemental anchorage is considered. A section modulus per unit length of bending is calculated based upon the thickness of this angle leg material. An allowable bending stress is calculated based upon allowable stress design (Ref. 5) adjusted with a 1.7 factor from DOE-STD-1020-02 (Ref. 6). The total moment in the base angle is calculated, and an effective bending length determined. Because this bending length is less than the distance from the anchor bolts to the edge of the angle, no further consideration of baseplate bending is deemed necessary.

Finally, the capacity of the connection between the supplemental anchorage and the cabinet is considered. This is based upon the allowable shear stress for the connection bolts, and the tear-out capacity over the bolt holes in the base angle. Both of these are found adequate.

Additional analysis is added in Revision 1 to consider the as-installed condition with fewer anchors, and variances in anchor bolt location. The same methods and approach used for the original design are applied to the as-installed design.

Recommendations

It is recommended the supplemental anchorage design be installed consistent with the Drawing 600848 (Ref. 1).

Conclusions

The design documented in Drawing 600848 provides adequate capacity to secure the ATR PPS cabinets against PC-4 level SSE loading.

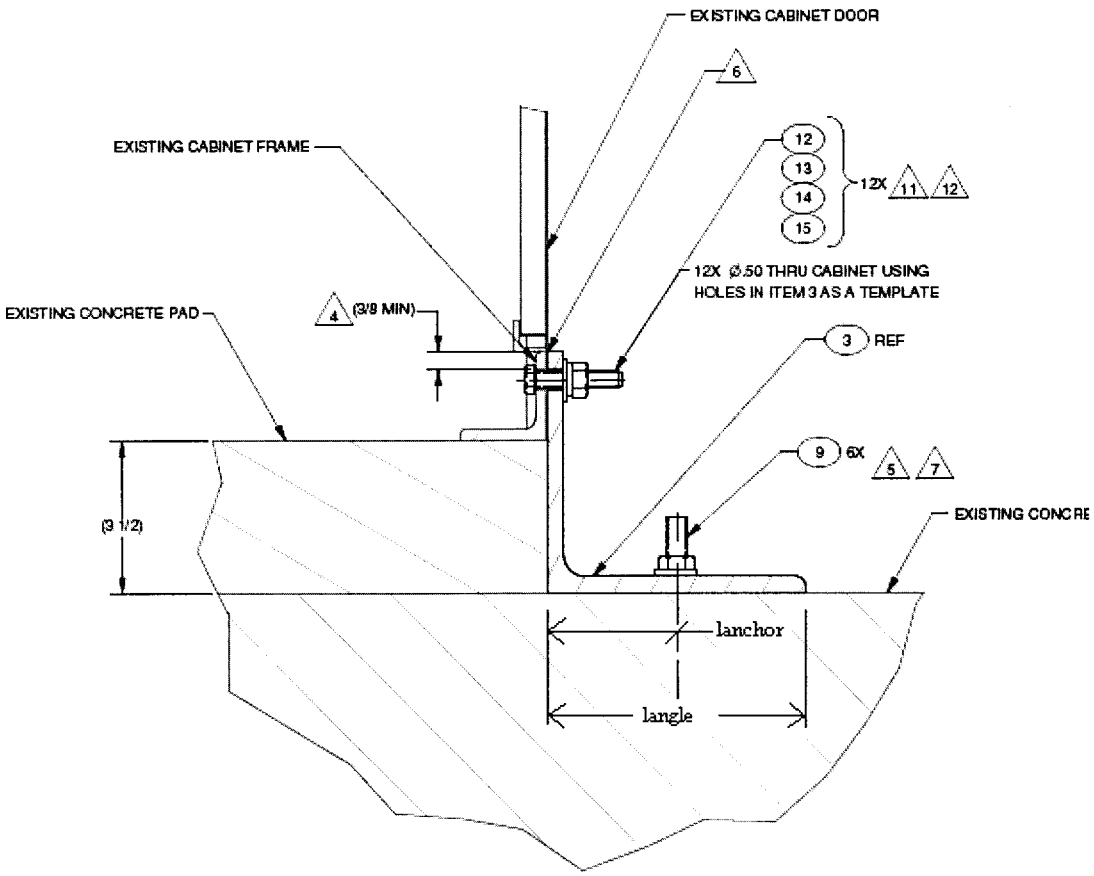
Revision 1 concludes that the as-installed configuration with a minimum of four Hilti HDA anchors per side of a long PPS cabinet, and the corner anchor of the short PPS cabinet inset about 17 inches from the end, also satisfies the applicable seismic requirements and is therefore acceptable.

References

1. Drawing 600848, "ATR FIRST BASEMENT PPS CABINETS ANCHORAGE INSTALLATION & DETAILS," October 2008.
2. PLN-588, "ATR Seismic Assessment Plan," Rev. 3, May 2007.
3. "Probabilistic Soil-Structure Interaction of TRA-670," Report No. CJC-INL-C-003 Revision 1, Carl J. Costantino and Associates, Spring Valley NY, November 2007.
4. "Experience-Based Seismic Qualification of Advanced Test Reactor Seismic Category 1 Equipment," ARES Corporation Report No. 060230101-002 Revision 0, September 2008.
5. AISC, Manual of Steel Construction, Allowable Stress Design, Ninth Edition, 1989.
6. "Natural Phenomena Hazards Design and Evaluatioin Criteria for Department of Energy Facilities," STD-1020-02, U. S. Department of Energy, January 2002.
7. J.E. Shigley and C. R. Mischke, "Mechanical Engineering Design," Fifth Ed., McGraw-Hill, 1989.
8. ASTM A36-05, "Standard Specification for Carbon Structural Steel," ASTM, 2005.

Appendix A: Calculations

Calculate the demands and capacities of the supplemental anchorge. Anchorage is shown on multisheet Drawing 600848. Unless otherwise noted, sheet references are from that drawing.



$l_{angle} := 6 \cdot in$ — item 3 drawing 600848

$l_{anchor} := 4 \cdot in$ — -3 detail zone D-7 sheet 5 drawing 600848, see note 3 sheet 1 for +/- 1.0 inch location

$t_{angle} := \frac{3}{8} \cdot in$ — item 3 drawing 600848

$m_{cab} := 400 \cdot \frac{lbf}{ft \cdot g}$ — total cabinet weight calculated at 3000 lb in Appendix C -- conservatively use 400 lb/ft

$h_{cab} := 88.75 \cdot in$ cabinet height from sheet 2

$d_{cab} := 35.78 \cdot in$ cabinet depth from Appendix C

$d_{cg} := 29.6 \cdot in$ depth of center of gravity -- from Appendix C

$h_{cg} := 57.44 \cdot in$ height of center of gravity -- from Appendix C

$d_n := 0.75 \cdot d_{cab}$ conservatively assume neutral axis for cabinet overturning halfway from the center

$a_v := 0.534 \cdot g$ Node 796 vertical ZPA

$a_{ew} := 1.122 \cdot g$ Node 796 3% east-west spectral peak

$a_{ns} := 0.716 \cdot g$ Node 796 3% north-south spectral peak

$M_o := m_{cab} \cdot h_{cg} \cdot a_{ns}$ overturning moment

$$M_o = 1.645 \times 10^4 \cdot \frac{in \cdot lbf}{ft}$$

$M_r := m_{cab} \cdot (d_{cab} - d_{cg}) \cdot (1 \cdot g - .4 \cdot a_v)$ restoring moment, using 100-40-40 rule from ASCE 4 3.2.7.2

$$M_r = 1.944 \times 10^3 \cdot \frac{in \cdot lbf}{ft}$$

$M_{net} := M_o - M_r$ Net moment

$$M_{net} = 1.451 \times 10^4 \cdot \frac{in \cdot lbf}{ft}$$

$$F_v := \frac{M_{net}}{d_n}$$

$$F_v = 540.594 \cdot \frac{lbf}{ft}$$ required holdown force

$$F_{anchor} := F_v \cdot \frac{l_{angle}}{l_{angle} - l_{anchor}}$$ anchor force, considering prying on the angle base

$$F_{anchor} = 1.622 \times 10^3 \cdot \frac{lbf}{ft}$$

Check anchor demands in the short cabinet for long-axis overturning. In this case use total loads rather than per foot, and assume a single anchor point on each side at the uplifting end.

$l_{short} := 61 \cdot in$

Approximate length of short cabinet, section D-D sheet 4

$Mo_{short} := m_{cab} \cdot l_{short} \cdot a_{ew} \cdot h_{cg}$

overturning moment about long axis on short cabinet -- again assume center of gravity at 2/3 up the cabinet

$$Mo_{short} = 1.31 \times 10^5 \cdot in \cdot lbf$$

$Mr_{short} := m_{cab} \cdot l_{short} \cdot \frac{l_{short}}{2} \cdot (1 \cdot g - .4 \cdot a_v)$

restoring moment, using 100-40-40 rule

$$Mr_{short} = 4.877 \times 10^4 \cdot in \cdot lbf$$

$Fanch_{short} := \frac{Mo_{short} - Mr_{short}}{2(0.75) l_{short}}$

Calculate anchor force, assuming an effective moment arm of 3/4 the cabinet length. Divide be two anchors, one each on north and south.

$$Fanch_{short} = 899.166 \cdot lbf$$

The anchorage demand to resist long-axis overturning of the short cabinet is less than the demand per foot for the short axis. The short axis will govern for all cabinets.

Calculate the number of concrete anchors required for a long cabinet

$T_{allow} := 5456 \cdot lbf$

allowable tensile and shear loads in anchors, from HILTI technical data sheet

$S_{allow} := 6675 \cdot lbf$

$Panch_{each} := \frac{F_{anchor} \cdot 126 \cdot in}{6}$

$$Panch_{each} = 2.838 \times 10^3 \cdot lbf$$

$Panch_{tot} := Panch_{each} + 0.4 \cdot Fanch_{short}$

Add the short axis overturning resistance using 100-40-40 rule

$Panch_{tot} = 3.198 \times 10^3 \cdot lbf$

$\frac{Panch_{tot}}{T_{allow}} = 0.586$

Demand to capacity ratio of concrete anchors in tension

Shear capacity, at 6675 lbf per bolt times 12 bolts, is adequate by inspection.

Calclulate the length of angle required to resist the bending imposed at the angle leg by the uplift of the cabinet and the holdown of the anchor bolt.

$S_{angle} := \frac{t_{angle}^2}{6}$

Section modulus of angle per unit length

$S_{angle} = 0.281 \cdot \frac{in^3}{ft}$

$\sigma y_{angle} := 36000 \cdot psi$

Yield stress of the base angle - Ref. 8

$Fb_{angle} := \sigma y_{angle} \cdot 0.6 \cdot 1.7$

Allowable bending stress in the base angle 0.6 per Ref. 5, 1.7 per Ref. 6 2.3.2.

$M_{angle} := F_v \cdot (l_{angle} - l_{anchor})$

Moment demand on the angle

$lreq_{angle} := \frac{M_{angle} \cdot 126 \cdot in}{S_{angle} \cdot Fb_{angle}}$

required length to develop adquate section modulus to resist imposed bending.

$lreq_{angle} = 13.191 \cdot in$

There are six anchor bolts, each at least 2 inches from an edge. There will clearly be adquate bending resistance in the base angle regardless of the yield line pattern.

Check connection between the new angle base and the cabinet frame:

$a_{bolt} := 0.0775 \cdot in^2$

tensile area of 3/8-16UNC - Ref 7 pg 328

REVISION 1 CHANGE: CABINET BOLTS ARE CHANGED TO GRADE 5 FROM GRADE 8

$\sigma ut_{bolt} := 120000 \cdot psi$

ultimate strength of SAE grade 5 bolting -- Ref. 7 pg 341

$Fs_{bolt} := 0.17 \cdot a_{bolt} \cdot \sigma ut_{bolt}$

Allowable shear stress in bolting - Ref. 5

$Fs_{bolt} = 1.581 \times 10^3 \cdot lbf$

$$Nreq_{bolt} := \frac{F_v \cdot 126 \cdot in}{Fs_{bolt}}$$

Number of required connetion bolts

$$Nreq_{bolt} = 3.59$$

Twelve bolts are provided per side; about 4 would be required. By inspection, the design is also adequate for the contribution from east-west motion

No need to check tear out of the angle in the cabinet frame, because the bolts are holding the angle down and are loading the angle in its large direction. Check tear out of the base angle.

$$d_{bolthole} := \frac{3}{8} \cdot in$$

minimum required web above drilled hole, Section G-G sheet 4 (see note 4 sheet 1)

$$N_{bolt} := 12$$

number of bolts attaching base angle to long cabinet, sheet 3 section B-B

$$Fv_{tot} := F_v \cdot 126 \cdot in$$

Total shear demand for long cabinet

$$\tau_{bolt} := \frac{Fv_{tot}}{N_{bolt} \cdot 2\left(t_{angle} \cdot d_{bolthole}\right)}$$

Shear stress in tear-out area above the bolt hole. Assume a V-pattern tear-out.

$$\tau_{bolt} = 1.682 \times 10^3 \cdot psi$$

shear stress acceptable by inspection.

REVISION 1 CALCULATIONS

Calculate the minimum required number of anchors for the long cabinets in PPS rooms A-C

$$l_{long} := 126 \cdot in$$

Length of long cabinets, approximate, as used in Revision 0 above

$$F_{anchor} = 1.622 \times 10^3 \cdot \frac{lbf}{ft}$$

Anchor load from Rev. 0 above

$$T_{allow} = 5.456 \times 10^3 \cdot lbf$$

Alllowable tensile capacity, as in Rev 0 above

$$N_{req} := \frac{F_{anchor} \cdot l_{long}}{T_{allow}}$$

Minimum number of required anchors

$$N_{req} = 3.121$$

Minimum anchors. Round up to 4. A long cabinet with at least 4 properly installed anchors on each side will be adequately restrained.

Calculate the new maximum anchor load on the short cabinet in PPS room D. This is based upon the actual placement location of the corner anchor, which was not consistent with the original design due to problems in drillilng the anchor hole. At the corner where the first anchor is farthest in from the corner, the distance is approximately 17 inches.

$l_{short} = 61 \cdot in$

Approximate length of short cabinet, section D-D sheet 4, from Rev 0 above

$Mo_{short} = 1.31 \times 10^5 \cdot in \cdot lbf$

overturning moment about long axis on short cabinet, from Rev. 0 above

$Mr_{short} = 4.877 \times 10^4 \cdot in \cdot lbf$

restoring moment, using 100-40-40 rule, from Rev 0 above

$$Fanch_{shortrev1} := \frac{Mo_{short} - Mr_{short}}{2\left[(0.75)l_{short} - 17 \cdot in\right]}$$

$$Fanch_{shortrev1} = 1.431 \times 10^3 \cdot lbf$$

Calculate anchor force, assuming a neutral axis at 3/4 the cabinet length. The anchors are approximately 17 inches from the end of the cabinet Divide by two anchors, one each on north and south.

Calculate anchor loads for short axis overturning on the short cabinets

$$Feach := \frac{F_{anchor} \cdot l_{short}}{3}$$

$$Feach = 2.748 \times 10^3 \cdot lbf$$

The long axis overturning demand is the force times the short cabinet length, divided by the number of anchors for the short cabinet

The demand for short axis overturning is greater than that for long axis. Multiply the long axis overturning demand by 0.4 and add to the short axis demand, using the 100-40-40 directional combination rule from ASCE 4-98.

$$Fmax := Feach + 0.4 \cdot Fanch_{shortrev1}$$

$$Fmax = 3.32 \times 10^3 \cdot lbf$$

$$\frac{Fmax}{T_{allow}} = 0.609$$

Demand to capacity ratio for the maximally loaded anchor on the short cabinet.

The number of installed anchors and the demand to capacity ratio for the maximally loaded anchor are acceptable based upon the new design information in revision 1. The shear demand remains very small relative to capacity as in revision 0. The revised design is acceptable.

Appendix B: Hilti Product Data

4.3.1 HDA Undercut Anchor

Table 6 - HDA-P/T, HDA-PF/TF & HDA-PR/TR Allowable Seismic Tension (ASD), Normal Weight Concrete (lb)[1,3,4]

Nominal Anchor Diameter	Embedment Depth h_{ef}		Concrete Compressive Strength[2]			
	mm	in.	f'_c= 2000 psi	f'_c= 3000 psi	f'_c= 4000 psi	f'_c= 6000 psi
M10	100	3.94	3,564	4,365	5,041	5,339
M12	125	4.92	4,455	5,457	6,301	7,717
M16	190	7.48	8,911	10,914	12,603	14,414
M20	250	9.84	13,367	16,371	18,904	22,541

1 Values are for single anchors with no edge distance or spacing reduction. For other cases, see ICC ESR-1546, Section 4.2.

2 Values are for normal weight concrete. For sand-lightweight concrete, multiply values by 0.85. For all-lightweight concrete, multiply values by 0.75. See ACI 318-05 D.3.4.

3 All values applicable to either Condition A or Condition B (pullout or steel failure control). See ACI 318-05 D.4.4.

4 Allowable seismic tension loads for 2,500 psi are calculated by multiplying the pullout strength N_{pn} by the strength reduction ϕ factor of 0.65, then multiplying by a 0.75 factor describe in ACI 318-05 D.3.3.3, and dividing by an α of 1.1 according to ICC ESR-1546 Section 4.2. See Table 2 for N_{pn}. This load may be adjusted for other concrete strengths according to ICC ESR-1546 Section 4.1.3 by using the following equation.

$$N_{pn,\alpha,f'c} = N_{pn,cr}\sqrt{\frac{f'c}{2500}}$$

Table 7 - HDA-P, HDA-PF & HDA-PR Allowable Static and Seismic Shear (ASD), Steel (lb)[1]

Design parameter	Units	Nominal anchor diameter						
		M10		M12		M16		M20
		HDA	HDA-R	HDA	HDA-R	HDA	HDA-R	HDA
Allowable static steel capacity[2] HDA-P/PR	lb	2,327	2,818	3,382	4,175	6,294	7,828	9,644
Allowable seismic steel capacity[3] HDA-P/PR	lb	1,993	2,491	2,889	3,587	5,380	6,675	8,269

1 Values are for single anchors with no edge distance or spacing reduction due to concrete failure.

2 Allowable static shear loads are calculated by multiplying V_{sa} by the strength reduction ϕ factor of 0.65 and dividing by an α of 1.4 according to ICC ESR-1546 Section 4.2. See Table 2 for V_{sa}.

3 Allowable seismic shear loads are calculated by multiplying V_{sa} by the strength reduction ϕ factor of 0.65, then multiply by 0.75 as per ACI 318-05 D.3.3.3, and dividing by an α of 1.1 according to ICC ESR-1546 Section 4.2. See Table 2 for V_{sa}.

Table 8 - HDA-T/TF/TR Allowable Static and Seismis Shear (ASD), Steel (lb)[1,2]

Anchor Designation		Thickness of fastened part(s)		Allowable Static Steel Capacity	Allowable Seismic Steel Capacity
		mm	in.	V_s	$V_{s,seismic}$
HDA-T HDA-TF	HDA-T 20-M10x100	10 ≤ t < 15	3/8 ≤ t < 5/8	6,471	5,579
		15 ≤ t < 20	5/8 ≤ t < 13/16	7,306	6,277
	HDA-T 22-M12x125	10 ≤ t < 15	3/8 ≤ t < 5/8	7,724	6,675
		15 ≤ t ≤ 50	5/8 ≤ t < 2	8,663	7,373
	HDA-T 30-M16x190	15 ≤ t < 20	5/8 ≤ t < 13/16	14,195	12,155
		20 ≤ t < 25	13/16 ≤ t < 1	16,074	13,849
		25 ≤ t < 30	1 ≤ t < 1-3/16	17,744	15,244
		30 ≤ t ≤ 60	1-3/16 ≤ t < 2-3/8	19,205	16,439
	HDA-T 37-M20x250	20 ≤ t < 35	13/16 ≤ t < 1-3/8	20,980	18,033
		35 ≤ t < 50	1 ≤ t < 2	23,589	20,225
		50 ≤ t ≤ 100	2 ≤ t < 4	25,363	21,819
HDA-TR	HDA-TR 20-M10x100	10 ≤ t < 15	3/8 ≤ t < 5/8	7,202	6,177
		15 ≤ t < 20	5/8 ≤ t < 13/16	7,515	6,476
	HDA-TR 22-M12x125	10 ≤ t < 15	3/8 ≤ t < 5/8	9,394	7,971
		15 ≤ t ≤ 50	5/8 ≤ t < 2	10,333	8,867
	HDA-TR 30-M16x190	15 ≤ t < 20	5/8 ≤ t < 13/16	16,596	14,247
		20 ≤ t < 25	13/16 ≤ t < 1	17,535	15,044
		25 ≤ t < 30	1 ≤ t < 1-3/16	18,370	15,742
		30 ≤ t ≤ 60	1-3/16 ≤ t < 2-3/8	18,996	16,340

1 Values are for single anchors with no edge distance or spacing reduction due to concrete failure.

2 Allowable shear loads calculated using the steel strengths in shear from Table 3, multiplying by by the strength reduction ϕ factor of 0.65, and dividing by 1.4 according to ICC ESR-1546 Section 4.2.

Appendix C: Cabinet Weight Estimate

Approximate weight of PPS cabinets

Cabinet A, B, and C overall dimensions from manual measurements and verified in drawing 911978:

$W_{cab} := 127.5\,in$ $H_{cab} := 88.75\,in$ $D_{cab} := 35.78\,in$

Cabinet made up of 11 gauge plate material while doors are made up of 12 guage. Weight for these materials was taken from http://www.engineeringtoolbox.com/gauge-sheet-d_915.html

$Plate_{den} := 5\,\frac{lbf}{ft^2}$ $Door_{den} := 4.375\,\frac{lbf}{ft^2}$

Internal sheet material (item # 5 in drawing 911978)

$Int_Plate := 76.71\,in$ long

Internal Bracket Information (item # 15 on drawing 911978)

$Int_bracket := 76.71\,in$ long

Weight of known components:

Cabinet Shell

$Area_back := W_{cab} \cdot H_{cab}$ $Area_back = 1.132 \times 10^4 \cdot in^2$

$Area_side := 2 \cdot H_{cab} \cdot D_{cab}$ $Area_side = 6.351 \times 10^3 \cdot in^2$

$Area_top := D_{cab} \cdot W_{cab}$ $Area_top = 4.562 \times 10^3 \cdot in^2$

$Total_shell := Area_back + Area_side + Area_top$

$Total_shell = 2.223 \times 10^4 \cdot in^2$

$Weight_shell := Total_shell \cdot Plate_{den}$ $Weight_shell = 771.824 \cdot lbf$

Cabinet doors

$Area_door := 6 \cdot 19.12\,in \cdot 84.05\,in$ $Area_door = 9.642 \times 10^3 \cdot in^2$

$Area_front := 2.38\,in \cdot 127.5\,in \cdot 2 + 2.12\,in \cdot 84.05\,in \cdot 5 + 1.06\,in \cdot 84.05\,in \cdot 2$

$Weight_front := Area_front \cdot Plate_{den}$ $Weight_front = 58.195 \cdot lbf$

$Weight_door := Area_door \cdot Door_{den}$ $Weight_door = 292.949 \cdot lbf$

Larger Internal Components

$Area_plate := Int_Plate \cdot 8\,in \cdot 12$ $Area_plate = 7.364 \times 10^3 \cdot in^2$

$Bracket := 11 \cdot (Int_bracket \cdot 8in + Int_bracket \cdot 2in \cdot 4)$

$Bracket = 1.35 \times 10^4 \cdot in^2$

Weight of Larger Internal Components

$Weight_internal := Area_plate \cdot Plate_{den} + Bracket \cdot Plate_{den}$

$Weight_internal = 724.483 \cdot lbf$

ASSUME: The frame, bolts, wires, etc. are about 25% of the total cabinet weight.

Total Weight of Shell for PPS cabinets A, B, and C with 25% added for misc parts such as bolts and smaller components

$Weight_cab := (Weight_shell + Weight_front + Weight_door + Weight_internal) \cdot 1.25$

$Weight_cab = 2.309 \times 10^3 \cdot lbf$

Weight of cabinet components (rough approximation of controls was made)

Comparator Cabinets:

$Weight_Amp := 30lbf$ $Weight_widerange := 30lbf$ $Weight_monitor := 25lbf$

$Weight_switch := 5lbf$ $Weight_modules := 60 \cdot lbf$

$Weight_psc := 140lbf$

$Weight_comp := Weight_Amp + Weight_switch + Weight_psc + Weight_widerange \ldots$
$+ Weight_modules + Weight_monitor$

$Weight_comp = 290 \cdot lbf$

Logic Cabinets:

$Weight_modules_l := 39lbf$ $Weight_psl := 200lbf$

$Weight_logic := Weight_modules_l + Weight_psl$

$Weight_logic = 239 \cdot lbf$

Test Cabinet:

$Weight_test := 80lbf$

$$Weight_total := Weight_cab + Weight_comp + Weight_logic + Weight_test$$

Total weight for PPS Cabinets A, B, And C:

$$Weight_total = 2.918 \times 10^{3} \cdot lbf$$

ASSUME: Cabinet D has only 65% of total metal of Cabinets A, B, and C becasue it is a shorter cabinet without the three comparator cabinets.

Total weight for PPS Cabinet D

$$Weight_cabinetD := 0.65 \cdot Weight_cab + Weight_logic + Weight_test$$

$$Weight_cabinetD = 1.82 \times 10^{3} \cdot lbf$$

Location of Center of Gravity

Comparator Cabinet:

$$Height_{CGcp1} := \frac{[(25lbf \cdot 31.225in) + (30lbf \cdot 41.755in) + (30lbf \cdot 52.255in) + (75lbf \cdot 64.94in)]}{160lbf}$$

$$Height_{CGcp2} := \frac{[(10lbf \cdot 18.57in) + (8lbf \cdot 29in) + (9lbf \cdot 39.57in) + (5lbf \cdot 52.255in) + (60lbf \cdot 64.94in}{92lbf}$$

$$Height_{CGcp3} := \frac{[(5lbf \cdot 18.57in) + (12lbf \cdot 29in) + (4lbf \cdot 39.57in) + (12lbf \cdot 52.255in) + (60lbf \cdot 64.94i}{94lbf}$$

$$Height_{CGl1} := \frac{[(7lbf \cdot 39.56in) + (7lbf \cdot 50.675in) + (100lbf \cdot 62.755in)]}{114lbf}$$

$$Height_{CGl2} := \frac{[(12lbf \cdot 39.56in) + (12lbf \cdot 50.675in) + (100lbf \cdot 62.755in)]}{124lbf}$$

$$Height_{CGt} := 50in$$

$$Height_{CG} := \frac{\left[\begin{array}{l}\left(Height_{CGcp1}\cdot 160lbf\right) + \left(Height_{CGcp2}\cdot 92lbf\right) + Height_{CGcp3}\cdot 94lbf \ldots \\ + \left(Height_{CGl1}\cdot 114lbf\right) + \left(Height_{CGl2}\cdot 124lbf\right) + \left(Height_{CGt}\cdot 80lbf\right)\end{array}\right]}{160lbf + 92lbf + 94lbf + 114lbf + 124lbf + 80lbf}$$

$$Height_{CG} = 55.408\cdot in$$

$$Width_{CG} := \frac{\left[\begin{array}{l}(160lbf\cdot 10.625in) + (92lbf\cdot 31.88in) + (94lbf\cdot 53.125in) + 114lbf\cdot 74.375in \ldots \\ + (124lbf\cdot 95.625in) + (80lbf\cdot 116.875in)\end{array}\right]}{160lbf + 92lbf + 94lbf + 114lbf + 124lbf + 80lbf}$$

$$Width_{CG} = 59.206\cdot in$$

$$Depth_{CG} := 0.25\cdot D_{cab}$$

$$Depth_{CG} = 8.945\cdot in$$

Center of Gravity for Cabinet D

$$Height_{CGD} := \frac{\left(Height_{CGl1}\cdot 114lbf\right) + \left(Height_{CGl2}\cdot 124lbf\right) + \left(Height_{CGt}\cdot 80lbf\right)}{114lbf + 124lbf + 80lbf}$$

$$Width_{CGD} := \frac{[(114lbf\cdot 10.625in) + (124lbf\cdot 31.88in) + (80lbf\cdot 53.125in)]}{114lbf + 124lbf + 80lbf}$$

$$Height_{CGD} = 57.439\cdot in$$

$$Width_{CGD} = 29.605\cdot in$$

Depth of Center of Gravity same on cabinet D as on cabinets A, B, and C

Appendix D: Analysis Plan

Analysis Plan for
ANALYSIS OF TRA-670 PPS CABINET SUPPLEMENTAL ANCHORAGE

Analysis Plan

Scope: The purpose of this calculation is to evaluate the proposed supplemental anchorage for the ATR PPS cabinets shown in Drawing 600848.

Deliverables: The deliverable shall be a checked and approved ECAR.

Assumptions: It will be assumed that drawings and specification accurately represent the physical items. The cabinet weight shall be estimated.

Quality Level: 1 per QLD RTC-000550, "Seismic Analysis of ATR Seismic Category 1 SSC"

Natural Phenomena Hazards criteria: PC-4 per PLN-588 Rev 3.

Load scenarios and acceptance criteria – anchorage only supports seismic loads. Use DOE-STD-1020-02 load combination, where Dns=0 (for the bracing). DOE-STD-1020-02 acceptance criteria apply. Use in-structure spectra from the probabilistic SSI analysis.

Calculation and analysis software to be used: Mathcad versions 13 and 14 will be used.

Verification/validation requirements for calculation and analysis software: Calculations will be checked by hand.

Budget: not defined

Schedule: not defined

Approvals

Requester & Performer's Manager – Dave Rowsell	10/30/08 Date
Performer – Stuart Jensen	10/30/08 Date