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Technical Evaluation Study

ATR Second Basement 6 Tier Cable Tray Seismic Support

Idaho National Laboratory

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1. INTRODUCTION

During recent seismic walk downs at the Advanced Test Reactor by Ares personnel, the cable tray in the second basement adjacent to the east stairwell was identified to have insufficient anchorage due to the bending moments applied to the ½" bolts that are generated by the weight of the cable trays during postulated design basis earthquake. The pullout strength of the ½"-13 strut nuts is 2000 lbs when used in 12 Ga unistrut channels, which is less than the 2538.46 lbs force generated from the moment about the vertical edge of the unistrut channel. The derivation of this moment can be found in the Ares report titled Limited Analytical Review of Cable Tray Supports with the Calc No. 0602301.01-S-006. See Appendix A.

2. RECOMMENDATION

The recommendation from ATR engineering is fabricate a bracket that can be inserted between the stairwell block wall and the vertical member of the 6 tier cable tray. This bracket will remove the bending moment from the cable tray anchorage as it will be constrained in all 3 orthogonal directions. The bracket will be placed at the end of the vertical member and will need to resist a moment of 3637.5 in-lbs. This moment translates in to a force of about 50 lbs in and out of the vertical wall plane.

The 50 lbs load is transferred to the bracket via a ½" grade 5 Hex Capscrew (HCS) that is oriented in a manner that places it in a double shear condition. The bracket is bolted to the wall via two through bolt connections in order to allow the wall to accept the force in either direction. Plates will be utilized on both sides of the wall to ensure the though bolt can not "blow out" the block. The bracket design can be found on DWG-600846 ATR Second Basement 6-tier Cable Tray Anchorage Installation and Detail.

3. CONCLUSIONS

The recommended bracket design is robust and by inspection all of the components are adequate to withstand the 50 lbs of force which would be applied during the postulated seismic event.

4. APPENDIXES

Appendix A, Limited Analytical Review of Cable Tray Supports

Calc No. 0602301.01-S-006

Appendix B, Vendor Data

Appendix A

Limited Analytical Review of Cable Tray Supports

Calc No. 0602301.01-S-006

6.3 Support 2B-C-3

This support is a cantilever bracket type as shown in Figure 6-3.

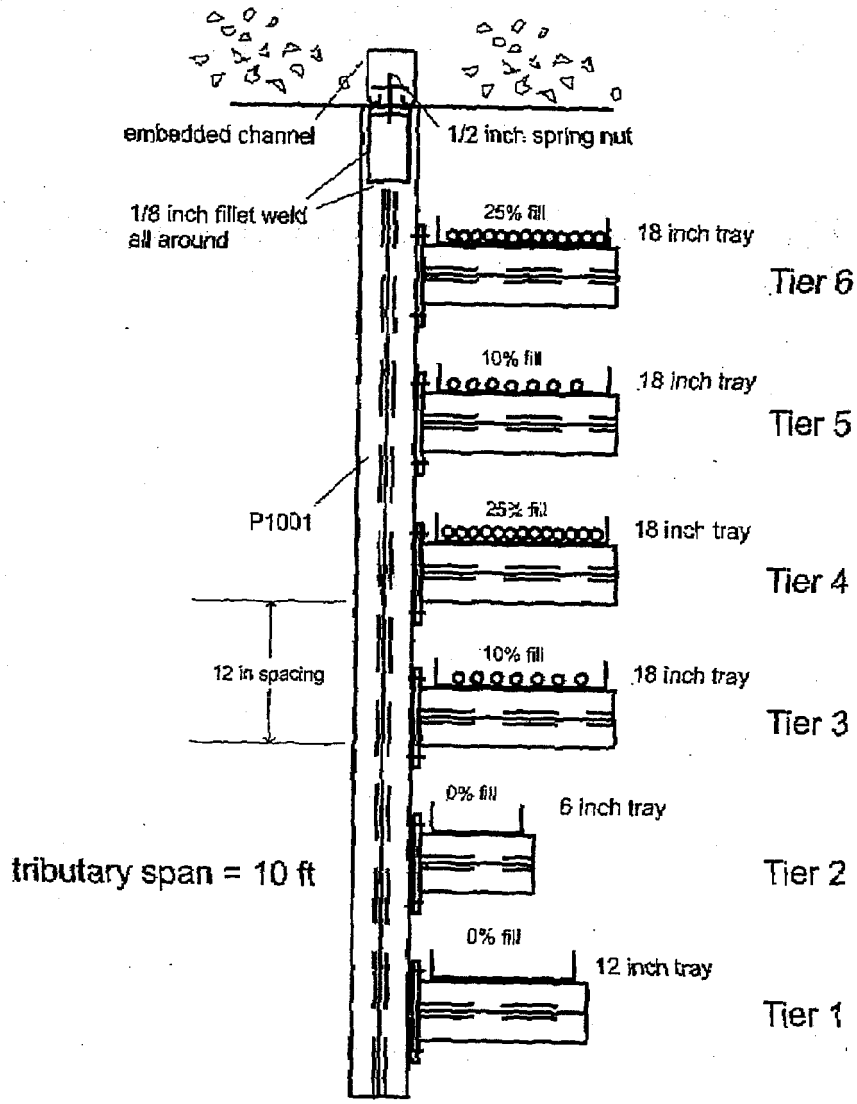


Figure 6-3. Support 2B-C-3.

Dead Load Check (DOE/EH-0545 Section 9.2.1.3.1)

Determine the tray weights from DOE/EH-0545 Section 9.2.1.3.9.

$Wt := 25 \cdot \frac{lb}{ft^2}$ Weight of standard tray with 4 inches of cable fill, from DOE/EH-0545 Section 9.2.1.3.9.

$W_6 := Wt \cdot 6 \cdot in$

$W_6 = 12.5 \frac{lb}{ft}$ Weight per foot of 6" wide cable tray with 100% fill.

$W_{12} := Wt \cdot 12 \cdot in$

$W_{12} = 25 \frac{lb}{ft}$ Weight per foot of 12" wide cable tray with 100% fill.

$W_{18} := Wt \cdot 18 \cdot in$

$W_{18} = 37.5 \frac{lb}{ft}$ Weight per foot of 18" wide cable tray with 100% fill.

$L_{trib_2B_C_3} := 10 \cdot ft$ Tributary span of support 2B-C-3.

The lowest tray (bottom tray) is called tier 1. The tier 1 and 2 trays are empty. Use 10% fill for these trays to cover dead load of the tray. Tier 3 has 10% fill, tier 4 has 25% fill, tier 5 has 10% fill and tier 6 has 25% fill.

$W_{tier1} := (10\%) \cdot (W_{12}) \cdot (L_{trib_2B_C_3})$ Tier 1 (bottom) cable tray weight.

$W_{tier1} = 25\,lb$

$W_{tier2} := (10\%) \cdot (W_6) \cdot (L_{trib_2B_C_3})$ Tier 2 cable tray weight.

$W_{tier2} = 12.5\,lb$

$W_{tier3} := (10\%)\cdot(W_{18})\cdot(L_{trib_2B_C_3})$ Tier 3 cable tray weight.

$W_{tier3} = 37.5\,lb$

$W_{tier4} := (25\%)\cdot(W_{18})\cdot(L_{trib_2B_C_3})$ Tier 4 cable tray weight.

$W_{tier4} = 93.75\,lb$

$W_{tier5} := (10\%)\cdot(W_{18})\cdot(L_{trib_2B_C_3})$ Tier 5 cable tray weight.

$W_{tier5} = 37.5\,lb$

$W_{tier6} := (25\%)\cdot(W_{18})\cdot(L_{trib_2B_C_3})$ Tier 6 (top) cable tray weight.

$W_{tier6} = 93.75\,lb$

Check the horizontal members supporting the trays. Each tray is supported by a standard Unistrut P2543 cantilever bracket with a P1001 member. Tier 6 governs with the largest load. The load is applied at the center of the cable tray.

$$M_{P2543_DL} := W_{tier6}\cdot\left(\frac{18\cdot in}{2} + 2\cdot in\right)$$

$M_{P2543_DL} = 1031.25\cdot in\cdot lb$ Dead load reaction moment at end of tier 6.

The rated capacity of the P2543 member is 1300 lbs. uniform load over the 18 inch length, from Unistrut Catalog No. 12 Page 110.

$$M_{P2543} := 1300\cdot lb\cdot\frac{18\cdot in}{2}$$

$M_{P2543} = 11700\cdot in\cdot lb$ Rated capacity of P2543 member from Unistrut Catalog No. 12 Page 110.

$M_{P2543_DL} = 1031.25\cdot in\cdot lb$ < $M_{P2543} = 11700\cdot in\cdot lb$ The P2543 member is adequate.

All of the horizontal member connections are standard P2543 bolted connections that are covered by the capacity of the P2543.

Check the vertical P1001 member for bending due to load eccentricity. The trays are spaced 12" apart. Take moments about the center of the P1001 member. The P1001 member is 3.25" deep.

$$M_{P1001} := \left(W_{tier1}\right)\cdot\left(\frac{12\cdot in}{2} + 2\cdot in + \frac{3.25\cdot in}{2}\right) + \left(W_{tier2}\right)\cdot\left(\frac{6\cdot in}{2} + 2\cdot in + \frac{3.25\cdot in}{2}\right) \ldots$$
$$+\left(W_{tier3}\right)\cdot\left(\frac{18\cdot in}{2} + 2\cdot in + \frac{3.25\cdot in}{2}\right) + \left(W_{tier4}\right)\cdot\left(\frac{18\cdot in}{2} + 2\cdot in + \frac{3.25\cdot in}{2}\right) \ldots$$
$$+\left(W_{tier5}\right)\cdot\left(\frac{18\cdot in}{2} + 2\cdot in + \frac{3.25\cdot in}{2}\right) + \left(W_{tier6}\right)\cdot\left(\frac{18\cdot in}{2} + 2\cdot in + \frac{3.25\cdot in}{2}\right)$$

$$M_{P1001} = 3637.5\cdot in\cdot lb$$

Check bending stress in the vertical P1001 member. The allowable bending moment for a P1001 section is 14,390 in-lbs from Unistrut Catalog No. 12 Page 23.

$$S_{P1001} := 0.572\cdot in^3$$

P1001 section modulus from Unistrut Catalog No.12 Page 25.

$$F_{b_P1001} := \frac{14390\cdot in\cdot lb}{S_{P1001}}$$

Derived allowable bending stress from Unistrut Catalog No. 12.

$$F_{b_DL} := F_{b_P1001}$$

Set allowable bending stress equal to derived catalog value.

$$F_{b_DL} = 25157.34\cdot psi$$

Check bending stress:

$$f_{b_P1001} := \frac{M_{P1001}}{S_{P1001}}$$

$f_{b_P1001} = 6359.27 \cdot psi$ < $F_{b_DL} = 25157.34 \cdot psi$ The vertical P1001 member is adequate for bending.

Check the vertical P1001 member for combined bending and tension stress.

$F_{y_DL} := W_{tier1} + W_{tier2} + W_{tier3} + W_{tier4} + W_{tier5} + W_{tier6}$

$F_{y_DL} = 300\,lb$ Total dead load on the support.

$A_{P1001} := 1.112 \cdot in^2$ Area of P1001 section from Unistrut Catalog No. 12 Page 25.

$$f_{t_P1001} := \frac{F_{y_DL}}{A_{P1001}}$$

$f_{t_P1001} = 269.78 \cdot psi$

The allowable bending stress in the Unistrut catalog is 0.6 times the material yield strength, from AISI Cold Formed Design Manual Section 3.1.1. Determine the material yield strength from the allowable stress:

$F_{b_DL} = 25157.34 \cdot psi$

$$F_y := \frac{F_{b_DL}}{0.6}$$

$F_y = 41928.9 \cdot psi$

The allowable strength in tension is taken as 0.6 times the material yield strength, from AISC (9th edition) Section D1.

$F_{t_DL} := F_{b_DL}$

$F_{t_DL} = 25157.34 \cdot psi$

Check combined tension and bending stress:

$F_{t_DL} = 25157.34 \cdot psi$ $\quad$ $F_{b_DL} = 25157.34 \cdot psi$

$f_{t_P1001} = 269.78 \cdot psi$ $\quad$ $f_{b_P1001} = 6359.27 \cdot psi$

$$Ratio_{bend_tens_P1001} := \frac{f_{t_P1001}}{F_{t_DL}} + \frac{f_{b_P1001}}{F_{b_DL}}$$

$Ratio_{bend_tens_P1001} = 0.264 \quad < \quad 1.0$ $\quad$ Vertical P1001 passes dead load check.

Check the anchorage of the vertical P1001 member. The connection consists of two angle fittings welded to each side of the P1001 and anchored to embedded Unistrut with two 1/2" bolts. From review of the walkdown photographs, the horizontal leg of the fitting has one bolt hole, and appears to be approximately 2-1/2" long. The vertical long leg of the fitting appears to be approximately 4" long. Assume the fitting is a P1458 member from Unistrut General Engineering Catalog No. 9. The fitting is welded on three sides with a fillet weld. The weld size is at least 1/8". The weld does not govern since the capacity of a 1/8" fillet weld is 2.7 kips per inch from DOE/EH-0545 Section 6.3.10.1.1. The 1/2" bolts with a pullout capacity of 2000 lbs govern the connection capacity. The embedment is assumed to be a Unistrut P3200 series continuous insert. The moment is resisted about the edge of the vertical P1001.

$F_{y_DL} = 300\,lb$ $\quad$ Total dead load on the support.

$M_{P1001} = 3637.5 \cdot lb \cdot in$ $\quad$ Moment due to load eccentricity.

$$P_{P1001_DL} := F_{y_DL} + \frac{M_{P1001}}{1.625 \cdot in}$$

$P_{P1001_DL} = 2538.46\,lb$ $\quad$ Pullout force applied to the embedment.

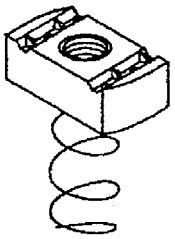
$F_{p_P3200_cap} := 2000 \cdot lb$ $\quad$ P3200 insert pullout capacity.

$P_{P1001_DL} = 2538.46\,lb \quad > \quad F_{p_P3200_cap} = 2000\,lb$ $\quad$ The connection fails the dead load check.

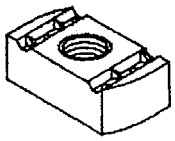
Conclusion: Support 2B-C-3 fails the dead load check

Appendix B

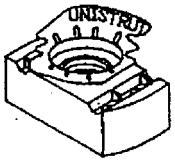
Vendor Data



SPRING NUT
P1006-1420
P1008
P1010



NUT WITHOUT SPRING
P3006-1420
P3008
P3010

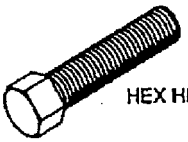


NUT WITH TOP RETAINER
P1006-1420T
P1008T
P1010T

Table 17 – UNISTRUT NUT DIMENSION & DESIGN LOADS

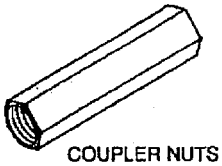
Channel nut	Thread Size	Nut Thickness in.	Nut Thickness mm	Resistance to Slip 12 Ga. Channel Lbs.	Resistance to Slip 12 Ga. Channel N	Pull-Out Strength* 12 Ga. Channel Lbs.	Pull-Out Strength* 12 Ga. Channel N
P1010 P3010 P1010T	½" - 13	½"	13	1500	6,670	2000	8,900
P1008 P3008 P1008T	⅜" - 16	⅜"	10	800	3,560	1000	4,450
P1006-1420 P3006-1420 P1006-1420T	¼" - 20	¼"	6	300	1,330	600	2,670

*Safety factor of 3



HEX HEAD CAP SCREWS
HHCS

HEX NUTS
HHXN



COUPLER NUTS
HRCN

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HFLW

LOCK WASHER
HLKW

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