Appendix H

Redlands & Cottonwood Booster
Electrical Replacement
Cable Tray Weight/Fill Calculations and Structural Load Assessment

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Eastern Municipal Water District (EMWD) Redlands and Cottonwood Booster Electrical Replacement

Cable Tray Weight Fill Calculations & Structural Load Assessment

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Prepared by:

Michael Baker
INTERNATIONAL

5 Hutton Centre Drive, Suite 500
Santa Ana, CA 92707
949.472.3505 Telephone
949.472.8373 Fax

The following tables and calculations are provided to determine how many cables can be safely carried by each size of wire mesh or ladder cable tray and to determine the appropriate distance between supports for the load, based on number of cables, cable tray size, and bracket type.

Fill Area Calculations

For the Redlands and Cottonwood Booster Electrical Replacement, the maximum size of cable used in the cable trays is 3/0 AWG. Based on this information, the calculations for the maximum allowable fill area for multiconductor cables follow NEC Article 392.22(A)(1)(b) for any mixture of multiconductor power, lighting, control, and signal cables.

NEC article 392.22(A)(1)(b) is as follows:

> Where all of the cables are smaller than 4/0 AWG, the sum of the cross-sectional areas of all cables shall not exceed the maximum allowable cable fill area in Column 1 of Table 392.22(A) for the appropriate cable tray width.

Table 392.22(A): Allowable Cable Fill Area for Multiconductor Cables in Ladder, Ventilated Trough, or Solid Bottom Cable Trays Rated 2000 Volts or Less

Inside Width of Cable Tray		Ladder or Ventilated Trough or Wire Mesh Cable Trays, 392.22(A)(1)			
		Column 1 Applicable for 392.22(A)(1)(b) Only		Column 2[a] Applicable for 392.22(A)(1)(c) Only	
mm	in.	mm^2	$in.^2$	mm^2	$in.^2$
50	2.0	1,500	2.5	1,500 – (30 Sd)[b]	2.5 – (1.2 Sd)[b]
100	4.0	3,000	4.5	3,000 – (30 Sd)[b]	4.5 – (1.2 Sd)
150	6.0	4,500	7.0	4,500 – (30 Sd)[b]	7 – (1.2 Sd)
200	8.0	6,000	9.5	6,000 – (30 Sd)[b]	9.5 – (1.2 Sd)
225	9.0	6,800	10.5	6,800 – (30 Sd)	10.5 – (1.2 Sd)
300	12.0	9,000	14.0	9,000 – (30 Sd)	14 – (1.2 Sd)
400	16.0	12,000	18.5	12,000 – (30 Sd)	18.5 – (1.2 Sd)
450	18.0	13,500	21.0	13,500 – (30 Sd)	21 – (1.2 Sd)
500	20.0	15,000	23.5	15,000 – (30 Sd)	23.5 – (1.2 Sd)
600	24.0	18,000	28.0	18,000 – (30 Sd)	28 – (1.2 Sd)
750	30.0	22,500	35.0	22,500 – (30 Sd)	35 – (1.2 Sd)
900	36.0	27,000	42.0	27,000 – (30 Sd)	42 – (1.2 Sd)

Maximum Allowable Fill Area:

The cable tray widths used in the Redlands and Cottonwood Booster Electrical Replacement project is summarized below with the maximum allowable fill. The allowable fill is based on Table 392.22(A) per NEC for Ladder Cable Trays

Inside Width of Cable Tray	$in.^2$
18 in.	21.00
9 in.	10.50

Cable Cross Sectional Area:

The Cross-sectional Area for each cable size is based on Table 5 of Chapter 9 in the 2017 NEC and is summarized in the table below. Cross sectional area for standard cable sizes are based on XHHW, XHHW-2, & XHH insulation. CAT6 cables are based on the equivalent sized 23AWG, RS-485 cables are based on equivalent sized 22AWG, 2C#18SH cables are per the Southwire R40013-1 product datasheet, and coaxial cables are based on the RG-213 standard size.

Cable Size	$in.^2$
#3/0	0.2642
#14	0.0139
#4	0.0814
#2/0	0.219
#1	0.1534
CAT6	0.000401
MODBUS RS-485	0.000505
#12	0.0181
2C#18SH	0.020348
COAX RG-213	0.12876
#6	0.059

The following tables provide a tabulated calculation of the total cross-sectional area occupied by the cables within the designated cable tray. The "Cable Run" column is in reference to the conduit schedule per sheet E-7, Electrical Conduit and Cable Schedule, of the plans.

9" Cable Tray Fill Calculations:

Cable Run	Qty. of Cables	Cable Run Area	
10A	(4)CAT6, MODBUS	0.00211	$in.^2$
25A	2C#18SH	0.020348	$in.^2$
21A	CAT6, MODBUS	0.000906	$in.^2$
9A	COAX, MODBUS	0.129265	$in.^2$
9C	25#14	0.3475	$in.^2$
23C	15#14	0.2085	$in.^2$
14A	2C#18SH	0.020348	$in.^2$
15A	2C#18SH	0.020348	$in.^2$
16A	2C#18SH	0.020348	$in.^2$
17A	2C#18SH	0.020348	$in.^2$
18A	2C#18SH	0.020348	$in.^2$
19A	2C#18SH	0.020348	$in.^3$
22A	(2)2C#18SH	0.040696	$in.^4$
Total Cross-sectional Area		**0.871413**	**$in.^2$**

18" Cable Tray Fill Calculations:

Cable Run	Qty. of Cables	Cable Run Area	
10P	3#1, 2#14, 1#4G	0.5694	$in.^2$
11P	3#2/0, 2#14, 1#4G	0.7662	$in.^2$
12P	3#2/0, 2#14, 1#4G	0.7662	$in.^2$
13P	3#3/0, 2#14, 1#4G	0.9018	$in.^2$
5P	3#1, 1#6G	0.5192	$in.^2$
6P	3#2/0, 1#4G	0.7384	$in.^2$
7P	3#2/0, 1#4G	0.7384	$in.^2$
8P	3#3/0, 1#4G	0.874	$in.^2$
9P	2#12, 1#12G	0.0543	$in.^2$
22P	2#12, 1#12G	0.0543	$in.^2$
Total Cross-sectional Area		**5.9822**	**$in.^2$**

Conclusion:

The total cross-sectional area of the cables within the 9 inch cable tray is 0.8714 in.^{2}, and is well under the 10.5 in.^{2} maximum area allowed. The total cross-sectional area of the cables within the 18 inch cable tray is 5.982 in.^{2}, and is well under the 21 in.^{2} maximum area allowed. Based on this analysis, the 9 and 18 inch cable trays do not exceed 50 percent of the interior cross section of the tray and provide spare capacity to accommodate any future cable additions complying with the NEC code requirements.

Weight Calculations

The following tables in this section provide the information for the cable weight per foot and cable trays per foot for the structural load calculations. All weights were referenced from manufacturer data sheets.

Cable Weights per Foot:

Cable Size	Lbs/1000 ft	Lbs/Ft
#3/0	567	0.567
#14	20	0.02
#4	153	0.153
#2/0	456	0.456
#1	296	0.296
CAT6	46	0.046
MODBUS RS485	43	0.043
#12	29	0.029
2C#18SH	19	0.019
COAX RG-213	115	0.115
#6	107	0.107

Cable Tray Weights per Foot:

Tray Component	Lbs/Ft
B-Line 24 Single Side Rail Alum.	0.615
9" Spacing, 18" Wide Tray Bottom	0.59
9" Spacing, 9" Wide Tray Bottom	0.29

The following tables provide a tabulated calculation of the total weight for the entire cable tray with all designated cabling within it. The "Cable Run" column is in reference to the conduit schedule per sheet E-7, Electrical Conduit and Cable Schedule, of the plans.

9" Cable and Cable Tray Weight Calculations:

Cable Run	Qty. of Cables	Cable Run Weight	
10A	(4)CAT6, MODBUS	0.227	Lbs/Ft
25A	2C#18SH	0.046	Lbs/Ft
21A	CAT6, MODBUS	0.019	Lbs/Ft
9A	COAX, MODBUS	0.158	Lbs/Ft
9C	25#14	0.5	Lbs/Ft
23C	15#14	0.3	Lbs/Ft
14A	2C#18SH	0.019	Lbs/Ft
15A	2C#18SH	0.019	Lbs/Ft
16A	2C#18SH	0.019	Lbs/Ft
17A	2C#18SH	0.019	Lbs/Ft
18A	2C#18SH	0.019	Lbs/Ft
19A	2C#18SH	0.019	Lbs/Ft
22A	(2)2C#18SH	0.038	Lbs/Ft
	Cable Tray	1.52	Lbs/Ft
	Total Lbs per foot	**2.922**	**Lbs/Ft**

18" Cable and Cable Tray Weight Calculations:

Cable Run	Qty. of Cables	Cable Run Weight	
10P	3#1, 2#14, 1#4G	1.081	Lbs/Ft
11P	3#2/0, 2#14, 1#4G	1.561	Lbs/Ft
12P	3#2/0, 2#14, 1#4G	1.561	Lbs/Ft
13P	3#3/0, 2#14, 1#4G	1.894	Lbs/Ft
5P	3#1, 1#6G	0.995	Lbs/Ft
6P	3#2/0, 1#4G	1.521	Lbs/Ft
7P	3#2/0, 1#4G	1.521	Lbs/Ft
8P	3#3/0, 1#4G	1.854	Lbs/Ft
9P	2#12, 1#12G	0.087	Lbs/Ft
22P	2#12, 1#12G	0.087	Lbs/Ft
	Cable Tray Weight	1.82	Lbs/Ft
	Total Lbs per foot	**13.982**	**Lbs/Ft**

Structural Load Calculation

The existing structure is a prefabricated steel frame structure building with metal roof over steel purlins. There were no structural plans, specifications or calculations available for review. To comply with the building code requirements the roof should have been designed for dead load plus 20psf minimum live load.

The new cable trays are being supported on the existing steel channel purlins with the maximum imposed load of 75# at each hanger support (see attached) which translates to about 4 psf based on the site photo information. The added load is very minimal and, in our judgement, would not overstress the purlin members.

If structural drawings are made available with actual member size and spacing, member capacity can be accurately computed.

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