LOWER CLEANROOM

ROOF QUICK

LOAD ANALYSIS

D-ZERO ENGINEERING NOTE # 3823.111- EN - 440

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RD/DØ Mech.

Approved: _____

A handwritten signature in black ink, appearing to read 'Russ Rucinski', is written over a horizontal line.

Summary

This engineering note documents calculations done to determine the margin of safety for the lower clean room roof. The analysis was done to give me a feeling of what the loads, stresses and capacity of the roof is prior to installation and installation work to be done for the helium refrigerator upgrade.

Results & Conclusion

The result of this quick look showed that the calculated loads produce stress values and loads at about half the allowables. Based on this result, I do not think that special precautions above personal judgement are required for the installation work.

Loads Applied

- 1.) Uniform floor loading of 50 lbs./ft² to account for rated capacity.
- 2.) Uniform floor loading of 3.1 lbs./ft² for the corrugated floor.
- 3.) Roof hatch weight of 28 lb/ft on support beams plus 3.1 lbs./ft² for the skin material. (Total weight used = 1360 lbs.)
- 4.) Dead weight of the W8 x 21 beams. (Actually used 28 lbs./ft in analysis.)
- 5.) Dead weight of upgrade piping along south wall, 150 lbs. at each support beam location. Total weight = 750 lbs.

Stresses/Load Capacities

Beams: Worst loaded beams are those to the east and west of the hatch. This worst loaded beam was the only one analyzed. There was a 3580 lb reaction at the north end of this beam and a 4700 lb reaction at the south end. The highest bending moment was 241,275 in-lbs which results in a bending stress of 13.3 ksi. The allowable bending stress per the AISC manual is 23.8 ksi. The shear stress was not calculated but would be very low (less than 3 ksi) compared to the AISC manual allowable shear stress of 16.8 ksi.

Framed connection: A framed connection is used to attach beams to beams and the beams to the wall. A 5 x 5 x 3/8" angle with two 3/4" dia. bolts are used on each side of the web. The allowable load for this connection based on the bolts (which I assume are low quality A307) is 17,700 lbs. The calculated load was 4700 lb.

Wall Anchors: 3/4" dia. wall anchors were used. I will use data for 3/4" Hilti's brand wedge anchors. They have an allowable shear of 5120 lbs each or together could support 20,500 lbs. Although the exact brand is not known, the loading is a factor of four less than the Hilti allowable. Any quality brand wedge anchor used will have comparable strength and allowable to the Hilti brand. The maximum calculated load one of these connections could see was 4700 lb.

References

AISC steel Construction manual, 8th edition.

D-Zero Engineering note 3823.115-EN-428, "Upgrade Piping loads on Cleanroom Roof", by Steve Sakla 8/28/95.

ROOF HATCH $\approx 25 \text{ */ft}$ ALONG ① ③ ⑤ ⑥

DIMENSIONS AND BEAM DETERMINATION MADE BY STEVE SAKLA,
EN-428.

PIPING LOAD ALSO CALCULATED IN EN-428.

CORRUGATED FLOORING DETERMINED BY MEASUREMENTS:

LOADS ARE NOT REALLY A CONCERN.
150 lbs ADDITIONAL LOAD CAN BE TAKEN
BY 3 FT² OF AREA.

→ LOOK @ BEAM LOADINGS:

q_3 - ROOF HATCH @ 28 ¹/₂ lb/ft

$q_2 = 320$ ¹/₂ lb/ft FLOOR LOADING + WT. CORRUGATION.

$q_1 = 28$ ¹/₂ lb/ft BEAM WT. *

$P_1 = 1595$ * OVERESTIMATE OF BEAM ④

$P_2 = 1595$ * FROM BEAM ⑤

BEAM ②

$q_2 = 320$ ¹/₂ lb/ft FLOOR LOAD + WT. FLOOR

$q_1 = 28$ ¹/₂ lb/ft BEAM WT. *

NOTE FUDGE TO MIDDLE FOR SIMPLE ANALYSIS

BEAM ③

SAME AS BEAM ①

* BEAM WEIGHT ACTUALLY IS 21 ¹/₂ lb/ft. I MADE MISTAKE & USED 28 ¹/₂ lb/ft.

BEAM ④

LESS LOADING THAN BEAM ① & LESS SPAN

BEAM ⑤

$q_2 = 394$ ¹/₂ lb/ft FLOOR LD + WT.

$q_1 = 56$ ¹/₂ lb/ft BEAM WT. + ROOF HATCH *

P_1 = BEAM ② REACTION LESS FLOOR LOADING ON ②

BEAM ⑥ LOADING IS LESS THAN BEAM ⑤

$$q_1 = 56 \frac{\text{lb}}{\text{ft}} \text{ BEAM WT. + ROOF HATCH}$$

BEAM ⑦ - SMALL LOADING

BEAM ⑧

$$q_1 = 28 \frac{\text{#}}{\text{ft}} + 160 \frac{\text{#}}{\text{ft}} \text{ FLOOR LOADING} \\ = 188 \frac{\text{#}}{\text{ft}}$$

BY INSPECTION, BEAM ① IS MUCH WORSE.

ANALYZE BEAM ①

$$\begin{aligned} P_1 &= 1595 * \\ P_2 &= 1595 * \\ P_3 &= 150 * \\ q_4 &= 348 \text{ lb/ft} \\ q_5 &= 28 \text{ lb/ft} \end{aligned}$$

$$\sum F_y = 0 \quad P_1 + P_2 + P_3 + q_5 \left(\frac{89}{12} \right) + q_4 \left(\frac{163}{12} \right) = R_a + R_b$$

$$R_a + R_b = 8274.7 *$$

$$\sum M_A = 0 \quad P_1(8) + q_5 \left(\frac{89}{12} \right) (52.5) + P_2(97) + P_3(133) + q_4 \left(\frac{163}{12} \right) (81.5) = R_b(163)$$

$$R_b = 3580.2 * \quad R_a = 4694.5 *$$

M_{max} occurs @ $x=97$.

$$\sum M = 0 \quad M + P_3(36) + q_4 \left(\frac{66}{12} \right) (33) - R_b(66) = 0$$

$$M = 241,275 \text{ in.-lbs.}$$

W8 x 21 BEAM

$$I = 75.3 \text{ in}^4$$

$$S = 18.2 \text{ in}^3$$

FROM AISC 8TH ED

$$\sigma_b = \frac{M}{S} = \frac{241,275 \text{ in-lbs}}{18.2 \text{ in}^3} = \underline{13,257 \text{ psi}}$$

$$F_b = 0.66 F_y = 0.66(36) = 23.76 \text{ ksi}$$

$$F_v = 0.30 F_u = 16.8 \text{ ksi}$$

LOOK @ CONNECTION TO WALL:

FRAMED CONNECTION

{ ANGLE STRENGTH FROM TABLE 11C pg. 4-27 }

$$L = 5 \frac{1}{2}'' \quad n = 2 \quad 50.6 \text{ KIPS}$$

ANGLE DID NOT NEED TO BE CHECKED BECAUSE NOT FOOTNOTED IN 11A.

TABLE 11A

$$L = 5 \frac{1}{2}'' \quad n = 2$$

$$\text{SAY ANGLE } t = \frac{1}{4}$$

A 307 BOLTS

} CONSERVATIVE
FRICTION
TYPE
CONN.

$$\text{ALLOWABLE LOAD} = 17.7 \text{ KIPS.} \leftarrow$$

WALL ANCHORS

 $\frac{3}{4}''$ HILTI'S EACH HAVE ALLOWABLE SHEAR OF 5120 LBS

$$\therefore 4 \times 5120 = 20.5 \text{ KIPS} \approx \text{COMPARABLE TO}$$

CONCLUSION:

THIS QUICK LOOK @ CLEANROOM ROOF
SHOWS STRESSES ARE BELOW
AISC ALLOWABLES FOR THE WORST
LOADED BEAM ① WITH FULL
 $50 \text{ * } 1 \text{ ft}^2$ LOADING.

W SHAPES Dimensions

Designation	Area A	Depth d		Web			Flange				Distance		
				Thickness t_w		$\frac{t_w}{2}$	Width b_f		Thickness t_f		T	k	k_1
	in. ²	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	
W 8x67	19.7	9.00	9	0.570	$\frac{9}{16}$	$\frac{5}{16}$	8.280	8 $\frac{1}{4}$	0.935	$\frac{15}{16}$	6 $\frac{1}{8}$	17 $\frac{1}{8}$	11 $\frac{1}{16}$
x58	17.1	8.75	8 $\frac{3}{4}$	0.510	$\frac{1}{2}$	$\frac{1}{4}$	8.220	8 $\frac{1}{4}$	0.810	$\frac{13}{16}$	6 $\frac{1}{8}$	15 $\frac{1}{16}$	11 $\frac{1}{16}$
x48	14.1	8.50	8 $\frac{1}{2}$	0.400	$\frac{3}{8}$	$\frac{3}{16}$	8.110	8 $\frac{1}{8}$	0.685	$\frac{11}{16}$	6 $\frac{1}{8}$	13 $\frac{1}{16}$	$\frac{5}{8}$
x40	11.7	8.25	8 $\frac{1}{4}$	0.360	$\frac{3}{8}$	$\frac{3}{16}$	8.070	8 $\frac{1}{8}$	0.560	$\frac{9}{16}$	6 $\frac{1}{8}$	11 $\frac{1}{16}$	$\frac{5}{8}$
x35	10.3	8.12	8 $\frac{1}{8}$	0.310	$\frac{5}{16}$	$\frac{3}{16}$	8.020	8	0.495	$\frac{1}{2}$	6 $\frac{1}{8}$	1	$\frac{9}{16}$
x31	9.13	8.00	8	0.285	$\frac{5}{16}$	$\frac{3}{16}$	7.995	8	0.435	$\frac{7}{16}$	6 $\frac{1}{8}$	15 $\frac{1}{16}$	$\frac{9}{16}$
W 8x28	8.25	8.06	8	0.285	$\frac{5}{16}$	$\frac{3}{16}$	6.535	6 $\frac{1}{2}$	0.465	$\frac{7}{16}$	6 $\frac{1}{8}$	15 $\frac{1}{16}$	$\frac{9}{16}$
x24	7.08	7.93	7 $\frac{7}{8}$	0.245	$\frac{1}{4}$	$\frac{1}{8}$	6.495	6 $\frac{1}{2}$	0.400	$\frac{3}{8}$	6 $\frac{1}{8}$	$\frac{7}{8}$	$\frac{9}{16}$
W 8x21	6.16	8.28	8 $\frac{1}{4}$	0.250	$\frac{1}{4}$	$\frac{1}{8}$	5.270	5 $\frac{1}{4}$	0.400	$\frac{3}{8}$	6 $\frac{5}{8}$	13 $\frac{1}{16}$	$\frac{1}{2}$
x18	5.26	8.14	8 $\frac{1}{8}$	0.230	$\frac{1}{4}$	$\frac{1}{8}$	5.250	5 $\frac{1}{4}$	0.330	$\frac{5}{16}$	6 $\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{16}$
W 8x15	4.44	8.11	8 $\frac{1}{8}$	0.245	$\frac{1}{4}$	$\frac{1}{8}$	4.015	4	0.315	$\frac{5}{16}$	6 $\frac{5}{8}$	$\frac{3}{4}$	$\frac{1}{2}$
x13	3.84	7.99	8	0.230	$\frac{1}{4}$	$\frac{1}{8}$	4.000	4	0.255	$\frac{1}{4}$	6 $\frac{5}{8}$	11 $\frac{1}{16}$	$\frac{7}{16}$
x10	2.96	7.89	7 $\frac{7}{8}$	0.170	$\frac{3}{16}$	$\frac{1}{8}$	3.940	4	0.205	$\frac{3}{16}$	6 $\frac{5}{8}$	$\frac{5}{8}$	$\frac{7}{16}$
W 6x25	7.34	6.38	6 $\frac{3}{8}$	0.320	$\frac{5}{16}$	$\frac{3}{16}$	6.080	6 $\frac{1}{8}$	0.455	$\frac{7}{16}$	4 $\frac{3}{4}$	13 $\frac{1}{16}$	$\frac{7}{16}$
x20	5.87	6.20	6 $\frac{1}{4}$	0.260	$\frac{1}{4}$	$\frac{1}{8}$	6.020	6	0.365	$\frac{3}{8}$	4 $\frac{3}{4}$	$\frac{3}{4}$	$\frac{7}{16}$
x15	4.43	5.99	6	0.230	$\frac{1}{4}$	$\frac{1}{8}$	5.990	6	0.260	$\frac{1}{4}$	4 $\frac{3}{4}$	$\frac{5}{8}$	$\frac{3}{8}$
W 6x16	4.74	6.28	6 $\frac{1}{4}$	0.260	$\frac{1}{4}$	$\frac{1}{8}$	4.030	4	0.405	$\frac{3}{8}$	4 $\frac{3}{4}$	$\frac{3}{4}$	$\frac{7}{16}$
x12	3.55	6.03	6	0.230	$\frac{1}{4}$	$\frac{1}{8}$	4.000	4	0.280	$\frac{1}{4}$	4 $\frac{3}{4}$	$\frac{5}{8}$	$\frac{3}{8}$
x 9	2.68	5.90	5 $\frac{7}{8}$	0.170	$\frac{3}{16}$	$\frac{1}{8}$	3.940	4	0.215	$\frac{3}{16}$	4 $\frac{3}{4}$	$\frac{9}{16}$	$\frac{3}{8}$
W 5x19	5.54	5.15	5 $\frac{1}{8}$	0.270	$\frac{1}{4}$	$\frac{1}{8}$	5.030	5	0.430	$\frac{7}{16}$	3 $\frac{1}{2}$	13 $\frac{1}{16}$	$\frac{7}{16}$
x16	4.68	5.01	5	0.240	$\frac{1}{4}$	$\frac{1}{8}$	5.000	5	0.360	$\frac{3}{8}$	3 $\frac{1}{2}$	$\frac{3}{4}$	$\frac{7}{16}$
W 4x13	3.83	4.16	4 $\frac{1}{8}$	0.280	$\frac{1}{4}$	$\frac{1}{8}$	4.060	4	0.345	$\frac{3}{8}$	2 $\frac{3}{4}$	11 $\frac{1}{16}$	$\frac{7}{16}$

W SHAPES Properties

Nom- inal Wt. per Ft.	Compact Section Criteria				r_T	$\frac{d}{A_f}$	Elastic Properties						Tor- sional con- stant J	Plastic Modulus	
	$\frac{b_f}{2t_f}$	F_y'	$\frac{d}{t_w}$	F_y'''			Axis X-X			Axis Y-Y				Z_x	Z_y
							I	S	r	I	S	r			
							in. ⁴	in. ³	in.	in. ⁴	in. ³	in.			
Lb.		Ksi		Ksi	in.		in. ⁴	in. ³	in.	in. ⁴	in. ³	in.	in. ⁴	in. ³	in. ³
67	4.4	—	15.8	—	2.28	1.16	272	60.4	3.72	88.6	21.4	2.12	5.06	70.2	32.7
58	5.1	—	17.2	—	2.26	1.31	228	52.0	3.65	75.1	18.3	2.10	3.34	59.8	27.9
48	5.9	—	21.3	—	2.23	1.53	184	43.3	3.61	60.9	15.0	2.08	1.96	49.0	22.9
40	7.2	—	22.9	—	2.21	1.83	146	35.5	3.53	49.1	12.2	2.04	1.12	39.8	18.5
35	8.1	64.4	26.2	—	2.20	2.05	127	31.2	3.51	42.6	10.6	2.03	0.77	34.7	16.1
31	9.2	50.0	28.1	—	2.18	2.30	110	27.5	3.47	37.1	9.27	2.02	0.54	30.4	14.1
28	7.0	—	28.3	—	1.77	2.65	98.0	24.3	3.45	21.7	6.63	1.62	0.54	27.2	10.1
24	8.1	64.1	32.4	63.0	1.76	3.05	82.8	20.9	3.42	18.3	5.63	1.61	0.35	23.2	8.57
							↓	↓							
21	6.6	—	33.1	60.2	1.41	3.93	75.3	18.2	3.49	9.77	3.71	1.26	0.28	20.4	5.69
18	8.0	—	35.4	52.7	1.39	4.70	61.9	15.2	3.43	7.97	3.04	1.23	0.17	17.0	4.66
15	6.4	—	33.1	60.3	1.03	6.41	48.0	11.8	3.29	3.41	1.70	0.876	0.14	13.6	2.67
13	7.8	—	34.7	54.7	1.01	7.83	39.6	9.91	3.21	2.73	1.37	0.843	0.09	11.4	2.15
10	9.6	45.8	46.4	30.7	0.99	9.77	30.8	7.81	3.22	2.09	1.06	0.841	0.04	8.87	1.66
25	6.7	—	19.9	—	1.66	2.31	53.4	16.7	2.70	17.1	5.61	1.52	0.46	18.9	8.56
20	8.2	62.1	23.8	—	1.64	2.82	41.4	13.4	2.66	13.3	4.41	1.50	0.24	14.9	6.72
15	11.5	31.8	26.0	—	1.61	3.85	29.1	9.72	2.56	9.32	3.11	1.46	0.10	10.8	4.75
16	5.0	—	24.2	—	1.08	3.85	32.1	10.2	2.60	4.43	2.20	0.966	0.22	11.7	3.39
12	7.1	—	26.2	—	1.05	5.38	22.1	7.31	2.49	2.99	1.50	0.918	0.09	8.30	2.32
9	9.2	50.3	34.7	54.8	1.03	6.96	16.4	5.56	2.47	2.19	1.11	0.905	0.04	6.23	1.72
19	5.8	—	19.1	—	1.38	2.38	26.2	10.2	2.17	9.13	3.63	1.28	0.31	11.6	5.53
16	6.9	—	20.9	—	1.37	2.78	21.3	8.51	2.13	7.51	3.00	1.27	0.19	9.59	4.57
13	5.9	—	14.9	—	1.10	2.97	11.3	5.46	1.72	3.86	1.90	1.00	0.15	6.28	2.92

A/C