D-ZERO

UPPER CLEAN ROOM

ROOF LOADING

CALCUALTIONS

D-ZERO ENGINEERING NOTE # 3823.115-EN-569

February 12, 2004

Author: Russell A. Rucinski

Project Engineer

PPD/MSD/D0 Operations

Ed and company,

I took a formal look at the upper clean room strength for adding more relay racks. What I propose is that we set four additional racks in line with the existing two. They will sit inside some angle structural members. The angle will be somewhere between 1 1/2" and 2 1/2" deep, so it will not interfere with the opening in the rack. The angle will carry the loading out to the north-south running structural members.

It shouldn't take more than a day or two to find the angle. We might paint it so it looks nice and then we will then start setting the racks as they become ready.

The calculations will be filed as D0 engineering note 3823.115-EN-569.

Russ

----- Original Message -----

From: Ed Arko

To: Russ Rucinski

Sent: Wednesday, February 11, 2004 8:21 AM

Subject: Re: Clean Room Roof

Hi Russ,

I would like to get together on this sometime next week.(At your convenience).

I don't see a problem with the weight since a relay rack weighs about 290 lbs. by itself and we will add less than 100 lbs. of equipment. Pete probably can weigh it after the equipment is in it.

This rack is for Fred Borcherding and is not one of the ones that you mention above.

Placement of the rack would be at your discretion.

Thanks

Ed Arko

----- Original Message -----

From: Russ Rucinski

To: Kurt Krempetz

Cc: Ed Arko

Sent: Tuesday, February 10, 2004 4:23 PM

Subject: Re: Clean Room Roof

Ed,

I'll have to take a look at it. The rated floor loading is 50 lb/ft^2 or 200 lb per relay rack. We need to load wisely. Let's get together and you can show me what general area of the roof you are considering.

Russ

P.S. Is this part of the 3 additional racks Paul Rubinov/Juan Estrada are considering adding to the clean room roof?

-----Original Message-----
From: Ed Arko [mailto:earko@fnal.gov]
Sent: Tuesday, February 10, 2004 10:38 AM
To: krempetz@fnal.gov
Subject: Clean Room Roof

Hi Kurt,

I'm putting a test relay rack together which will be used on the clean room roof.The rack and equipment therein will weigh approximately 400 lbs. It has been suggested that I contact you to determine if there is a possibility of overloading the support structure.

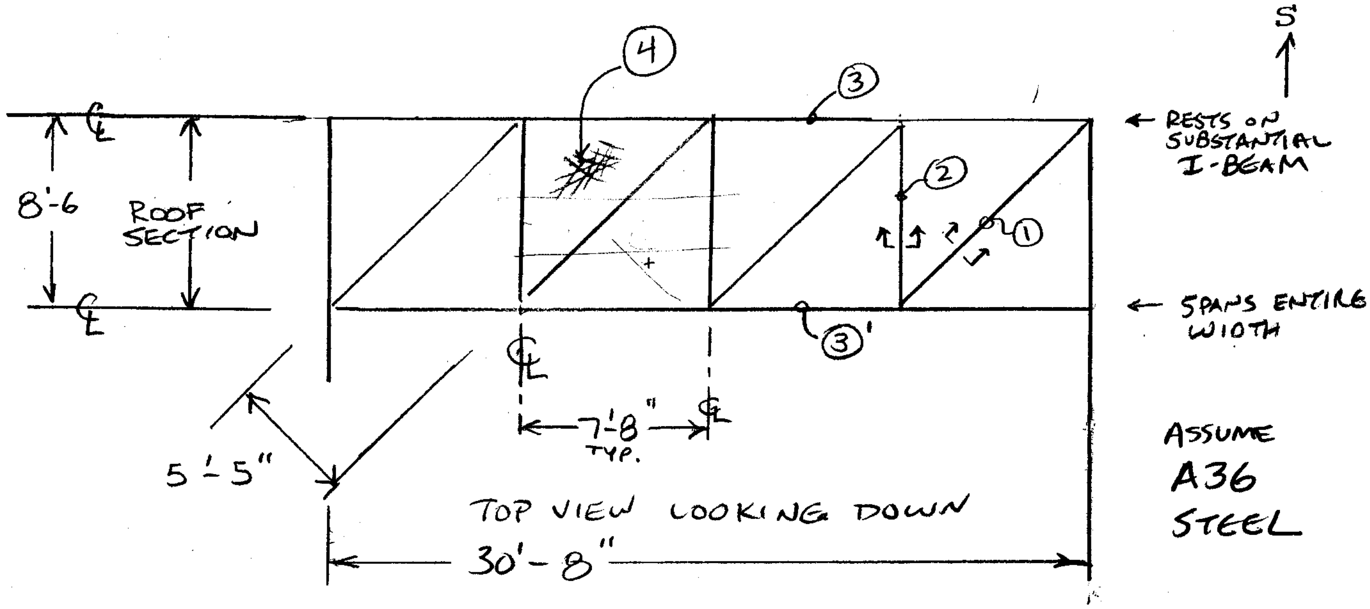
Please let me know if you think there will be a problem.

Thanks

Ed Arko

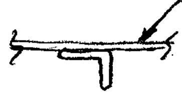
FERMILAB ENGINEERING NOTE	SECTION PPD/MD DØ OPS	PROJECT MECHANICAL	SERIAL-CATEGORY 3823.115 EN-569	PAGE 1

SUBJECT	NAME	
UPPER CLEAN ROOM ROOF CHECK LOADING	RUSS RUCINSKI	
	DATE 2-12-04	REVISION DATE



ASSUME A36 STEEL

DIAMOND PLATE

(1) ANGLE  50% STITCH WELD 4x4x3/8

(2) CHANNEL  C8x11.5, 8'-6" SPAN.

PER AISC, 9th EDITION, PG. 2-85, A36 STEEL 9' SPAN, 13,000 lbs.
OR 1444 lb/ft

(3) I-BEAM  W14x22, 30'-8" SPAN,

FOR 31 FOOT SPAN, ALLOWABLE LOAD = 14,500 lbs UNIFORM
OR 468 lb/ft

AISC. 9th EDITION PG. 2-66 LATERALLY SUPPORTED A36

(4) FLOOR PLATE, 1/4" 5'-5" SPAN

5'-0" SPAN ALLOWABLE LOAD = 53 lb/ft²

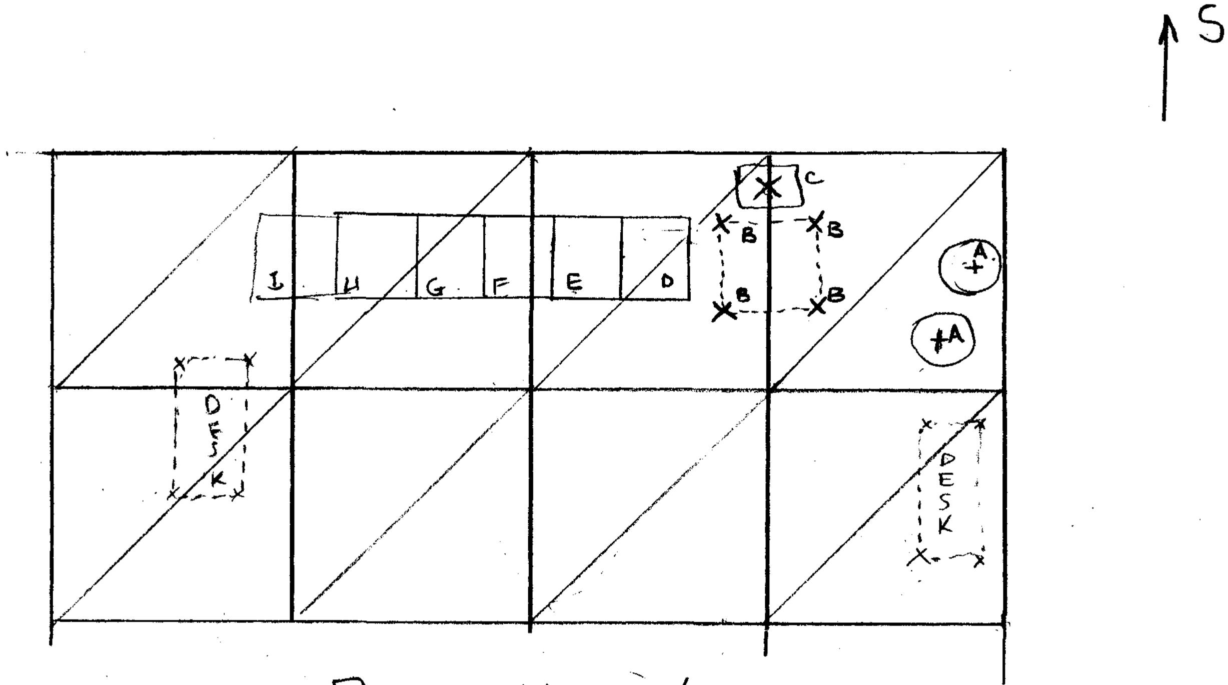
3'-0' SPAN " " 148 lb/ft²

AISC 9th EDITION PG. 2-145 FLOOR PLATE BENDING CAPACITY

FERMILAB ENGINEERING NOTE	SECTION PPD / MD DØ OPS	PROJECT MECHANICAL	SERIAL-CATEGORY	PAGE 2

SUBJECT	NAME	
CURRENT / PROPOSED LOADS	Russ Rucinski	
	DATE 2-12-04	REVISION DATE

SCALE: $5 \times \frac{1}{4}'' = 8$ ft., 1 SQUARE = $\frac{8}{5}$ ft = 1.6 FEET



PLAN VIEW

A. BAYONET CANS 400 lbs?

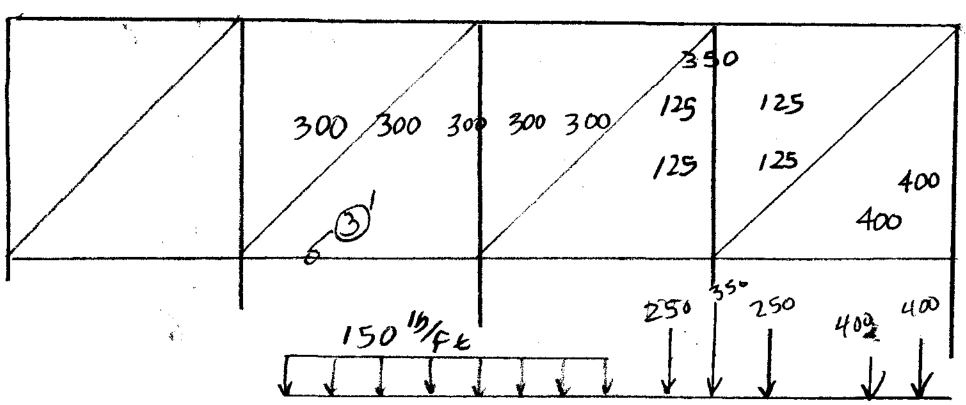
B. VLPC TEST CRYOSTAT; 500 lbs/4 FEET = 125 lbs POINT LOADS

C. LEAD SHIELDING + APARATUS 350 lbs / 3.2 ft^2 $\approx$ 110 lb/ft^2

D. RACK w/ POWER SUPPLIES & CRATES 300 lbs / (2')(2.5') = 60 lb/ft^2

E. RACK, CRYO BASE, EQUIPMENT 300 lbs?

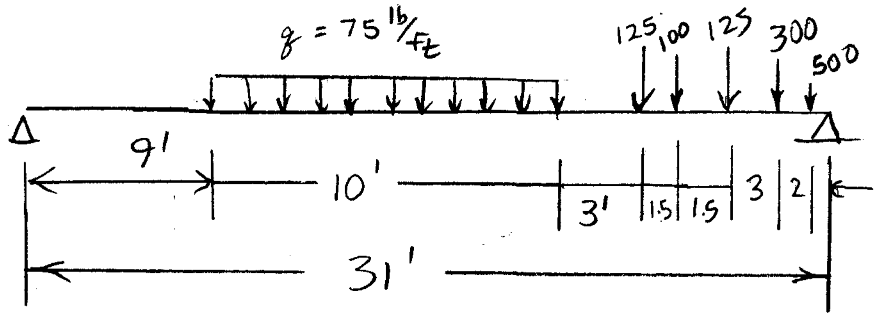
F., G., H. FUTURE RACKS ?



FERMILAB ENGINEERING NOTE	SECTION: PPD / MD DØ OPS	PROJECT: MECHANICAL	SERIAL-CATEGORY	PAGE: 3

SUBJECT	NAME	REVISION DATE
CLEANROOM ROOF MEMBER LOADING	RUSS RUCINSKI	
	DATE: 2-12-04	

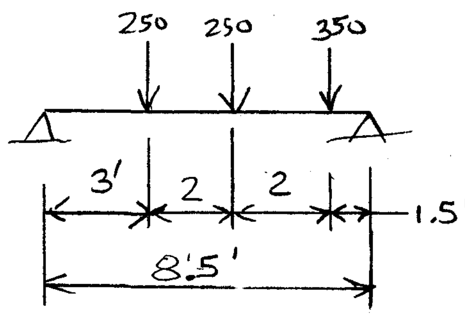
MEMBER (3)'



NOTE EACH MEMBER (3) & (3)' SHARE LOADING PROFILE ON PREVIOUS PAGE.

ALLOWABLE FOR (3)' IS 419 lb/ft UNIFORM LOAD SO BY INSPECTION, LOADING IS OKAY.

MEMBER (2)



WORST CASE LOADING AT CRYOSTAT LOCATION

ALLOWABLE UNIFORM LOADING = 1444 lb/ft SO BY INSPECTION, IT IS OKAY.

MEMBER (4) DIAMOND PLATE; THIS IS THE REAL LIMITING FACTOR. 5'-0 SPAN - 53 lb/ft^2

3'-0 SPAN 148 lb/ft^2

EFFECTIVE SPAN IS < 5'-5", DIAGONAL, BETWEEN ANGLE & CORNER.

FOR 8' SQUARE, $(64\ ft^2)(50\ lb/ft^2) \doteq 3200$ lb/SQUARE SECTION

WE ARE PUTTING ABOUT 1000 lbs PER SECTION.

FERMILAB ENGINEERING NOTE	SECTION PPD/MD DØ OPS	PROJECT	SERIAL-CATEGORY	PAGE 4

SUBJECT: UPPER CLEAN ROOM ROOF LOADING (cont.)

NAME: RUSS RUCINSKI

DATE: 2-12-04

REVISION DATE:

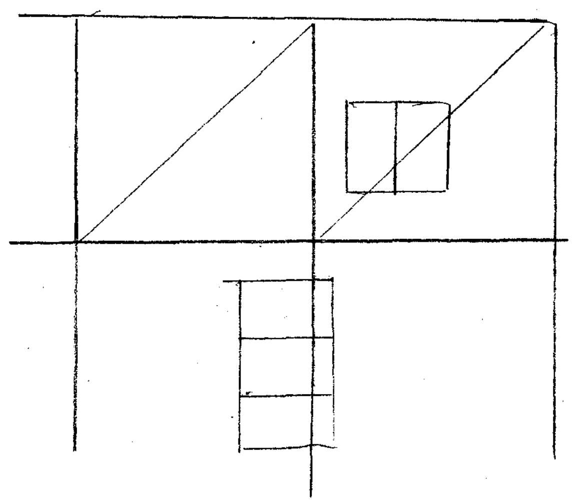
TO ELIMINATE CONCERN OF FLOOR PLATE LOADING, COULD BOLT RACKS TOGETHER SO THEY TRANSMIT LOADS ACROSS TO C-CHANNEL MEMBERS. → RIGGING & TIMING ISSUE

OR

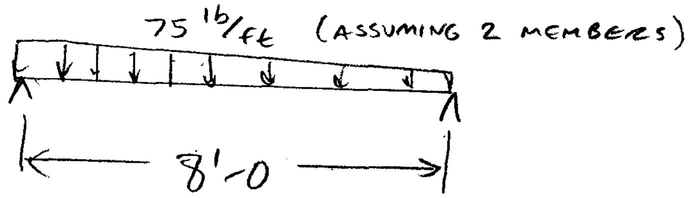
COULD REST RACKS ON SUFFICIENTLY STRONG CROSS MEMBERS. → BEST SOLUTION

OR

COULD ALIGN RACKS ON C CHANNEL MEMBERS. → PROBABLY NOT PRACTICAL.



WHAT SIZE MEMBER I REQ'D FOR INSERTION UNDER RACK?



LIMIT DEFLECTION TO $\frac{1}{164}$ SPAN = .585" ? TOO MUCH
SAY 1/4"

$$\Delta X_{MAX} = \frac{5wl^3}{384EI}$$

PG. 2-296, AISC 9th EDITION BEAM FORMULAS

FERMILAB
ENGINEERING NOTE

SECTION	PROJECT	SERIAL-CATEGORY	PAGE
PPD / MD DØ OPS	PPD / MD DØ OPS	—	5

SUBJECT	NAME
UPPER CLEAN ROOF LOADING	RUSS RUCINSKI
	DATE 2-12-04
	REVISION DATE

$$I_{REQ'D} = \frac{5 w l^3}{384 E \Delta_{ALLOW}} =$$

$$= \frac{5(75 \text{ lb/ft})(96 \text{ in})^3}{384(30 \times 10^6 \frac{\text{lb}}{\text{in}^2})(.25 \text{ in.})} = .115 \text{ in}^4$$

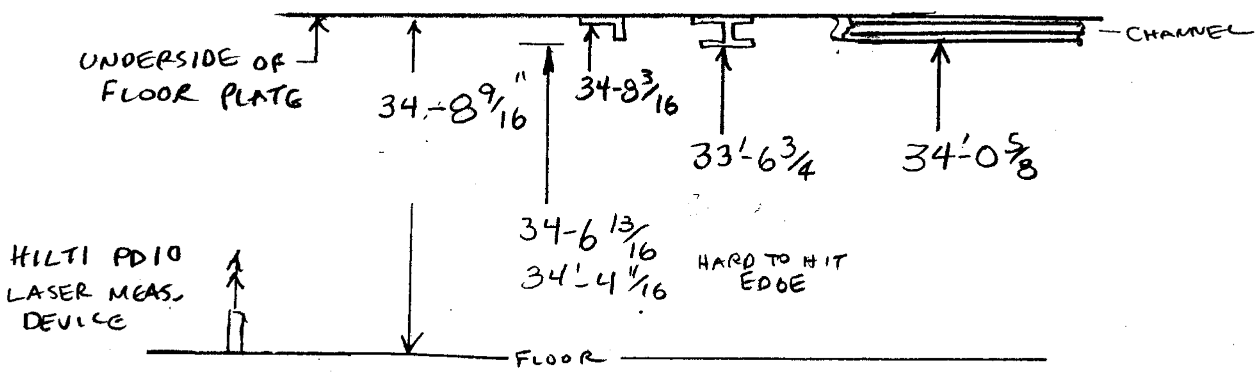
$\angle$ $1\frac{1}{2} \times 1\frac{1}{2} \times \frac{1}{4}$ WORKS.

I WOULD PROPOSE BOLTING RACKS TOGETHER AS A UNIT & LOWERING THEM, OR SETTING THEM ON ANGLES OR OTHER MEMBER.

RACKS ARE $2\frac{1}{2}$" AT BASE, SO ANYTHING $2\frac{1}{2}$" ON LEG WOULD NOT INTERFERE. GO WITH 2 ~8 FT LONG PIECES TO COVER 4 NEW RACKS. LEAVE EXISTING 2 RACKS ALONE.

FERMILAB ENGINEERING NOTE	SECTION PPD/MD DØ OPS	PROJECT MECHANICAL	SERIAL-CATEGORY	PAGE 6

SUBJECT	NAME	
CLEAN ROOM ROOF MEMBER SIZE MEASUREMENTS	RUSS RUCINSKI	
	DATE 2/12/04	REVISION DATE



③' I-BEAM; ③' $(34\text{-}8\tfrac{9}{16}) - (33'\text{-}6\tfrac{3}{4}) = 13\tfrac{13}{16}''$ DEEP

ABOUT 5" WIDE FLANGES BASED ON COMPARISON TO 24' WIDE VERTICAL WALL PANELS.

W14×26 OR W14×22

$13\tfrac{3}{4}$ DEPTH 5.025" OR 5.000" FLANGE WIDTH.

① ANGLE; ANGLE DEPTH = 4" × 4" × 3/8" LOOKS ½ DEPTH OF CHANNEL

② CHANNEL; $(34'\text{-}8\tfrac{9}{16}) - (34\text{-}0\tfrac{5}{8}) = 7\tfrac{15}{16}''$ DEPTH C8

ABOUT 2¼" FLANGE, bf BASED ON COMPARISON TO FIRE SPRINKLER PIPE, 1.5+(1.50" DIA.)

↑ MEASURED ELSEWHERE

C8×11.5

C8 x 11.5, 9 Ft. SPAN

kip
tea
e 2-146

MC 9	Deflection In.
23.9	
3½	
9.80	
	.002
104	.01
91	.02
68	.04
54	.06
45	.09
39	.12
34	.16
30	.20
27	.25
25	.30
23	.36
21	.42
19	.49
18	.56
17	.63
16	.72
15	.80
14	.90
14	.99
13	1.09
12	1.20
18.9 52 28.2 9.50 38.3 7.91 61	For explanation of deflection see page 2-32

shear.

ION

8 [

BEAMS
Channels
Allowable uniform loads in kips for beams laterally supported

F_y = 36 ksi

For beams laterally unsupported, see page 2-146

Designation	C 8			MC 8		MC 8		MC 8	Deflection In.
Wt./ft	18.75	13.75	11.5	22.8	21.4	20	18.7	8.5	
Flange Width	2½	2⅜	2¼	3½	3½	3	3	1⅞	
L_u	5.70	5.30	5.10	10.6	10.5	8.80	8.60	3.40	
F_y = 36 ksi, Span in Feet									
1	112	70							.003
2	79	65	51	98	86	92	81	41	.01
3	53	43	39	77	74	65	63	28	.03
4	40	33	29	58	55	49	47	21	.04
5	32	26	23	46	44	39	38	17	.07
6	26	22	20	38	37	33	31	14	.10
7	23	19	17	33	32	28	27	12	.14
8	20	16	15	29	28	24	24	10	.18
9	18	14	13	26	25	22	21	9.3	.23
10	16	13	12	23	22	20	19	8.4	.28
11	14	12	11	21	20	18	17	7.6	.34
12	13	11	9.8	19	18	16	16	7.0	.40
13	12	10	9.0	18	17	15	15	6.5	.47
14	11	9.3	8.4	16	16	14	13	6.0	.55
15	11	8.7	7.8	15	15	13	13	5.6	.63
16	9.9	8.1	7.3	14	14	12	12	5.2	.71
17	9.3	7.6	6.9	14	13	12	11	4.9	.81
18	8.8	7.2	6.5	13	12	11	10	4.7	.90
19	8.3	6.8	6.2	12	12	10	9.9	4.4	1.01
20	7.9	6.5	5.9	12	11	9.8	9.4	4.2	1.12

Properties and Reaction Values

	C 8			MC 8		MC 8		MC 8	
S_x in.^{3}	11.0	9.03	8.14	16.0	15.4	13.6	13.1	5.83	For explanation of deflection, see page 2-32
V kips	56	35	25	49	43	46	41	21	
R_1 kips	27.1	16.9	12.3	30.1	26.5	26.7	23.6	7.97	
R_2 kips/in.	11.6	7.20	5.23	10.1	8.91	9.50	8.39	4.25	
R_3 kips	43.3	21.2	13.1	41.2	33.9	36.5	30.3	8.62	
R_4 kips/in.	22.7	5.46	2.09	11.3	7.68	9.79	6.73	1.41	
R kips	**68**	**40**	20	**65**	**58**	**60**	**53**	14	

Load above heavy line is limited by maximum allowable web shear.
Values of R in **bold face** exceed maximum web shear.

W14 x 22 , 31 Ft. SPAN

F_y = 36 ksi

BEAMS
W Shapes
Allowable uniform loads in kips for beams laterally supported

W 14

For beams laterally unsupported, see page 2-146

Designation	W 14			W 14			W 14		Deflection in.
Wt./ft	53	48	43	38	34	30	26	22	
Flange Width	8	8	8	6¾	6¾	6¾	5	5	
L_c	8.50	8.50	8.40	7.10	7.10	7.10	5.30	5.30	
L_u	17.7	16.0	14.4	11.5	10.2	8.70	7.00	5.60	
F_y = 36 ksi, Span in Feet: 5							102	91	.04
6				126	115	108	93	77	.06
7				124	110	95	80	66	.09
8	148	135	120	108	96	83	70	57	.11
9	137	124	110	96	86	74	62	51	.14
10	123	111	99	86	77	67	56	46	.18
11	112	101	90	79	70	60	51	42	.21
12	103	93	83	72	64	55	47	38	.25
13	95	86	76	67	59	51	43	35	.30
14	88	80	71	62	55	48	40	33	.34
15	82	74	66	58	51	44	37	31	.40
16	77	70	62	54	48	42	35	29	.45
17	72	66	58	51	45	39	33	27	.51
18	68	62	55	48	43	37	31	26	.57
19	65	59	52	46	41	35	29	24	.63
20	62	56	50	43	38	33	28	23	.70
21	59	53	47	41	37	32	27	22	.77
22	56	51	45	39	35	30	25	21	.85
23	54	48	43	38	33	29	24	20	.93
24	51	46	41	36	32	28	23	19	1.01
25	49	45	40	35	31	27	22	18	1.10
26	47	43	38	33	30	26	22	18	1.19
27	46	41	37	32	29	25	21	17	1.28
28	44	40	35	31	27	24	20	16	1.38
30	41	37	33	29	26	22	19	15	1.58
32	39	35	31	27	24	21	17	14	1.80
34	36	33	29	25	23	20	16	14	2.03

Properties and Reaction Values

	53	48	43	38	34	30	26	22	
S_x in.^{3}	77.8	70.3	62.7	54.6	48.6	42.0	35.3	29.0	For explanation of deflection, see page 2-32
V kips	74	68	60	63	57	54	51	46	
R_1 kips	31.6	27.8	23.8	19.6	16.9	15.0	14.2	12.0	
R_2 kips/in.	8.79	8.08	7.25	7.37	6.77	6.42	6.06	5.46	
R_3 kips	37.3	31.2	25.0	25.3	20.9	17.8	17.0	13.0	
R_4 kips/in.	3.37	2.93	2.40	2.51	2.23	2.26	1.74	1.62	
R kips	49	41	33	34	29	26	23	19	

Load above heavy line is limited by maximum allowable web shear.

1/4" FLOOR PLATE

FLOOR PLATE
BENDING CAPACITY
Pounds per Sq. Ft

Theoretical Weight per sq. ft in lbs.	Plate Thickness inches	SPAN 1′–6″	2′–0″	2′–6″	3′–0″	3′–6″	4′–0″	4′–6″	5′–0″	6′–0″	7′–0″	Section Modulus per ft of width
6.15	1/8	148	83	53	37	—	—	—	—	—	—	.031
8.70	3/16	333	188	120	83	61	47	—	—	—	—	.070
11.25	1/4	593	333	213	148	109	83	66	53	—	—	.125
13.80	5/16	927	521	333	232	170	130	103	83	58	—	.195
16.35	3/8	1333	750	480	333	245	188	148	120	83	61	.281
18.90	7/16	1814	1021	653	453	333	255	201	163	113	83	.383
21.45	1/2	2370	1333	853	593	435	333	263	213	148	109	.500
24.00	9/16	3000	1688	1080	750	551	422	333	270	188	138	.633
26.55	5/8	3703	2084	1333	926	680	521	412	333	232	170	.781
29.10	11/16	4482	2521	1613	1121	823	630	498	403	280	206	.945
31.65	3/4	5333	3000	1920	1333	980	750	593	480	333	245	1.125
34.20	13/16	6260	3521	2253	1565	1150	880	696	563	391	287	1.320
36.75	7/8	7258	4088	2613	1815	1333	1022	807	653	454	333	1.531
39.30	15/16	8333	4688	3000	2083	1531	1172	926	750	521	383	1.758
41.85	1	9481	5333	3413	2370	1741	1333	1053	853	593	435	2.000
44.40	1-1/16	10705	6021	3853	2676	1966	1505	1190	963	669	492	2.258
46.95	1-1/8	11999	6749	4319	3000	2204	1687	1333	1080	750	551	2.531
49.50	1-3/16	13369	7520	4813	3343	2456	1880	1486	1203	836	614	2.820
52.05	1-1/4	14815	8333	5333	3704	2721	2083	1646	1333	926	680	3.125
54.60	1-5/16	16332	9186	5879	4083	3000	2297	1815	1470	1021	750	3.445
57.15	1-3/8	17925	10082	6453	4482	3292	2521	1992	1613	1120	823	3.781
59.70	1-7/16	19593	11021	7053	4898	3599	2755	2177	1764	1225	900	4.133
62.25	1-1/2	21333	12000	7680	5333	3919	3000	2371	1920	1333	980	4.500
64.80	1-9/16	23149	13021	8333	5787	4252	3255	2572	2084	1447	1063	4.883
67.35	1-5/8	25036	14082	9013	6260	4599	3521	2782	2253	1565	1150	5.281
69.90	1-11/16	26998	15186	9719	6750	4959	3797	3000	2430	1687	1240	5.695
72.45	1-3/4	29037	16333	10453	7259	5334	4084	3227	2614	1815	1333	6.125
75.00	1-13/16	31146	17520	11212	7787	5721	4380	3461	2803	1947	1430	6.570
77.55	1-7/8	33332	18749	11999	8333	6123	4688	3704	3000	2083	1531	7.031
80.10	1-15/16	35593	20021	12813	8898	6538	5006	3955	3204	2225	1634	7.508
82.65	2	37926	21333	13653	9482	6966	5334	4214	3414	2370	1742	8.000
Deflection Coefficient E = 29,000 ksi		.037	.066	.104	.149	.203	.265	.335	.414	.596	.700	.810

Loads above and to the right of the heavy black lines will cause deflections of more than 1/164 of the span.

To find the actual deflections for the loads given above, divide the coefficient of deflection for the span by the thickness of the plate in inches.

To find the deflection caused by loads less than shown above, first find the deflection caused by the loads given above. Multiply this by the actual load and divide by the load given above. For safety, loads greater than those given in the above table should not be used.

Loads are based on an extreme fiber stress of 16 ksi and simple span bending.