Design of fire-resistive exposed wood members

SIMPLE DESIGN PROCEDURES - LOAD RATIO TABLES

For members stressed in one principle direction, simplifications can be made which allow the creation of load ratio tables. These load ratio tables can be used to determine the structural design load ratio, Rs, at which the member has sufficient capacity for a given fire resistance time. The following load ratio tables are based on a nominal char rate of 1.5 in./hr. For more complex calculations where stress interactions must be considered, or where standard reference conditions do not apply, the user should use the provisions of Technical Report No. 10, along with the appropriate NDS provisions.

FLEXURAL MEMBERS - NORDIC LAM BEAMS

Table 1A Design load ratios, R_s, for flexural members exposed on three sides, 1-hour rating

Width, b (in.)	3 3/8	5 3/8	7 1/4	9	11	12 7/8
Depth, d (in.)						
5	--					
5 3/8		0,42				
7	--	0,52				
7 1/4			0,81			
8 3/4	--	0,59	0,91			
9				1,00		
10 1/2	--	0,65	0,99	1,00		
11					1,00	
12 1/2	--	0,69	1,00	1,00	1,00	
12 7/8						1,00
14 1/4	--	0,72	1,00	1,00	1,00	1,00
16	--	0,74	1,00	1,00	1,00	1,00
18	--	0,76	1,00	1,00	1,00	1,00
19 3/4	--	0,78	1,00	1,00	1,00	1,00
21 1/2	--	0,79	1,00	1,00	1,00	1,00
23 1/2	--	0,80	1,00	1,00	1,00	1,00
25 1/4	--	0,81	1,00	1,00	1,00	1,00
27	--	0,82	1,00	1,00	1,00	1,00
29	--	0,83	1,00	1,00	1,00	1,00
30 3/4	--	0,83	1,00	1,00	1,00	1,00
32 1/2	--	0,84	1,00	1,00	1,00	1,00
34 1/4	--	0,84	1,00	1,00	1,00	1,00
36 1/4	--	0,85	1,00	1,00	1,00	1,00

See notes on page 2.

Design of fire-resistive exposed wood members

Table 1B Design load ratios, R_s, for flexural members exposed on three sides, 1.5-hour rating

Width, b (in.)	3 3/8	5 3/8	7 1/4	9	11	12 7/8
Depth, d (in.)						
5	--					
5 3/8		0,06				
7	--	0,08				
7 1/4			0,38			
8 3/4	--	0,10	0,45			
9				0,66		
10 1/2	--	0,11	0,51	0,73		
11					0,93	
12 1/2	--	0,13	0,56	0,81	0,99	
12 7/8						1,00
14 1/4	--	0,13	0,60	0,86	1,00	1,00
16	--	0,14	0,63	0,90	1,00	1,00
18	--	0,15	0,65	0,94	1,00	1,00
19 3/4	--	0,15	0,67	0,96	1,00	1,00
21 1/2	--	0,15	0,69	0,99	1,00	1,00
23 1/2	--	0,16	0,70	1,00	1,00	1,00
25 1/4	--	0,16	0,72	1,00	1,00	1,00
27	--	0,16	0,73	1,00	1,00	1,00
29	--	0,16	0,74	1,00	1,00	1,00
30 3/4	--	0,17	0,74	1,00	1,00	1,00
32 1/2	--	0,17	0,75	1,00	1,00	1,00
34 1/4	--	0,17	0,76	1,00	1,00	1,00
36 1/4	--	0,17	0,76	1,00	1,00	1,00

Table 1C Design load ratios, R_s, for flexural members exposed on three sides, 2-hour rating

Width, b (in.)	3 3/8	5 3/8	7 1/4	9	11	12 7/8
Depth, d (in.)						
5	--					
5 3/8		--				
7	--	--				
7 1/4			0,12			
8 3/4	--	--	0,15			
9				0,36		
10 1/2	--	--	0,18	0,41		
11					0,61	
12 1/2	--	--	0,20	0,47	0,68	
12 7/8						0,83
14 1/4	--	--	0,22	0,51	0,73	0,88
16	--	--	0,23	0,55	0,78	0,93
18	--	--	0,25	0,58	0,82	0,99
19 3/4	--	--	0,26	0,60	0,85	1,00
21 1/2	--	--	0,26	0,62	0,88	1,00
23 1/2	--	--	0,27	0,63	0,91	1,00
25 1/4	--	--	0,28	0,65	0,93	1,00
27	--	--	0,28	0,66	0,94	1,00
29	--	--	0,29	0,67	0,96	1,00
30 3/4	--	--	0,29	0,68	0,97	1,00
32 1/2	--	--	0,30	0,69	0,99	1,00
34 1/4	--	--	0,30	0,70	1,00	1,00
36 1/4	--	--	0,30	0,71	1,00	1,00

Notes to Tables 1A, 1B, and 1C:

1. Design load ratio, R_s, assume bending about the X-X axis, and continuous lateral support along the compression edge.
2. For the purposes of this table, the dimension d is measured in the direction normal to the axis about which bending occurs.
3. The design moment for fire is approximated by multiplying the adjusted ASD design moment used in structural design by R_s ($F_{b,f}'S_f = F_b'S\ R_s$).
4. Structural calculations at standard reference conditions: $C_D = 1.0$, $C_M = 1.0$, $C_t = 1.0$, $C_i = 1.0$, $C_L = 1.0$.

Design of fire-resistive exposed wood members

COMPRESSION MEMBERS - NORDIC LAM COLUMNS

Table 2A Design load ratios, $R_s = R_{s1}\, R_{s2} \leq 1.0$, for compression members exposed on four sides, 1-hour rating

Depth, d (in.)	5 3/8	7 1/4	9	11	12 7/8	14 1/4
L_e/d	R_{s1} = Design stress adjustment for L_e/d					
0	0,29	0,65	0,93	1,17	1,33	1,43
5	0,18	0,50	0,78	1,03	1,20	1,31
10	0,068	0,35	0,63	0,89	1,08	1,20
15	0,047	0,25	0,47	0,68	0,84	0,95
20	0,026	0,15	0,30	0,47	0,61	0,70
25	0,025	0,15	0,29	0,45	0,58	0,68
30	0,024	0,14	0,27	0,43	0,56	0,65
35	0,024	0,14	0,27	0,43	0,55	0,65
40	0,023	0,13	0,27	0,42	0,55	0,64
45	0,023	0,13	0,27	0,42	0,55	0,64
50	0,023	0,13	0,27	0,42	0,55	0,63
Width, b (in.)	R_{s2} = Design stress adjustment for width, b, of column					
5 3/8	1,00	0,66	0,55	0,49	0,46	0,44
7 1/4	1,52	1,00	0,84	0,75	0,70	0,67
9	1,82	1,19	1,00	0,89	0,83	0,80
11	2,04	1,34	1,12	1,00	0,93	0,90
12 7/8	2,18	1,43	1,20	1,07	1,00	0,96

Table 2B Design load ratios, $R_s = R_{s1}\, R_{s2} \leq 1.0$, for compression members exposed on four sides, 1.5-hour rating

Depth, d (in.)	7 1/4	9	11	12 7/8	14 1/4	16
L_e/d	R_{s1} = Design stress adjustment for L_e/d					
0	0,25	0,51	0,77	0,96	1,08	1,22
5	0,15	0,37	0,61	0,81	0,94	1,08
10	0,055	0,22	0,45	0,66	0,80	0,95
15	0,039	0,16	0,33	0,49	0,60	0,73
20	0,022	0,090	0,20	0,32	0,40	0,51
25	0,021	0,086	0,20	0,31	0,39	0,49
30	0,019	0,082	0,19	0,29	0,37	0,46
35	0,019	0,081	0,19	0,29	0,37	0,46
40	0,019	0,080	0,18	0,29	0,37	0,46
45	0,019	0,080	0,18	0,29	0,36	0,46
50	0,019	0,080	0,18	0,28	0,36	0,45
Width, b (in.)	R_{s2} = Design stress adjustment for width, b, of column					
7 1/4	1,00	0,70	0,57	0,51	0,48	0,45
9	1,43	1,00	0,81	0,73	0,68	0,65
11	1,76	1,23	1,00	0,89	0,84	0,79
12 7/8	1,97	1,38	1,12	1,00	0,94	0,89

See notes on page 4.

Design of fire-resistive exposed wood members

Table 2C Design load ratios, $R_s = R_{s1} R_{s2} \leq 1.0$, for compression members exposed on four sides, 2-hour rating

Depth, d (in.)	9	11	12 7/8	14 1/4	16	18
L_e/d	R_{s1} = Design stress adjustment for L_e/d					
0	0,23	0,47	0,66	0,79	0,94	1,09
5	0,14	0,33	0,51	0,64	0,79	0,95
10	0,047	0,19	0,36	0,49	0,64	0,80
15	0,033	0,13	0,26	0,36	0,47	0,61
20	0,018	0,076	0,16	0,22	0,31	0,41
25	0,018	0,073	0,15	0,21	0,29	0,39
30	0,017	0,069	0,15	0,20	0,28	0,37
35	0,017	0,069	0,14	0,20	0,28	0,37
40	0,016	0,068	0,14	0,20	0,28	0,36
45	0,016	0,068	0,14	0,20	0,28	0,36
50	0,016	0,067	0,14	0,19	0,28	0,36
Width, b (in.)	R_{s2} = Design stress adjustment for width, b, of column					
9	1,00	0,70	0,58	0,53	0,49	0,46
11	1,43	1,00	0,84	0,76	0,70	0,66
12 7/8	1,71	1,20	1,00	0,91	0,84	0,78

Notes to Tables 2A, 2B, and 2C:
1. Design load ratios are calculated as the product of R_{s1} and R_{s2}, but should not be taken as greater than 1.0 ($R_s = R_{s1} R_{s2} \leq 1.0$).
2. For the purposes of this table, the dimension d is measured in the direction normal to the axis about which buckling is considered. The designer should consider buckling about both axes and use the lesser design value.
3. Structural calculations at standard reference conditions: $C_D = 1.0$, $C_M = 1.0$, $C_t = 1.0$, $C_i = 1.0$.

TIMBER DECKS - NORDIC LAM DECKING

Table 3. Design load ratios, R_s, for Nordic Lam decking

Fire resistance rating	1 h	1,5 h	2 h
Depth, d (in.)			
1 1/2	--	--	--
1 3/4	--	--	--
2 1/8	0,07	--	--
2 1/2	0,22	--	--
3 1/2	0,67	0,23	0,03

Notes:
1. Decking protected on top face and sides per NDS Section 16.2.5.
2. Structural calculations at standard reference conditions: $C_D = 1.0$, $C_M = 1.0$, $C_t = 1.0$, $C_i = 1.0$, $C_L = 1.0$.

CONNECTIONS

Where a specified fire resistance rating is required, Section 16.3 of the NDS requires connectors and fasteners to be protected from fire exposure. This protection can be achieved by any of the following:
- Wood members having dimensions sufficient to prevent the char front (at a depth of a_char/1.2, where a_char is the effective char depth) from reaching the connectors and fasteners for the duration of the required fire resistance rating time,

$$a_{char} = t\,\beta_{eff} = 1.2\,\beta_n\,t^{0.813}$$

where t is the fire exposure time, in hours, and β_n the nominal char rate of 1.5 in./hr.

- Fire-rated gypsum board having a finish rating greater than or equal to the required fire resistance rating, or
- Any approved coating having a fire rating greater than or equal to the required fire resistance rating time.