Chapter 19

STEEL COMPRESSION MEMBERS

1 This chapter will cover the elementary analysis and design of steel column according to the LRFD provisions.

19.1 AISC Equations

2 By introducing a **slenderness parameter** λ_c (not to be confused with the slenderness ratio) defined as

$$\lambda_c^2 = \frac{F_y}{F_{cr}^{Euler}} = \frac{F_y}{\frac{\pi^2 E}{\left(\frac{KL}{r_{min}}\right)^2}} \tag{19.1-a}$$

$$\lambda_c = \frac{KL}{r_{min}}\sqrt{\frac{F_y}{\pi^2 E}} \tag{19.1-b}$$

Hence, this parameter accounts for both the slenderness ratio as well as steel material properties. This new parameter is a more suitable one than the slenderness ratio (which was a delimeter for elastic buckling) for the inelastic buckling.

3 Equation 18.53 becomes

$$\frac{F_{cr}}{F_y} = 1 - \frac{\lambda_c^2}{4} \qquad \text{for } \lambda_c \leq \sqrt{2} \tag{19.2}$$

4 When $\lambda_c > \sqrt{2}$, then Euler equation applies

$$\frac{F_{cr}}{F_y} = \frac{1}{\lambda_c^2} \qquad \text{for } \lambda_c \geq \sqrt{2} \tag{19.3}$$

Hence the first equation is based on inelastic buckling (with gross yielding as a limiting case), and the second one on elastic buckling. The two curves are tangent to each other.

5 The above equations are valid for concentrically straight members.

$\frac{Kl}{r_{min}}$	λ_c	$\phi_c F_{cr}$	$\frac{Kl}{r_{min}}$	λ_c	$\phi_c F_{cr}$	$\frac{Kl}{r_{min}}$	λ_c	$\phi_c F_{cr}$	$\frac{Kl}{r_{min}}$	λ_c	$\phi_c F_{cr}$	$\frac{Kl}{r_{min}}$	λ_c	$\phi_c F_{cr}$
1	0.01	30.60	41	0.46	28.01	81	0.91	21.66	121	1.36	14.16	161	1.81	8.23
2	0.02	30.59	42	0.47	27.89	82	0.92	21.48	122	1.37	13.98	162	1.82	8.13
3	0.03	30.59	43	0.48	27.76	83	0.93	21.29	123	1.38	13.80	163	1.83	8.03
4	0.04	30.57	44	0.49	27.63	84	0.94	21.11	124	1.39	13.62	164	1.84	7.93
5	0.06	30.56	45	0.50	27.51	85	0.95	20.92	125	1.40	13.44	165	1.85	7.84
6	0.07	30.54	46	0.52	27.37	86	0.96	20.73	126	1.41	13.27	166	1.86	7.74
7	0.08	30.52	47	0.53	27.24	87	0.98	20.54	127	1.42	13.09	167	1.87	7.65
8	0.09	30.50	48	0.54	27.10	88	0.99	20.35	128	1.44	12.92	168	1.88	7.56
9	0.10	30.47	49	0.55	26.97	89	1.00	20.17	129	1.45	12.74	169	1.90	7.47
10	0.11	30.44	50	0.56	26.83	90	1.01	19.98	130	1.46	12.57	170	1.91	7.38
11	0.12	30.41	51	0.57	26.68	91	1.02	19.79	131	1.47	12.40	171	1.92	7.30
12	0.13	30.37	52	0.58	26.54	92	1.03	19.60	132	1.48	12.23	172	1.93	7.21
13	0.15	30.33	53	0.59	26.39	93	1.04	19.41	133	1.49	12.06	173	1.94	7.13
14	0.16	30.29	54	0.61	26.25	94	1.05	19.22	134	1.50	11.88	174	1.95	7.05
15	0.17	30.24	55	0.62	26.10	95	1.07	19.03	135	1.51	11.71	175	1.96	6.97
16	0.18	30.19	56	0.63	25.94	96	1.08	18.84	136	1.53	11.54	176	1.97	6.89
17	0.19	30.14	57	0.64	25.79	97	1.09	18.65	137	1.54	11.37	177	1.99	6.81
18	0.20	30.08	58	0.65	25.63	98	1.10	18.46	138	1.55	11.20	178	2.00	6.73
19	0.21	30.02	59	0.66	25.48	99	1.11	18.27	139	1.56	11.04	179	2.01	6.66
20	0.22	29.96	60	0.67	25.32	100	1.12	18.08	140	1.57	10.89	180	2.02	6.59
21	0.24	29.90	61	0.68	25.16	101	1.13	17.89	141	1.58	10.73	181	2.03	6.51
22	0.25	29.83	62	0.70	24.99	102	1.14	17.70	142	1.59	10.58	182	2.04	6.44
23	0.26	29.76	63	0.71	24.83	103	1.16	17.51	143	1.60	10.43	183	2.05	6.37
24	0.27	29.69	64	0.72	24.66	104	1.17	17.32	144	1.61	10.29	184	2.06	6.30
25	0.28	29.61	65	0.73	24.50	105	1.18	17.13	145	1.63	10.15	185	2.07	6.23
26	0.29	29.53	66	0.74	24.33	106	1.19	16.94	146	1.64	10.01	186	2.09	6.17
27	0.30	29.45	67	0.75	24.16	107	1.20	16.75	147	1.65	9.87	187	2.10	6.10
28	0.31	29.36	68	0.76	23.99	108	1.21	16.56	148	1.66	9.74	188	2.11	6.04
29	0.33	29.27	69	0.77	23.82	109	1.22	16.37	149	1.67	9.61	189	2.12	5.97
30	0.34	29.18	70	0.79	23.64	110	1.23	16.18	150	1.68	9.48	190	2.13	5.91
31	0.35	29.09	71	0.80	23.47	111	1.24	16.00	151	1.69	9.36	191	2.14	5.85
32	0.36	28.99	72	0.81	23.29	112	1.26	15.81	152	1.70	9.23	192	2.15	5.79
33	0.37	28.90	73	0.82	23.11	113	1.27	15.62	153	1.72	9.11	193	2.16	5.73
34	0.38	28.79	74	0.83	22.94	114	1.28	15.44	154	1.73	9.00	194	2.18	5.67
35	0.39	28.69	75	0.84	22.76	115	1.29	15.25	155	1.74	8.88	195	2.19	5.61
36	0.40	28.58	76	0.85	22.58	116	1.30	15.07	156	1.75	8.77	196	2.20	5.55
37	0.41	28.47	77	0.86	22.40	117	1.31	14.88	157	1.76	8.66	197	2.21	5.50
38	0.43	28.36	78	0.87	22.21	118	1.32	14.70	158	1.77	8.55	198	2.22	5.44
39	0.44	28.25	79	0.89	22.03	119	1.33	14.52	159	1.78	8.44	199	2.23	5.39
40	0.45	28.13	80	0.90	21.85	120	1.35	14.34	160	1.79	8.33	200	2.24	5.33

Table 19.1: Design Stress ϕF_{cr} for F_y=36 ksi in Terms of $\frac{KL}{r_{min}}$