SUPPLEMENT NO. 3

TO THE SPECIFICATION FOR THE DESIGN, FABRICATION & ERECTION OF STRUCTURAL STEEL FOR BUILDINGS

(ADOPTED FEBRUARY 12, 1969)

Effective June 12, 1974

(INCLUDING ADDENDA TO THE **COMMENTARY** ON THE SPECIFICATION)

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PREFACE

Since its adoption on February 12, 1969, the AISC Specification has been under constant review. Modifications, when adopted, are issued in the form of Supplements.

To date, three Supplements to the Specification have been issued, of which this document is the latest. Encircled numbers (①, ②) along the page margin indicate that the noted section was also modified in Supplement No. 1 (November 1, 1970) or Supplement No. 2 (December 8, 1971) and that reference should be made to the earlier Supplement.

Addenda to the Commentary on the AISC Specification, which follow Supplement No. 3 in this printing, are the first additions to the Commentary since its publication in July, 1969.

June, 1974

Supplement No. 3

TO THE SPECIFICATION FOR THE DESIGN, FABRICATION AND ERECTION OF STRUCTURAL STEEL FOR BUILDINGS (*Adopted February 12, 1969*)

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NOMENCLATURE

In the definition of C_c, immediately following the word "ratio", delete "dividing" and substitute "separating".

Delete the symbol h and its definition in their entirety.

Add the following symbols and respective definitions:

"F_u Specified minimum tensile strength of the type of steel being used (kips per square inch)"

"H Length of a stud shear connector"

"f_p Computed bearing stress"

"h Largest clear distance between flanges within an unstiffened segment of a beam or girder"

"h_r Height of rib for steel deck"

"w_r Average rib width for open rib deck"

"Δ Displacement of the neutral axis of a loaded member from its position when the member is not loaded"

SECTION 1.2 TYPES OF CONSTRUCTION

In the eighth paragraph, first line, after the word "In", delete "tier".

SECTION 1.3 LOADS AND FORCES

1.3.3 Impact

In the first line, add an asterisk after the word "loads", and add the following footnote:

"*Live loads on crane support girders shall be taken as the maximum crane wheel loads."

In the second paragraph, second category, between the words "For" and "traveling", insert the words "cab operated". Between the second and third categories, insert the following:

"For pendant operated traveling crane support girders and their connections. . . . . .10 percent"

1.3.4 Crane Runway Horizontal Forces

In the first paragraph, delete the second sentence in its entirety and substitute the following:

"The force shall be assumed to be applied at the top of the rails, acting in either direction normal to the runway rails, and shall be distributed with due regard for lateral stiffness of the structure supporting these rails."

SECTION 1.4 MATERIAL

② 1.4.1 Structural Steel

1.4.1.1 In the first paragraph, delete the following line from the list of materials: "High Strength Structural Steel, ASTM A440".

In the second paragraph, second line, immediately after "ASTM A6' add: "or A568, as applicable,".

1.4.4 Bolts

Delete the second item in the list, "Quenched and Tempered Steel Bolts and Studs, ASTM A449".

① 1.4.6 Stud Shear Connectors

In the first paragraph, delete "Article 429 and 430, Code for Welding in Building Construction, AWS D1.0-69" and substitute: "4.22 and 4.27, AWS Structural Welding Code, AWS D1.1-72."

SECTION 1.5 ALLOWABLE STRESSES

In the first paragraph, fourth line, after the words "rounded off in Appendix A.", add the following:

"See Appendix D for allowable stresses for web-tapered members."

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① See Supplement No. 1 to the AISC Specification.
② See Supplement No. 2 to the AISC Specification.

1.5.1 Structural Steel

1.5.1.4 Bending

① **1.5.1.4.1** In the first paragraph, second line, after the words "(except hybrid girders)", add: ", tapered girders".

In subparagraph b, delete "$52.2/\sqrt{F_y}$" and substitute "$65/\sqrt{\mathbf{F}_y}$"

In subparagraph d (see Supplement No. 1), change Formula (1.5-4a) to the following:

$$d/t = \frac{640}{\sqrt{F_y}}\left(1 - 3.74\,\frac{f_a}{F_y}\right) \qquad \text{when } \frac{f_a}{F_y} \le 0.16$$

Delete subparagraph e in its entirety and substitute the following:

"e. The laterally unsupported length of the compression flange of members other than box members shall not exceed the value $76.0b_f/\sqrt{F_y}$ nor $\dfrac{20{,}000}{(d/A_f)F_y}$."

Add the following subparagraph:

"f. The laterally unsupported length of the compression flange of a box-shaped member of rectangular cross section whose depth is not more than 6 times the width and whose flange thickness is not more than 2 times the web thickness shall not exceed the value

$$\left(1950 + 1200\,\frac{M_1}{M_2}\right)\frac{b}{F_y}$$

except that it need not be less than $1200\,(b/F_y)$."

In the third paragraph, third line, after the word "sub-paragraphs", delete "a, b, c, d and e" and substitute: "a through f".

1.5.1.4.2 In the third line, delete "$52.2/\sqrt{F_y}$" and substitute: "$65/\sqrt{F_y}$".

Change Formula (1.5-5a) to read:

$$F_b = F_y\left[0.79 - 0.002\left(\frac{b_f}{2t_f}\right)\sqrt{F_y}\right]$$

1.5.1.4.3 In the second paragraph (see Supplement No. 1), fourth line, delete "$52.2/\sqrt{F_y}$" and substitute: "$65/\sqrt{F_y}$".

Change Formula (1.5-5b) to read:

$$F_b = F_y\left[1.075 - 0.005\left(\frac{b_f}{2t_f}\right)\sqrt{F_y}\right]$$

1.5.1.4.4 Delete this section in its entirety and substitute the following:

"**1.5.1.4.4** Tension and compression on extreme fibers of box-type flexural members whose compression flange or web width-thickness ratio does not meet the requirements of Sect. 1.5.1.4.1 but does conform to the requirements of Sect. 1.9:

$$F_b = 0.60F_y$$

Lateral torsional buckling need not be investigated for a box section whose depth is less than 6 times its width. Lateral support requirements for box sections of larger depth to width ratios must be determined by special analysis."

(1) **1.5.1.4.6a** In the first paragraph, sixth line, immediately after the words "but not more than $0.60F_y$.", add a triple asterisk (***). Add the following footnote:

"*** See Sect. 1.10 for further limitations in plate girder flange stress."

Delete the second footnote in its entirety and substitute the following:

"** See Appendix D and Commentary Sects. 1.5.1.4.5 and 1.5.1.4.6, last two paragraphs, for alternate procedures."

In the definition of the symbol l, add a period after the last word, "flange", and add the following:

"For cantilevers braced against twist only at the support, l may conservatively be taken as the actual length."

In the definition of the symbol C_b, delete the next to last sentence beginning "C_b shall also. . ." in its entirety and substitute the following:

"When computing F_{bx} and F_{by} to be used in Formula (1.6-1a), C_b may be computed by the formula given above for frames subject to joint translation, and it shall be taken as unity for frames braced against joint translation. C_b may conservatively be taken as unity for cantilever beams.***"

Add the following footnote:

"*** For the use of larger C_b values, see Column Research Council *Guide to Design Criteria for Metal Compression Members*, Second Edition, page 101."

Delete the last sentence of the definition of C_b, "See Sect. 1.10 for further limitation in plate girder flange stress.", in its entirety.

1.5.1.5 Bearing (on contact area)

1.5.1.5.1 Delete the words "including bearing stiffeners and".

Delete the colon after the word "holes", and continue the sentence with "and ends of fitted bearing stiffeners:".

1.5.2 Rivets, Bolts, and Threaded Parts

1.5.2.1 In Table 1.5.2.1, under the column headed "Description of Fastener", immediately after "A325" in the fifth and sixth items, delete "and A449".

Delete Table 1.5.3 in its entirety and substitute new Table 1.5.3.

TABLE 1.5.3 ALLOWABLE STRESS

Type of Weld and Stress[1]	Allowable Stress	Required Weld Strength Level[2,3]
	Complete Penetration Groove Welds	
Tension normal to the effective area	Same as base metal	"Matching" weld metal must be used; see Table 1.17.2.
Compression normal to the effective area	Same as base metal	Weld metal with a strength level equal to or less than "matching" weld metal may be used.
Tension or compression parallel to the axis of the weld	Same as base metal	
Shear on the effective area	0.30 × nominal tensile strength of weld metal (ksi), except stress on base metal shall not exceed 0.40 × yield stress of base metal	
	Partial Penetration Groove Welds[4]	
Compression normal to effective area	Same as base metal	Weld metal with a strength level equal to or less than "matching" weld metal may be used.
Tension or compression parallel to axis of the weld[5]	Same as base metal	
Shear parallel to axis of weld	0.30 × nominal tensile strength of weld metal (ksi), except stress on base metal shall not exceed 0.40 × yield stress of base metal	
Tension normal to effective area	0.30 × nominal tensile strength of weld metal (ksi), except stress on base metal shall not exceed 0.60 × yield stress of base metal	
	Fillet Welds	
Stress on effective area	0.30 × nominal tensile strength of weld metal (ksi), except stress on base metal shall not exceed 0.40 × yield stress of base metal	Weld metal with a strength level equal to or less than "matching" metal may be used.
Tension or compression parallel to axis of weld[5]	Same as base metal	
	Plug and Slot Welds	
Shear parallel to faying surfaces (on effective area)	0.30 × nominal tensile strength of weld metal (ksi), except stress on base metal shall not exceed 0.40 × yield stress of base metal	Weld metal with a strength level equal to or less than "matching" weld metal may be used.

[1] For definition of effective area see Sect. 1.14.7.
[2] For "matching" weld metal, see Table 1.17.2.
[3] Weld metal one strength level stronger than "matching" weld metal will be permitted.
[4] See Sect. 1.10.8 for a limitation on use of partial penetration groove welded joints.
[5] Fillet welds and partial penetration groove welds joining the component elements of built-up members, such as flange-to-web connections, may be designed without regard to the tensile or compressive stress in these elements parallel to the axis of the welds.

1.5.2.2 In the last sentence, delete "A325, A449 or A490" and substitute: "A325 or A490".

1.5.5 Masonry Bearing

For the third listed category, "On the full area of a concrete support", delete "$0.25f'_c$" and substitute "$0.35f'_c$".

Delete the fourth listed category, "On one third of this area. . . F_p = $0.375f'_c$" in its entirety and substitute the following:

"On less than the full area of a concrete support. . . . . $F_p = 0.35f'_c\sqrt{A_2/A_1} \leq 0.7f'_c$"

In the last line, delete "where f'_c is the specified compression strength of the concrete." and substitute the following:

"where f'_c = specified compressive strength of concrete
A_1 = bearing area
A_2 = area of concrete"

1.5.6 Wind and Seismic Stresses

In the first line, after the word "values", add: "otherwise".

In the second line, delete "in Sect. 1.5.1, 1.5.2, 1.5.3, 1.5.4 and 1.5.5".

In the sixth line, delete the period after the word "increase" and add the following: "and provided that stresses are not otherwise* required to be calculated on basis of reduction factors applied to design loads in combinations. The above does not apply to allowable stress ranges provided in Appendix B."

Add the following footnote:

"* For example, see ANSI A58.1-72, Section 4.2."

SECTION 1.6 COMBINED STRESSES

1.6.3 Shear and Tension

In the fourth listed category delete "and A449".

At the end of the first paragraph, after "given in Sect. 1.5.2.", add the following: "When allowable stresses are increased for wind or seismic loads in accordance with Sect. 1.5.6, the constants in the above formulas shall be increased by one-third, but the factor 1.6 shall not be increased."

In the second paragraph, in the first listed category, immediately following "For A325", delete "and A449".

At the end of the second paragraph, after the word "bolt.", add the following: "When allowable stresses are increased for wind or seismic loads in accordance with Sect. 1.5.6, the term 1 in the above equations shall be increased to 1.33."

SECTION 1.10 PLATE GIRDERS AND ROLLED BEAMS

1.10.5 Stiffeners

1.10.5.2 In the definitions following Formula (1.10-1), delete the definition of h in its entirety and substitute the following:

"h = largest clear distance between flanges within an unstiffened segment, in inches"

In the paragraph preceding Formula (1.10-2), first line, after the words "other than hybrid girders", add: "and tapered members".

1.10.6 Reduction in Flange Stress

In the definitions following Formula (1.10–5), delete the definition of A_w in its entirety and substitute the following:

"A_w = largest area of the web within an unstiffened segment"

1.10.10 Web Crippling

1.10.10.2 In the first subparagraph of the last paragraph, after the words "Concentrated loads", delete the following:

"and loads distributed over partial length of a panel"

In the second subparagraph of the last paragraph, delete "Any other distributed loading" and substitute: "Distributed loads".

SECTION 1.11 COMPOSITE CONSTRUCTION

1.11.2 Design Assumptions

①,② **1.11.2.2** Add the following sentence to the first paragraph: "In calculations involving composite sections in positive moment areas, the steel cross section is exempt from the compactness requirements of Subparagraphs b, c, and e of Sect. 1.5.1.4.1."

In the second paragraph, fourth line, delete the words "subject to negative bending moment".

In the fourth paragraph, delete the text material preceding Formula (1.11-2) in its entirety and substitute the following:

"For construction without temporary shoring, stress in the steel section may be computed from the total dead plus live load moment and the transformed section modulus, S_{tr}, provided that the numerical value of S_{tr} so used shall not exceed:"

In the fourth paragraph, delete the text following Formula (1.11-2) in its entirety and substitute the following:

"In this expression for the limiting value of S_{tr}, M_L is the moment caused by loads applied subsequent to the time when the concrete has reached 75 percent of its required strength, M_D is the moment caused by loads applied prior to this time, and S_s is the section modulus of the steel beam referred to the flange where the stress is being computed. At sections subject to positive bending moment, the stress shall be computed for the steel tension flange. At sections subject to negative bending moment, the stress shall be computed for the steel tension and compression flanges. These stresses shall not exceed the appropriate value of Sect. 1.5.1. Section 1.5.6 shall not apply to stresses computed under the provisions of this paragraph."

1.11.3 End Shear

Delete the last four words in the sentence, "dead and live load", and substitute the word "reaction".

② 1.11.4 Shear Connectors

Add an asterisk after the margin formula identification "(1.11-3)", and add the following footnote:

"* The term $\frac{1}{2} A'_s F_{yr}$ should be added to the right-hand side of Formula (1.11-3) if longitudinal reinforcing steel with area A'_s located within the effective width of the concrete flange is included in the properties of the composite section."

Delete the third paragraph in its entirety and substitute the following:

"For full composite action, the number of connectors resisting the horizontal shear, V_h, each side of the point of maximum moment, shall not be less than that determined by the relationship V_h/q, where q, the allowable shear load for one connector, is given in Table 1.11.4 for flat soffit concrete slabs made with ASTM C33 aggregates. For flat soffit concrete slabs made with rotary kiln produced aggregates, conforming to ASTM C330 with concrete unit weight not less than 90 pcf, the allowable shear load for one connector is obtained by multiplying the values from Table 1.11.4 by the coefficient from Table 1.11.4A. Working values for use with concrete having aggregate not conforming to ASTM C33 or ASTM C330 produced by rotary kiln and for connector types other than those shown in Table 1.11.4 must be established by a suitable test program."

In Table 1.11.4, change the last column subheading from "4.0" to "$\geq$4.0". Add an asterisk after the column heading "Connector" and add the following footnote to the table:

"* The allowable horizontal loads tabulated may also be used for studs longer than shown."

Delete Table 1.11.4A (see Supplement No. 2) in its entirety and substitute the following new Table 1.11.4A:

TABLE. 1.11.4A

Air Dry Unit Weight, pcf	90	95	100	105	110	115	120
Coefficient, $f'_c \leq 4.0$ ksi	0.73	0.76	0.78	0.81	0.83	0.86	0.88
Coefficient, $f'_c \geq 5.0$ ksi	0.82	0.85	0.87	0.91	0.93	0.96	0.99

In the fourth paragraph, immediately following Table 1.11.4A, delete the second word of the first sentence, "incomplete", and substitute the word "partial". Delete the second sentence in its entirety (see Supplement No. 2) and substitute the following:

"The value of V_h' shall not be less than one-fourth the smaller value of Formula (1.11-3), using the maximum permitted effective width of the concrete flange, or Formula (1.11-4). The effective moment of inertia for deflection computations shall be determined by:

$$I_{eff} = I_s + \sqrt{\frac{V_h'}{V_h}}\,(I_{tr} - I_s) \qquad (1.11\text{-}7)$$

where

I_s = moment of inertia of the steel beam (in.^{4})
I_{tr} = moment of inertia of the transformed composite section (in.^{4})"

Delete the last (seventh) paragraph in its entirety and substitute the following:

"Except for connectors installed in the ribs of formed steel decks, shear connectors shall have at least 1 inch of lateral concrete cover. Unless located directly over the web, the diameter of studs shall not be greater than 2.5 times the thickness of the flange to which they are welded. The minimum center-to-center spacing of stud connectors shall be 6 diameters along the longitudinal axis of the supporting composite beam and 4 diameters transverse to the longitudinal axis of the supporting composite beam. The maximum center-to-center spacing of stud connectors shall not exceed 8 times the total slab thickness."

Add a new Section, as follows:

"1.11.5 Special Cases

When composite construction does not conform to the requirements of Sects. 1.11.1 through 1.11.4, allowable load per shear connector must be established by a suitable test program."

SECTION 1.14 GROSS AND NET SECTIONS

1.14.7 Effective Areas of Weld Metal

In the last paragraph, fourth line, add a period after the words "be ⅛-inch less than the depth of the groove" and delete the remainder of the paragraph in its entirety. Add the following new sentence:

"The effective throat of each partial penetration groove weld shall be not less than the size shown in Table 1.17.5."

SECTION 1.15 CONNECTIONS

① 1.15.5 Restrained Members

In the first paragraph, fourth and fifth lines, immediately before the asterisk, delete the words, "when the member is fully loaded".

1.15.10 Rivets and Bolts in Combination with Welds

In first paragraph, fourth and fifth lines, delete the words "accordance with the provisions of Sect. 1.16.1 as".

At the end of the first paragraph, add the following:

"When such bolts and welds connect the same piece of material at a common shear plane, the bolts shall be installed in accordance with Sect. 1.16.1 prior to welding."

SECTION 1.16 RIVETS AND BOLTS

1.16.1 High Strength Bolts

Delete the second and third sentences in their entirety.

SECTION 1.17 WELDS

1.17.1 Welder, Tacker, and Welding Operator Qualifications

Delete the words "Code for Welding in Building Construction, AWS D1.0.69" and substitute "Structural Welding Code, AWS D1.1-Rev 1-73".

1.17.2 Qualification of Weld and Joint Details

In the first and second paragraphs, delete "AWS D1.0-69" and substitute "AWS D1.1-Rev 1-73".

In the third paragraph, second line, delete the words "complete penetration". Delete the last sentence in its entirety and substitute the following: "Lower strength weld metal may be used for other welds."

Delete the fourth paragraph in its entirety.

In Table 1.17.2, footnote 2, delete the words "Article 422 of AWS D1.0-69" and substitute: "4.20 of AWS D1.1-Rev 1-73."

In Table 1.17.2, delete footnote 4 in its entirety and substitute the following:

"[4] For architectural exposed bare unpainted applications requiring weld metal with atmospheric corrosion resistance and coloring characteristics similar to that of the base metal, see 4.1.4 and 4.1.5 of AWS D1.1-Rev 1-73."

1.17.3 Submerged-Arc, Gas Metal-Arc, and Flux Cored-Arc Welding of High Strength Steel

Delete the words "Tables 1.5.3 and" and substitute: "Table".

Delete the words "Sections 412, 417 or 418 of AWS D1.0-69" and substitute: "4.12 of 4.16 of AWS D1.1-Rev 1-73"

1.17.4 Electroslag and Electrogas Welding

In the second line, delete the words "Article 422 of AWS D1.0-69" and substitute: "4.20 of AWS D1.1-Rev 1-73".

1.17.5 Minimum Size of Fillet Welds

Change the Section heading to read as follows:

"1.17.5 Minimum Size of Fillet Welds and Partial Penetration Welds"

Delete the first sentence in its entirety and substitute the following:

"The minimum size of fillet weld or partial penetration groove weld shall be as shown in Table 1.17.5."

In Table 1.17.5, second and fourth column headings, between the words "Minimum Size of" and "Weld", delete the word "Fillet" and in both column headings insert an asterisk after the word "Minimum". Add the following footnote to the table:

"* Leg dimension of fillet welds; minimum effective throat for partial penetration groove welds."

1.18.2 Compression Members

1.18.2.3 In the third sentence, immediately after the word "When", delete the words "rivets or bolts" and substitute: "rivets, bolts, or welds".

SECTION 1.23 FABRICATION

1.23.4 Riveted and Bolted Construction—Holes

In the second line, delete the period after the word "bolt" and add the following to the sentence: "except oversize holes, short slotted holes or long slotted holes as defined by the Research Council on Riveted and Bolted Structural Joints may be used when approved by the engineer."

② 1.23.5 Riveted and High Strength Bolted Construction—Assembling

In the last paragraph, first line, immediately after the word "All", delete "A325, A449, and A440" and substitute: "A325 and A490".

In the last paragraph, third line, directly after the asterisk, insert the following: ", by a direct tension indicator,".

In Table 1.23.5, in the subheading to the second column, delete "and A449".

In the last paragraph, next to last line, add a period after "40 ksi" and delete the following: "and a hardened washer is required under the head of A449 bolts used in lieu of A325 bolts."

①,② 1.23.6 Welded Construction

In the sixth paragraph, third line, immediately after the words "other parts of the member.", insert the following:

"Steel backing shall be made continuous for the full length of the weld. All necessary joints in the steel backing shall be complete joint penetration butt welds meeting all workmanship requirements of Sect. 3 of AWS D1.1-Rev 1-73."

In the next to last paragraph, delete "Article 310 of AWS D1.0-69" and substitute "3.9 of AWS D1.1-Rev 1-73".

In the last paragraph, make the following changes: In the second line, between the words "correcting" and "work", delete the word "defective". In the third line, delete the words "Section 3—Workmanship and Section 4—Technique of the *Code for Welding in Building Construction,* D1.0-69 of the American Welding Society" and substitute "Sects. 3 and 4 of AWS D1.1-Rev. 1-73". In the fifth line, delete "Article 305" and substitute "3.5".

1.26.4 Inspection of Welding

In the first paragraph, second line, delete the words "the Code for Welding in Building Construction, D1.0-69, of the American Welding Society" and substitute: "the Structural Welding Code, AWS D1.1-Rev 1-73".

1.26.5 Identification of High Strength Steel

Delete this section in its entirety, including the heading, and substitute the following:

"1.26.5 Identification of Steel

The fabricator shall be able to demonstrate by a written procedure and by actual practice a method of material application and traceability, visible at least through the 'fit up' operation, of the main stress carrying elements of a shipping piece.

The traceability method shall be capable of verifying proper material application as it relates to:

A. Material specification designation
B. Heat number, if required
C. Material test reports for special requirements"

SECTION 2.1 SCOPE

In the first paragraph, second line, delete the words "one and two story rigid frames,". Immediately after the word "braced", delete the word "multi-story" and add: "and unbraced planar".

In the second paragraph, after the sentence ending "provided in Sect.1.2.", add the following:

"This does not preclude the use of some simple connections, provided that the provisions of Sect. 2.3 are satisfied."

SECTION 2.3 VERTICAL BRACING SYSTEM

Delete the Section heading **"VERTICAL BRACING SYSTEM"** and substitute the following new heading: **"BASIS FOR MAXIMUM STRENGTH DETERMINATION".**

Immediately following the heading, add the following paragraph:

"For one or two story frames, the maximum strength may be determined by a routine plastic analysis procedure and the frame instability effect ($P\Delta$) may be ignored. For braced multistory frames, provisions should be made to include the frame instability effect in the design of bracing system and frame members. For unbraced multistory frames, the frame instability effect should be included directly in the calculations for maximum strength."

Between the above new paragraph and the paragraph beginning "The vertical bracing system", insert the following subheading:

"2.3.1 Stability of Braced Frames"

At the end of Sect. 2.3, add a new section, as follows:

"2.3.2 Stability of Unbraced Frames

The strength of an unbraced multistory frame shall be determined by a rational analysis which includes the effect of frame instability and column axial deformation. Such a frame shall be designed to be stable under (1) factored gravity loads and (2) factored gravity plus factored horizontal loads. The axial force in the columns at factored load levels shall not exceed 0.75 P_y."

APPENDIX A

SECTION 1.5.1.4

Delete the data in Sects. 1.5.1.4.1, 1.5.1.4.2, and 1.5.1.4.3 in its entirety and substitute the data on pages 18 through 23 (on facing pages).

	Yield Stress — F_y (ksi)		
	36.0	42.0	45.0
1.5.1.4 Bending			
1.5.1.4.1 Tension and compression for compact, adequately braced members symmetrical about, and loaded in, the plane of their minor axis:			
$F_b = 0.66F_y$	24.0	28.0	29.7
when			
a. Flanges are continuously connected to web			
b. $b_f/2t_f \leq 65/\sqrt{F_y}$	10.8	10.0	9.7
c. $b/t_f \leq 190/\sqrt{F_y}$	31.7	29.3	28.3
d. Formula (1.5–4a):			
$d/t \leq 640\left(1 - 3.74\frac{f_a}{F_y}\right)\Big/\sqrt{F_y}$	$107 - 11.1f_a$	$98.8 - 8.8f_a$	$95.4 - 7.9f_a$
Formula (1.5-4b): $d/t \leq 257F_y$	42.8	39.7	38.3
e. $l \leq 76.0b_f/\sqrt{F_y}$	$12.7b_f$	$11.7b_f$	$11.3b_f$
and			
$l \leq \frac{20{,}000}{(d/A_f)F_y}$	$\frac{556}{d/A_f}$	$\frac{476}{d/A_f}$	$\frac{444}{d/A_f}$
f. Box members			
$l = \left[1950 + 1200\frac{M_1}{M_2}\right]\frac{b}{F_y}$			
M_1/M_2			
+1.0	$87.5b$	$75.0b$	$70.0b$
+0.8	$80.8b$	$69.3b$	$64.7b$
+0.6	$74.2b$	$63.6b$	$59.3b$
+0.4	$67.5b$	$57.9b$	$54.0b$
+0.2	$60.8b$	$52.1b$	$48.7b$
0	$54.2b$	$46.4b$	$43.3b$
−0.2	$47.5b$	$40.7b$	$38.0b$
−0.4	$40.8b$	$35.0b$	$32.7b$
−0.6	$34.2b$	$29.3b$	$27.3b$
but not less than			
$1200\ b/F_y$	$33.3b$	$28.6b$	$26.7b$

Yield Stress – F_y (ksi)					
50.0	55.0	60.0	65.0	90.0	100.0
33.0	36.3	39.6	42.9	—	—
9.2	8.8	8.4	8.1	—	—
26.9	25.6	24.5	23.6	—	—
$90.5 - 6.8f_a$	$86.3 - 5.9f_a$	$82.6 - 5.2f_a$	$79.4 - 4.6f_a$	—	—
36.3	34.7	33.2	31.9	—	—
$10.7b_f$	$10.2b_f$	$9.8b_f$	$9.4b_f$	—	—
$\frac{400}{d/A_f}$	$\frac{364}{d/A_f}$	$\frac{333}{d/A_f}$	$\frac{308}{d/A_f}$	—	—
63.0*b*	57.3*b*	52.5*b*	48.5*b*	—	—
58.2*b*	52.9*b*	48.5*b*	44.8*b*	—	—
53.4*b*	48.5*b*	44.5*b*	41.1*b*	—	—
48.6*b*	44.2*b*	40.5*b*	37.4*b*	—	—
43.8*b*	39.8*b*	36.5*b*	33.7*b*	—	—
39.0*b*	35.5*b*	32.5*b*	30.0*b*	—	—
34.2*b*	31.1*b*	28.5*b*	26.3*b*	—	—
29.4*b*	26.7*b*	24.5*b*	22.6*b*	—	—
24.6*b*	22.4*b*	20.5*b*	18.9*b*	—	—
24.0*b*	21.8*b*	20.0*b*	18.5*b*	—	—

	Yield Stress — F_y (ksi)		
	36.0	42.0	45.0
1.5.1.4 Bending (cont'd)			
1.5.1.4.2 Tension and compression for members which meet the requirements of Sect. 1.5.1.4.1 except subparagraph b:			
when $\frac{65}{\sqrt{F_y}} < \frac{b_f}{2t_f}$	10.8	10.0	9.7
and $\frac{b_f}{2t_f} < \frac{95.0}{\sqrt{F_y}}$	15.8	14.7	14.2
use Formula (1.5–5a): $F_b = F_y\left[0.79 - 0.002\left(\frac{b_f}{2t_f}\right)\sqrt{F_y}\right]$			
Values of F_b — $\frac{b_f}{2t_f}$ = 9.0	—	—	—
10.0	—	27.7	29.5
11.0	23.7	27.2	28.9
12.0	23.3	26.6	28.3
13.0	22.8	26.1	27.7
14.0	22.4	25.6	27.1
15.0	22.0	—	—
1.5.1.4.3 Tension and compression for: doubly-symmetrical I and H shape members meeting the requirements of Sect. 1.5.1.4.1, except subparagraphs c, d and e, and bent about their minor axis (except members of A514 steel); solid round and square bars; and solid rectangular bars bent about their weaker axis:			
$F_b = 0.75F_y$	27.0	31.5	33.8
Tension and compression for doubly-symmetrical I- and H-shape members bent about their minor axis (except hybrid members and members of A514 steel) which meet the requirement of Sect. 1.5.1.4.1a:			
when $\frac{65.0}{\sqrt{F_y}} < \frac{b_f}{2t_f}$	10.8	10.0	9.7

Yield Stress — F_y (ksi)					
50.0	55.0	60.0	65.0	90.0	100.0
7.4	8.8	8.4	8.1	—	—
13.4	12.8	12.3	11.8	—	—
—	36.1	39.0	41.9	—	—
32.4	35.3	38.1	40.9	—	—
31.7	34.5	37.2	39.8	—	—
31.0	33.7	36.2	—	—	—
30.3	—	—	—	—	—
—	—	—	—	—	—
—	—	—	—	—	—
9.2	8.8	8.4	8.1	—	—

		Yield Stress — F_y (ksi)		
		36.0	42.0	45.0
1.5.1.4 Bending (cont'd)				
and $\frac{b_f}{2t_f} > \frac{95.0}{\sqrt{F_y}}$		15.8	14.7	14.2
use Formula (1.5-5b): $F_b = F_y \left[1.075 - 0.0005 \left(\frac{b_f}{2t_f}\right) \sqrt{F_y}\right]$				
	$\frac{b_f}{2t_f}$			
Values of F_b	9.0	—	—	—
	10.0	—	—	33.3
	11.0	26.8	30.2	31.8
	12.0	25.7	28.8	30.3
	13.0	24.7	27.5	28.8
	14.0	23.6	26.1	27.2
	15.0	22.5	—	—

Yield Stress — F_y (ksi)					
50.0	55.0	60.0	65.0	90.0	100.0
13.4	12.8	12.3	11.8	—	—
—	40.8	43.6	46.3	—	—
36.1	38.7	41.3	43.7	—	—
34.3	36.7	38.9	41.1	—	—
32.5	34.7	36.6	—	—	—
30.8	—	—	—	—	—
—	—	—	—	—	—
—	—	—	—	—	—

APPENDIX B

SECTION B2 ALLOWABLE STRESSES

In the third line, add a period after the words "given in Table B3". and delete the balance of the paragraph in its entirety.

Make the following changes in Table B2:

Delete the term "C" wherever it appears in the columns headed "Kind of Stress".

For "Built-up members", delete the footnote reference "*3" in the column headed "Stress Category".

For "Mechanically fastened connections", at the end of the second paragraph in the column headed "Situation", change the footnote reference from "4" to "3".

For "Groove welds", in the column headed "Stress Category", delete the asterisks after "C" and "D".

In footnote 1, first line, after the words "stress only:", delete " "C" signifies range in compressive stress only;". Delete footnote 3 in its entirety. Change the number of the final footnote from "4" to "3".

APPENDIX D

Add the following new Appendix D to the Specification:

"APPENDIX D TAPERED MEMBERS"

NOMENCLATURE

The following nomenclature is applicable only to Appendix D. Notations not defined are the same as in the Nomenclature to Part 1 of the Specification.

B = Bending coefficient dependent upon computed moment or stress at the ends of unbraced lengths of a tapered member

C_m = Coefficient applied to bending term in interaction formula and dependent upon column curvature caused by applied moments (see Sect. D4 for values)

$F_{a\gamma}$ = Axial stress permitted in a tapered member in the absence of bending moment

$F_{b\gamma}$ = Bending stress permitted in a tapered member in the absence of axial force

$F'_{e\gamma}$ = Euler stress for a tapered member divided by factor of safety; equal to

$$\frac{12\pi^2 E}{23(K_\gamma l/r_{bo})^2}$$

$F_{s\gamma}$ = St. Venant torsion resistance bending stress; equal to

$$\frac{12 \times 10^3}{h_s l d_o / A_f}$$

$F_{w\gamma}$ = Flange warping torsion resistance bending stress; equal to

$$\frac{170 \times 10^3}{(h_w l / r_{To})^2}$$

K_γ = Effective length factor for a tapered member as determined by a rational analysis

S = Governing slenderness ratio of a tapered member

d_L = Depth at the larger end of a tapered member

d_l = Depth at the larger end of an unbraced segment of a tapered member

d_o = Depth at the smaller end of a tapered member or at the smaller end of an unbraced segment of a tapered member

f_{ao} = Computed axial stress at the smaller end of a tapered member or unbraced segment thereof

f_{bl} = Computed bending stress at the larger end of a tapered member or unbraced segment thereof

h_s = Factor applied to the unbraced length of a tapered member; equal to

$$1.0 + 0.0230\gamma\sqrt{l d_o / A_f}$$

h_w = Factor applied to the unbraced length of a tapered member; equal to

$$1.0 + 0.00385\gamma\sqrt{l / r_{To}}$$

l = Length of member or unbraced segment thereof, inches

r_o = Radius of gyration at the smaller end of a tapered member

r_{To} = Radius of gyration at the smaller end of a tapered member or unbraced segment, considering only the compression flange plus one-third of the compression web area, taken about an axis in the plane of the web

z = Distance from the smaller end of a tapered member, inches

γ = Tapering ratio of a tapered member or unbraced segment of a tapered member; also subscript relating symbol to tapered members

SECTION D1 GENERAL

The design of tapered members meeting the requirements herein shall be governed by the provisions of Part 1 except as modified by this Appendix.

In order to qualify under this Specification a tapered member must meet the following requirements:

a. It shall possess at least one axis of symmetry which shall be perpendicular to the plane of bending if moments are present.
b. The flanges shall be of equal and constant area.

c. The depth shall vary linearly as

$$d_o\left(1 + \gamma\,\frac{z}{l}\right)$$

where $\gamma = (d_L - d_o)/d_o$ and where γ must be less than the smaller of $0.268l/d_o$ or 6.0.

SECTION D2 ALLOWABLE STRESSES—COMPRESSION

On the gross section of axially loaded tapered compression members when S, the effective slenderness ratio, is less than C_c:

$$F_{a\gamma} = \frac{\left(1.0 - \dfrac{S^2}{2C_c^2}\right) F_y}{\dfrac{5}{3} + \dfrac{3S}{8C_c} - \dfrac{S^3}{8C_c^3}} \tag{D2-1}$$

When the effective slenderness ratio, S, exceeds C_c:

$$F_{a\gamma} = \frac{12\pi^2 E}{23S^2} \tag{D2-2}$$

where

$S = Kl/r_{oy}$ for weak axis bending
$\quad = K_\gamma l/r_{ox}$ for strong axis bending

in which

K = effective length factor for a prismatic member
K_γ = effective length factor for a tapered member as determined by a rational analysis*
r_{ox} = strong axis radius of gyration at the smaller end of a tapered member
r_{oy} = weak axis radius of gyration at the smaller end of a tapered member

SECTION D3 ALLOWABLE STRESSES—BENDING**

Tension and compression on extreme fibers of tapered flexural members:

$$F_{b\gamma} = \frac{2}{3}\left[1.0 - \frac{F_y}{6B\sqrt{F_{s\gamma}^2 + F_{w\gamma}^2}}\right] F_y \le 0.6F_y \tag{D3-1}$$

unless $F_{b\gamma} \le F_y/3$, in which case

$$F_{b\gamma} = B\sqrt{F_{s\gamma}^2 + F_{w\gamma}^2} \tag{D3-2}$$

---

* See Commentary Addendum, Section D2.
** See Commentary Addendum, Section D3.

In the above equations,

$$F_{s\gamma} = \frac{12 \times 10^3}{h_s l d_o / A_f}$$

$$F_{w\gamma} = \frac{170 \times 10^3}{(h_w l / r_{To})^2}$$

where

h_s = $1.0 + 0.0230\gamma\sqrt{ld_o/A_f}$
h_w = $1.0 + 0.00385\gamma\sqrt{l/r_{To}}$
l = distance between cross-sections braced against twist or lateral displacement of the compression flange, inches
r_{To} = radius of gyration of a section at the smaller end, considering only the compression flange plus one-third of the compression web area, taken about an axis in the plane of the web
A_f = area of the compression flange
γ = $(d_l - d_o)/d_o$

and where B is determined as follows:

a. When the maximum moment, M_2, in three adjacent segments of approximately equal unbraced length, is located within the central segment and M_1 is the larger moment at one end of the three-segment portion of a member: *

$$B = 1.0 + 0.37\left[1.0 + \frac{M_1}{M_2}\right] + 0.50\gamma\left[1.0 + \frac{M_1}{M_2}\right] \geq 1.0$$

b. When the largest computed bending stress, f_{b2}, occurs at the larger end of two adjacent segments of approximately equal unbraced lengths and f_{b1} is the computed bending stress at the smaller end of the two-segment portion of a member: **

$$B = 1.0 + 0.58\left[1.0 + \frac{f_{b1}}{f_{b2}}\right] - 0.70\gamma\left[1.0 + \frac{f_{b1}}{f_{b2}}\right] \geq 1.0$$

c. When the largest computed bending stress, f_{b2}, occurs at the small end of two adjacent segments of approximately equal unbraced length and f_{b1} is the computed bending stress at the larger end of the two-segment portion of a member: **

$$B = 1.0 + 0.55\left[1.0 + \frac{f_{b1}}{f_{b2}}\right] + 2.2\gamma\left[1.0 + \frac{f_{b1}}{f_{b2}}\right] \geq 1.0$$

In the foregoing, $\gamma = (d_l - d_o)/d_o$ calculated for the unbraced length that contains the maximum computed bending stress.

---

* M_1/M_2 is considered as negative when producing single curvature. In the rare case where M_1/M_2 is positive, it is recommended that it be taken as zero.

** f_{b1}/f_{b2} is considered as negative when producing single curvature. If a point of contraflexure occurs in one of two adjacent unbraced segments, f_{b1}/f_{b2} is considered as positive. The ratio $f_{b1}/f_{b2} \neq 0$.

d. When the computed bending stress at the smaller end of a tapered member or segment thereof is equal to zero:

$$B = \frac{1.75}{1.0 + 0.25\sqrt{\gamma}}$$

where $\gamma = (d_l - d_o)/d_o$ calculated for the unbraced length adjacent to the point of zero bending stress.

The value of B shall be taken as unity when computing the value of $F_{b\gamma}$ to be used in Formula (D4-1). B shall also be taken as unity for tapered members or segments thereof not covered above.

SECTION D4 COMBINED STRESSES

Tapered members and unbraced segments thereof subjected to both axial compression and bending stresses shall be proportioned to satisfy the following requirements:

$$\left(\frac{f_{ao}}{F_{a\gamma}}\right) + \frac{C_m}{\left(1 - \frac{f_{ao}}{F'_{e\gamma}}\right)}\left(\frac{f_{bl}}{F_{b\gamma}}\right) \leq 1.0 \qquad \text{(D4-1a)}$$

and

$$\frac{f_{ao}}{0.6F_y} + \frac{f_{bl}}{F_{b\gamma}} \leq 1.0 \qquad \text{(D4-1b)}$$

When $f_{ao}/F_{a\gamma} \leq 0.15$, Formula (D4-2) may be used in lieu of Formulas (D4-1a) and (D4-1b):

$$\left(\frac{f_{ao}}{F_{a\gamma}}\right) + \left(\frac{f_{bl}}{F_{b\gamma}}\right) \leq 1.0 \qquad \text{(D4-2)}$$

where

$F_{a\gamma}$ = axial stress that would be permitted if axial force alone existed

$F_{b\gamma}$ = compressive bending stress that would be permitted if bending moment alone existed

$F'_{e\gamma}$ = $\frac{12\pi^2 E}{23(K_\gamma l/r_{bo})^2}$ where l is the actual unbraced length in the plane of bending and r_{bo} is the corresponding radius of gyration at its smaller end

f_{ao} = computed axial stress at the smaller end of the member or unbraced segment, as applicable

f_{bl} = computed bending stress at the larger end of the member or unbraced segment, as applicable

C_m = $1.0 + 0.1\left(\frac{f_{ao}}{F'_{e\gamma}}\right) + 0.3\left(\frac{f_{ao}}{F'_{e\gamma}}\right)^2$

when the member is subjected to end moments which cause single curvature bending and approximately equal computed bending stresses at the ends

= $1.0 - 0.9\left(\frac{f_{ao}}{F'_{e\gamma}}\right) + 0.6\left(\frac{f_{ao}}{F'_{e\gamma}}\right)^2$

when the computed bending stress at the smaller end of the unbraced length is equal to zero"

Addenda to the Commentary

ON THE SPECIFICATION FOR THE DESIGN, FABRICATION AND ERECTION OF STRUCTURAL STEEL FOR BUILDINGS

June 21, 1974

SECTION 1.5 ALLOWABLE STRESSES

In the section heading, add an asterisk after the word "**STRESSES**" and add the following footnote:

"* Appendix D covers design provisions for frames consisting of members which are linearly tapered in the plane of their web. While allowable stress provisions for tapered members are basically similar to those provided in this Section, certain modifications are required because of the tapering. This has resulted in the introduction of special notations, often defined by algebraic expressions not applicable to prismatic members. Since the use of tapered members is somewhat limited, these notations and the design provisions in which they appear are omitted from Sect. 1.5 and are covered only in Appendix D."

1.5.1 Structural Steel

1.5.1.3 Compression

In the section heading, add a double asterisk after the word "**Compression**" and add the following footnote:

"** For tapered members, also see Commentary Sect. D2."

1.5.1.4 Bending

In the section heading, add an asterisk after the word "**Bending**" and add the following footnote:

"* For tapered members, also see Commentary Sect. D3."

SECTION 1.8 STABILITY AND SLENDERNESS RATIOS

After the seventh paragraph, preceding the paragraph beginning "If roof decks or floor slabs", add the following four paragraphs:

"For a rigid unbraced multistory frame under combined gravity and lateral loads, drift occurs at the start of loading. At a given value of the applied loads, the frame has a definite amount of drift, Δ. Due to this drift additional secondary bending moments, known as the $P\Delta$ moments, are developed in each story, where P is the total gravity load above the story. As the applied loads increase, the $P\Delta$ moments increase as well. Therefore, the effect which should be accounted for in frame design is the $P\Delta$ effect. The intent of effective length factors greater than unity and a C_m value of 0.85 in Formula (1.6-1a) is to conservatively provide for this effect.

Recent research at Lehigh University* on the load-carrying capacity of regular rectangular rigid planar frames has shown that it is not necessary to account for the $P\Delta$ effect for a certain class of adequately stiff rigid frames. The frames included in this study were 10 to 40 stories high and the in-plane column slenderness ratios ranged from 18 to 42. The live load, including partition, varied from 40 to 100 psf and the dead load from 50 to 75 psf. A uniform wind load of 20 psf was used throughout. The results show that adequate strength and stability can be assured under combined gravity and lateral loads when these rigid frames are designed to meet the following criteria:

1. All their columns are proportioned in accordance with Sect. 1.6.1, except that:
   (a) The effective length factor K is assumed to be unity in the calculations of F_a and F_e'.
   (b) The coefficient C_m is computed as for braced frames.
2. The maximum column axial load ratio f_a/F_a does not exceed 0.75.**
3. The maximum in-plane column slenderness ratio h/r_x does not exceed 35.**
4. The bare frame working load drift index (roof level drift divided by total frame height) does not exceed 0.004.

The key feature of these recommendations is that Item 4 represents a minimum level of rigid frame stiffness for frame stability under combined load. This recommendation does not intend to suggest drift limits for serviceability. Frames with less than 10 stories were outside the scope of the Lehigh study. Several other references† are available concerning alternatives to effective length factors for multi-story rigid frames under combined loads.

Frame stability under gravity loads only is under current study. Previous work‡ suggests that when combined gravity and lateral loads control the design of beams and columns in a story, adequate rigid frame stiffness for frame stability under the combined loads, as described in Item 4 above,

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* *Okten, O. S., S. Morino, J. H. Daniels, and L. W. Lu* Effective Column Length and Frame Stability *Fritz Engineering Laboratory Report No. 375.2, Lehigh University, November, 1973.*

** These are the maximum axial load ratio and column slenderness present in the 1973 Lehigh Study.

† *Springfield, J. and P. F. Adams,* Aspects of Column Design in Tall Steel Buildings, *Journal of the Structural Division, ASCE, Vol. 98, No. ST5, May, 1972.*

Yura, J. A., The Effective Length of Columns in Unbraced Frames *AISC Engineering Journal, Vol. 8, No. 2, April, 1971.*

Liapunov, S., Ultimate Load Studies of Plane Multi-Story Steel Rigid Frames *Ph.D. Dissertation, New York University, April, 1973.*

Daniels, J. H. and L. W. Lu, Platic Subassemblage Analysis for Unbraced Frames *Journal of the Structural Division, ASCE, Vol. 98, No. ST8, August, 1972.*

‡ *McNamee, B. H.,* The General Behavior and Strength of Unbraced Multi-Story Frames Under Gravity Loading *Ph.D Dissertation, Lehigh University, 1967*

can be expected to provide adequate frame stability under gravity loads only. Pending the results of current studies, effective length factors larger than unity and a C_m value of 0.85 continue to be recommended for columns in upper stories where gravity load only controls the rigid frame column design."

APPENDIX D

Add the following new sections after Commentary Sect. 2.9:

"APPENDIX D—TAPERED MEMBERS

The provisions contained in Appendix D cover only those aspects of the design of tapered members that are unique to tapered members. For other criteria of design not specifically covered in Appendix D, see the appropriate portions of Part 1 of the Specification and Commentary.

SECTION D2 ALLOWABLE STRESSES—COMPRESSION

The approach in formulating $F_{a\gamma}$ of tapered columns is based on the concept that the critical stress for an axially loaded tapered column is equal to that of a prismatic column of different length but of the same cross section as the smaller end of the tapered column. This has resulted in an equivalent effective length factor K_γ for a tapered member subjected to axial compression.* This factor, which is used to determine the value of S in Formulas (D2-1) and (D2-2), can be determined accurately for a symmetrical rectangular rigid frame composed of prismatic beams and tapered columns.

With modifying assumptions, such a frame can be used as a mathematical model to determine, with sufficient accuracy, the influence of the stiffness, $\Sigma(I/b)_g$, of members which afford restraint at the ends of a tapered column. From Formulas (D2-1) and (D2-2), the critical load P_{cr} can be expressed as $\pi^2 EI_o/(K_\gamma l)^2$. The value of K_γ can be obtained by interpolation, using the appropriate chart (Figures CD1.5.1 to CD1.5.16) and restraint modifiers G_T and G_B. In each of these modifiers the tapered column, treated as a prismatic member having a moment of inertia I_o, computed at the smaller end, and its actual length l, is assigned the stiffness I_o/l, which is then divided by the stiffness of the restraining members at the end of the tapered column under consideration. Such an approach is well documented. Typical cases are shown in Fig. CD1.5-17.

Thus, it is to be noted that in these charts the values of K_γ represent the combined effects of end restraints and tapering. For the case $\gamma = 0$, K_γ becomes K, which can also be determined from the alignment chart for effective length of columns in continuous frames (Fig. C1.8.2). For cases when the restraining beams are also tapered, the procedure used in WRC Bulletin No. 173 can be followed, or appropriate estimation of K_γ can be made based on these charts.

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* *Lee, G. C., M. L. Morrell, and R. L. Ketter* Design of Tapered Members *WRC Bulletin No. 173, June 1972.*

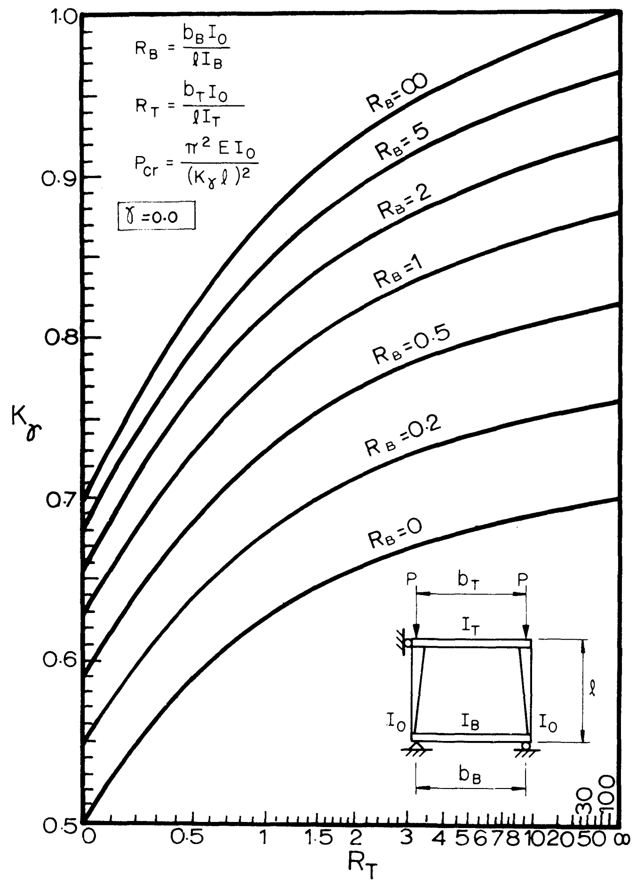


Fig. CD1.5-1. Effective length factors for tapered columns: sidesway prevented ($\gamma = 0$)

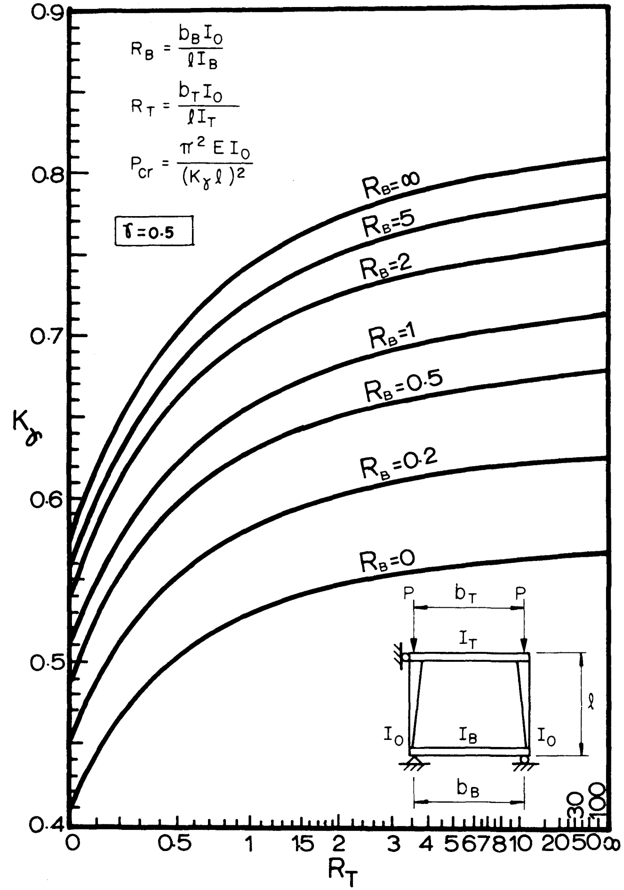


Fig. CD1.5-2. Effective length factors for tapered columns: sidesway prevented ($\gamma = 0.5$)

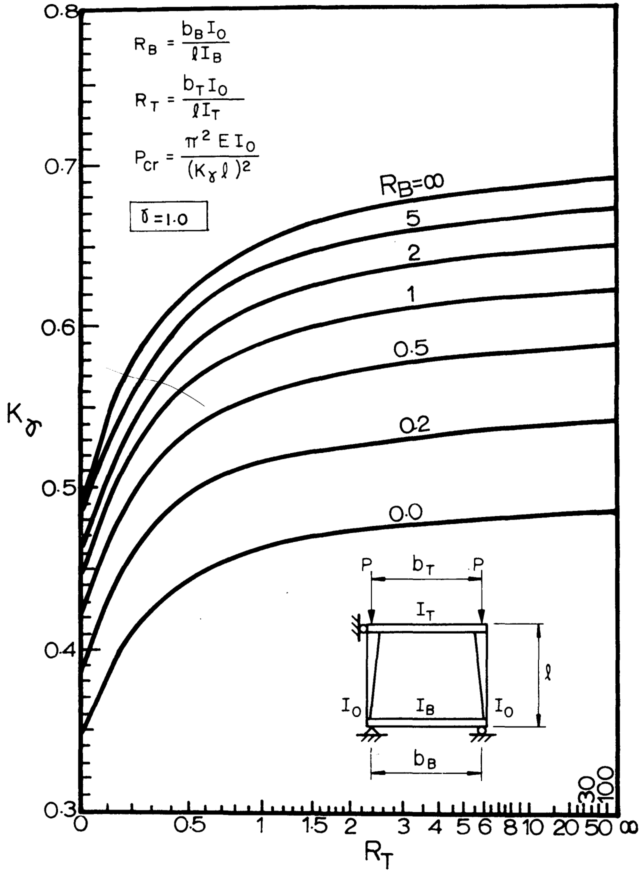


Fig. CD1.5-3. Effective length factors for tapered columns: sidesway prevented ($\gamma = 1.0$)

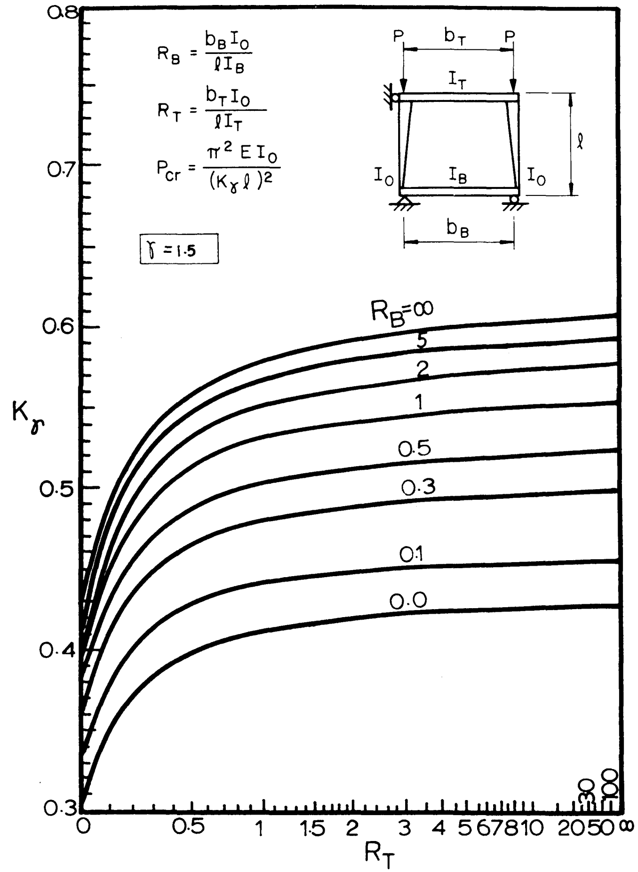


Fig. CD1.5-4. Effective length factors for tapered columns: sidesway prevented ($\gamma = 1.5$)

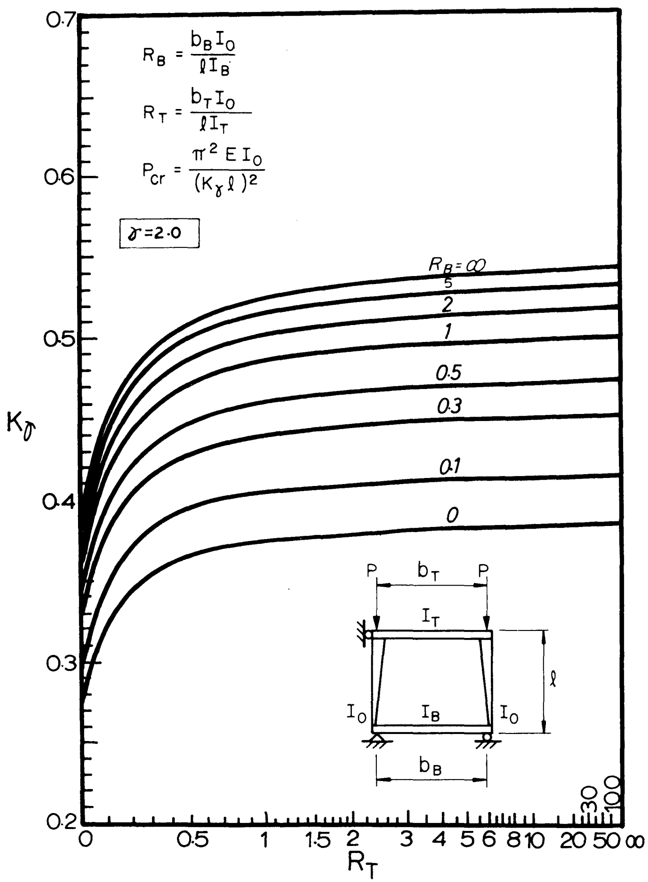


Fig. CD1.5-5. Effective length factors for tapered columns: sidesway prevented ($\gamma = 2.0$)

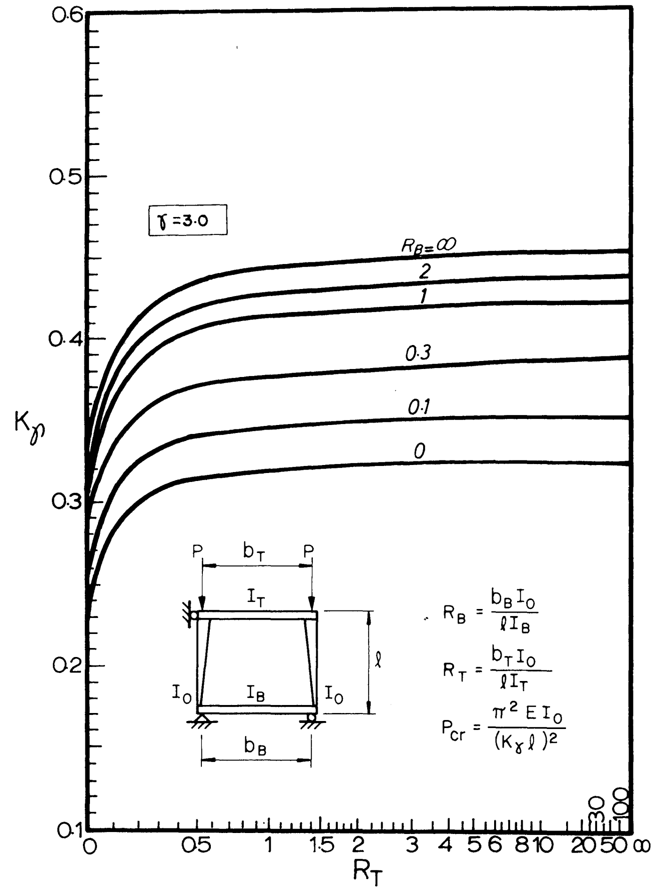


Fig. CD1.5-6. Effective length factors for tapered columns: sidesway prevented ($\gamma = 3.0$)

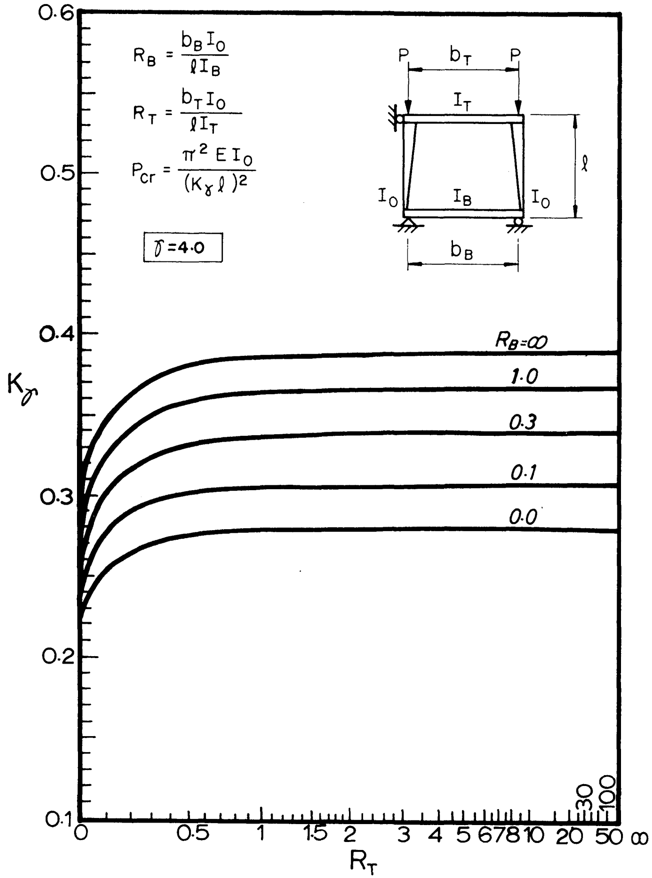


Fig. CD1.5-7. Effective length factors for tapered columns: sidesway prevented ($\gamma = 4.0$)

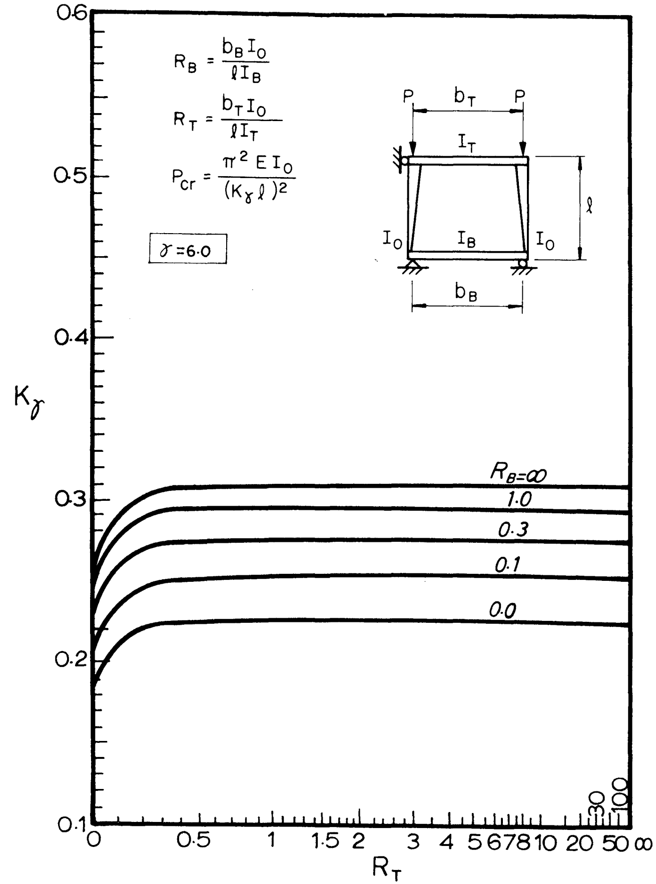


Fig. CD1.5-8. Effective length factors for tapered columns: sidesway prevented ($\gamma = 6.0$)

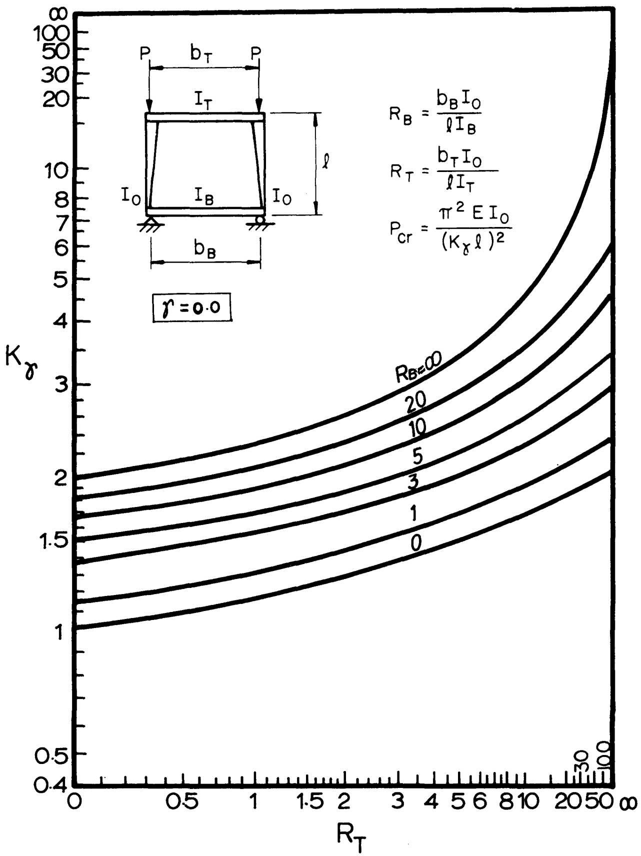


Fig. CD1.5-9. Effective length factors for tapered columns: sidesway permitted (γ = 0)

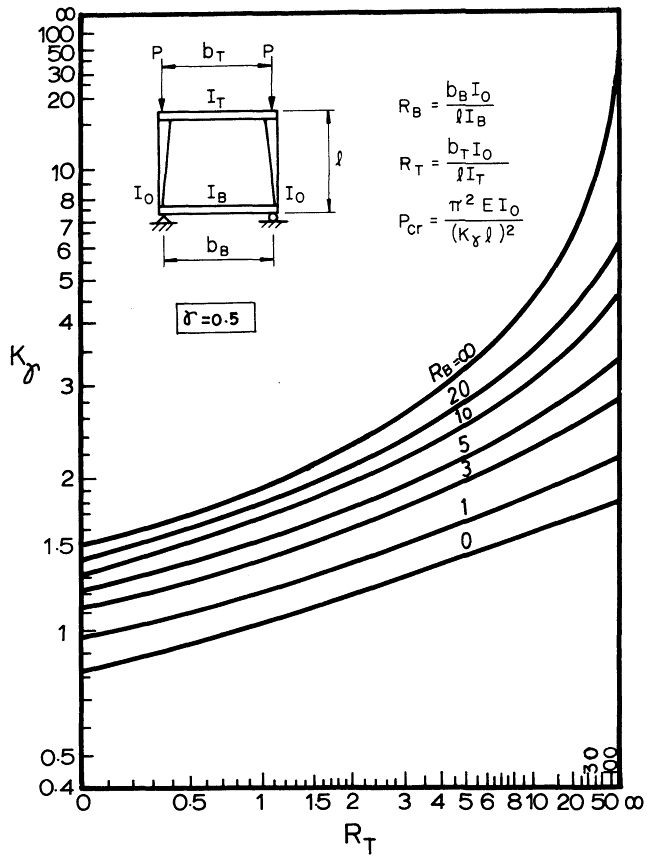


Fig. CD1.5-10. Effective length factors for tapered columns: sidesway permitted (γ = 0.5)

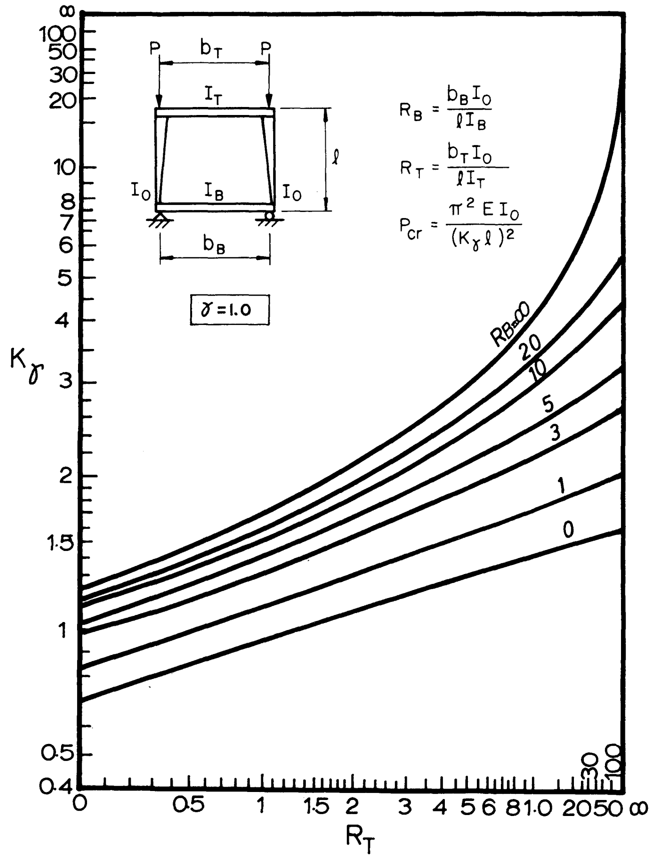


Fig. CD1.5-11. Effective length factors for tapered columns: sidesway permitted ($\gamma = 1.0$)

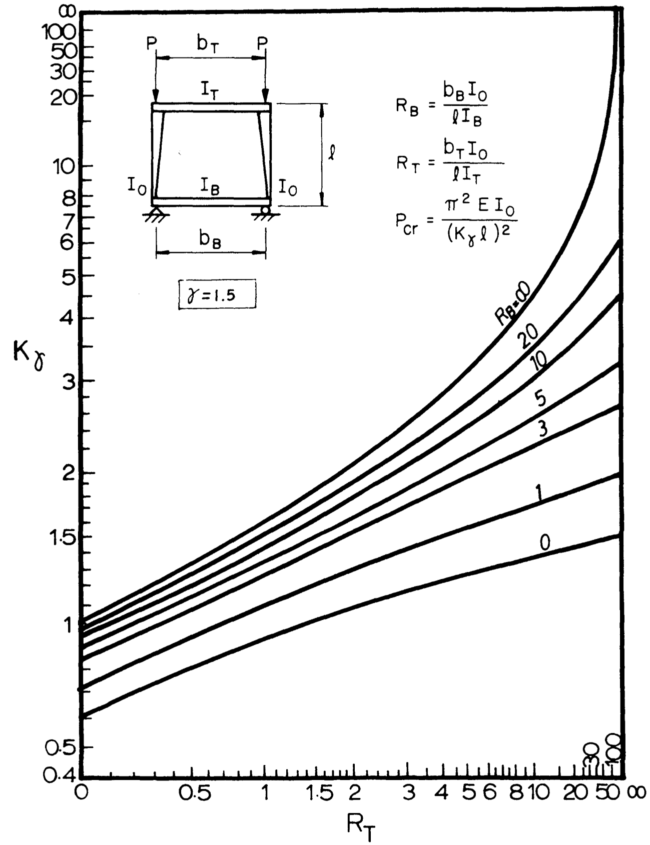


Fig. CD1.5-12. Effective length factors for tapered columns: sidesway permitted ($\gamma = 1.5$)

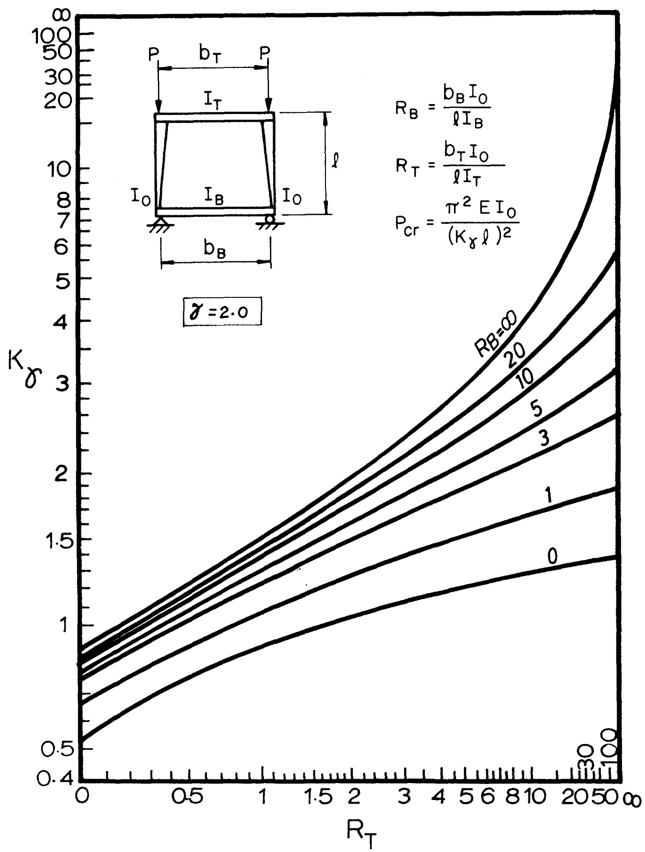


Fig. CD1.5-13. Effective length factors for tapered columns: sidesway permitted (γ = 2.0)

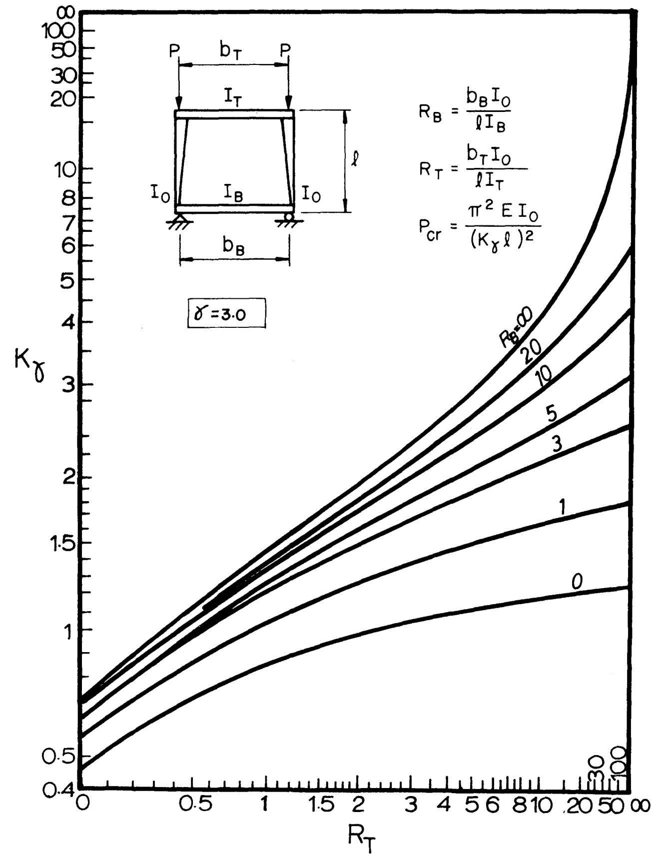


Fig. CD1.5-14. Effective length factors for tapered columns: sidesway permitted (γ = 3.0)

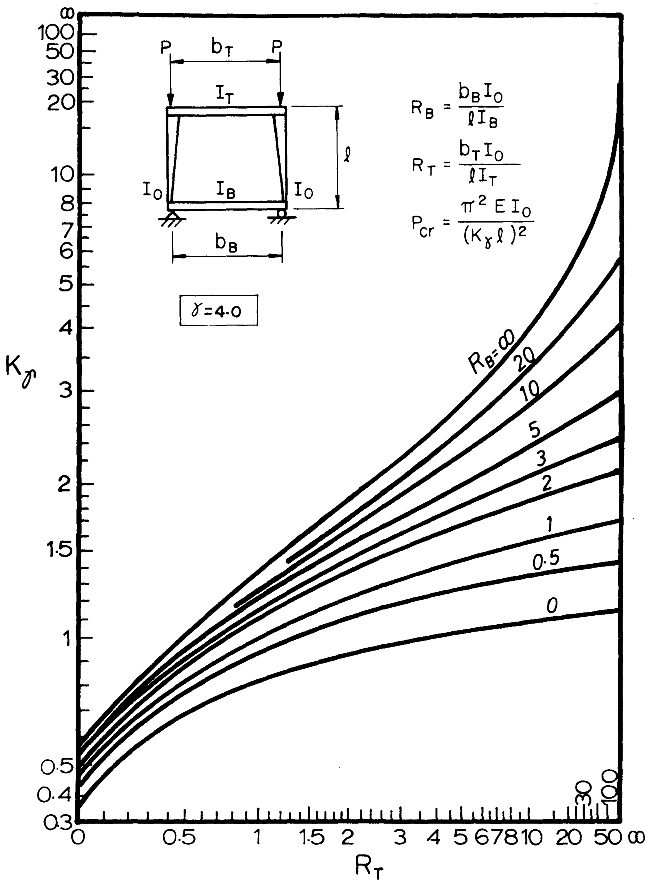


Fig. CD1.5-15. Effective length factors for tapered columns: sidesway permitted (γ = 4.0)

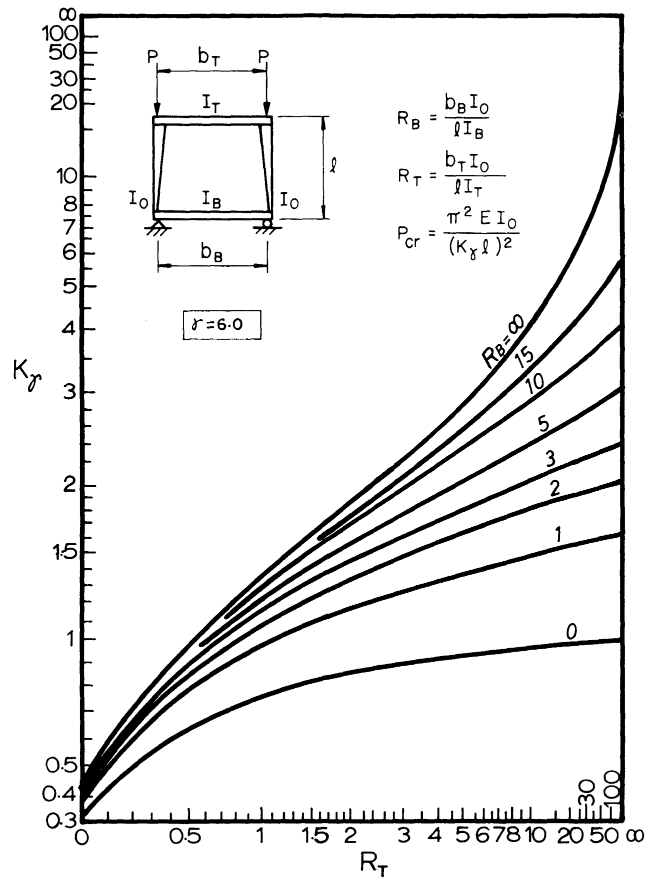
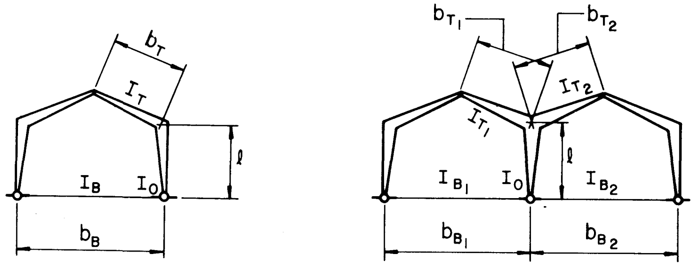


Fig. CD1.5-16. Effective length factors for tapered columns: sidesway permitted (γ = 6.0)



$$G_T = \frac{b_T I_O}{\ell I_T} \qquad G_B = \frac{b_B I_O}{\ell I_B}$$

$$G_T = \frac{I_O}{\ell} \sum \frac{b_T}{I_T} \qquad G_B = \frac{I_O}{\ell} \sum \frac{b_B}{I_B}$$

Figure CD1.5-17

SECTION D3 ALLOWABLE STRESSES—BENDING

The development of the allowable bending stress for tapered beams follows closely with that for prismatic beams. The basic concept is to replace a tapered beam by an equivalent prismatic beam with a different length, but with a cross section identical with that of the smaller end of the tapered beam.* This has led to the modified length factors h_s and h_w in Formulas (D3-1) and (D3-2).

Formulas (D3-1) and (D3-2) are based on total resistance to lateral buckling, using both St. Venant and warping resistance. The factor B modifies the basic $F_{b\gamma}$ to account for moment gradient and lateral restraint offered by adjacent segments. For members which are continuous past lateral supports, categories a, b, and c of Section D3 usually apply; however, it is to be noted that they apply only when the axial force is small and adjacent unbraced segments are approximately equal in length. For a single member, or segments which do not fall into category a, b, c or d, the recommended value for B is unity. The value of B should also be taken as unity when computing the value of $F_{b\gamma}$ to be used in Formula (D4-1), since the effect of moment gradient is provided for by the factor C_m. The background material is given in WRC Bulletin No. 192.** Design examples dealing with various applications of Appendix D are given in a technical report.†

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* *Lee, G. C., M. L. Morrell and R. L. Ketter* Design of Tapered Members *WRC Bulletin No. 173, June 1972.*

** *Morrell, M. L., and G. C. Lee* Allowable Stress for Web-Tapered Beams with Lateral Restraints *WRC Bulletin No. 192, Feb. 1974.*

† *Lee, G. C., and M. L. Morrell* Application of AISC Design Provisions for Tapered Members *SUNYAB Dept. of Civil Engrg. Rept., April 1974* (*unpublished*)

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