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LOCAL BUCKLING RULES for STRUCTURAL STEEL MEMBERS

by

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INTRODUCTION

It is customary for any specification governing the design of structural steel members to provide rules concerning local buckling*. These rules identify the combination of cross-sectional dimensions and yield strength at which local buckling can be expected to occur. For a designer, the usual procedure is to proportion the cross-section in such a way that the capacity is not controlled by local buckling, but will be that associated with the particular member, that is, the column, beam, or beam-column. The local buckling rules, therefore, play an important part in the design of structural steel members.

Generally speaking, the development of rules for local buckling has not received the same amount of attention as has the examination of the strength or overall stability of the member. In about the last decade, however, more time has been spent on both experimental examination of the local buckling problem and on analytical models which predict local buckling behavior. However, the topic has not achieved a level of maturity wherein the leading specifications covering the design of structural steel members agree as to what the local buckling limits should be. It seemed appropriate, therefore, to prepare a comparative review of local buckling rules, using a selected list of specifications, so that those responsible for a particular specification can make a critical assessment of their own position. Wherever possible, the rules will be compared with what is considered to be the best information on the subject.

The specifications included in the examination have been selected

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* Terminology varies, but the document setting forth these rules is generally called a specification, building code, standard, or norm. The word "specification" will be used in this report.

somewhat arbitrarily, but the list does include most of the major ones in the world. Not included, however, are any specifications from the Eastern Bloc countries or from Asia. Either these have not been readily available or questions of interpretation have not been resolved by the authors. The format of the report is such that readers who wish to include the rules provided by another specification can do so readily. The authors hope that if this done, the new information will be sent (to the second-named author) so that it can be included in any future publication of the summary.

The experimental and analytical studies on local buckling of I-shaped cross-sections conducted in the Department of Civil Engineering at the University of Alberta over the last 15 years provided the impetus for this report. Those studies of course drew on the work of others throughout the world, but the examination is not supposed to have been exhaustive. Nevertheless, the authors believe that the synthesis of this work in the report by Dawe and Kulak (1) represents the best information now available on the subject. This work is also included as a "specification", and is taken as the benchmark for comparison in the case of I-shaped sections.

REPORT FORMAT AND DESCRIPTION OF TABLES

There is a significant amount of redundancy in the tables contained in this report. This is deliberate and is intended to allow for easy inclusion of new material and checking of existing entries. Most readers will not find it necessary to deal with all of these tables; it will usually be satisfactory to work with the general information and nomenclature tables (Tables 1 and 2) and then to examine the summary tables (Tables 6 and 7). A synopsis of the information presented in each of the tables follows:

TABLE 1 - This table lists the specifications cited and identifies them by an abbreviation and a reference number.

TABLE 2 - Identifies the structural shapes examined and notes the loading condition for the various components of the cross-section. The shapes include I-sections (usually called W-shapes in North American practice), box sections made by welding together four plates, rectangular and circular hollow structural shapes (HSS in North American terminology), tees, channels, and angles. Some specifications make a distinction between those sections which are hot-rolled and those which have been fabricated by welding together three plates. These cases are noted in Table 5 as they arise.

TABLE 3 - This table gives the formats used by the various specifications. Four different formats have been introduced; the α-format is independent of dimensions, the β-format gives actual b/t ratios for steel of 235 MPa yield strength (including a conversion factor accounting for other strengths), the γ- and δ-formats define b/t depending on the yield strength, either in SI (γ) or in US Customary units (δ). Some specifications use still different formats

which do not fit uniquely into the descriptions provided in Table 3. Adjustments had to be made in these cases. In addition, conversion factors are listed in Table 3 which enable "movement" from one specification and format to another.

TABLE 4 - This table shows the definitions of element width as used in the various specifications. In this pictorial, "b" is the terminology used throughout to define the width of the element of the cross-section under examination. This is for convenience; most specifications use a variety of letters or symbols to identify width, depth, etc. The differences that show up in the definitions of width as used by various specifications are generally minor, and no attempt has been made in this report to try to reconcile them. However, it will be noted in Table 5 that one specification (Ref. 3) provides some rules that accommodate more than one definition of element width.

TABLE 5 - Table 5 summarizes the rules for local buckling provided by each specification in turn. The numerical entry given corresponds to the format for that specification, as identified in Table 3. (Numerical entries are not always possible, but the exceptions are noted in the tables.)

This table introduces the terminology Class 1, Class 2, and Class 3 when referring to cross-sections. As most readers will know, this refers to the capacity of a beam or of a beam-column. A Class 1 section, also called a plastic design cross-section, is one which can both reach its plastic moment capacity and has enough rotation capacity to permit redistribution of moments. A Class 2 section, also called a compact section, is one which can just reach its plastic moment capacity but has a rapid drop-off in capacity at that point. A Class 3 section, also called a non-compact section, is one which is able to reach only the yield moment capacity. In these definitions it is understood that any moment capacity includes the effect of axial force if that is present. In the case of members subjected only to axial load, the definitions pertaining to Class 1, 2, or 3 have no meaning, although some specifications continue to make a distinction.

Examination of the local buckling rules for Class 1 sections introduces a complication. There is no recognized standard for the amount of rotation capacity necessary in order that a member be qualified as a Class 1 section, and individual specifications generally do not describe the rotation capacity used to establish their rule. This topic requires a complete examination on its own, and in presentation of the data herein it is assumed that the expectations for rotation capacity are reasonably similar in all specifications. The writers of any specification which seems to stand out as either extremely liberal or conservative as compared to the rules for Class 1 sections provided by others may wish to examine this aspect further.

The width designation (A, B, or C) used in Table 5 refers to the definition of element width provided in Table 4.

TABLE 6 - The information tabulated in Table 5 for each individual specification is presented in a comparative form. The comparison is provided for each type of shape, element, and loading situation, and is presented in each of the four alternative formats. The same summary information as contained in Table 6 is also shown in pictorial form in Table 7.

TABLE 7 - The comparison contained within Table 6 is presented in pictorial form in this table for seven of the 11 cases. Readers who wish to have more precise information than that observable from the pictorial representation can refer to Table 6.

LIST OF REFERENCES

1. Dawe, J.L., and Kulak, G.L., "Local Buckling of W Shapes used as Columns, Beams and Beam-Columns", Structural Engineering Report No. 95, Department of Civil Engineering, University of Alberta, March, 1981.
2. International Standards Organization, ISO/TC 167/SC 1, "Steel Structures, Materials and Design (N 132)", Draft, Oslo, Norway, January, 1986.
3. Commission of the European Communities, EUROCODE 3, "Common Unified Code of Practice for Steel Structures", Draft, Brussels, Belgium, November, 1983.
4. Canadian Standards Association, CAN3-S16.1-M84, "Steel Structures for Buildings - Limit States Design", Rexdale, Ontario, December, 1984.
5. American Institute of Steel Construction, "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings", Chicago, Illinois, November, 1978.
6. American Institute of Steel Construction, "Load and Resistance Factor Design Specification for Structural Steel Buildings", Draft, Chicago, Illinois, September, 1983.
7. Deutsches Institut für Normung, DIN 18800 Teil 2, "Stahlbauten, Stabilitätsfälle, Knicken von Stäben und Stabwerken", Draft, Berlin, West Germany, December, 1980.
8. Swiss Society of Engineers and Architects, SIA 161, "Steel Structures", Zürich, Switzerland, 1979.
9. British Standards Institution, BS 5950 Part 1, "Structural Use of Steelwork in Building", London, United Kingdom, 1985.
10. Standards Association of Australia, AS 1250, "SAA Steel Structures Code", Sydney, Australia, 1975.

NOMENCLATURE

Note: Specifications frequently use different symbols for the same definition. When this occurs, all the symbols used in this report are noted.

b	Width of element, see Table 4
C_f, N^*, P, P_n	Factored axial load
C_y, N_p, P_y	Axial compressive load at yield stress
E	Elastic modulus of steel, 210 000 MPa assumed
F_y, f_y	Yield strength
f_a	Working stress due to axial load
k_c, k_σ, κ	Buckling coefficient
n	Ratio of axial capacity in presence of moment to product of yield strength times area
R	Ratio of mean longitudinal stress in web to yield strength
t	Thickness of element
α	Format factor, see Table 3, or fraction of web in compression as used in Table 5
β	Format factor, see Table 3
γ	Format factor, see Table 3
δ	Format factor, see Table 3
ν	Poisson's ratio
ϕ_b	Performance factor
ψ	Ratio of stresses at extremities of element

Table 1. Specifications

Ref. No.	Country	Specification	Year	Abbr.
1	Canada	J.L. Dawe, G.L. Kulak: Local Buckling of W Shapes used as Columns, Beams and Beam-Columns, Structural Engineering Report No. 95	1981	DK
2	-	ISO/TC 167/SC 1, Steel Structures, Materials and Design (N 132) - Draft	1986	ISO
3	-	EUROCODE 3, Common Unified Code of Practice for Steel Structures - Draft	1983	EC
4	Canada	CAN3-S16.1-M84, Steel Structures for Buildings - Limit States Design	1984	CSA
5	USA	AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings	1978	AISC
6	USA	AISC Load and Resistance Factor Design, Specification for Structural Steel Buildings - Draft	1983	LRFD
7	West Germany	DIN 18800 Teil 2, Stahlbauten, Stabilitätsfälle, Knicken von Stäben und Stabwerken (Stability of Steel Constructions, Buckling of Bars and Systems of Bars) - Draft	1980	DIN
8	Switzerland	SIA 161, Steel Structures	1979	SIA
9	United Kingdom	BS 5950 Part 1, Structural Use of Steelwork in Building	1985	BSI
10	Australia	AS 1250, SAA Steel Structures Code	1975	AS

Table 2. Sections

Section	Element	Contained in Specification	Case No.
I-shape	Flange in compression	DK,ISO,EC,CSA,AISC,LRFD, DIN,SIA,BSI,AS	1
	Web in axial compression	DK,ISO,EC,CSA,AISC,LRFD, DIN,SIA,BSI	2
	Web in bending	DK,ISO,EC,CSA,AISC,LRFD, DIN,SIA,BSI,AS	3
	Web in combined axial compression & bending	DK,ISO,EC,CSA,AISC,LRFD, DIN,SIA,BSI	4
Box section	Flange in compression	ISO,EC,CSA,AISC,LRFD,DIN, SIA,BSI,AS	5
Rectangular HSS	Flange in compression	ISO,EC,CSA,AISC,LRFD,SIA, BSI	6
Circular HSS	Section in bending and/or compression	ISO,EC,CSA,AISC,LRFD,SIA, BSI	7
Tee section	Flange in compression	ISO,EC,CSA,AISC,LRFD,DIN, SIA,BSI	8
	Stem in bending	ISO,EC,CSA,AISC,LRFD,DIN, SIA,BSI	9
Channel section	Flange in compression	ISO,EC,CSA,AISC,LRFD,DIN, SIA,BSI	10
Angle section	Leg in bending or compression	ISO,EC,CSA,AISC,LRFD,DIN, SIA,BSI	11

Table 3. Format of Local Buckling Rules

Formats:

Max. b/t =		Dimensions	Used in Specifications
Plate Sections	Circular Sections		
$\alpha \cdot \sqrt{\frac{E}{f_y}}$	$\alpha' \cdot \frac{E}{f_y}$	E, f_y [MPa]	ISO,DIN,SIA
$\beta \cdot \sqrt{\frac{235}{f_y}}$	$\beta' \cdot \frac{235}{f_y}$	f_y [MPa]	EC,BSI
$\gamma \cdot \frac{1}{\sqrt{f_y}}$	$\gamma' \cdot \frac{1}{f_y}$	f_y [MPa]	CSA,AS
$\delta \cdot \frac{1}{\sqrt{f_y}}$	$\delta' \cdot \frac{1}{f_y}$	f_y [ksi]	DK,AISC,LRFD

Conversion Factors:

Plate Sections (= All Sections Except Circular Sections)

	α	β	γ	δ
α =	1	0.0334522	0.00218218	0.00572994
β =	29.8934	1	0.0652328	0.171287
γ =	458.258	15.3297	1	2.62579
δ =	174.522	5.83814	0.380838	1

Circular Sections

	α'	β'	γ'	δ'
α' =	1	0.00111905	0.00000476190	0.0000328322
β' =	893.617	1	0.00425532	0.0293394
γ' =	210000	235	1	6.89476
δ' =	30457.9	34.0839	0.145038	1

Table 4. Definition of Plate Width

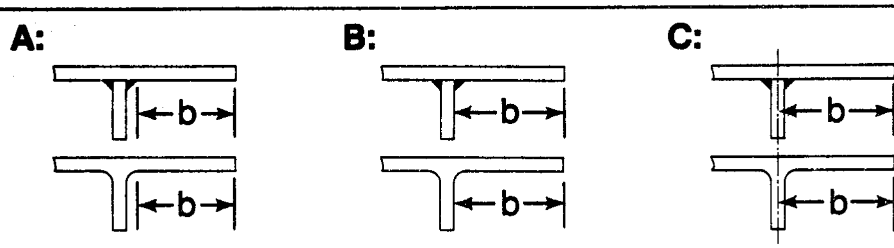
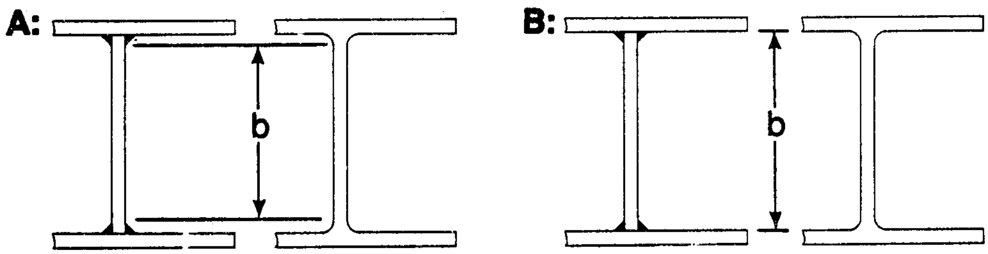
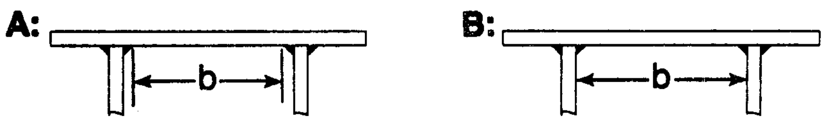
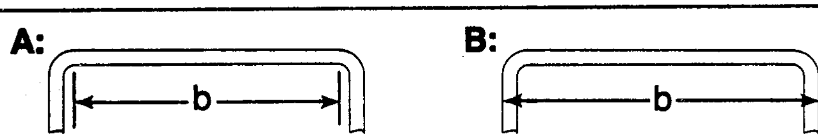
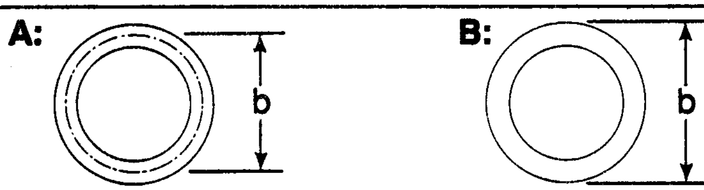
Definition	Case No.*
	1 8
	2 3 4
	5
	6
	7
	9
 — Note: Thickness designated as "t" in all cases *(See Table 2)	10 11

Table 5. Synopsis of Local Buckling Rules

Table 5.1. Synopsis of Local Buckling Rules

Specification: J.L. Dawe, G.L. Kulak: Local Buckling of W Shapes used as Columns, Beams and Beam-Columns, Structural Engineering Report No. 95, 1981

Abbr., Ref. No.: DK, 1
Format (Refer to Table 3): δ

Case No. (see Table 2)	Section	Element	Width (see Table 4)	Class 1	Class 2	Class 3
1	I-shape	Flange in compression	C	54	64	72
2		Web in axial compression	B	300	300	300
3		Web in bending	B	430	660	725
4		Web in combined axial compression and bending	B	$430(1-0.93\frac{P}{P_y})$ when $\frac{P}{P_y} < 0.15$; $382(1-0.22\frac{P}{P_y})$ when $\frac{P}{P_y} > 0.15$	$660(1-0.55\frac{P}{P_y})$	$725(1-0.59\frac{P}{P_y})$
5	Box section	Flange in compression				
6	Rect. HSS	Flange in compression				
7	Circ. HSS	Section in bending and/or compression				
8	Tee section	Flange in compression				
9		Stem in bending				
10	Channel section	Flange in compression				
11	Angle section	Leg in bending or compression				

Table 5.2. Synopsis of Local Buckling Rules

Specification: ISO/TC 167/SC 1, Steel Structures, Materials and Design (N 132) - Draft, 1986

Abbr., Ref. No.: ISO, 2
Format (Refer to Table 3): α

Case No. (see Table 2)	Section	Element	Width (see Table 4)	Class 1	Class 2	Class 3
1	I-shape	Flange in compression	A	0.30	0.35	0.45
2		Web in axial compression	A	1.10	1.30	1.40
3		Web in bending	A	2.20	2.50	3.40
4		Web in combined axial compression and bending	A	† $\frac{1.10}{\alpha}$	$\frac{1.30}{\alpha}$	* $0.70\sqrt{k_c}$
5	Box section	Flange in compression	A	1.10	1.30	1.40
6	Rect. HSS	Flange in compression	B	1.10	1.30	1.50
7	Circ. HSS	Section in bending and/or compression	B	$\alpha' = 0.055$	$\alpha' = 0.077$	$\alpha' = 0.110$
8Δ	Tee section	Flange in compression	A	0.30	0.35	0.45
9Δ		Stem in bending (compression at flange-stem junction)	B	$\frac{0.30}{\alpha\sqrt{\alpha}}$	$\frac{0.33}{\alpha\sqrt{\alpha}}$	§ $0.70\sqrt{k_c}$
10Δ	Channel section	Flange in compression	B	0.30	0.35	0.45
11	Angle section	Leg in compression	B	-	-	0.40

† Throughout Table 5.2, α = fraction of web in compression = $(n + 1)/2$.

* k_c = buckling coefficient for element supported at each end

$$= 4 - 2.73(\psi-1) - 1.79(\psi-1)^2 - 2.70(\psi-1)^3 = 23.90 - 55.94n + 57.64n^2 - 21.60n^3$$

§ k_c = buckling coefficient for element supported only at one end

$$= 0.425 + 9.1(\psi-1) + 10.4(\psi-1)^2 = 23.82 - 65.0n + 41.6n^2$$

where $\psi = 2n - 1$
and n = axial capacity in presence of moment/product of yield strength times area.

Δ Not shown explicitly in ISO document but inferred.

Table 5.3. Synopsis of Local Buckling Rules

Specification: EUROCODE 3, Common Unified Code of Practice for Steel Structures - Draft, 1983

Abbr., Ref. No.: EC, 3
Format (Refer to Table 3): β

Case No. (see Table 2)	Section	Element	Width (see Table 4)	Class 1	Class 2	Class 3
1	I-shape	Flange in compression	A;C	9 ; 10	10 ; 11	14 ; 15
2		Web in axial compression	A	33	39	42
3		Web in bending	A	66	78	102
4		Web in combined axial compression and bending	A	† $\frac{33}{\alpha}$	$\frac{39}{\alpha}$	* $21\sqrt{k_\sigma}$
5	Box section	Flange in compression	A	33	39	42
6	Rect. HSS	Flange in compression	B	33	37	45
7	Circ. HSS	Section in compression	B	$\beta' = 50$	$\beta' = 70$	$\beta' = 100$
8Δ	Tee section	Flange in compression	A;C	9 ; 10	10 ; 11	14 ; 15
9Δ		Stem in bending (compression at flange-stem junction)	B	$\frac{9}{\alpha\sqrt{\alpha}}$	$\frac{10}{\alpha\sqrt{\alpha}}$	§ $21\sqrt{k_\sigma}$
10Δ	Channel section	Flange in compression	B	9	10	14
11Δ	Angle section	Leg in bending (compression at free edge)	B	$\frac{9}{\alpha}$	$\frac{10}{\alpha}$	° $21\sqrt{k_\sigma}$

† Throughout Table 5.3, α = fraction of web in compression = $(n + 1)/2$.

* k_σ = buckling coefficient for element supported at each end

$$= \begin{cases} 8.4/(\psi + 1.1) & \text{when } \psi > 0 \\ 7.64 - 6.26\,\psi + 10\psi^2 & \text{when } \psi < 0 \end{cases} = \begin{cases} 4.2/(n + 0.05) & \text{when } n > 0.5 \\ 23.90 - 52.52n + 40n^2 & \text{when } n < 0.5 \end{cases}$$

§ k_σ = buckling coefficient for element supported only at one end (compression side)

$$= \begin{cases} 0.578/(\psi + 0.34) & \text{when } \psi > 0 \\ 1.70 - 5\psi + 17.1\psi^2 & \text{when } \psi < 0 \end{cases} = \begin{cases} 0.289/(n - 0.33) & \text{when } n > 0.5 \\ 23.80 - 78.40n + 68.40n^2 & \text{when } n < 0.5 \end{cases}$$

° k_σ = buckling coefficient for element supported only at one end (tension side)

$$= 0.57 - 0.21\psi + 0.07\psi^2 = 0.85 - 0.70n + 0.28n^2$$

where $\psi = 2n - 1$
and n = axial capacity in presence of moment/product of yield strength times area.

Δ Not shown explicitly in EC document but inferred.

Table 5.4. Synopsis of Local Buckling Rules

Specification: CAN3-S16.1-M84, Steel Structures for Buildings - Limit States Design, 1984

Abbr., Ref. No.: CSA, 4
Format (Refer to Table 3): γ

Case No. (see Table 2)	Section	Element	Width (see Table 4)	Class 1	Class 2	Class 3
1	I-shape	Flange in compression	C	145	170	200
2		Web in axial compression	B	670	670	670
3		Web in bending	B	1100	1370	1810
4		Web in combined axial compression and bending	B	$1100(1-1.40\frac{C_f}{C_y})$ > 670	$1370(1-1.28\frac{C_f}{C_y})$ when $\frac{C_f}{C_y} < 0.15$; $1180(1-0.43\frac{C_f}{C_y})$ when $\frac{C_f}{C_y} > 0.15$	$1810(1-1.69\frac{C_f}{C_y})$ when $\frac{C_f}{C_y} < 0.15$; $1470(1-0.54\frac{C_f}{C_y})$ when $\frac{C_f}{C_y} > 0.15$
5	Box section	Flange in compression	A	525	525	670
6	Rect. HSS	Flange in compression	A	420	525	670
7	Circ. HSS	Section in bending	B	$\gamma' = 13000$	$\gamma' = 18000$	$\gamma' = 23000$
8	Tee section	Flange in compression	C	145	170	200
9		Stem in bending	B	145	170	340
10	Channel section	Flange in compression	B	-	-	200
11	Angle section	Leg in bending	B	-	-	200

Table 5.5. Snyopsis of Local Buckling Rules

Specification: AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings, 1978

Abbr., Ref. No.: AISC, 5
Format (Refer to Table 3): δ

Case No. (see Table 2)	Section	Element	Width (see Table 4)	Class 1	Class 2	Class 3
1	I-shape	Flange in compression	C	* 50	65	§ 95
2		Web in axial compression	A	257	257	257
3		Web in bending	A	412	640	° 760
4		Web in combined axial compression and bending	A	$412(1-1.40\frac{P}{P_y})$ > 257	† $640(1-3.74\frac{f_a}{F_y})$ > 257	-
5	Box section	Flange in compression	A	190	190	253
6	Rect. HSS	Flange in compression	A	-	190	238
7	Circ. HSS	Section in bending and/or compression	B	-	δ' = 3300	δ' = 3300
8	Tee section	Flange in compression	C	* 50	65	§ 95
9		Stem in bending	B	-	65	127
10	Channel section	Flange in compression	B	-	65	§ 95
11	Angle section	Leg in bending or compression	B	-	65	76

* Depends on yield strength. Value shown is mean for steels between 36 ksi and 65 ksi yield.

§ A transition is provided from Class 2 to Class 3.

° Maximum unless a reduced allowable bending stress is accepted.

† A safety factor of 1.5 has been assumed for f_a when this equation is applied in Table 6.4.

Table 5.6. Synopsis of Local Buckling Rules

Specification: AISC Load and Resistance Factor Design, Specification for Structural Steel Buildings - Draft, 1983

Abbr., Ref. No.: LRFD, 6
Format (Refer to Table 3): δ

Case No. (see Table 2)	Section	Element	Width (see Table 4)	Class 1	Class 2	Class 3
1	I-shape	Flange in compression	C	* 52	65	† 165
2		Web in axial compression	A	253	253	253
3		Web in bending	A	§ 412	640	970
4		Web in combined axial compression and bending	A	° 412 > $191(2.33-\frac{P_n}{\phi_b P_y})$	$640(1-2.75\frac{P_n}{\phi_b P_y})$ when $\frac{P_n}{\phi_b P_y} < 0.125$; $191(2.33-\frac{P_n}{\phi_b P_y})$ when $\frac{P_n}{\phi_b P_y} > 0.125$	970
5	Box section	Flange in compression	A	190	190	238
6	Rect. HSS	Flange in compression	A	190	190	238
7	Circ. HSS	Section in bending and/or compression	B	δ' = 1300	δ' = 1300	δ' = 3300
8	Tee section	Flange in compression	C	* 52	65	† 165
9		Stem in bending	B	-	-	127
10	Channel section	Flange in compression	B	* 52	65	† 165
11	Angle section	Leg in bending or compression	B	-	-	76

* When a rotation capacity less than 3 is sufficient: 65

§ When a rotation capacity less than 3 is sufficient: 640

° When a rotation capacity less than 3 is sufficient: Class 2 requirements apply.

† Depends on yield strength. Value shown is mean for steels between 36 ksi and 65 ksi yield.

Table 5.7. Synopsis of Local Buckling Rules

Specification: DIN 18800 Teil 2, Stahlbauten, Stabilitätsfälle, Knicken von Stäben und Stabwerken (Stability of Steel Constructions, Buckling of Bars and Systems of Bars) - Draft, 1980

Abbr., Ref. No.: DIN, 7
Format (Refer to Table 3): α

Case No. (see Table 2)	Section	Element	Width (see Table 4)	Class 1	Class 2	Class 3
1	I-shape	Flange in compression	A	0.29	-	0.436
2		Web in axial compression	A	1.00	-	1.33
3		Web in bending	A	2.00	-	3.25
4		Web in combined axial compression and bending	A	† $\frac{1.00}{\alpha}$	-	* $0.665 \sqrt{k_\sigma}$
5	Box section	Flange in compression	A	1.00	-	1.33
6	Rect. HSS	Flange in compression				
7	Circ. HSS	Section in bending and/or compression				
8[Δ]	Tee section	Flange in compression	A	0.29	-	0.436
9[Δ]		Stem in bending (compression at flange-stem junction)	A	$\frac{0.29}{\alpha}$	-	§ $0.665 \sqrt{k_\sigma}$
10[Δ]	Channel section	Flange in compression	A	0.29	-	0.436
11[Δ]	Angle section	Leg in bending (compression at free edge)	A	$\frac{0.29}{\alpha}$	-	° $0.665 \sqrt{k_\sigma}$
12	Any	Web in constant shear	A	-	-	1.539

† Throughout Table 5.7, α = fraction of web in compression = $(n + 1)/2$.

* k_σ = buckling coefficient for element supported at each end

$$= \begin{cases} 4.00 & \text{when } n = 1 \\ 7.81 & \text{when } n = 0.5 \\ 23.90 & \text{when } n = 0 \end{cases}$$

§ k_σ = buckling coefficient for element supported only at one end (compression side)

$$= \begin{cases} 0.43 & \text{when } n = 1 \\ 1.70 & \text{when } n = 0.5 \\ 23.80 & \text{when } n = 0 \end{cases}$$

° k_σ = buckling coefficient for element supported only at one end (tension side)

$$= \begin{cases} 0.43 & \text{when } n = 1 \\ 0.57 & \text{when } n = 0.5 \\ 0.85 & \text{when } n = 0 \end{cases}$$

where n = axial capacity in presence of moment/product of yield strength times area.

Δ Not shown explicitly in DIN document but inferred.

Table 5.8. Synopsis of Local Buckling Rules

Specification: SIA 161, Steel Structures, 1979

Abbr., Ref. No.: SIA, 8
Format (Refer to Table 3): α

Case No. (see Table 2)	Section	Element	Width (see Table 4)	Class 1	Class 2	Class 3
1	I-shape	Flange in compression	C	0.38	0.45	0.56
2		Web in axial compression	B	1.50	1.625	1.71
3		Web in bending	B	2.40	3.00	4.20
4		Web in combined axial compression and bending	B	$2.40(1-1.40\frac{N^*}{N_p})$ > 1.50	$3.00(1-1.60\frac{N^*}{N_p})$ when $\frac{N^*}{N_p} < 0.125$; $2.50(1-0.35\frac{N^*}{N_p})$ when $\frac{N^*}{N_p} > 0.125$	* $0.856\sqrt{\kappa}$
5	Box section	Flange in compression	B	1.20	1.40	1.71
6	Rect. HSS	Flange in compression	B	1.20	1.40	1.71
7	Circ. HSS	Section in compression	A	-	-	α' = 0.125
8	Tee section	Flange in compression	C	0.38	0.45	0.56
9		Stem in bending	B	-	-	Δ 0.56
10	Channel section	Flange in compression	B	Δ 0.38	Δ 0.45	0.56
11	Angle section	Leg in compression	B	-	-	0.56

* κ = buckling coefficient for element supported at each end

$$\kappa = \begin{cases} 4.00 & \text{when } n = 1 \\ 7.81 & \text{when } n = 0.5 \\ 23.90 & \text{when } n = 0 \end{cases}$$

where n = axial capacity in presence of moment/product of yield strength times area.

The factor 0.856 follows from $\frac{\pi}{\sqrt{12(1-\nu^2)}} \cdot \bar{\lambda}_B$

where $\bar{\lambda}_B$ = slenderness factor = 0.9

and ν = Poisson's ratio = 0.3.

Δ Not shown explicitly in SIA document but inferred.

Table 5.9. Synopsis of Local Buckling Rules

Specification: BS 5950 Part 1, Structural Use of Steelwork in Building, 1985

Abbr., Ref. No.: BSI, 9
Format (Refer to Table 3): β *

Case No. (see Table 2)	Section	Element	Width § (see Table 4)	Class 1 §	Class 2 §	Class 3 §
1	I-shape	Flange in compression	B;C	8.1 ; 9.2	9.2 ; 10.3	14.1 ; 16.2
2		Web in axial compression	B;A	-	-	30.3 ; 42.2
3		Web in bending	B;A	85.5	106.0	129.8
4		Web in combined axial compression and bending	B;A	† $\frac{85.5}{0.4+0.6\alpha}$	† $\frac{106.0}{\alpha}$	° $\frac{129.8}{1+1.6R}$ when R < 0.5 ; 112.5 - 82.2R, 100.6 - 58.4R when R > 0.5
5	Box section	Flange in compression	B	24.9	27.0	30.3
6	Rect. HSS	Flange in compression	A	28.1	34.6	42.2
7	Circ. HSS	Section in bending or compression	B	β' = 46.8	β' = 66.7	β' = 93.6
8	Tee section	Flange in compression	B;C	8.1 ; 9.2	9.2 ; 10.3	14.1 ; 16.2
9		Stem in bending	B	9.2	10.3	20.6
10	Channel section	Flange in compression	B	9.2	10.3	16.2
11	Angle section	Leg in bending	B	9.2	10.3	Δ 16.2

* The reference yield stress in BSI is 275 MPa; β-values are derived.

§ When two entries shown, first entry refers to welded sections, second entry refers to rolled sections.

† α = 2 x fraction of web in compression = n + 1.

° R = ratio of the mean longitudinal stress in the web to f_y ; when R > 0.5: first entry = welded section, second entry = rolled section.

Δ In addition, average of both legs is restricted to 12.4.

Table 5.10. Synopsis of Local Buckling Rules

Specification: AS 1250, SAA Steel Structures Code, 1975

Abbr., Ref. No.: AS, 10
Format (Refer to Table 3): γ

Case No. (see Table 2)	Section	Element	Width (see Table 4)	Class 1	Class 2	Class 3
1	I-shape	Flange in compression	B	128	136	256
2		Web in axial compression				
3		Web in bending	B	-	-	3200
4		Web in combined axial compression and bending				
5	Box section	Flange in compression (see also item 12 below)	B	400	512	800
6	Rect. HSS	Flange in compression				
7	Circ. HSS	Section in bending and/or compression				
8	Tee section	Flange in compression				
9		Stem in bending				
10	Channel section	Flange in compression				
11	Angle section	Leg in bending or compression				
12	Box section	Flange in compression, with welding residual stress	B	280	-	560

Table 6. Numerical Comparisons of Local Buckling Rules

Table 6.1. Numerical Comparisons of Local Buckling Rules

Section: I-Shape
Element: Flange in Compression

Case No. 1

Ref. No. (see Table 1)	Specification	α - values			β - values		
		Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
1	DK	0.309	0.367	0.413	9.2	11.0	12.3
2	ISO	0.30	0.35	0.45	9.0	10.5	13.5
3	EC	0.335	0.368	0.502	10	11	15
4	CSA	0.316	0.371	0.436	9.5	11.1	13.0
5	AISC	0.286	0.372	0.544	8.6	11.1	16.3
6	LRFD	0.298	0.372	0.945	8.9	11.1	28.3
7	DIN	0.29	-	0.436	8.7	-	13.0
8	SIA	0.38	0.45	0.56	11.4	13.5	16.7
9	BSI	0.271→0.308	0.308→0.344	0.470→0.543	8.1→9.2	9.2→10.3	14.1→16.2
10	AS	0.279	0.297	0.559	8.3	8.9	16.7
		γ - values			δ - values		
		Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
1	DK	142	168	189	54	64	72
2	ISO	137	160	206	52.4	61.1	78.5
3	EC	153	169	230	58.4	64.2	87.6
4	CSA	145	170	200	55.2	64.7	76.2
5	AISC	131	171	249	50	65	95
6	LRFD	137	171	433	52	65	165
7	DIN	133	-	200	50.6	-	76.1
8	SIA	174	206	257	66.3	78.5	97.7
9	BSI	124→141	141→158	216→249	47.4→53.7	53.7→60.0	82.1→94.7
10	AS	128	136	256	48.7	51.8	97.5

When a specification provides rules for both welded and hot-rolled fabrication, a range of values is indicated (→). The lower number listed applies to welded shapes.

Table 6.2. Numerical Comparisons of Local Buckling Rules

Section: I-Shape
Element: Web in Axial Compression

Case No. 2

Ref. No. (see Table 1)	Specification	α - values			β - values		
		Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
1	DK	1.719	1.719	1.719	51.4	51.4	51.4
2	ISO	1.10	1.30	1.40	32.9	38.9	41.9
3	EC	1.104	1.305	1.405	33	39	42
4	CSA	1.462	1.462	1.462	43.7	43.7	43.7
5	AISC	1.473	1.473	1.473	44.0	44.0	44.0
6	LRFD	1.450	1.450	1.450	43.3	43.3	43.3
7	DIN	1.00	-	1.33	29.9	-	39.8
8	SIA	1.50	1.625	1.71	44.8	48.6	51.1
9	BSI	-	-	1.013→1.411	-	-	30.3→42.2
10	AS						
		γ - values			δ - values		
		Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
1	DK	788	788	788	300	300	300
2	ISO	504	596	642	192	227	244
3	EC	506	598	644	193	228	245
4	CSA	670	670	670	255	255	255
5	AISC	675	675	675	257	257	257
6	LRFD	664	664	664	253	253	253
7	DIN	458	-	609	175	-	232
8	SIA	687	745	784	262	284	298
9	BSI	-	-	464→647	-	-	177→246
10	AS						

When a specification provides rules for both welded and hot-rolled fabrication, a range of values is indicated (→). The lower number listed applies to welded shapes.

Table 6.3. Numerical Comparisons of Local Buckling Rules

Section: I-Shape
Element: Web in Bending

Case No. 3

Ref. No. (see Table 1)	Specification	α - values			β - values		
		Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
1	DK	2.464	3.782	4.154	73.7	113.0	124.2
2	ISO	2.20	2.50	3.40	65.8	74.7	101.6
3	EC	2.208	2.609	3.412	66	78	102
4	CSA	2.400	2.990	3.950	71.8	89.4	118.1
5	AISC	2.361	3.667	4.355	70.6	109.6	130.2
6	LRFD	2.361	3.667	5.56	70.6	109.6	166
7	DIN	2.00	-	3.25	59.8	-	97.2
8	SIA	2.40	3.00	4.20	71.7	89.7	125.6
9	BSI	2.859	3.546	4.342	85.5	106.0	129.8
10	AS	-	-	6.98	-	-	209
		γ - values			δ - values		
		Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
1	DK	1129	1733	1904	430	660	725
2	ISO	1008	1146	1558	384	436	593
3	EC	1012	1196	1564	385	455	595
4	CSA	1100	1370	1810	419	522	689
5	AISC	1082	1681	1996	412	640	760
6	LRFD	1082	1681	2547	412	640	970
7	DIN	917	-	1489	349	-	567
8	SIA	1100	1375	1925	419	524	733
9	BSI	1310	1625	1990	499	619	758
10	AS	-	-	3200	-	-	1219

Table 6.4.a. Numerical Comparisons of Local Buckling Rules

Section: I-Shape
Element: Web in Combined Axial Compression and Bending

Case No. 4, Format: α

Ref. No. (see Table 1)	Specification	Class 1	Class 2	Class 3
1	DK	2.464(1−0.93n), n<0.15 2.189(1−0.22n), n>0.15 (1.707 → 2.464)	3.782(1−0.55n) (1.702 → 3.782)	4.154(1−0.59n) (1.703 → 4.154)
2	ISO	$\frac{2.20}{n+1}$ (1.10 → 2.20)	$\frac{2.60}{n+1}$ (1.30 → 2.60)	$0.70\sqrt{k_c(n)}$ (see Table 5.2) (1.40 → 3.42)
3	EC	$\frac{2.208}{n+1}$ (1.104 → 2.208)	$\frac{2.609}{n+1}$ (1.305 → 2.609)	$0.702\sqrt{k_\sigma(n)}$ (see Table 5.3) (1.405 → 3.434)
4	CSA	2.400(1−1.40n), n<0.28 1.462 , n>0.28 (1.462 → 2.400)	2.990(1−1.28n), n<0.15 2.575(1−0.43n), n>0.15 (1.468 → 2.990)	3.950(1−1.69n), n<0.15 3.208(1−0.54n), n>0.15 (1.476 → 3.950)
5	AISC	2.361(1−1.40n), n<0.27 1.473 , n>0.27 (1.473 → 2.361)	3.667(1−2.49n), n<0.24 1.473 , n>0.24 (1.473 → 3.667)	-
6	LRFD	2.361 , n<0.172 2.550(1−0.43n), n>0.172 (1.450 → 2.361)	3.667(1−2.75n), n<0.125 2.550(1−0.43n), n>0.125 (1.450 → 3.667)	5.56
7	DIN	$\frac{2.00}{n+1}$ (1.00 → 2.00)	-	$0.665\sqrt{k_\sigma(n)}$ (see Table 5.7) (1.33 → 3.25)
8	SIA	2.40(1−1.40n), n<0.27 1.50 , n>0.27 (1.50 → 2.40)	3.00(1−1.60n), n<0.125 2.50(1−0.35n), n>0.125 (1.625 → 3.00)	$0.856\sqrt{\kappa(n)}$ (see Table 5.8) (1.71 → 4.18)
9	BSI	$\frac{2.859}{0.6n+1}$ (1.787 → 2.859)	$\frac{3.546}{n+1}$ (1.773 → 3.546)	$\frac{4.342}{1.6n+1}$, n<0.5 3.763(1−0.73n) [welded] } n>0.5 3.365(1−0.58n) [rolled] } $\left(\begin{matrix}1.013\\1.411\end{matrix} \rightarrow 4.342\right)$
10	AS			

The values in parentheses show the range of the α-values from axial compression to pure bending (→).

Table 6.4.b. Numerical Comparisons of Local Buckling Rules

Section: I-Shape
Element: Web in Combined Axial Compression and Bending

Case No. 4, Format: β

Ref. No. (see Table 1)	Specification	Class 1	Class 2	Class 3
1	DK	73.7(1−0.93n), n≤0.15 65.4(1−0.22n), n>0.15 (51.0 → 73.7)	113.0(1−0.55n) (50.9 → 113.0)	124.2(1−0.59n) (50.9 → 124.2)
2	ISO	$\frac{65.8}{n+1}$ (32.9 → 65.8)	$\frac{77.7}{n+1}$ (38.9 → 77.7)	$20.9\sqrt{k_c(n)}$ (see Table 5.2) (41.9 → 102.3)
3	EC	$\frac{66}{n+1}$ (33 → 66)	$\frac{78}{n+1}$ (39 → 78)	$21\sqrt{k_\sigma(n)}$ (see Table 5.3) (42 → 102.7)
4	CSA	71.8(1−1.40n), n≤0.28 43.7 , n>0.28 (43.7 → 71.8)	89.4(1−1.28n), n≤0.15 77.0(1−0.43n), n>0.15 (43.9 → 89.4)	118.1(1−1.69n), n≤0.15 95.9(1−0.54n), n>0.15 (44.1 → 118.1)
5	AISC	70.6(1−1.40n), n≤0.27 44.0 , n>0.27 (44.0 → 70.6)	109.6(1−2.49n), n≤0.24 44.0 , n>0.24 (44.0 → 109.6)	-
6	LRFD	70.6 , n≤0.172 76.2(1−0.43n), n>0.172 (43.3 → 70.6)	109.6(1−2.75n), n≤0.125 76.2(1−0.43n), n>0.125 (43.3 → 109.6)	166
7	DIN	$\frac{59.8}{n+1}$ (29.9 → 59.8)	-	$19.9\sqrt{k_\sigma(n)}$ (see Table 5.7) (39.8 → 97.2)
8	SIA	71.7(1−1.40n), n≤0.27 44.8 , n>0.27 (44.8 → 71.7)	89.7(1−1.60n), n≤0.125 74.7(1−0.35n), n>0.125 (48.6 → 89.7)	$25.6\sqrt{\kappa(n)}$ (see Table 5.8) (51.2 → 125.0)
9	BSI	$\frac{85.5}{0.6n+1}$ (53.4 → 85.5)	$\frac{106.0}{n+1}$ (53.0 → 106.0)	$\frac{129.8}{1.6n+1}$, n≤0.5 112.5(1−0.73n) [welded] } n>0.5 100.6(1−0.58n) [rolled] } $\left(\begin{matrix}30.3\\42.2\end{matrix} \rightarrow 129.8\right)$
10	AS			

The values in parentheses show the range of the β-values from axial compression to pure bending (→).

Table 6.4.c. Numerical Calculation of Local Buckling Rules

Section: I-Shape
Element: Web in Combined Axial Compression and Bending

Case No. 4, Format: γ

Ref. No. (see Table 1)	Specification	Class 1	Class 2	Class 3
1	DK	1129(1-0.93n), $n \leq 0.15$ 1003(1-0.22n), $n > 0.15$ (782 → 1129)	1733(1-0.55n) (780 → 1733)	1904(1-0.59n) (781 → 1904)
2	ISO	$\frac{1008}{n+1}$ (504 → 1008)	$\frac{1191}{n+1}$ (596 → 1191)	321 $\sqrt{k_c(n)}$ (see Table 5.2) (642 → 1568)
3	EC	$\frac{1012}{n+1}$ (506 → 1012)	$\frac{1196}{n+1}$ (598 → 1196)	322 $\sqrt{k_\sigma(n)}$ (see Table 5.3) (644 → 1574)
4	CSA	1100(1-1.40n), $n \leq 0.28$ 670, $n > 0.28$ (670 → 1100)	1370(1-1.28n), $n \leq 0.15$ 1180(1-0.43n), $n > 0.15$ (673 → 1370)	1810(1-1.69n), $n \leq 0.15$ 1470(1-0.54n), $n > 0.15$ (676 → 1810)
5	AISC	1082(1-1.40n), $n \leq 0.27$ 675, $n > 0.27$ (675 → 1082)	1681(1-2.49n), $n \leq 0.24$ 675, $n > 0.24$ (675 → 1681)	-
6	LRFD	1082, $n \leq 0.172$ 1168(1-0.43n), $n > 0.172$ (664 → 1082)	1681(1-2.75n), $n \leq 0.125$ 1168(1-0.43n), $n > 0.125$ (664 → 1681)	2547
7	DIN	$\frac{917}{n+1}$ (458 → 917)	-	305 $\sqrt{k_\sigma(n)}$ (see Table 5.7) (609 → 1489)
8	SIA	1100(1-1.40n), $n \leq 0.27$ 687, $n > 0.27$ (687 → 1100)	1375(1-1.60n), $n \leq 0.125$ 1146(1-0.35n), $n > 0.125$ (745 → 1375)	392 $\sqrt{\kappa(n)}$ (see Table 5.8) (784 → 1917)
9	BSI	$\frac{1310}{0.6n+1}$ (819 → 1310)	$\frac{1625}{n+1}$ (813 → 1625)	$\frac{1990}{1.6n+1}$, $n \leq 0.5$ 1725(1-0.73n) [welded] } $n > 0.5$ 1542(1-0.58n) [rolled] } ($\{^{464}_{647}$ → 1990)
10	AS			

The values in parentheses show the range of the γ-values from axial compression to pure bending (→).

Table 6.4.d. Numerical Comparisons of Local Buckling Rules

Section: I-Shape
Element: Web in Combined Axial Compression and Bending

Case No. 4, Format: δ

Ref. No. (see Table 1)	Specification	Class 1	Class 2	Class 3
1	DK	430(1-0.93n), n<0.15 382(1-0.22n), n>0.15 (298 → 430)	660(1-0.55n) (297 → 660)	725(1-0.59n) (297 → 725)
2	ISO	$\frac{384}{n + 1}$ (192 → 384)	$\frac{454}{n + 1}$ (227 → 454)	$122\sqrt{k_c(n)}$ (see Table 5.2) (244 → 597)
3	EC	$\frac{385}{n + 1}$ (193 → 385)	$\frac{455}{n + 1}$ (228 → 455)	$123\sqrt{k_\sigma(n)}$ (see Table 5.3) (245 → 599)
4	CSA	419(1-1.40n), n<0.28 255 , n>0.28 (255 → 419)	522(1-1.28n), n<0.15 449(1-0.43n), n>0.15 (256 → 522)	689(1-1.69n), n<0.15 560(1-0.54n), n>0.15 (258 → 689)
5	AISC	412(1-1.40n), n<0.27 257 , n>0.27 (257 → 412)	640(1-2.49n), n<0.24 257 , n>0.24 (257 → 640)	-
6	LRFD	412 , n<0.172 445(1-0.43n), n>0.172 (253 → 412)	640(1-2.75n), n<0.125 445(1-0.43n), n>0.125 (253 → 640)	970
7	DIN	$\frac{349}{n + 1}$ (175 → 349)	-	$116\sqrt{k_\sigma(n)}$ (see Table 5.7) (232 → 567)
8	SIA	419(1-1.40n), n<0.27 262 , n>0.27 (262 → 419)	524(1-1.60n), n<0.125 436(1-0.35n), n>0.125 (284 → 524)	$149\sqrt{\kappa(n)}$ (see Table 5.8) (299 → 730)
9	BSI	$\frac{499}{0.6n+1}$ (312 → 499)	$\frac{619}{n + 1}$ (309 → 619)	$\frac{758}{1.6n+1}$, n<0.5 657(1-0.73n) [welded] } n>0.5 587(1-0.58n) [rolled] } ({177 / 246} → 758)
10	AS			

The values in parentheses show the range of the δ-values from axial compression to pure bending (→).

Table 6.5. Numerical Comparisons of Local Buckling Rules

Section: Box Section
Element: Flange in Compression

Case No. 5

Ref. No. (see Table 1)	Specification	α - values			β - values		
		Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
1	DK						
2	ISO	1.10	1.30	1.40	32.9	38.9	41.9
3	EC	1.104	1.305	1.405	33	39	42
4	CSA	1.146	1.146	1.462	34.2	34.2	43.7
5	AISC	1.089	1.089	1.450	32.5	32.5	43.3
6	LRFD	1.089	1.089	1.364	32.5	32.5	40.8
7	DIN	1.00	-	1.33	29.9	-	39.8
8	SIA	1.20	1.40	1.71	35.9	41.9	51.1
9	BSI	0.832	0.905	1.013	24.9	27.0	30.3
10	AS	0.873	1.117	1.746	26.1	33.4	52.2
		γ - values			δ - values		
		Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
1	DK						
2	ISO	504	596	642	192	227	244
3	EC	506	598	644	193	228	245
4	CSA	525	525	670	200	200	255
5	AISC	499	499	664	190	190	253
6	LRFD	499	499	625	190	190	238
7	DIN	458	-	609	175	-	232
8	SIA	550	642	784	209	244	298
9	BSI	381	415	464	145	158	177
10	AS	400	512	800	152	195	305

Table 6.6. Numerical Comparisons of Local Buckling Rules

Section: Rectangular HSS
Element: Flange in Compression

Case No. 6

Ref. No. (see Table 1)	Specification	α - values			β - values		
		Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
1	DK						
2	ISO	1.10	1.30	1.50	32.9	38.9	44.8
3	EC	1.104	1.238	1.505	33	37	45
4	CSA	0.917	1.146	1.462	27.4	34.2	43.7
5	AISC	-	1.089	1.364	-	32.5	40.8
6	LRFD	1.089	1.089	1.364	32.5	32.5	40.8
7	DIN						
8	SIA	1.20	1.40	1.71	35.9	41.9	51.1
9	BSI	0.941	1.158	1.411	28.1	34.6	42.2
10	AS						
		γ - values			δ - values		
		Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
1	DK						
2	ISO	504	596	687	192	227	262
3	EC	506	567	690	193	216	263
4	CSA	420	525	670	160	200	255
5	AISC	-	499	625	-	190	238
6	LRFD	499	499	625	190	190	238
7	DIN						
8	SIA	550	642	784	209	244	298
9	BSI	431	531	647	164	202	246
10	AS						

Table 6.7. Numerical Comparisons of Local Buckling Rules

Section: Circular HSS
Element: Section in Bending and/or Compression

Case No. 7

Ref. No. (see Table 1)	Specification	α' - values			β' - values		
		Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
1	DK						
2	ISO	0.055	0.077	0.110	49.1	68.8	98.3
3	EC	0.0560	0.0783	0.1119	50	70	100
4	CSA	0.0619	0.0857	0.1095	55.3	76.6	97.9
5	AISC	-	0.1083	0.1083	-	96.8	96.8
6	LRFD	0.0427	0.0427	0.1083	38.1	38.1	96.8
7	DIN						
8	SIA	-	-	0.125	-	-	111.7
9	BSI	0.0524	0.0746	0.1048	46.8	66.7	93.6
10	AS						
		γ' - values			δ' - values		
		Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
1	DK						
2	ISO	11550	16170	23100	1675	2345	3350
3	EC	11750	16450	23500	1704	2386	3408
4	CSA	13000	18000	23000	1885	2611	3336
5	AISC	-	22753	22753	-	3300	3300
6	LRFD	8963	8963	22753	1300	1300	3300
7	DIN						
8	SIA	-	-	26250	-	-	3807
9	BSI	11000	15675	22000	1595	2273	3191
10	AS						

Table 6.8. Numerical Comparisons of Local Buckling Rules

Section: Tee Section
Element: Flange in Compression

Case No. 8

Ref. No. (see Table 1)	Specification	α - values			β - values		
		Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
1	DK						
2	ISO	0.30	0.35	0.45	9.0	10.5	13.5
3	EC	0.335	0.368	0.502	10	11	15
4	CSA	0.316	0.371	0.436	9.5	11.1	13.0
5	AISC	0.286	0.372	0.544	8.6	11.1	16.3
6	LRFD	0.298	0.372	0.945	8.9	11.1	28.3
7	DIN	0.29	-	0.436	8.7	-	13.0
8	SIA	0.38	0.45	0.56	11.4	13.5	16.7
9	BSI	0.271→0.308	0.308→0.344	0.470→0.543	8.1→9.2	9.2→10.3	14.1→16.2
10	AS						
		γ - values			δ - values		
		Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
1	DK						
2	ISO	137	160	206	52.4	61.1	78.5
3	EC	153	169	230	58.4	64.2	87.6
4	CSA	145	170	200	55.2	64.7	76.2
5	AISC	131	171	249	50	65	95
6	LRFD	137	171	433	52	65	165
7	DIN	133	-	200	50.6	-	76.1
8	SIA	174	206	257	66.3	78.5	97.7
9	BSI	124→141	141→158	216→249	47.4→53.7	53.7→60.0	82.1→94.7
10	AS						

When a specification provides rules for both welded and hot-rolled fabrication, a range of values is indicated (→). The lower number listed applies to welded shapes.

Table 6.9. Numerical Comparisons of Local Buckling Rules

Section: Tee Section
Element: Stem in Bending

Case No. 9

Ref. No. (see Table 1)	Specification	α - values			β - values		
		Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
1	DK						
2	ISO	0.30→0.85	0.33→0.93	0.456→3.42	9.0→25.4	9.9→27.8	13.6→102.2
3	EC	0.301→0.853	0.335→0.947	0.458→3.426	9→25.5	10→28.3	13.7→102.4
4	CSA	0.316	0.371	0.742	9.5	11.1	22.2
5	AISC	-	0.372	0.728	-	11.1	21.8
6	LRFD	-	-	0.728	-	-	21.8
7	DIN	0.29→0.58	-	0.436→3.24	8.7→17.3	-	13.0→97.0
8	SIA	-	-	0.56	-	-	16.7
9	BSI	0.308	0.344	0.688	9.2	10.3	20.6
10	AS						
		γ - values			δ - values		
		Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
1	DK						
2	ISO	137→390	151→426	209→1567	52.4→148	57.6→162	79.6→597
3	EC	138→391	153→434	210→1570	52.5→149	58.4→165	80.0→598
4	CSA	145	170	340	55.2	64.7	129.5
5	AISC	-	171	333	-	65	127
6	LRFD	-	-	333	-	-	127
7	DIN	133→266	-	200→1487	50.6→101.2	-	76.1→566
8	SIA	-	-	257	-	-	97.7
9	BSI	141	158	315	53.7	60.0	120.0
10	AS						

When a specification provides rules for beam-columns, a range of values is indicated (→). The lower number listed applies to columns, the greater number to beams.

Table 6.10. Numerical Comparisons of Local Buckling Rules

Section: Channel Section
Element: Flange in Compression

Case No. 10

Ref. No. (see Table 1)	Specification	α - values			β - values		
		Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
1	DK						
2	ISO	0.30	0.35	0.45	9.0	10.5	13.5
3	EC	0.301	0.335	0.468	9	10	14
4	CSA	-	-	0.436	-	-	13.0
5	AISC	-	0.372	0.544	-	11.1	16.3
6	LRFD	0.298	0.372	0.945	8.9	11.1	28.3
7	DIN	0.29	-	0.436	8.7	-	13.0
8	SIA	0.38	0.45	0.56	11.4	13.5	16.7
9	BSI	0.308	0.344	0.543	9.2	10.3	16.2
10	AS						
		γ - values			δ - values		
		Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
1	DK						
2	ISO	137	160	206	52.4	61.1	78.5
3	EC	138	153	215	52.5	58.4	81.7
4	CSA	-	-	200	-	-	76.2
5	AISC	-	171	249	-	65	95
6	LRFD	137	171	433	52	65	165
7	DIN	133	-	200	50.6	-	76.1
8	SIA	174	206	257	66.3	78.5	97.7
9	BSI	141	158	249	53.7	60.0	94.7
10	AS						

Table 6.11. Numerical Comparisons of Local Buckling Rules

Section: Angle Section
Element: Leg in Bending or Compression

Case No. 11

Ref. No. (see Table 1)	Specification	α - values			β - values		
		Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
1	DK						
2	ISO	-	-	0.40	-	-	12.0
3	EC	0.301→0.602	0.335→0.669	0.458→0.649	9→18	10→20	13.7→19.4
4	CSA	-	-	0.436	-	-	13.0
5	AISC	-	0.372	0.435	-	11.1	13.0
6	LRFD	-	-	0.435	-	-	13.0
7	DIN	0.29→0.58	-	0.436→0.613	8.7→17.3	-	13.0→18.3
8	SIA	-	-	0.56	-	-	16.7
9	BSI	0.308	0.344	0.543	9.2	10.3	16.2
10	AS						

Ref. No. (see Table 1)	Specification	γ - values			δ - values		
		Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
1	DK						
2	ISO	-	-	183	-	-	69.8
3	EC	138→276	153→307	210→297	52.5→105	58.4→117	80.0→113
4	CSA	-	-	200	-	-	76.2
5	AISC	-	171	200	-	65	76
6	LRFD	-	-	200	-	-	76
7	DIN	133→266	-	200→281	50.6→101.2	-	76.1→107
8	SIA	-	-	257	-	-	97.7
9	BSI	141	158	249	53.7	60.0	94.7
10	AS						

When a specification provides rules for beam-columns, a range of values is indicated (→). The lower number listed applies to columns, the greater number to beams.

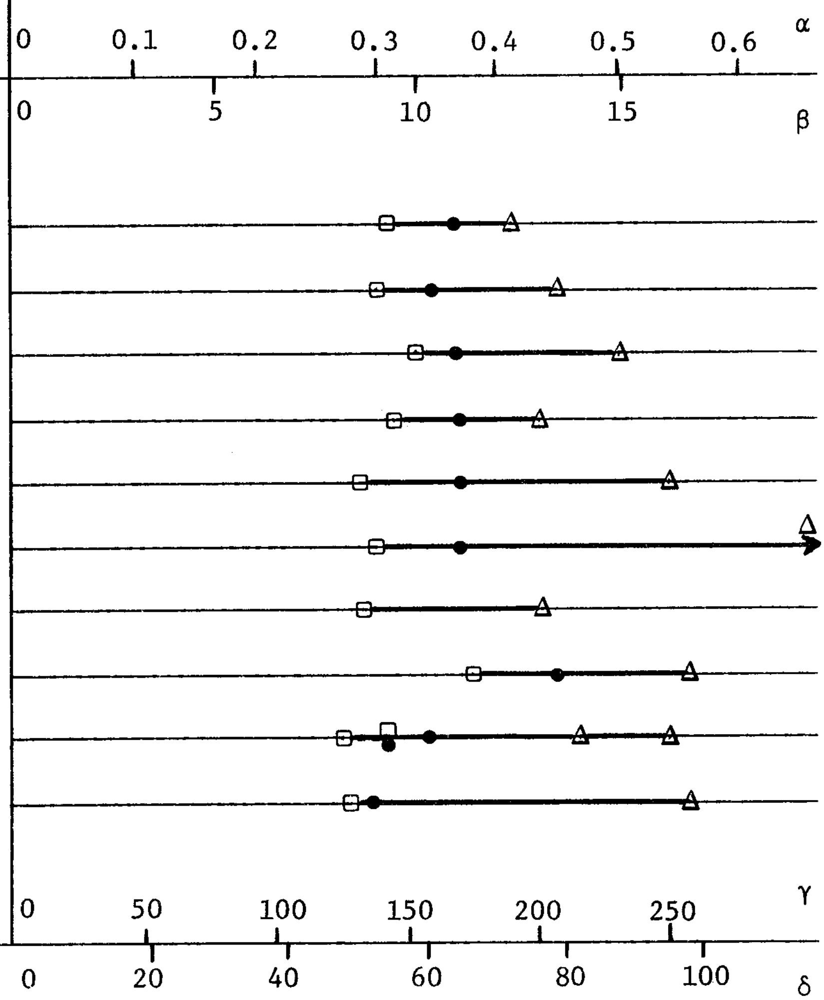
Table 7. Pictorial Representation of Local Buckling Rules

Table 7.1. Pictorial Representation of Local Buckling Rules

Section: I-Shape
Element: Flange in Compression

Case No. 1

Ref. No. (see Table 1)	Specification
1	DK
2	ISO
3	EC
4	CSA
5	AISC
6	LRFD
7	DIN
8	SIA
9	BSI
10	AS



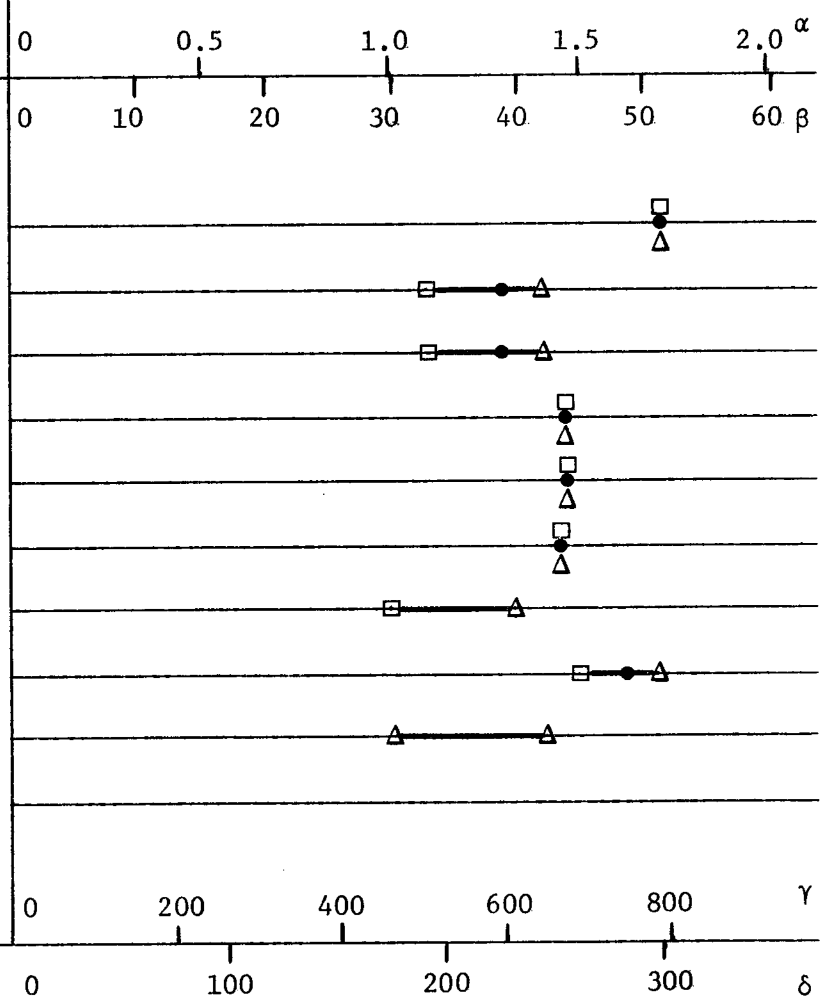
Legend: Class 1 □ Class 2 ● Class 3 Δ

Table 7.2. Pictorial Representation of Local Buckling Rules

Section: I-Shape
Element: Web in Axial Compression

Case No. 2

Ref. No. (see Table 1)	Specification
1	DK
2	ISO
3	EC
4	CSA
5	AISC
6	LRFD
7	DIN
8	SIA
9	BSI
10	AS



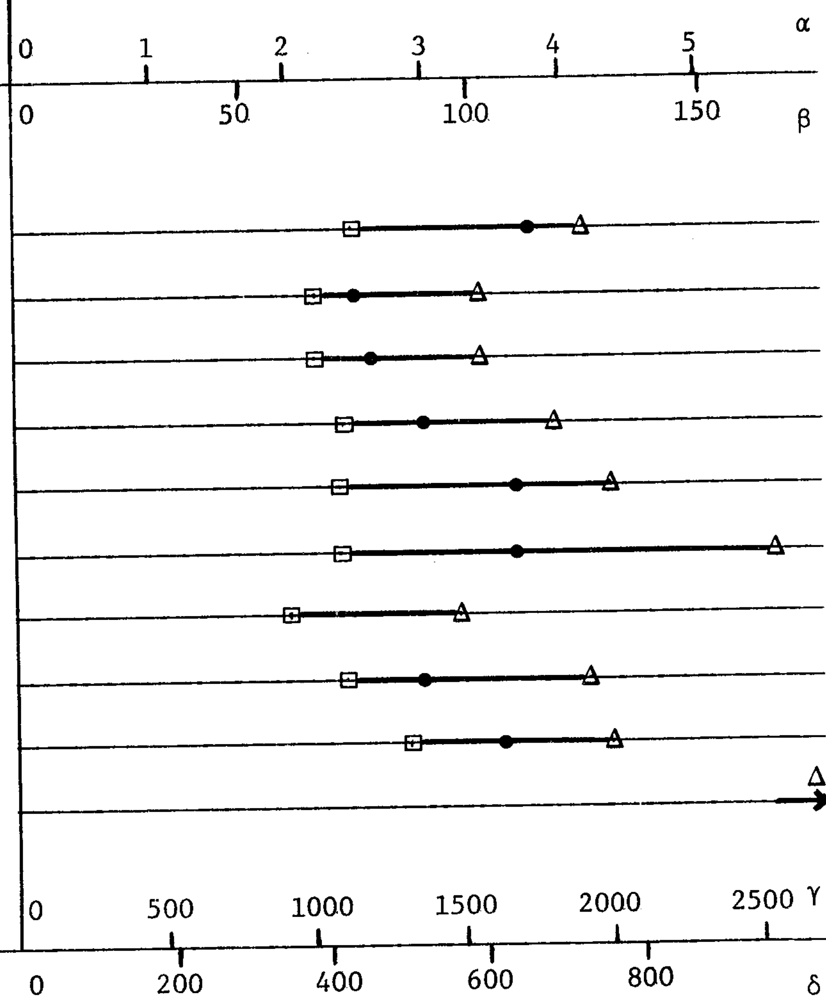
Legend: Class 1 □ Class 2 ● Class 3 Δ

Table 7.3. Pictorial Representation of Local Buckling Rules

Section: I-Shape
Element: Web in Bending

Case No. 3

Ref. No. (see Table 1)	Specification
1	DK
2	ISO
3	EC
4	CSA
5	AISC
6	LRFD
7	DIN
8	SIA
9	BSI
10	AS

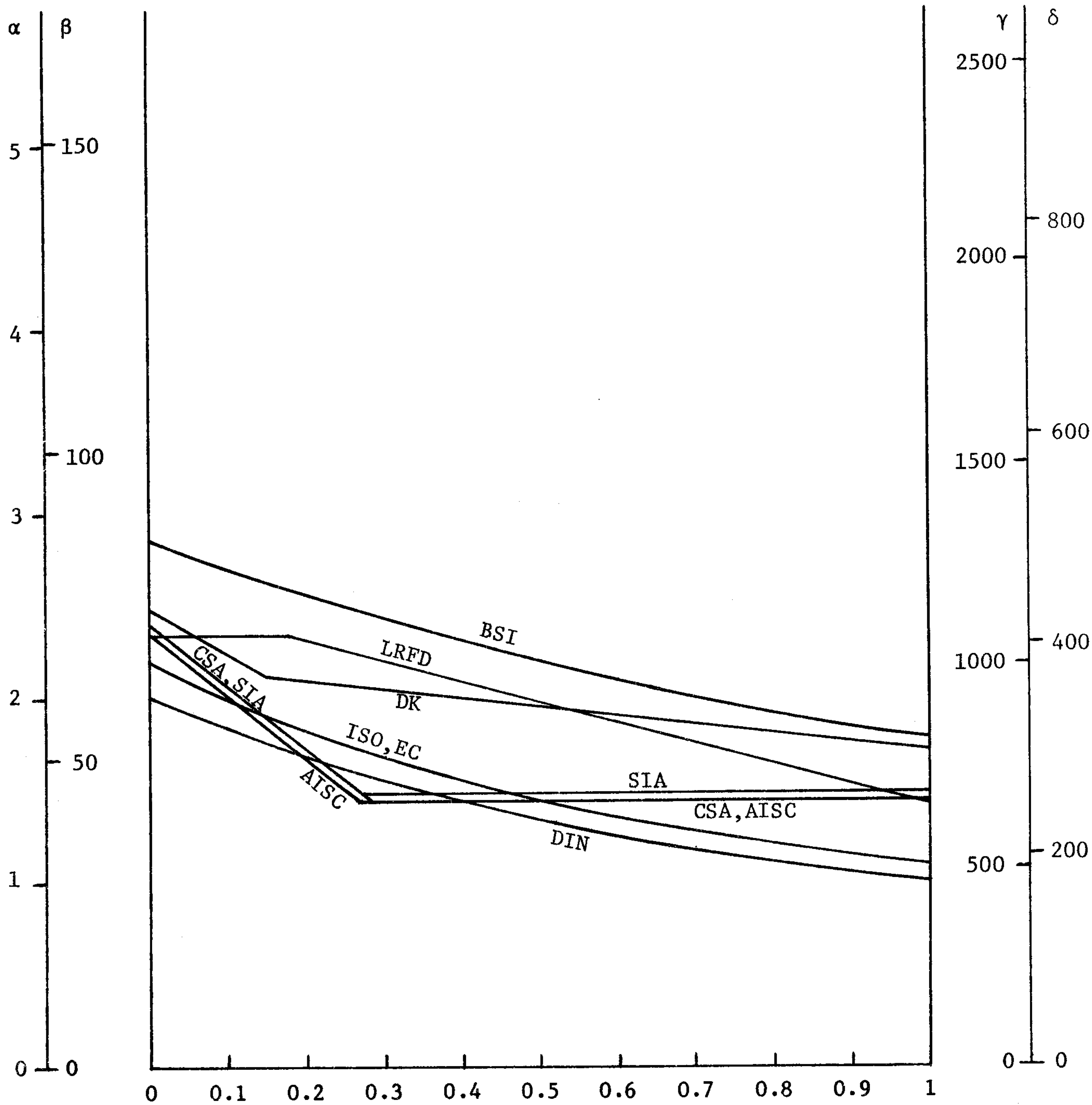


Legend: Class 1 □ Class 2 ● Class 3 Δ

Table 7.4.a. Pictorial Representation of Local Buckling Rules

Section: I-Shape
Element: Web in Combined Axial Compression and Bending

Case No. 4, Class 1

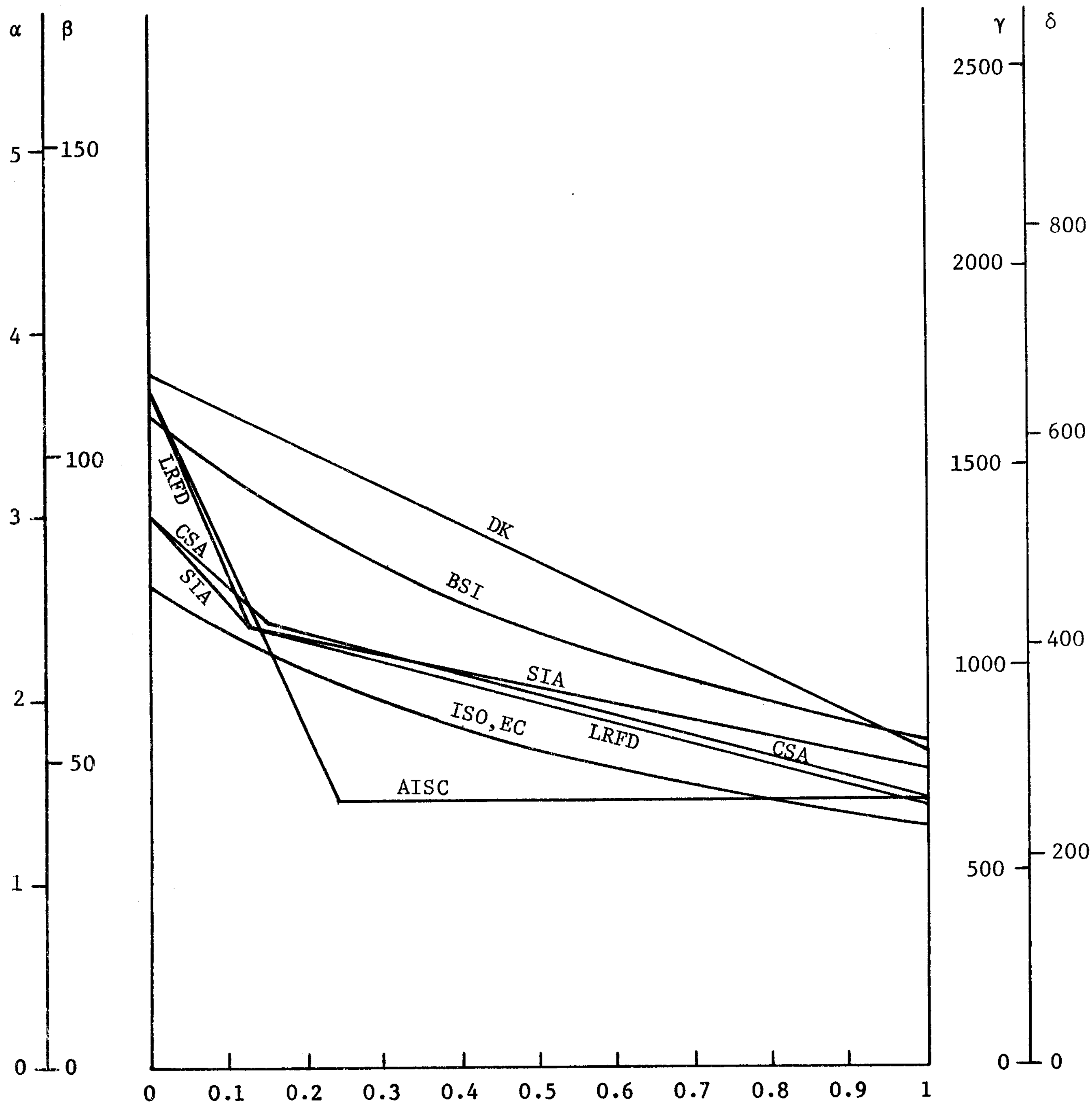


$n = \frac{\text{axial capacity in presence of moment}}{\text{product of yield strength times area}}$

Table 7.4.b. Pictorial Representation of Local Buckling Rules

Section: I-Shape
Element: Web in Combined Axial Compression and Bending

Case No. 4, Class 2

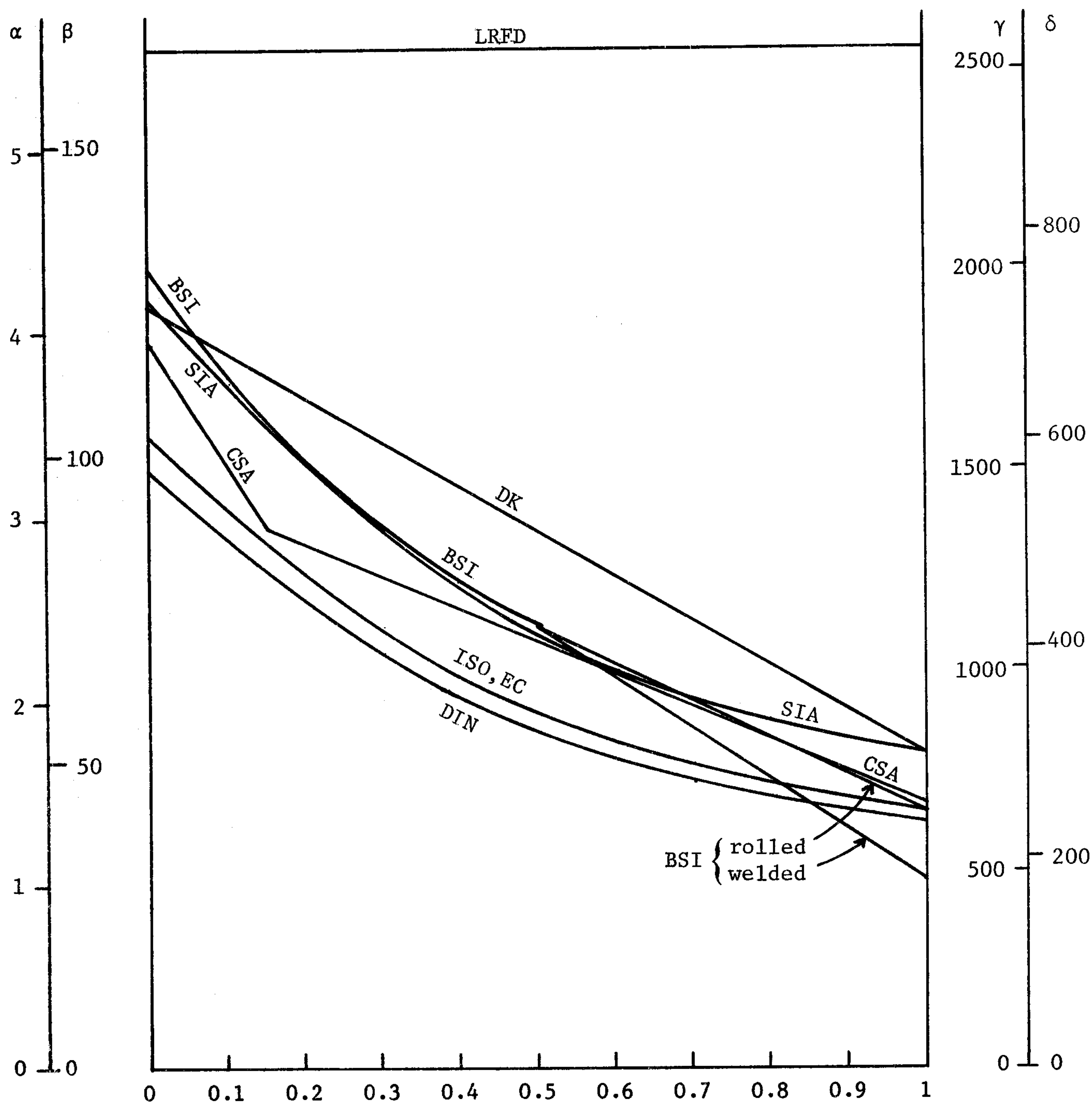


$$n = \frac{\text{axial capacity in presence of moment}}{\text{product of yield strength times area}}$$

Table 7.4.c. Pictorial Representation of Local Buckling Rules

Section: I-Shape
Element: Web in Combined Axial Compression and Bending

Case No. 4, Class 3



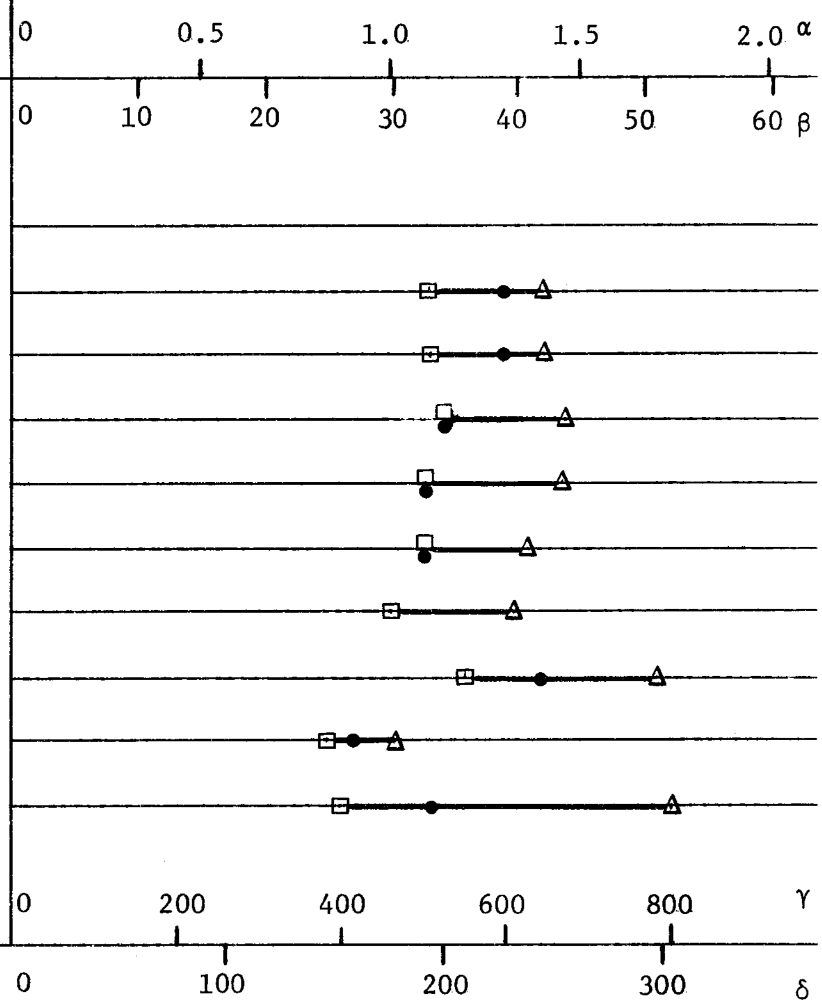
$$n = \frac{\text{axial capacity in presence of moment}}{\text{product of yield strength times area}}$$

Table 7.5. Pictorial Representation of Local Buckling Rules

Section: Box Section
Element: Flange in Compression

Case No. 5

Ref. No. (see Table 1)	Specification
1	DK
2	ISO
3	EC
4	CSA
5	AISC
6	LRFD
7	DIN
8	SIA
9	BSI
10	AS



Legend: Class 1 □ Class 2 ● Class 3 Δ

Table 7.6. Pictorial Representation of Local Buckling Rules

Section: Rectangular HSS
Element: Flange in Compression

Case No. 6

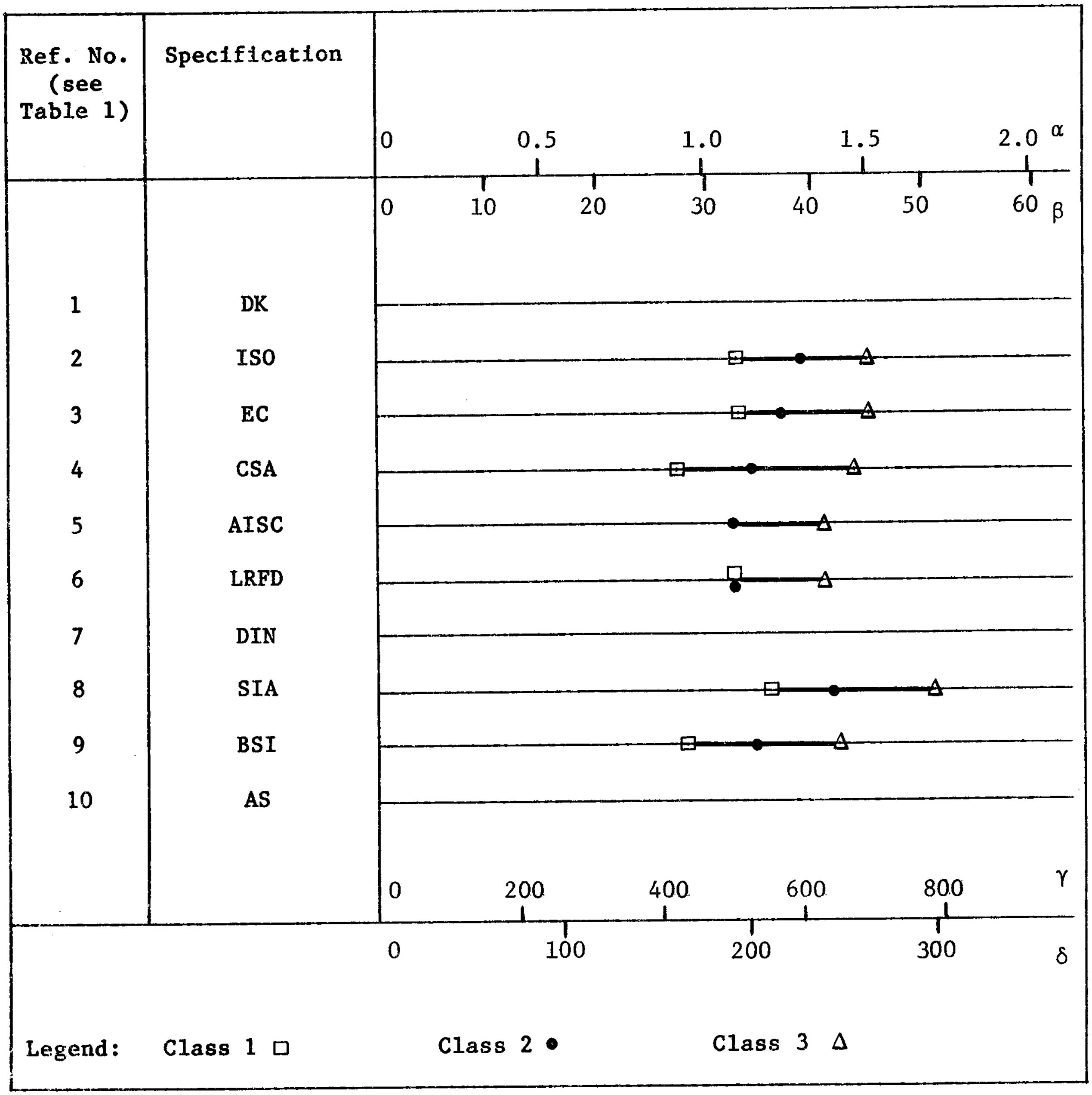
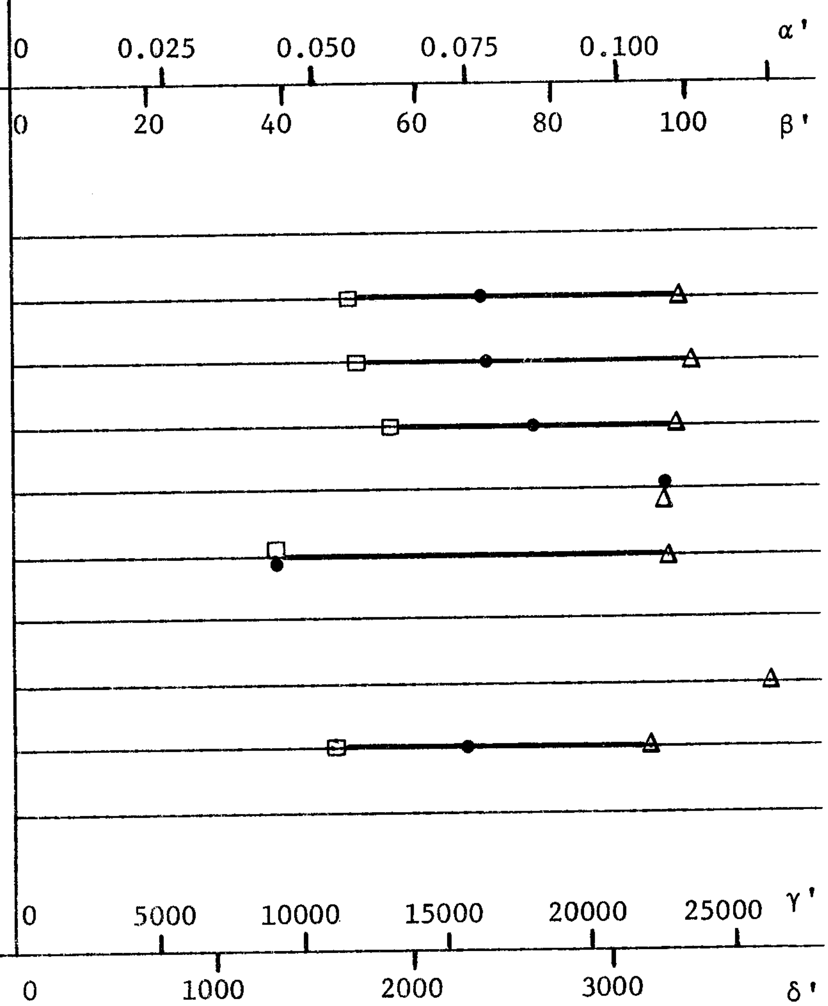


Table 7.7. Pictorial Representation of Local Buckling Rules

Section: Circular HSS
Element: Section in Bending and/or Compression

Case No. 7

Ref. No. (see Table 1)	Specification
1	DK
2	ISO
3	EC
4	CSA
5	AISC
6	LRFD
7	DIN
8	SIA
9	BSI
10	AS



Legend: Class 1 □ Class 2 ● Class 3 Δ

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