Chapter 10-C
Steel Structures According to British Standard 5950 (1985)

CivilFEM Theory Manual
Chapter 10-C – Table of Contents

10-C.1 Scope

BS 5950 (1985) is the British standard for the structural use of steelwork in building, widely in use in regions which experience or have experienced British influence. The purpose of this manual is to define the reach and method of implementing this method within CivilFEM.

The types of analyses considered in this standard have been developed according to the ultimate limit state in agreement with the simple and rigid design methods. Semi-rigid design and experimental verification fall beyond the scope of this specification.

The applicable cross sections for checking procedures include rolled or welded sections subjected to axial forces, shear, and bending in 2D and 3D as well as solid sections subjected to the aforementioned forces.

The calculations made by CivilFEM correspond to the design recommendations of British Standard 5950 (1985) Structural use of steelwork in building: Part 1. Code of practice for design in simple and continuous construction.

10-C.2 Checking Types

With CivilFEM, it is possible to accomplish the following checking and analysis types:

- Checking of sections subjected to:

- Bending	British Standard 5950 (1985) apt. 4.2
- Bending and Shear	British Standard 5950 (1985) apt. 4.2
- Lateral Torsional Buckling	British Standard 5950 (1985) apt. 4.3
- Axial Tension	British Standard 5950 (1985) apt. 4.6
- Axial Compression	British Standard 5950 (1985) apt. 4.7
- Axial Tension with Moments	British Standard 5950 (1985) apt. 4.8.2
- Axial Compression with Moments	British Standard 5950 (1985) apt. 4.8.3

10-C.3 Valid Element Types

The valid element types supported by CivilFEM are the following 2D and 3D ANSYS link and beam elements:

2D Link	LINK1
3D Link	LINK8
3D Link	LINK10
2D Beam	BEAM3
3D Beam	BEAM4
3D Tapered Unsymmetrical Beam	BEAM44
2D Tapered Elastic Unsymmetrical Beam	BEAM54
2D Plastic Beam	BEAM23
3D Thin-walled Beam	BEAM24
3D Elastic Straight Pipe	PIPE16
3D Plastic Straight Pipe	PIPE20
3D Finite Linear Strain Beam	BEAM188
3D Quadratic Linear Strain Beam	BEAM189

Moreover, it is possible to check solid sections captured from 2D or 3D models with a transversal cross section classified as “structural steel”.

10-C.4 Valid Cross-Section Types

The valid cross-sections supported by CivilFEM for checking according to British Standard 5950 (1985) are the following:

All the rolled shapes included in the program libraries (see the hot rolled shapes library and **~SSECLIB** command)

The following welded beams: I shapes, U or channel shapes, T shapes, box, equal and unequal legs angles and pipes. (**~SSECDMS** command).

Structural steel sections defined by plates (command **~SSECPLT**). Although the code does not contemplate them explicitly, these sections can be checked following the same general criteria and procedures specified in the code. The user is responsible for accepting these criteria and procedures.

Shapes from solid sections captured from 2D or 3D models with transverse cross sections classified as “structural steel”.

CivilFEM considers the above sections as sections composed of elements (plates), for example, an I section is composed by five elements or plates: four flanges and one web. In this way, checking according to British Standard 5950 (1985) is easier because this code analyses sections like that. Obviously, circular sections cannot be discomposed into elements so these sections are analyzed differently.

10-C.5 Reference Axis

With checks according to BS 5950 (1985), CivilFEM includes three different coordinate reference systems. All of these systems are right-handed:

1. CivilFEM Reference Axis (X_{CF}, Y_{CF}, Z_{CF}).
2. Cross-Section Reference Axis (X_S, Y_S, Z_S).
3. BS 5950 (1985) Reference Axis (Code Axis), (X_{BS}, Y_{BS}, Z_{BS}).The description of the first two coordinate systems can be found in Chapter 5: Axis Orientation in Beam Sections

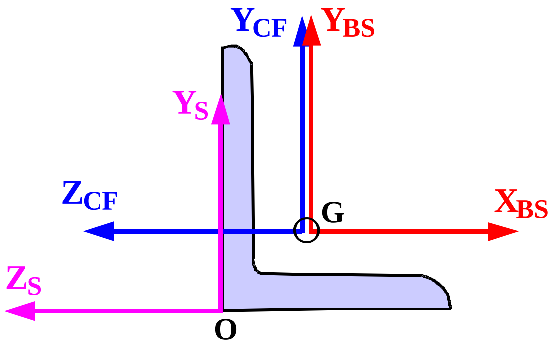

Figure 10-C.5-1 Axis Orientation in Beam Sections

For the BS 5950 (1985) axis system:

The system origin coincides with the CivilFEM axis origin.

The Z_{BS} axis coincides with the CivilFEM X axis

The X_{BS} axis is the principal axis for bending and its orientation is defined by the user (**~MEMBPRO** and **~CHKSTL** commands).

The Y_{BS} axis is perpendicular to the plane defined by the X and Y-axis to ensure a right-handed system.

To define this reference system, the user must indicate which of the CivilFEM axis: -Z, -Y, +Z or +Y coincides with the relevant axis for positive bending. The user may define this reference system with the commands: **~MEMBPRO** when defining member properties for British Standard 5950 (1985) or **~CHKSTL** when checking according to this code. However, in case of any contradiction, the adopted option will be the definition established with **~MEMBPRO** command and the one introduced through **~CHKSTL** command is neglected.

10-C.6 Data and Results used by CivilFEM

The British Standard 5950 (1985) considers all sections as composed of elements or plates. Therefore, there are two types of properties: those which correspond to the whole cross section and those which correspond to the individual section elements.

CivilFEM uses the following data and result groups for checking according to British Standard 5950 (1985):

- Data pertaining to sections: properties and dimensions of gross, net and effective sections; characteristics and dimensions of section elements.
- Code Properties.
- Properties at member level.
- Material properties.
- Forces and moments in the section.
- Checking results.

10-C.6.1 Section Data

BS 5950 (1985) considers the following data set for the cross section:

- Gross section data.
- Net section data.
- Effective section data.
- Data concerning the section and element class.

Gross section data correspond to the nominal properties of the cross-section.

From the net section, only the area is considered. This area is calculated by subtracting the area of holes for screws and rivets and other holes from the gross section area, taking into account the deduction for fastener holes according to section 3.4 of the code. The area of holes is introduced through the parameter AHOLES as a code property (see **~SECMDF** command).

In the case of the effective section, the only data considered is the area; this value is attained from the net area by multiplying it by a coefficient K_e which depends on the type of steel selected.

The section and element class data are obtained using table 7 (section 3.5.2) of BS 5950 (1985), which limits the width to thickness ratios for each section class according to section type (hot-rolled or welded), element type (web or flange) and position (internal or external element). CivilFEM adopts the section class as the largest value from all the elements (least favorable).

A stress reduction factor (f_r) is calculated for slender (class 4) sections. For other sections, no stress reduction factor is applied (f_r=1).

The initial required data for the BS 5950 (1985) module includes the gross section data in user units and the CivilFEM axis or section axis (see the section corresponding to Reference axis in beam sections in Chapter 5 of this Manual). The data are then properly converted from the section's axis into the BS 5950 (1985) axis and the results are given in the code axis. The program calculates the effective and net section data and the class data and stores the values in CivilFEM's results file in user units and in the CivilFEM coordinate system. All of the data can be listed and plotted with **~CSLST** and **~PRSTL** commands.

The section data used in BS 5950-1985 is shown in the following tables:

I.- Section Dimensions

Description	Data
Input data:	
1.- Height	H
2.- Web thickness	Tw
3.- Flanges thickness	Tf
4.- Flanges width	B
5.- Distance between flanges	Hi
6.- Radius of fillet (Rolled shapes)	r1
7.- Toe radius (Rolled shapes)	r2
8.- Weld throat thickness (Welded shapes)	a
9.- Web free depth	d
Output data	(None)

I.- Section Resistant Properties

Description	Data
Input data:	
1.- Area	A
2.- Shear area for major axis (X)	Avx
3.- Sv parameter for major axis (X)	Svx
4.- Shear area for minor axis (Y)	Avy
5.- Sv parameter for minor axis (Y)	Svy
6.- Critical shear strength of web panel for major axis	Vcrx
7.- Critical shear strength of web panel for minor axis	Vcry
8.- Moments of inertia for torsion	It
9.- Moments of inertia for bending	Ixx, Iyy
10.- Product of inertia	Ixy
11.- Elastic resistant modulus	Wx, Wy
12.- Plastic resistant modulus	Wpx, Wpy

13.- Radius of gyration	ix, iy
14.- Coordinates of the center of gravity	Ymin, Ymax, Xmin, Xmax
15.- Distance between GC and SC in X and in Y	Xms, Yms
16.- Distance CG to shear center along Y axis	Ys
17.- Distance CG to shear center along X axis	Xs
18.- Warping Constant	Iw
19.- Shear resistant areas	Yws, Xws
20.- Torsional resistant modulus	Zwt
Output Data:	
1.- Y coordinate of plastic center	Yp
2.- X coordinate of plastic center	Xp
3.- Stress Reduction Factor	fr
4.- Maximum thickness	EPSmax
5.- N Parameter	NsupCmp
6.- Section Class	Cls
7.- Web class for shear buckling check (X axis)	ClsAlmX
8.- Web class for shear buckling check (Y axis)	ClsAlmY
* The section properties listed here in are related to the BS coordinate system (XBS, YBS, ZBS)	

III.- Net section data

Description	Data
Input data:	
1.- AHOLES*	
Output data:	
1.- Net area	An
$A_n = A - AHOLES$	

* Deduction for holes are introduced as a code property (see chapter 5 of this manual)

IV.- Effective section data

The effective area is obtained by multiplying the previously obtained net area by a coefficient K_e, dependent on the material properties (see chapter 3 of this manual).

Description	Data
Input data:	
1.- Net Area	Anet

Description	Data
2.- Ke	Ke
Output data: 1.- Effective Area	 Ae
* $A_e = K_e \cdot A_n$ with $A_e \leq A$ (Gross area)	

V.- Section element data

Description	Data
Input data: 1.- Number of elements 2.- Element type: flange or web (for the relevant axis of bending) 3.- Union condition at the ends: free or fixed 4.- Element thickness 5.- Coordinates of the extreme points of the element (using Section axis)	 N Pltype Cp1, Cp2 t Yp1, Yp2, Zp1, Zp2
Output data: 7.- Element class 6.- Reduction factor 8.- Web Class	 Cl fr Webclass

10-C.6.2 Member Properties

The data used at member level by BS 5950 (1985) is shown in the following table. All of the data are stored with the section data in user units and in the CivilFEM coordinate system. (Parameters L, Kcxy, Kcxz, KLtxy, KLtxz, CFBUCKXY, CFBUCKXZ CteRob, n, m, DL and CHCKAXIS of the **~MEMBPRO** command).

Table 10-C.6-1 Member Properties

Description	Data	Article
Input data:		
1.- Unbraced length of member	L	
2.- Compression buckling factor for plane XY	Kcxy	Section 4.7.2
3.- Compression buckling factor for plane XZ	Kcxz	Section 4.7.2
4.- Lateral torsional buckling factor for plane XY	KLtxy	Section 4.3.5
5.- Lateral torsional buckling factor for plane XZ	Kltxz	Section 4.3.5
6.- Buckling factors for planes XY and XZ (Unbraced length for plane XY =L*Cfbuckxy) (Unbraced length for plane XZ =L*Cfbuckxz)	Cfbuckxy, Cfbuckxz	
7.- Robertson Constant	CteRob	Appendix C.2
8.- Equivalent uniform moment factor	m	Section 4.3.7.6
9.- Slenderness correction factor	n	Section 4.3.7.6
10.- Depth of the lip	DL	Section 4.3.7.5
11.- CivilFEM Axis which is the X axis in BS 5950 (1985) 0: Not defined 1: -Z CivilFEM 2: +Y CivilFEM 3: +Z CivilFEM 4: -Y CivilFEM	CHCKAXIS	
Output data:		

10-C.6.3 Material Properties

Checking according to BS 5950 (1985) uses the following material properties and the code refers to BS 4360:

Table 10-C.6-2 Material properties

Description	Properties, Symbol
Specified minimum yield strength	Y_s
Specified minimum ultimate tensile strength	U_s
Design strength (from table 6, 3.1.1)	P_y
Modulus of elasticity	$E = 205 kN.mm^{-2}$
Poisson's ratio	$\nu = 0.3$
Coefficient of linear thermal expansion	$\alpha = 12 \cdot 10^{-6} °C^{-1}$
Effective/net area ratio (section 3.3.3)	K_e
Material strength factor	$\gamma_m = 1$
Constant ϵ	$\epsilon = \left(\frac{275}{P_y}\right)^{1/2}$
Shear Modulus	G

*th =thickness of plate considered

Notes:

1. From the coefficients above, those used by ANSYS are the steel elasticity modulus E, Poisson's ratio ν, and the coefficient of linear thermal expansion α.
2. The value of the material strength factor γ_m is taken as 1 (section 2.1.1).
3. The standard utilizes other safety coefficients such as γ_I, γ_p and γ_f, which depend on the type of load and are input by the user manually in the load combination module.
4. The constant ϵ is calculated by CivilFEM and stored in the material properties.

10-C.6.4 Forces and Moments

The forces applicable for each check are obtained from the CivilFEM results file (.RCV) for the selected load step and substep. CivilFEM performs the necessary operations to convert the data to BS 5950 (1985) units, axis and criteria of, including sign-changes according the conventions used in the standard. Internally, CivilFEM performs analyzes using the standard's units and conventions.

The forces and moments considered are shown in the following table. The forces and moments represented below refer to the BS 5950 (1985) axis (relevant axis for bending X). All the terms are the used by the code.

Table 9.7-3 Forces and moments

External Load	Description
F	Axial force
FVX	Shear force about major axis (X)
FVY	Shear force about minor axis (Y)
MX	Bending moment about major axis
MY	Bending moment about minor axis

10-C.7 Checking Process

The steps for the checking process are the following:

1. Read the checking type requested by the user.
2. Read the CivilFEM axis that is going to be considered as the principal bending axis, so that it coincides with the X axis of BS5950. In CivilFEM, by default, the principal bending axis that coincides with the +X axis of BS 5950 (1985) is the –Z axis.
3. The following operations are necessary for each selected element:
   a. Obtain material properties corresponding to the element, stored in CivilFEM database, and calculate the rest of the properties needed for checking:
      Properties obtained from CivilFEM database (**~CFMP** command):

Elasticity modulus	E
Poisson's ratio	ν
Yield strength	Ys
Ultimate strength	Us
Design strength	ρ_y
Ke parameter	Ke
Safety factor	γ_M

Calculated properties:

Shear Modulus:

$$G = \frac{E}{2^*(1+v)}$$

Epsilon, material coefficient:

$$\varepsilon = \sqrt{275/\rho_y} \quad (\rho_y \text{ en N/mm}^2)$$

   b. Obtain the cross-section data corresponding to the element.
   c. Determine the section class.
   d. Calculate reduction factors to be applied to the design strength in the case of slender sections (class 4).
   e. Obtain forces acting on the section (Fx, Fvx, Fvy, Mx, My).
   f. Check specific sections according to the type of external load.
   g. Store results in the CivilFEM results file (.RCV) as an alternative.

10-C.7.1 General Processing of Sections. Section Class and Reduction Factor Calculation.

BS 5950 (1985) considers sections composed of different elements, which can be classified according to:

a) The way they work:

Webs and flanges in the X and Y axis, depending on which is the principal bending axis.

The classification of the elements according to the way they work (webs or flanges) is included in the program section library. In other cases the user can specify it or, by default, the program will automatically determine it as a function of the angle α with respect to the principal axis of bending, following the below criterion:

For $\alpha > 45$ Web

For $\alpha < 45$ Flange

b) Their relation to the other elements:

Internal or outside elements

The sections of the shapes included in the program libraries contain this information for each element. CivilFEM classifies the element as either a flange or web according to its axis and provides the element union condition for each end. The ends can be classified as fixed or free (i.e. an end is fixed if it is in contact with another plate and free if it is not).

For checking the structure for safety, BS 5950 (1985) classifies cross sections into four different classes according to their width to thickness ratio (section 3.5.2):

Class 1	Plastic cross sections are those in which a plastic hinge can be developed with sufficient rotation capacity to allow redistribution of moments within the structure.
Class 2	Compact cross sections are those in which the full plastic moment capacity can be developed but local buckling may prevent development of a plastic hinge with sufficient rotation capacity to permit plastic design.
Class 3	Semi-compact sections are those in which the stress at the extreme fibers can reach the design strength but local buckling may prevent the development of the full plastic moment.
Class 4	Slender sections are those which contain slender elements subject to compression due to moment or axial load. Local Buckling may prevent the stress in a slender section from reaching the design strength.

The cross-section class is the highest (least favorable) class of all the elements: flanges and webs (plates). The class of each element is first determined according to the limits of table 7 of BS 5950 (1985). According to this table, the class of an element depends on:

1. The width to thickness ratio.

Rd = Width / Thickness

2. The limits of this ratio, according to the type of section, element and position. The elements whose ratio exceeds the limits specified in this table are considered to be class 4. The limits are the following (refer to figure 3 of the code for dimensions):

- **Sections Built Up by Welding**:

Type of element	Element Class		
	Class 1	Class 2	Class 3
Flange, external	$Rd \leq 7.5 \cdot \varepsilon$	$Rd \leq 8.5 \cdot \varepsilon$	$Rd \leq 13 \cdot \varepsilon$
Flange, internal	$Rd \leq 23 \cdot \varepsilon$	$Rd \leq 25 \cdot \varepsilon$	$Rd \leq 28 \cdot \varepsilon$
Web, internal*	$Rd \leq \frac{79 \cdot \varepsilon}{0.4 + 0.6 \cdot \alpha}$	$Rd \leq \frac{98 \cdot \varepsilon}{\alpha}$	If $R > 0.5$ $Rd \leq (104 - 76 \cdot R) \cdot \varepsilon$ If $0.5 \geq R > -0.45$ $Rd \leq \frac{120 \cdot \varepsilon}{1 + 1.6 \cdot R}$ If $R \leq -0.45$ see note at the end
Stem of T-section	$Rd \leq 8.5 \cdot \varepsilon$	$Rd \leq 9.5 \cdot \varepsilon$	$Rd \leq 19 \cdot \varepsilon$

* Check webs for shear buckling in accordance with section 4.4.5 of the code when $Rd > 63 \cdot \varepsilon$ (see section 9.8.2 of this manual)

- **Rolled Sections**:

Type of element	Element Class		
	Class 1	Class 2	Class 3
Flange, external	$Rd \leq 8.5 \cdot \varepsilon$	$Rd \leq 9.5 \cdot \varepsilon$	$Rd \leq 15 \cdot \varepsilon$
Flange, internal	$Rd \leq 26 \cdot \varepsilon$	$Rd \leq 32 \cdot \varepsilon$	$Rd \leq 39 \cdot \varepsilon$
Web, internal*	$Rd \leq \frac{79 \cdot \varepsilon}{0.4 + 0.6 \cdot \alpha}$	$Rd \leq \frac{98 \cdot \varepsilon}{\alpha}$	If $R > 0.5$ $Rd \leq (93 - 54 \cdot R) \cdot \varepsilon$ If $0.5 \geq R > -0.45$ $Rd \leq \frac{120 \cdot \varepsilon}{1 + 1.6 \cdot R}$

			If $R \leq -0.45$ see note at the end
Stem of T-section	$Rd \leq 8.5 \cdot \varepsilon$	$Rd \leq 9.5 \cdot \varepsilon$	$Rd \leq 19 \cdot \varepsilon$

* Check webs for shear buckling in accordance with section 4.4.5 of the code when $Rd > 63 \cdot \varepsilon$ (see section 9.8.2 of this manual)

- **Angular Sections**:

Angular sections	Element Class		
	Class 1	Class 2	Class 3
	$Rd \leq 8.5 \cdot \varepsilon$	$Rd \leq 9.5 \cdot \varepsilon$	$Rd \leq 15 \cdot \varepsilon$ and $\frac{b+d}{t} \leq 23 \cdot \varepsilon$

* where b and d are the different widths and t is the thickness

3. Apart from the type of section, element and position, the limits of the width to thickness ratio also depend on the material parameter ε, the stress distribution along the element and the parameter α, which are represented by the following relationships.

$$\varepsilon = \sqrt{275/\rho_y}\,\left(\rho_y \text{in N/mm}^2\right)$$

$$\alpha = \frac{2 \cdot y_c}{d}$$

$$R = \frac{\sigma_{mean}}{\rho_y}$$

Where:

y_c	Distance from the plastic neutral axis to the edge of the web connected to the compression flange. If $\alpha > 2$ the section is considered as experiencing compression throughout.
ρ_y	Design resistance of the material.
σ_{media}	Mean longitudinal stress in the web. Compression is positive and tension is negative.

- Note: If $R \leq -0.45$ the code does not specify how to determine the element class. Analyzing the expression $120/(1 + 1.6 \cdot R)$, we can observe that the element is experiencing tension throughout from $R = -0.5$. The code takes $R = -0.45$ as a limit value and therefore, the program assumes that for $R < -0.45$, the element is having tension throughout and assigns class 1 to the element.

- **Tubular Sections**:

In the case of a circular tube subject to moment or axial compression, the class of the section is determined directly as if it were a single element, using the Rd and the following limits:

$$Rd = D/t$$

D External diameter.

t Thickness.

Tubular sections	Element Class		
	Class 1	Class 2	Class 3
	$Rd \leq 40 \cdot \varepsilon^2$	$Rd \leq 57 \cdot \varepsilon^2$	$Rd \leq 80 \cdot \varepsilon^2$

Note: For cross sections where the web has a width/thickness relationship (Rd) greater than $63 \cdot \varepsilon$ (shear slender web), the code recommends that these cross sections should be checked for shear buckling, according to art. 4.4.5 of the code. For this case, a web classification (Webclass) is established.

Stress Reduction Factor (fr) Calculation for Slender Elements

According to BS 5950 (1985), when designing for slender sections in compression, the material design strength ρ_y has to be multiplied by a reduction factor f_r (BS 5950 (1985) part 1, section 3.6.4).

The method to determine the reduction factor of the section is the following:

1. The reduction factor of each element (flanges) of the section is determined in the table below.
2. The smallest of these reduction factors is used as the overall reduction factor of the section.

Table 10-C.7-1 Stress reduction factor for slender elements (f_r)

Element type	Section type	Reduction factor
External flange	welded	$\dfrac{10}{\dfrac{b}{T \cdot \varepsilon} - 3}$
	rolled	$\dfrac{11}{\dfrac{b}{T \cdot \varepsilon} - 4}$
Internal flange	welded	$\dfrac{21}{\dfrac{b}{T \cdot \varepsilon} - 7}$

	rolled	$\frac{31}{\frac{b}{T \cdot \varepsilon} - 8}$
Legs of single angle and double angle members with components separated		the lesser of $\frac{11}{\frac{b}{T \cdot \varepsilon} - 4}$ and $\frac{19}{\frac{(b+d)}{T \cdot \varepsilon} - 4}$
Outstand legs of double angle members with angles in contact back to back		$\frac{11}{\frac{b}{T \cdot \varepsilon} - 4}$
Stems of T-sections		$\frac{14}{\frac{b}{T \cdot \varepsilon} - 5}$

The dimensions b, d, t and T are as defined in figure 3 of BS 5950 (1985) part 1.

10-C.7.2 Checking of Bending Moment and Shear Force (BS 4.2.5 and 4.2.6)

1. Forces and moments selection.
   The forces and moments considered for this checking type are:

   $FV = FZ \text{ or } FY$ Design value of the shear force perpendicular to the relevant axis of bending.

   $MX = MY \text{ or } MZ$ Design value of the bending moment along the relevant axis of bending.

2. Class determination and calculation of the design strength reduction factor for slender sections (for all other section class $f_r = 1$).
3. Criteria Calculation:

For members subjected to bending moment and shear force:

3. Shear checking (Article 4.2.3 of BS 5950 (1985))

The first condition to be checked is the shear criteria at each section:

$$F_v \leq P_v \quad \rightarrow \quad Crt\_V = \frac{F_v}{P_y} \leq 1$$

Where:

P_v Design value of the shear capacity: $P_v = 0.6 \cdot \rho_y \cdot A_v$

ρ_y Design strength of the material (reduced for slender sections).

A_v Shear area, obtained by subtracting the summation of the area of the flanges from the gross area.

Shear Area Calculation (AV)

According to section 4.2.3, the shear area is calculated as follows:

Section type	Shear area
Rolled I, H and channel sections, load parallel to web.	$t \cdot D$
Built-up sections and boxes, load parallel to webs.	$t \cdot d$
Solid bars and plates.	$0.9 \cdot A$
Rectangular hollow sections, load parallel to webs.	$\left(\frac{D}{D+B}\right) A$
Circular hollow sections.	$0.6 \cdot A$
Any other case.	$0.9 \cdot A_0$

where:

t Total web thickness

B Breadth

D Overall depth

d Depth of the web

A Area of the section

A_0 Area of the rectilinear element of the section with the largest dimension in the direction parallel to the load

$\sum_{i=\text{web elements}} \text{breadth}_i \times \text{thickness}_i$

In the case of biaxial bending, both shear areas, perpendicular to the standard's X- and Y-axis, are calculated.

3.2 Shear buckling resistance of thin webs (Article 4.4.5)

If the section's web is class 4 (i.e. slender, d/t ≥ 63ϵ), it should be checked for shear buckling and satisfy the following criterion:

$$Crt\_PV = \frac{F_v}{V_{cr}} \le 1$$

$$V_{cr} = \sum q_{cr} \cdot d \cdot t$$

Where:

V_{cr} Shear buckling resistance (summation extended to all section webs).

q_{cr} Critical shear strength.

d Depth of the web.

t Thickness of the web.

The critical shear strength is obtained from tables 21(a) to (d) from BS 5950 (1985) part 1 where $q_{cr} = Fn(\rho_y\, d/t, a/d)$ and *a* is the distance between stiffeners. The program takes the stiffener spacing as infinity.

These tables are only defined for the following design strength of the material: $\rho_y 265\,N/mm^2$, $\rho_y 275\,N/mm^2$, $\rho_y 340\,N/mm^2$, $\rho_y 355\,N/mm^2$,. For the remaining values of design strength, the program adopts the following tables for the calculation of q_{cr}:

Table 10-C.7-2 Determination of Critical Shear Strength (q_{cr})

ρ_y (N/mm^2)	Grade 40 Thickness (mm)	Grade 43 Thickness (mm)	Grade 50 Thickness (mm)	Grade 55 Thickness (mm)	Grade WR50A Thickness (mm)	Grade WR50B Thickness (mm)	Grade WR50C Thickness (mm)	Adopted Table (*)
450				16				21 d
430				25				21 d
415				40				21 d
355			16					21 d (*)
345			40		12	12/25/40	12/25/40	21 c
340			63			50	63	21 c (*)
325			100		25/40			21 c
275		16						21 b (*)
265		40						21 a (*)
260	16							21 a
255		63						21 a
245	40	100						21 a
240	63							21 a
225	100							21 a

* The code only establish these four tables.

If the web of the section is not slender (d/t<63):

$$Crt\_PV = 0$$

3.3 Bending moment check

Besides the shear checking, the following condition at each section is checked (Articles 4.2.5 and 4.2.6 of BS 5950 (1985)):

$$M_x \leq M_c \quad \rightarrow \quad Crt\_M = \frac{M_x}{M_c} \leq 1$$

$$M_c = f_r \cdot \rho_y \cdot M_{df}$$

Where:

M_c	Moment capacity.
f_r	Stress reduction factor.
M_{df}	Bending resistant modulus.

The reduction of the bending resistant modulus due to the effect of shear load is only applied if the shear load is above 60% of shear capacity of the section:

$$F_v > 0.6\, P_v$$

The bending resistant modulus is obtained is following:

a. For slender and semi-compact sections:

$$M_{df} = Z$$

b. For plastic and compact sections:

If $F_v > 0.6 \cdot P_v$

$$M_{df} = S < 1.2 \cdot Z$$

If $F_v > 0.6 \cdot P_v$

$$M_{df} = S - S_v \cdot \rho_1$$

$$\rho_1 = \frac{2.5 \cdot F_v}{P_v} - 1.5$$

If $M_{df} < 0$ then $M_{df} < 0$

Where:

Z	Elastic resistant modulus of the section.
S	Plastic resistant modulus of the section.
S_v	Parameter to obtain the plastic reduced modulus due to the effect of shear force.

Sv Parameter Calculation

The S_v calculation is done following the expression below:

$$S_v = S - S_R$$

Where:

S	Plastic resistant modulus of the section: $S = \sum_{i = elements} S_i$
S_R	Plastic modulus of the section remaining after deduction of the shear area: $S_R = \sum_{i = webs}$

4. Calculation of the total criterion:

$$CRT\_TOT = Max\,(Crt\_V, Crt\_PV, Crt\_M)$$

5. Output results are written in the CivilFEM results file (.RCV) as an alternative. Checking results: criteria and variables are described in the following table:

Table 10-C.7-3 Art. 4.2 Checking of Bending Moment and Shear Force

Result	Concepts	Articles	Description
MX	M_x		Design value of the bending moment
MC	Mc	4.2.5 and 4.2.6	Moment capacity
FV	Fv		Design value of the shear force
PV	Pv	4.2.3	Design value of the shear capacity
CRT_V	F_v/V_{cr}	4.2.3	Shear criterion
CRT_PV	F_v/V_{cr}	4.4.5	Buckling web criterion
CRT_M	M_x/M_c	4.2.5 and 4.2.6	Bending criterion
CRT_TOT			BS Global criterion
CLASS		3.5.2	Section class
WEBCLASS		3.5.2	Web Class
MDF	Mdf	4.2.5	Plastic or elastic modulus of the section
VCR	V_{cr}	4.4.5	Shear buckling resistance

10-C.7.3 Checking of Lateral Torsional Buckling Resistance (BS 4.3)

1. Forces and moments selection.
   The forces and moments considered in this check are:

   $M_x = My \text{ or } Mz$ Design value of the bending moment about the relevant axis of bending.

2. Class determination.
3. Criteria calculation.

   When checking for lateral torsional buckling (LTB) of beams the criterion shall be taken as:

$$\text{Crt\_TOT} = \frac{\overline{M}}{M_b} \leq 1$$

$$\overline{M} = m * M_A$$

Where:

$\overline{M}$	Equivalent uniform moment
M_b	Lateral torsional buckling resistance moment
m	Equivalent uniform moment factor, assumed as 1 by default. Must be entered as a member property.
M_A	Maximum bending moment on the member or the portion of the member under consideration

Determination of the buckling resistance moment Mb (Article 4.3.7 and Appendix B.2)

The value of M_b may be determined from:

$$Mb = \frac{M_E \cdot Mp}{\Phi_b + \left(\Phi_b{}^2 - M_E \cdot Mp\right)^{1/2}}$$

$$\Phi_b = \frac{Mp + (\eta_{LT} + 1) \cdot M_E}{2}$$

Where:

Mp	Plastic moment capacity $\left(Mp = Sx \cdot \rho_y\right)$
Sx	Plastic modulus about the major axis (X axis of the British Standard).
ρ_y	Design strength of the material.
M_E	Elastic critical moment: $M_E = \frac{Mp \cdot \pi^2 \cdot E}{\lambda_{LT}^2 \cdot \rho_y}$
η_{LT}	Perry coefficient.

The Perry coefficient η_{LT} for lateral torsional buckling should be taken as follows:

a) For rolled sections:

$$\eta_{LT} = \alpha_b * (\lambda_{LT} - \lambda_{L0}) \text{ with } \eta_{LT} \geq 0$$

b) For welded sections:

$$\eta_{LT} = 2 * \alpha_b * \lambda_{L0}$$

with:

$$\eta_{LT} \leq 2\, \alpha_0 * (\lambda_{LT} - \lambda_{L0})$$

$$\eta_{LT} \geq \alpha_0 * (\lambda_{LT} - \lambda_{L0})$$

$$\eta_{LT} \geq 0$$

Where:

λ_{L0} Limiting equivalent slenderness.

$$\lambda_{L0} = 0.4 * \left(\frac{\pi^2 E}{\rho_y}\right)^{1/2}$$

α_0 Is a constant taken as 0.007.

λ_{LT} Equivalent slenderness.

Equivalent slenderness determination for Plate Girders

The equivalent slenderness λ_{LT} for plate girders should be taken as:

$$\lambda_{LT} = nvu\lambda$$

$$\lambda = \frac{L_E}{r_y}$$

Where:

n Slenderness correction factor. Introduced by the user as a member property. By default its value is 1.0.

v Slenderness factor.

u Buckling parameter.

The buckling parameter u is taken as following for sections symmetrical about one axis:

$$u = \left(\frac{I_y S_x^2 \lambda}{A^2 H}\right)^{1/4}$$

Where:

I_y Second moment of area about the minor axis

Sx Plastic modulus about the major axis

γ Factor $\gamma = \left(1 - \frac{I_y}{I_x}\right)$

A Cross sectional area of the member

H Warping constant

The slenderness factor v is given by:

$$v = \left[\left(4N(N-1) + \frac{1}{20}\left(\frac{\lambda}{x}\right)^2 + \Psi^2\right)^{1/2} + \Psi\right]^{1/2}$$

$$N = \frac{I_{cf}}{I_{cf} + I_{tf}}$$

Where:

I_{cf}	second moment of area of the compression flange about the minor axis of the section
I_{tf}	second moment of area of the tension flange about the minor axis of the section
Ψ	monosymmetry index, for I and T sections with lipped flanges

The monosymmetry index ψ is taken as follows:

$$\Psi = 0.8 \cdot (2N - 1) \cdot \left(1 + \frac{D_L}{2D}\right) \quad \text{For } N > 0.5$$

$$\Psi = 1.0 \cdot (2N - 1) \cdot \left(1 + \frac{D_L}{2D}\right) \quad \text{For } N < 0.5$$

Where:

D	Overall depth of the section.
DL	Depth of the lip (Member property). By default DL=0.

The torsional index x is taken as follows.

$$x = 1.132 \left(\frac{A \cdot H}{I_y \cdot J}\right)^{1/2}$$

Where:

J	torsional constant

Equivalent slenderness determination for Box Sections

The equivalent slenderness, λ_{LT}, for box sections is taken directly from the expression below:

$$\lambda_{LT} = 2.25 \cdot n \cdot (\phi_b \cdot \lambda)^{1/2}$$

$$\phi_b = \left(\frac{S_x^2 \cdot \gamma'}{A \cdot J}\right)^{1/2}$$

$$\gamma' = \left(1 - \frac{I_y}{I_x}\right) \cdot \left(1 - \frac{J}{2.6 \cdot I_x}\right)$$

Box Sections with uniform wall thickness need not be checked for lateral torsional buckling effects, provided that λ is not greater than the limiting values of λ given in table 38 of the Appendix B.2 of the code.

Table 10-C.7-1 Slenderness limit

D/B	Slenderness Limit λ
1	infinite
2	$\frac{350 \cdot 275}{\rho_y}$

3	$\frac{225 \cdot 275}{\rho_y}$
4	$\frac{170 \cdot 275}{\rho_y}$

Determination of the buckling resistance moment Mb for Single Angles (Article 4.3.8)

The buckling resistance moment for a single angle is taken as:

$$M_b = 0.8 \cdot \rho_y \cdot Z \quad \text{for } L/r_{vv} \leq 100$$

$$M_b = 0.7 \cdot \rho_y \cdot Z \quad \text{for } L/r_{vv} \leq 180$$

$$M_b = 0.6 \cdot \rho_y \cdot Z \quad \text{for } L/r_{vv} \leq 300$$

Where:

- Z Elastic modulus about the relevant axis.
- r_{vv} Radius of gyration about the weakest axis.
- L Unrestrained length.

Note: Generic steel sections defined by plates do not have specific guidelines set by the code for checking lateral torsional buckling. Therefore, these kinds of sections will not be checked by the program for lateral torsional buckling.

Table 10-C.7-4 Art. 4.3 Checking of Lateral Torsional Buckling Resistance

Result	Concepts	Articles	Description
MB	Mb	B.2 and 4.3.8	Buckling resistance moment
UNF_MOMT	$\bar{M} = m \cdot M_A$	4.3.7.2	Equivalent uniform moment
M	m	4.3.7.6	Equivalent uniform moment factor
LAMBDA	Lambda	4.3.7.5	Slenderness
LAMBDALT	LambdaLT	4.3.7.5	Equivalent slenderness
LAMBDALO	LambdaLO	B.2.4	Limiting equivalent slenderness
CRT_TOT	$\bar{M}/M_b$	4.3.7.1	Global criterion
CLASS		3.5.2	Section class
WEBCLASS		3.5.2	Web's class

10-C.7.4 Checking of Members in Axial Tension (BS 4.6)

1. Forces and moments selection.
   The forces and moments considered for this checking type are:

   $F = FX$ Design value of the axial force (positive if it is tensile, element not processed if compressive)

2. Class determination.
3. Criteria calculation.
   For members under axial tension, the general criterion Crt_TOT is checked at each section. This criterion coincides with the axial criterion Crt_N:

$$F \leq Pt \quad \rightarrow \quad Crt\_TOT = Crt\_N = \frac{F}{Pt} \leq 1$$

   Where:

   Pt Tension capacity: Pt = Ae/ρ_y

   Ae Effective area of the section (see section 3.3.3 of the BS).

   ρ_y Design strength of the material.

4. Output results are written in the CivilFEM results file (.RCV) as an alternative. Checking results: criteria and variables are described in the following table:

Table 10-C.7-5 Art. 4.6 Checking of Members in Axial Tension

Result	Concepts	Articles	Description
F	F	4.6.1	Tension Force
PT	P_t	4.6.1	Tension capacity
CRT_TOT	F/P_t	4.6.1	Global criterion

10-C.7.5 Checking of Members in Axial Compression (BS 4.7)

1. Forces and moments selection.
   The forces and moments considered for this checking type are:

   $F = FX$ Design value of the axial force (negative if it is compressive, if it is tensile, the element is not processed).

2. Class determination and calculation of the material resistance reduction factor in the case of slender sections (for all other cases $f_r = 1$).
3. Criteria calculation.

   For members under axial compression, the general criterion Crt_TOT is checked at each section. This criterion coincides with the axial compression criterion Crt_CB:

$$F \leq Pc \quad \rightarrow \quad Crt\_TOT = Crt\_CB = \frac{F}{Pc} \leq 1$$

Where:

- F Axial compression force.
- Pc Compressive resistance: $Pc = A_g \cdot \rho_c$
- A_g Gross sectional area.
- ρ_c Compressive strength.

The compressive strength may be obtained from (see appendix C):

$$\rho_c = \frac{\rho_E \cdot \rho_y}{\phi + \left(\phi^2 - \rho_E \cdot \rho_y\right)^{1/2}}$$

$$\phi = \frac{\rho_y \cdot (\eta + 1) \cdot \rho_E}{2}$$

Where:

- ρ_y Design strength (factored depending on the section's class) should be reduced by $20N/mm^2$, therefore:

  for class 1, 2, or 3 welded sections: $\rho_{yfinal} = \rho_y - 20N/mm^2$

  for class 4 welded sections: $\rho_{yfinal} = \rho_y \cdot f_r - 20N/mm^2$
- ρ_E Euler strength: $\rho_E = \pi^2 \cdot E/\lambda^2$
- E Material elasticity modulus.
- λ Slenderness $\lambda = L_E/i_g$
- L_E Effective length: $L_E = \max\left(L \cdot K_x, L \cdot K_y\right)$.
- i_g Radius of gyration about the relevant axis.
- L Actual length of the member.
- K_x, K_y Correction factors for planes XZ and YZ.

The Perry coefficient, η, for flexural buckling under load should be taken as follows:

$$\eta = 0.001 \cdot a \cdot (\lambda - \lambda_o)$$

Where λ_o is the limiting slenderness:

$$\lambda_o = 0.2 \cdot \left(\frac{\pi^2 \cdot E}{\rho_y}\right)^{1/2}$$

The constant *a* (Robertson constant) is determined by the program from the type of section and buckling axis, according to table 25 of the BS 5950 (1985). However, if the user introduces a value for this constant in member properties, the program user's value will precedence over the value determined by the.

a = 2.0 for table 27 (a)

a = 3.5 for table 27 (b)

a = 5.5 for table 27 (c)

a = 8.0 for table 27 (d)

To distinguish between I and H shapes, the program follows the criteria below:

4. I shapes if $i_x/i_y > 2$
5. H shapes if $i_x/i_y < 2$
6. Output results are written in the CivilFEM results file (.RCV) as an alternative. Checking results: criteria and variables are described in the following table.

Table 10-C.7-6 Art. 4.7 Checking of Members Axial Compression

Result	Concepts	Articles	Description
F	F	4.7	Compression Force
PC	P_c	4.7.4	Compression capacity
RHOC	ρ_c	4.7.5	Compression Resistance
LAMBDA	Lambda	4.7.3	Slenderness
LAMBDA0	Lambda0	C.2	Limiting slenderness
PERRYFCT	NU	C.2	Perry factor
ROBERSTS	a	C.2	Robertson constant
CRT_TOT	F/P_c	4.7	Global criterion
WEBCLASS		3.5.2	Web class
CLASS		3.5.2	Section class

10-C.7.6 Tension Members with Moments (BS 4.8.2)

1. Forces and moments selection.

   The forces and moments considered for this checking type are:

   $F = FX$ Design value of the axial force.

   $Mx = MY \text{ or } MZ$ Design value of the bending moment along the primary bending axis.

   $My = MZ \text{ or } MY$ Design value of the bending moment about the secondary bending axis.

2. Class determination (for members with a tension force and moments, the design strength p_y isn't reduced for slender sections).
3. Criteria calculation.

Each section of a member subjected to an axial tension force and bending moments should be checked for the same conditions as a member subjected to a shear force and bending moments.
Therefore, for this type of checking, the following conditions are checked:

3.1 Shear checking in both directions.

$$Crt\_VX = \frac{Fvx}{Pvx} \leq 1$$

$$Crt\_VY = \frac{Fvy}{Pvy} \leq 1$$

Where:

Fvx and Fvy	Shear forces about X and Y axis.
Fvx and Fvy	Shear capacity about X and Y axis.

3.2 Shear buckling resistance of shear webs.

$$Crt\_PVX = \frac{Fvx}{Vcrx} \leq 1$$

$$Crt\_PVY = \frac{Fvy}{Vcry} \leq 1$$

Where Vcrx and Vcry are the shear buckling resistance respect to X and Y axis, respectively:

$$Vcrx = \sum q_{rc} \cdot d \cdot t$$

$$Vcry = \sum q_{rc} \cdot d \cdot t$$

3.3 Checking of axial force and bending moments.

Each section is checked according to the following condition:

$$\frac{F}{A_e \cdot \rho_y} + \frac{M_x}{M_{cx}} + \frac{M_y}{M_{cy}} \leq 1$$

Equivalent to:

$$Crt\_CMP = Crt\_AXL + Crt\_Mx + Crt\_My \leq 1$$

$$Crt\_AXL = \frac{|F|}{P_t}$$

$$Crt\_Mx = \frac{M_x}{M_{cx}}$$

$$Crt\_My = \frac{M_y}{M_{cy}}$$

Where:

F Axial force.

M_x Bending moment about major axis.

M_y Bending moment about minor axis.

A_e Effective area of the section.

ρ_y Design strength of the material.

M_{cx} Moment capacity about major axis.

M_{cy} Moment capacity about minor axis.

Mcx and Mcy are calculated according to the Articles 4.2.5 and 4.2.6 of BS 5950 (1985).

For this checking type (moments in both directions), the shear area, the plastic modulus and the Sv parameter are calculated with respect to both directions (X and Y axis).

3.3 Checking of global criterion.

$$CRT\_TOT = Max\,(Crt\_CMP, Crt\_VX, Crt\_VPX, Crt\_VY, Crt\_VPY)$$

4. Output results are written in the CivilFEM results file (.RCV) as an alternative. Checking results: criteria and variables are described in the following table.

Table 10-C.7-7 Art. 4.8.2 Checking of Tension Members with Moments

Result	Concepts	Articles	Description
F	F		Axial tension force
MX	M_x	4.2.5	Bending moment about major axis
MY	M_y	4.2.5	Bending moment about minor axis
FVX	F_{vx}		Shear force about major axis
FVY	F_{yv}		Shear force about minor axis
PVX	P_{vx}	4.2.3	Shear capacity about major axis
PVY	P_{vy}	4.2.3	Shear capacity about minor axis
PT	P_t	4.6.1	Axial Tension Capacity
MCX	M_{cx}	4.2.5, 4.2.6	Moment capacity about major axis
MCY	M_{cy}	4.2.5, 4.2.6	Moment capacity about minor axis
CRT_AXL	F/$(Ae \cdot \rho_y)$	4.8.2	Axial Criterion
CRT_VX	F_{vx}/P_{vx}	4.2.3	Shear Criterion about major axis
CRT_VY	F_{vy}/P_{vy}	4.2.3	Shear Criterion about minor axis
CRT_MX	M_x/M_{cx}	4.2.5,	Bending Criterion about major axis

Result	Concepts	Articles	Description
		4.2.6	
CRT_MY	M_y/M_{cy}	4.2.5, 4.2.6	Bending Criterion about minor axis
CRT_PVX	F_{vx}/V_{crx}	4.4.5	Buckling web Criterion about major axis
CRT_PVY	F_{vy}/V_{cry}	4.4.5	Buckling web Criterion about minor axis
CRT_CMP	Crt_AXL+ Crt_MX+ Crt_MY	4.8.2	Axial + moments Criterion
SVX	S_{vx}	4.2.6	Sv parameter for major axis
SVY	S_{vy}	4.2.6	Sv parameter for minor axis
CRT_TOT		4.8.2	Global criterion
AVX	A_{vx}	4.2.3	Shear Area for major axis
AVY	A_{vy}	4.2.3	Shear Area for minor axis
VCRX	V_{crx}	4.4.5	Shear buckling resistant for major axis
VCRY	V_{cry}	4.4.5	Shear buckling resistant for minor axis
MDFX	$S_x, Z_x, S_x - S_{vx}{*}R_o1$	4.2.6	Resistant modulus for major axis
MDFY	$S_y, Z_y, S_y - S_{vy}{*}R_o1$	4.2.6	Resistant modulus for minor axis
ZX	Z_x	4.2.6	Elastic Modulus about major axis
SX	S_x	4.2.6	Plastic Modulus about major axis
ZY	Z_y	4.2.6	Elastic Modulus about minor axis
SY	S_y	4.2.6	Plastic Modulus about minor axis
CLASS		3.5.2	Sections class
WEBCLASS		3.5.2	Web class

10-C.7.7 Compression Members with Moments (BS 4.8.3)

1. Forces and moments selection.
   The forces and moments considered for this checking type are:

   $F = FX$ Design value of the axial force.

$F_{vx} = Fy \ or \ Fz$	Design value of the shear force perpendicular to the primary bending axis.
$F_{vy} = Fz \ or \ Fy$	Design value of the shear force perpendicular to the secondary bending axis.
$M_x = My \ or \ Mz$	Design value of the bending moment along the primary bending axis.
$M_y = Mz \ or \ My$	Design value of the bending moment about the secondary bending axis.

2. Class determination (for members with a compressive force and moments, the design strength p_y isn't reduced for slender sections).
3. Criteria calculation.

Compression members are checked for local capacity at the points of greatest bending and axial load. This capacity may be limited either by yielding or local buckling depending on the section properties. The member is then checked for overall buckling.

Therefore, for this checking type contains the following conditions:

3.1 Local Capacity Check

3.1.1 Axial Criterion

$$\mathrm{Crt\_AX\_L} = \frac{F}{F_c} \leq 1$$

Where:

F	Axial load.
F_c	Compresión capacity $F_c = A_g \cdot \rho_y$

3.1.2 Local criteria as for Tension Members with Moments

Bending criterion (primary axis)= Crt_MX_L

Bending criterion (secondary axis)= Crt_MY_L

Shear criterion about major axis= Crt_VX

Shear criterion about minor axis = Crt_VY

Buckling web Criterion about major axis = Crt_PVX

Buckling web Criterion about minor axis = Crt_PVY

$$\mathrm{Crt\_CM\_L} = \mathrm{Crt\_AX\_L} + \mathrm{Crt\_MX\_L} + \mathrm{Crt\_MY\_L} \leq 1$$

3.1 Overall Buckling Check

3.1.1 Axial Criterion (Buckling)

$$\mathrm{Crt\_AX\_O} = \frac{F}{P_c} \leq 1$$

Where:

- F Design value of the axial compressive force.
- P_c Compression resistance: $P_c = A_g \cdot \rho_c$
- A_g Gross section area.
- ρ_c Compressive strength.

3.1.2 Bending Moment Criterion (Primary axis)

$$Crt\_MX\_O = \frac{m \cdot M_x}{M_b} \leq 1$$

Where:

- m Equivalent uniform moment factor. Introduced as a member property. By default m=1.
- M_x Bending moment about major axis.
- M_b Buckling resistance moment capacity about the major axis.

3.1.3 Bending Moment Criterion (secondary axis)

$$Crt\_MY\_O = \frac{m \cdot M_y}{\rho_y \cdot Z_y} \leq 1$$

Where:

- m Equivalent uniform moment factor. Introduced as a member property. By default m=1.
- M_y Bending moment about minor axis.
- ρ_y Design strength of the material.
- Z_y Elastic modulus about the minor axis.

3.1.4 Component Global Criterion

$$Crt\_CM\_O = Crt\_AX\_O + Crt\_MX\_O + Crt\_MY\_O \leq 1$$

3.1 Total Criterion

$$Crt\_TOT = Max(Crt\_CM\_L\ , Crt\_CM\_O\ , Crt\_VX, Crt\_VPX, Crt\_VY, Crt\_VPY)$$

4. Output resultsare written in the CivilFEM results file (.RCV) as an alternative. Checking results: criteria and variables are described in the following table.

Table 10-C.7-8 Art. 4.8.3 Checking of Compression Members with Moments

Results	Concepts	Articles	Description
F	F		Design value of the axial

Results	Concepts	Articles	Description
			compressive force
PC	P_c	4.7.4	Compression resistance
FVX	F_{vx}		Shear force about major axis
MX	M_x		Bending moment about major axis
ZX	Z_x	4.2.6	Elastic Modulus about major axis
SX	S_x	4.2.6	Plastic Modulus about major axis
SVX	S_{vx}	4.2.6	Sv parameter for major axis
AVX	A_{vx}	4.2.3	Shear Area for major axis
VCRX	V_{crx}	4.4.5	Shear buckling resistant for major axis
MDFX	$S_x, Z_x, S_x - S_{vx} * Ro1$	4.2.6	Resistant modulus for major axis
PVX	P_{vx}	4.2.3	Shear capacity about major axis
MCX	M_{cx}	4.2.5, 4.2.6	Moment capacity about major axis
FVY	F_{vy}		Shear force about minor axis
MY	M_y		Bending moment about minor axis
ZY	Z_y	4.2.6	Elastic Modulus about minor axis
SY	S_y	4.2.6	Plastic Modulus about minor axis
SVY	S_{vy}	4.2.6	Sv parameter for minor axis
AVY	A_{vy}	4.2.3	Shear Area for minor axis
VCRY	V_{cry}	4.4.5	Shear buckling resistant for minor axis
MDFY	$S_y, Z_y, S_y - S_{vy} * Ro1$	4.2.6	Resistant modulus for minor axis
PVY	P_{vy}	4.2.3	Shear capacity about minor axis
MCY	M_{cy}	4.2.5, 4.2.6	Moment capacity about minor axis

Results	Concepts	Articles	Description
M	M	4.8.3.3	Equivalent uniform moment factor
LAMBDA	Lambda	4.3.7.5	Slenderness
LAMBDA0	Lambda0	C.2	Limiting slenderness
LAMBDALT	LambdaLT	4.3.7.5	Equivalent slenderness
LAMBDAL0	LambdaL0	B.2.4	Limiting equivalent slenderness
PERRYFCT	NU	C.2	Perry Factor
MB	M_b	4.3.7	Buckling resistance moment capacity
CRT_TOT	Max(Crt_CM_L, Crt_CM_O, Crt_VX,Crt_VY...)	4.8.3	Total Criterion
CRT_CM_L	Crt_AX_L + Crt_MX_L + Crt_MY_L	4.8.3	Local Axial + moments Criterion
CRT_CM_O	Crt_AX_O + Crt_MX_O + Crt_MY_O	4.8.3	Global Axial + moments Criterion
CRT_AX_L	F/F_c	4.8.3	Local axial criterion
CRT_MX_L	M_x/M_{cx}	4.2.5, 4.2.6	Local bending moment criterion about X axis
CRT_MY_L	M_y/M_{cy}	4.2.5, 4.2.6	Local bending moment criterion about Y axis
CRT_AX_O	F/P_c	4.8.3	Global axial criterion
CRT_MX_O	$\frac{m \cdot M_x}{M_b}$	4.8.3	Global bending moment criterion about X axis
CRT_MY_O	$\frac{m \cdot M_y}{\rho_y \cdot Z_y}$	4.8.3	Global bending moment criterion about Y axis
CRT_VX	F_{vx}/P_{vx}	4.2.3	Shear criterion about X axis
CRT_PVX	F_{vx}/W_{crx}	4.4.5	Buckling web Criterion about major axis
CRT_VY	F_{vy}/P_{vy}	4.2.3	Shear criterion about Y axis
CRT_PVY	F_{vy}/V_{cry}	4.4.5	Buckling web Criterion about minor axis
CLASS	Class	3.5.2	Section Class
WEBCLASS	Webclass	3.5.2	Web Class