IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 3 Ver. II (May - Jun. 2015), PP 160-169
www.iosrjournals.org

Comparison of a steel column design buckling resistance between the South African/Canadian (SANS 10162-1:2005/CAN/CSA-S16-01:2005), Eurocode 3 (EN 1993-1-1:2005) and Australian /New Zealand (AS4100:1998/NZS3404:1997) standards- Part I: PFC-SA (South African Parallel Flange Channel Section)

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Abstract: *Nowadays; design, fabrication and erection of steel structures can be taken place at different locations as a result of rapid globalization; owners may require the use of widely accepted steel design codes. Therefore, engineers are faced with the challenge of being competent with several design specifications for a particular material type. The South African/Canadian Standard (SANS 10162-1:2005/CAN/CSA-S16-01:2005), European code(Eurocode 3) and Australian/New Zealand (AS4100:1998/NZS3404:1997) standard are accepted steel structure design specifications that utilize limit state principles with some similarities and differences in application. Hereby a study has been undertaken to identify the similarities and the differences presented in these standards/codes through steel column design buckling resistance. Classification of cross-sections, effective lengths, column buckling curves and a worked example are considered in this paper. The results show that the differences in capacity between codes vary with the slenderness ratio of the column.*

Keywords: *AS 4100:1998/NZS3404:1997, classification of sections, design buckling resistance, effective lengths, EN 1993-1-1:2005, SANS 10162: 1-2005/ CAN/CSA-S16-01:2005.*

I. Introduction

During last two decades many changes had occurred in the science of Structural Engineering. Knowledge of structural theory had expanded and the use of computer aided design has encouraged greater sophistication in the analysis of steel structure in the elastic and inelastic range. Also steel quality and constructional methods are continually being improved and these factors help in development of “rational design technique”. Design in steel used to be regarded as a “black art” where one only reached a level of competence after 20 years of hard work experience. Whilst, of course, experience is still very important, the designer is now much better supported and is able to be more accurate. Computers have made routine, levels of analysis that would otherwise have taken much manual calculation much easier. Codes of practice have become more comprehensive.

In Europe, “Design of Steel Structures, EN 1993(2003)” was developed by the European Committee for Standardization. This specification, hereafter referred to as EC3, is based on limit state principles using partial safety factor (γ_M). In general, the characteristic strength is divided by a partial safety factor and then compared with the factored loads.

The Canadian Standard on limit states design of steel structures was developed in collaboration with the South African SANS 10162-1, as a result of an initiative by and cooperation between the Canadian Institute of Steel Construction and the Southern African Institute of Steel Construction. The outcome is an identical standard being applied in both countries. The Canadian standard was reaffirmed in 2007, with some changes. None of these changes affect the clauses under consideration.

The New Zealand standard on steel structures, NZS 3404:1997 was published jointly with the Australian standard on steel structures, AS 4100:1998.

This paper compares the design buckling resistance of a steel column section between SANS 10162: 1-2005/ CAN/CSA-S16-01:2005; EN 1993-1-1:2005 and AS 4100:1998/NZS3404:1997.

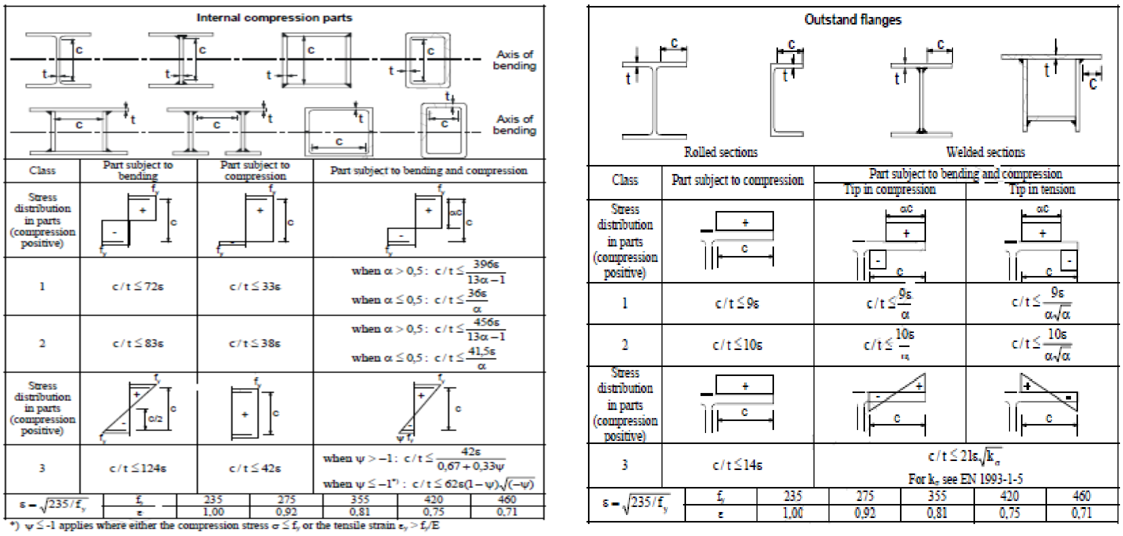
The cross-sections classification is compared. The effective lengths and the buckling curves are also compared. In order to illustrate what has been said below a worked example is proposed. Results and discussion are presented. Finally, conclusions for this research are given.

II. Classification of Cross Sections

The definitions of cross-sections in SANS 10162: 1-2005/ CAN/CSA-S16-01:2005, Eurocode 3 and AS 4100:1998/NZS 3404:1997 codes have similarities. The classification of a specific cross-section in SANS 10162 : 1-2005/ CAN/CSA-S16-01:2005, Eurocode 3 and AS 4100:1998/NZS 3404:1997 codes depends on the width-to-thickness ratio and the material yield strength, f_y of each of its compression members. SANS 10162 : 1-2005/ CAN/CSA-S16-01:2005, Eurocode 3 and AS 4100:1998/NZS 3404:1997gives the formulation to calculate the effective dimensions of class 4 (slender) section and subsequently specify the corresponding design strength formulae for class 4 (slender) sections. Eurocode 3 specifies the limiting width-to-thickness ratios for class 1, class 2, class 3 and class 4 cross sections whereas in SANS 10162 : 1-2005/ CAN/CSA-S16-01:2005 we have to just check that the section doesn't fall in slender class (class 4) so that whole cross sectional area is effective in compression (see in Table 1 and Table 2 the limiting values to Eurocode 3 for each class and SANS 10162 : 1-2005/ CAN/CSA-S16-01:2005 for sections other than class 4 respectively).

Table1. (a)(Sheet 1 of 2): Maximum width-to- thickness ratios for compression parts (Eurocode 3), (b) (Sheet 2 of 2): Maximum width-to-thickness ratios for compression parts (Eurocode 3).

(a) (b)



(a)

Class	Part subject to bending	Part subject to compression	Part subject to bending and compression
Stress distribution in parts (compression positive)			
1	$c/t \le 72\varepsilon$	$c/t \le 33\varepsilon$	when $\alpha > 0{,}5$: $c/t \le \frac{396\varepsilon}{13\alpha - 1}$ when $\alpha \le 0{,}5$: $c/t \le \frac{36\varepsilon}{\alpha}$
2	$c/t \le 83\varepsilon$	$c/t \le 38\varepsilon$	when $\alpha > 0{,}5$: $c/t \le \frac{456\varepsilon}{13\alpha - 1}$ when $\alpha \le 0{,}5$: $c/t \le \frac{41{,}5\varepsilon}{\alpha}$
Stress distribution in parts (compression positive)			
3	$c/t \le 124\varepsilon$	$c/t \le 42\varepsilon$	when $\psi > -1$: $c/t \le \frac{42\varepsilon}{0{,}67 + 0{,}33\psi}$ when $\psi \le -1^{*)}$: $c/t \le 62\varepsilon(1-\psi)\sqrt{(-\psi)}$

$\varepsilon = \sqrt{235/f_y}$	f_y	235	275	355	420	460
	ε	1,00	0,92	0,81	0,75	0,71

*) $\psi \le -1$ applies where either the compression stress $\sigma \le f_y$ or the tensile strain $\varepsilon_y > f_y/E$

(b)

Class	Part subject to compression	Part subject to bending and compression	
		Tip in compression	Tip in tension
Stress distribution in parts (compression positive)			
1	$c/t \le 9\varepsilon$	$c/t \le \frac{9\varepsilon}{\alpha}$	$c/t \le \frac{9\varepsilon}{\alpha\sqrt{\alpha}}$
2	$c/t \le 10\varepsilon$	$c/t \le \frac{10\varepsilon}{\alpha}$	$c/t \le \frac{10\varepsilon}{\alpha\sqrt{\alpha}}$
Stress distribution in parts (compression positive)			
3	$c/t \le 14\varepsilon$	$c/t \le 21\varepsilon\sqrt{k_\sigma}$ For k_σ see EN 1993-1-5	

$\varepsilon = \sqrt{235/f_y}$	f_y	235	275	355	420	460
	ε	1,00	0,92	0,81	0,75	0,71

Table 2. Maximum width-to-thickness ratios: elements in axial compression (Extract from SANS 10162-1:2005 /CAN/CSA-S16-01:2005).

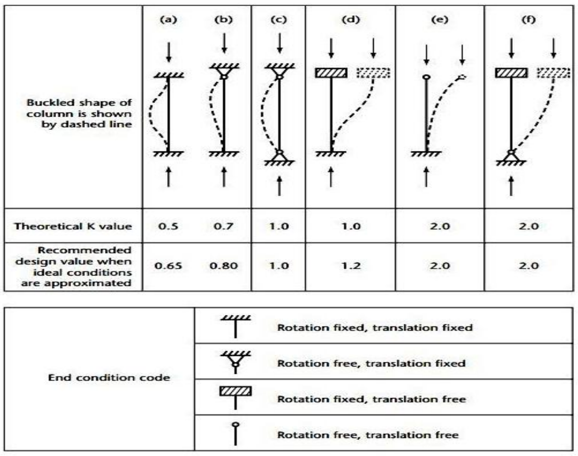
Description of element	Maximum width-to-thickness ratio W
Flange of I - sections, T- sections, and channels	$\frac{b}{t} \le \frac{200}{\sqrt{f_y}}$
Webs supported on both edges	$\frac{b}{t} \le \frac{670}{\sqrt{f_y}}$

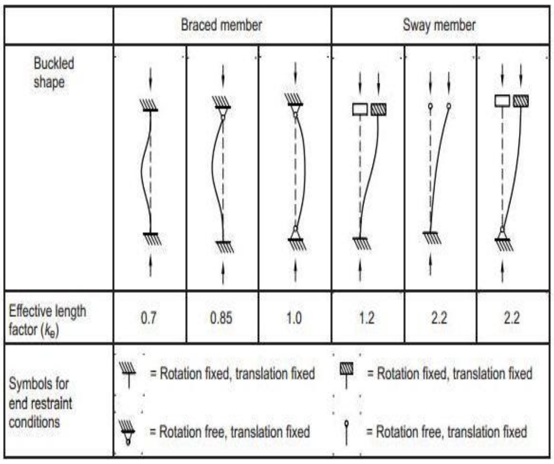
It should also be emphasized that minor differences in the width-thickness ratio definitions are also present. For example, in SANS 10162: 1-2005/ CAN/CSA-S16-01:2005 and AS 4100:1998/NZS 3404:1997 half the flange width is used in determining the flange slenderness. In Eurocode 3, however, only the outstanding portion of the flange that is measured from the toe of the fillet is used in calculations.

For a compression member AS 4100:1998/NZS 3404:1997 doesn't classify the section as compact,non-compact and slender, but to calculate the effective dimensions AS 4100:1998/NZS 3404:1997 gives the plate element slenderness formula which the values are compared with plate element yield slenderness limits given in table of AS 4100:1998/NZS 3404:1997.

III. Effective Lengths (Buckling Lengths) and The Column Buckling Curves

Eurocode 3 gives no direct guidance on calculating the buckling length. In SANS 10162: 1-2005/ CAN/CSA-S16-01:2005 in variation between 0.65 and 2.0 would apply to the majority of cases likely to be encountered in actual structures whereas in AS 4100:1998/NZS 3404:1997 in variation between 0.7 and 2.2 would apply as well. Figure 1(a) and Figure 1(b) illustrates six idealized cases to SANS 10162: 1-2005/ CAN/CSA-S16-01:2005 and AS 4100:1998/NZS3404:1997respectively.





(a) (b)

Figure 1: Effective length factors to: (a) SANS 10162: 1-2005/ CAN/CSA-S16-01:2005 (CSA, 2001); (b) AS 4100:1998/NZS 3404:1997 (AS, 1998).

To take into account the various imperfections (lack of verticality, lack of straightness, lack of flatness, lack of fit, eccentricity of loading, residual stresses etc.) which the Euler formula does not allow for, SANS 10162: 1-2005/CAN/CSA-S16-01:2005, Eurocode 3 and AS 4100:1998/NZS 3404:1997 uses the Perry-Robertson approach (Ayrton and Perry 1886; Robertson 1925).

Figure 3 shows the column buckling curves; it presents the strength reduction factor, χ as a function of the non-dimensional slenderness, $\bar{\lambda}$ to Eurocode 3. The figure 3 indicates that increasing the non-dimensional slenderness reduces the strength reduction factor of the columns. Figure 4 shows the buckling curves and defines the parameter (n) used to take into account the column imperfections to SANS 10162: 1-2005/ CAN/CSA-S16-01:2005. Figure 5 shows the buckling curves and the variation of slenderness reduction factor, α_c with modified slenderness ratio, λ_n as given in the Australian/New Zealand standard. It indicates that increasing the modified slenderness ratio reduces the slenderness reduction factor of the columns.

Two column strength curves are given in SANS 10162: 1-2005/ CAN/CSA-S16-01:2005 whereas five separate curves are presented in Eurocode 3 and in AS 4100:1998/NZS 3404:1997 (see in Fig. 3, Fig. 4 and Fig. 5 column buckling curves to Eurocode 3, SANS 10162: 1-2005/ CAN/CSA-S16-01:2005 and AS 4100:1998/NZS 3404:1997 respectively).

Eurocode 3 utilizes an imperfection coefficient (α) to distinguish between different column strength curves. For flexural buckling, five cases termed as a_o, a, b, c, d (see Fig. 3) are given for which the α values are 0.13, 0.21, 0.34, 0.49, and 0.76, respectively. The choice as to which buckling curve to adopt is dependent upon the geometry and material properties of the cross section and upon the axis of buckling. The rules for selecting the appropriate column strength curve are tabulated in Table 6.2 of Eurocode 3. Hereby the appropriate column strength curve is presented in Table 3 of this paper.

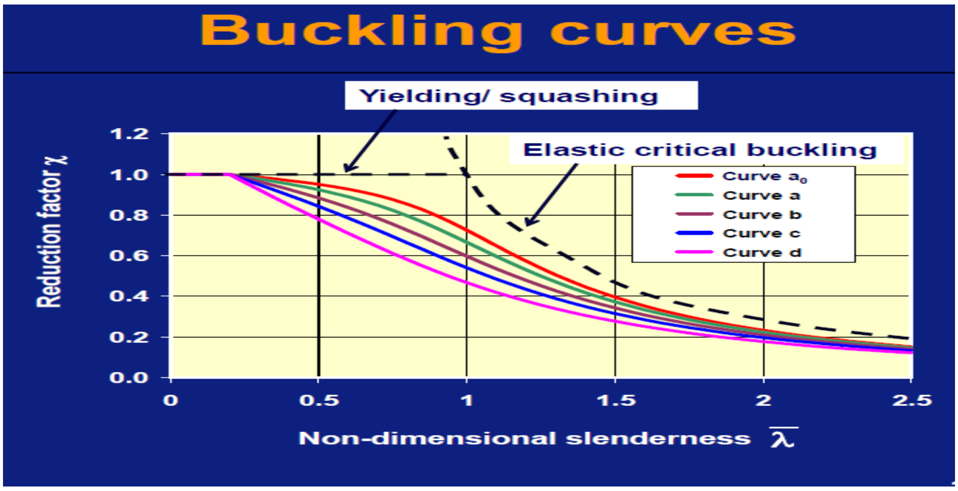
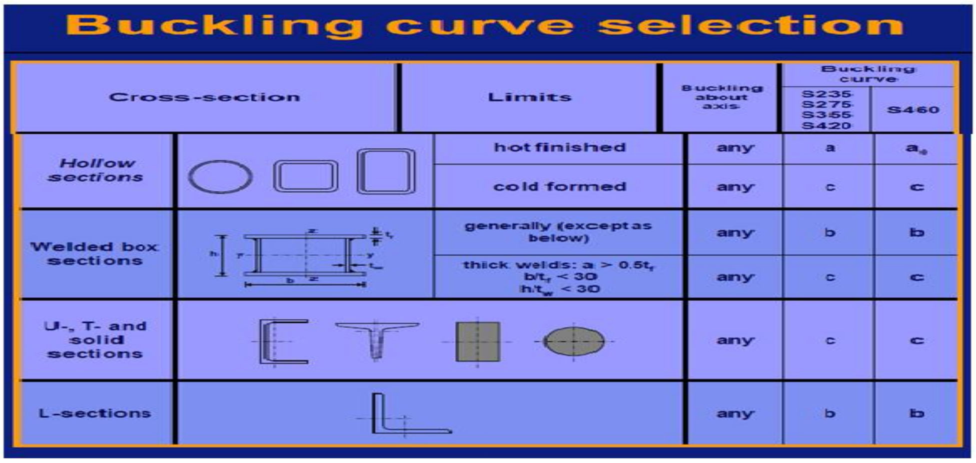


Figure 3: Eurocode 3 Part 1.1 buckling curves -Structural Steel Design: Eurocodes and Deformation Based Approach (CSM). Presentation at School of Civil and Environmental Engineering, University of The Witwatersrand (Gardner, 2011).

Table 3. Selection of buckling curve for a cross-section (Extract from Table 6.2 of EN 1993-1-1).



Buckling curve selection

Cross-section		Limits	Buckling about axis	Buckling curve S235 S275 S355 S420	Buckling curve S460
Hollow sections		hot finished	any	a	a_0
		cold formed	any	c	c
Welded box sections		generally (except as below)	any	b	b
		thick welds: $a > 0.5t_f$ $b/t_f < 30$ $h/t_w < 30$	any	c	c
U-, T- and solid sections			any	c	c
L-sections			any	b	b

SANS 10162: 1-2005/ CAN/CSA-S16-01:2005 utilizes a parameter (n) (see Fig. 4) to take into account the column imperfections. For flexural buckling, n= 1.34 (for hot-rolled, fabricated structural sections, and hollow structural sections manufactured according to SANS 657-1/CSA Standard G40.20,class C); or 2.24 (for doubly symmetric welded three-plate members with flange edges oxy-flame-cut and hollow structural sections manufactured according to ISO 657-14/CSA Standard G40.20,class H).

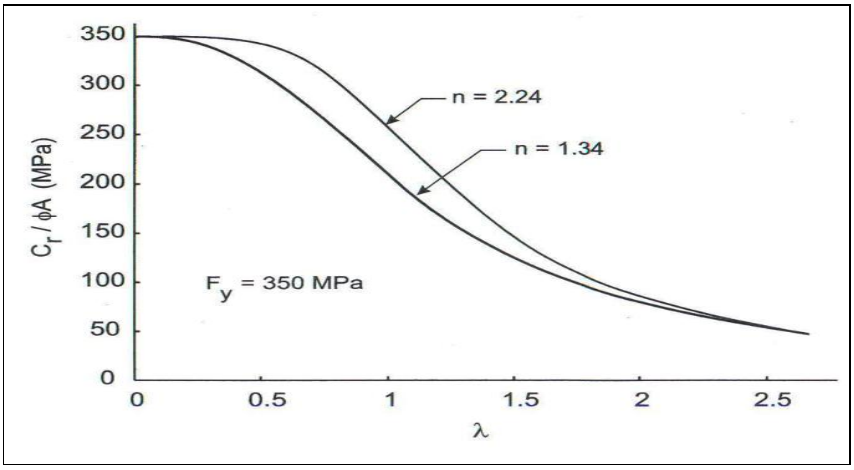


Figure 4: SANS 10162-1:2005/CAN/CSA-S16-01:2005 buckling curves (CSA, 2005).

AS 4100:1998/NZS 3404:1997 uses a member section type constant (α_b) (see Fig. 5) ($\alpha_b = -1, -0.5, 0, 0.5, 1$) to allow for imperfections. The value of this constant varies according to the member type (hot- rolled, cold-formed, welded, etc).

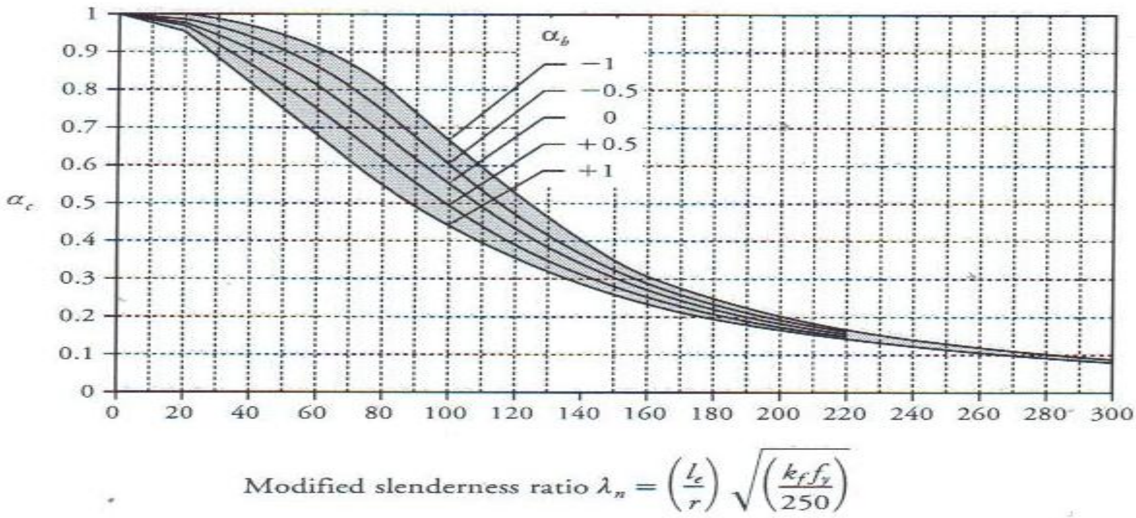


Figure 5: AS 4100:1998/ NZS 3404:1997 buckling curves- Steel Designers' Handbook, Seventh Edition (Branko et al., 2005).

IV. Worked Example

4.1. General

To compare the design buckling resistance between codes it is best to consider same section with same properties;same steel grades;same effective lengths; same modulus of elasticities and same shear modulus.

4.2. Example

Determine the design buckling resistance of a PFC 180x70 SA parallel flange channel section,Grade 300W steel. Assume the effective length is 2000mm. Take modulus of Elasticity E= 200x10^3 N/mm^2 and shear modulus G= 77 000 N/mm^2.

4.3. Solution by SANS 10162: 1-2005/ CAN/CSA-S16-01:2005 Method

Section properties of PFC 180x70 SA Parallel Flange Channel:
$A = 2.68 \times 10^3 mm^2$ h_w=136 mm h=180 mm
b =70 mm t_f=10.9 mm t_w =7.0 mm
a_c =43.5mm a_y =21.5 mm r_x =71.0mm
r_y = 21.8 mm I_x =13.5 x10^6 mm^4
I_y =1.27x $10^6 mm^4$ C_w =6.52x10^9 mm^6 J= 82.3x10^3 mm^4
Calculation of the elastic critical buckling stress in axial compression (f_e) :

The elastic critical buckling stress in axial compression for x-x and y-y axis flexural buckling are determined, by the following expressions:

$$f_{ex} = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)_x^2} = 2482 \text{ Mpa} \quad (1)$$

and

$$f_{ey} = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)_y^2} = 235 \text{ Mpa respectively.} \quad (2)$$

where *E* is the Young's modulus, *K* the effective length factor, *L* the actual length of the column and *r* the radius of gyration about x-x or y-y axis.

$$f_{ez} = \left[\frac{\pi^2 E\ C_w}{(KL)_z^2} + GJ\right] x \frac{1}{A r_o^2} = 481 \text{ Mpa} \quad (3)$$

is the elastic critical buckling stress in axial compression for torsional buckling in which E is the Young's modulus, C_w the warping torsional constant, KL the effective length, G the shear modulus, J St. venant torsional constant, A the area of cross-section and $\bar{r}_o^2$ the polar radius of gyration.

$$\Omega = 1 - \left[\frac{x_o^2 + y_o^2}{\bar{r}_o^2}\right] = 1 - \frac{x_o^2}{\bar{r}_o^2} = 0.745 \tag{4}$$

is the factor which takes into account the position of the shear centre relative to the centroid of the cross-section as well as the radius of gyration.

$$f_{exz} = \frac{f_{ex} + f_{ez}}{2\Omega}\left[1 - \sqrt{1 - \frac{4 f_{ex} f_{ez} \Omega}{(f_{ex} + f_{ez})^2}}\right] = 455 \text{ Mpa} \tag{5}$$

is the flexural-torsional buckling stress.

$$f_e = \min\{f_{ey}, f_{exz}\} = 235 \text{ Mpa} \tag{6}$$

is the elastic critical buckling stress in axial compression.

Therefore the factored compressive resistance of member (C_r) is:

$$C_r = \Phi A\, f_y\, (1 + \lambda^{2n})^{-1/n} \tag{7}$$

where $\lambda = \sqrt{\frac{f_y}{f_e}} = 1.130$; $\Phi = 0.9$; $A = 2.68\text{x}10^3 \text{mm}^2$; $f_y = 300$ Mpa and $n = 1.34$.

$C_r = 0.9\text{x}2.68\text{x}10^3\text{x}300\text{x}10^{-3}\ (1 + 1.130^{2.68})^{-1/1.34}$

$\therefore C_r = 378$ kN

4.4. Solution by Eurocode 3 Method

Section properties of PFC 180x70 SA Parallel Flange Channel:

$A = 2.68\text{x}10^3 \text{mm}^2$	$d = 136$ mm	$h = 180$ mm
$b = 70$ mm	$t_f = 10.9$ mm	$t_w = 7.0$ mm
$r = 12$mm	$I_y = 13.5 \text{ x}10^6 \text{ mm}^4$	$I_z = 1.27 \text{ x } 10^6 \text{ mm}^4$

Calculation of reduction factor (χ):

The elastic critical buckling loads for y-y and z-z axis are given by:

$$N_{cr,y} = \frac{\Pi^2 E I_y}{L_{cr}^2} = 6667347 \text{ N} \tag{8}$$

and

$$N_{cr,z} = \frac{\Pi^2 E I_z}{L_{cr}^2} = 627224.5 \quad \text{N} \tag{9}$$

respectively.

$$\bar{\lambda}_y = \sqrt{\frac{A f_y}{N_{cr,y}}} = 0.347 \tag{10}$$

and

$$\bar{\lambda}_z = \sqrt{\frac{A f_y}{N_{cr,z}}} = 1.132 \tag{11}$$

are the non-dimensional slenderness for major and minor axis respectively.

$$\Phi_y = 0.5[1 + \alpha_y(\bar{\lambda}_y - 0.2) + \bar{\lambda}_y^2] = 0.596 \tag{12}$$

and

$$\Phi_z = 0.5[1 + \alpha_z(\bar{\lambda}_z - 0.2) + \bar{\lambda}_z^2] = 1.369 \tag{13}$$

are values to determine the reduction factor for major and minor axis respectively, where $\alpha_y = 0.49$ and $\alpha_z = 0.49$ are the imperfection factors for major and minor axis respectively.

$$\chi_y = \frac{1}{\Phi_y + \sqrt{\Phi_y^2 - \bar{\lambda}_y^2}} = 0.924 \tag{14}$$

and

$$\chi_z = \frac{1}{\Phi_z + \sqrt{\Phi_z^2 - \bar{\lambda}_z^2}} = 0.467 \qquad (15)$$

are the reduction factors for major and minor axis respectively.

$$\chi = \min(\chi_y\ ,\chi_z) = 0.467 \qquad (16)$$

is the reduction factor.

Therefore the design buckling resistance $(N_{b,Rd})$ is:

$$N_{b,Rd} = \chi A f_y / \gamma_{M1} \qquad (17)$$

for class 1, 2 or 3 cross-sections.

$N_{b,Rd}$ = 0.468 x2.68x10^3x300/ 1.00 = 373943.3 N

$\therefore\ N_{b,Rd}$ = 374 KN

4.5. Solution by AS 4100:1998/NZS 3404:1997 Method

Section properties of PFC 180x70 SA Parallel Flange Channel:

$A = 2.68x10^3 mm^2$ h_w =136 mm d=180 mm

b_f =70 mm t_f =10.9 mm t_w =7.0 mm

r_x =71.0mm r_y = 21.8 mm I_x =13.5 x10^6 mm^4 I_y =1.27x 10^6mm^4 J= 82.3x10^3 mm^4

Column section is a hot-rolled PFC (flange thickness of 10.9 mm) with form factor k_f =1 so from Table of AS 4100:1998/NZS3404:1997, α_b=0.5.

From Table of AS 4100:1998/NZS3404:1997, α_{cx} = 0.912 (Interpolating between values of λ_{nx} = 30 and 35), and α_{cy} = 0.482(interpolating between values of λ_{ny} = 100 and 105).

$$\alpha_c = \min\ (\alpha_{cx}\ ,\alpha_{cy}\ ) = \min\ (0.912;\ 0.482) \qquad (18)$$

$\therefore\ \alpha_c$ = 0.482 where α_c is the member slenderness reduction factor.

Therefore the member capacity (ΦN_c) is:

$$\Phi N_c = \Phi k_f\ A_n\ f_y \alpha_c = 0.9 \text{ x1x } 2.68\text{x}10^{3`}\text{x300 x } 0.482 = 351 \text{ KN} \qquad (19)$$

$\therefore\ \Phi N_c$ = 351 KN

V. Results And Discussion

The section slenderness, slenderness limits and section classification for a PFC SA of each standard/code are listed in Table 4. It indicates that the flange slenderness of the sections in the three standards are very similar. The AS 4100:1998/NZS3404:1997 web slenderness of the sections, flange and web slenderness limits are higher than Eurocode 3 and SANS 10162: 1-2005/ CAN/CSA-S16-01:2005. The web slenderness of Eurocode 3 and SANS 10162: 1-2005/ CAN/CSA-S16-01:2005 are the same.

Table 4: Summary of a PFC SA section slenderness, slenderness limits and section classification.

Standard/Code	Flange Slenderness	Web Slenderness	Flange Slenderness Limit	Web Slenderness Limit	Section Classification
AS 4100:1998/NZS3404:1997	6.33	24.75	16	45	N/A*
Eurocode 3	4.67	19.42	7.92	29.04	Class 1
SANS 10162: 1-2005/ CAN/CSA-S16-01:2005	6.4	19.4	11.5	38.7	Not Class 4

* Not Applicable

Table 5 shows the comparison results between codes for a PFC 180x70 SA for slenderness ratio ranging from 45.87 to 504.58. The positive and negative percentage difference shown in table indicate that applicable standards/code overestimate and underestimate capacity respectively.

Table 5: Summary of differences in capacity between codes for varying slenderness ratios for a PFC SA section. Positive values indicate that applicable standards overestimate member capacity (un-conservative).

	AS 4100:1998 /NZS 3404:1997		**Eurocode 3**		**SANS 10162:1-2005/CAN/CSA-S16-01:2005**	
Slenderness ratio	**ΦN_c (N)**	**% Diff. With EC3**	**$N_{b,Rd}$ (N)**	**% Diff. With SANS/CAN***	**C_r (N)**	**% Diff.With AS 4100:1998/NZS 3404:1997**
45.87	723600	10.66	646408.9	3.30	625030	-13.62
91.74	350946	-6.15	373943.3	-1	377739.7	7.09
137.61	195372	-5.25	206213.7	-3.60	213933.5	8.67
183.48	120117.6	-4.78	126156.1	-3.50	130723.4	8.11
229.35	78872.4	-6.60	84441.47	-2.51	86617.89	8.94
275.22	57888	-4.03	60321.5	-1.40	61180.76	5.38
321.1	43416	- 3.94	45197	- 0.37	45368.04	4.30
366.97	33285.6	-5.19	35110.24	0.52	34926.82	4.70
412.84	26049.6	-7.14	28054.36	1.28	27692.9	5.93
458.71	21708	-5.32	22928.21	1.94	22483.36	3.44
504.58	17366.4	-9.01	19087.97	2.50	18611.18	6.68

* SANS 10162:1-2005/CAN/CSA-S16-01:2005

It shows that the differences in capacity between codes vary with the slenderness ratio of the column.

For a PFC SA parallel flange channel section, Eurocode 3 gives higher capacity about a range of 3% - 10 % than AS 4100:1998/NZS3404:1997 (see Table 5) between the slenderness ratio values of 91.74 - 504.58. And at slenderness ratio value of 45.87, AS 4100:1998/NZS3404:1997 gives 10.66% (see Table 5) higher capacity compared to Eurocode 3. The difference between Eurocode 3 and SANS 10162-1:2005/CAN/CSA-S16-01:2005 is minimal and in the range of 0% - 4 % (see Table 5). From slenderness ratio value of 91.74 - 504.58, SANS 10162-1:2005/CAN/CSA-S16-01:2005 gives higher capacity compared to AS 4100:1998/NZS3404:1997 about a range of 4% - 9 % (see Table 5). And at slenderness ratio value of 45.87, AS 4100:1998/NZS3404:1997 gives 13.62 % (see Table 5) higher capacity compared to SANS 10162-1:2005/CAN/CSA-S16-01:2005.

The curves of Figure 6 illustrate the comparison of the column design buckling resistance for varying slenderness ratio of the PFC SA column section. We observe that the design buckling resistance of the column of each standard/ code decreases when its slenderness ratio increases also the differences in capacity between codes vary with the slenderness ratio of the column.

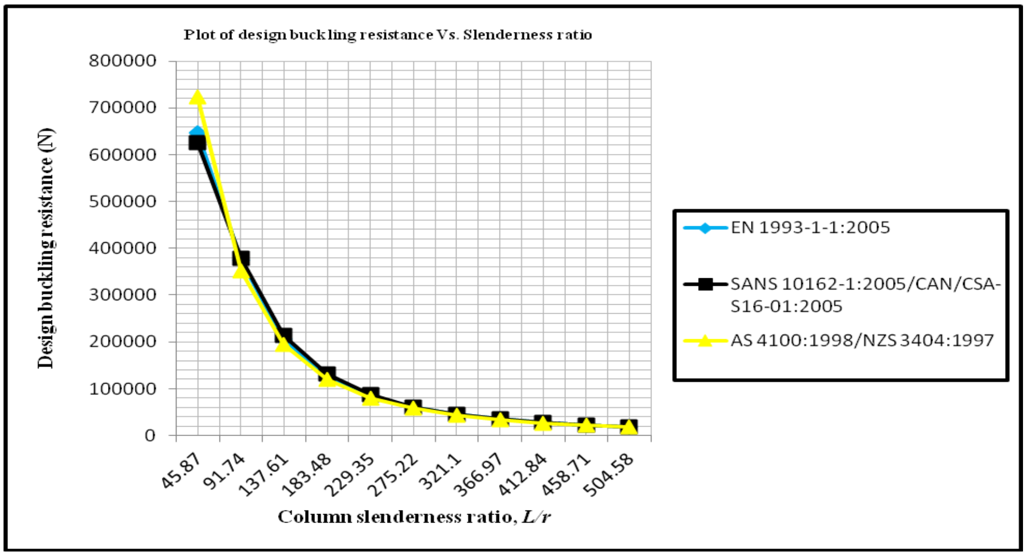


Figure 6: Comparison of a steel column design buckling resistance for varying slenderness ratios.

VI. Conclusions

The following conclusions were obtained based on the conducted studies in this paper:

1- Eurocode 3 allows for a greater number of design options and analysis technique than AS4100:1998/NZS3404:1997 and SANS 10162-1:2005/CAN/CSA-S16-01:2005.

2- SANS 10162: 1-2005/ CAN/CSA-S16-01:2005, Eurocode 3 and AS 4100:1998/NZS 3404:1997 uses the Perry-Robertson approach to evaluate the compression capacity of member. Two column strength curves are given in SANS 10162: 1-2005/ CAN/CSA-S16-01:2005 whereas five separate curves are presented in

Eurocode 3 and in AS 4100:1998/NZS 3404:1997 to define the reduction in capacity for compression members.

3- SANS 10162-1:2005/CAN/CSA-S16-01:2005 and AS4100:1998/NZS3404:1997 uses $\Phi = 0.9$ as resistance factor while Eurocode 3 uses $1/\gamma_{M1}=1.0$ as resistance factor in flexural buckling equations.

4- Table 4 indicate that the flange slenderness of the sections in the three standards are very similar. The AS 4100:1998/NZS3404:1997 web slenderness of the sections, flange and web slenderness limits are higher than Eurocode 3 and SANS 10162: 1-2005/ CAN/CSA-S16-01:2005. The web slenderness of Eurocode 3 and SANS 10162: 1-2005/ CAN/CSA-S16-01:2005 are the same.

5- Eurocode 3 offers much more detailed provisions, through multiple curves compared to AS 4100:1998/NZS 3403: 1997 and SANS 10162-1:2005/CAN/CSA-S16-01:2005.

6- AS 4100:1998/NZS 3403:1997 is significantly less complex compared to Eurocode 3 and SANS 10162-1:2005/CAN/CSA-S16-01:2005.

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Notations

A	Area of cross-section
A_e	Effective area of cross-section
A_g	Gross section area
A_n	Net area of cross-section
b	Width of a cross-section
b_f	Width of a cross-section
C_r	Factored compressive resistance of member

C_w	Warping torsional constant
d	Depth of straight portion of a web
E	Elastic modulus of steel
f_e	Elastic critical buckling stress in axial compression
f_{ex}	Elastic critical buckling stress in axial compression for x-x axis flexural buckling
f_{exz}	Flexural-torsional buckling stress
f_{ey}	Elastic critical buckling stress in axial compression for y-y axis flexural buckling
f_{ez}	Elastic critical buckling stress in axial compression for torsional buckling
f_y	Yield stress
G	Shear modulus of steel
h	Depth of a cross-section
h_w	Depth of straight portion of a web
I_x	Moment of inertia about x-x axis
I_y	Moment of inertia about y-y axis
I_z	Moment of inertia about z-z axis
J	St Venant torsional constant of a cross-section
k_f	Form factor
$K.L$	Effective length
$\frac{K.L}{r}$	Effective slenderness ratio
L_{cr}	Buckling length
n	Parameter
$N_{b,Rd}$	Design buckling resistance
N_c	Nominal compressive capacity of member
$N_{cr,y}$	Elastic critical buckling force for y-y axis
$N_{cr,z}$	Elastic critical buckling force for z-z axis
$\bar{r}_o^2$	Polar radius of gyration
r_x	Radius of gyration about x
r_y	Radius of gyration about y
t_f	Flange thickness
t_w	Web thickness
x_o	Principal x-coordinate of shear centre with respect to centroid of cross-section
y_o	Principal y-coordinate of shear centre with respect to centroid of cross-section
$\overline{\lambda_y}$	Non-dimensional slenderness for major axis
$\overline{\lambda_z}$	Non-dimensional slenderness for minor axis
α_b	Member section constant
α_c	Member slenderness reduction factor
α_{cx}	Member slenderness reduction factor for x-axis
α_{cy}	Member slenderness reduction factor for y-axis
α_y	EC3 imperfection factor for major axis
α_z	EC3 imperfection factor for minor axis
Φ_y	Value to determine the reduction for major axis
Φ_z	Value to determine the reduction for minor axis
χ_y	Reduction factor for major axis
χ_z	Reduction factor for minor axis
χ	Reduction factor
Φ	Capacity reduction factor
γ_{M1}	Partial factor for member instability
λ_{nx}	Modified slenderness ratio for x-axis
λ_{ny}	Modified slenderness ratio for y-axis
Ω	A factor which takes into account the position of the shear centre relative to the centroid of the cross-section as well as the radius of gyration