

## Welded I Sections Seismic Category Classification

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### Key Words

Seismic, Category, Earthquake, welded sections

### Introduction

All steel members which form part of a seismic resisting frame are classified into one of 4 categories for the purpose of seismic design. Category 1 members are capable of sustaining high displacement ductility demands. Category 2 members are capable of sustaining low ductility demands. Category 3 members are capable of developing their nominal section capacity where required to in bending. Category 4 members need not be designed to sustain any displacement ductility demand. Limits are placed on member section geometry for the various categories and this is found in section 12.5 of the *Steel Structures Standard* (SNZ, 2007).

Previous tables have been developed classifying I section members into the appropriate categories (Feeney, 1993). These tables were developed based on the 1992 version of the *Steel Structures Standard*. Hot rolled steel sections classified were grades 250 and 350. Welded sections classified were limited to WB and WC sections.

This article updates the *Member ductility category of I sections for seismic design* tables for Grade 300 welded sections in accordance with the latest *Steel Structures Standard* (SNZ, 2007).

### Member Ductility Category of Sections for Seismic Design

The following tables show the minimum member ductility category for Grade 300 welded sections complying with AS/NZS 3679.2 (SAA/SNZ, 1996).

The minimum member ductility category for any section is determined in accordance with the requirements given in section 12.4 (material requirements) and section 12.5 (section geometry requirements) of NZS 3404:1997. The minimum member ductility category can then be used to satisfy the relationships given in Table 12.2.6.

For the I sections given, the member ductility category is a function of both the web plate and flange plate slenderness limits. These slenderness values, 'modified' by the ratio  $\sqrt{f_y}/250$  are given in the tables. The corresponding minimum member category in accordance with Table 12.5 is tabulated for the:

- (i) Flange plate
- (ii) Web plate for a section in bending, without axial compression
- (iii) Web plate for a section in axial compression

The member ductility category is then given for the section used as a:

- Beam (typically in a moment-resisting frame)
- Column or brace, without any limit on axial compression force (this gives an absolute limit for a member ductility)
- Active link in an eccentrically braced frame

Note that for some sections, the web plate slenderness exceeds the upper limits for webs in compression ( $\lambda_{e4}=60$ ) given in Table 12.5 for Category 4 members. These sections may still be used for columns in seismic-resisting systems provided that the axial compression force on the column is small. Clause 8.1.4 of NZS 3404 specifies this limit as  $N^*/\phi N_s \leq 0.05$ .

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**Table 1: NZS3404:1997/2007 Seismic Member Ductility - Grade 300 Welded Beams to AS/NZS 3679.2:1996**

Welded Beams - Grade 300						Member Ductility Category		
Modified Web Plate Slenderness	Modified Flange Plate Slenderness	Designation	Flange Plate Category	Web Element Category (Bending)	Web Element Category (Compn)	Beam (MRF)	Column or Brace (Axial Force Unlimited) <sup>1</sup>	Active Link (EBF)
$d_1/t_w * \sqrt{f_y/250}$	$(b_f - t_w)/2t_f * \sqrt{f_y/250}$							
76.7	6.4	1200 WB 455.0	1	1	*	1	n. p.	1
76.7	7.1	1200 WB 423.0	1	1	*	1	n. p.	1
76.7	8.0	1200 WB 392.0	1	1	*	1	n. p.	1
76.7	6.3	1200 WB 342.0	1	1	*	1	n. p.	1
76.7	7.3	1200 WB 317.0	1	1	*	1	n. p.	1
76.7	7.1	1200 WB 278.0	1	1	*	1	n. p.	1
76.7	5.5	1200 WB 249.0	1	1	*	1	n. p.	1
65.7	6.3	1000 WB 322.0	1	1	*	1	n. p.	1
65.7	7.3	1000 WB 296.0	1	1	*	1	n. p.	1
65.7	7.1	1000 WB 258.0	1	1	*	1	n. p.	1
65.7	7.8	1000 WB 215.0	1	1	*	1	n. p.	1
79.8	6.4	900 WB 282.0	1	1	*	1	n. p.	1
79.8	7.3	900 WB 257.0	1	1	*	1	n. p.	1
79.8	7.2	900 WB 218.0	1	1	*	1	n. p.	1
79.8	7.9	900 WB 175.0	1	1	*	1	n. p.	1
84.6	5.5	800 WB 192.0	1	3	*	3	n. p.	3
84.6	5.6	800 WB 168.0	1	3	*	3	n. p.	3
84.6	7.3	800 WB 146.0	1	3	*	3	n. p.	3
84.6	8.2	800 WB 122.0	3	3	*	3	n. p.	3
73.5	5.0	700 WB 173.0	1	1	*	1	n. p.	1
73.5	5.1	700 WB 150.0	1	1	*	1	n. p.	1
73.5	6.6	700 WB 130.0	1	1	*	1	n. p.	1
73.5	8.2	700 WB 115.0	3	1	*	3	n. p.	3

Notes

1. This classification is based on uniform compression. For beam-column elements the limiting web slenderness values are a function of the applied axial load. Refer to table 3.
2. Sections with "n. p." are not permitted by NZS 3404 to be used as members in seismic-resisting systems.
3. Sections denoted \* exceed the slenderness limits for webs in compression in Category 4 members

**Table 2: NZS3404:1997/2007 Seismic Member Ductility - Grade 300 Welded Columns to AS/NZS 3679.2:1996**

Welded Columns - Grade 300						Member Ductility Category		
Modified Web Plate Slenderness	Modified Flange Plate Slenderness	Designation	Flange Plate Category	Web Element Category (Bending)	Web Element Category (Compn)	Beam (MRF)	Column or Brace (Axial Force Unlimited) <sup>1</sup>	Active Link (EBF)
$d_1/t_w * \sqrt{f_y/250}$	$(b_f - t_w)/2t_f * \sqrt{f_y/250}$							
10.6	6.1	500 WC 440.0	1	1	1	1	1	1
13.2	6.2	500 WC 414.0	1	1	1	1	1	1
13.2	6.9	500 WC 383.0	1	1	1	1	1	1
19.0	7.9	500 WC 340.0	1	1	1	1	1	1
24.6	9.1	500 WC 290.0	4	1	1	4	4	4
24.6	10.2	500 WC 267.0	4	1	1	4	4	4
24.6	13.1	500 WC 228.0	4	1	1	4	4	4
9.3	4.8	400 WC 361.0	1	1	1	1	1	1
13.2	4.9	400 WC 328.0	1	1	1	1	1	1
13.2	5.5	400 WC 303.0	1	1	1	1	1	1
14.8	6.2	400 WC 270.0	1	1	1	1	1	1
19.2	8.0	400 WC 212.0	3	1	1	3	3	3
19.2	10.4	400 WC 181.0	4	1	1	4	4	4
24.0	13.1	400 WC 144.0	4	1	1	4	4	4
10.4	4.3	350 WC 280.0	1	1	1	1	1	1
10.4	4.7	350 WC 258.0	1	1	1	1	1	1
11.6	5.4	350 WC 230.0	1	1	1	1	1	1
15.1	6.2	350 WC 197.0	1	1	1	1	1	1

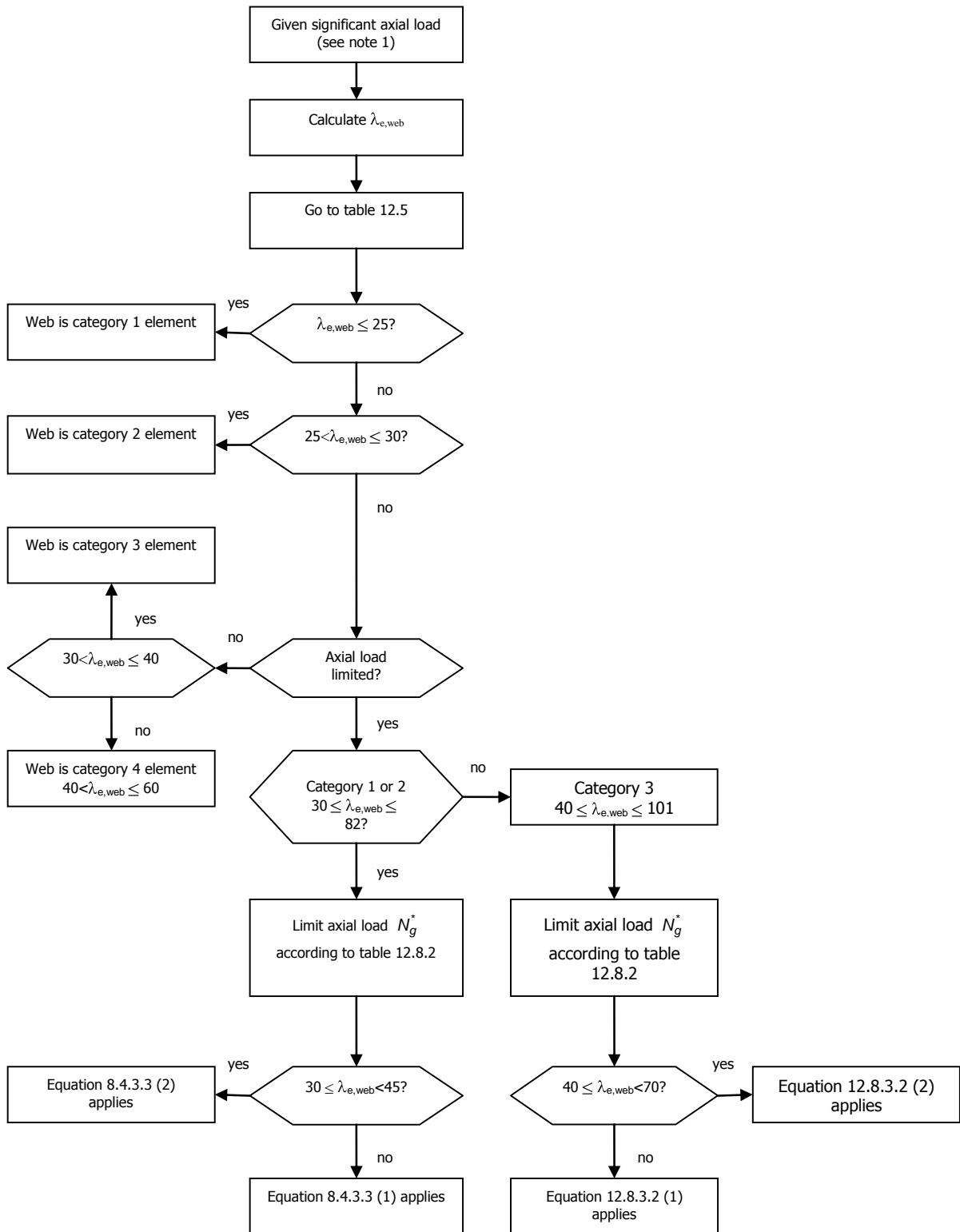
**Notes**

1. This classification is based on uniform compression. For beam-column elements the limiting web slenderness values are a function of the applied axial load. Refer to table 4.

**Section Category Classification for Beam Columns**

The *Steel Structures Standard* (SNZ, 2007) presents limiting web slenderness ratios as a function of the constant applied axial load  $N_g^*$  for category 1, 2 and 3 members. The background to these requirements is discussed in the commentary section of clause 12.8.3.1(c) (SNZ, 2007). The principle reason for a constant load limitation is to control inelastic shortening of the yielding region of beam columns subject to inelastic bending. This inelastic shortening increases the extent of local combined web and flange buckling which has an undesirable effect on the overall member performance as it tends to accelerate the loss of member capacity.

The following tables classifies I sections for beam columns in accordance with Table 12.5 NZS 3404 and clause 12.8.3.1(c) for additional axial compression force limitations. Figure 1 shows a flowchart to classify webs of beam columns to NZS3404 (SNZ, 2007).



**Figure 1: Web seismic category flow diagram for beam columns**

Note 1 Refer to clause 8.1.4 for the definition of a significant axial load

**Table 3: Seismic Section Classification for Beam Columns – Grade 300 Welded Beams**

Designation	Web (Constant Axial Load Limit)		Flange Category
	Category 1, 2	Category 3	
	$N_g^*/\phi N_s \leq$	$N_g^*/\phi N_s \leq$	
1200 WB 455.0	0.040	0.245	1
1200 WB 423.0	0.040	0.245	1
1200 WB 392.0	0.040	0.245	1
1200 WB 342.0	0.040	0.245	1
1200 WB 317.0	0.040	0.245	1
1200 WB 278.0	0.040	0.245	1
1200 WB 249.0	0.040	0.245	1
1000 WB 322.0	0.120	0.413	1
1000 WB 296.0	0.120	0.413	1
1000 WB 258.0	0.120	0.413	1
1000 WB 215.0	0.120	0.413	1
900 WB 282.0	0.017	0.214	1
900 WB 257.0	0.017	0.214	1
900 WB 218.0	0.017	0.214	1
900 WB 175.0	0.017	0.214	1
800 WB 192.0	-	0.165	1
800 WB 168.0	-	0.165	1
800 WB 146.0	-	0.165	1
800 WB 122.0	-	0.165	3
700 WB 173.0	0.064	0.237	1
700 WB 150.0	0.064	0.237	1
700 WB 130.0	0.064	0.278	1
700 WB 115.0	0.064	0.278	3

- indicates not suitable for category 1 or 2 elements.

**Table 4: Seismic Section Classification for Beam Columns – Grade 300 Welded Columns**

Designation	Web (Constant Axial Load Limit)		Flange Category
	Category 1, 2	Category 3	
	$N_g^*/\phi N_s \leq$	$N_g^*/\phi N_s \leq$	
500 WC 440.0	1.000	-	1
500 WC 414.0	1.000	-	1
500 WC 383.0	1.000	-	1
500 WC 340.0	1.000	-	1
500 WC 290.0	1.000	-	4
500 WC 267.0	1.000	-	4
500 WC 228.0	1.000	-	4
400 WC 361.0	1.000	-	1
400 WC 328.0	1.000	-	1
400 WC 303.0	1.000	-	1
400 WC 270.0	1.000	-	1
400 WC 212.0	1.000	-	3
400 WC 181.0	1.000	-	4
400 WC 144.0	1.000	-	4
350 WC 280.0	1.000	-	1
350 WC 258.0	1.000	-	1
350 WC 230.0	1.000	-	1
350 WC 197.0	1.000	-	1

- indicates no axial load limit applies, web slenderness values comply with the requirements for category 1 or 2 elements. Refer to table 2

## References

Feeney, M., Seismic Design Tables for Structural Steel I Sections, HERA Report R4-75, New Zealand Heavy Engineering Research Association, Manukau City, 1993

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