Moment Resistance Calculation of a Class 4 Beam

CISC Handbook of Steel Construction, 9th Edition
Beam Selection Table, page 5-98

Beam section: W150x22

Calculate M_r' for L = 4000 mm according to CSA S16-01 Clause 13.6(b).

Material properties:
- $E = 200\ 000$ MPa
- $G = 77\ 000$ MPa
- $F_y = 345$ MPa (ASTM A992)

Section data:

$d = 152$ mm	$I_x = 12.1 \times 10^6$ mm^4
$b = 152$ mm	$S_x = 150 \times 10^3$ mm^3
$t = 6.6$ mm	$I_y = 3.87 \times 10^6$ mm^4
$w = 5.8$ mm	$J = 43.4 \times 10^3$ mm^4
$h = d - 2t = 138.8$ mm	$C_w = 20.4 \times 10^9$ mm^6

1) Class of section, Clause 11

Web: $h / w = 23.93 < 1900 / F_y^{0.5} = 102.3$ (not Class 4)
Flange: $(b/2) / t = 11.52 > 200 / F_y^{0.5} = 10.77$ (Class 4)
The section is a Class 4 due to the flanges.

2) Effective section properties

Effective flange width, Clause 13.5(c)(iii):
$b_e = 2 \times 200\ t / F_y^{0.5} = 142$ mm

Conservatively and for simplicity, the same effective flange width is used for both the compression and tension flanges. This keeps the section doubly-symmetric. In reality, the full tension flange width would remain effective.

Effective moment of inertia:
$I_{xe} = I_x - 2\ (b - b_e)\ t^3 / 12 - 2\ (b - b_e)\ t\ (d / 2 - t / 2)^2 = 11.4 \times 10^6$ mm^4

Effective section modulus:
$S_{xe} = 2\ I_{xe} / d = 150 \times 10^3$ mm^3

3) Factored moment resistance

Laterally supported (L = 0):
Let $M_{ye} = S_{xe}\ F_y = 51.8$ kN·m
$\phi = 0.9$
$M_{r0} = \phi\ M_{ye} = 46.6$ kN·m

Laterally unsupported ($L = 4000$ mm $> L_u = 2480$ mm):
$\omega_2 = 1.0$ (uniform bending moment)
$M_u = (\omega_2\ \pi / L)\ [E\ I_y\ G\ J + (\pi\ E / L)^2\ I_y\ C_w]^{0.5} = 52.9$ kN·m

$M_u = 52.9$ kN·m $> 0.67\ M_{ye} = 34.7$ kN·m
$M_r' = 1.15\ M_{r0}\ (1 - 0.28\ M_{ye} / M_u) = 38.9$ kN·m $\leq M_{r0}$