----- 310 UB 40.4 DESIGN SUMMARY (AS 4100) -----

CATEGORY: Universal Beam
TYPE: OneSteel 300PLUS

LOAD CASE 01: 1.2G + 1.5Q [98.71%]

Mx*:	74.70 kNm (COMPRESSION: Top Flange)
SEGMENT RESTRAINT:	FF
LOAD POSITION:	WITHIN SEGMENT
LOAD HEIGHT:	TOP FLANGE
ROTATION RESTRAINT:	NEITHER END
SEGMENT LENGTH:	2750 mm
My*:	29 kNm
Vx*:	162 kN
R*:	134 kN (X-AXIS)
bs:	200 mm
bd:	350 mm
RESTRAINT:	BOTH FLANGES
N*:	217 kN (TENSION)
FORCE DISTRIBUTION:	UNIFORM

----- SECTION PROPERTIES -----

Class:	HR	Grade:	300	Mass:	40.9 kg/m	d:	304.0 mm
b:	165.0 mm	t,f:	10.2 mm	t,w:	6.1 mm	r1:	11.4 mm
r2:	0.0 mm	fy,f:	320 MPa	fy,w:	320 MPa	fu:	440 MPa
Ag:	5210 mm²	Ix:	8.6400E+7 mm⁴	Iy:	7.6500E+6 mm⁴	rx:	129 mm
ry:	38.3 mm	Zx:	5.6900E+5 mm³	Zy:	9.2700E+4 mm³	Sx:	6.3300E+5 mm³
Sy:	1.4200E+5 mm³	J:	1.5700E+5 mm⁴	Iw:	1.6500E+11 mm⁶	λsx:	COMPACT
λsy:	COMPACT	Zex:	6.3300E+5 mm³	Zey:	1.3900E+5 mm³	kf:	0.952
αb:	0						

----- BENDING [98.71%] -----

• No holes specified in the flanges, such that the full effective section modulus will be used (5.2.6).

```
ϕMsx     = ϕ × fy × Zex
         = 0.9 × 320 × 6.3300E+5
         = 182.30 kNm [40.98%]
```

• Any element assumed to provide full, partial, or lateral restraint must be designed to transfer 2.5% of the critical flange force (0.025 × 74.7 kNm / 0.2938 m) = 6.36 kN as per Section 5.4.3.1.

• Segment is subject to transverse loads, such that βm = -0.8 as per Section 5.3.2.4 (b).

```
Lmax     = ry × (80 + 50 βm) × √(250/fy)
         = 38.3 × (80 + 50 × -0.80) × √(250/320)
         = 1354.11 mm
```

• Lateral buckling check required for this segment as Segment Length > Lmax as per Section 5.3.2.4.

```
Leb      = kt × kl × kr × Segment Length
         = 1.0000 × 1.4 × 1.00 × 2750
         = 3850.00 mm

Mo       = √[(π² × E × Iy / Leb²) × (G × J + π² × E × Iw / Leb²)]
         = √[(π² × 200000 × 7.6500E+6 / 3850.00²) × (80000 × 1.5700E+5 + π² × 200000 × 1.6500E+11 / 3850.00²)]
         = 187.57 kNm
```

• Calculate Moment Modification Factor (αm) as per Table 5.6.1.

```
αm       = 1.35 + 0.4 × (2 × a / Segment Length)²
         = 1.35 + 0.4 × (2 × 850 / 2750)²
         = 1.5029 (0 ≤ 2a/Segment Length ≤ 1)

αs       = 0.6 × {√[(Msx/Mo)² + 3] - Msx/Mo} ≤ 1.0
         = 0.6 × {√[(202.56/187.57)² + 3] - 202.56/187.57}
         = 0.5767

ϕMbx     = αm × αs × ϕMsx ≤ ϕMsx
         = 1.5029 × 0.5767 × 182.30 ≤ 182.30 kNm
         = 158.01 kNm [47.27%]

ϕMsy     = ϕ × fy × Zey
         = 0.9 × 320 × 1.3900E+5
         = 40.03 kNm [72.44%]
```

• Calculate biaxial bending section capacity for doubly-symmetric members compact about both axes as per Section 8.3.4.

```
Biaxial  = (Mx*/ϕMsx) ^ 1.4 + (My*/ϕMsy) ^ 1.4 ≤ 1.0
         = (74.7/182.30) ^ 1.4 + (29/40.03) ^ 1.4
         = 0.9235 [92.35%]
```

• Calculate biaxial bending member capacity as per Section 8.4.5.

```
Biaxial  = (Mx*/ϕMbx) ^ 1.4 + (My*/ϕMsy) ^ 1.4 ≤ 1.0
         = (74.7/158.01) ^ 1.4 + (29/40.03) ^ 1.4
         = 0.9871 [98.71%]
```

----- SHEAR [50.56%] ---

```
d1       = d - 2 × t,f
         = 304.0 - 2 × 10.2
         = 283.60 mm
```

• Calculate web area (Aw) using full section depth (d) for hot-rolled (HR) sections as per AISC 2009 Section 5.2.2.4.

```
Aw       = d × t,w
         = 304.0 × 6.1
         = 1854 mm²

ϕVw      = ϕ × 0.6 × fy,w × Aw
         = 0.9 × 0.6 × 320 × 1854
         = 320.44 kN [50.56%]
```

• As d1/t,w × √(fy,w/250) (52.60) ≤ 82, buckling check not required, such that ϕVu = ϕVw (5.11.2).

```
ϕVu      = 320.44 kN [50.56%]
```

• Section has approximately uniform shear stress distribution, such that ϕVv = ϕVu as per Section 5.11.2.

```
ϕVv      = 320.44 kN [50.56%]
```

----- BEARING [42.61%] ---

```
d1       = d - 2 × t,f
         = 304.0 - 2 × 10.2
         = 283.60 mm
```

• Interior bearing can be assumed as bo = bbw as per Figure 5.13.1.1.

```
bo       = d1 / 2
         = 283.60 / 2
         = 141.80 mm

bbf      = bs + 5 × t,f
         = 200 + 5 × 10.2
         = 251.00 mm

bbw      = d1 / 2
         = 283.60 / 2
         = 141.80 mm

bb       = bo + bbf + bbw
         = 141.80 + 251.00 + 141.80
         = 534.60 mm

ϕRby     = ϕ × 1.25 × bbf × t,w × fy,w
         = 0.9 × 1.25 × 251.00 × 6.1 × 320
         = 551.20 kN [24.31%]
```

• Both flanges restrained against lateral movement of the web. Use αb = 0.5 and kf = 1.0 to calculate the bearing buckling capacity as per Section 5.13.4.

```
λn       = 2.5 × d1/t,w × √(kf) × √(fy,w/250)
         = 2.5 × 283.60/6.1 × √(1.0) × √(320/250)
         = 131.50

ϕRbb     = ϕ × αc × bb × t,w × fy,w
         = 0.9 × 0.3348 × 534.60 × 6.1 × 320
         = 314.47 kN [42.61%]

ϕRb      = MIN (ϕRby, ϕRbb)
         = MIN (551.20, 314.47)
         = 314.47 kN [42.61%]
```

----- TENSION [14.46%] ---

```
ϕNty     = ϕ × fy × Ag
         = 0.9 × 320 × 5210
         = 1500.48 kN [14.46%]
```

• No holes specified in the section, such that An = Ag (7.2).

• Uniform force distribution assumed, such that the Correction Factor (kt) is 1.0 as per Section 7.3.1.

```
ϕNtf     = ϕ × 0.85 × fu × An × kt
         = 0.9 × 0.85 × 440 × 5210 × 1.00
         = 1753.69 kN [12.37%]

ϕNt      = MIN (ϕNty, ϕNtf)
         = MIN (1500.48, 1753.69)
         = 1500.48 kN [14.46%]
```

----- BENDING & SHEAR [98.71%] --

• CHECKSTEEL calculates bending and shear interaction using both methods permitted by Section 5.12. The appropriateness of each method for the situation should be decided by the engineer. The proportioning method is suitable for members with slender webs, while the interaction method is suitable for members with stocky webs as per AS 4100 Commentary Section C5.12.1.

• Calculate with the proportioning method as per Section 5.12.2.

```
Ag,tf    = b × t,f
         = 165.0 × 10.2
         = 1683 mm²
```

• No holes specified in the tension flange, such that An,tf = Ag,tf.

```
Aft      = MIN [Ag,tf, (0.85 × An,tf × fu/fy)]
         = MIN [1683, (0.85 × 1683 × 440/320)]
         = 1683 mm²

λe       = (b - t,w)/(2 × t,f) × √(fy/250)
         = (165.0 - 6.1)/(2 × 10.2) × √(320/250)
         = 8.81

bef      = MIN [b, (b - t,w) × λey/λe + t,w]
         = MIN [165.0, (165.0 - 6.1) × 16/8.81 + 6.1]
         = 165.00 mm

Afc      = bef × t,f
         = 165.00 × 10.2
         = 1683 mm²

Afm      = MIN (Aft, Afc)
         = MIN (1683, 1683)
         = 1683 mm²

df       = d - t,f
         = 304.0 - 10.2
         = 293.80 mm

ϕMf      = ϕ × Afm × df × fy
         = 0.9 × 1683 × 293.80 × 320
         = 142.41 kNm
```

• As Mx* ≤ ϕMf, moment can be assumed to be resisted by flanges, such that ϕVvmx = ϕVvx.

```
ϕVvmx    = 320.44 kN [50.56%]
```

• As Mx* < 0.75 ϕMsx, bending and shear interaction about the x-axis check not required, such that ϕVvmx = ϕVvx as per Section 5.12.3.

```
ϕVvmx    = 320.44 kN [50.56%]
```

----- BENDING & AXIAL [98.71%] --

• Calculate bending section capacity about the x-axis (ϕMrx) for tension members compact about the x-axis as per Section 8.3.2 (a).

```
ϕMrx     = 1.18 × ϕMsx × (1 - T*/ϕNt) ≤ ϕMsx
         = 1.18 × 182.30 × (1 - 217/1500.48) ≤ 182.30 kNm
         = 182.30 kNm [40.98%]
```

• Calculate out-of-plane bending member capacity about the x-axis (ϕMox) as per Section 8.4.4.2.

```
ϕMox     = ϕMbx × (1 + T*/ϕNt) ≤ ϕMrx
         = 158.01 × (1 + 217/1500.48) ≤ 182.30 kNm
         = 180.86 kNm [41.30%]
```

• Calculate bending section capacity about the y-axis (ϕMry) for doubly-symmetric I-section tension members compact about the y-axis as per Section 8.3.3 (a).

```
ϕMry     = 1.19 × ϕMsy × [1 - (T*/ϕNt)²] ≤ ϕMsy
         = 1.19 × 40.03 × [1 - (217/1500.48)²] ≤ 40.03 kNm
         = 40.03 kNm [72.44%]
```

• Calculate biaxial bending section capacity for tension members compact about both axes as per Section 8.3.4.

```
γ        = 1.4 + (T*/ϕNt) ≤ 2.0
         = 1.4 + (217/1500.48)
         = 1.54

Biaxial  = (Mx*/ϕMrx) ^ γ + (My*/ϕMry) ^ γ ≤ 1.0
         = (74.7/182.30) ^ 1.54 + (29/40.03) ^ 1.54
         = 0.8598 [85.98%]
```

• Calculate biaxial bending member capacity as per Section 8.4.5.2.

```
ϕMtx     = MIN (ϕMrx, ϕMox)
         = MIN (182.30, 180.86)
         = 180.86 kNm

Biaxial  = (Mx*/ϕMtx) ^ 1.4 + (My*/ϕMry) ^ 1.4 ≤ 1.0
         = (74.7/180.86) ^ 1.4 + (29/40.03) ^ 1.4
         = 0.9267 [92.67%]
```

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