Bending

1. Classify section (4-8, 4-1)
2. Find Z, I_y, J, C_w

   $I_y = 1/12\, bh^3 + Ad^2$

   $J = \sum \frac{b_i t_i^3}{3}$ (thin-walled)

   $C_w = I_y \left(\frac{d-t}{2}\right)^2$ (I section)

   $Z = \sum A_c y_c + \sum A_t y_t$

3. Find $\omega_2 \le 2.5$

   $$\omega_2 = \frac{4M_{max}}{\sqrt{M_{max}^2+4M_a^2+7M_b^2+4M_c^2}}$$

   $\omega_2 = 1.75+1.05\kappa+0.3\kappa^2$
   - κ = ratio of M at ends of unbraced; − single curv, + double curv

   ω_2 = 4-24 Tables

4. Find M_u and M_p

   If doubly symmetric Class 1/2,

   $$M_u = \frac{\omega_2 \pi}{L}\sqrt{EI_y GJ + \left(\frac{\pi E}{L}\right)^2 I_y C_w}$$
   - L = unbraced length

   $M_p = Z F_y$

5. Find M_r

   If $M_u \le 0.67 M_p$

   $M_r = \phi M_u$

   Else

   $M_r = 1.15\phi M_p \left(1 - \frac{0.28 M_p}{M_u}\right) \le \phi M_p$

Plate Girder - Check Adequacy

1. Classify sections
   - Flange $b/t \le 200/\sqrt{F_y}$ (Typ)
   - web $h/w > 1900/\sqrt{F_y}$ (Typ)
2. Check max slenderness

   $h/w \le \frac{83000}{F_y}$

3. Section properties
   - Note use S_x not Z_x if Class 4, $S_x = \frac{I_x}{y}$
4. Find M_r for each span
5. Find M_r' for each span and compare to max M_f — must exceed zero ↓

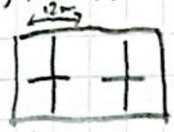
   $$M_r' = M_r\left[1.0 - \frac{A_w}{2000 A_f}\left(h/w - \frac{1900}{\sqrt{F_y}}\right)\right]$$

6. Ensure aspect ratio okay - if not satisfied, $F_t = 0$
   - if $h/w \le 150$ $a/h \le 3$
   - if $h/w > 150$, $a/h \le 67500/(h/w)^2$
7. Solve k_v
   - if $a/h < 1$, $k_v = 4 + 5.34/(a/h)^2$
   - if $a/h \ge 1$, $k_v = 5.34 + 4/(a/h)^2$
8. Find F_s (5-10)
9. Find A_w and V_r, $V_r = \phi A_w F_s$.
   - $A_w = dw$ (rolled), hw (girder), $2ht$ (rectangular HSS)
10. Repeat 6-9 for all spaces, comparing to V_f
11. If combined and $F_s > 0.6F_y$, ensure $2.2 - \frac{16M_f}{10M_r} \le 1.0$
    - If $F_s > 0.6F_y$
12. Check bearing resistance (Bearing stiffeners diff from intermediate shear ones)
    - If no stiffeners, check for web. yield crippling
      → Interior, $B_r = \min[\phi_{bi} w(N+10t)F_y,\ 1.45\phi_{bi} w^2\sqrt{F_y E}]$
      → End, $B_r = \min[\phi_{be} w(N+4t)F_y,\ 0.6\phi_{be} w^2\sqrt{F_y E}]$
      - N = bearing length, $\phi_{bi} = 0.8$, $\phi_{be} = 0.75$
13. Check combined shear / mom!

- if bearing stiffener, check as column
  - ↳ $KL > 3/4$ length stiffener
  - ↳ $b/t \le 200/\sqrt{F_y}$
  - ↳ $I_s > \sqrt[4]{h/50}$

i. Check if $h/w > 1100/F_y$; if so, stiffener req'd
ii. Check c/c distance between stiffener:

→ if c/c > 12w,



→ else

$A_{stiffener} = 4\, A_{stiff} + [25w\,(\text{interior}),\ 12w\,(\text{end})]$

iii. Find x-sectional properties
iv. Find C_r

13. Ensure sufficient stiffener area provided

$$A_s \ge \frac{aw}{2}\left(1 - \frac{a/h}{\sqrt{1+(a/h)^2}}\right)\left(1 - \frac{310000\,k_v}{F_y\,(h/w)^2}\right)\frac{F_y}{F_{ys}}\,D$$

- A_s = cross-sectional area of pair of stiffeners
- F_{ys} = yield stress stiffeners, F_y = yield stress web
- D : stiffener factor
  - → 1 (stiffener in pairs)
  - → 1.8 (single angle stiffener)
  - → 2.4 (single plate stiffener)

14. Ensure bearing of stiffener with flange OK

- $B_r = 1.5\,\phi\,F_y\,A_s \ge V_f/2$

15. Ensure weld sufficient

(stiffener to web) → $v_r = 1E{-}4 \cdot h \cdot F_y^{3/2}$ (N/mm)
- Plate cut so distance between weld and stiffener

16. Fatigue resistant − 4w to 6w left on bottom

Plate girder design

1. Choose economical girder depth . $h = 540\sqrt[3]{\frac{M_f}{F_y}}$
2. Required flange area $A_f = M_f/hF_y$
   - Ensure flange class 3
3. Required web area $A_w = wh = \frac{V_f}{\phi F_s}$, $h/w \le \frac{83000}{F_y}$
4. Stiffener placement:
   - At 1-2 × girder depth, ensuring tension field action
   - At concentrated load location
5. Determine end panel length by back calculating a
6. Check shear resistance for unstiffened web and diff regions
7. Find max factored shear in regions, then find max allowable spacing a, then find k_v, solve F_s, and ensure $\phi F_s > f_s = \frac{\text{load}}{A_w}$
8. Check combined shear/moment
9. Try plates out and check C_r, B_r and V_r

   $V_r = \min[0.67\,\phi_w A_m X_u,\ 0.67\,\phi_w A_w X_u]$ (kN/mm)
10. Weld length req: V_f/V_r
    - ↳ Verify weld length requirements
11. Choose intermediate stiffener area > A_{min}
    - ↳ Ensure $v_r > f/A_{w}$, and spacing acceptable
12. Check if bearing stiffeners req'd
13. Design the weld between the flange and the web to resist the shear flow

Tension 23-25, 213
1. $L/r < 300$, 240 (lines)
2. Check gross yielding
3. Check net yielding
4. Check block shear

Welds 217-221
1. Select preliminary member size from A_g
2. Determine weld length required w/ the welds
3. Check shear lag
4. Check 6-185 reg'mts

Bolts 222-226

Compression 318-322
1. Check section classification
2. $KL/r \leq 200$
3. Find governing F_e
4. If class 4, find A_e
   - Use gross section properties for LT
5. Solve C_r
   - Built up on 331

Sway Frame 336, 338
1. Solve for I of columns & beams
   ↳ if pinned column $G=10$, fixed column $G=1$
2. $\Sigma I/L$ for columns and beams
   ↳ x1.5 for end hinged } beams
   ↳ x2 for end fixed } beams
3. Use alignment chart to find K
4. Find λ and C_r

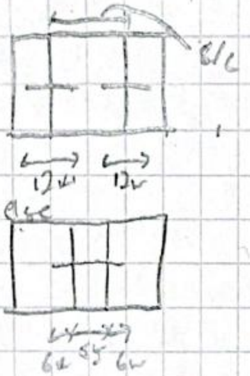
Beams 410
1. Classify section
2. If unbraced, check if unsupported
   ↳ M_y
   ↳ Check if $0.67\,M_p > M_u$, if so $M_r = \phi M_u$
   else, LT-buckling controls

Shear 432
1. Find h/w
2. Check yielding type
3. $V_r = \phi A_w F_s$
4. Check if combined shear/moment

Bearing 433
1. Check if web yielding and crippling governs

Plate girder shear 510-511, 52
1. Calculate h/w, Also section classification
2. If post-buckling strength, find a/h. (region 511)
3. Find k_v and F_s $A_w = dw$ (rolled), hw (girder)
4. Check if required A_s 511 (intermediate stiffener)
5. M_r' from local buckling 52
6. Check combined 516

Bearing stiffeners
1. Check if $h/w > 1100/\sqrt{F_y}$, if so, stiffener req'd
2. Check c/c distance between stiffeners
   ↳ if c/c > 12w,



$A = 4\,A_{stiffener} + [25w$ (interior), $12w$ (end)$]$

3. Find cross-sectional properties
4. Solve C_r

Tension & Bending -63

Compression and Bending 615-618
Classify section 64
Check cross-sectional overall, and LT buckling strength

1. Check Tension / bending strength alone
2. Check together