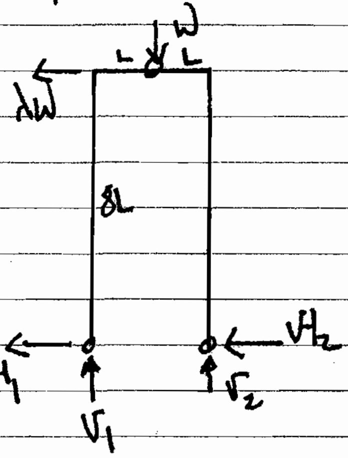
4D10 : FINAL CRIB 2006/07 KAS

1) All solutions are bookwork : see chapter 3 of notes.

2) 3 pinned, tall "arch", i.e. stat. det. portal frame.



$R\uparrow$: $V_1+V_2=W$ $R\rightarrow$ $H_1+H_2=-\lambda W$

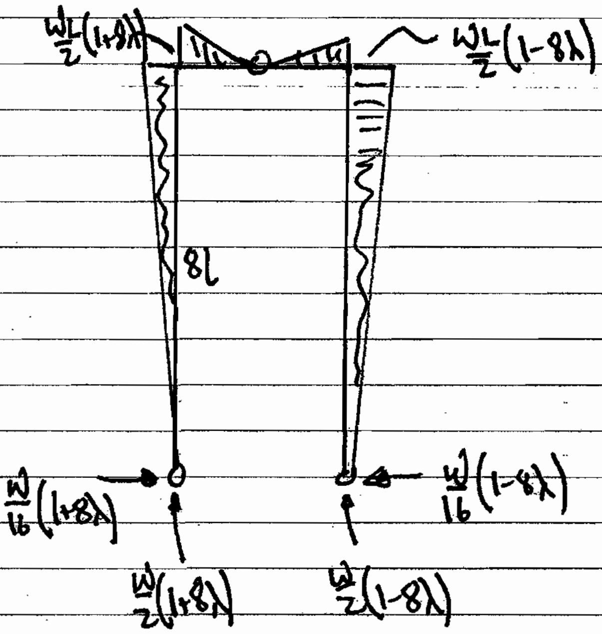
$M\uparrow$ left foot : $2L\cdot V_2 - WL + \lambda W\cdot 8L = 0$

$\Rightarrow V_2 = \frac{W}{2}[1-8\lambda]$; $V_1 = \frac{W}{2}[1+8\lambda]$.

Moments for either half free body:

$V_1\cdot L + H_1\cdot 8L = 0 \Rightarrow H_1 = -V_1/8$; $H_2 = +\frac{V_2}{8}$

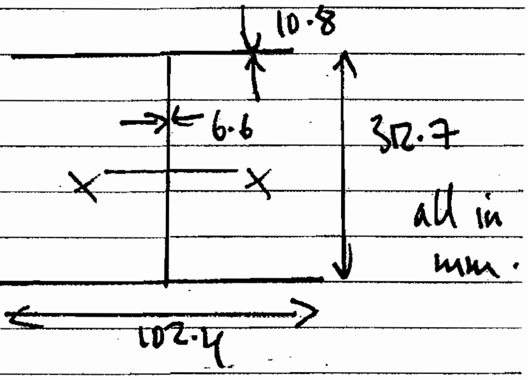
b.m. profile.



Left column has largest axial force and top end moment, hence most critical column. Treat as pin-ended, beam-column loaded by axial force and moment at top end.

Section is 305×102×33 kg/m grade S355 UB, major axis bending!

$r_{xx} = 12.5$ cm, $Z_p = 481$ cm^3
$A = 41.8$ cm^2 } Struct. data book.

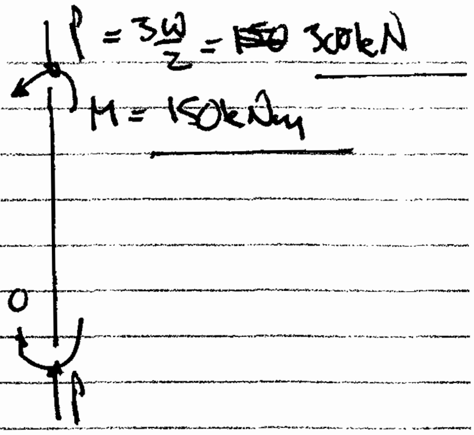


$\sigma_y = 355$ MPa, $y = \frac{312.7}{2}$ mm (extm)

$\lambda_{web} < 56 \Rightarrow$ OK to use CDC method

P.T.O.

2/1.



$\underbrace{\lambda = 1/4, \ L = 1/2, \ W = 200\text{kN}}_{\text{given.}}$

$\Rightarrow V_1 = \frac{W}{2}\left(1+8.\frac{1}{4}\right) = \frac{W}{2}.3 = \frac{3W}{2}$

$M(\text{top left}) = \frac{WL}{2}\left(1+2.1/4\right) = \frac{W}{4}.3 = \frac{3W}{4}$

$P_p(\text{squash}) = A\sigma_y = 1482\text{kN}$

$M_p(\text{full plastic}) = Z_p\sigma_y = 171\text{kNm}$ greater than these $\Rightarrow$ potentially viable loads

$T/y = \frac{125}{312.7/2} = 0.8 > 0.7 \Rightarrow$ use curve A BS~~2~~ (hot-rolled

$\sigma/\sigma_c = P/P_p = \frac{300}{1482} = 0.2 \Rightarrow \lambda \sim 160 = \frac{L_c}{r}\sqrt{\frac{\sigma_y}{355}}$

$\Rightarrow L_c = 160 \times r = 160 \times 0.125 = 20\text{m}.$

L (or total length) $/L_c = 4/20 = 1/4$. Now $\beta = 0$ (pin at one end)

$\Rightarrow$ BS3 (UB axis bending) that

$\underline{M_c = M_p'}$ (no reduction of M_c).

To estimate M_p', assume compressive core confined to ~~f~~ web

$\Rightarrow \underset{300\text{kN}}{P} = \sigma_y \cdot A_{core} = \underset{355\text{MPa}}{\sigma_y} \cdot [d \times 0.0066] \Rightarrow d = 128\text{mm}$ ✓

$M_p' = M_p - \underbrace{\frac{bd^2}{4}\sigma_y}_{\text{due to } P} = 171\text{ kNm} - 9.3\text{kNm}$

$= \underline{\underline{162\text{kNm}}}$

Just greater than 150kNm applied

∴ SAFE.

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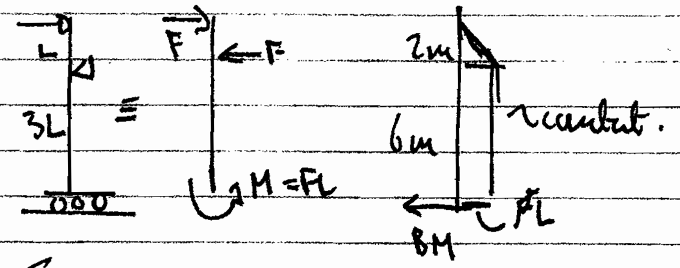
4D10 CRIB DRAFT 2006/07.

3(a)



$L = 2m$ 457x152x82 UB S2:

$I_{yy} = 1185 cm^4$, $J = 89.2 cm^4$, $Z_p = 1811 cm^3$, $G = 81 GPa$ $E = 205 GPa$ $\sigma_y = 275 MPa$.

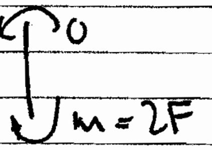
3(b) Tackle by BS2, two critical spans, $L = 2, 6m$. Must evaluate:

$$M_E = \sqrt{M_1^2 + M_2^2}, \quad M_1 = \frac{\pi}{L}\sqrt{GJEI_{yy}} \quad M_2 = \frac{\pi^2}{L^2} Eh \boxed{\frac{I_{yy}}{2}} \leftarrow I_f$$

$h = 465.8 - 18.4 = 446.9 mm$ (mid-flange depth). $(M_p = Z_p \sigma_y)$

	L=2m	L=6m.
M_1 (kNm)	658	219
M_2 (kNm)	1339	149
M_E (kNm)	1491	265.
M_p (kNm)	498	498
$\lambda_{LT} = 75\sqrt{\frac{M_p}{M_E}}$	43	102
$\bar{M}_c$ (BS2)	1	0.44.

L=2m span

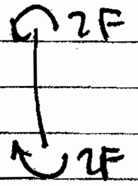


$\beta = 0 \Rightarrow M_u = 0.6m \Rightarrow 1.2F = M_u$

strength: $m \leq M_p \Rightarrow 2F \leq 498 \Rightarrow F \leq 249k$

stability: $M_u < M_c \Rightarrow 1.2F < M_p \Rightarrow F \leq 415kN$

L=6m span.



$\beta = 1 \Rightarrow M_u = m \Rightarrow M_u = 2F.$

Strength ~~$M_u \leq M_c \Rightarrow 2F \leq$~~
$m \leq M_p \Rightarrow 2F < 498, F < 2$

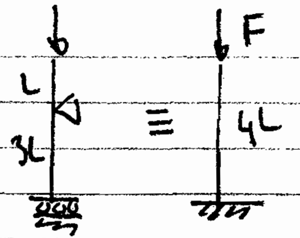
stability $M_u \leq M_c \Rightarrow 2F \leq 0.44 M_p$

$F \leq 0.22 M_p = 109.5$

$F_{min} = 109.5 kN$ (stability controls).

3/2.

3(c)



k, effective length, = 2 by BS1.

$I_{xx} = Ar^2$. $\Rightarrow$ $r \sim 195$ mm $\Rightarrow$ $r/y = 0.8$

$y = 465.8/2$ mm

$\Rightarrow$ use curve A.

$L_E = kl = 2 \cdot 4 \cdot 2 = 16$m.

$$L_E/r \sqrt{\sigma_y/355} = \frac{16}{0.195}\sqrt{\frac{275}{355}} = 72.$$

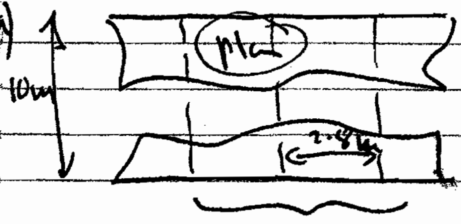
$\Rightarrow \hat{\sigma}_c = 0.65 \Rightarrow \sigma_c \simeq 179$ MPa.

$F_c = A \cdot \sigma_c \simeq \underline{\underline{1924 \text{ kN}}}$ $\therefore$ $\underline{18 \text{ fold}}$ increase.

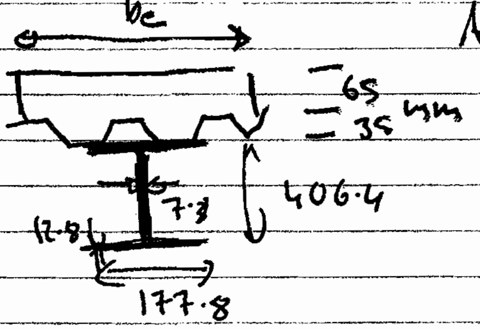
4/1.

4V10 CRIB HWAFT 2006/07

4/a)



406×178×60kg/m S275



$A_s = 7600 mm^2$

Assume 50% of slab below 35 in concrete

Compactness of UB – OK (<56 for buckling in web).

Eff. span $b_e = \underset{(2.8m)}{b}$ or $\underset{(10/4)}{span/4}$ ✓ = 2.5m.

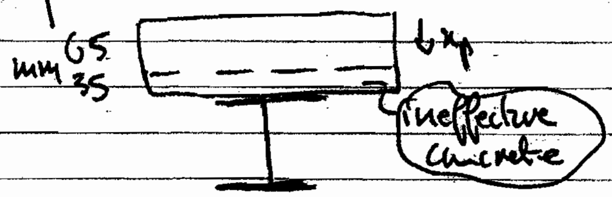
Load intensities: slab wt 24 × (0.065 + 0.035/2) × 2.8 = 5.5 kN/m.
UB self wt ≈ given 0.6 "
services 3 × 2.8 8.4
14.5 kN/m

Imposed load = 55 × 2.8 = 15.4 kN/m.

Total load = 1.4 × 14.5 + 1.6 × 15.4 = 44.9 kN/m.

Max moment = $\frac{wL^2}{8} = \frac{44.9 \times 10^3 \times 10^2}{8}$ = 561 kNm

Capacity?



Axial eqlm ⇒

$x_p \cdot 0.6 k_e \cdot f_{cd} = A_s \sigma_y$

⇒ x_p = 46.4mm (<65 OK

$M_d = A_s \sigma_y \cdot \left[\frac{\overset{406.4}{h}}{2} + \underset{100mm}{h_c} - x_p/2 \right]$ = 585kNm > 561kN

pass OK

b) Studs: P_d = 47 kN for ø16 axial force in concrete = $A_s \sigma_y$

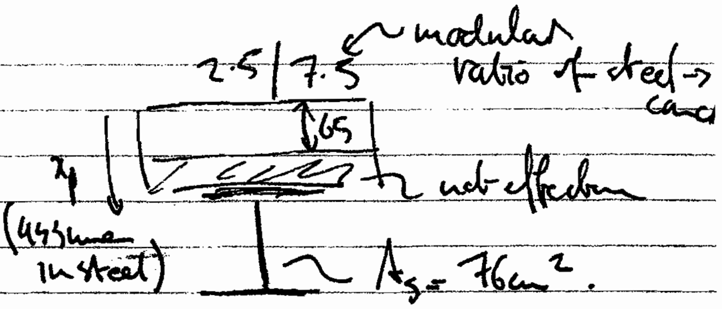
studs in span: ⇒ $\frac{2\times \text{axial force}}{P_d}$ ⇒ total no = 90 studs

spacing = $\frac{10m}{90}$ = 111 mm

⇒ 2 studs/trough (@ 80% strength ⇒ 160 studs sufficient).

4/2.

4(c) Imposed load deflection.
$\Rightarrow$ transformed section.



$$\left[\frac{2500}{7.5}\cdot 65 + 7600\right]\cdot x_p = \left[\frac{2500}{7.5}\times 65\times\frac{65}{2} + 7600\times\left[100+\frac{406}{2}\right.\right.$$

$\Rightarrow$ $x_p = 103$mm (>100, in stee

$$\underset{(mm^4)}{I_{xx}} = \frac{1}{12}\cdot\left[\frac{2500}{7.5}\times 65^3\right] + \frac{2500}{7.5}\times 65\times\left[102.8-32.5\right]^2$$
$$+ \underbrace{21504\times10^4}_{I_o\ \text{steel}} + 7600\times\left[203.2+100-102.3\right.$$

$$= 636.4\times10^6\ mm^4.$$

$$\delta = \frac{5\cdot \overset{\text{actual}}{w}L^4}{384 I_{xx}\cdot \underset{\uparrow\ \text{steel}}{E}} = \frac{5\times[15.4]^{\times10^3}\times 10^4}{384\times 205\times10^9\times 636.4\times10^{-6}}$$

$$= \underline{\underline{15.0mm}} < \frac{10m}{250} = \underline{\underline{40mm}}$$