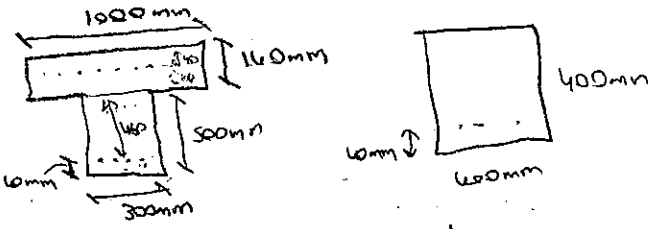
CE382 HW-4

Materials C25 $\Rightarrow f_{cd} = 16.7$ MPa

S420 $\Rightarrow f_{yd} = 365$ MPa



Beam Column

$M_{fd1} = M_{cd1} - \frac{V_a}{3} = 120 - \frac{(150)(0.4)}{3} = 100$ kNm

$M_{fd2\,left} = M_{cd2\,left} - \frac{V_a}{3} = 310 - \frac{(180)(0.4)}{3} = 286$ kNm

$M_{fd2\,right} = M_{cd2\,right} - \frac{V_a}{3} = 110 - \frac{(50)(0.4)}{3} = 103.3$ kNm

$M_{fd3\,left} = 100 - \frac{(70)(0.4)}{3} = 90.7$ kNm

$M_{fd3\,right} = 100 - \frac{(110)(0.4)}{3} = 85.3$ kNm

$M_{fd4} = 40 - \frac{(120)(0.4)}{3} = 24$ kNm

Left Midspan:

$jd = 0.9d = (0.9)(460) = 414$
$jd = d - \frac{t}{2} = 460 - 70 = 390$
$414 > 390$ take 414 mm

$A_s = \frac{M}{(f_{yd})(jd)} = \frac{268000}{(365)(10^3)(414)} = 1773.6\,mm^2$

$3\,\emptyset 28 \Rightarrow \pi \times 3 \times \frac{28^2}{4} = 1846.32\,mm^2$ ✓

bend $1\emptyset 28$ (later we realise that we need to bent 2)

Middle Midspan

90 negative & 20 positive; since -90 is more critical design steels according to -90kNm.

$K = \frac{bd^2}{M} = \frac{(300)(460)^2}{90} = 705.3 \frac{mm^2}{kN} > KL = 178 \frac{mm^2}{kN}$

$A_s = \frac{90}{(365)(0.86)(460)} = 623.3\,mm^2$

$3\,\emptyset 18 \Rightarrow \frac{18^2\pi}{4} \times 3 = 763.02\,mm^2$ ✓ bend $1\emptyset 18$

Right Midspan

$jd = 414$

$A_s = \frac{(187000)}{(365)(414)10^3} = 575.74\,mm^2$

$2\,\emptyset 20 \Rightarrow \frac{20^2\pi}{4} \times 2 = 628\,mm^2$ ✓ bend $1\emptyset 20$

Support 1

$K = \frac{(b_w)(d)^2}{M} = \frac{(300)(460)^2}{100 \times 10^3} = 634.8 \frac{mm^2}{kN} > K_L = 294 \frac{mm^2}{kN}$

so use single reinforcement.

$A_s = \frac{100 \times 10^3}{(365)(0.86)(460)} = 692.5\,mm^2$

$1\,\emptyset 28$ comes from L. Midspan $= 615.44\,mm^2$ } $728.48\,mm^2$ ✓

add $1\emptyset 12 = 113.04\,mm^2$

later changed to $2\,\emptyset 28$ bent so no need for extra $1\emptyset 12$

$615 \times 2 = 1230 > 692.5\,mm^2$ ✓

Support 2

Use $M_{fd\,2\,left} = 286$ kNm $= M$

$K = \frac{(b_w)(d^2)}{M} = \frac{(300)(460)^2}{286 \times 10^3} = 222 \frac{mm^2}{kN} < KL = 291$

$222 > Km = 199$

so use double reinforcement.

$M_1 = \frac{(b_w)(d^2)}{K_L} = \frac{(300)(460)^2}{291} = 218.14$ kNm

$A_{s_1} = \frac{M_1}{f_{yd}\,jd} = \frac{218}{(365)(0.86)(460)} = 1511\,mm^2$

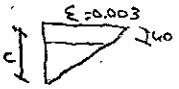
$M_2 = M_d - M_1 = 286 - 218.14 = 67.86$ kNm $\Rightarrow$

$A_{s_2} = \frac{67.86}{(365)(460-40)} = 442.66\,mm^2$

since we assumed compression steel has yielded $\Rightarrow$

$(0.85)(16.7)(0.85c)(300) = (365)(1511)$

$\Rightarrow c = 152.36$



$\frac{0.003}{152.36} = \frac{\varepsilon_s'}{152.36 - 40} \Rightarrow \varepsilon_s' = 0.00221$

$\varepsilon_s' > 0.001825$ ✓

for top steel A_{s_4} $1\emptyset 28$ (from L.M.S) $+ 2\emptyset 18$ (M.M.S) $= 1124.12\,mm^2$

$1511 - 1124 \cong 387$ so bend $1\emptyset 28$ from LMS $\Rightarrow$

$1124 + 615 = 1739$ ✓

for bottom steel A_{s_2} $1\emptyset 28 + 1\emptyset 18 = 869.78\,mm^2$ $>$ $442\,mm^2$ ✓

- $\frac{869}{1739} \times 100 = 0.4997 \cong 0.5$ so it is

for for earthquake zone 1 & 2.

Support 3

$K = \frac{bwd^2}{M} \cong 700 > K_L \rightarrow$ single reinf.

$A_s = \frac{M}{f_{yd} J.d} = \frac{90.7}{(365)(0.86)(460)} = 635\ mm^2$

$1\text{Ø}20 + 2\text{Ø}18 = 822.68\ mm^2$ ✓
from R.M.S from M.M.S

Support 4

$K = \frac{bwd^2}{M} = \frac{(300)(460)^2}{(24)(10^3)} = 2645 \frac{mm^2}{so}$

$A_{st} = \frac{(24)(10)^6}{(365)(0.86)(460)} = 166\ mm^2$