CE 414: Prestressed Concrete
Lecture 13
Flexural Design (final design II)

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Contents

- Large M_G/M_T ratio
- Stress distribution for no tension in concrete
- Final design for T- section beam

Large Ratios of M_G/M_T. When the ratio of M_G/M_T is large, the value of $e-k_b$ computed from equation 6-6 may place c.g.s. outside of the practical limit, for example, below the section of the beam. Then it is necessary to place the c.g.s. only as low as practicable and design accordingly.

For such a condition, the bottom fiber stress is seldom critical. Under the initial condition, just after transfer, the bottom fiber stress is shown in Fig. 6-9(b) and is given by the formula

$$f_b = \frac{F_0}{A_c} + \frac{(F_0 e - M_G)C_b}{I}$$

$$= \frac{F_0}{A_c}\left(1 + \frac{e-(M_G/F_0)}{k_t}\right)$$

from which the required area A_c can be computed as

$$A_c = \frac{F_0}{f_b}\left(1 + \frac{e - (M_G/F_0)}{k_t}\right) \tag{6-10}$$

The top fiber is always under some compression and does not control the design under this condition.

Under the working load, the stress distribution is the same as for the first case (small ratios), and is pictured in Fig. 6-9(c). The design is practically the same as before except that equation 6-10 should be used in place of equation 6-7a. For convenience, the procedure will be outlined as follows.

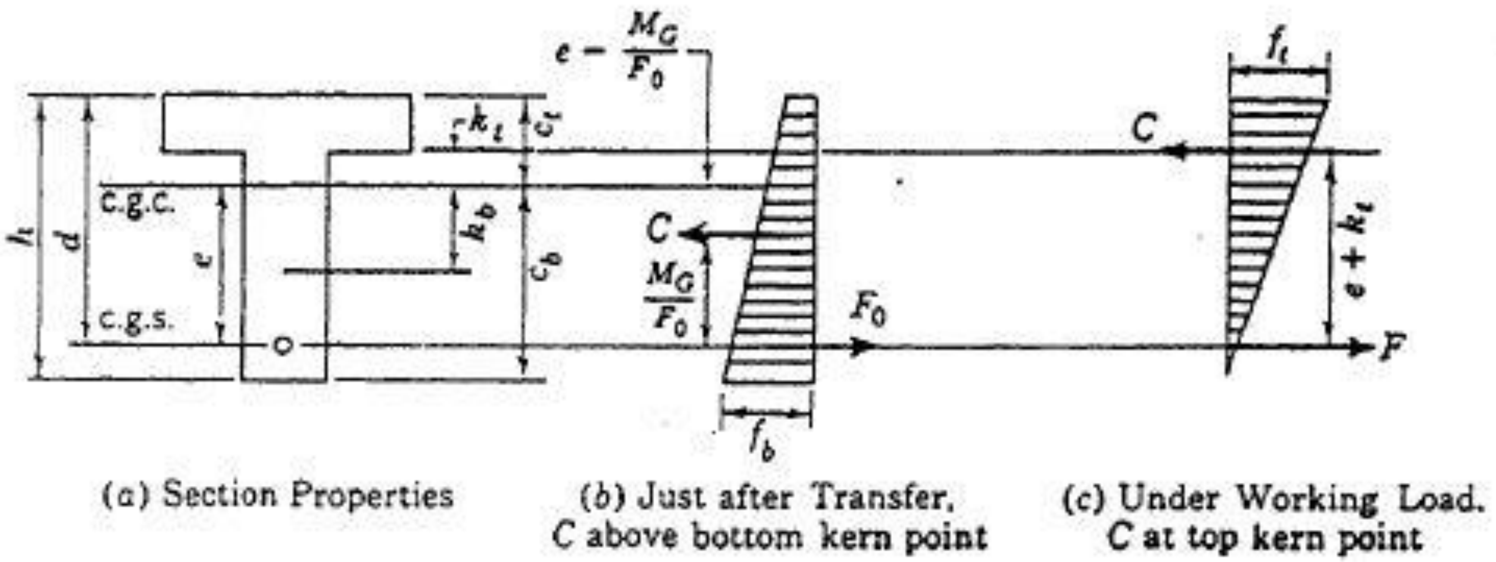

Fig. 6-9. Stress distribution, no tension in concrete (large ratios of M_G/M_t).

Step **1.** From the preliminary section, compute the theoretical location for c.g.s. by

$$e - k_b = M_G / F_0$$

If it is feasible to locate c.g.s. as indicated by this equation, follow the first procedure. If not, locate c.g.s. at the practical lower limit and proceed as follows.

Step **2.** Compute F (and then F_0) by

$$F = \frac{M_T}{e + k_t}$$

Step 3. Compute the required area by equations 6-9*a* and 6-10.

$$A_c = Fh/f_t c_b$$

$$A_c = \frac{F_0}{f_b}\left(1 + \frac{e - (M_G/F_0)}{k_t}\right)$$

Step 4. Use the greater of the two A_c's and the new value of F, and revise the preliminary section. Repeat steps 1 through 4 if necessary.

EXAMPLE 6-4

Make final design for the preliminary section obtained in example 6-1, $M_G = 210$ k-ft, allowing $f_b = -1.80$ ksi, $f_0 = 150$ ksi. Other values given were $M_T = 320$ k-ft; $h = 36$ in.; $f_{se} = 125$ ksi; $f_t = -1.60$ ksi. The preliminary section is shown in Fig. 6-10, with $A_c = 200$ sq in., $c_t = 13.5$ in., $c_b = 22.5$ in., $I = 26{,}000$ in.^{4}, $k_t = 5.8$ in., $k_b = 9.6$ in., $F = 164$ k, $F_0 = 164(150/125) = 197$ k ($M_G = 285$ kN-m, $f_b = -12.41$ N/mm^2, $f_0 = 1034$ N/mm^2; $M_T = 434$ kN-m, $h = 914.4$ mm, $f_{se} = 862$ N/mm^2; $f_t = -11.03$ N/mm^2, $A_c = 129 \times 10^3$

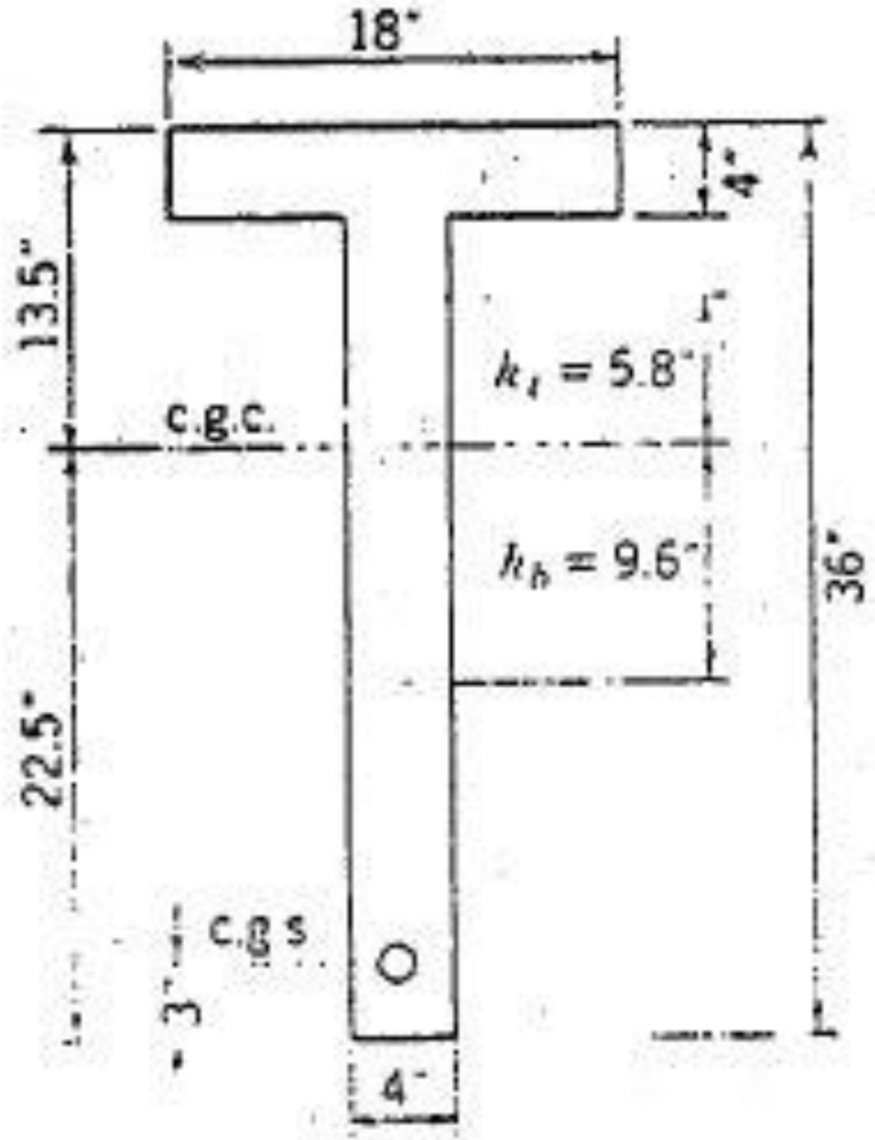

Fig. 6-10. Example 6-4. Trial section.

mm, $c_t = 343$ mm; $c_b = 572$ mm, $I = 10.82 \times 10^9$ mm^4, $k_t = 147$ mm; $k_b = 244$ mm, $F = 730$ kN, and $F_0 = 876$ kN).

Solution *Step 1.* Theoretical lowest location for c.g.s. is given by

$$e - k_b = M_G / F_0$$
$$= (210 \times 12)/197$$
$$= 12.8 \text{ in. } (325 \text{ mm})$$

indicating 12.8 in. (325 mm) below the bottom kern, or 0.1 in. (2.54 mm) above the bottom fiber, which is obviously impossible. Suppose that for practical reasons the c.g.s. has to be kept 3 in. (76.2 mm) above the bottom fiber to provide sufficient concrete protection. This problem then belongs to the second case, and we proceed as below.

Step 2. The effective prestress required is, corresponding to a lever arm of $e + k_t = 22.5 - 3 + 5.8 = 25.3$ in. (643 mm),

$$F = (320 \times 12)/25.3 = 152 \text{ k } (676 \text{ kN})$$

$$F_0 = 152(150/125) = 182 \text{ k } (810 \text{ kN})$$

Step 3. Compute the area required by

$$A_c = \frac{Fh}{f_t c_b}$$

$$= \frac{152 \times 36}{1.60 \times 22.5}$$

$$= 152 \text{ sq in. } (98 \times 10^3 \text{ mm}^2)$$

$$A_c = \frac{F_0}{f_b}\left(1 + \frac{e - (M_G/F_0)}{k_t}\right)$$

$$= \frac{182}{1.80}\left(1 + \frac{19.5 - 210 \times 12/182}{5.8}\right)$$

$$= 199 \text{ sq in. } (128 \times 10^3 \text{ mm}^2)$$

which indicates that the trial preliminary section with $A_c = 200$ sq in. (129×10^3 mm^2) is just about right for the stress in the bottom fibers, but much more than enough as far as the top fibers are concerned. In other words, if practical conditions permit, it may be desirable to reduce the concrete area in the top flange and to add concrete area to the bottom flange, to obtain a more economical section. The reader may try this out to see whether a better section is obtainable for this example.