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Structural Design of Hydraulic Structures

Design of Prestress Members

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As in reinforced concrete problems, in prestressed concrete can be separated generally as analysis problems or design problems.

Flexural design based on concrete stress limit:
OR (allowable stress design method):

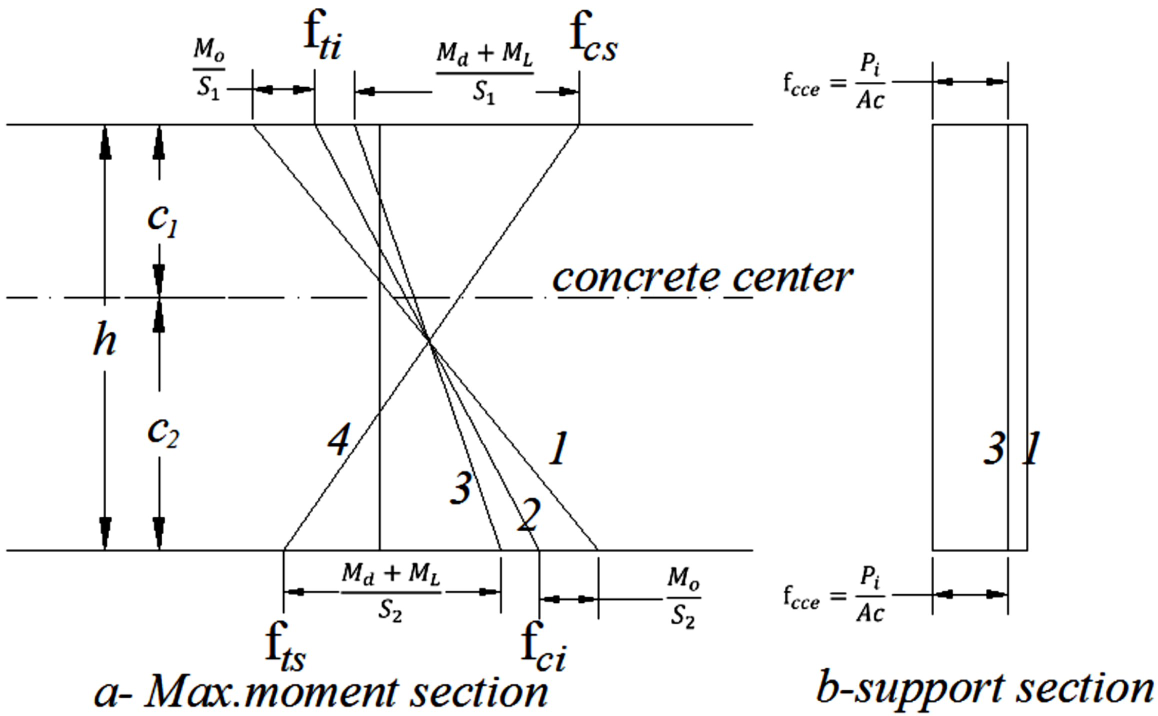
If the dimensions of a concrete section, the amount of prestress area A_{ps}, the prestress force P_i or P_e and eccentricity location e are to be found; the problems must be design according to the allowable stresses of ACI with many interrelated variables.

a- Beam with variable eccentricity:

For a typical class U or T beam in which tendon eccentricity permitted to vary along span flexural stress distribution in the concrete at the maximum moment section are shown in Figure (4-1).

Summarizing the design process to determine the best cross section and the required prestress force and eccentricity based on stress limitations.

The requirement for the section moduli $S1$ and $S2$ with respect to the top and bottom surfaces respectively is:



1-P_i

2-$P_i + M_g$

3-$P_e + M_g$

4-$P_e + M_t$

Figure (4-1) Flexural stress distribution for beam with variable eccentricity
(a) maximum moment section (b) support section

b- Beam with constant eccentricity:

The design method presented in the previous section was based on stress conditions at the maximum moment section of a beam with the maximum value of moment (Mg). If Pi and e were to held constant along the span, the eccentricity is controlled by conditions at the supports,

where Mg=$Zero$. The requirements on the section moduli are that:

$$S_1 \geq \frac{(1-R)\ M_g + M_d + M_L}{R\ f_{ti} - f_{cs}}$$

$$S_2 \geq \frac{(1-R)\ M_g + M_d + M_L}{f_{ts} - R\ f_{ti}}$$

$$R = \text{ effective ratio } = \frac{P_e}{P_i}$$

$$P_e = R \times P_i$$

$$R = 1 - \text{Losses}$$

$$S_1 = \frac{I_c}{C_1}, \qquad S_2 = \frac{I_c}{C_2}$$

$$I_c = S_1 C_1 = S_2 C_2$$

$$\frac{C_1}{C_2} = \frac{S_2}{S_1}$$

Or in terms of total section depth:

$$h = C_1 + C_2$$

$$\frac{C_1}{h} = \frac{S_2}{S_{1+}S_2}$$

The concrete centroid stress under initial condition f_{cci} is given:

$$f_{cci} = f_{ti} - \frac{C_1}{h}(f_{ti} - f_{ci})$$

The initial prestress force is:

$$P_i = A_c |f_{cci}|$$

e_{max} at the maximum moment section:

$$e_{max} = e = (f_{ti} - f_{cci})\frac{S_1}{P_i} + \frac{M_g}{P_i}$$

Or

The same result will be obtained from consideration of requirement at the bottom fiber.

$$e_{max} = e = (f_{cci} - f_{ci})\frac{S_2}{P_i} + \frac{M_g}{P_i}$$

The required area of pre-stressing steel A_{Ps}:

$$A_{Ps} = P_i / \textbf{permissible stress in the steel}$$

Permissible stress in the strand immediately after transfer must not exceed 0.82 f_{Py} or 0.74 f_{Pu}.

The requirements on the section moduli are that:

$$S_1 \geq \frac{M_g + M_d + M_L}{R\,f_{ti} - f_{cs}}$$

$$S_2 \geq \frac{M_g + M_d + M_L}{f_{ts} - R\,f_{ci}}$$

The required eccentricity is:

$$e = (f_{ti} - f_{cci})\frac{S_1}{P_i}$$

or

$$e = (f_{cci} - f_{ci})\frac{S_2}{P_i}$$

The concrete centroid stress and the initial prestress force may be found as before in previous section.

Step of design procedure:

a- Assume a concrete section

b- Calculate the required prestresses force and eccentricity.

For that will be the controlling load stage

c- Check the stresses at all stage

d- Check the flexural strength

The trial section is then evicted if necessary.