University of Al-Qasim Green
College of Water Resources
Hydraulic Structures Department

Structural Design of Hydraulic Structures

Flexural Strength

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2-Ultimate Strength Analysis (Flexural Strength):

ACI-18.7.1 design moment strength of flexural members shall be computed by the strength design method of the code, for prestressing steel f_{ps} shall be substituted for f_y in strength computing.

$W_u=1.2\ w_d+1.6w_L$

$M_u=1.2\ M_d+1.6M_L$

$\emptyset Mn \geq M_u$

The condition of incipient failure is shown in figure, which shows beam carrying a factored load.

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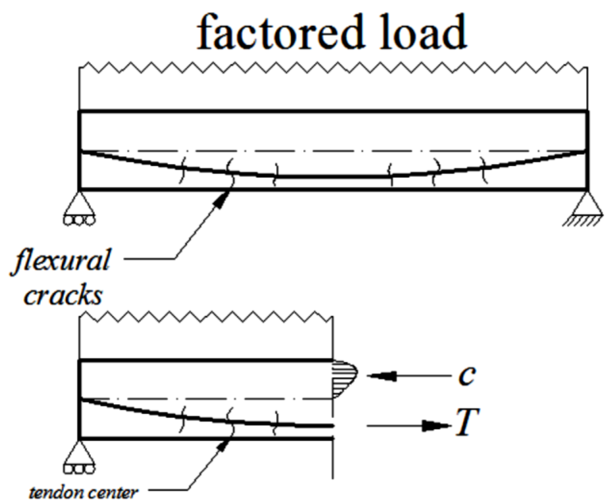
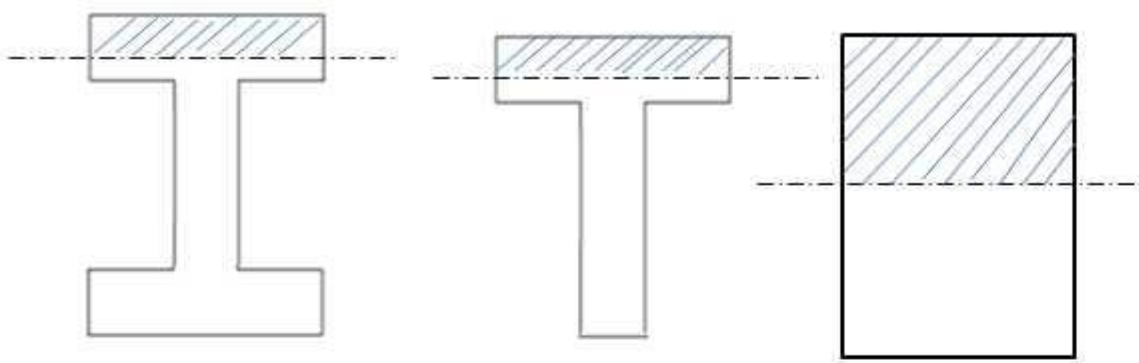
The maximum moment section, only the concrete in compression is effective, and all of the tension taken by the steel. The external moment from the applied loads is resisted by the internal force couple: $CZ=TZ$

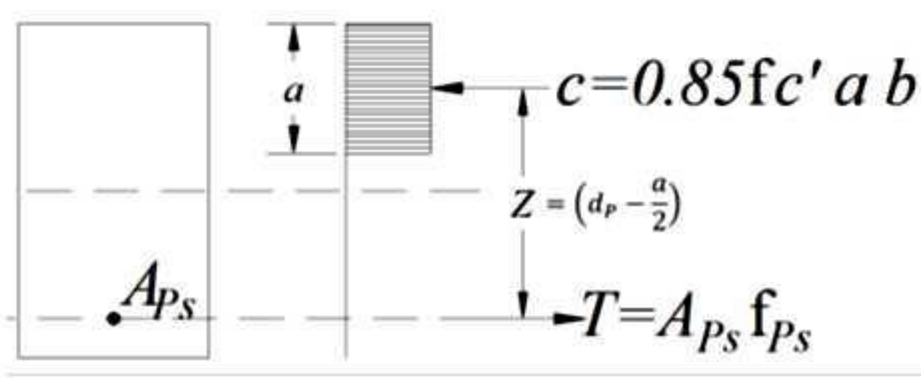


The strength of a pre-stressed beam can be predicted by the same methods developed for ordinary reinforced concrete beams.

a- Rectangular Section: (a ≤ h_f)

For rectangular cross section or flanged section such as (I or T) beams in which the stress block depth is equal to or less than the average flange thickness:





$$C = 0.85 f_{c'}\, a\, b$$

$$T = A_{ps}\, f_{ps}$$

$$a = \frac{A_{ps} f_{ps}}{0.85\, f_{c'}\, b}$$

$$\rho_p = \frac{A_{ps}}{bd}$$

The nominal flexural strength is:

$$M_n = A_{ps} f_{ps} (d_p - \frac{a}{2})$$

<u>OR</u>

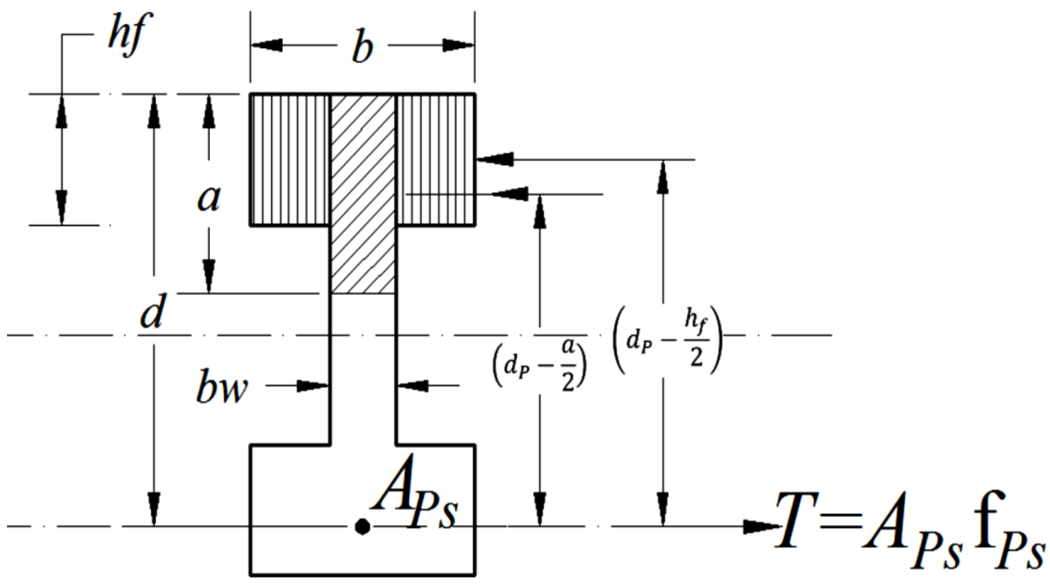
$$M_n = \rho_p f_{ps}\, b d_p{}^2 (1 - 0.59 \times \rho_p \times \frac{f_{ps}}{f_{c'}})$$

Flexural design strength$= \emptyset M_n$

where $\emptyset$: strength reduction factor $=0.9$

b- T- Section: (a > h_f)

If the stress block depth exceeds the average flange thickness the total prestressed tensile steel area is divided into two parts for computational purposes. The first part Apf acting on the stress fps provides a tensile force to balance the compression in the overhanging parts of the flange thus:



$$A_{ps} = A_{pf} + A_{pw}$$

$$A_{pf} f_{ps} = 0.85\, f_{c'} (b - b_w) h_f$$

$$A_{pf} = 0.85 \frac{f_{c'}}{f_{ps}} (b - b_w) h_f$$

$$A_{pw} = A_{ps} - A_{pf}$$

$$A_{pw} f_{ps} = 0.85\, f_{c'} b_w\, a$$

$$a = \frac{A_{pw} f_{ps}}{0.85\, f_{c'} b_w}$$

A_{Pw} provided tension to balance the compression in the web

$$M_n = A_{pw}\, f_{ps} \left(d_p - \frac{a}{2}\right) + A_{ps}\, f_{ps} \left(d_p - \frac{h_f}{2}\right)$$

Or

$$M_n = A_{pw}\, f_{ps} \left(d_p - \frac{a}{2}\right) + 0.85 f_{c'} (b - b_w) h_f \left(d_p - \frac{h_f}{2}\right)$$