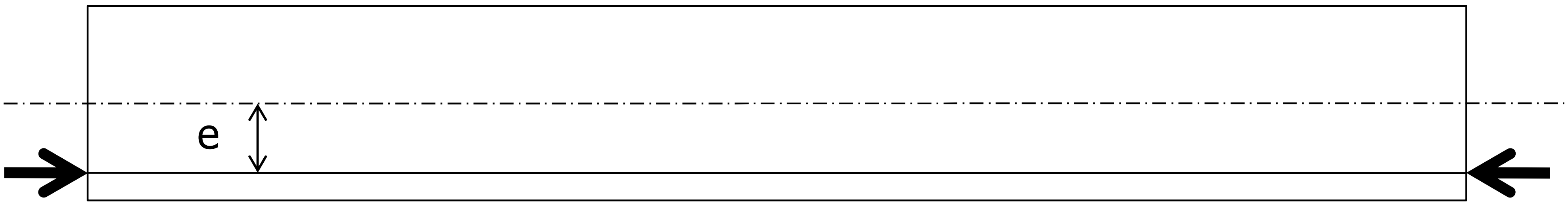
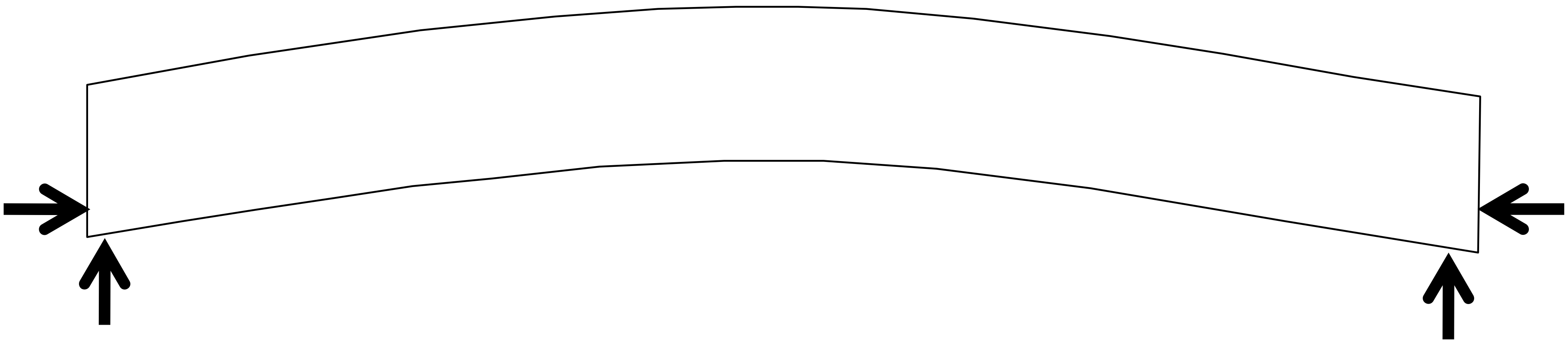
Secondary Effects



$M = P \cdot e$



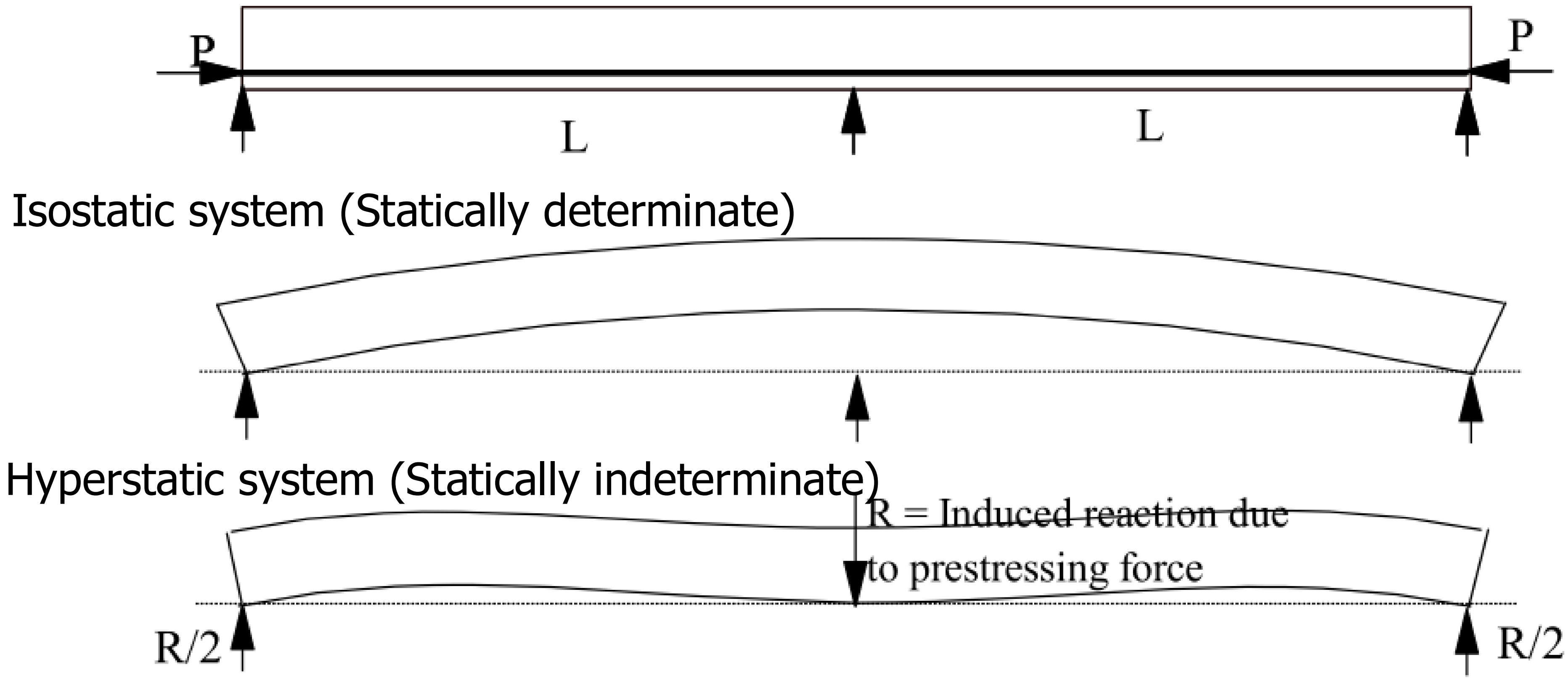
Simply supported beams have no restraints against translation and rotation (deformations).

Secondary Effects

The magnitude of reaction, and hence that of the secondary effects depends upon:

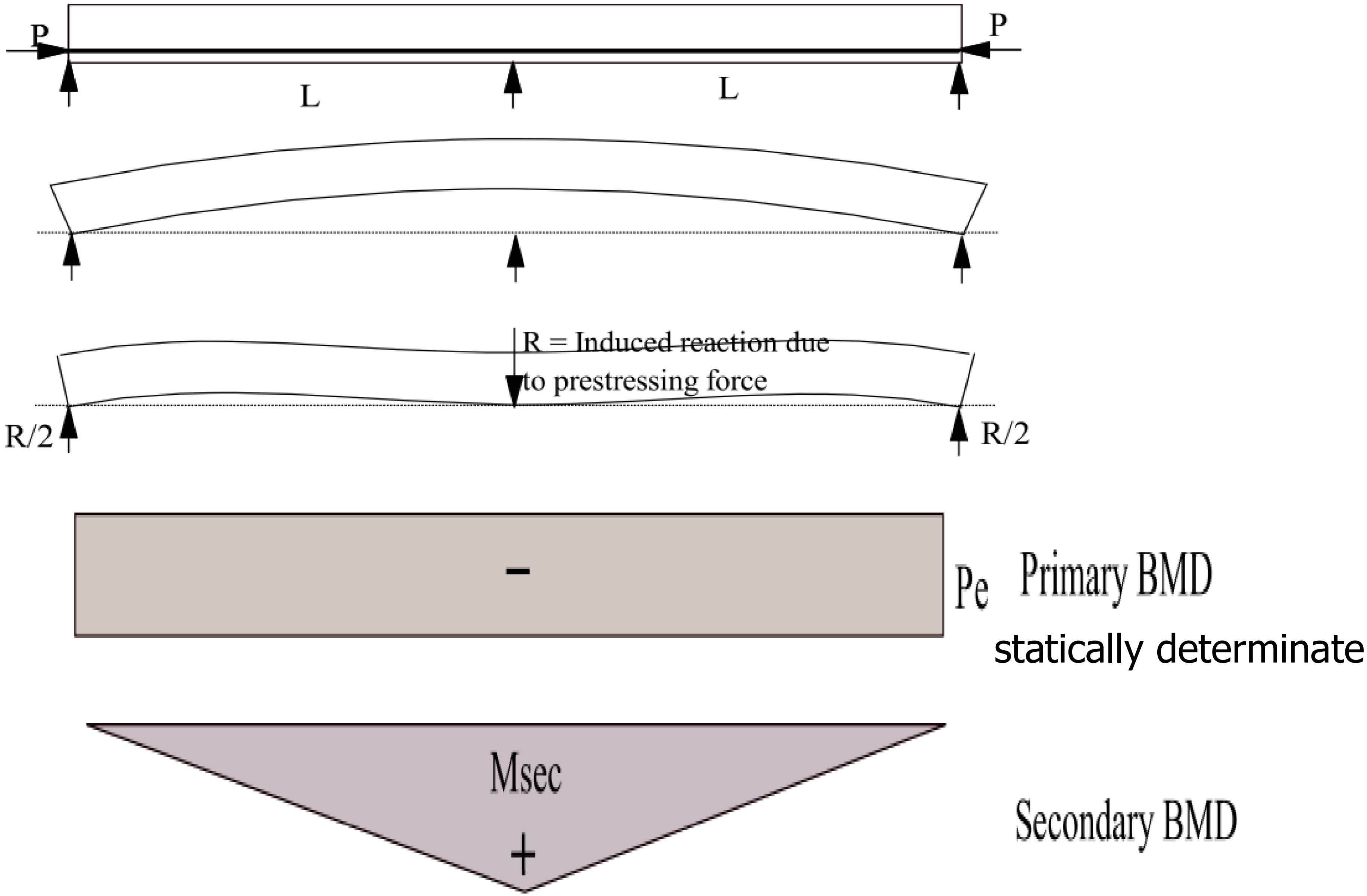
- The magnitude of prestressing force
- The layout of the beam
- Tendon profile

Secondary Effects



In continuous members, additional restraints at supports causes secondary effects.

Secondary Effects



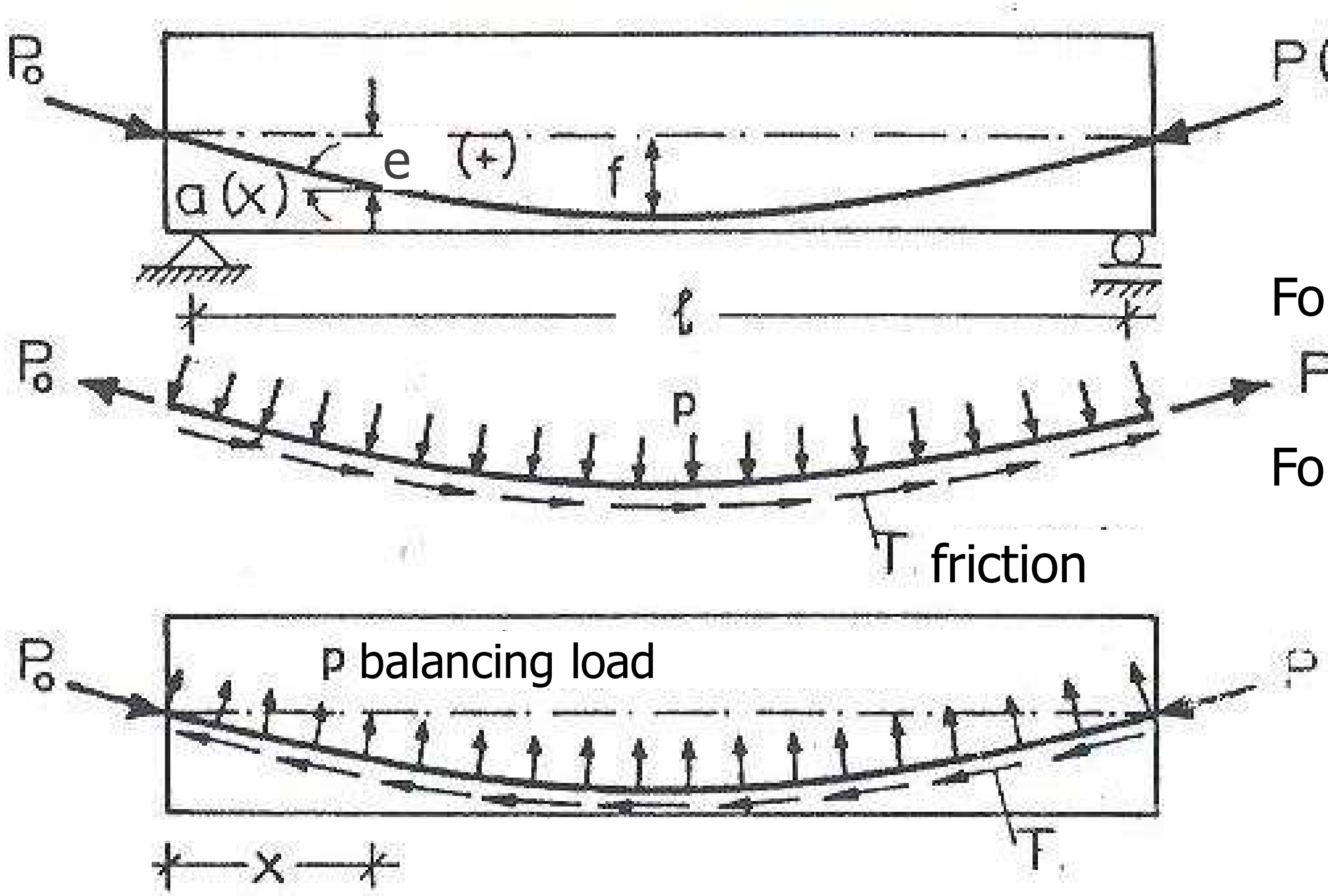
Guidance

Is the structural system statically indeterminate?

If **yes** then secondary moments are developed if:

- The tendon has **eccentricity** with respect the CG of the section (to a non-fixed end) or when
- The tendon has **curvature** or changes in direction (**polygonal** tendon)

For the above cases balancing load method can be used

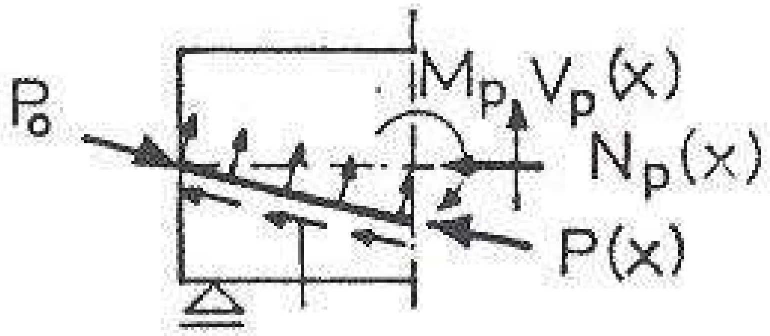


Prestressed beam

Forces along the tendons

Forces on the concrete

How much are the reactions here?



<u>Internal actions-Equilibrium</u>

$$N_p(x) = -P(x).\cos a(x)$$

$$M_p(x) = -e(x).P(x).\cos a(x)$$

$$V_p(x) = -P(x).\sin a(x)$$

$$dV = \frac{p}{\cos da} dS \qquad da = \frac{dS}{R}$$

$$dV = P \sin da \cong P da$$

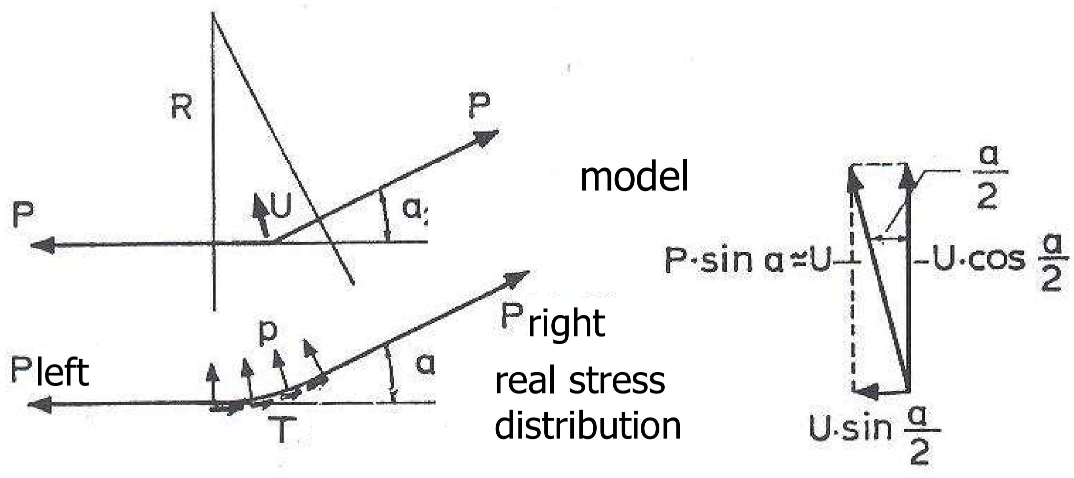
$$p = \frac{dV \cos da}{dS} = \frac{P \sin da \cos da}{dS} = \frac{P da}{dS} = P \cdot \frac{1}{R} = -uP$$

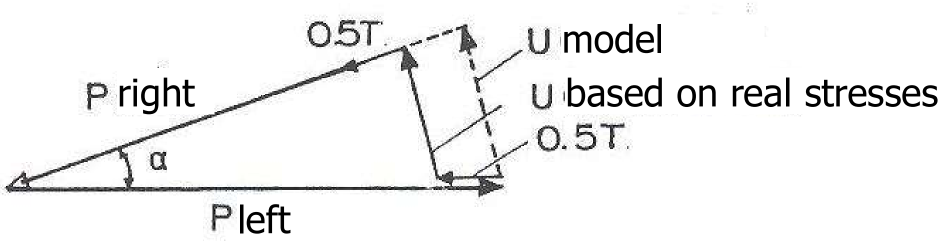
$$\boxed{p = -uP}$$

And the curvature can be calculated by the tendon's parabola:

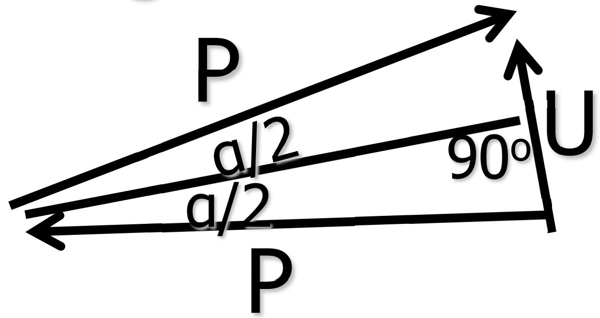
$$u = (-1/R) = \frac{-8\, f}{\ell^2}$$

Show that: U=Pα when tendon changes direction





$$U = \begin{cases} P \sin \alpha & \text{:model (without friction)} \\ \frac{1}{2}\left[P_{left} + P_{right}\right] \sin \alpha & \text{(with friction)} \end{cases}$$



From the above figure:

$U/2 = P \cdot \sin(\alpha/2)$

$U = 2\,P \cdot \sin(\alpha/2) = P \cdot \alpha$

Remember : sin(a) = 2·sin(a/2)·cos(a/2)

If friction is negligible (T<0,05P):

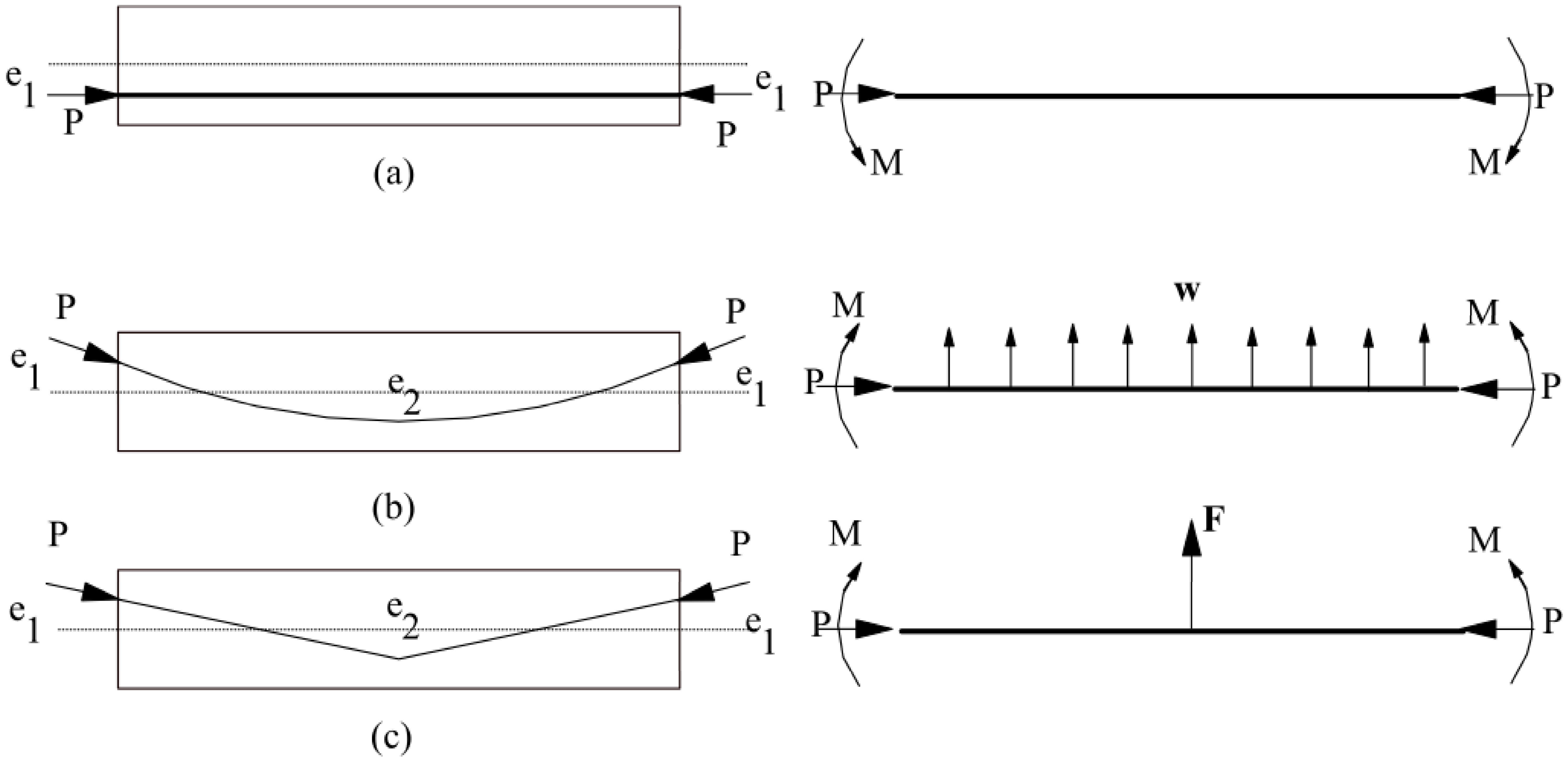
$P_{right} = P_{left}$

$$U = P \sin\alpha = P\,\alpha$$

Equivalent Load Analysis

- Another method of estimating **secondary** effects
- Can be used to calculate the total moments **directly**
- Can easily be used for **complicated profiles** and multiple spans.

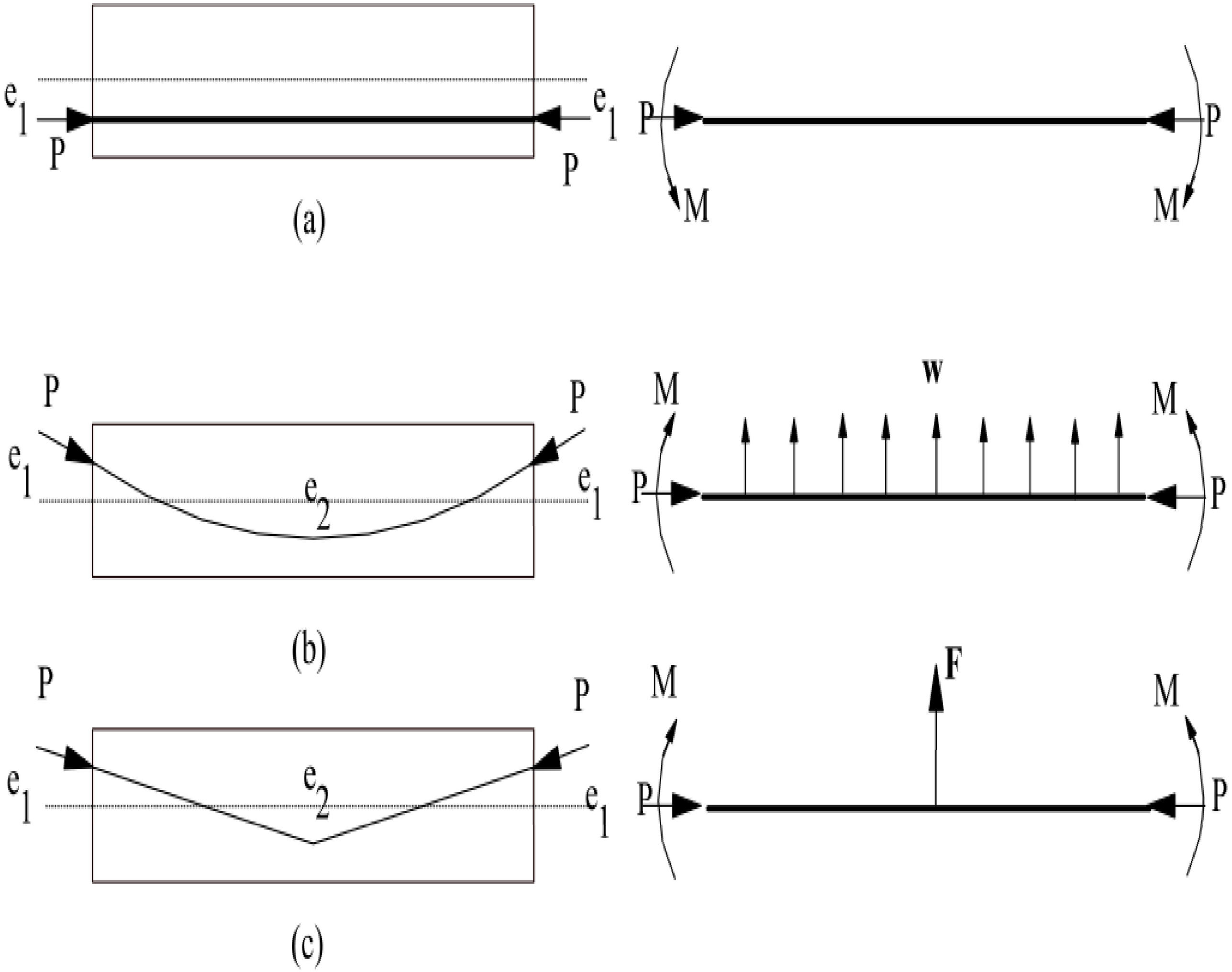
Equivalent Load Analysis



Apply these loads to the beam and you get M_{tot}

What if you want to calculate the M_{sec}?

Equivalent Load Analysis



$M = P.e_1$

$M = P.e_1$

$w = 8P(e_1 + e_2)/L^2$

$w = uP = P/R_{ps}$

$M = P.e_1$

$F = 4P(e_1 + e_2)/L$