4 (cont'd) $\delta_0 - \delta_c = \Delta = 0.2$ mm.

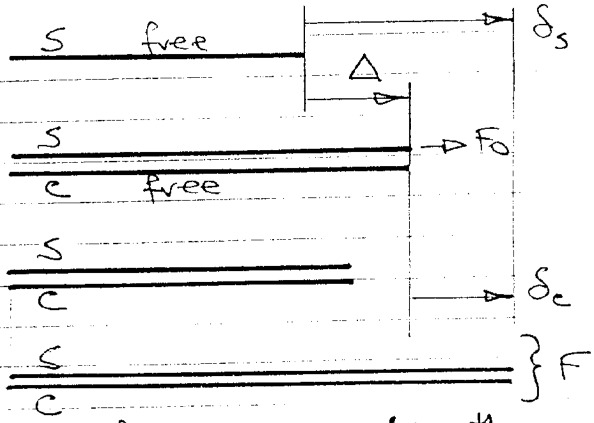
Equilibrium tensions F_0, F_c
$2F_0 + F_c = P = 15$ kN.

Constitutive Laws.
Tensile forces & elongations
$\therefore F = k\delta$ for both central & outer.

Solution
$F_0 = (P + k\Delta)/3 = 6.38$ kN ; $n = \frac{5 \times 2.5}{6.38} = \underline{2.0}$
$F_c = (P - 2k\Delta)/3 = 2.24$ kN. – O.K.
i.e. safety dictated by outer bars.

For the case of the central bar being the shortest, repeat with new compatibility equation, or changing sign of Δ in above, giving
$F_0 = (P - k\Delta)/3 = 3.62$ kN – OK
$F_c = (P + 2k\Delta)/3 = 7.76$ kN ; $n = \frac{5 \times 2.5}{7.76} = \underline{1.6}$
i.e. safety dictated by central bar.

5 Statically indeterminate – have to adopt 3-pronged attack: Sketch components in various states:–

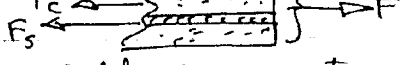


(i) Steel rod as made.
(ii) Prestress steel & cast concrete
– concrete is at free length.
– steel extends by Δ, under F_0
(iii) Release initial load.
– this intermediate state is irrelevant here.
(iv) Apply external load:
– note δ_c & δ_s are deflexions from FREE lengths.

Compatibility Let Δ be the initial extension of the steel rod, and assume steel & concrete deflexions (from corresponding free lengths) are δ_s and δ_c in the loaded condition, as shown

a) $\Delta = \delta_s - \delta_c$

Equilibrium Let F_s & F_c be the tensions in steel and concrete respectively under load.



b) $F = F_s + F_c$

Constitutive Laws. – all parameters are tensile, so

c) $\begin{cases} \Delta = F_0/k_s & \text{– initially} \\ \delta_s = F_s/k_s \\ \delta_c = F_c/k_c \end{cases}$ } under load.

These five equations in the five unknowns Δ, δ_s,