Then, from our general discussion, we readily deduce the following equations:

$$x = \frac{1}{1 + \frac{T}{Ce}} = \sqrt{\tfrac{4}{5}\,ep\left(\tfrac{4}{5}\,ep + 2\right)} - \tfrac{4}{5}\,ep \qquad \text{(A)}$$

$$\frac{T}{C} = \frac{e(1 - x)}{x} \qquad \text{(B)}$$

$$p = \frac{5}{8\,\frac{T}{C}\left(1 + \frac{T}{Ce}\right)} \qquad \text{(C)}$$

$$M_0 = \tfrac{5}{8}\,C\,bd^2\left(1 - \tfrac{2}{5}\,x\right) = p\,T\,bd^2\left(1 - \tfrac{2}{5}x\right) \qquad \text{(D)}$$

Case I.

To design a beam of any assumed quality of steel and concrete to carry a given load.

Here we have given T, C, E_s and E_c

To find p, b, d, for any definite M_0

Example:—

Let $C = 700$ lbs per sq. in. $T = 14{,}000$ lbs. per sq. in.

$E_s = 30{,}000{,}000$. $E_c = 3{,}000{,}000$.

then $\frac{T}{C} = 20$ and $e = 10$.

From (A), $x = \dfrac{1}{1 + \frac{T}{Ce}} = \dfrac{1}{1 + \frac{20}{10}} = \dfrac{1}{3}$

From (C), $p = \dfrac{5}{8 \times 20 \times \left(1 + \frac{20}{10}\right)} = 0.0104$ or 1.04%

$M_0 = \tfrac{5}{8}\,700 \times \tfrac{1}{3}\left(1 - \tfrac{2}{5} \times \tfrac{1}{3}\right) = 126.7\,bd^2$

which gives bd^2 for any value of M_0 that may be given.

Case II.

To determine the stresses in a given beam under any given loading.

Here we have given b, d, p, also E_s and E_c

To determine T and C for any value of M_0

Example:—

Let $b = 6''$, $d = 10''$, $p = 0.0104$

$E_s = 30{,}000{,}000$ $E_c = 3{,}000\,000$, so that $e = 10$

Then from (A):

$$x = \sqrt{\tfrac{4}{5}\,0.104\left(\tfrac{4}{5}\,0.104 + 2\right)} - \tfrac{4}{5}\,0.104 = \tfrac{1}{3}$$

and from (B):

$$\frac{T}{C} = 10\,\frac{1 - \frac{1}{3}}{\frac{1}{3}} = 20$$