Step 5: Compute strain in compression reinforcement ε_{sc} and stress in compression reinforcement σ_{sc}

$$\varepsilon_{sc} = 0.0035\left(1-\frac{d'}{x_m}\right) = 0.0035\left(1-\frac{70}{300}\right) = 2.7\,x10^{-3}$$

From table of stresses σ_{sc} in compression steel

$\therefore$ $\sigma_{sc} = 353\ N/mm^2$

Step 6: Compute area of compression steel

$$A_{sc} = \frac{M - M_{lim}}{\sigma_{sc}(d-d')} = \frac{(576-326)\,x10^6\ N-mm}{353(630-70)} = 1265\,mm^2$$

Step 7: Compute additional area of tension steel

$$A_{t2} = \frac{\sigma_{sc}A_{sc}}{0.87\sigma_y} = 1237\,mm^2$$

Step 7: Compute total area of tension steel

$$A_t = A_{t1} + A_{t2} = 1790 + 1237 = 3027\,mm^2$$

Step 8: Provide reinforcement

Provide 5 - 28 mm bars at bottom (A_t = 3078 mm^2) and provide 5 - 18 mm bars at top (A_{sc} = 1272 mm^2).

Step 9: Check for maximum tension steel

$$A_{max} = 0.04bD = 0.04\,x\,300\,x\,700 = 8400\,mm^2 > 3078\,mm^2$$ Hence O.K.

Example (SSC, Junior Engineer, 2010, Working stress method)

Determine the maximum superimposed distributed load which the beam section 220 mm x 440 mm (effective cover = 40 mm) reinforced with total area of tension steel 1256.64 mm2, can carry, if the effective span is 5 m. Use M20 concrete and Fe 415 steel. Take m = 13.33.

Solution

Size of beam = 220 mm x 440 mm

D =440 mm d = 440 - 40 = 400 mm

A_{st} = 1256.64 mm^2

Effective depth, l = 5 m

Design constants

For M20 concrete σ_{cbc} = 7 N/mm^2

For Fe 415 steel, σ_{st} = 230 N/mm^2

m = 13.33

Critical depth of neutral axis (x_c)

$$x_c = \frac{m\sigma_{cbc}}{m\sigma_{cbc}+\sigma_{st}}xd = \frac{13.33x7}{13.33x7+230}x400 = 115.44\,mm$$