Procedure for the calculation of deflection to EC2

1. **Calculate $E_{c,ef}$:**

$$E_{c,ef} = E_{cm} / (1 + \phi)$$

   Where: ϕ = creep coefficient from table (p154 of Mosley & Bungey)
   $E_{cm} = 9.5 \, (f_{ck} + 8)^{\frac{1}{3}}$

2. **Calculate the modular ratio, m**

$$m = E_s / E_{c,ef}$$

3. **Calculate the uncracked section properties:**

   Depth to the neutral axis, x_u:

$$x_u = (\text{Area moments}) / (\text{Area})$$

   Where: Area moments $= (m - 1)A_{sc}d' + (m - 1)A_s d + bh^2 / 2$

   Area $= (m - 1)A_{sc} + (m - 1)A_s + bh$

   The uncracked second moment of area, I_u:

$$I_u = I_{u,conc} + I_{u,\,asc} + I_{u,as}$$

   Where: $I_{u,conc} = bh^3 / 12 + bh(x_u - h / 2)^2$

   $I_{u,\,asc} = (m - 1)A_{sc}(x_u - d')^2$

   $I_{u,as} = (m - 1)A_s(d - x_u)^2$

4. **Calculate the cracking moment M_{cr}:**

$$M_{cr} = f_{ct} I_u / (h - x_u)$$

5. **Calculate the stress in the tension steel just as the beam cracks, f_{sr}:**

$$f_{sr} = m \, M_{cr} \, (d - x_u) / I_u$$

6. **Calculate the cracked section properties:**

   Depth to the neutral axis, x_c:

$$x_c = [-b_{eq} + (b_{eq} - 4ac)^{0.5}] / 2a$$

Where: $a = b / 2$

$b_{eq} = (m - 1)A_{sc} + mA_s$

$c = - [(m - 1)A_{sc}d' + mA_sd]$

The cracked second moment of area, I_c:

$$I_c = I_{c,conc} + I_{c,\,asc} + I_{c,as}$$

Where: $I_{c,conc} = bx_c^3 / 3$

$I_{c,\,asc} = (m - 1)A_{sc}(x_c - d')^2$

$I_{c,as} = mA_s(d - x_c)^2$

7. Calculate the maximum stress in the tension steel in the cracked section, f_s:

$$f_s = m \, M_{max} \, (d - x_c) / I_c$$

Where: $M_{max} = w_sl^2 / 8$
w_s = total service load on the beam

8. Calculate the tension stiffening factor, ξ:

$$\xi = 1 - \beta_1 \, \beta_2 \, (f_{sr} / f_s)^2$$

Where: β_1 = bond coefficient
= 1   for deformed bars
= 0.5   for plain bars

Where: β_2 = load duration factor
= 1   for short term loads
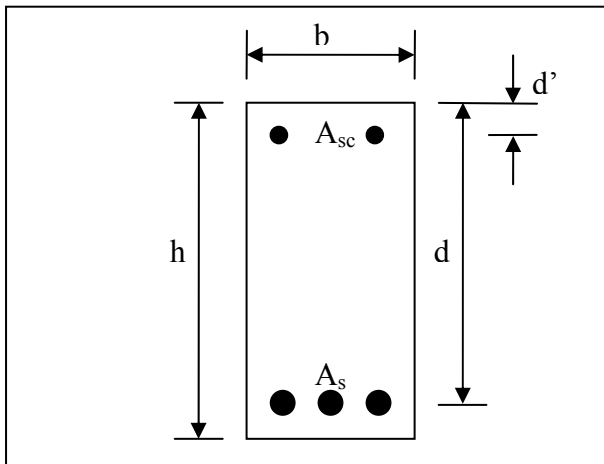= 0.5   for sustained or cyclic loads

9. Calculate the final deflection, δ_{fin}, which must be < span / 250:
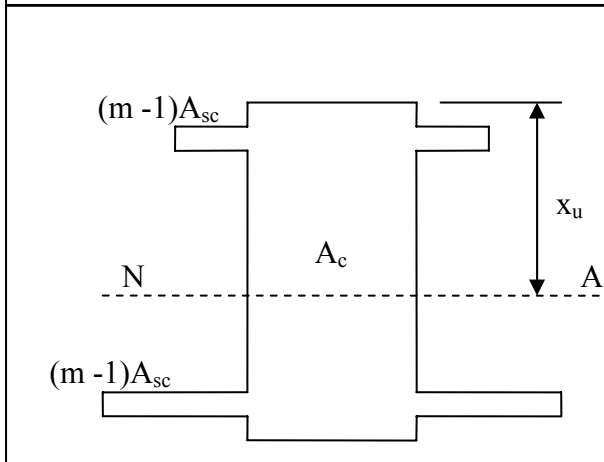
$$\delta_{fin} = \xi \, \delta_c + (1 - \xi) \, \delta_u$$

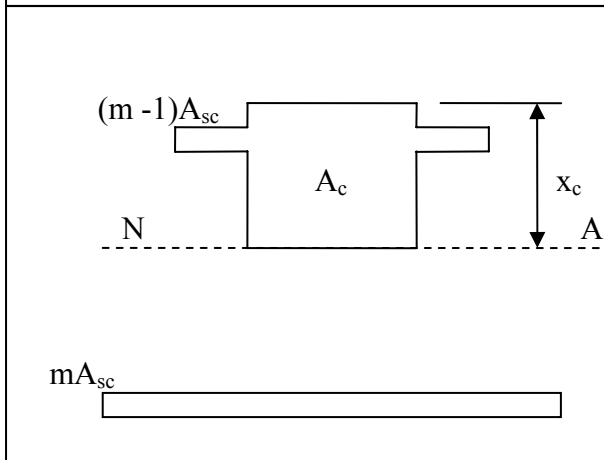Where: $\delta_u = 5 \, w_s \, l^4 / [384 \, E_{c,ef} I_u]$
$\delta_c = 5 \, w_s \, l^4 / [384 \, E_{c,ef} I_c]$

RC BEAM GENERAL FORM

b

d'

A_{sc}

h

d

A_s

RC BEAM: UNCRACKED TRANSFORMED SECTION

$(m-1)A_{sc}$

x_u

A_c

N   A

$(m-1)A_{sc}$

RC BEAM: CRACKED TRANSFORMED SECTION

$(m-1)A_{sc}$

A_c

x_c

N   A

mA_{sc}
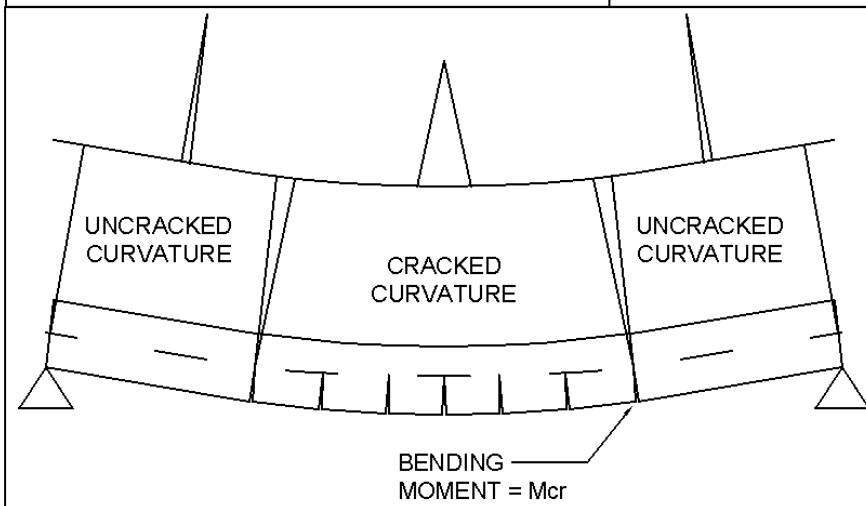
DEFLECTION BEHAVIOUR OF RC BEAM

UNCRACKED CURVATURE

CRACKED CURVATURE

UNCRACKED CURVATURE

BENDING MOMENT = Mcr