Design of Slabs

1 MODULE NO. 1: ULTIMATE FLEXURE STRENGTH

1.1 Inputs

1.1.1 Material Properties

- ✓ Concrete compressive strength (f_{cu})
- ✓ Reduction factor of concrete compressive strength (γ_c=1.50)
- ✓ Yield strength of longitudinal reinforcing steel bars (f_y)
- ✓ Reduction factor of reinforcing steel yield strength(γ_s=1.15)
- ✓ Modulus of elasticity of reinforcing steel bars (E_s = 200,000 N/mm^2)

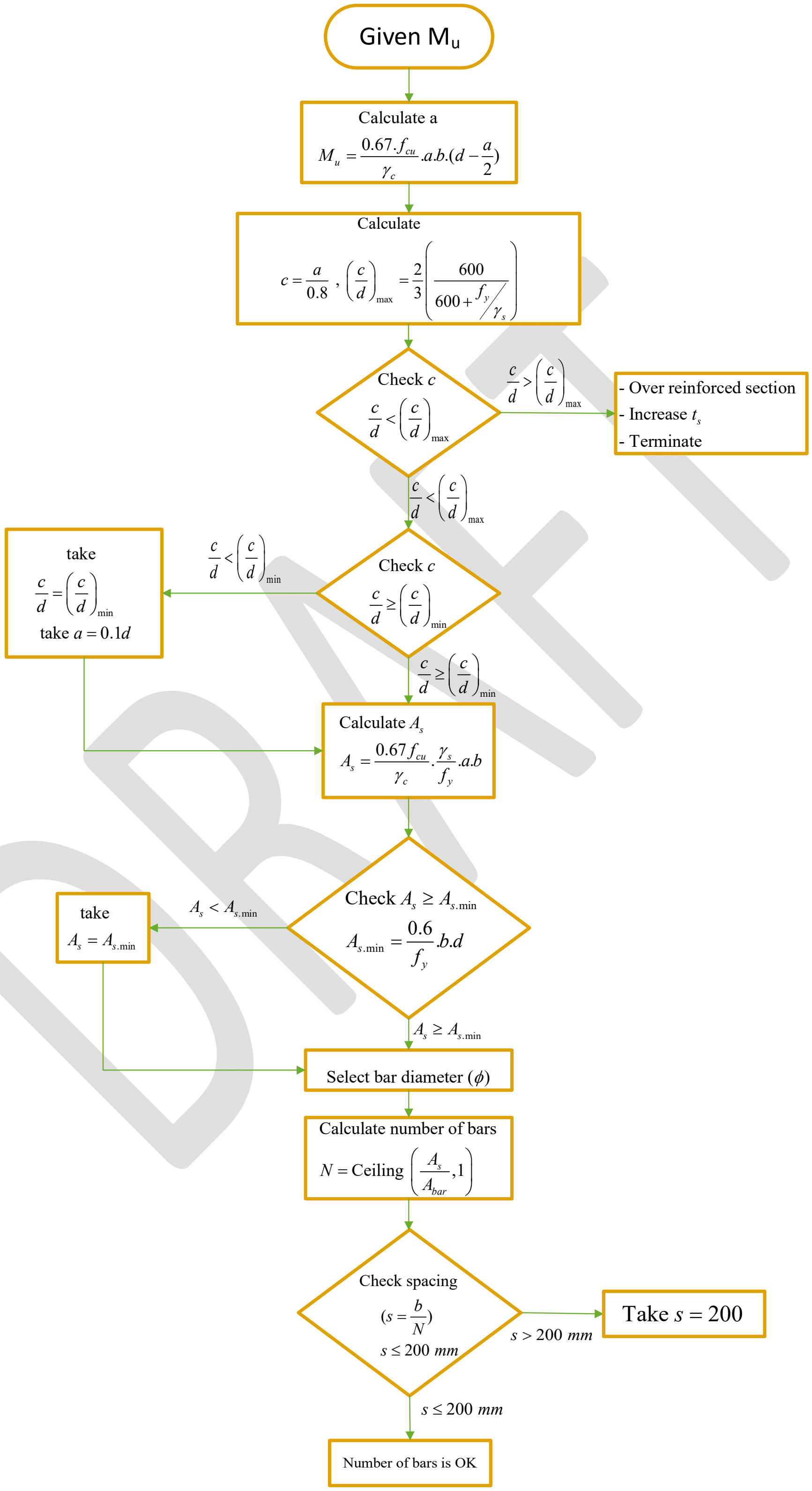
1.1.2 Section Definition

- ✓ Section width (b=1000 mm for 1 meter wide strip)
- ✓ Slab thickness (t_s)
- ✓ Concrete cover

1.1.3 Internal Forces

- ✓ Ultimate Factored Moment from analysis (M_u)

1.2 Calculation Procedure



1.3 Design Outputs

- ✓ Slab thickness (t_s).
- ✓ Diameter of bars.
- ✓ Number of bars.
- ✓ Spacing between bars.

1.4 Example of Calculations using Mathcad

1- Module No. 1: Ultimate Flexure Strength

1.1 Input

1.1.1 Material Properties

$f_{cu} := 30 \dfrac{N}{mm^2}$ Concrete compressive strength

$f_y := 360 \dfrac{N}{mm^2}$ Yield strength of reinforcing steel bar

$E_s := 200000 \dfrac{N}{mm^2}$ Modulus of easticity of steel

$\gamma_c := 1.5$ Concrete strength reduction factor

$\gamma_s := 1.15$ Steel strength reduction factor

1.1.2 Section Definition

$b := 1000\ mm$ Section width

$t_s := 160\ mm$ Slab thickness

$conc.cover := 20\ mm$ Concrete Cover

1.1.3 Internal Forces

$M_u := 20\ kN \cdot m$ Ultimate Factored Moment from analysis

1.2 Calculation Procedure

$d := t_s - conc.cover = 140\ mm$

$a := 1\ mm$

$$a := \textbf{root}\left(M_u - 0.67 \frac{f_{cu}}{\gamma_c} \cdot a \cdot b \cdot \left(d - \frac{a}{2}\right), a\right) = 11.1\ mm$$

$c := \dfrac{a}{0.8} = 13.9\ mm$

$$f_{c1} := \textbf{if}\left(\frac{c}{d} > \frac{2}{3} \cdot \frac{0.003}{0.003 + \frac{f_y}{\gamma_s \cdot E_s}}, \text{“Over reinforced section, increase ts”}, \frac{c}{d}\right)$$

$f_{c1} = 0.099$ fc1 = c/d

$c_1 := \text{if}\left(c < 0.125 \cdot d, 0.125 \cdot d, c\right)$

$c := c_1 = 17.5\ mm$

$a := 0.8 \cdot c = 14\ mm$

$A_s := 0.67 \cdot \frac{f_{cu}}{\gamma_c} \cdot \frac{\gamma_s}{f_y} \cdot a \cdot b = 599\ mm^2$ Calculate As required

$A_{smin} := \frac{0.6 \frac{N}{mm^2} \cdot b \cdot d}{f_y} = 233\ mm^2$ Check of As is >= Asmin

$A_s := \mathbf{if}(A_s < A_{smin}, A_{smin}, A_s)$

$A_s = 599\ mm^2$

$\phi 6 := 28.3\ mm^2$

$\phi 8 := 50.3\ mm^2$

$\phi 10 := 78.5\ mm^2$

$\phi 12 := 113\ mm^2$

$\phi 14 := 154\ mm^2$

$\phi 16 := 201\ mm^2$

$\phi 18 := 254\ mm^2$

$\phi 20 := 314\ mm^2$

$\phi 22 := 380\ mm^2$

$\phi 25 := 491\ mm^2$

$\phi 28 := 616\ mm^2$

$\phi 32 := 804\ mm^2$

$\phi 38 := 1134\ mm^2$

$N := \frac{A_s}{\phi 10} = 7.6$

$N := \mathrm{Ceil}(N, 1) = 8$

$s := \frac{b}{N} = 125\ mm$

$s := \mathbf{if}(s > 200\ mm, 200, s)$

$N := \mathrm{Ceil}\left(\frac{b}{s}, 1\right) = 8$

1.3 Output

$t_s = 160\ mm$ Use $N = 8$ $\phi 10$ @ $s = 125\ mm$