Chapter Two: Flexure in Beams

2.1Introduction

Methods of design:

1. Working Stress Design :WSD
2. Strength Design Method : SDM

2.2. Strength Design Method: SDM

Advantage of SDM over WSD:

1) Consider mode of failure
2) Nonlinear behavior of concrete
3) More realistic F.S.
4) Ultimate load prediction ≅ 5%
5) Saving (lower F.S.)

2.2.1. Load Factors

Factored Load= Load Factors × Service load

Dead Load Factor = 1.2

Live Load Factor = 1.6

-Other type of loads

Wind Load: load factor= 1.6

Lateral Earth Pressure: load factor =1.6

-Load Combinations

Factored Load = 1.2 DL + 1.6 LL

2.2.2. Strength Reduction Factors

Nominal Strength (N) = Strength of a member calculated using Strength Design Method

Strength Reduction Factor = factor that account for

(1) Variations in material strengths and dimensions
(2) Inaccuracies in the design equations
(3) Degree of ductility and required reliability of member
(4) Importance of member in the structure

Bending $\varphi = 0.90$

Shear and Torsion $\varphi = 0.75$

Compression $\varphi = 0.65$ (column with ties) or 0.7 (column with spirals)

$\varphi M_n = M_u$, $\varphi V_n = V_u$, $\varphi P_n = P_u$ *where:*

n = Nominal strength

u = Ultimate load

2.2.3. Rectangular section with singly reinforcement

Singly reinforced section means that the section is subject to bending moment only.

Many necessary terms must be known before the start of design:

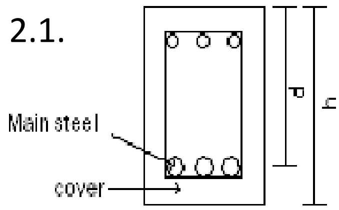
1-The effective depth (d) is the difference between the overall depth and the distance from the concrete cover to the center of gravity of the reinforced steel as in figure 2.1.

2-The main steel is the necessary steel to resist the tension according to the bending moment as shown in figure 2.1.

3-The concrete cover as in figure 2.1 is necessary to protect the main steel and it is taken according to codes depends on:

a) Environment conditions.
b) Size of main reinforced steel bars.
c) Type of structure.

Figure 2.1.



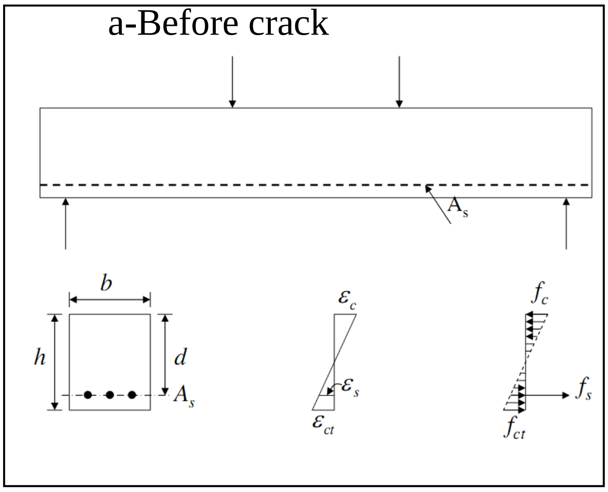
The following minimum concrete cover shall be provided for reinforcement,

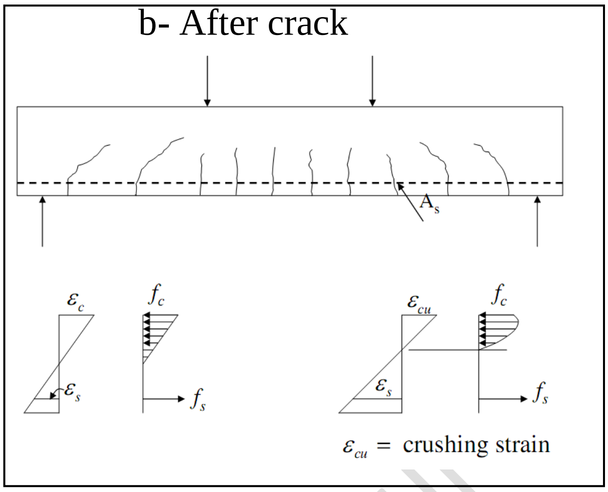
Case			Min. cover (mm)
Concrete cast against and permanently exposed to earth			75
Concrete exposed to earth or weather	No. 19 through No. 57 bars		50
	No. 16 bar, MW 200 or MD 200 wire، and smaller		40
Concrete not exposed to weather or in contact with ground	Slabs, walls, joists:	No. 43 and No. 57 bars	40
		No. 36 bar and smaller	20
	Beams, columns:		40

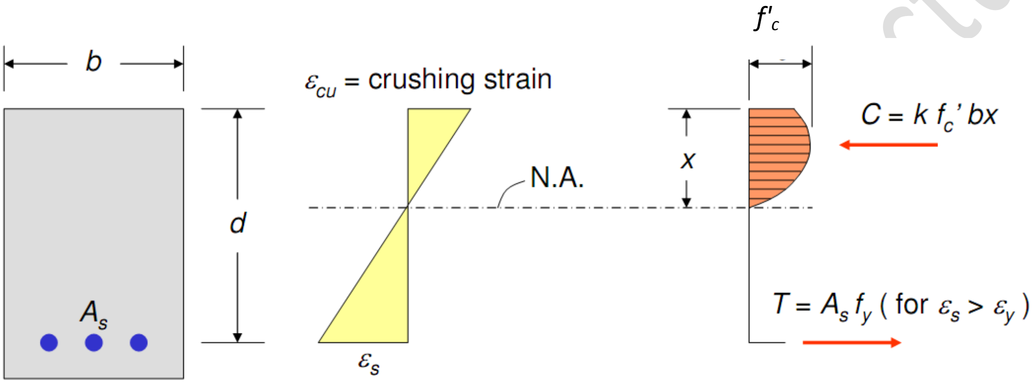
From the practical we can use concrete cover depend on the type of structure as follows:

a) Beam subject to moderate conditions, take cover 40 mm.
b) Foundation exposed to earth permanently, take cover 75 mm.
c) Slab exposed to earth permanently, take cover 20 mm.

2.2.3.1. Behavior of Concrete Beam





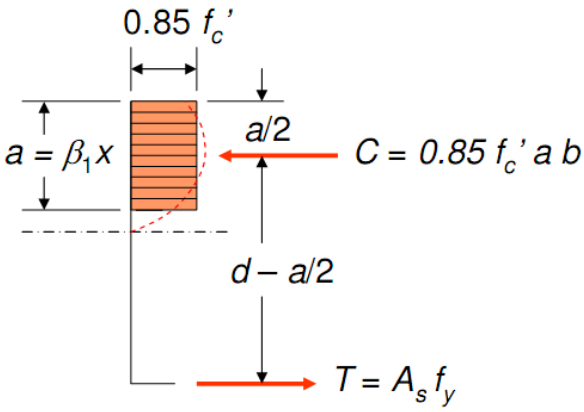


Equivalent Stress Distribution (Whitney stress block)

$$\sum Fx = 0 \qquad\qquad C = T$$

$$0.85 f'_c * ab = A_s f_y$$

$$a = \frac{A_s f_y}{0.85\, f'_c b} = \frac{\rho f_y d}{0.85\, f'_c}$$



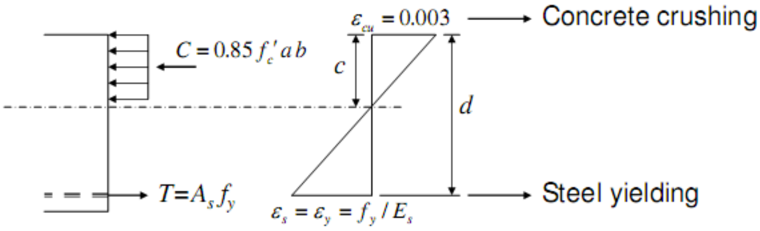
$$M_n = T\left(d - \frac{a}{2}\right)$$

$$= A_s f_y \left(d - \frac{\rho f_y d}{2(0.85) f'_c}\right)$$

$$M_n = \rho f_y b d^2 \left(1 - \frac{\rho f_y}{1.7\, f'_c}\right)$$

$For\, f'_c \leq 28\, MPa,$ $\qquad \beta_1 = 0.85$

$For\, f'_c > 28\, MPa,$ $\qquad \beta_1 = 0.85 - 0.05\left(\frac{f'_c - 28}{7}\right) \geq 0.65$



$$\frac{c}{d} = \frac{\varepsilon_{cu}}{\varepsilon_{cu} + \varepsilon_y}$$

$$c = \left(\frac{\varepsilon_{cu}}{\varepsilon_{cu} + \varepsilon_y}\right) d$$