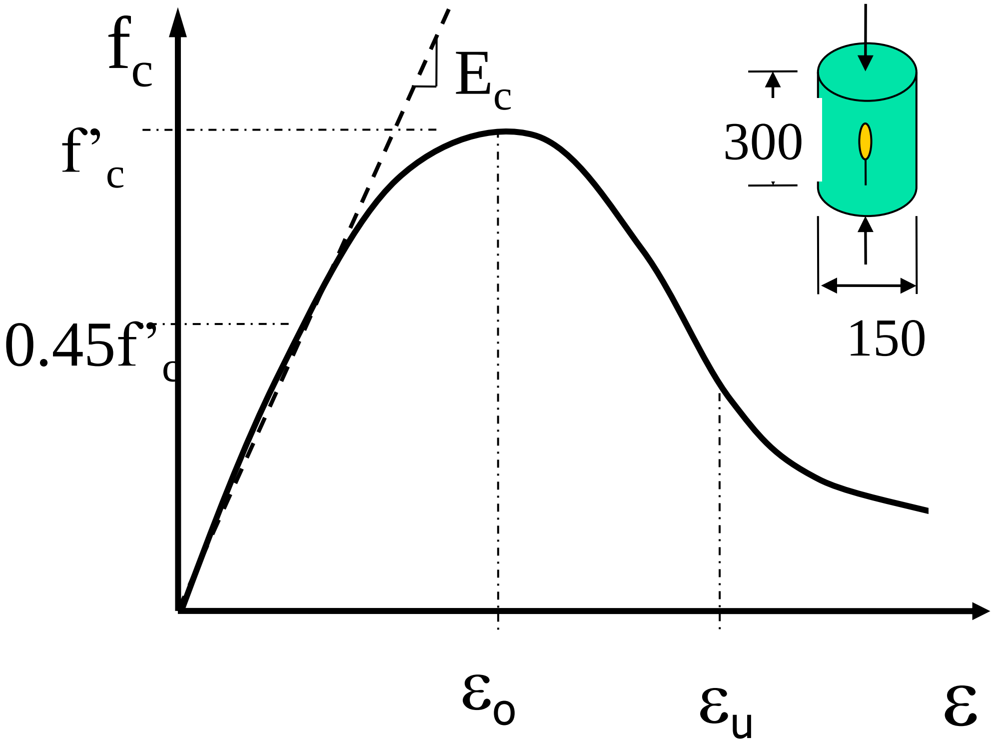
King Saud University
Civil Engineering Department

Material Properties of Concrete and Steel

Concrete Properties

1. Uniaxial Stress versus Strain Behavior in Compression



Concrete Properties

The standard strength test generally uses a cylindrical sample. It is tested after 28 days to test for strength, f'_c. The concrete will continue to harden with time.

Concrete Properties

- Compressive Strength, f'_c
  - Normally use 28-day strength for design strength
- Poisson's Ratio, ν
  - $\nu \sim 0.15$ to 0.20
  - Usually use $\nu = 0.17$

Modulus of Elasticity, E_c

- Corresponds to secant modulus at 0.45 f'_c
- ACI 318-02 (Sec. 8.5.1):

$$E_c\,(MPa) = 0.043\,w^{1.5}\sqrt{f'_c\,(MPa)}$$

where w = unit weight

1500 kg/m3 < w_c <2500 kg/m3

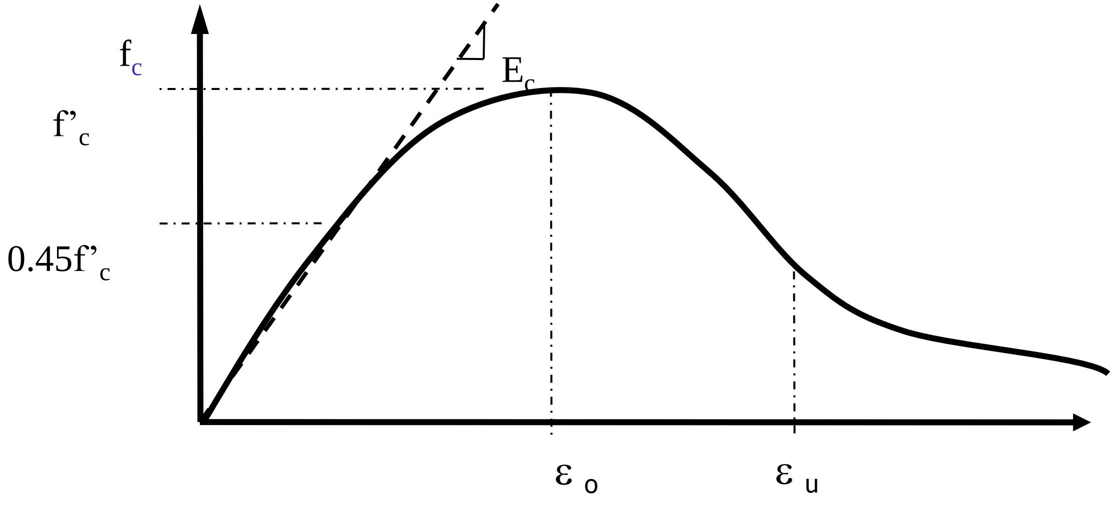
$$E_c\,(MPa) = 4{,}700\sqrt{f'_c\,(MPa)}$$

For normal weight concrete

($w_c \cong$ 2300kg/m3)= 23 Kn/m3, for Reinforced Concrete Wc= 24 Kn/m3)

Concrete strain at max. compressive stress, ε_0

- For typical ε curves in compression
- ε varies between 0.0015-0.003
- For normal strength concrete, $\varepsilon_0 \sim 0.002$



Concrete Properties

- Maximum usable strain, ε_u
  - ACI Code: $\varepsilon_u = 0.003$
  - Used for flexural and axial compression

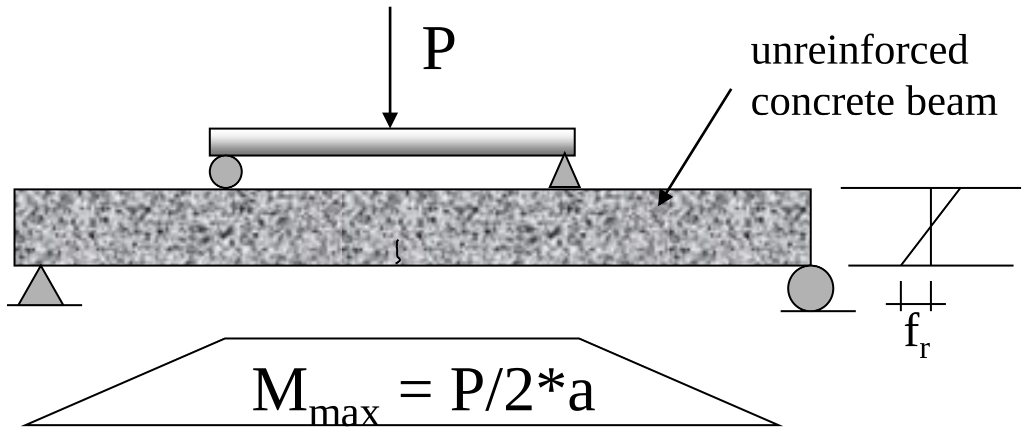
Tensile Strength

Tensile strength ~ 8% to 15% of f'_c

- Modulus of Rupture, f_r
  - For deflection calculations, use:

$$f_r = 0.7\sqrt{f'_c}\ (MPa) \qquad \text{ACI Eq. 9-10}$$

- Test:

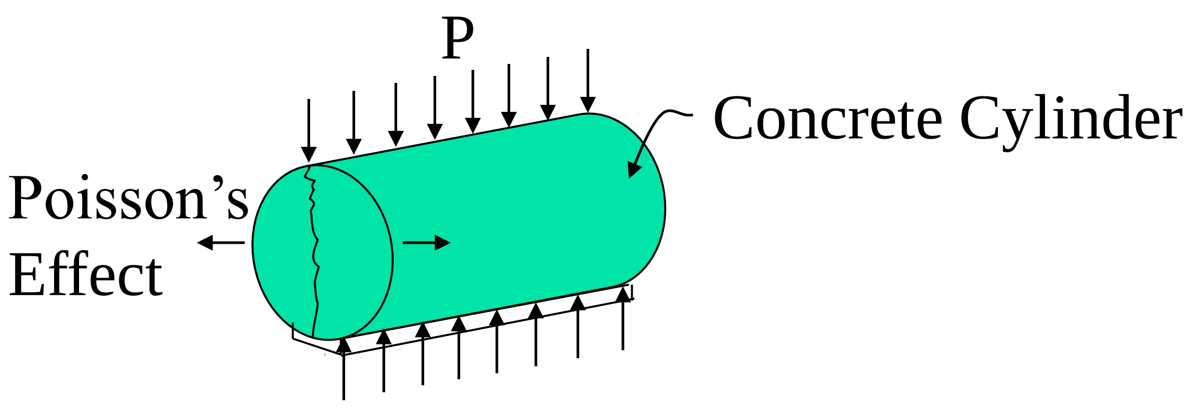


$$f_r = \frac{Mc}{I} = \frac{6M}{bh^2}$$

Tensile Strength (cont.)

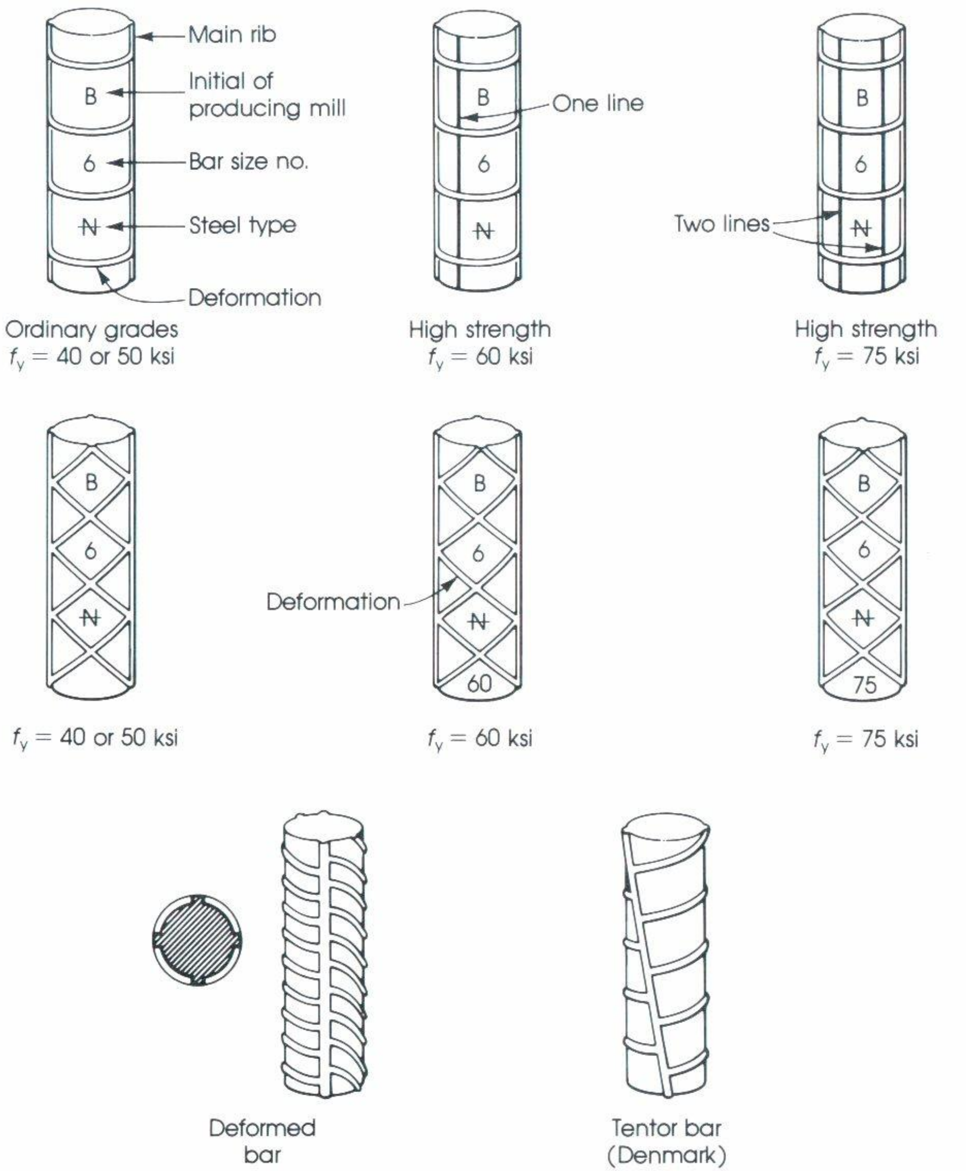
- Splitting Tensile Strength, f_{ct}
- Split Cylinder Test

- $f_{ct} = 2P/\pi DL$



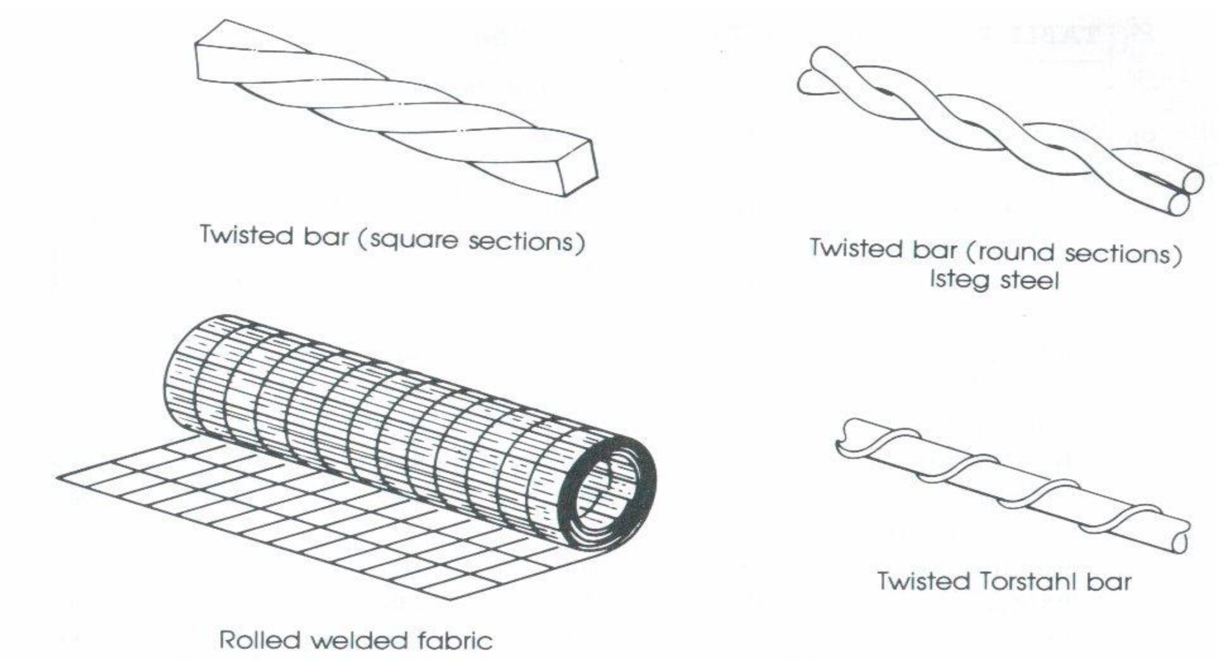
Steel Reinforcement

1. General
   - Standard Reinforcing Bar Markings



Steel Reinforcement

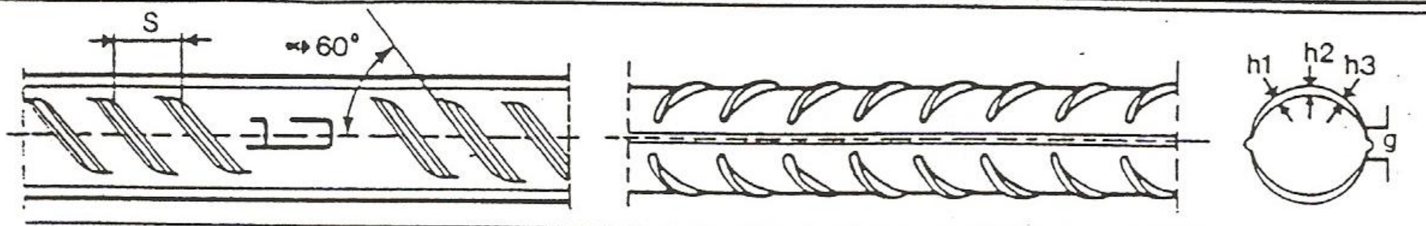
- Most common types for non-prestressed members:
  - hot-rolled deformed bars
  - welded wire fabric



Steel Reinforcement

- Areas, Weights, Dimensions

Bar Dimensions



Transverse rib average spacing = S
The mark ( ) is not applicable for smaller sizes. (6,8) mm

Transverse rib average height
$h = (h_1 + h_2 + h_3) \times 1/3$

Transverse rib gap = g

NOMINAL BAR SIZES			TRANSVERSE RIB MEASUREMENTS			
NOMINAL DIAMETER mm	NOMINAL WEIGHT Kg/m	NOMINAL CROSS SECTIONAL AREA mm2	MAXIMUM AVERAGE SPACING S, mm	MINIMUM AVERAGE HEIGHT h, mm	MAXIMUM GAP g, mm	No. of 12 M LONG BARS/ 2T BUNDLE
6	0.222	28.3	4.20	0.24	2.36	751
8	0.395	50.3	5.60	0.32	3.14	422
10	0.617	78.5	7.00	0.40	3.93	270
12	0.888	113	8.40	0.48	4.71	188
14	1.21	154	9.80	0.63	5.50	138
16	1.58	201	11.20	0.72	6.28	106
18	2.00	254	12.60	0.90	7.07	84
20	2.47	314	14.00	1.00	7.85	68
22	2.98	381	15.40	1.10	8.64	56
25	3.85	491	17.50	1.25	9.82	44
28	4.83	616	19.60	1.40	11.00	34
32	6.31	804	22.40	1.60	12.57	26
36	7.99	1018	25.20	1.80	14.14	21
40	9.86	1257	28.00	2.00	15.71	17

BINDING: 4 equidistant straps with 5.5 mm wire

Steel Reinforcement

2. Types
   - ASTM A615 - Standard Specification for Deformed and Plain-Billet Steel Bars
     - Grade 420: f_y = 420 MPa, Dia 6 to Dia50
       - most common in buildings and bridges
     - Grade 300: f_y = 300 MPa, Dia 6 to Dia 12
       - most ductile

Steel Reinforcement

3. Stress versus Strain
   - Stress-Strain curve for various types of steel reinforcement bar.

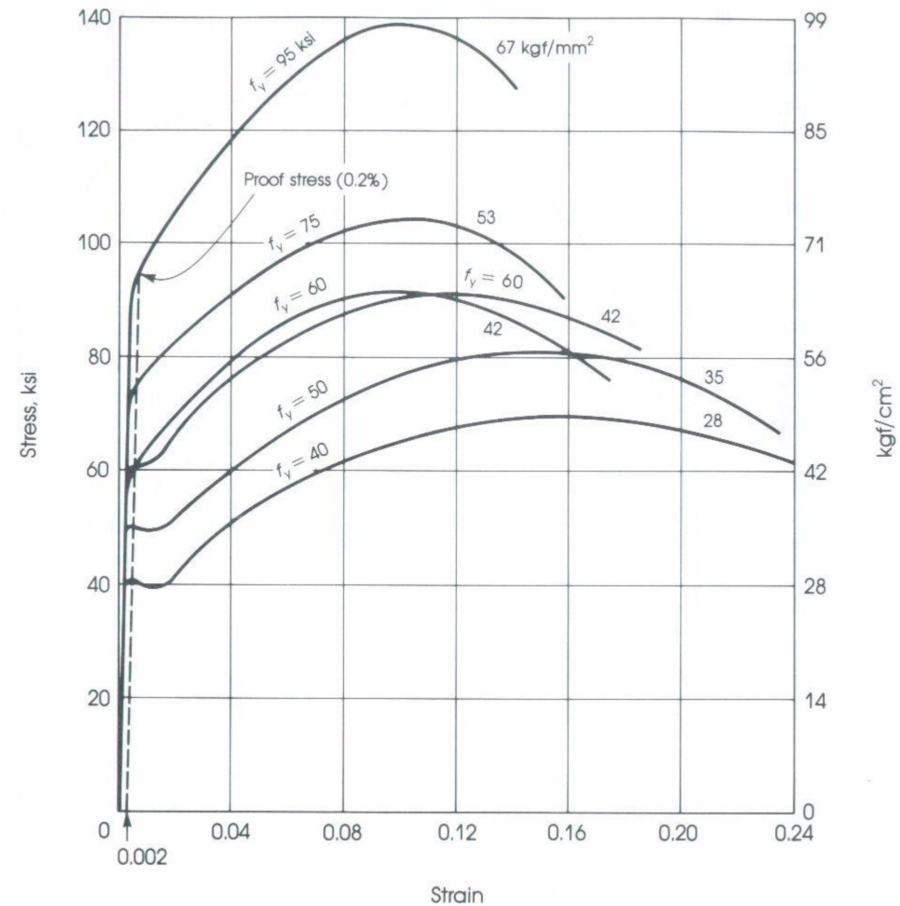


FIGURE 2.15. Typical stress-strain curves for some reinforcing steel bars of different grades. Note that 60-ksi steel may or may not show a definite yield point.

Steel Reinforcement

E_s = Initial tangent modulus = 200,000 MPa
(all grades)

Note:
GR300 has a longer yield plateau