

# Introduction to Infrastructural Engineering

## Construction Materials4

by

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# Strength

Concrete has relatively

- High compressive strength,
- Low tensile strength
- Fair to assume that a concrete sample's tensile strength is about 10%-15% of its compressive strength
- The ultimate strength of concrete is influenced by
  - water-cementitious ratio
  - the design constituents
  - the mixing
  - placement
  - curing methods



# Elasticity

- Function of the modulus of elasticity of the aggregates and the cement matrix and their relative proportions
- The American Concrete Institute allows the modulus of elasticity to be calculated using the following equation:

$$E_c = 33w_c^{1.5} \sqrt{f'_c}$$

where

$w_c$  = weight of concrete (pounds per cubic foot) and where

$$90 \frac{\text{lb}}{\text{ft}^3} \leq w_c \leq 160 \frac{\text{lb}}{\text{ft}^3}$$

$f'_c$  = compressive strength of concrete at 28 days (psi)

# Example

Determine the Modulus of Elasticity of Concrete by the ACI formula for a concrete cylinder that has a unit weight of 120pcf (1920kg/m<sup>3</sup>) and a compressive strength of 3000 psi (21MPa).

$$E_c = 33w_c^{1.5} \sqrt{f'_c}$$

$$= 33 \times 120^{1.5} \sqrt{3000}$$

$$= 2.38 \times 10^6 \text{ psi}$$

# Cracking

- All concrete structures will crack to some extent.
- Cracks due to tensile stress induced by shrinkage or stresses occurring during setting or use



<http://www.hughpearman.com/2007/illustrations/shibboleth01.jpg>



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# Shrinkage cracking

- Occur when concrete members undergo restrained volumetric changes (shrinkage) as a result of either drying, autogenous shrinkage or thermal effects.
- The number and width of shrinkage cracks that develop are influenced by
  - the amount of shrinkage that occurs
  - the amount of restraint present
  - the amount and spacing of reinforcement provided.

# Tension cracking

- Most common in concrete beams where a transversely applied load will put one surface into compression and the opposite surface into tension due to induced bending.
- The size and length of cracks is dependent on
  - The magnitude of the bending moment
  - The design of the reinforcing in the beam at the point under consideration.

# Types of concrete

- Regular concrete
- High-strength concrete
- Stamped concrete
- High-performance concrete
- Self-consolidating concretes
- Vacuum concretes
- Shotcrete
- Pervious concrete
- Cellular concrete,
- Cork-cement composites
- Roller-compacted concrete
- Glass concrete
- Asphalt concrete
- Rapid strength concrete
- Rubberized concrete
- Polymer concrete
- Geopolymer or green concrete
- Limecrete
- Refractory Cement
- Concrete cloth
- Innovative mixtures
- Gypsum concrete





# Concrete testing



Compression testing of a concrete cylinder

<http://www.antouncivil.com.au/vca/Images/testing.jpg>

Same cylinder after failure



<http://www.concrete-curb.com/wp-content/uploads/BreakageCylinder.jpg>



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# General test methods

- Compaction Factor Test (Compacting Factor Test, Glanville)
- Compaction Test
- Free Orifice Test (Orimet Test)
- K-Slump Tester
- Free Flow Test Methods
- Slump Test
- Modified Slump Test
- Slump Rate Machine
- Kelly Ball Test
- Ring Penetration Test
- Cone Penetration Test
- Moving Sphere Viscometer
- Flow Trough Test
- Delivery-Chute Torque Meter
- Delivery-Chute Depth Meter
- Surface Settlement Test

