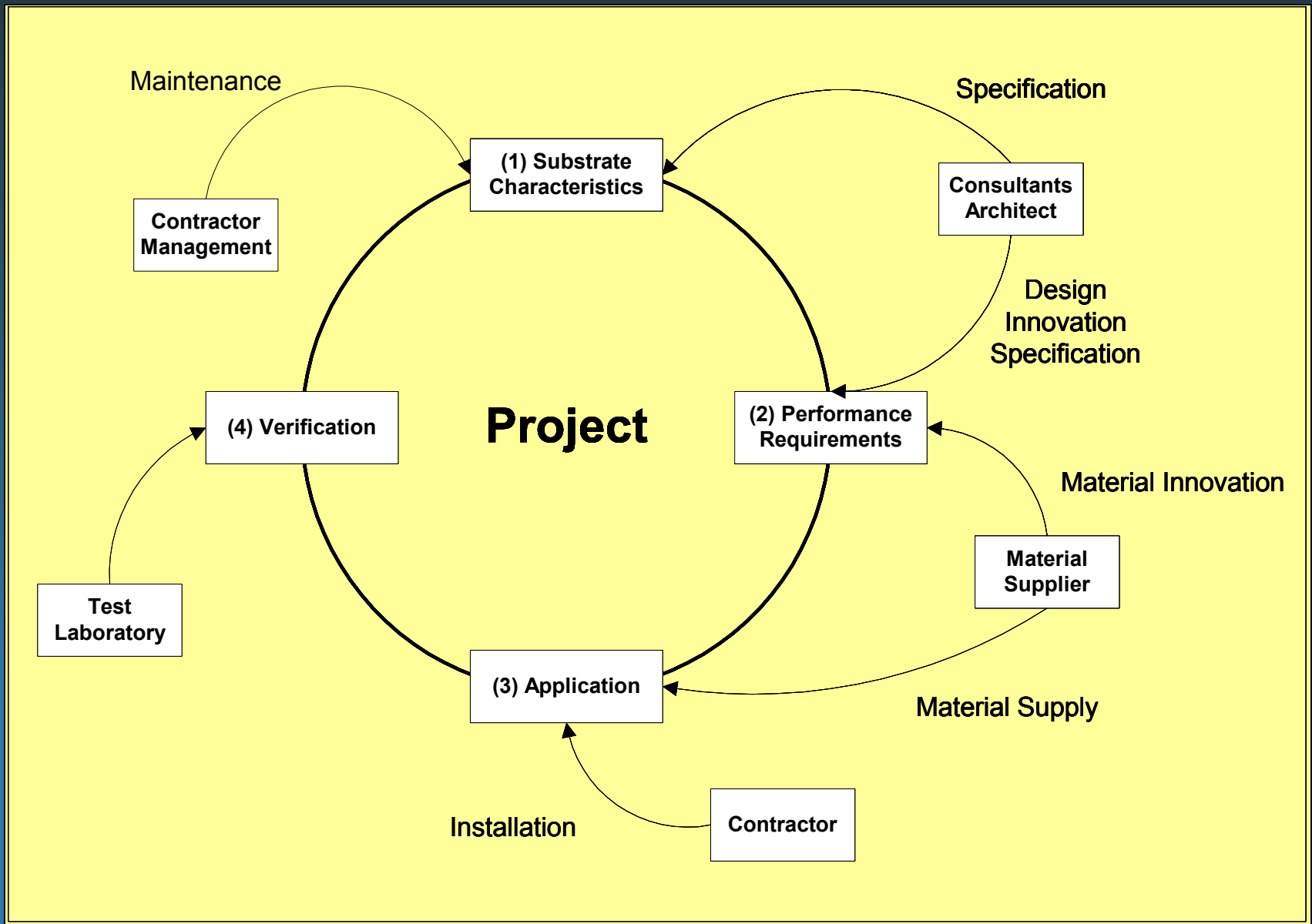
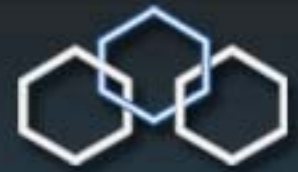
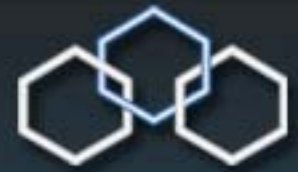


Project Cycle





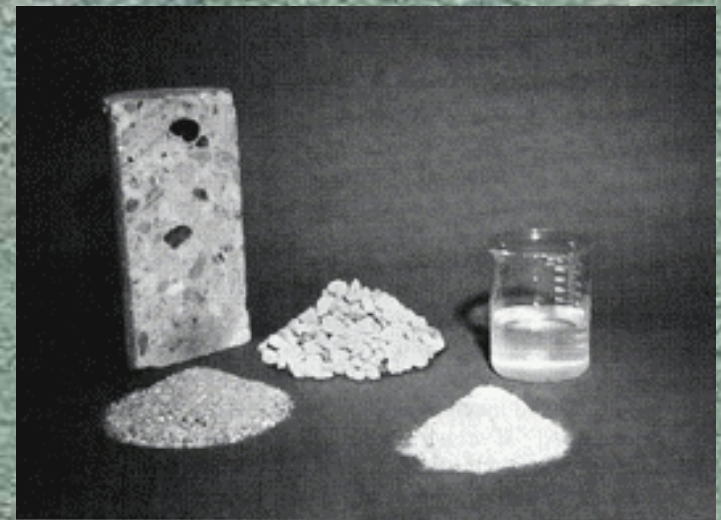
Substrate Characteristics

1. Concrete Chemistry
2. Physical Properties
3. Concrete Protection



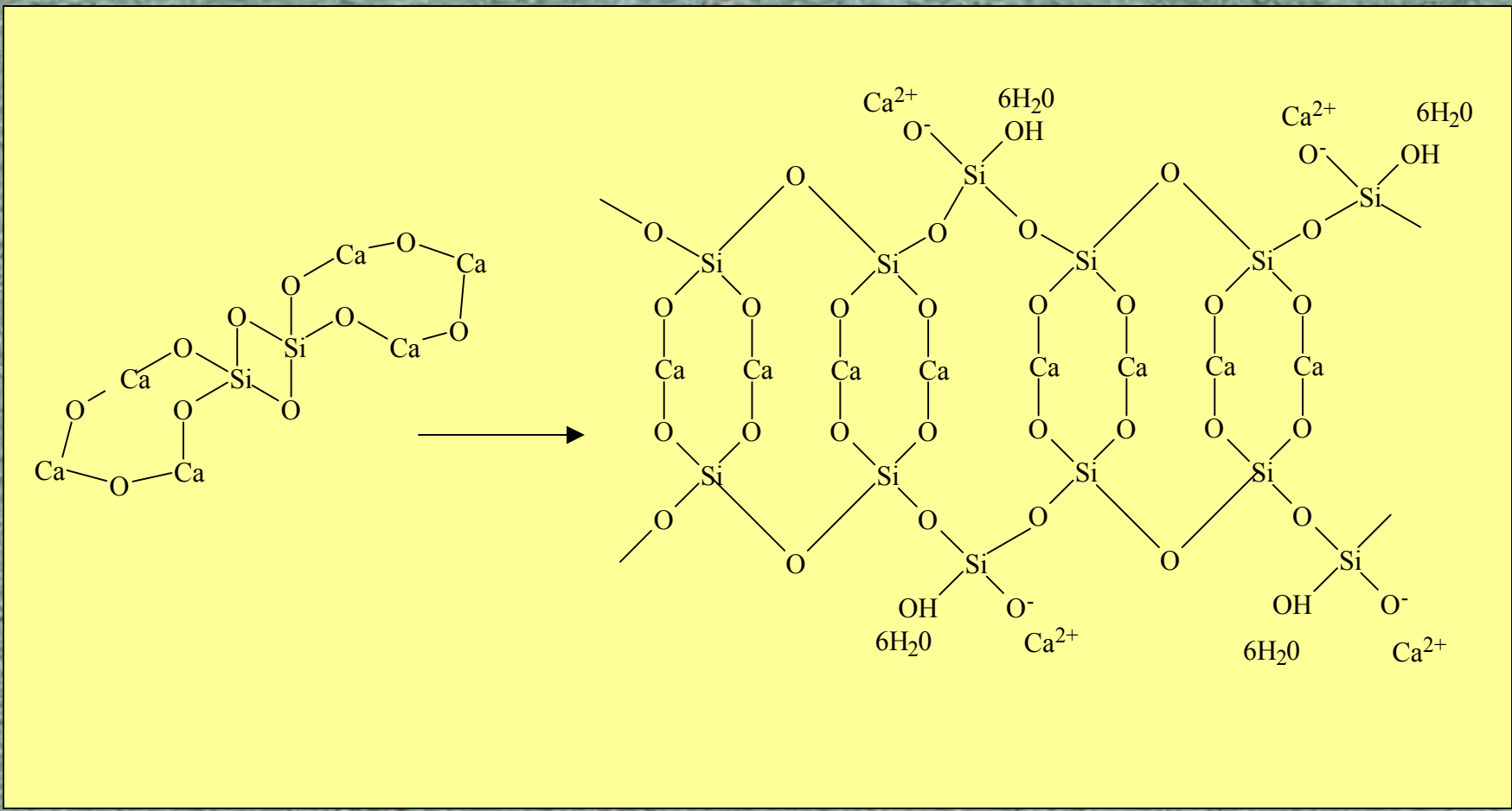
Ingredients of Concrete

- Cement
- Admixtures
- Water
- Aggregate





Chemical Structure





Curing Process of Concrete

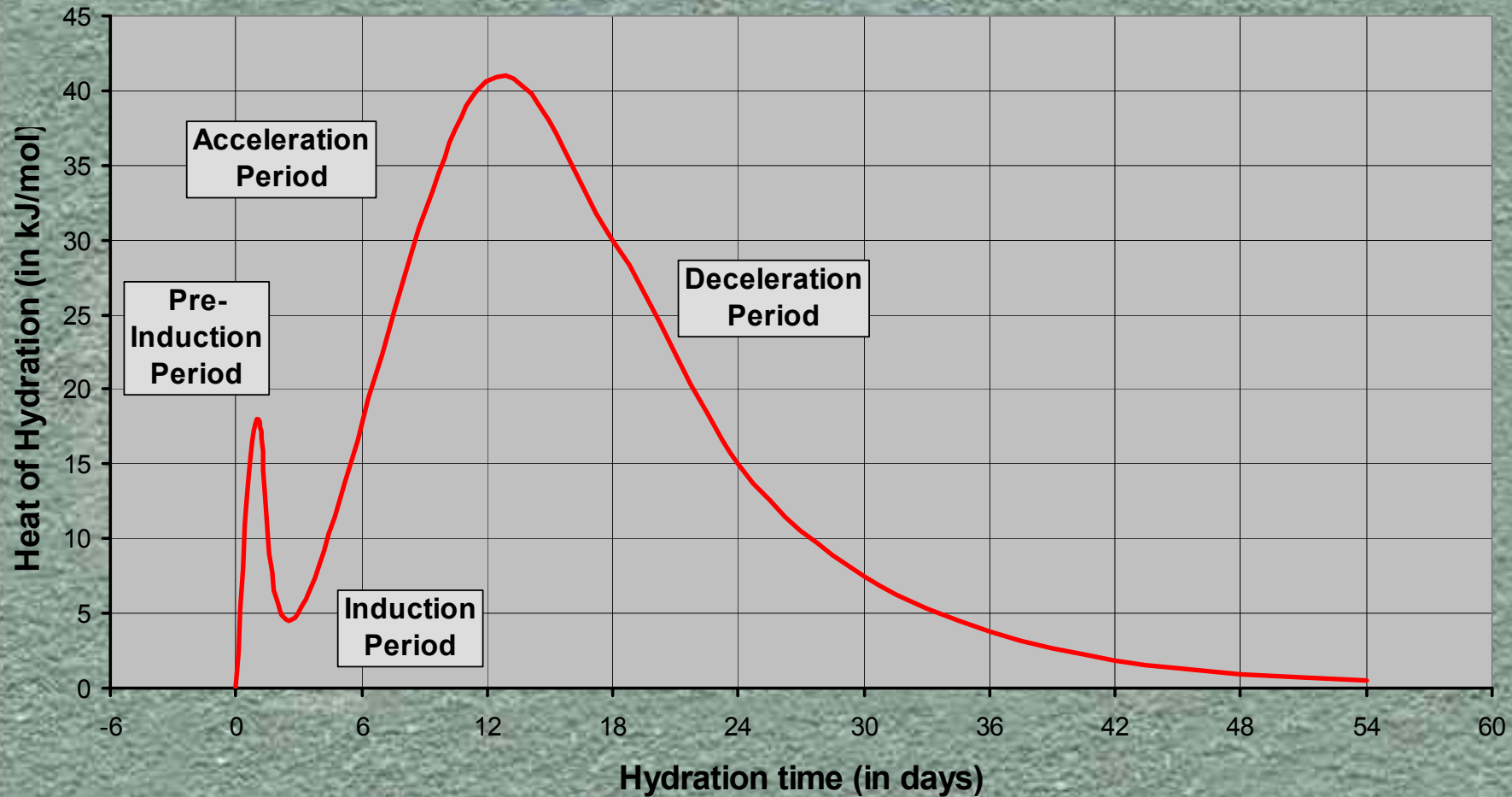
Hydration Process

Tricalcium Silicate $3\text{CaO}\cdot\text{SiO}_2$

- Pre-induction period
- Induction period
- Acceleration period
- Deceleration period



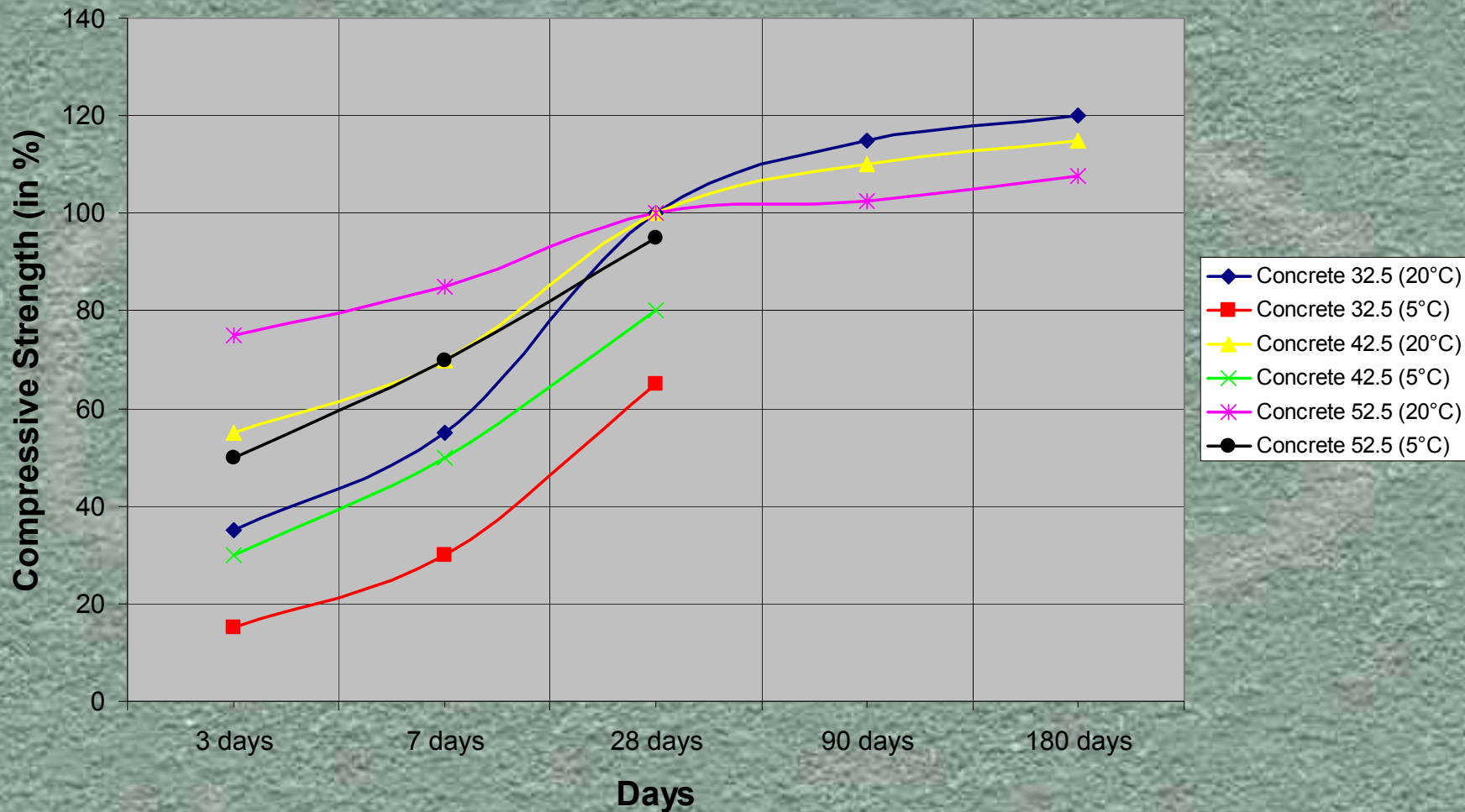
Hydration Heat Evolution



Note: Enthalpy of Portland Cement



Setting: Development of Strength of Concrete





Substrate Characteristics (2)

1. Concrete Chemistry
- 2. Physical Properties**
3. Concrete Protection



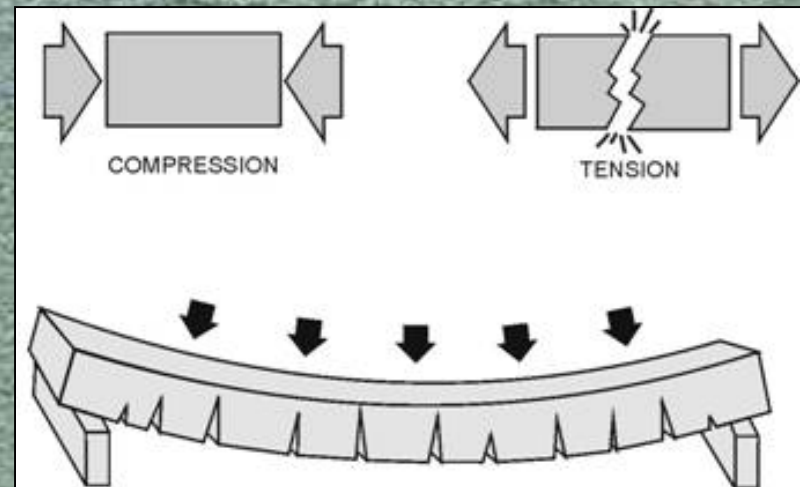
Properties of Concrete

- Strong in compression (4000 psi)
- Weak under tension (<1% elongation)
- Tendency to crack
- Reinforcing bars ("rebar") embedded as tensile reinforcement



Concrete Cracking

- **Surface Cracking**
cracks along rebar
surface spider-web cracking
- **Structural Cracking**
tension cracks
deflection cracks
shear cracks





Concrete Reinforcement

Methods of reinforcement by steel strands or bars (tendons):

- Pre-cast Concrete
- Pre-tensioned Concrete
- Post-tensioned Concrete



Pre-Cast Concrete

- Rebar tensioned before concrete poured
- Cured concrete adheres and bonds to rebar
- Tension released and transferred to concrete
- pre-fabricated elements



**Lazarus Department Store,
Use of precast cladding
allowed architects
to model the façade**



Pre-tension Concrete

- Concrete poured in place
- Pre-tensioned rebar
- Rebar = “passive” reinforcement force carried when concrete deflects



Post-tension Concrete

- Monostrand tendons separated from concrete by duct or plastic sheathing
- Concrete placement and curing
- Tendons stressed (elongated) and anchored
- Compression counteracts tensile forces from loads applied (i.e. cars, people)
“active” reinforcement



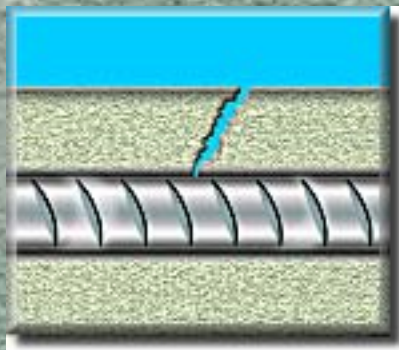
Substrate Characteristics (3)

1. Concrete Chemistry
2. Physical Properties
- 3. Concrete Protection**

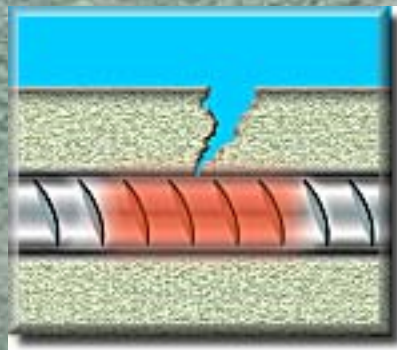


Concrete Protection

Crack develops in concrete. Water migrates to steel rebar initiating corrosion



Crack continues to deteriorate and corrosion of steel rebar increases



Increased loss of structural steel and expansive force of corrosion spalls concrete





Types of Surface Protection

- Sealer
- Coating



Key Properties of Coatings

- Waterproofing
- Crack-bridging
- Weather protection
- Chemical Resistance
- Aesthetics



References

- [1] HEWLETT, P. (Editor): *Lea's Chemistry of Cement and Concrete*, 4th ed., Burlington, MA: Elsevier, 2004
- [2] EBERLING, K.: *Concrete in accordance with DIN*. Published by Assoc. of German Cement Industry, 12th ed., Verlag Bau+Technik GmbH: 1994
- [3] ASTM C125-03: *Standard Terminology Relating to Concrete and Concrete Aggregates*, West Conshohocken, PA: ASTM International 2003
- [4] Usmani, A.M.; *Asphalt Science and Technology*. 1st ed.; New York, NY: Marcel Dekker, Inc., 1997