



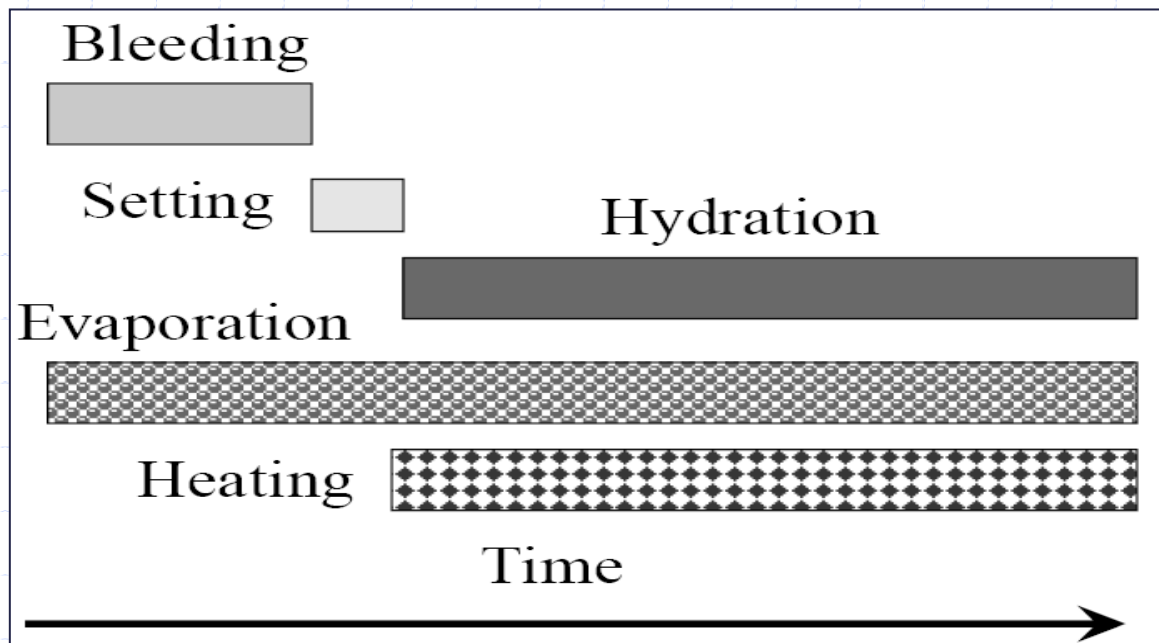
Dimensional Stability



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During First 12 Hours after Concrete Casting

- Bleeding Occurs
- Setting Occurs
- Hydration “Begins”
- Evaporation (Drying)
- Heating (Heat of Hydration plus External Heating)



Bleeding

- Solids settle (gravity)
- Water rises (lower specific gravity)
- Volume change not a problem (no cracking), no structure to resist volume change
- But bleeding channels could form

Setting

- Structure Established in Concrete
 - Structure resists deformation
 - Structure inhibits bleeding

Hydration

- Chemical shrinkage (also called le Chatelier contraction)
Hydration products take less space than cement & water
- Water consumed in hydration : (Autogenous Shrinkage)
- Heat produced
- Strength develops

Hydration

- Consequences of Water Consumption and Autogenous Shrinkage
 - Internal humidity decreases below 100%
 - Concrete shrinks in response to internal tensions

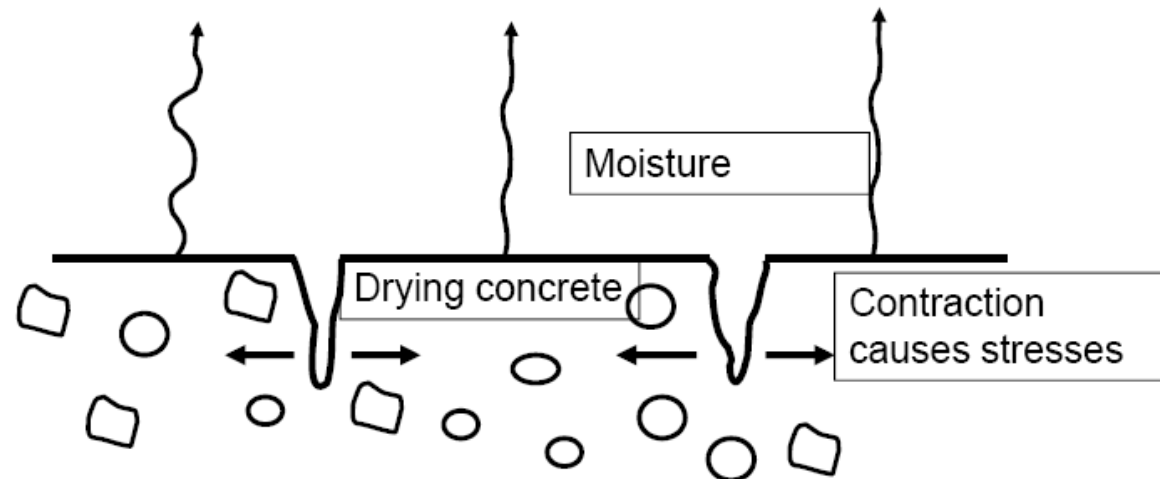
Plastic Shrinkage

- Very Rapid Loss of Moisture, Concrete still Plastic

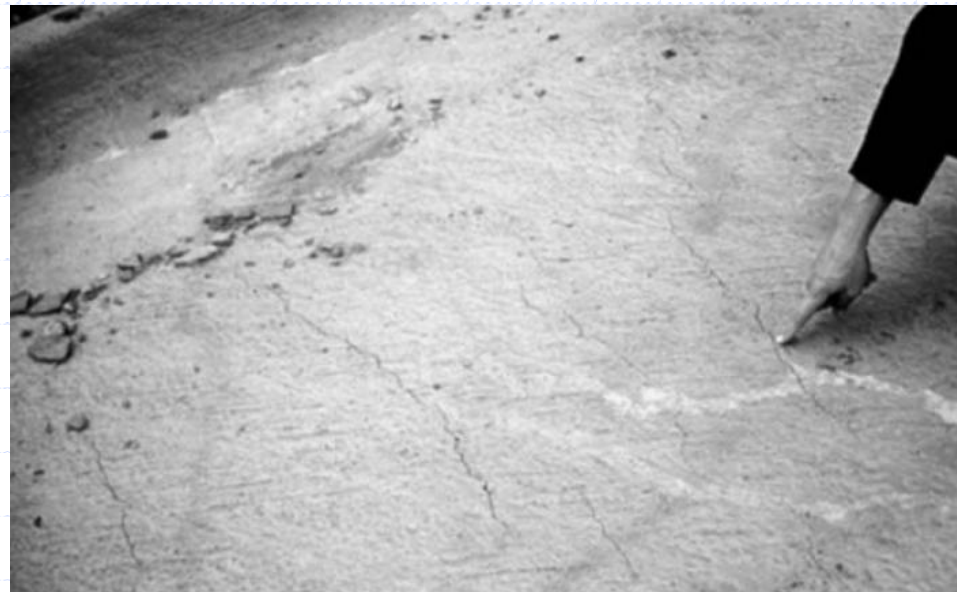
Factors are:

- Concrete and air temperature
- Relative humidity
- Wind velocity

Results in differential volume change in top layer



Plastic Shrinkage



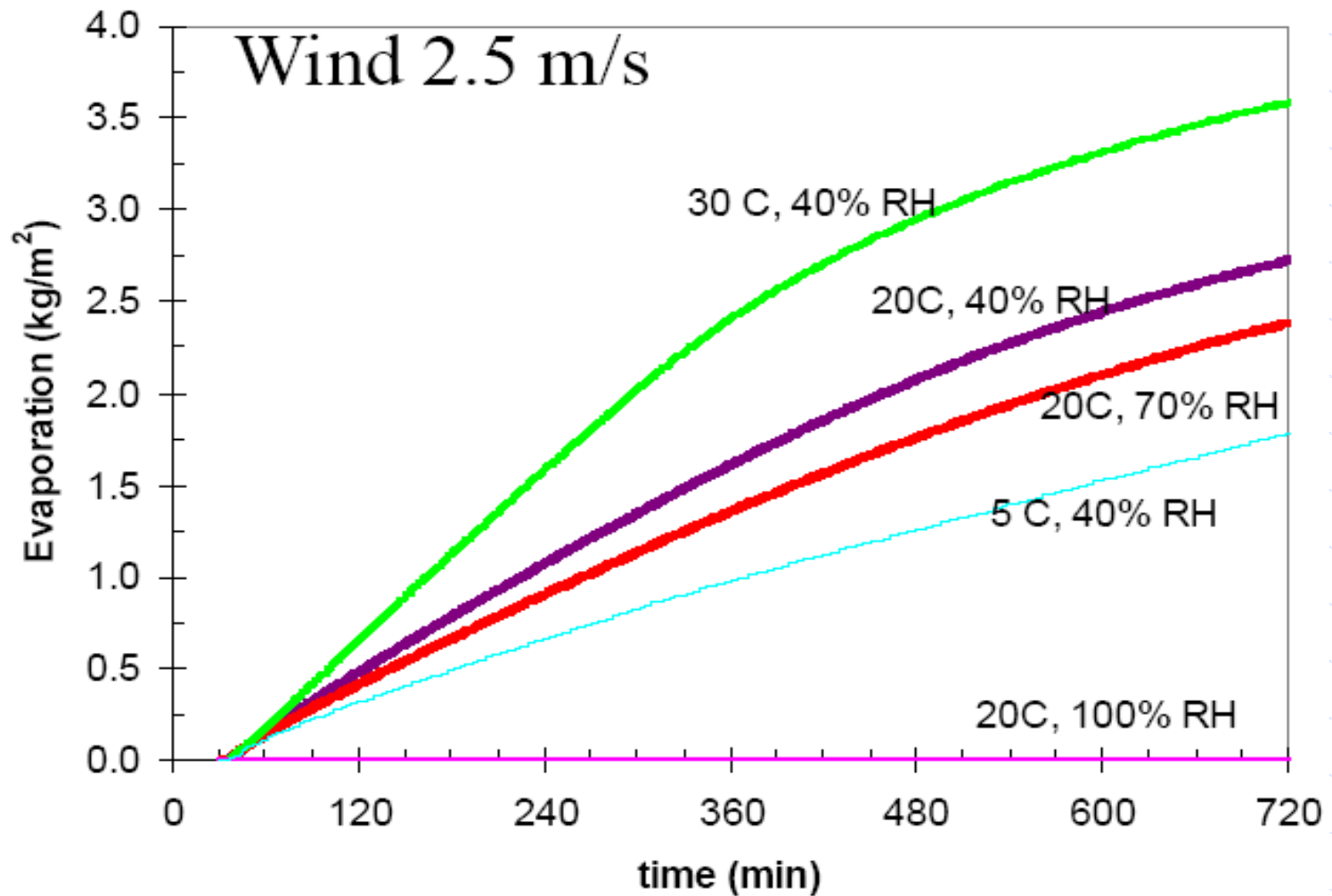
Consequences of Strength Development

- Elastic Modulus Increases
- Tensile Strain Capacity Decreases
- Thermal Expansion Coefficient Decreases

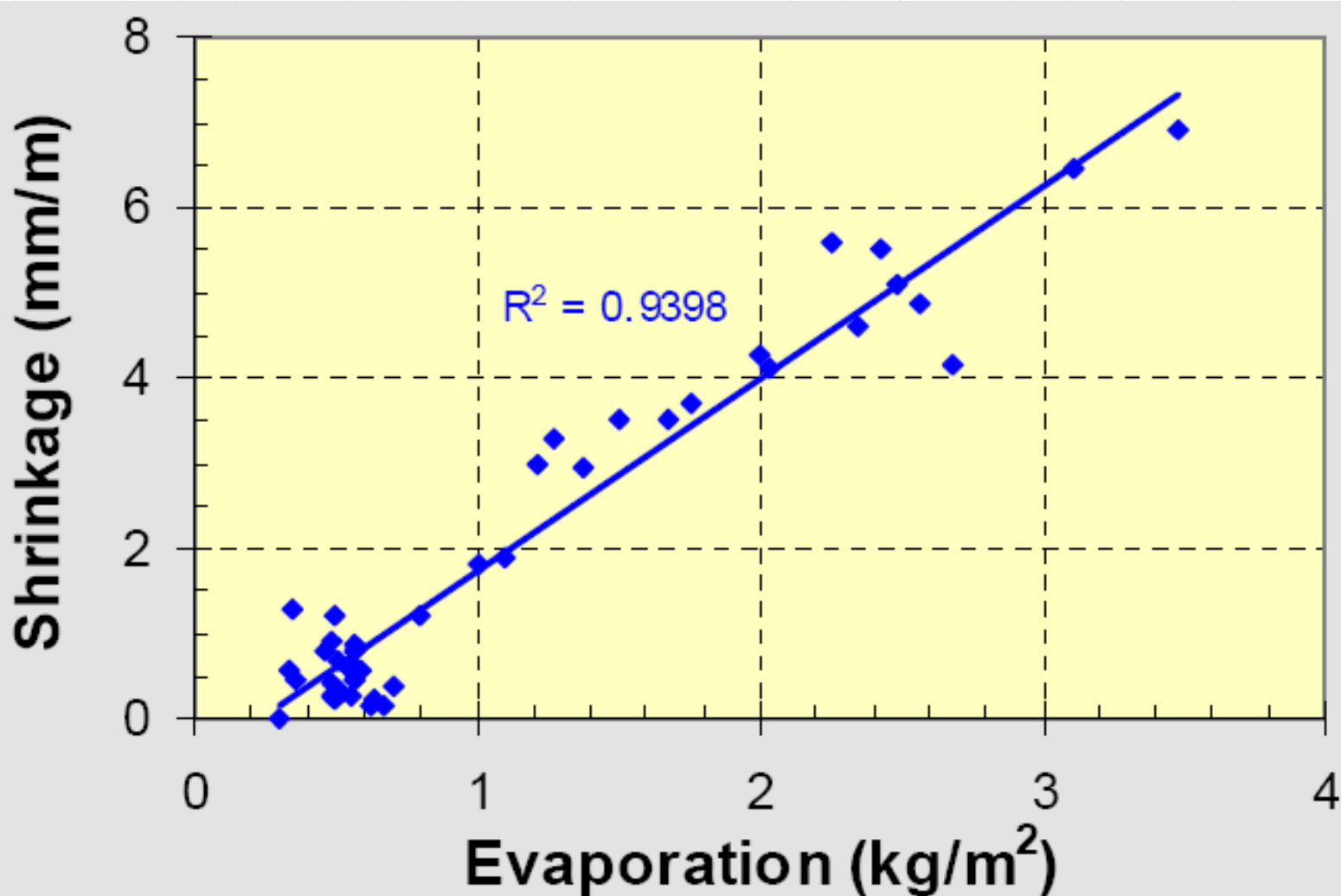
Evaporation

- Linear Until About 4-6 Hours, Then Logarithmic
- Removes Bleed Water Before it can be Re-absorbed
- Decreases Internal Relative Humidity
- Increases Shrinkage

Evaporation



Effect of Evaporation on Shrinkage



Preventing Plastic Shrinkage Crack

- Keep water-cement ratio low
- Prevent rapid moisture loss
 - Wet curing
 - Wind break
 - Shade concrete surface



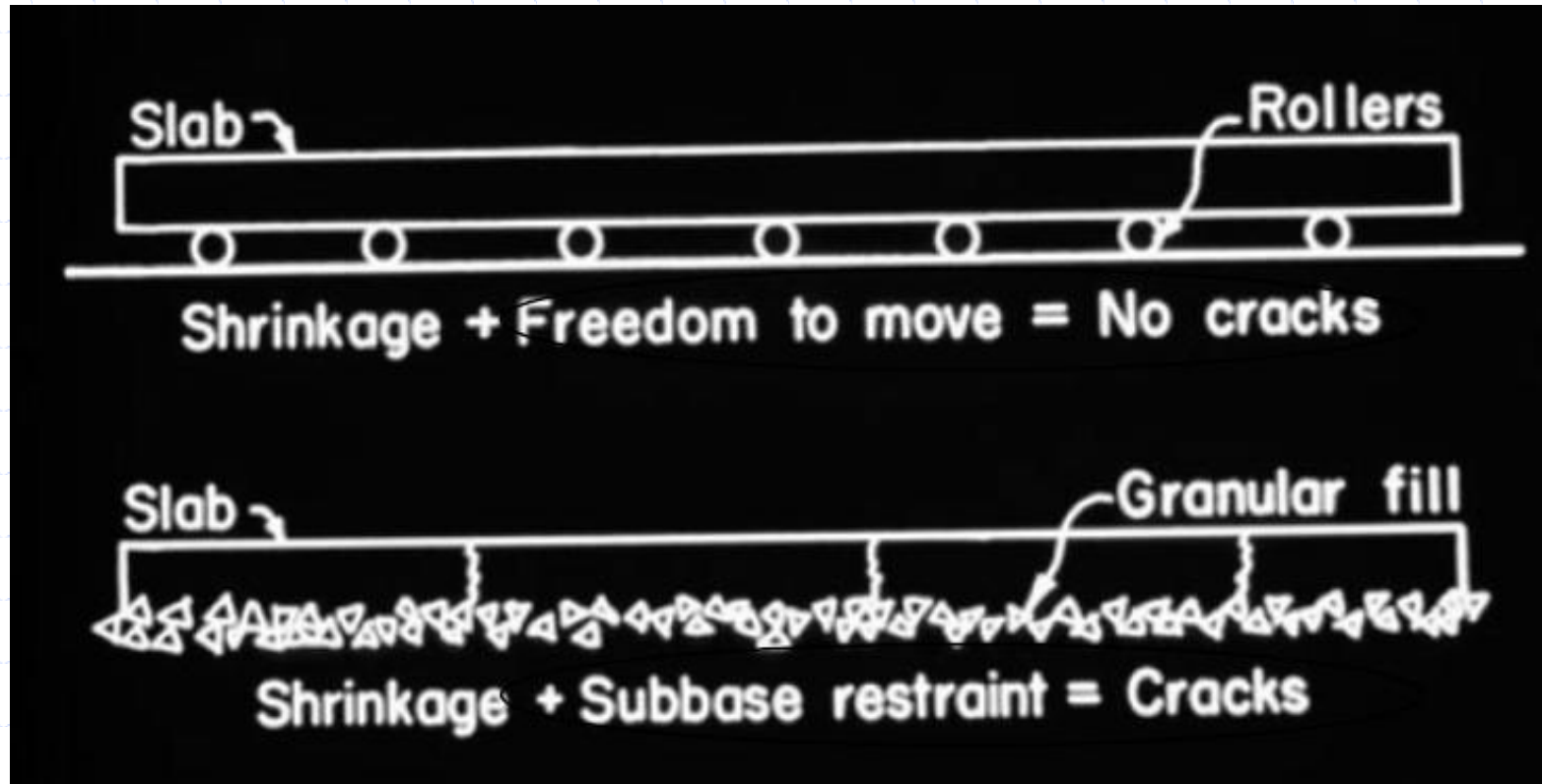
Drying Shrinkage

Drying shrinkage cracking caused by volume change (decrease) due to loss of moisture in combination with restraint of soil or structure

Factors Influencing Drying Shrinkage

- Cement
 - Fineness
 - Chemical composition
- Aggregate
 - Size
 - Absorption
 - Bond
 - Compressibility
- Water Content
 - Water/paste/aggregate
 - Temperature

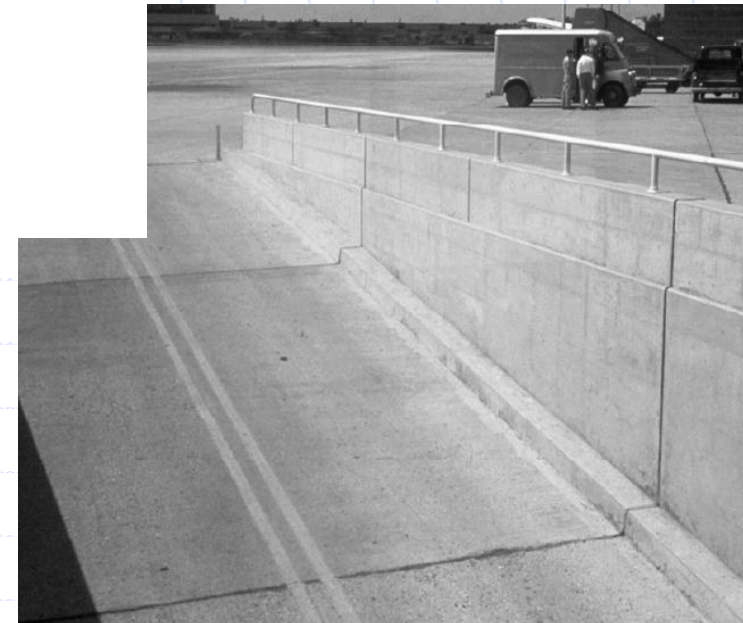
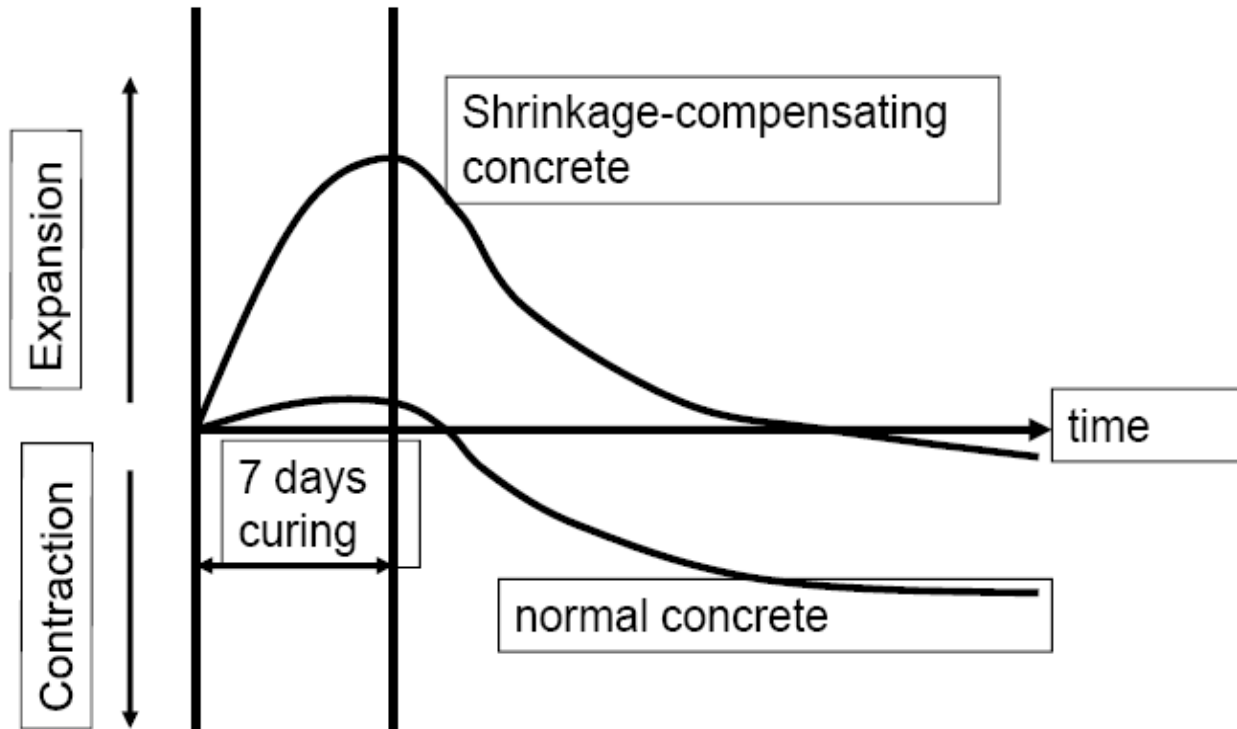
Shrinkage and Cracking



Methods for Reducing Shrinkage

- Less water in mix
- More coarse aggregate
- Reduced restraint on underside or at ends
- Adequate reinforcement
- Shrinkage compensating cement
- Joints properly spaced

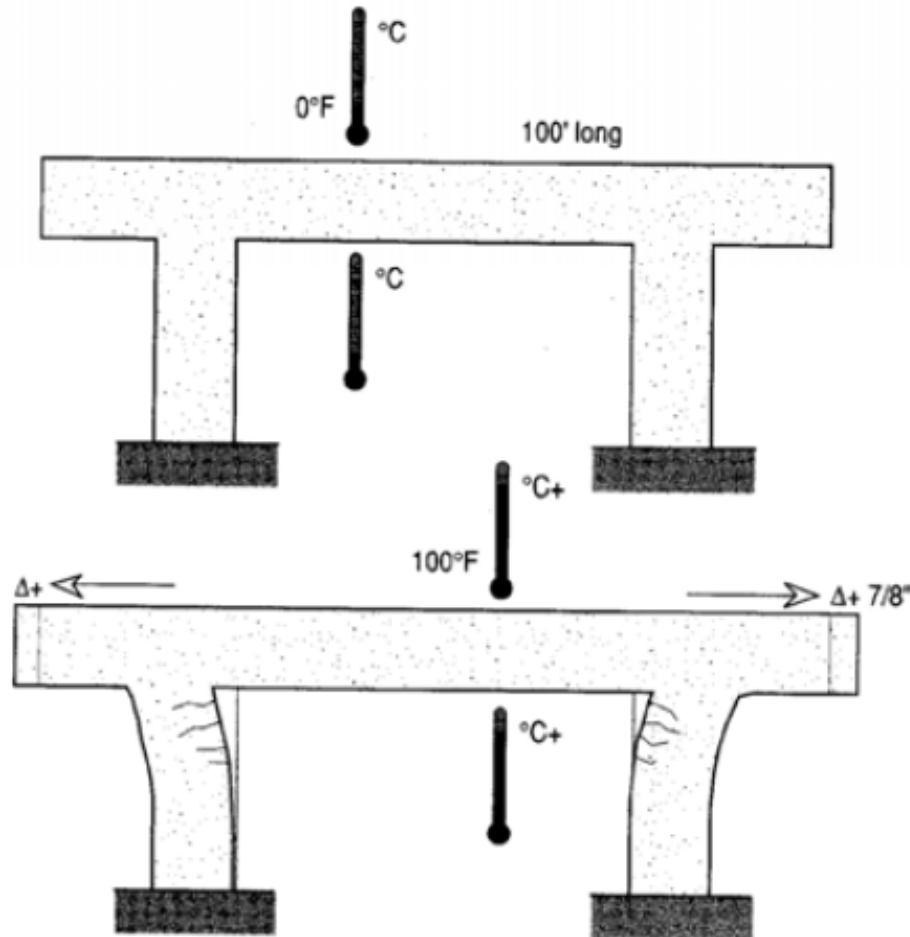
Methods for Reducing Shrinkage



Thermal Effects

- Thermal expansion/contraction
- Uneven thermal loads
- Restraint to volume change
- Early thermal cracking of concrete
- Thermal movement in existing cracks
- Fire damage

Thermal Effects



Coefficient of thermal expansion
 $= 9 \times 10^{-6} \text{ mm/mm/}^\circ\text{C}$

Cantilever portion moves in opposite direction to center of span, in proportion to length of cantilever

Early Age Temperature Cracking

- Initial temperature of materials
- Ambient temperature
- Dimensions
- Formwork type and removal time
- Cement type and content
- Cement replacement

Fire Effect on Concrete

- Fire has extreme effects on concrete:
 - uneven volume changes
 - distortion, buckling, cracking
- Spalling of rapidly expanding concrete near source of fire
- Moisture changes to steam causing localized bursting
- Cement mortar converts to quicklime beyond 400 °C causing disintegration
- Reinforcing steel loses tensile capacity and yields



Questions and Assignment