ACCELERATED CURING

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WHAT IS CURING?
• Curing is a procedure that is adopted to promote the hardening of concrete under conditions of humidity and temperature.
• Which are conducive to the progressive and proper setting of the constituent cement.
• Internal concrete temperature is the most important factor affecting early compressive strength of concrete.

Curing Concrete (ASTM C31)

EFFECTS OF CURING OF HARDENED CONCRETE
Increased
• Strength
• Water tightness
• Abrasion resistance
• Freeze-thaw resistance
• Volume stability

CURING
• Hardening of concrete
• Hydration → CSH (Calcium silicate hydrate) gel
  • a reaction between the cementitious products and the free water within the mix called the hydration process.
• Accelerated curing
  • The rate of hydration increases as the ambient temperature increases.
  • Maintaining moisture in the concrete is critical.

PROPER CURING IS ESSENTIAL
• Reduces permeability
  • Essential for structure water tightness
  • Improves durability
• Optimal strength achieved

ESSENTIALS FOR PROPER CURING
• Maintain moisture
• Maintain temperature
  • Essential for cement hydration (ASTM C186)
  • Temperature is critical to meeting the dual concerns of higher early strength or reduced curing time.
CURING METHODS

- Maintaining moisture by wetting
- Prevent moisture loss by sealing
- Accelerated curing

MAINTAINING MOISTURE BY WETTING

- Wet burlap
- Spraying/Misting
- Fogging

SPRAYING/MISTING

- Cold or hot
- Very fine droplets
- Effective for higher cement content and warmer climates

PREVENT MOISTURE LOSS BY MEMBRANE SEALING

- Forms
- Tarps / Polyethylene
- Curing Compounds
  - Caution:
    - If w/c <0.5
    - With pozzolanic mixes

LOW PRESSURE STEAM CURING

- Provides both heat and humidity
- Product is heated by the warmer steam condensing on it
- Moisture evaporation is minimized

WET CAST PRODUCTS

- Leave forms on as long as possible
- Manage concrete and curing temperature
- Exercise caution for thin sections with openings
- Check with supplier when using accelerated admixtures
DRY CAST PRODUCTS

- Require 90 to 100% humidity
- Have shorter preset period
- Must protect from drafts

ACCELERATING STRENGTH GAIN

4 ways
- Curing steam
- Heating coils
- Electrical heated forms or pads
- Concrete blanket or Tarps

CONSIDERATIONS FOR ACCELERATED CURING

- As a rule of thumb, a temperature increase of 18°F doubles rate of hydration
- High temperatures with low humidity can crack the product
- The lower the curing temperature, the longer the product must be cured to achieve comparable early strengths.

EFFECT OF LOW TEMPERATURES ON COMPRESSIVE STRENGTH

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Compressive Strength, psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>70 F</td>
<td>2700</td>
</tr>
<tr>
<td>60 F</td>
<td>2150</td>
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<tr>
<td>50 F</td>
<td>1600</td>
</tr>
<tr>
<td>40 F</td>
<td>1200</td>
</tr>
<tr>
<td>30 F</td>
<td>850</td>
</tr>
<tr>
<td>20 F</td>
<td>400</td>
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ACCELERATING STRENGTH GAIN

1st way
- Steam Curing
  - Advantageous where early strength gain is required, or
  - Additional heat is required to accomplish hydration, ex. cold weather.
- Two Methods:
  - Live steam (atmospheric pressure)
    - steam converted into water (hot water curing)
  - Autoclave (high pressure)
    - closed chamber, superheated steam,
    - high temperatures 170 °C – 338 °F

ACCELERATED CURING CYCLE

The accelerated curing cycle can be divided into three periods—
- preset
- rising temperature
- maximum temperature
**TYPICAL ACCELERATED STEAM CURING CYCLE**

- Preset (< 90 degrees) – at least one hour
- Ramp (Temperature Rise) – at 20°F to 40°F per hour
- Hold / Soak (at target temperature) – varies with the product
- Cool Down

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**IDEALIZED ACCELERATED CURING CYCLE**

- 1) Preseting
- 2) Ramping
- 3) Holding
- 4) Cooling

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**STEAM CURING**

- Initial concrete temp. = 21°C (70°F)
- Steam temp. in enclosure held at 60°C (140°F)
- Temp. reduced at 20°C (40°F) per hour within 10°C (20°F) of outside air
- Outside air at 10°C (50°F)
- Steam applied at rate of 10 to 20°C (20 to 40°F)/hr

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**CONCRETE TARGET TEMPERATURES**

- Concrete Pipe (Typical for Accelerated)
  - 120°F to 140°F (50°C to 60°C)
  - 4 to 6 hours

- Precast (including Pipe)/Prestress limits (ACI)
  - 140°F (60°C) in Canada
  - 160°F (71°C) in USA
  - 8 to 12 Hours

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**ACCELERATING STRENGTH GAIN**

2nd way

- Heating coils
  - Embedded near surface of concrete elements
  - Prevention from freezing in cold weather

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**ACCELERATING STRENGTH GAIN**

3rd way

- Electrical heated forms or pads
  - Primarily used by precast concrete producers
  - Now used in some sensitive projects
ACCELERATING STRENGTH GAIN

4th way

Concrete blanket
- Insulate the surfaces in cold temperatures
- ASTM C167

Winter Concrete Curing Blankets
- Prevents freezing, rapid drying, & cracking all winter
- Heat spreading technology cures concrete fast
- Roll it out, Plug it in, the blanket does the rest
- Maintain optimal curing temperatures year-round
- Only pennies a day to operate

ACCELERATED CURING

- Dry Heat
  - Use with caution: difference between accelerated curing and maintaining heat
  - Heated beds (hollow core)
  - Electric or gas heaters – convection heat
  - Infrared heating – radiant heat
- Low pressure steam
  - Boilers
  - Steam generators
- Admixtures

Note: Raise concrete temperature while maintaining high humidity

ACCELERATING ADMIXTURES

2 Classes of Admixtures:
- Set Accelerator
- Strength Accelerator (Early Age)

- Calcium Chloride is the most common in Ready mix, but BEWARE, should not be used in precast reinforced concrete
- Several non-chloride, non-corrosive accelerators, but generally most are not as effective as calcium chloride

ACCELERATING ADMIXTURES

Accelerating admixtures are added to concrete to increase the rate of early strength development.

Why accelerators?
- Permit earlier removal of formwork.
- Reduce the required period of curing.
- Advance the time that a structure can be placed into service.
- Partially compensate for the retarding effect of low temperature during cold weather concreting.
- Allows for secondary pours or double pouring options.
- Reverse affect. More is not always better.
- Follow manufactures recommended dosage.
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