CONCRETE CONSTRUCTION TECHNIQUES

Tips, Tricks and Traps when ordering, placing, finishing and curing concrete

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Concrete project to pour?

• What do I need to do?
  – Pre-job planning
  – Ordering concrete
  – Site preparation
  – Placing & Finishing
  – Jointing & Curing
  – Post job follow-up
Pre-job Planning

• Any specifications? If so – what required?
  – Strength, air, slump, w/c, etc.
  – Special requirements – aggregates, super, color, texture, etc.
• Any rebar, dowels – pre-order requirement
• Curing or surface treatment requirement
• Placement or job access difficulties
• Provisions for weather – wind, cold, hot, rain
Ordering Concrete

- Discuss planned use:
  - Inside or outside?
  - Slab, curb, wall or other structure
  - Temperature/weather considerations

- Requirements & specifications
  - Strength, air, min. cement, fly ash, slump etc.
  - Accelerators/retarders
  - Special aggregates or color
  - Fibers
Ordering Concrete

• Calculate and order quantity needed
  – Estimate extra concrete for waste and placement dimensions over nominal dimensions.
  – Allow 4-10% for plan dimension waste and over excavation

• Call in order the day before
  – Provide estimate of quantity required
  – Time needed
  – Have far apart want trucks at jobsite
  – Comments on will call – 10+
Portland Cement is a hydraulic cement, meaning that it hardens by a chemical reaction with water.
Remember

- Paint dries out to become hard
- Dry Wall compound dries out to become hard
- Cement reacts with water in order to make concrete hard
- Cement needs to have water present for the concrete to keep gaining strength.
ASTM C150 PORTLAND CEMENTS
REQUIREMENTS
STRENGTH COMPRESSION RELATIVE

Age, days

28

14

3

100

125

150

0

50

75

100

125

150

20

50

75

100

125

150

Type I

Type II

Type III

Type IV
Aggregate Gradation Affects

- Workability
- Pumpability
- Economy
- Porosity
- Shrinkage
- Durability
Aggregate Affects Performance

- D-Cracking – if exterior application, use INDOT AP aggregate
- Chert = Pop outs
- Water Demand
  - Dry/absorption
  - Free water
THE ONLY REAL USE FOR JOB SITE WATER

- Water should not be added at the jobsite, unless absolutely necessary.
- Water additions can alter air contents as well as reducing durability and strength by diluting the cement content.
- Too much water allows the “other stuff” to come to the surface. This may cause problems later.
Too Much Water

- **Excessive Bleed Water.** If the bleed water is finished back into the surface before it can evaporate, then the concrete may craze, dust and scale.

- **Water Reservoirs.** The channels and reservoirs allow water and deicers to enter concrete and test the durability of the concrete.
Anneals develops to allow the bleed channels to develop and allow the bleed water to come to the surface.
Too much water

Water reservoir becomes an air pocket
Water addition - rules of thumb
Additives Concrete may also have in it:

- Pozzolans - Fly Ash / Granulated Slag
- Air Entraining Agent
- Retarders
- Accelerators
- Water Reducer/Superplasticizers
POZZOLANS

- GGBF SLAG
- MICRO SILICA
- FLY ASH
CEMENT + WATER

CS(glue) + Ca(OH)$_2$ + H$_2$O
Ca(OH)$_2$ + H$_2$O + Pozzolan

\[
\text{Ca(OH)}_2 + \text{H}_2\text{O} + \text{Pozzolan} \\
\text{CS(glue)} + \text{H}_2\text{O}
\]
TYPES OF FLY ASH

- Class C
- Class F
No cementitious properties •
LOI varies with source
High Sulfur Content
Eastern Coal

Class F Fly Ash
Slightly cementitious

Consistent L0I

Low L0I

Low Sulphur Content

Western Coal

Class C Fly Ash
Effects of Fly Ash

• Time of Set
• Durability
• Placability
Air Entraining Admixtures
Air Entrained

- Air loses some of its effectiveness in a soupy mix.
- In the concrete, when the water shock absorber, when the water expands when it freezes.
- We all know that water

Non-Air Entrained
Air Entrainment/
Hardened Concrete

- Reduced concrete weight
- Increased watertightness
- Better freeze-thaw resistance
Water Reducing Admixtures
Water Reducing Admixtures

**ASTM C 494 Definition**

- An admixture that *reduces the quantity of mixing water* required to produce concrete of a given consistency.
Water Reducing Admixtures

What Are They?

- Admixtures that either increase slump of freshly-mixed mortar or concrete without increasing water content OR maintain slump with a reduced amount of water, the effect being due to factors other than air entrainment.

(ACI 116.R-2)
Water Reducing Admixtures

How do they function?
Water Reducing Admixtures

How do they function?

Dispersion of Cement
Water Reducer Chemical Action

Cement Flocculation

Water Molecule

Cement
Set Time

VS.

Admixtures

Accelerating & Retarding
## Setting Time of Concrete at Various Temperature

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Approximate Setting Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>70°F (21°C)</td>
<td>6 hours</td>
</tr>
<tr>
<td>60°F (16°C)</td>
<td>8 hours</td>
</tr>
<tr>
<td>50°F (10°C)</td>
<td>11 hours</td>
</tr>
<tr>
<td>40°F (4°C)</td>
<td>14 hours</td>
</tr>
<tr>
<td>30°F (-1°C)</td>
<td>19 hours</td>
</tr>
<tr>
<td>20°F (-7°C)</td>
<td>Set does not occur - Concrete will freeze</td>
</tr>
</tbody>
</table>
RETARDERS:
Delay setting or hardening rate for

- Hot-weather Concreting
- Difficult placements
- High-strength concrete
- Special finishing processes
ACCELERATORS
Increase early strength gain for:

• Cold-weather Concreting
  – Accelerators speed up the setting time and strength development of concrete

• Rapid placement practices

• Types
  – Calcium chloride
  – Non chloride
Improving Set Times with Accelerators (45 Degrees)

*It is easier to talk about % improvement by adding the following accelerators or other methods.*

- Adding another bag of type I cement 10%
- A minimum dosage rate of Non-chloride Accelerator 25%
- A 1% - dosage rate of low level chlorine accelerator 30%
- 1% calcium chloride 40%
- Changing to Type III cement 40%
- A 2% = dosage rate of low level accelerator 50%
- 2 % calcium chloride 50%

(“Normal” 45 degrees set time was 10 hours)
Summary – Materials Affecting Performance

• Cement
• Water
  – Batch Water
  – Free Water
• Aggregates
  – Gradation & Uniformity
  – Deleterious
• Admixtures
  – Fly Ash
  – Air Entrainment
  – Water Reducers, Retarders & Accelerators
General Finishing Practices & Comments
Site Preparation

• BE READY!!
• Concrete must be unloaded within 90 minutes from time of adding water to mixer
• Delays at jobsite generally = water addition
• Water addition = reduced performance

See water addition – rules of thumb
Typical concrete on subgrade.

Bleed water leaves through the surface

Excess water leaves the concrete into the soil

Soil/Sand/Stone
On subgrade with plastic.

Finishing may take longer
A well prepared, uniformly compacted subgrade at correct elevation is essential.

The subgrade should NOT be:

- Soft
- Frozen
- Muddy
Placing

• Place as soon as possible. Must be delivered and discharged with 90 from the time of adding the mixing water.

• Testing. Air, Slump, Strength, Temperature

• **Standard test generally performed by agency or hired representative of agency.**
PLACING

SLUMP TEST

Rod

Slump Cone

Concrete

Number of inches
PLACING

• Place as close as possible to final location – the less you move concrete the better
• If must move concrete – use square-nose shovels or concrete rakes; other tools cause segregation
• Start at corner & work away from corner
• If on slope, start at low end and work uphill
SAFETY WARNING!!

- Fresh portland cement concrete can cause skin irritation and burns. Wash skin promptly after contact.
- When placing concrete workers should wear:
  - Full-length trousers and shirts
  - Rubber boots & gloves
  - Eye protection when exposed to concrete splatter
WARNING!!

• The tires of a ready mix truck must be kept away from below-grade walls, excavations and trenches
  – Rule of thumb: stay 1 foot away from an excavation for every 1 foot of depth

• A loaded truck can weigh over 25 tons, DO NOT cross sidewalks, curbs, lawns or other on-site areas that can be damaged by the trucks weight.
FILLING THE FORMS

• Chute, wheel, or shovel concrete directly into its final position
• Do NOT dump it in piles and then flow, drag or rake it the rest of the way.
• Do not drop the concrete more than 4 feet to its final location to prevent aggregate segregation.
Finishing

• **Interior Concrete.**
  – Strength - Mix
  – Durable surface - Trowel

• **Exterior Concrete**
  – Strength - Mix
  – Resist Freeze / Thaw Cycles - Entrained Air
  – Skid Resistance - Broom Finish
Jointing to Control Cracking of Concrete Surface

• All concrete has a tendency to crack. However, cracking can be reduced and controlled.
Cracking of Concrete Surface
Causes of Cracking

- Improper joints
- Improper subgrade preparation
- The use of high slump concrete
- Addition of water on the job
- Improper finishing
- Inadequate or no curing
Control joints may be hand tooled, sawed or formed by use of inserts.

When grooved or sawed, **joints must be cut to a depth of at least 1/4 the thickness of the slab.**
Joints

- Control joints should be spaced so that the dimension in either direction does not exceed:

  \[2-1/2 \times \text{the thickness expressed in feet}\]

  4" slab = 10 ft joint spacing

  5" slab = 12 ft joint spacing
Joints

• The panels should be as square as possible.
• Under no circumstances should the long side be $1.5 \times$ the length of the short side.
Joints

- This means that, in addition to lateral jointing, a joint must be cut down the center for the full length of a driveway that is 16’ wide and 4” thick.

- When control joints are sawed, this should be done after all other finishing and curing application are complete and as soon as the concrete has hardened sufficiently to permit sawing without raveling.
Isolation Joints

- Isolation. Before concrete is delivered, install isolation material against buildings, steps, walls, existing slabs, etc..
- Isolation joint material must go to the bottom of the slab.
Durability = resistance to freeze-thaw.

Effective curing is absolutely essential for surface durability.

Curing is one of the most important construction and quality concrete steps in quality concrete.
Curing

- Apply curing as soon after brooming and edging as it can be done without eroding the surface.
- As long as concrete is allowed to cure, it continues to gain strength and water tightness for years after it is placed.
Curing

- Fresh concrete must be kept warm and moist until the mixing water combines chemically with the cement (hydration).
- Without curing, the strength of the concrete can be reduced in half. A 4000 psi mix becomes a 2000 psi mix at the surface with no curing.
- The surface is where it needs it the most!
Curing

- The simplest, most economical and widely used method is a liquid membrane which is sprayed on the surface of a slab as soon as possible after finishing.
- Apply at manufacture’s rate of coverage.
- Perform field check to verify application rate.
Questions?