Extending Concrete Slump Life: Proven Technologies and Projects with Challenging Placement

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ACI Fall Convention “Hot Topic Session”
Rio Hotel
Sunday, October 14, 2018
Las Vegas, NV 2018
Overview

- Concrete Slump Loss
- Workability Retention – Options
- Admixture Solutions and Impacts
- Projects
Slump Loss

Typical concrete mix

Factors affecting workability
- Materials
- Production
- Environmental factors

Batching and Mixing
Hydration Leads to Flocculation

Loss of workability over time
Rethinking 90 Minutes

- It is an unnecessary limit

- What does a producer do?
  - Distance – project is hundreds of miles away
  - Time – traffic or weather conditions
  - Application – example: drilled shaft placement
    1. Batch, mix, and transit time
    2. Position truck to pump
    3. Very fluid mixes (SCC)
    4. Slow placement
    5. Position next truck
    6. Need workability retention
      - Minimize cold joints
Industry Methods to Counteract Slump Loss

- Retemper (late addition of water)
- Batch higher-than-required slump
- Use of chemical admixtures
  - Retarders
  - Redose with high-range water-reducing admixture
  - Extended-set control (Hydration-Controlling Admixture)
  - Workability-retaining

**Admixtures**

* retard ing admixture - an admixture that causes a decrease in the rate of hydration of the hydraulic cement and lengthens the time of setting.

* extended set-control admixture - function by stopping or severely retarding the cement hydration process in unhardened concrete thereby lengthening the setting time

* workability-retaining admixture – provide workability (slump) retention when used in combination with normal, mid, and high-range water-reducing admixtures without affecting the setting time of concrete
Stage of Cement Hydration

Source: FHWA HIF-07-004: Integrated Materials and Construction Practices for Concrete Pavement
Stage of Cement Hydration

Stage 2:
- Slump life
- Workability retention

Source: FHWA HIF-07-004: Integrated Materials and Construction Practices for Concrete Pavement
Retarding Admixture (a.k.a. retarders)

Retarding admixture - slows the hydration of cement in concrete.

- Rate of slump loss may be decreased and working time can be extended – ACI 212.3R-16

- ASTM C 494/C494M types
  - Type B – Retarding admixture
  - Type D – Water-reducing and retarding admixture
  - Type G – Water-reducing, high-range, and retarding admixtures
Hydration-Control Admixture (a.k.a HCAs)
Industry Innovation - 1987

- Effectively puts concrete to sleep
  - controls (stops) hydration
  - Works on both the silicate and aluminate phases
- Forms a protective barrier around cement
  - over time effect dissipates
  - barrier breaks down
- Normal hydration, setting & strength development follows
- ASTM C 494/C494M Type B and D admixture
Workability-Retaining Admixture
Industry Innovation 2006

- Added at the batch plant
- Effectiveness based on dosage
- Maintains concrete slump and workability
  - does not retard
  - does not affect early strength
- ASTM C 494/C494 Type S

Water reducer - 3.0 fl oz/cwt

Water reducer - 3.0 fl oz/cwt + WRA – 4.5 fl oz/cwt
Slump Life Options

- **Batch slump higher than needed**
  - Add HRWR
  - Retemper with water

- **Extended Set Control Admixture**
- **Target**
- **No measures taken**

**Workability-retaining admixture**
## Slump Life Options

<table>
<thead>
<tr>
<th>Method</th>
<th>Effect on Slump</th>
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<tbody>
<tr>
<td></td>
<td>Minimize Loss</td>
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<tr>
<td>Retemper (late addition of water)</td>
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</tbody>
</table>
Project: Microwave Tower

Project: Microwave Tower - foundation footing

Owner: U.S. Dept. of Energy

Location: Monument Valley, UT

Ready-Mix Supplier: Tanner Companies, United Metro Materials - Flagstaff, AZ
Project:
Microwave Tower

Haul Time: 8 hours
Distance: 250 miles (400 km)

Approximate Yardage: 45 yd³ (34 m³)
HCA Dosage: 8 fl oz/cwt (520 mL/100 kg)
Project: Neebish Light Cell (US Coast Guard)
- Navigation system

Location: St Mary’s River, Sault Ste. Marie, Michigan

Ready-Mix Supplier: Northern Sand and Gravel

Approximate Yardage: Treated - 210 yd³ [161 m³]

Temperature Range: 64° – 82°F [18° – 28 °C]

Base seal underwater
- 12 ft (3 m) cobble stone base
- Antiwashout admixture
- HCA Dosage: 11 fl oz/cwt [715 mL/100 kg]
- 50 yd³ [38 m³] concrete
Project:
Neebish Light Cell

Concrete transit
- plant to barge, loaded on barge
- barged to site (5 - 7 hour delivery)
- **One way – 12 hours**

Placement
- tremie – self-leveling, no vibration
- minimal washout

Performance
- Good flowing characteristics required
- Strength - 6,820 psi [47 MPa] @ 28 days
Project: World Trade Center - Manhattan, New York

Challenges:

- Compressive strength: 14,000 psi (83 MPa)@ 56 days
- Over-design for safety: 1,900 psi (13 MPa)
- Modulus of elasticity: 7.25 million psi (48 GPa)
- Heat of hydration: Not to exceed 160 °F (70 °C)
- Non-air-entrained

- Slump flow: 24 - 28 inches (610 - 710 mm)
- Ability to pump to at least 100 floors
- No loss in concrete workability during transit and placement
- Aesthetically pleasing

- Quantity of portland cement in the mixture:
  Less than 400 lb/yd³ (240 kg/m³)
Project:
World Trade Center - Manhattan, New York

Batch and Delivery
- New Jersey to New York City
- 2+ hours
- SCC

Solution:
- Optimized mixture proportions
  - Workability-retaining admixture
  - Hydration-control admixture

Project Participants
OWNER: Port Authority of New York and New Jersey
CONCRETE CONTRACTOR: Callovino Construction Co., New York
CONCRETE PRODUCER: Eastern Concrete Materials, Elmwood Park, N.J.
ADMIXTURE SUPPLIER: BASF Construction Chemicals, Beachwood, Ohio
Project:
World Trade Center - Manhattan, New York

World Trade Center
Tower One

8,600 psi to 14,000 psi pumped columns
Innovative optimized Concrete mixture designs exceeded the project performance requirements.
The environmental footprint of the concrete was reduced.
**Project:**  
**U.S. Courthouse**

- White cement – reactive like Type III
- Ambient temperature:
  - mornings - 70’s and 80’s
  - afternoon - high 90’s - low 100’s
- Slump: 5.0 in. [125 mm]
- Design Strength: 4,000 psi [27.6 MPa]
- Transport and placement time: 2 + hours
- Slump maintained without water addition
- Admixture: Extended Hydration Control

Supplier: Vulcan Concrete  
Contractor: TB Pennick
Project:
William Moore Bridge – Skagway, AK

- Roller-compacted concrete application
  - 12 in. [305 mm] thick
- Requirement – stop hydration for 14 hours
- Extended set control admixture @ 10 fl oz/cwt [652 mL/100 kg cement]
- Challenging placement – 3 yd³ [2.3 m³] buckets by crane into a canyon
- Roller compactor is lowered into canyon to finish
- Volume - 23,000 yd³ [17,585 m³]
Project(s):
MTO – Ontario, Canada

- Long-haul MTO applications in northern Ontario
- Placement Requirement: concrete must be plastic
  - > 3 hours after batching
- Durability study - Air-entrained concrete containing a superplasticizer
  - Compressive strength, air void structure, scaling
  - exceeded performance requirements
- Workability-retaining admixture approved for long haul applications
  - ASTM C 494, Type S
Fisher Island
Miami, FL

- Volume: 15,000 yd³ [11,468 m³] project
  - 500 yd³ [382 m³] pours
- 5-minute spacing
- 3,500 psi [24.1 MPa] in 72 hours post-tension decks
- No jobsite water allowed
- Can't start before 7:00 am
- 20-minute travel to barge dock
- 30-minute barge trip
- 3 trucks / barge, 4 barges in use
  - wait times of 15+ minutes
- 98° F [36.7° C] ambient temperature (July through October)

Producer: Titan America
Fisher Island
Miami, FL

**Without Treatment/Measures**

- Losing 4+ in. [102+ mm] slump in transit
- Could not pump mix vertically
- Pump constantly clogged due to stiff concrete
- Cold joints in every deck
- Losing 12% to 15% of loads
  - 2-hour round trip to the dump
- Inconsistent set times / flash sets
Fisher Island
Miami, FL

Utilized Workability-Retaining Admixture
✓ Slump loss was eliminated
✓ Pumping issues were eliminated
✓ Cold joints were eliminated
✓ Lost loads for slump were eliminated
✓ Rejections for time were eliminated
✓ Trips to the dump were eliminated
Summary

- Concrete can be placed beyond 90 minutes after batching
- Chemical admixture technology can control slump life
  - Extended set control
  - Workability-retaining
- Thirty+ years of successful projects
  - Engineering properties maintained
- Applications
  - Every day concrete
  - Transit time - long-hauls or traffic/weather conditions
  - Underwater concrete
  - Sustainable concrete
  - High-performance concrete
  - Self-consolidating concrete
  - Roller-compacted concrete
We create chemistry