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

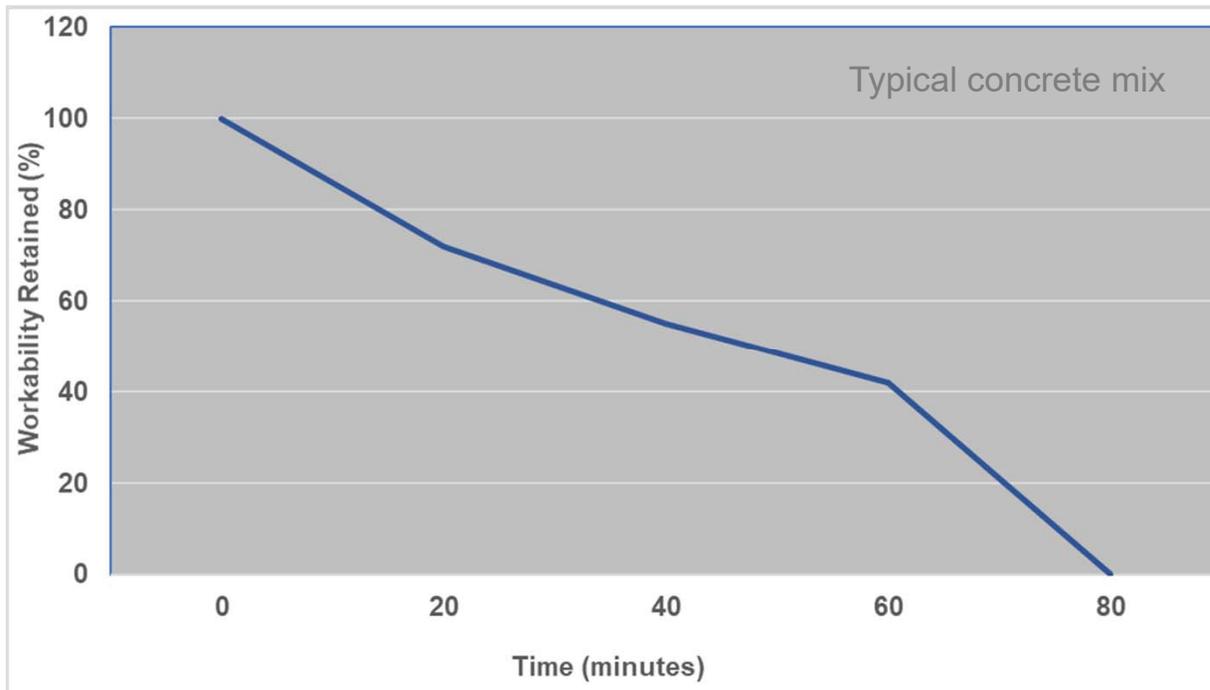
Mark A. Bury FCI
ACI Fall Convention "Hot Topic Session"
Rio Hotel
Sunday, October 14, 2018
Las Vegas, NV 2018



Overview

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

Slump Loss



Batching and Mixing



Hydration Leads to Flocculation



Loss of workability over time



Factors affecting workability

- Materials
- Production
- Environmental factors

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



Review Slump Life - Options

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

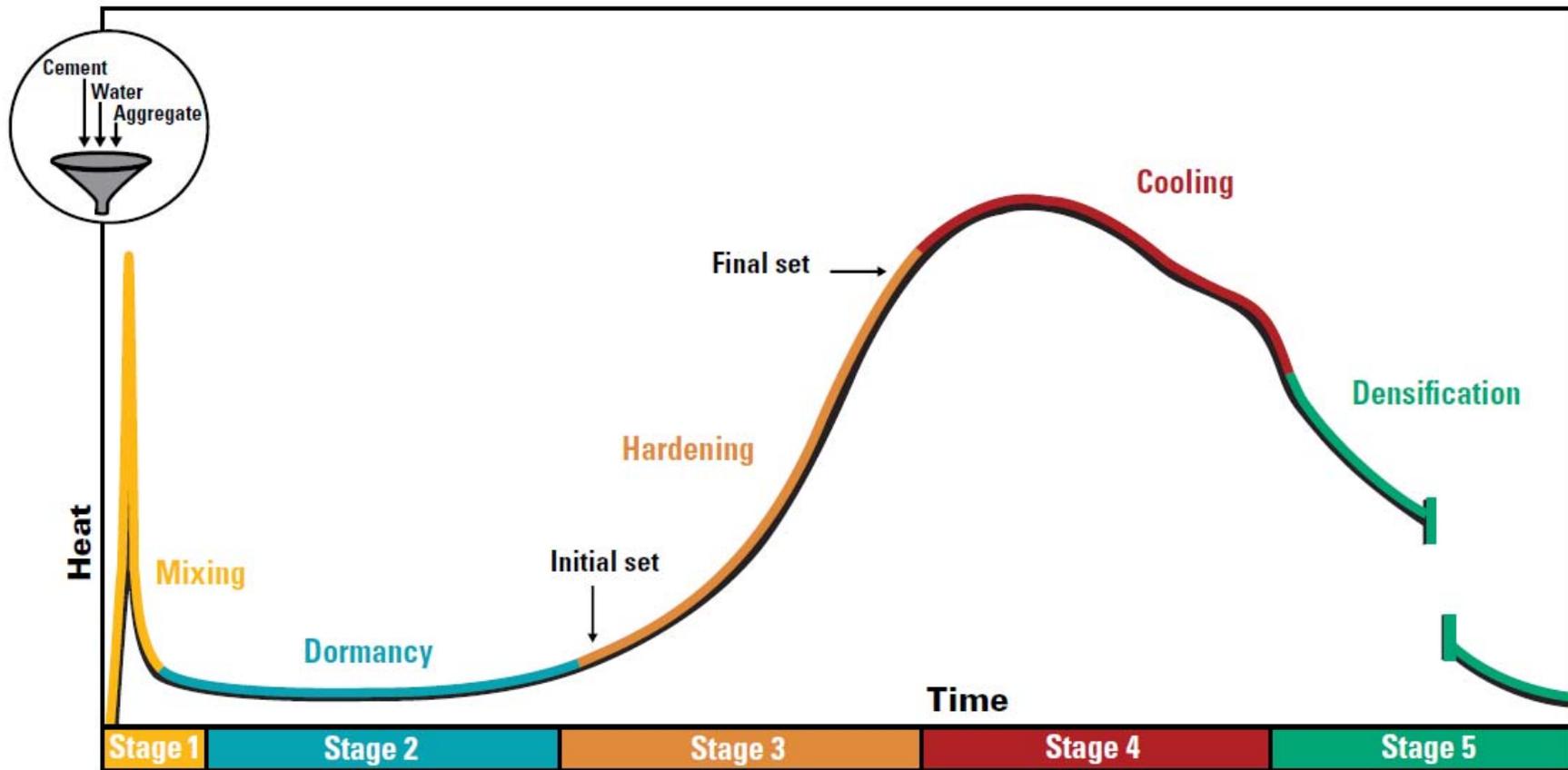
Admixtures

retarding 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

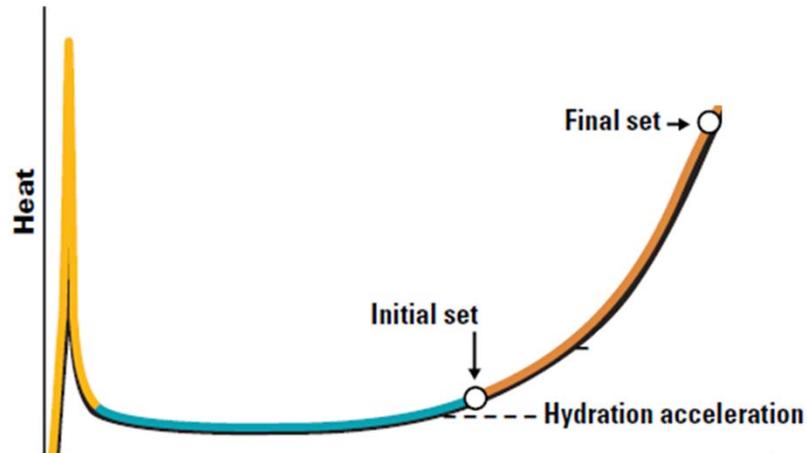
workability-retaining admixture – provide workability (slump) retention when used in combination with normal, mid, and high-range water-reducing admixtures without affecting the setting time of concrete

Stage of Cement Hydration



Source: FHWA HIF-07-004: Integrated Materials and Construction Practices for Concrete Pavement

Stage of Cement Hydration



	Stage 1	Stage 2	Stage 3
	Mixing	Dormancy	Hardening
	Lasts about 15 minutes	Lasts about 2–4 hours	Lasts about 2–4 hours
Characteristics of concrete mixture	High heat is generated immediately, followed by rapid cooling.	Mixture is plastic, workable, and not generating significant heat.	<ul style="list-style-type: none"> • Hydration generates significant heat. • Mixture sets, begins to harden, and gains strength. • Stress begins developing in the concrete.

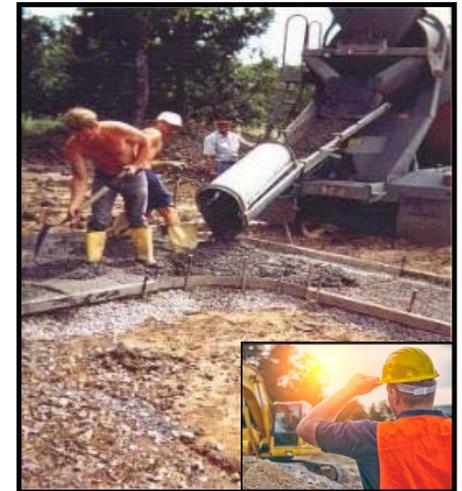
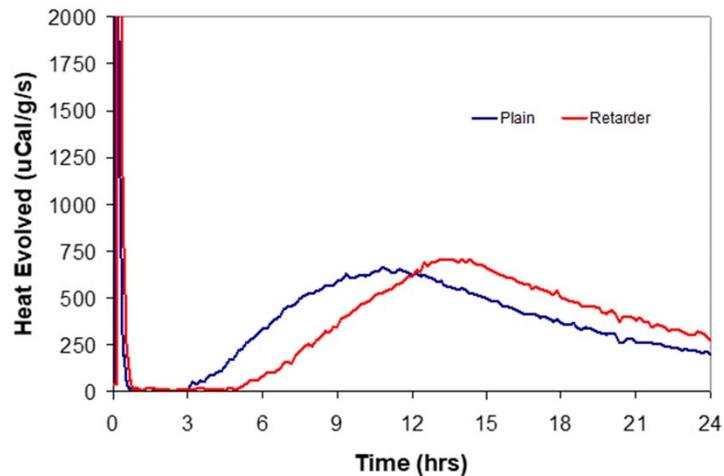
Stage 2:

- Slump life
- Workability retention

Retarding Admixture (a.k.a. retarders)

Retarding admixture - slows the hydration of cement in concrete.

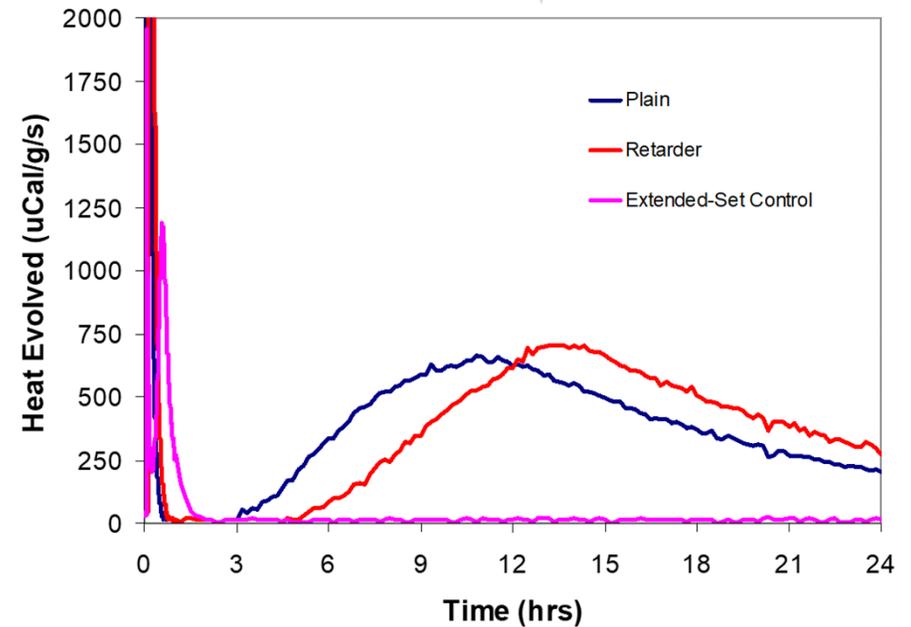
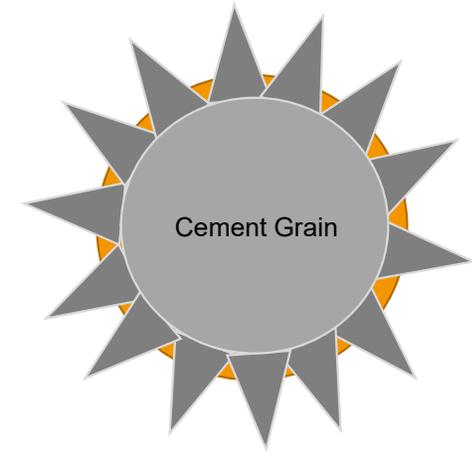
- Rate of slump loss may be decreased and working time can be extended – ACI 212.3R-16
- ASTM C 494/C494M types
 - ❑ Type B – Retarding admixture
 - ❑ Type D – Water-reducing and retarding admixture
 - ❑ Type G – Water-reducing, high-range, and retarding admixtures



Hydration-Control Admixture (a.k.a HCAs)

Industry Innovation - 1987

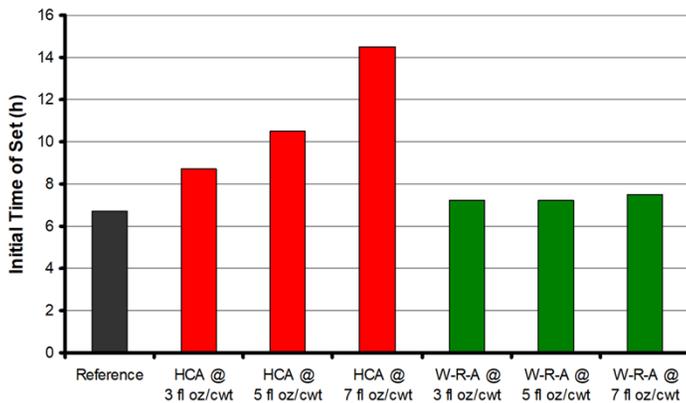
- Effectively puts concrete to sleep
 - ❖ controls (stops) hydration
 - ❖ Works on both the silicate and aluminate phases
- Forms a protective barrier around cement
 - ❖ over time effect dissipates
 - ❖ barrier breaks down
- Normal hydration, setting & strength development follows
- ASTM C 494/C494M 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



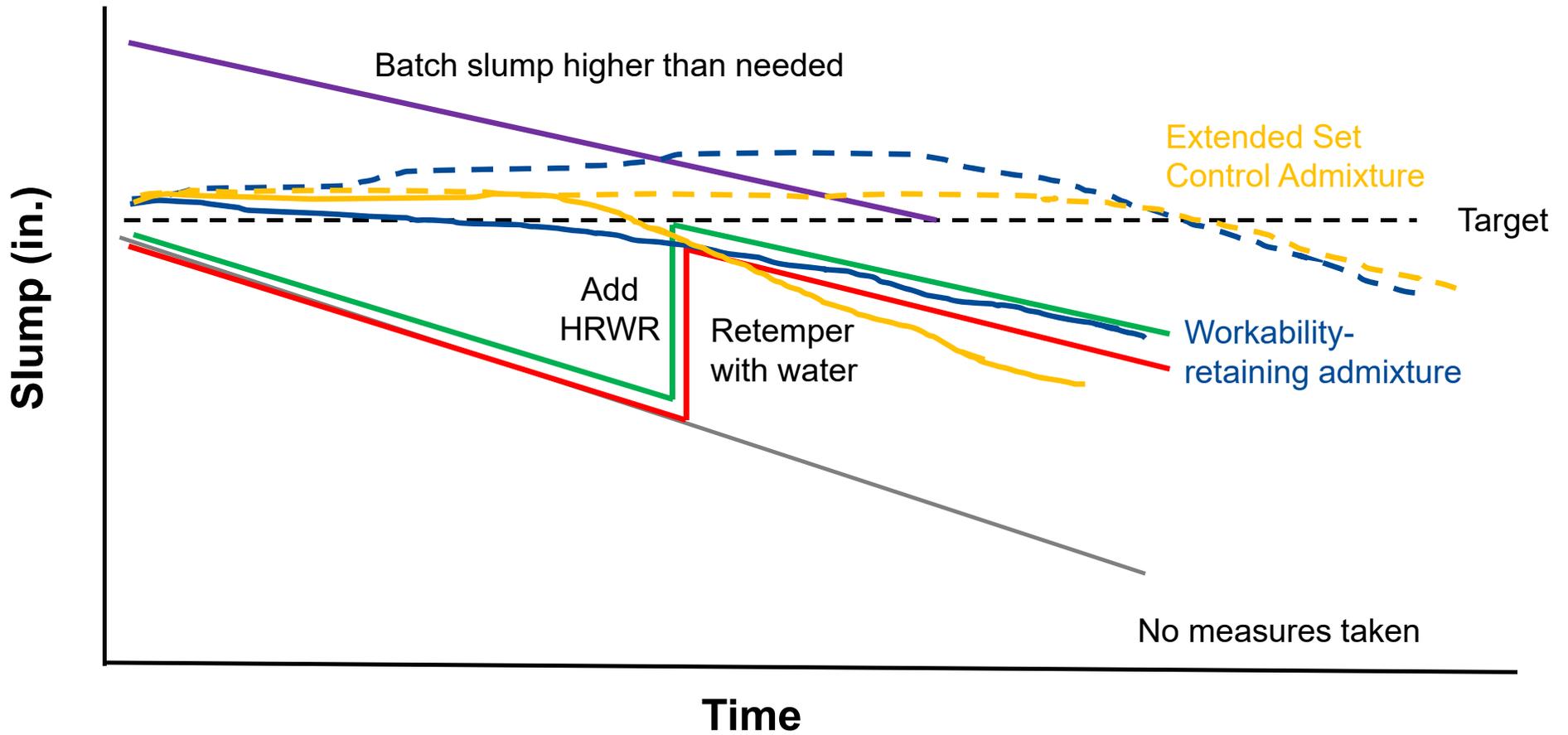
Water reducer - 3.0 fl oz/cwt



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



Slump Life Options



Slump Life Options

Method	Effect on Slump		
	Minimize Loss	Restore	Maintain
Retemper (late addition of water)		X	
Batch higher-than-required slump	X		
Redose with high-range water-reducing admixture		X	
Retarding admixture	X		
Extended Set-Controlling admixture	X		X ¹
Workability-Retaining admixture	X		X ²



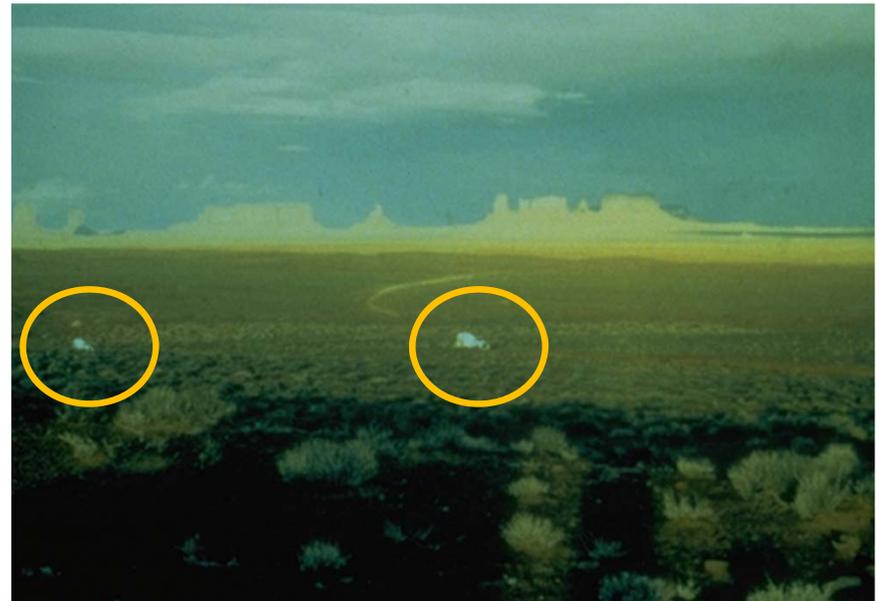
Project: **Microwave Tower**

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: Light Cell - Underwater Placement

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

THE PORT AUTHORITY
OF NEW YORK & NEW JERSEY

Quantity of portland cement in the mixture:
Less than 400 lb/yd³ (240 kg/m³)



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



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]



Source: Wordpress.com



Photo Credit Miguel Paz /Alaska DOT & PF

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

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