Current Admixture Technology

Background

Academic Institute of Chemistry (ACI) 116R-00 definition

• A material other than
  - water,
  - aggregates,
  - hydraulic cement, and
  - fiber reinforcement,
• used as an ingredient of a cementitious mixture to modify its freshly mixed, setting, or hardened properties and that is added to the batch before or during the mixing.

Chemical Admixtures

V.S. Ramachandran:

• ... important group of admixtures used in small amounts...
• Water soluble or emulsified systems
• Accelerators, retarders, water reducers, superplasticizers, etc.
• Air entraining, pumping aids, coloring, alkali-aggregate expansion-reducing, and others...

Fly Ash Particles
Admixture-Related Innovations Timeline

**Air Entrainers**

- Early 1900s
- 1960s
- 1970s
- 1980s
- 1990s
- 2000s

- Anti-Freeze
- Hydration Control
- Mid-Range Water Reducer

**Liquid Water Reducers**
- High-Range Water Reducers (HRWR)

**Viscosity Modifiers**
- Polycarboxylate (PC) HRWR
- Self-Consolidating Concrete

NextGen PC HRWR, Air Detrainers, and Cocktails

**Chemical Admixtures**

- Standard Specifications
  - Air Entraining Admixtures
  - Water-Reducing
  - Retarding
  - Accelerating
  - Water-Reducing and Retarding
  - Water-Reducing and Accelerating
  - High Range Water-Reducing
  - High Range Water-Reducing and Retarding

- NextGen PC HRWR, Anti-Freeze, Hydration Control, Mid-Range Water Reducer

**HRWR (Super P)**

- Comprised of four major groups
  - Sulfonated naphthalene-formaldehyde condensate (SNF)
  - Sulfonated melamine-formaldehyde condensate (SMF)
  - Modified lignosulfonate (MLS)
  - Polycarboxylates

**NextGen PC HRWR**

- Design molecules for specific performance and specific cement chemistries
- Molecular attributes can be altered to affect performance (via synthetic chemistry)
  - Density of side chain grafts
  - Density of charge on backbone
  - Molecular weight of side chain
  - Molecular weight of backbone

- Backbone and side chain chemistry are by design

- Results of PC HRWR molecular design
  - Dispersion efficiency
    - Electrostatic repulsion
    - Steric repulsion
  - Slump retention
  - Control over setting time
  - Early-age strength

- Image Source: www.cement.org
- Source: Joe Daczko, BASF Admixtures
A material added to concrete that changes its viscosity and improves the stability of the mixture

- Cellulose
- PEG – Glycol derivative
- Natural Gums (Welan, Diutan, Guar)

Increase in Viscosity

Viscosity Modifying Admixture

VMAs
- Provide cushion to aggregate particles
- Add more “body” or “cream” to concrete
- Keep particles suspended, reduced segregation

Rheology-Controlling Admixture
Rheology-Controlling Admixture

Rheology

- The study of the deformation and flow of matter under the influence of an applied stress, which might be shear stress or extensional stress.

Rheometer

- An H-shaped impeller spins in a bucket of concrete
- Data is converted to torque
- Torque data is then collected for various impeller rotation rates

Rheology-Controlling Admixture

Admixture effect

- Lowers force required to initiate flow, without affecting the viscosity
- Improves response to vibration
- Lubrication effect
- Enhances consolidation

Air Detrainer Admixture

- Not recommended for use in air-entrained concrete...
- Reduces the air content of concrete mixtures
- Helps to maintain design strengths of concrete mixtures
- May reduce rejected load potential
- Other benefits?
  - Interior flatwork

Compatibility of Admixture Systems
Combination of Water Reducer and HRWR
- Low water content concrete, i.e. zero slump (initial water content is critical)
- Add Type A (2.0 oz/cwt) to increase to 2 in slump
- Add type F (9.0 oz/cwt) to increase to 11 in slump
- Higher strengths, lower shrinkage
- High slump retention
- Good pumpability

Combination of Mid-Range and Retarder
- High temperatures, low humidity
- Longer working time
- Better control over set time
- Typically 8.0 oz/cwt and 2.0 oz/cwt, respectively

Combination of hydration stabilization admixture (HAS) and accelerator and HRWR
- Job Constraints/Specifications
  - 3000 psi in 6 hrs, Type I/II cement
  - 2 yd³ bucket placement, 8 yd³ per truck
  - 45 min haul to job
  - No staging of trucks, tight jobsite
- Admixture Sequencing
  - Type F added to truck
  - Type C added after Type F
  - Type B added after Type F and C

Admixture Cocktails
Admixture Cocktails
Admixture Cocktails
Admixture Cocktails

Conclusions

Concrete

Chemical Admixtures
- NextGen High-Range Water Reducers (Superplasticizers, aka Super P)
- Viscosity Modifying Admixtures
- Rheology-Controlling Admixtures
- Air Detrainer Admixture
- Compatibility of Admixture Systems
Thank You

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