PLC Performance and Recommended Best Practices

Presented By: Joshua D. Gilman, P.E.
Director, Sustainable Infrastructure
Portland Cement Association

U.S. Cement Standards

- **ASTM C150 Portland Cement**
  Types I, II, I/II, III, V
- **ASTM C595 Blended Cement**
  Types IP, IS, IL, IT
- ASTM C1157 Performance Spec
  - Types GU, HE, MS, HS, MH, LH

plc
portland-limestone cement

- 1:1 replacement
- Similar performance and workability
- Similar dosages of SCMs
- Up to 10% carbon footprint reduction
- www.greenercement.com

ROADMAP TO CARBON NEUTRALITY
Portland Cement Association

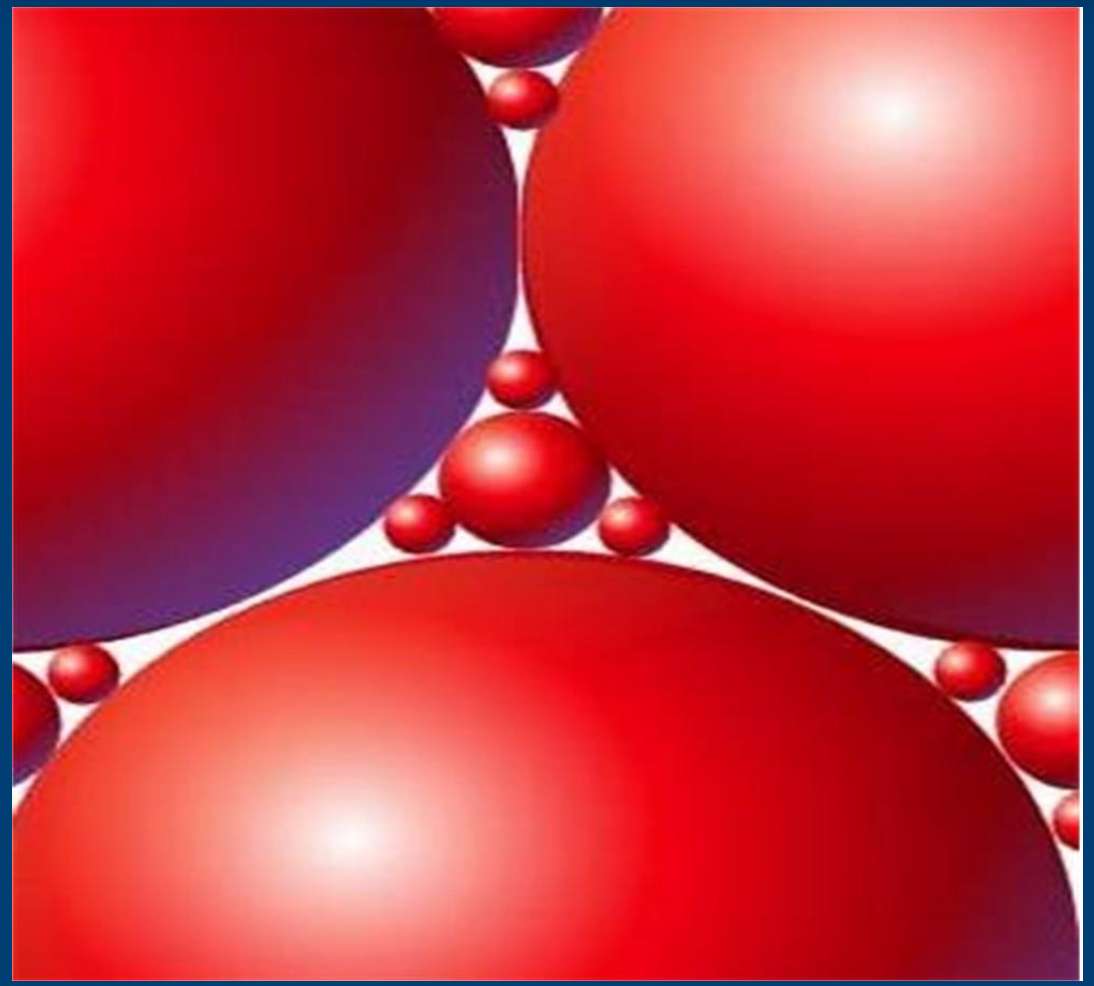
Blended Cement Share of Total U.S. Cement Consumption

70%

aci American Concrete Institute

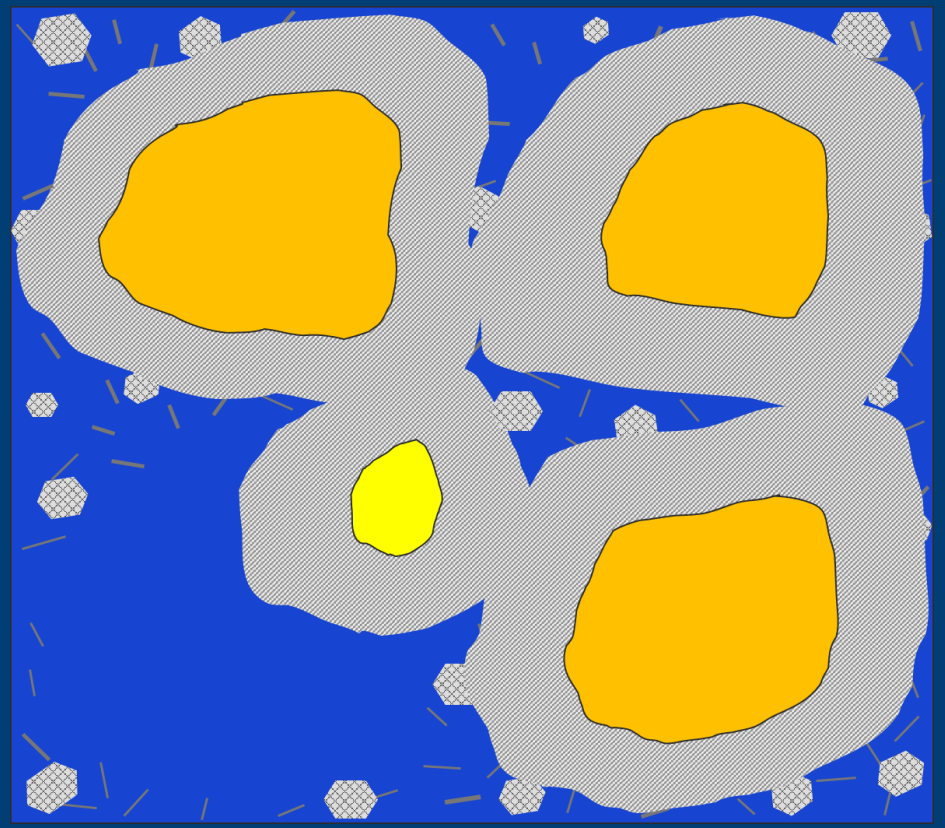
Limestone Contribution to Concrete Performance

- Particle Packing Effect
- softer limestone is preferentially finer, producing a broader particle size distribution, which can lead to denser concrete



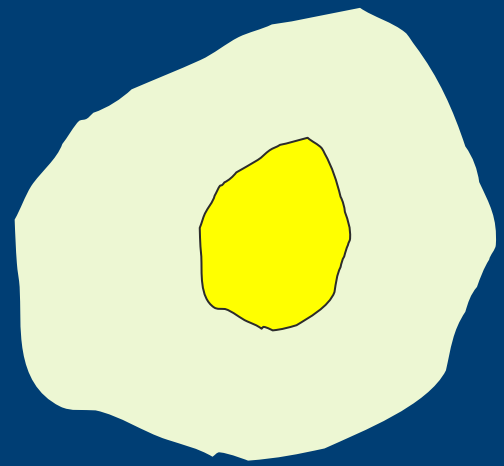
Limestone Contribution to Concrete Performance

- Nucleation Effects
- hydration products of traditional cement reactions are accelerated slightly



Limestone Contribution to Concrete Performance

- Chemical Reactions
- occur to a minor extent, but producing carboaluminate phases, which can reduce porosity, benefiting strength and permeability



$$CaCO_3 + C_3A = \text{Carboaluminates}$$

PLC for Special Properties

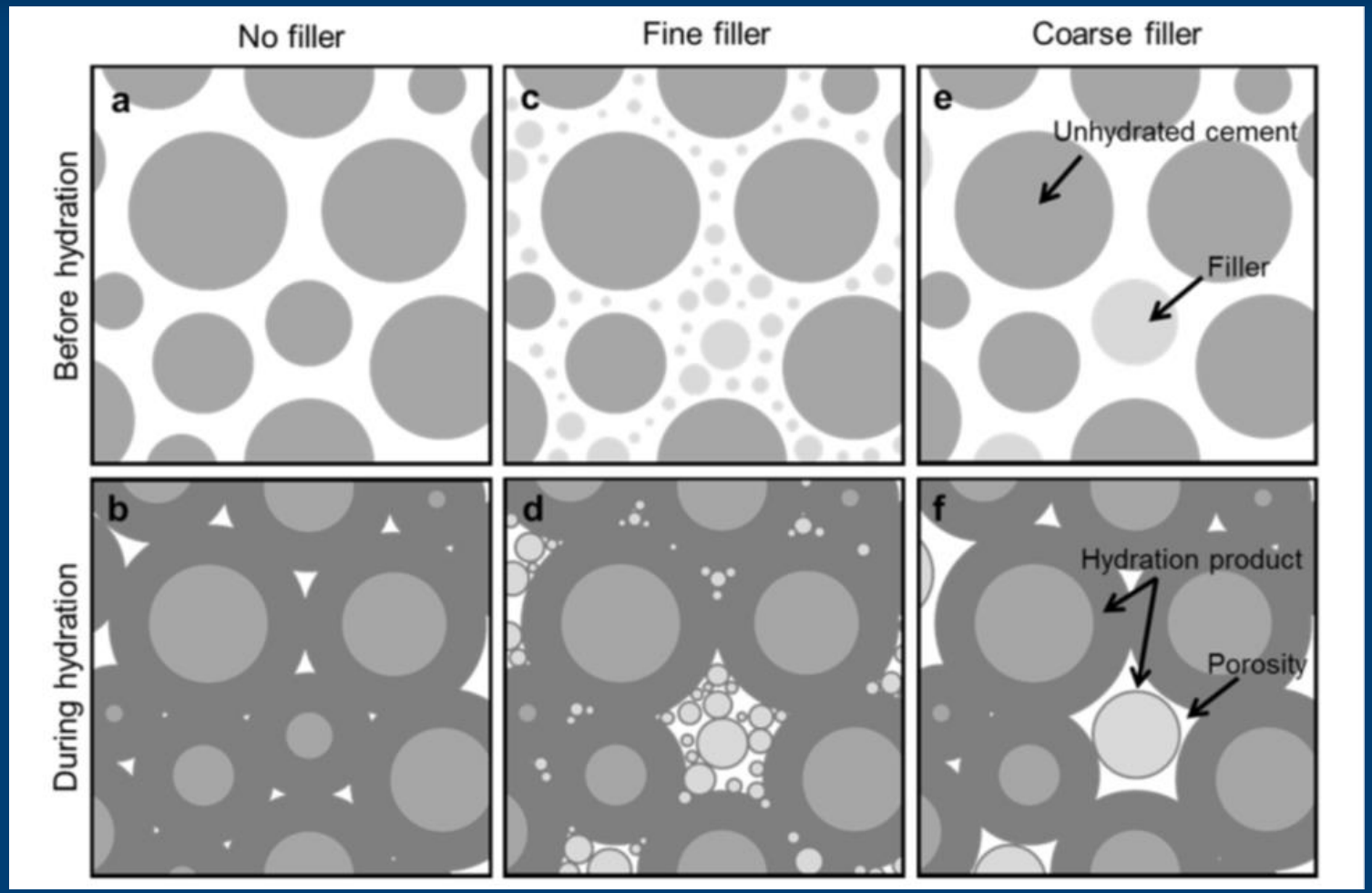
Cement Modifiers

- Sulfate resistance – MS, HS
  - » Sulfate-containing soils
  - » Sulfate-containing groundwaters
- High-early strength – HE
  - » For precast concrete

Cement type	OPC ASTMC150 (AASHTO M85)	PLC ASTMC595 (AASHTO M240)
General use	I	IL
Moderate sulfate resistance	II, II(MS)	IL(MS)
High sulfate resistance	V	IL(HS)
High-early strength	III	IL(HE)

Fresh Properties

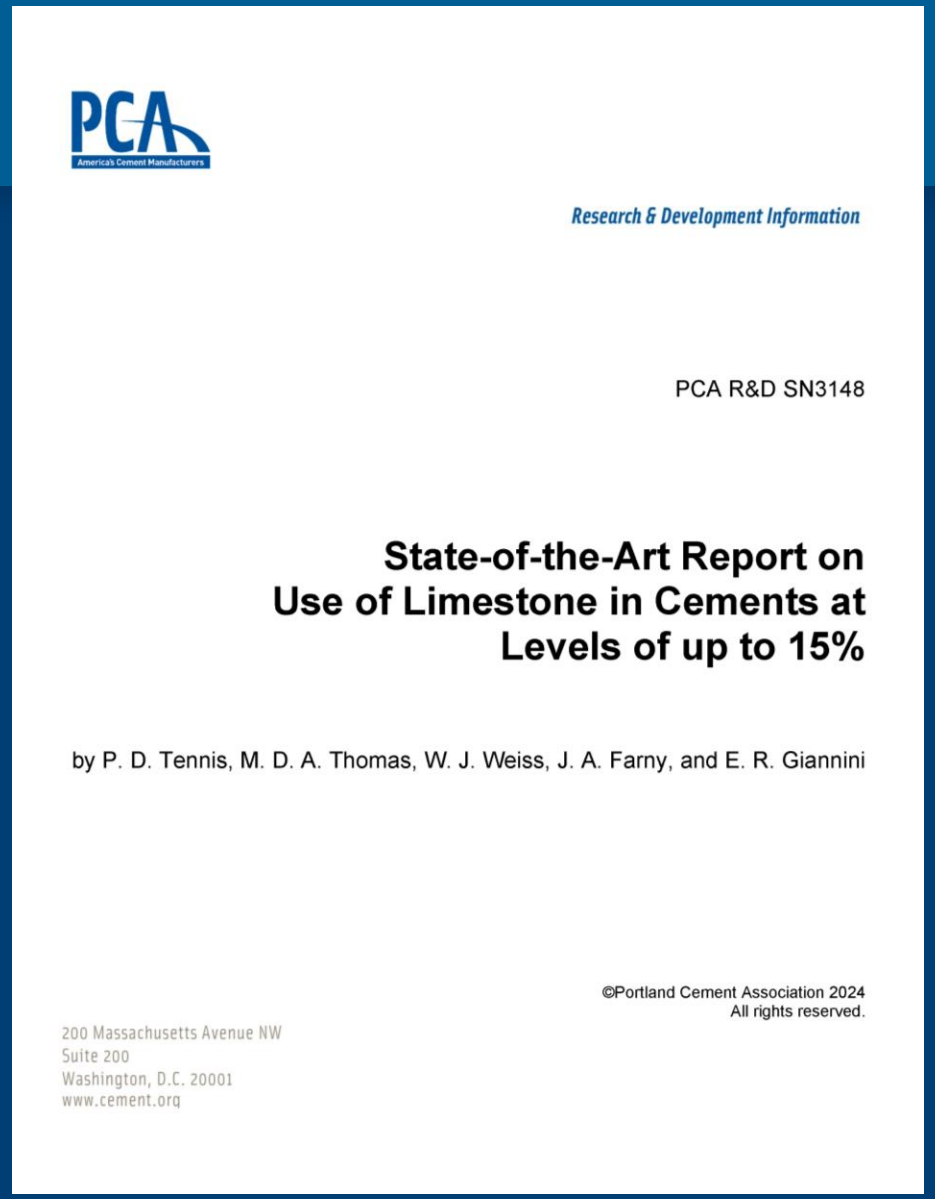
- Water Demand
- Bleed Rate
- Set Time
- Strength Gain



(Nadelman 2016)

PCA R&D SN3148

- State-of-the-Art Report on Use of Limestone in Cements at Levels of up to 15%
- Original Report - 2011
- Updated Report - 2024


PCA
America's Cement Manufacturers

Research & Development Information

PCA R&D SN3148

State-of-the-Art Report on Use of Limestone in Cements at Levels of up to 15%

by P. D. Tennis, M. D. A. Thomas, W. J. Weiss, J. A. Farny, and E. R. Giannini

200 Massachusetts Avenue NW
Suite 200
Washington, D.C. 20001
www.cement.org

Best Practices in Pre-Construction for PLC (Type IL) Projects

- Ferguson International Center
  - »Indiana University – Bloomington, IN

- Component Operations – Jacksonville Facility
  - »Scannell Properties – Jacksonville, FL

- Fashion Valley Mall Remodel
  - »Simon Property Group – San Diego, CA

Best Practices in Pre-Construction for PLC (Type IL) Projects

Ferguson International Center

- 5000 psi design, strength enhancing admixture to achieve 6000 psi
- Exterior Architectural Applications
  - 513 lb cement, 145 lb slag cement
  - Air entrainment, high-range water reducers, shrinkage reducing w/ waterproofing admixtures
- Post-tension Decks
  - Two mixes – one air-entrained mixture with slag, one not air-entrained with fly ash
  - High-range water reducers, and shrinkage reducing with waterproofing admixtures

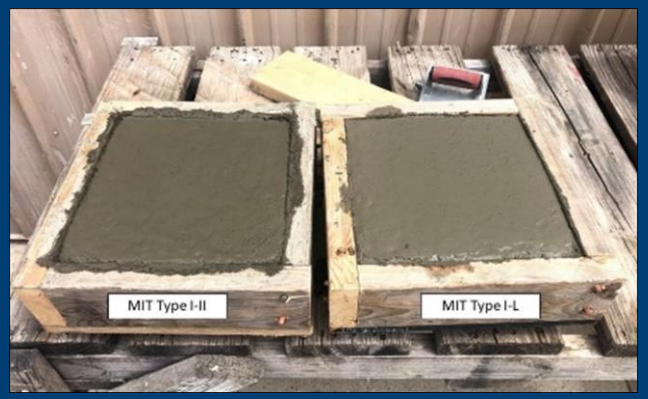
WEDDLE BROS. BUILDING GROUP, LLC
A Weddle Bros. Construction Company

imi

Best Practices in Pre-Construction for PLC (Type IL) Projects

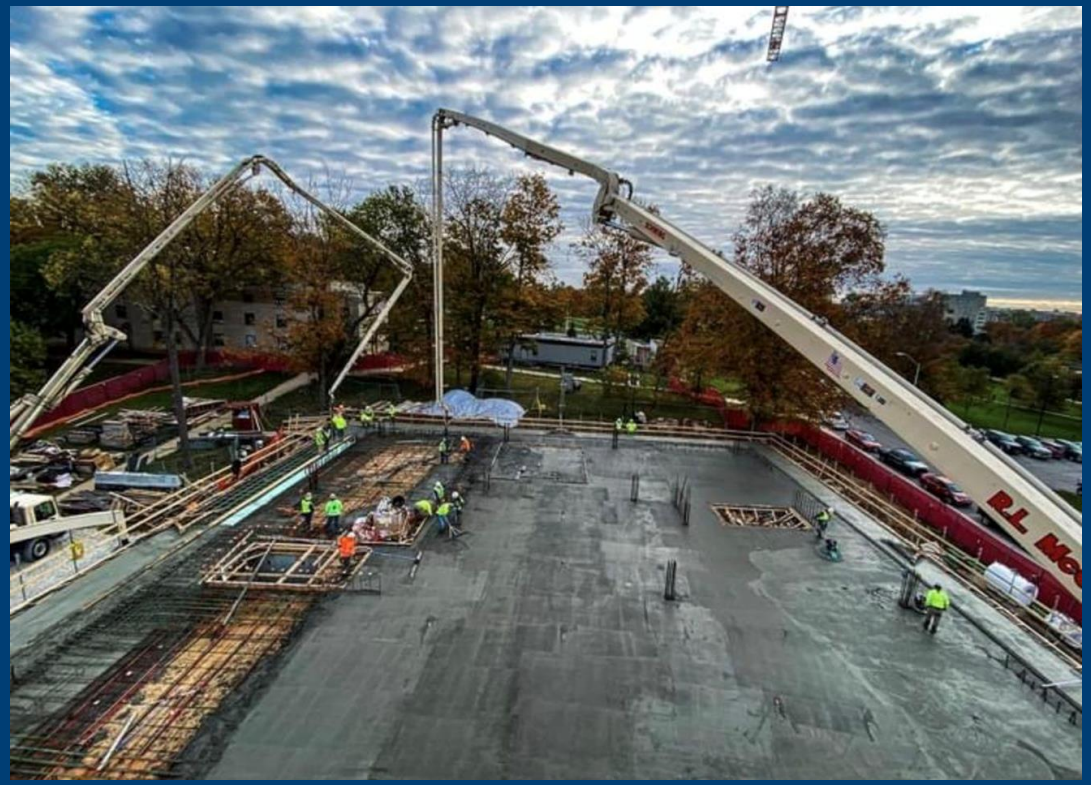
Ferguson International Center

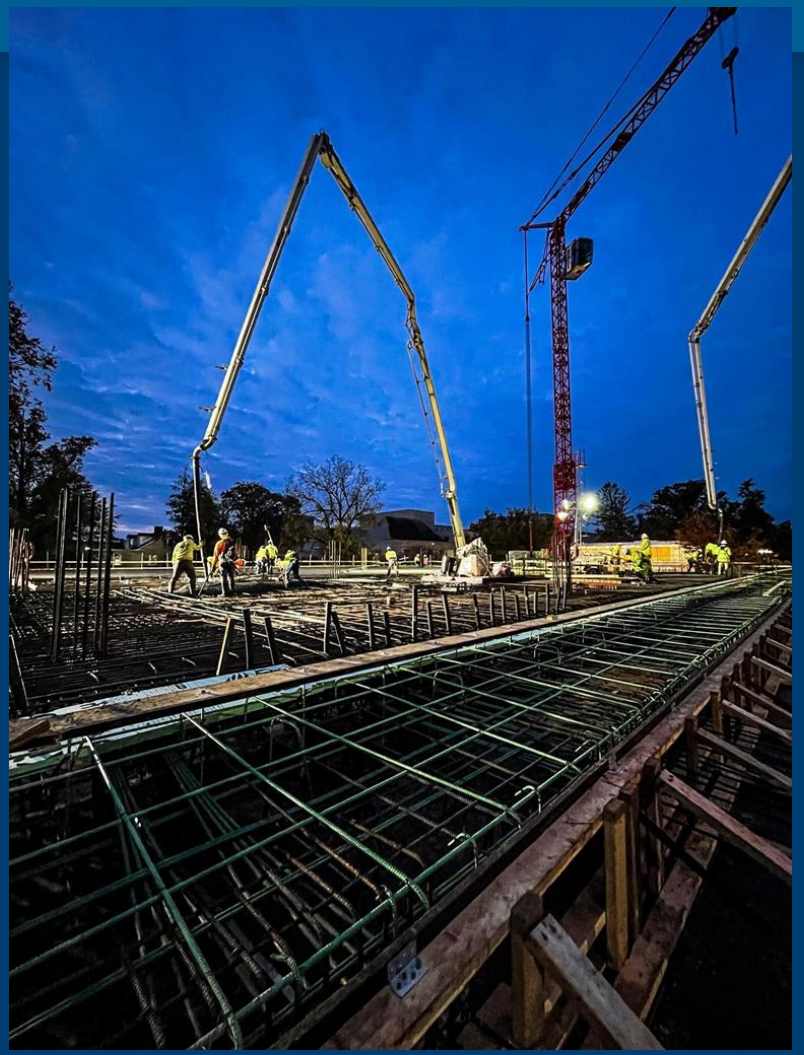
- Type IL Cement
  - Made with ASTM C150 Type I-II clinker
  - 11% typical limestone content
  - 497 m^2/kg Blaine
  - Met S1 Sulfate Resistance



Best Practices in Pre-Construction for PLC (Type IL) Projects

Ferguson International Center





Best Practices in Pre-Construction for PLC (Type IL) Projects

Component Operations – Jacksonville Facility

- 4000 PSI design
- Slab-on-Grade and Tilt-up Panels
  - » 400 lb cement, 130 lb Grade 120 Slag Cement
  - » Water reducing and set retarding admixture formulated with strength enhancing admixture
  - » w/c of 0.50

CONCRETE STRATEGIES
MORE TO THE POUR

Preferred MATERIALS, INC.
A CRH COMPANY

Best Practices in Pre-Construction for PLC (Type IL) Projects

Component Operations – Jacksonville Facility

- Type IL Cement
  - » 13% typical limestone content
  - » 490 m^2/kg Blaine (avg.)
  - » MS, MH, HE available

Best Practices in Pre-Construction for PLC (Type IL) Projects

Component Operations – Jacksonville Facility

- Slab Test Panel
- Tilt-Up Mock-Up

Best Practices in Pre-Construction for PLC (Type IL) Projects

Component Operations – Jacksonville Facility

Best Practices in Pre-Construction for PLC (Type IL) Projects

Fashion Valley Mall Remodel

- 3000 PSI design
- Walls, Slabs, Topping
  - 583 lb cement, 1” coarse agg
  - Non air entrained, high range water reducer and retarding admixture
  - Slump 4”, w/c of 0.6
  - Pumped Mix – 658 lb cement, 3/8” course agg, option for SRA and fibers, Slump 5”, w/c 0.52

T.B. PENICK & SONS, INC.

CEMEX

Best Practices in Pre-Construction for PLC (Type IL) Projects

Fashion Valley Mall Remodel

- Type IL HS Cement
  - Made w/ ASTM C150 Type I/II/V clinker
  - 11% limestone content
  - 526 m^2/kg Blaine
  - ASTM C1012 physical test to determine sulfate resistance
- Type IL “LT” Cement
  - Made w/ ASTM C150 Type III clinker
  - 13% limestone content
  - 544 m^2/kg Blaine
  - “LT” denotes light color

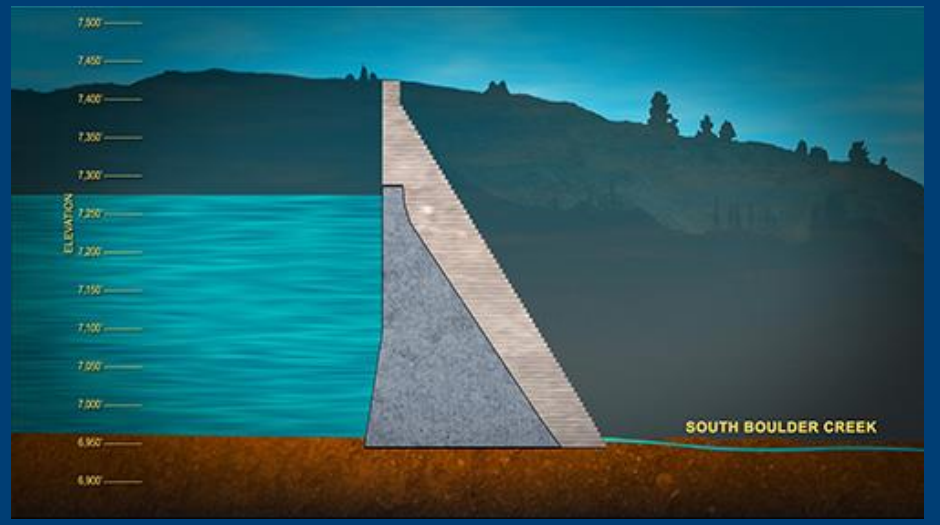
Best Practices in Pre-Construction for PLC (Type IL) Projects

Fashion Valley Mall Remodel

PLC Recommended Best Practices

Gross Reservoir Expansion Project

- RCC dam raise with CVC facing
  - » 740,000 CY RCC; 68,000 CY CVC
  - » Preliminary Target for RCC - 150 lb cement, 210 lb fly ash
  - » Max. Placement Temperature 50˚F
    - Coarse Aggregate Cooling (Chilled Water)
    - Fine Aggregate Cooling (Cold Air)
    - Replace Mixing Water w/ Ice (Up to 80%)



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BARNARD

PLC Recommended Best Practices

Gross Reservoir Expansion Project

- Test Section

PLC Recommended Best Practices

Gross Reservoir Expansion Project

- Test Section Complete
- RCC Placement 2024/25
  - » Year 1 - top of existing dam
  - » Year 2 – new crest elevation
- Begin Filling Reservoir 2027

PLC Recommended Best Practices

- Pre-Construction Communication and Partnerships are Key
  - Review specification requirements and customer needs
  - visual appearance, schedule, fresh and hardened concrete properties
- Trial Batches on New Mixtures
  - Consider admixtures
  - Simulate drive times and ambient conditions
- Curing Plan
- Field Mock-Ups
  - Follow specification requirements- sample size
  - Validate placing and finishing characteristics
  - Revise as needed

Thank You!