



Strength. Performance. Passion.

## Evaluation of Portland/Limestone Performance Cements (ASTM C1157) in Colorado and Utah Transportation and Commercial Projects – 2007 to present

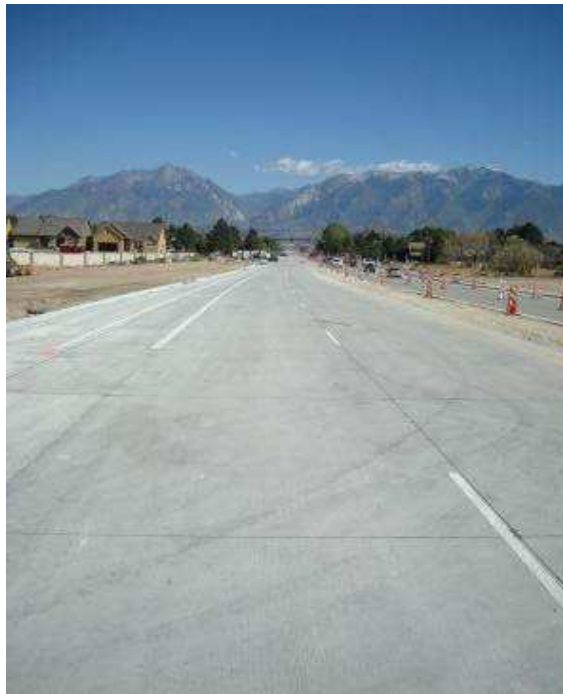


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# Portland/Limestone Cement Projects

- +150 miles of concrete paving in Colorado and Utah



Performance and Environmental Benefit

# CDOT and UDOT Specifications

- Allow portland-limestone cements that meet ASTM C1157 performance specification for GU (General Use), MS (Moderate Sulfate Resistance) and HS (High Sulfate Resistance)
- Supplementary cementitious materials required for applications that require resistance for sulfate attack and/or alkali silica reactivity for both ASTM C150 and ASTM C1157 cements



## Verifying Portland Limestone Cement Durability

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- Holcim ASTM C595 (Type IL) or ASTM C1157 cements are tested for durability performance. Tests generally include:
  - ▶ Fresh & Hardened concrete properties
    - Requirements are met through concrete mix design – ASTM
  - ▶ Sulfate Resistance - ASTM C1012
  - ▶ Alkali-Silica Reactivity - ASTM C1260/1567
  - ▶ Freeze Thaw & Deicer Scaling Resistance - ASTM C666 & C672
  - ▶ Shrinkage – ASTM C157
  - ▶ Chloride Ion Penetration – ASTM C1202

## How do Portland/Limestone Cements compare?

ASTM Designation	PLC vs C150	PLC vs C150	PLC vs C150	PLC vs C150	PLC vs C150
Strength 28D (C39)	Equal	Better	Better	Better	Equal
Sulfate (C1012)	Equal	Equal	Equal	Equal	Equal
ASR (C1260/C1567)	Better	Equal	Equal	Equal	Equal
Freeze-Thaw (C666)	Equal	Equal	Equal	Equal	Equal
Deicer Scaling (C672)	Equal	Equal	Equal	Equal	Equal
Shrinkage (C157)	Equal	Equal	Equal	Equal	Equal
Permeability (C1202)	Slightly Better	Equal	Equal	Equal	Equal

# How do Portland/Limestone cements perform in the field?

- Equal or improved to C150 cements
  - ▶ Strength
  - ▶ Set time
  - ▶ Water demand
  - ▶ Compatibility with fly ash
  - ▶ Compatibility with admixtures
- Improved finishability
- Lower environmental impact



# Devil's Slide, Utah Cements



- Type V clinker
  - ▶  $C_3A < 5\%$
- ASTM C150 Type II/V
  - ▶ High sulfate resistance
    - $C_3A < 5\%$
  - ▶  $< 5\%$  limestone per ASTM C150
  - ▶  $N_{aeq} < 0.60\%$
- ASTM C1157 Type GU/MS
  - ▶ General Use/Moderate Sulfate resistance
    - ASTM C1012, sulfate performance test
  - ▶ 10% limestone

# Utah PLC Case Studies



**Performance & Lower Environmental Impact**



# Lost Creek Road Morgan, Utah

- Rural County Road
  - ▶ Constructed 2009
  - ▶ Major Truck Traffic
  - ▶ Construction Limitations
  - ▶ Mountain weather issues
- Performance System
  - ▶ 10% Limestone Cement
  - ▶ 20% Class F fly ash
- Compressive strength
  - ▶ Design 4000 psi, average 5120 psi
- Flexural strength
  - ▶ Design 650 psi, avg 720 psi





# 104<sup>th</sup> South, Salt Lake City, Utah

- Pooled Fund Ternary Study (2009)
  - ▶ University of Utah\* (Tikalsky)
  - ▶ 10% Limestone Cement
  - ▶ 25% Class F Fly ash
- Single days production
- Control Section Strength\*
  - ▶ 28 D Compressive - 4454 psi
- Actual Test Section Strength\*
  - ▶ 28 D Compressive - 5396 psi



# SR 201, Salt Lake City, Utah

- Eastbound lanes paved August 2009 with ASTM C150 Type II/V
- Westbound lanes paved October 2009 with ASTM C1157 10% portland/limestone cement
  - ▶ Both mixes contained 25% Class F fly ash
- Eastbound Strength
  - ▶ Compressive ~5000 psi
  - ▶ Average Concrete Temp ~70 F
- Westbound Strength
  - ▶ Compressive ~4500 psi
  - ▶ Average Concrete Temp ~50 F



# UTA FrontRunner South Lake City to Provo, Utah

Salt



# UTA FrontRunner South Lake City to Provo, Utah

Salt

- Keystone Concrete Masonry Units (CMU)
  - ▶ 10% Limestone Cement
  - ▶ 15% Class F Fly ash
- 350,000 square feet of retaining wall
- Block on the project Averages:
  - ▶ 28 D Compressive - 6,500 psi
  - ▶ Absorption of 5.3%
- 37 Foot Tall Retaining Wall
  - ▶ 55 block courses above grade
  - ▶ 10 block courses below grade

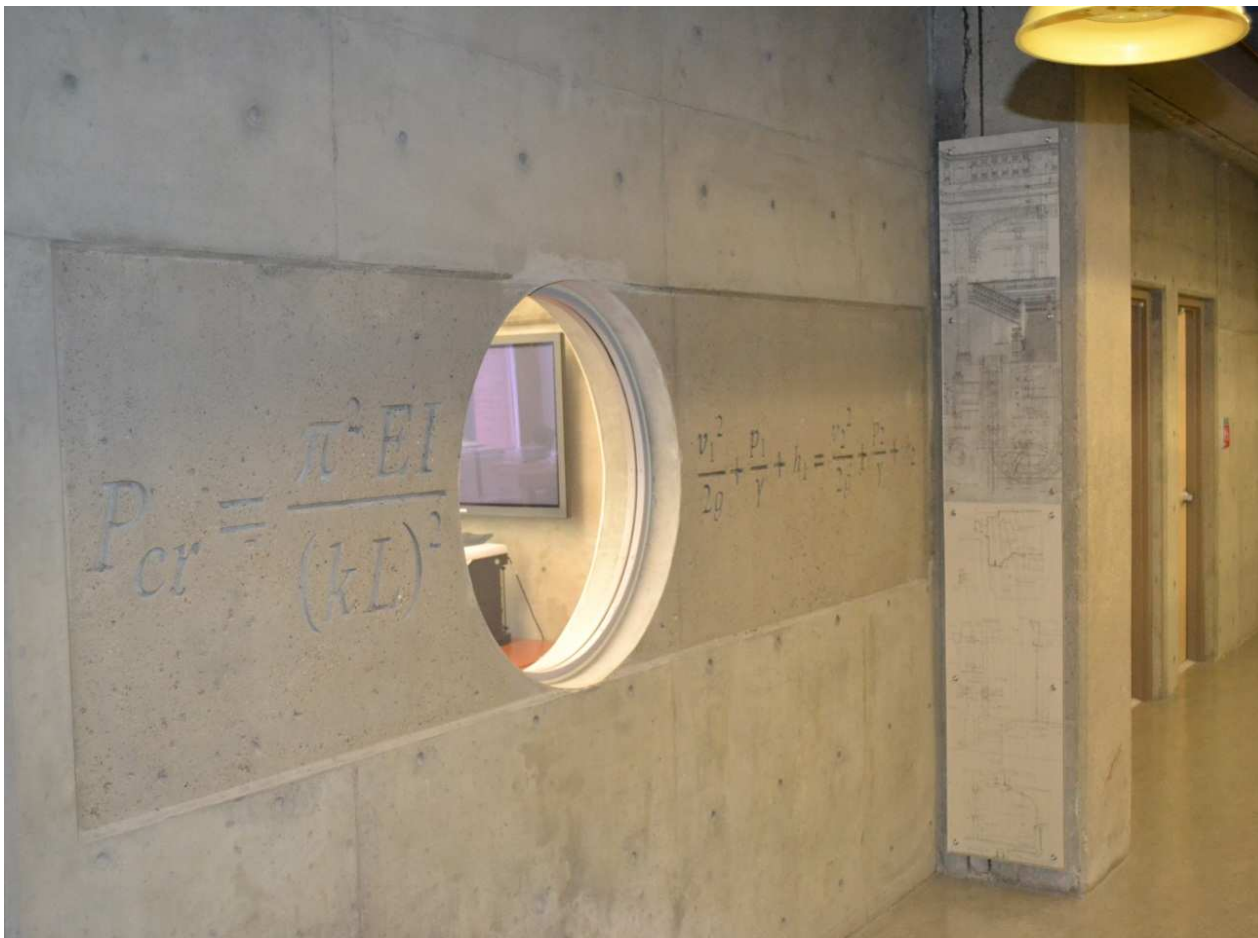


# University of Utah Meldrum Building

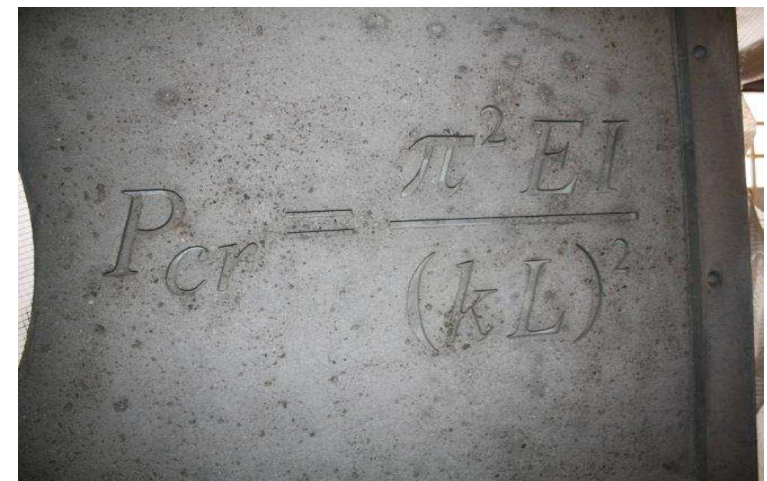
- Constructed 2009-2010
- Designed to meet LEED Silver certification
- Technical SCC mixtures
- Architectural Finishes
- Performance System
  - ▶ Portland/limestone cement
  - ▶ 20% Class F Fly Ash



# University of Utah Meldrum Building



- Lightweight
- Winter placement
- Compressive strength
  - ▶ SCC Design 4000 psi





# Ben Lomond High School – Ogden, Utah



# Ready Mix Maintenance Facility

- LEED Certification is pending
  - ▶ Silver or Gold
- 13, 915 Square feet
- Performance System
  - ▶ Portland/limestone cement
  - ▶ 20% Class F Fly Ash



# Portland, Colorado Cements



- Type II clinker
  - ▶  $C_3A < 8\%$
- ASTM C150 Type I/II
  - ▶ General use/Moderate sulfate resistance
    - $C_3A < 8\%$
  - ▶  $< 5\%$  limestone per ASTM C150
  - ▶  $N_{aeq} > 0.70\%$
- ASTM C595 Type IP(HS)
  - ▶ 25% Class F fly ash
- ASTM C1157 Type GU/MS
  - ▶ General Use/Moderate Sulfate resistance
    - ASTM C1012, sulfate performance test
  - ▶ 10% limestone

# Colorado PLC Case Studies



**Performance & Lower Environmental Impact**

# City of Denver Concrete Paving 40<sup>th</sup> & Havana and Holly Street



# City of Denver Concrete Paving

- Aligns with Denver Greenprint Program
- 40<sup>th</sup> & Havana - side by side comparison of ASTM C150 I/II and ASTM C1157 GU cements (2007)
  - ▶ 20% Class C fly ash
  - ▶ No noticeable performance differences
  - ▶ Winter construction
- Holly Street - Ready-mix concrete supply (2008)
  - ▶ 25% Class C fly ash



# City of Denver Concrete Paving Central Park Boulevard

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# DIA Pena Boulevard





# US HW 287 Near Lamar, CO



# US HW 287 Near Lamar, CO

- 7 Miles PCCP (2008)
  - ▶ Hot dry summer construction
- Ports to Plains US Highway route
  - ▶ Heavy truck traffic
- 20% Class F fly ash
- 695 psi average 28-day flexural strength
- Contractor received quality incentive per CDOT specifications
- Used in CDOT concrete paving on a regular basis

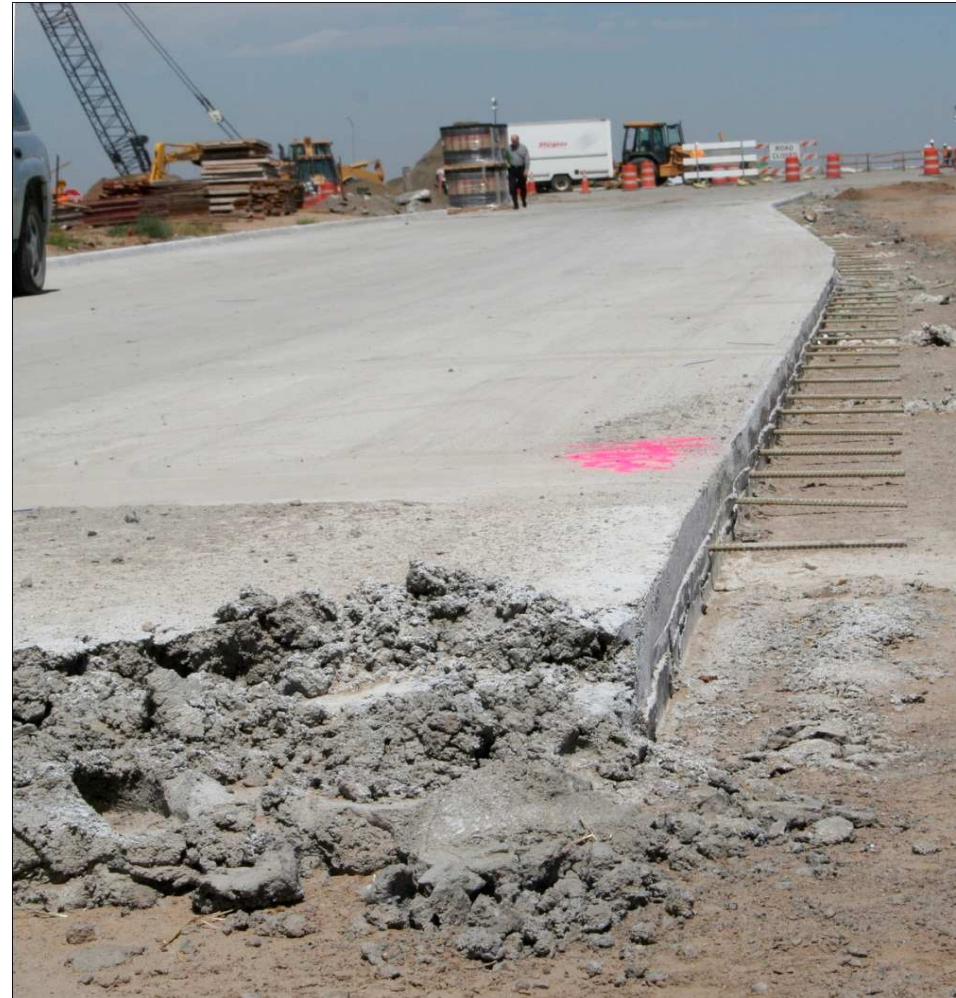


# US HW I-25 Near Castle Rock, CO



# US HW I-25 Near Castle Rock, CO

- 5 Miles PCCP (2008)
- Major Interstate Highway
- 20% Class F fly ash
- 720 psi average 28-day flexural strength
- Contractor received quality incentive per CDOT specifications
- Used in concrete paving on a regular basis in Colorado



# Pueblo County Health Department Pueblo, Colorado



# Pueblo Judicial Center – Pueblo, Colorado



# Blue Spruce Habitat for Humanity Project

- Part of AIA Design Build Contest
- Will be featured at 2013 AIA National Convention in Denver
- Portland/limestone cement in the concrete



**FLEXPLEX**

AIA Denver AIA Colorado CAD-1  
Blue Spruce Habitat for Humanity  
Habitat for Humanity of Colorado

Exterior View  
Design Build Competition 2011

## Keep in mind...

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- No cement or scm's can offset low quality concrete
- Durable concrete depends on:
  - ▶ Appropriate mixture proportions
  - ▶ Lower w/cm
  - ▶ Air entrainment in F/T conditions
  - ▶ Proper placement
  - ▶ Curing
  - ▶ Maintenance
- When good practices are followed, concrete will attain its expected service life



# Summary

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- Projects demonstrate concrete made with portland/limestone cements are readily constructible and can easily achieve specified strength requirements.
- Durability testing shows similar or improved performance to ASTM C150 cements
- Portland/limestone cements can provide performance and lower environmental impact



Over 150 miles of paving in Colorado and Utah



**Performance & Lower Environmental Impact**

Thank You!

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