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

- 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?

<table>
<thead>
<tr>
<th>ASTM Designation</th>
<th>PLC vs C150</th>
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<th>PLC vs C150</th>
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</thead>
<tbody>
<tr>
<td>Strength 28D (C39)</td>
<td>Equal</td>
<td>Better</td>
<td>Better</td>
<td>Better</td>
<td>Equal</td>
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<tr>
<td>Sulfate (C1012)</td>
<td>Equal</td>
<td>Equal</td>
<td>Equal</td>
<td>Equal</td>
<td>Equal</td>
</tr>
<tr>
<td>ASR (C1260/C1567)</td>
<td>Better</td>
<td>Equal</td>
<td>Equal</td>
<td>Equal</td>
<td>Equal</td>
</tr>
<tr>
<td>Freeze-Thaw (C666)</td>
<td>Equal</td>
<td>Equal</td>
<td>Equal</td>
<td>Equal</td>
<td>Equal</td>
</tr>
<tr>
<td>Deicer Scaling (C672)</td>
<td>Equal</td>
<td>Equal</td>
<td>Equal</td>
<td>Equal</td>
<td>Equal</td>
</tr>
<tr>
<td>Shrinkage (C157)</td>
<td>Equal</td>
<td>Equal</td>
<td>Equal</td>
<td>Equal</td>
<td>Equal</td>
</tr>
<tr>
<td>Permeability (C1202)</td>
<td>Slightly Better</td>
<td>Equal</td>
<td>Equal</td>
<td>Equal</td>
<td>Equal</td>
</tr>
</tbody>
</table>
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
  - Naeq < 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
104th 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
UTA FrontRunner South
Salt Lake City to Provo, Utah

- Keystone Concrete Masonry Units (CMU)
  - 10% Limestone Cement
  - 15% Class F Fly ash
- 350,000 square feet or 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**
  - C₃A <8%

- **ASTM C150 Type I/II**
  - General use/Moderate sulfate resistance
  - C₃A <8%
  - <5% limestone per ASTM C150
  - Naeq >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
40th & Havana and Holly Street
City of Denver Concrete Paving

- Aligns with Denver Greenprint Program
  - 20% Class C fly ash
  - No noticeable performance differences
  - Winter construction
  - 25% Class C fly ash
City of Denver Concrete Paving
Central Park Boulevard
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
Keep in mind…

- 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

- 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!

Any Questions?

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