Objectives

- Why the proposed change?
- What would change?
- How do we propose to proceed?
- What do we know about portland limestone blended cements?
- What additional information is needed?
Reason for Proposal

- Provide option that can:
  - Help DOTs and industry meet sustainability initiatives
  - Implement proven technology
  - Reduce GHG emissions by up to 10%
  - Conserve energy and natural resources
  - Address legislative and regulatory challenges
  - Harmonize standards
Concept – Changes to M240/C595

- Include provisions for a new portland-limestone blended cement containing from 5% to 15% limestone
- Have same physical requirements as existing Type IS, IP, and IT cements
Development Procedure

- Consider cement standards development objectives
- Gather, review, and evaluate information
- Identify and address questions
- Develop and submit ballot item(s) with supporting rationale and documentation
Known Use and Performance

- Experience in Europe and Canada
- Proven technology
- Fresh and hardened concrete properties
- Compatibility with admixtures and SCMs
Historical Use of Limestone in Cements

- 1965 Heidelberger produces 20% limestone cement in Germany for specialty applications (Schmidt 1992)
- 1979 French Cement Standards allows limestone additions.
- 1983 CSA A5 allows 5% in Type 10 (now GU) cement
- 1990, 15+-5% limestone blended cements being used in Germany
- 1992, in UK, BS 7583 allows up to 20% in Limestone Cement
- 2000 EN 197-1 allows 5% MAC (Typ. Limestone) in all 27 common cements, as was commonly practiced in various European cement standards prior to that.
- 2000 EN 197-1 creates CEM II/A-L (6-20%) and CEM II/B-L (21-35%)
- 2006 CSA A3001 allows 5% in other Types than GU
- 2004 ASTM C 150 allows 5% in Types I-V
- 2007 AASHTO M85 allows 5% in Types I-V
- 2008 CSA A3001 includes PLC containing 5%-15% limestone
Cements Used in Europe

PLC had the largest use in 2004

Most portland-composite cements contain limestone too!
<table>
<thead>
<tr>
<th>Portland cement</th>
<th>Blended cement</th>
<th>Portland-limestone cement</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>GU</td>
<td>GUb</td>
<td>GUL</td>
<td>General use</td>
</tr>
<tr>
<td>MS</td>
<td>MSb</td>
<td>*-</td>
<td>Moderate sulfate resistant</td>
</tr>
<tr>
<td>MH</td>
<td>MHb</td>
<td>MHL</td>
<td>Moderate heat of hydration</td>
</tr>
<tr>
<td>HE</td>
<td>HEb</td>
<td>HEL</td>
<td>High early strength</td>
</tr>
<tr>
<td>LH</td>
<td>LHb</td>
<td>LHL</td>
<td>Low heat of hydration</td>
</tr>
<tr>
<td>HS</td>
<td>HSb</td>
<td>*-</td>
<td>High sulfate resistant</td>
</tr>
</tbody>
</table>

* CSA does not have provisions for sulfate resistant PLC cements
Concrete Tests

- Cements and SCMs
  - 10% to 15% PLC
  - Slag (15, 25, 30, 50%) and fly ash 25%

- Slump, slump retention and air were measured

- Strength and durability tests were performed
Concrete Strengths with Slag or Class C FA

Almost no impact of 12% PLC on f’c at any age with 25% Slag or 20% Fly Ash
Durability Tests – w/cm = 0.40, 0.45 & SCM

Freeze-Thaw Resistance (ASTM C 666)

Scaling Resistance (ASTM C 672)

Chloride Permeability at 28 days

Chloride Permeability at 56 days
Field Trials – Jan CI, 8 Concretes
Cements = CSA A3001 PC and PLC (12% limestone)

- Blended SCM = 33% FA, 67% Slag
  - Replacement levels = 0, 25, 40, 50

- Tests
  - Cast specimens - compressive strength (ASTM C39), rapid chloride penetration (ASTM C1202), rapid freeze/thaw (ASTM C666), hardened air void analysis (ASTM C457), deicer scaling (C672),
  - Cored - strength (ASTM C42), chloride penetration (C1202), chloride diffusion (ASTM C1556)
Field Trials – Strength Results

The image shows a bar chart comparing the compressive strength of two different materials (PC and PLC) at various SCM replacement levels. The x-axis represents the SCM replacement level in percent (%), while the y-axis represents the compressive strength in MPa and ksi. The chart indicates the strength results over time (3d, 7d, 28d, 56d, 60d, 65d, and 35d core).
Field Trials – RCPT Results

- **Charge passed, Coulombs** vs. **SCM replacement level, %**

  - **PC at 28 days**
  - **PLC at 28 days**
  - **PC at 56 days**
  - **PLC at 56 days**

  - 28d
  - 56d
TRB Paper – Three Case Studies
All Used C1157 Cement Containing 10% Limestone

- 40th Avenue, Denver, 2007
  - Used with 20% Class C FA, Recycled Aggregate
  - Used with 20% Class F FA
- I-25, Castle Rock, 2008-2009
  - Used with 20% Class F FA
Summary

Why the proposal?
- Option to implement proven technology to obtain desired performance and improve sustainability of concrete

What would change?
- 5% to 15% limestone in ASTM C595/M240
- Same physical requirements as IP, IS, IT

How to proceed?
- Remember standards development objectives
- Gather, review, and evaluate information
- Identify and address questions
Questions to Address

- Sulfate exposure
- Others?
Portland Limestone Blended Cement in AASHTO M240 and ASTM C595
Presented to AASHTO TS3a August 2010

Thank you!