Contempra™ / Portland Limestone Cement (PLC) and its use in Lower Carbon Intensity Concrete

Ken Carrusca, P.Eng.
Cement Association of Canada
Contempra™ / PLC

- Background on cement making
- What is Contempra & why use it?
- Extensive research and testing
- Use of PLC in Europe
- BC marketplace and projects
Contempra™ / PLC

➢ Background on cement making
➢ What is Contempra & why use it?
➢ Extensive research and testing
➢ Use of PLC in Europe
➢ BC marketplace and projects
Cement Manufacturing

<table>
<thead>
<tr>
<th>Quarrying</th>
<th>Raw Materials Preparation</th>
<th>Clinker Production</th>
<th>Cement Grinding and Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone and small amounts of sand and clay are extracted, usually from a quarry located near the cement manufacturing plant.</td>
<td>The extracted materials are analyzed, blended with additional mineral components depending on the type of limestone available, and finely ground for further processing.</td>
<td>The materials are heated in a kiln reaching a temperature of 1,470°C. The heat transforms the materials into a molten product called clinker, which is then rapidly cooled.</td>
<td>The clinker is stored and then finely ground. Gypsum is added to control setting time, along with supplementary cementing materials, such as fly ash or slag, to obtain a fine powder called cement, with the desired properties of strength and chemical resistance.</td>
</tr>
</tbody>
</table>

Up to 15% unprocessed limestone finely inter-ground with clinker to produce Contempra™ / Portland Limestone Cement.
Cement Manufacturing Process

- Thermal and chemical reactions
- Energy intensive process
  - Combustion emissions
  - Process emissions
Cement and Concrete in BC

- **Cement Manufacturing Plants**
  - Lafarge in Richmond and Lehigh Hanson in Delta

- **Concrete Operations**
  - 135 ready-mixed concrete batch facilities
  - 17 precast concrete producers

- **Jobs and Investment**
  - More than 2000 direct and indirect BC jobs
  - Over $3 billion of investment in the economy
Contempra™ / PLC

- Background on cement making
- What is Contempra & why use it?
- Extensive research and testing
- Use of PLC in Europe
- BC marketplace and projects
Contempra™ / Portland Limestone Cement / PLC?

- Contempra™
- Portland-Limestone Cement or PLC
- CSA Cement Types
  - GU – General Use Cement
  - GUL – Portland-Limestone Cement
- EcoCem
A new category of cement is entering the Canadian market. Portland-limestone cement (PLC), used successfully in Europe for over 25 years, will be available in Canada in 2010.

What Is Portland-Limestone Cement (PLC)?

While regular portland cement may contain up to 5% limestone, PLC is manufactured by intergrinding portland cement clinker with between 8% and 15% limestone. The clinker used to make PLC is the same clinker that is used to manufacture regular portland cement. The performance of PLC is dependent on the high quality of the limestone. In recognition of this fact, limestone used in PLC is tested for calcium carbonate content, clay content, and total organic carbon content. The 15% limestone limit applied to PLC in Canada is well below the maximum limit of 33% permitted in European standards. PLC performance specifications are similar to those of regular portland cement in that PLC must meet the same CSA A3001 physical requirements as regular portland cement.

The CSA A3001-08 Standard lists the four types of PLC as follows:

### Types

<table>
<thead>
<tr>
<th>Portland cement type</th>
<th>Blended hydraulic cement type*</th>
<th>Portland-limestone cement type</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>G</td>
<td>G</td>
<td>General use cements</td>
</tr>
<tr>
<td>NS</td>
<td>M-I</td>
<td>M-I</td>
<td>Moderate sulphate-resistant cements</td>
</tr>
<tr>
<td>SR</td>
<td>M-II</td>
<td>M-II</td>
<td>Moderate heat of hydration cements</td>
</tr>
<tr>
<td>HP</td>
<td>H-I</td>
<td>H-I</td>
<td>High sulphate-resistant cements</td>
</tr>
<tr>
<td>LF</td>
<td>L-III</td>
<td>L-III</td>
<td>Low heat of hydration cements</td>
</tr>
<tr>
<td>High alkali-resistant cements</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: PLC is not available in either moderate or high sulphate-resistant designations.

How Does It Work?

PLC is manufactured in Canada by intergrinding regular cement clinker with up to 15% limestone. The limestone, being a softer material, is ground more finely than the clinker; however, both the clinker and the limestone in PLC are more finely ground than regular portland cement. Both the size and distribu-
A new category of cement is now available in Canada. Portland-limestone cement (PLC) for over 25 years, will be available.

What is Portland-Limestone Cement?

While regular portland cement is manufactured by intergrinding portland clinker and limestone, PLC is made by grinding regular portland cement and limestone together. This means that PLC is a cement that delivers excellent performance along with a lower carbon footprint. The limestone used in PLC is tested for its total organic carbon content. In Canada, it is well below the maximum levels, meaning that PLC must meet the same standards.

The CSA A3001-08 Standard for PLC is available at ECOCEM PLC.

4.1 Types

Table 4.1: Types of PLC

<table>
<thead>
<tr>
<th>Portland cement type</th>
<th>Blend ratio cement type</th>
</tr>
</thead>
<tbody>
<tr>
<td>GL</td>
<td>CTL</td>
</tr>
<tr>
<td>NS</td>
<td>M80</td>
</tr>
<tr>
<td>W80</td>
<td>H60</td>
</tr>
<tr>
<td>H80</td>
<td>L50</td>
</tr>
</tbody>
</table>

Note that PLC is not available in some regions.

How does it work?

PLC is manufactured in Canada up to 15% limestone. The limestone is ground more finely than the clinker; however, more finely ground than regular portland cement.

The EcoCem™ PLC Advantage

Lehigh Cement’s Commitment to Sustainability

Lehigh Cement is committed to delivering sustainable building materials which positively contribute to the well-being of society and the environment. Among other things, they produce cement and concrete products that contribute to sustainable building and communities across British Columbia. Concrete made with EcoCem™ PLC is energy efficient, durable, and cost-effective.

As the next step in its commitment to sustainability, Lehigh Cement has developed EcoCem™ PLC, a new portland-limestone cement that provides excellent performance but has a lower environmental impact than normal Type GP portland cement.

Lowering Emissions

Climate change is an issue that is important to people in British Columbia and those who live on Lehigh Cement’s properties. The process of converting raw materials into cement products emits greenhouse gases, and reducing those emissions is central to Lehigh’s commitment to sustainability. Manufacturing EcoCem™ PLC results in up to a 30% reduction in emissions, compared to normal Type GP Portland cement. With EcoCem™ PLC, Lehigh and its customers now have access to a more sustainable cement solution.

Green Building and LEED®

British Columbia has approved the use of Portland Limestone Cement (PLC) in its building codes. This approval now provides many new sustainable options for building and renovating projects.

Conclusion

EcoCem™ PLC is an environmentally responsible cement that delivers excellent performance along with a lower carbon footprint. This made in BC cement reduces greenhouse emissions and supports our local economy at the same time.
**Portland-Limestone Cement**

A new category of cement is now available in Canada. Portland-limestone cement, for over 25 years, will be available.

**What is Portland-Limestone Cement?**

While regular portland cement is manufactured by intergrinding portland cement and 15% limestone. The clinker used to manufacture regular portland cement is the only type on the high quality of the limestone used in PLC is tested for a total organic carbon content. Canada is well below the maximum standard. PLC performance specifications cement in that PLC must meet the minimum and regular portland cement.

The CSA A3001-08 Standard is used for the testing and determination of the performance of PLC.

### 4.1 Types

<table>
<thead>
<tr>
<th>Portland cement type</th>
<th>Blended cement type</th>
</tr>
</thead>
<tbody>
<tr>
<td>G7</td>
<td>G7</td>
</tr>
<tr>
<td>N1</td>
<td>M1</td>
</tr>
<tr>
<td>S1</td>
<td>M1</td>
</tr>
<tr>
<td>H1</td>
<td>M1</td>
</tr>
<tr>
<td>L1</td>
<td>M1</td>
</tr>
</tbody>
</table>

*Note: Tested to meet the requirement of Table 3.1 CAN/CSA.

The table below indicates that Portland limestone cement is available in Table 3.1 CAN/CSA.

**EcoCem™ PLC is here!**

EcoCem™ PLC is Lehigh’s Portland Limestone Cement that meets CSA’s Type GUL specification. EcoCem™ PLC is an environmentally responsible cement that delivers excellent performance along with a lower carbon footprint. This made in BC cement reduces greenhouse emissions and supports our local economy at the same time.

**The EcoCem™ PLC Advantage**

**Lehigh Cement’s Commitment to Sustainability**

Lehigh Cement is committed to delivering sustainable building materials which positively contribute to the well-being of society and the environment — during and after our lifetime. Cement and concrete products already contribute to sustainable building and communities across British Columbia. Concrete products are safe, energy-efficient, durable and cost-effective.

As the next step in its commitment to sustainability, Lehigh Cement has developed EcoCem™ PLC, a new portland limestone cement that provides excellent performance but has a lower environmental impact than normal Type GUL portland cement.

**Lowering Emissions**

Climate change is an issue not only important to the people of British Columbia and they are important to Lehigh Cement. The process of converting raw materials into cement produces emissions, and reducing those emissions is central to Lehigh’s commitment to sustainability. Manufacturing EcoCem™ PLC results in up to a 30% reduction in emissions when compared to normal Type GUL portland cement. With EcoCem™ PLC, Lehigh and its customers show leadership in sustainable cement production.

**Performance**

The performance of Portland cement, EcoCem™ PLC, was higher than that of the average.

**Green Build**

British Columbia’s commitment to reducing the impact of cement production is being realized with the adoption of EcoCem™ PLC.

These are some of EcoCem™ PLC available in LERO manufactured, and its associated with the system.
What is Contempra™?

- Contempra is made by **inter-grinding** regular clinker with up to 15% limestone, while regular cement contains 5% limestone.
- Contempra is a finer ground product than regular cement.

**Diagram: Regular Portland Cement**
- = ground clinker, precursor to cement
- = limestone (5%)

**Diagram: Contempra / Portland Limestone Cement**
- = finely ground clinker
- = finely ground limestone (15%)
CSA 3000-08

Defines Portland-limestone cement as a product obtained by:

- Inter-grinding portland cement clinker and limestone, to which the various forms of calcium sulphate, water, and processing additions may be added at the option of the manufacturer.

Notes:

1. Limestone is designated with the suffix L. Its proportion is indicated in Clause 4.3.1.

2. Portland-limestone cement may be produced by inter-grinding or blending, or a combination of both. The attainment of a homogeneous blend, in the dry state, of any two or more fine materials is important. Appropriate equipment and controls should be provided by the manufacturer.
Contempra™ / PLC

- Background on cement making
- **What is Contempra & why use it?**
- Extensive performance testing
- Use of PLC in Europe
- BC marketplace and projects
The Cement Association of Canada (CAC) is pleased to present this Canadian and CAC member industry average environmental product declaration (EPD) for General Use (GU) and Portland-Limestone (GUL) Cements. This EPD was developed in compliance with CAN/CSA-ISO 14025 and has been verified by François Charon Doucet, Groupe AGÉCO.

The EPD includes life cycle assessment (LCA) results for the product stage or cradle-to-gate manufacture of GU and GUL cements as produced in Canada by CAC members in 2014. It is intended for business-to-business communication.

For more information about Cement Association of Canada, please go to www.cement.ca.
### Table 3: LCA Results – Type GU one metric ton – absolute basis

<table>
<thead>
<tr>
<th>Category Indicator</th>
<th>Unit</th>
<th>Total</th>
<th>A1 Raw Material Supply</th>
<th>A2 Transport</th>
<th>A3 Manufacturing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global warming potential, GWP</td>
<td>kg CO₂ eq.</td>
<td>940.5</td>
<td>17.9</td>
<td>9.0</td>
<td>913.6</td>
</tr>
<tr>
<td>Acidification potential, AP</td>
<td>kg SO₂ eq.</td>
<td>3.7</td>
<td>0.1</td>
<td>0.1</td>
<td>3.5</td>
</tr>
<tr>
<td>Eutrophication potential, EP</td>
<td>kg N eq.</td>
<td>0.06</td>
<td>0.004</td>
<td>0.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Smog creation potential, FOCP</td>
<td>kg O₃ eq.</td>
<td>6.29</td>
<td>2.6</td>
<td>2.2</td>
<td>58.1</td>
</tr>
<tr>
<td>Ozone depletion potential, ODP</td>
<td>kg CFC-11 eq.</td>
<td>9.8E-06</td>
<td>1.9E-06</td>
<td>1.8E-06</td>
<td>7.3E-06</td>
</tr>
</tbody>
</table>

**Total primary energy consumption**

| Non-renewable fossil, FENR-fossil | MJ (HHV) | 5694 | 268 | 1224 | 6213.8 |
| Non-renewable nuclear, FENR-nuclear | MJ (HHV) | 586  | 38  | 1.5  | 546.7  |
| Renewable (solar, wind, hydroelectric, and geothermal), FENR-HWOG | MJ (HHV) | 249  | 33  | 0.2  | 216.5  |
| Renewable (biomass), FENR-biomass | MJ (HHV) | 481  | 453 | 0.03 | 27.9   |

**Material resources consumption**

| Non-renewable material resources, NRNM | kg | 1490 | 1490.0 | 0.0008 | 0.6 |
| Renewable material resources, RMR | kg | 25  | 24.2   | 0.0019 | 1.3 |
| Net fresh water, NFW | l | 1793 | 116  | 1     | 1676 |

**Waste generated**

| Hazardous waste generated, HW | kg | 0.09 | 0.004 | 0 | 0.09 |
| Non-hazardous waste generated, NHW | kg | 0.97 | 0.01 | 0 | 0.94 |

### Table 4: LCA Results – Type GUL one metric ton – absolute basis

<table>
<thead>
<tr>
<th>Category Indicator</th>
<th>Unit</th>
<th>Total</th>
<th>A1 Raw Material Supply</th>
<th>A2 Transport</th>
<th>A3 Manufacturing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global warming potential, GWP</td>
<td>kg CO₂ eq.</td>
<td>855.6</td>
<td>17.4</td>
<td>6.3</td>
<td>829.9</td>
</tr>
<tr>
<td>Acidification potential, AP</td>
<td>kg SO₂ eq.</td>
<td>3.4</td>
<td>0.1</td>
<td>0.1</td>
<td>3.2</td>
</tr>
<tr>
<td>Eutrophication potential, EP</td>
<td>kg N eq.</td>
<td>0.38</td>
<td>0.05</td>
<td>0.004</td>
<td>0.3</td>
</tr>
<tr>
<td>Smog creation potential, FOCP</td>
<td>kg O₃ eq.</td>
<td>6.77</td>
<td>2.6</td>
<td>2.1</td>
<td>52.8</td>
</tr>
<tr>
<td>Ozone depletion potential, ODP</td>
<td>kg CFC-11 eq.</td>
<td>9.0E-06</td>
<td>1.9E-06</td>
<td>1.6E-06</td>
<td>7.2E-06</td>
</tr>
</tbody>
</table>

**Total primary energy consumption**

| Non-renewable fossil, FENR-fossil | MJ (HHV) | 5111 | 261 | 112.7 | 4747.3 |
| Non-renewable nuclear, FENR-nuclear | MJ (HHV) | 555  | 37  | 1.5   | 516.1  |
| Renewable (solar, wind, hydroelectric, and geothermal), FENR-HWOG | MJ (HHV) | 237  | 32  | 0.2   | 204.7  |
| Renewable (biomass), FENR-biomass | MJ (HHV) | 480  | 453 | 0.03  | 26.4   |

**Material resources consumption**

| Non-renewable material resources, NRNM | kg | 1444 | 1443.2 | 0.0008 | 0.4 |
| Renewable material resources, RMR | kg | 28.2 | 24.2   | 0.0013 | 1.0 |
| Net fresh water, NFW | l | 1672 | 116  | 1     | 1629 |

**Waste generated**

| Hazardous waste generated, HW | kg | 0.09 | 0.003 | 0 | 0.09 |
| Non-hazardous waste generated, NHW | kg | 0.97 | 0.01 | 0 | 0.94 |
### Table 3: LCA Results – Type GU one metric ton – absolute basis

<table>
<thead>
<tr>
<th>Category Indicator</th>
<th>Unit</th>
<th>Total</th>
<th>A1 Raw Material Supply</th>
<th>A2 Transport</th>
<th>A3 Manufacturing</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRACI v.2.1 Category Indicators</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global warming potential, GWP</td>
<td>kg CO₂ eq</td>
<td>940.5</td>
<td>17.9</td>
<td>9.0</td>
<td>913.6</td>
</tr>
<tr>
<td>Acidification potential, AP</td>
<td>kg SO₂ eq</td>
<td>0.7</td>
<td>0.16</td>
<td>0.1</td>
<td>3.5</td>
</tr>
<tr>
<td>Eutrophication potential, EP</td>
<td>kg N eq</td>
<td>0.38</td>
<td>0.05</td>
<td>0.004</td>
<td>0.3</td>
</tr>
<tr>
<td>Smog creation potential, POCP</td>
<td>kg O₃ eq</td>
<td>57.4</td>
<td>2.5</td>
<td>2.1</td>
<td>52.8</td>
</tr>
<tr>
<td>Ozone depletion potential, ODP</td>
<td>kg CFC-11</td>
<td>9.0E-06</td>
<td>1.9E-06</td>
<td>1.6E-08</td>
<td>7.2E-06</td>
</tr>
</tbody>
</table>

### Table 4: LCA Results – Type GUL one metric ton – absolute basis

<table>
<thead>
<tr>
<th>Category Indicator</th>
<th>Unit</th>
<th>Total</th>
<th>A1 Raw Material Supply</th>
<th>A2 Transport</th>
<th>A3 Manufacturing</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRACI v.2.1 Category Indicators</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global warming potential, GWP</td>
<td>kg CO₂ eq</td>
<td>855.6</td>
<td>17.4</td>
<td>8.3</td>
<td>829.9</td>
</tr>
<tr>
<td>Acidification potential, AP</td>
<td>kg SO₂ eq</td>
<td>0.1</td>
<td>0.15</td>
<td>0.1</td>
<td>3.2</td>
</tr>
<tr>
<td>Eutrophication potential, EP</td>
<td>kg N eq</td>
<td>0.38</td>
<td>0.05</td>
<td>0.004</td>
<td>0.3</td>
</tr>
<tr>
<td>Smog creation potential, POCP</td>
<td>kg O₃ eq</td>
<td>57.4</td>
<td>2.5</td>
<td>2.1</td>
<td>52.8</td>
</tr>
<tr>
<td>Ozone depletion potential, ODP</td>
<td>kg CFC-11</td>
<td>9.0E-06</td>
<td>1.9E-06</td>
<td>1.6E-08</td>
<td>7.2E-06</td>
</tr>
</tbody>
</table>
Concrete EPDs

- Valid from January 6, 2017 to January 6, 2022
- Participation of all Provincial associations, including BCRMCA
- 125 concrete mix designs!
- Both GU and GUL
### Table 8. Summary Results (A1-A3): 31-35 MPa ready mixed concrete product, per cubic meter

<table>
<thead>
<tr>
<th>Indicator/LCI Metric</th>
<th>GWP</th>
<th>ODP</th>
<th>AP</th>
<th>EP</th>
<th>POCP</th>
<th>PEC</th>
<th>NRE</th>
<th>RE</th>
<th>NRM</th>
<th>RM</th>
<th>CBW</th>
<th>CWW</th>
<th>TW</th>
<th>CHW</th>
<th>CNHW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit (equivalent)</td>
<td>kg CO2</td>
<td>kg CFC-11</td>
<td>kg SO2</td>
<td>kg N</td>
<td>kg O3</td>
<td>MJ</td>
<td>MJ</td>
<td>kg</td>
<td>m3</td>
<td>m3</td>
<td>m3</td>
<td>m3</td>
<td>m3</td>
<td>m3</td>
<td>m3</td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td>260.49</td>
<td>3.69E-06</td>
<td>1.23</td>
<td>0.13</td>
<td>22.07</td>
<td>2558.11</td>
<td>2338.42</td>
<td>202.24</td>
<td>2244.44</td>
<td>6.41</td>
<td>0.16</td>
<td>0.14</td>
<td>0.95</td>
<td>0.86</td>
<td>8.94</td>
</tr>
<tr>
<td><strong>Maximum</strong></td>
<td>449.79</td>
<td>6.40E-06</td>
<td>1.95</td>
<td>0.20</td>
<td>35.25</td>
<td>3745.89</td>
<td>3412.16</td>
<td>333.73</td>
<td>2576.75</td>
<td>10.84</td>
<td>0.16</td>
<td>0.14</td>
<td>1.30</td>
<td>0.90</td>
<td>9.12</td>
</tr>
<tr>
<td>#39-35 GU with air 0-14% FA/SC</td>
<td>449.79</td>
<td>5.37E-06</td>
<td>1.95</td>
<td>0.20</td>
<td>35.25</td>
<td>3745.89</td>
<td>3412.16</td>
<td>333.73</td>
<td>2509.04</td>
<td>10.84</td>
<td>0.16</td>
<td>0.14</td>
<td>1.30</td>
<td>0.87</td>
<td>9.12</td>
</tr>
<tr>
<td>#40-35 GU without air 0-14% FA/SC</td>
<td>366.61</td>
<td>4.76E-06</td>
<td>1.69</td>
<td>0.17</td>
<td>30.85</td>
<td>3279.16</td>
<td>2993.18</td>
<td>285.98</td>
<td>2576.75</td>
<td>9.18</td>
<td>0.16</td>
<td>0.14</td>
<td>1.20</td>
<td>0.87</td>
<td>9.05</td>
</tr>
<tr>
<td>#41-35 Industry Average Benchmark</td>
<td>417.05</td>
<td>5.42E-06</td>
<td>1.85</td>
<td>0.19</td>
<td>33.37</td>
<td>3537.46</td>
<td>3229.68</td>
<td>307.77</td>
<td>2438.20</td>
<td>9.95</td>
<td>0.16</td>
<td>0.14</td>
<td>1.24</td>
<td>0.88</td>
<td>9.08</td>
</tr>
<tr>
<td>#42-35 GU with air 15-29% FA</td>
<td>403.66</td>
<td>4.89E-06</td>
<td>1.76</td>
<td>0.18</td>
<td>32.11</td>
<td>3406.28</td>
<td>3108.47</td>
<td>297.61</td>
<td>2405.27</td>
<td>9.61</td>
<td>0.16</td>
<td>0.14</td>
<td>1.21</td>
<td>0.87</td>
<td>9.07</td>
</tr>
<tr>
<td>#43-35 GU with air 15-29% FA</td>
<td>362.81</td>
<td>4.59E-06</td>
<td>1.57</td>
<td>0.17</td>
<td>27.56</td>
<td>3229.64</td>
<td>2956.83</td>
<td>293.00</td>
<td>2388.81</td>
<td>9.69</td>
<td>0.16</td>
<td>0.14</td>
<td>1.17</td>
<td>0.87</td>
<td>9.07</td>
</tr>
<tr>
<td>#44-35 GU without air 15-29% FA</td>
<td>347.87</td>
<td>4.35E-06</td>
<td>1.54</td>
<td>0.16</td>
<td>28.20</td>
<td>2993.85</td>
<td>2730.06</td>
<td>255.79</td>
<td>2490.00</td>
<td>8.15</td>
<td>0.16</td>
<td>0.14</td>
<td>1.12</td>
<td>0.86</td>
<td>9.01</td>
</tr>
<tr>
<td>#45-35 GU with air 15-29% FA</td>
<td>313.52</td>
<td>4.10E-06</td>
<td>1.37</td>
<td>0.14</td>
<td>24.38</td>
<td>2845.30</td>
<td>2593.54</td>
<td>251.75</td>
<td>2475.70</td>
<td>8.22</td>
<td>0.16</td>
<td>0.14</td>
<td>1.08</td>
<td>0.86</td>
<td>9.01</td>
</tr>
<tr>
<td>#46-35 GU with air 30-40% FA</td>
<td>353.84</td>
<td>4.36E-06</td>
<td>1.56</td>
<td>0.16</td>
<td>28.71</td>
<td>3039.14</td>
<td>2780.16</td>
<td>258.98</td>
<td>2293.08</td>
<td>8.29</td>
<td>0.16</td>
<td>0.14</td>
<td>1.12</td>
<td>0.86</td>
<td>9.02</td>
</tr>
<tr>
<td>#47-35 GU with air 30-40% FA</td>
<td>318.82</td>
<td>4.10E-06</td>
<td>1.40</td>
<td>0.15</td>
<td>24.81</td>
<td>2887.92</td>
<td>2633.06</td>
<td>254.66</td>
<td>2279.66</td>
<td>8.35</td>
<td>0.16</td>
<td>0.14</td>
<td>1.08</td>
<td>0.86</td>
<td>9.02</td>
</tr>
<tr>
<td>#48-35 GU with air 30-40% FA</td>
<td>305.99</td>
<td>3.90E-06</td>
<td>1.37</td>
<td>0.14</td>
<td>25.35</td>
<td>2865.42</td>
<td>2642.25</td>
<td>223.16</td>
<td>2396.23</td>
<td>7.04</td>
<td>0.16</td>
<td>0.14</td>
<td>1.04</td>
<td>0.86</td>
<td>9.07</td>
</tr>
<tr>
<td>#49-35 GU without air 30-40% FA</td>
<td>276.55</td>
<td>3.69E-06</td>
<td>1.23</td>
<td>0.13</td>
<td>22.07</td>
<td>2558.11</td>
<td>2338.42</td>
<td>219.70</td>
<td>2383.97</td>
<td>7.09</td>
<td>0.16</td>
<td>0.14</td>
<td>1.01</td>
<td>0.86</td>
<td>9.07</td>
</tr>
<tr>
<td>#50-35 GU with air 25-34% SC</td>
<td>364.06</td>
<td>4.11E-06</td>
<td>1.56</td>
<td>0.18</td>
<td>30.87</td>
<td>3249.29</td>
<td>2984.22</td>
<td>265.08</td>
<td>2327.80</td>
<td>8.48</td>
<td>0.16</td>
<td>0.14</td>
<td>1.12</td>
<td>0.90</td>
<td>9.02</td>
</tr>
<tr>
<td>#51-35 GU with air 25-34% SC</td>
<td>315.94</td>
<td>5.08E-06</td>
<td>1.59</td>
<td>0.17</td>
<td>27.01</td>
<td>3099.43</td>
<td>2838.43</td>
<td>261.00</td>
<td>2314.53</td>
<td>8.54</td>
<td>0.16</td>
<td>0.14</td>
<td>1.08</td>
<td>0.90</td>
<td>9.02</td>
</tr>
<tr>
<td>#52-35 GU with air 25-34% SC</td>
<td>314.59</td>
<td>5.08E-06</td>
<td>1.53</td>
<td>0.16</td>
<td>27.16</td>
<td>2862.04</td>
<td>2633.75</td>
<td>228.29</td>
<td>2425.43</td>
<td>7.20</td>
<td>0.16</td>
<td>0.14</td>
<td>1.04</td>
<td>0.89</td>
<td>9.07</td>
</tr>
<tr>
<td>#53-35 GU without air 25-34% SC</td>
<td>285.41</td>
<td>5.16E-06</td>
<td>1.39</td>
<td>0.15</td>
<td>23.92</td>
<td>2735.87</td>
<td>2511.02</td>
<td>224.86</td>
<td>2413.28</td>
<td>7.25</td>
<td>0.16</td>
<td>0.14</td>
<td>1.01</td>
<td>0.89</td>
<td>9.07</td>
</tr>
<tr>
<td>#54-35 GU with air 35-50% SC</td>
<td>329.77</td>
<td>6.40E-06</td>
<td>1.68</td>
<td>0.18</td>
<td>29.11</td>
<td>3050.66</td>
<td>2813.04</td>
<td>237.62</td>
<td>2255.30</td>
<td>7.54</td>
<td>0.16</td>
<td>0.14</td>
<td>1.04</td>
<td>0.90</td>
<td>9.08</td>
</tr>
<tr>
<td>#55-35 GU with air 35-50% SC</td>
<td>299.71</td>
<td>6.18E-06</td>
<td>1.54</td>
<td>0.17</td>
<td>25.77</td>
<td>2920.92</td>
<td>2686.83</td>
<td>234.09</td>
<td>2244.44</td>
<td>7.59</td>
<td>0.16</td>
<td>0.14</td>
<td>1.01</td>
<td>0.90</td>
<td>9.08</td>
</tr>
<tr>
<td>#56-35 GU with air 35-50% SC</td>
<td>285.78</td>
<td>5.62E-06</td>
<td>1.47</td>
<td>0.15</td>
<td>25.69</td>
<td>2695.19</td>
<td>2489.98</td>
<td>205.21</td>
<td>2364.90</td>
<td>6.41</td>
<td>0.16</td>
<td>0.14</td>
<td>0.90</td>
<td>0.89</td>
<td>9.04</td>
</tr>
<tr>
<td>#57-35 GU without air 35-50% SC</td>
<td>260.49</td>
<td>5.44E-06</td>
<td>1.35</td>
<td>0.15</td>
<td>22.38</td>
<td>2585.84</td>
<td>2383.61</td>
<td>202.24</td>
<td>2354.37</td>
<td>6.45</td>
<td>0.16</td>
<td>0.14</td>
<td>0.95</td>
<td>0.89</td>
<td>9.04</td>
</tr>
</tbody>
</table>
## Table 8. Summary Results (A1-A3): 31-35 MPa results

<table>
<thead>
<tr>
<th>Indicator/LCI Metric</th>
<th>GWP (kg CO₂)</th>
<th>ODP (kg CFC-11)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Minimum</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#39-35 GU with air 0-14% FA/SC</td>
<td>260.49</td>
<td>3.69E-06</td>
</tr>
<tr>
<td>#40-35 GU without air 0-14% FA/SC</td>
<td>449.79</td>
<td>6.40E-06</td>
</tr>
<tr>
<td>#41-35 Industry Average Benchmark</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#42-35 GU with air 15-29% FA</td>
<td>449.79</td>
<td>5.37E-06</td>
</tr>
<tr>
<td>#43-35 GUL with air 15-29% FA</td>
<td>386.61</td>
<td>4.76E-06</td>
</tr>
<tr>
<td>#44-35 GU without air 15-29% FA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#45-35 GUL without air 15-29% FA</td>
<td>347.87</td>
<td>4.35E-06</td>
</tr>
<tr>
<td>#46-35 GU with air 30-40% FA</td>
<td>313.52</td>
<td>4.10E-06</td>
</tr>
<tr>
<td>#47-35 GUL with air 30-40% FA</td>
<td>318.82</td>
<td>4.10E-06</td>
</tr>
<tr>
<td>#48-35 GU without air 30-40% FA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#49-35 GUL without air 30-40% FA</td>
<td>276.55</td>
<td>3.69E-06</td>
</tr>
</tbody>
</table>
Calculation of CO₂ Reduction

- For example:
  - GU = 403.68 kg CO₂ / cubic meter of concrete
  - GUL = 362.81 kg CO₂ / cubic meter of concrete
  - Reduction of 403.68 – 362.81 = 40.87 kg CO₂ per cubic meter

- Using 30,000 m³ of GUL / PLC / Contempra / EcoCem concrete:
  - 30,000 m³ x 40.87 kg CO₂/m³ = 1,226,100 kg = 1,226 tonnes CO₂
  - Equivalent to taking 260 cars* off the road for a year!

*US EPA: one car generates 4.7 metric tonnes of CO₂ per year
Why should we use Contempra™ / PLC?

- Can reduce GHG emissions by 1 million tonnes of CO₂ (eq) per year across Canada
- Equivalent to taking 210,000 cars off the road or the planting of 25 million trees a year
- Contempra reflects the industry’s continued commitment to sustainable development and a better environment
Contempra™ / PLC

- Background on cement making
- What is Contempra & why use it?
- Extensive research and testing
- Use of PLC in Europe
- BC marketplace and projects
Extensive Research and Testing

1: Literature Review
2: Prototypes and Trials
3: Extensive Testing
1. Literature Review, May 2007

- Results reported in the literature appeared to be affected by the quality and particle size distribution of the limestone.
- Variances also resulted depending on whether the limestone was inter-ground, blended, or added at the mixer.
- Proper interpretation of the data was carried out to fully investigate these effects.
2. Prototypes and Trials

- Various Canadian cement companies produced prototypes of Contempra cement at their plants.
- Chemical and physical analyses were performed with those products.
- Concrete performance and durability tests were carried out at universities and CAC member companies.
3. Extensive Testing

- Tests carried out with Canadian materials confirmed findings of the literature review and European experience.
- After optimization, the prototype concrete demonstrated equivalent strength to that achieved with regular cement.
- Field trials in the climates of Ontario, Quebec and Nova Scotia over two winters established that Contempra produces concrete with a durability equivalent to that from regular cement.
Adopted in Canadian Building Codes

- Included in CSA A3001 and A23.1 standards under the name Portland-limestone cement, and referenced in the 2010 National Building Code of Canada

- Approved for use in British Columbia, Manitoba, Ontario, Quebec and Nova Scotia

- Not yet used in high sulphate exposure environments, but additional testing has been carried out and changes to CSA requirements are pending
Contempra™ / PLC

- Background on cement making
- What is Contempra & why use it?
- Extensive research and testing
- Use of PLC in Europe
- BC marketplace and projects
Track Record in Europe

- Used in Europe for over 25 years in a variety of applications and exposure conditions
- Known as Portland-Limestone Cement
- 20% limestone used in popular European cement products
- Up to 35% limestone content is allowed
Contempra™ / PLC

- Background on cement making
- What is Contempra & why use it?
- Extensive research and testing
- Use in Europe
- BC marketplace and projects
Telus Garden Development

- West Georgia and Seymour, Vancouver
- $750 million project
- 1 million square feet
- LEED Platinum

- 60,000 m³ of concrete, of which about 55% was PLC

- avoided ~ 1,300 tonnes of CO₂eq (taking 287 cars* off the road for a year)
Solo District
Willingdon and Lougheed, Burnaby

- Mixed commercial, office, residential
- 2 towers, with the taller being 48-storeys high
- 90,000 m³ of concrete of which 75% was PLC
- 33,000 tonnes of cement
- avoided ~ 2,750 tonnes of CO₂eq (taking 590 cars* off the road for a year)
Vancouver House
Pacific and Howe

- 52 storey, 600,000 square foot tower
- Vertical and horizontal post-tensioned concrete
- Features twisting and overhanging floors

- 20,000 m³ concrete so far, 80% of which is PLC including high early strength, low shrinkage for post-tensioned slabs

- Avoided ~ 654 tonnes of CO₂eq so far (taking 139 cars* off the road for a year)
Wall Centre False Creek (originally Vancouver Playhouse)

- first Lafarge project completed with Contempra
- three 13-15 storey residential towers
- 30,000 m³ of 100% Contempra concrete
- avoided ~ 1,226 tonnes of CO₂eq (taking 260 cars* off the road for a year)
The Mark
1372 Seymour

- Located at north end of Granville Street Bridge
- 41 storey tower with 302 suites
- LEED Gold

- 35,000 m³ of 100% Contempra concrete
- avoided ~ 1,430 tonnes of CO$_{2}$eq (taking 304 cars* off the road for a year)
Trump International Hotel & Tower
1151 West Georgia, Vancouver

- Owned by Holborn Group
- Conceptual design by Arthur Erickson; similar to the “Turning Torso” in Malmö, Sweden
- 63-storey, 187.8 metre / 616 foot tower (2nd to Shangri-La at 201.2 m / 660 feet)
- LEED Silver
- 35,000 m³ of 100% Contempre based concrete
- avoided ~ 1,430 tonnes of CO₂eq (taking 204 cars* off the road for a year)
Teck Acute Care Centre
BC Children’s Hospital, Vancouver

- 640,000 square feet over 8 floors
- 231 private patient rooms
- LEED Gold
- 35,000 m³ of concrete of which 73% was PLC
- 9,600 tonnes of cement
- avoided ~ 1,040 tonnes of CO$_{2eq}$
  (taking 222 cars* off the road for a year)
Promoting use of Low Carbon and Renewable Materials in Infrastructure

“Approving use of Portland-limestone cement in public sector infrastructure. This material reduces GHG emissions associated with existing cement manufacturing by approximately 10 per cent, while producing concrete with similar strength and durability. This cement has been popular in Europe for over 25 years now, but is new to Canada.”

BC Climate Leadership Plan
August 19, 2016
In conclusion, Contempra / PLC:

- Has an extensive proven track record
- Can reduce GHG emissions by up to 10% when compared to regular cement
- Produces concrete with a equivalent strength and durability to that made with regular cement
- Included in the CSA cement and concrete standards
- Available from local cement / concrete producers in BC
- BC Public Sector should adopt PLC as the preferred option for concrete infrastructure
Thank you!

Ken Carrusca, P.Eng.
Vice President, Environment & Marketing
Cement Association of Canada
KCarrusca@Cement.ca
(604) 839-6627
@KenCarrusca