Materials: Data Selection

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Spatial Scales for Materials

- Regional/Local
- Regional
- Global/Regional
- Global
- Local
Cement and Concrete LCIs

• Production process for cement and concrete is well understood
• Doesn’t require an allocation process like bitumen
• Yet there is variability across datasets characterizing cement production
GHG emissions per kg cement

Differences due to tech

Possible differences due region, methods

Häkkinen and Mäkelä (1996)
Marceau et al (2006, low)
Marceau et al (2006, high)
Stripple (2001)
EIO-LCA (2002 database)
ETH-ESU 96
Ecoinvent
IDEMAT
Sources of Variability

- Production technology
- How cement is defined
- Fuel source
- Raw material source

These are *real* and *reasonable* sources of variability that should be captured in an LCI of cement.
Cement Production Technologies

• “Wet” versus “dry” process plants
• Older versus newer plants
  – Preheaters/precaldciners
• Data that is a decade old may not reflect modern cement
• How important is this?
What Constituents Cement?

• ASTM C150 (AASHTO M 85) portland cement
  – Now allows up to 5% limestone addition plus processing additions

• ASTM C595 (AASHTO M 240) blended cements
  – Portland cement blended with pozzolan, slag cement, or combination of two
  – May include limestone in future

• ASTM C1157 performance cements
  – Typically portland-limestone cements
Fuel Sources

• Main fossil fuel source is coal
• Waste fuels
  – Tires
  – Waste solvents and oils (major fuel source)
• Biofuels
• How is this currently modeled, how important is this?
What is the “Correct” LCI for cement?

• Cement is a global commodity
• Example: US reliance on foreign cement

<table>
<thead>
<tr>
<th>Year</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net import reliance as a % of apparent consumption</td>
<td>21%</td>
<td>25%</td>
<td>26%</td>
<td>19%</td>
<td>12%</td>
</tr>
<tr>
<td>Production (portland and masonry cement - includes imported clinker)</td>
<td>97,434</td>
<td>99,319</td>
<td>98,167</td>
<td>95,464</td>
<td>87,700</td>
</tr>
</tbody>
</table>

*97% of imports to the port of LA are from China and Thailand – but we don’t have good data on what fuels or production technology are being used in these places, nor do we have a good idea of the transportation burdens
* So for California, what is the “right dataset”?

Supplementary Cementitious Materials

• Hydraulic cement specifications allow for various additions of SCMs
  – ASTM C150 (AASHTO M 85), ASTM C595 (AASHTO M 240), ASTM C1157

• In U.S., SCMs are commonly added at concrete plant
  – Outside of control of cement company

• In an LCA, the impact of SCMs can be easily assessed
What About Emerging Cements?

• Alkali-activated fly ash and slag cement
  – Requires alkali solution (NaOH)
• Geopolymers
  – Requires alkali solution (NaOH)
  – Many are based on fly ash or metakaolin
• Magnesium silicates
• Carbon sequestering
  – Added as SCM and/or carbon negative cement
• How will this be reflected in an LCA?
Aggregate Transport

- 0.05 MJ / kg aggregate (for extraction and processing)
- 0.001 MJ/kg-km (truck)
  - 100 miles of truck travel is twice as much energy as producing the aggregate
  - So is using national average data appropriate for aggregate (e.g. the commodity flow survey)
Cement versus Concrete

• Concrete is what matters, not cement
• Approach must account for SCM additions at both cement plant and concrete mix plant
  – Limestone additions of 3% to 12%
  – 15% to 40% replacement of portland cement with SCMs
• Concrete mixture design must be considered
• And of course, it is the life-cycle that ultimately must dictate
  – Design, longevity, and so on
Concrete Mixtures for the I-35W Bridge (CI, February 2009)

<table>
<thead>
<tr>
<th>Component</th>
<th>Specified Strength (psi)</th>
<th>Specified Strength (lb/yd³)</th>
<th>Cementitious Materials</th>
<th>Portland Cement (%)</th>
<th>Fly Ash (%)</th>
<th>Slag (%)</th>
<th>Silica Fume (%)</th>
<th>Est. CO₂ (lb/yd³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superstructure</td>
<td>6500</td>
<td>700</td>
<td>71</td>
<td>25</td>
<td>-</td>
<td>4</td>
<td>467</td>
<td></td>
</tr>
<tr>
<td>Piers</td>
<td>4000</td>
<td>575</td>
<td>15</td>
<td>18</td>
<td>67</td>
<td>-</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Footings</td>
<td>5250</td>
<td>&lt; 600</td>
<td>40</td>
<td>18</td>
<td>42</td>
<td>-</td>
<td>235</td>
<td></td>
</tr>
<tr>
<td>Drilled Shafts</td>
<td>5000</td>
<td>&lt; 600</td>
<td>40</td>
<td>18</td>
<td>42</td>
<td>-</td>
<td>235</td>
<td></td>
</tr>
</tbody>
</table>
Observations/Questions

• LCIs are well developed for cement/concrete
• Datasets may not accurately reflect modern cements and U.S./regional practices
• Local cement production variations are not usually considered
• Aggregate transportation dominates their impact thus is average data useful?
• How are the impacts of emerging technologies validated and included in datasets?