avniR 2013 – Nov 5th:

LCA of recycled concrete: Environmentally superior to virgin concrete?

1. Why such a study, and how?
2. Results for (natural and/or recycled gravel):
   -- concrete
   -- a building
   -- construction in a region
3. Conclusions
Discussion

by Dr. Arthur Braunschweig (E2), Prof. Susanne Kytzia (HSR), S. Bischof (Holcim)
Goal of this LCA: Better vista, better insight!
Why such a study?

• Concrete is key for buildings and infrastructure
• CH is densely populated ➔ gravel gets un-attainable
• Growing consciousness ➔ Recycle concrete! (Minergy standard)
• 2005 CH: Demolished concrete covers 1/8 of gravel (9 of 70 mio t/a)
  In city areas, e.g. Zürich, 1/3 (0.8 of 2.2 m t/a)!
• Recycled concrete can be used
  - loosely, as gravel
  - fixed, in lean concrete
  - fixed, in high-quality ("construction") concrete
  and in all situations replaces virgin gravel!
• Technology✓, markets✓ - but eco? LCA!
Four LCA-studies on gravel and concrete

- a) Gravel (virgin & recycled)
  b) Concrete (high-quality & lean)
  c) A construction project
  d) Construction in a Swiss region

- Key assumptions, e.g.:

- Team: Prof. S. Kytzia & team, HSR / Holcim / A. Braunschweig, E2

Data sources: Ecoinvent, Holcim (CH)
LCA: Scope – Example 'concrete production'

1 m³ Concrete of a certain quality (at plant)
System definition details – Example "High quality concretes"

- Composition per m³ concrete "C30/37":

<table>
<thead>
<tr>
<th></th>
<th>100 % natural aggregate</th>
<th>with 25 % RC-granulate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel</td>
<td>2000 kg natural</td>
<td>1400 kg natural</td>
</tr>
<tr>
<td></td>
<td></td>
<td>460 kg recycled (RC) granulate</td>
</tr>
<tr>
<td>Cement</td>
<td>300 kg Portland limestone cement</td>
<td>320 kg</td>
</tr>
</tbody>
</table>

- Other assumptions, e.g. :
  - Cement production w/ 40 % alternative fuels
  - Transport distances
  - Swiss grid electricity
1st result: LCA of high quality concretes

<table>
<thead>
<tr>
<th>Beton C 30/37 (25% RC-Granulat)</th>
<th>Gravel use (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C 30/37</td>
<td></td>
</tr>
<tr>
<td>Beton C 30/37 (25% RC-Granulat)</td>
<td>Land use (m²-eq*a)</td>
</tr>
<tr>
<td>C 30/37</td>
<td></td>
</tr>
<tr>
<td>Beton C 30/37 (25% RC-Granulat)</td>
<td>Respiratory damages (PM10)</td>
</tr>
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<td>Acidification (SO₂eq)</td>
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<td>Beton C 30/37 (25% RC-Granulat)</td>
<td>Energy use (MJ-eq)</td>
</tr>
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</tr>
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</table>

- **Granulate production**
- **Cement production**
- **RC-Granulate production**
- **Concrete production**

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Lean Concrete w/ RC-content doesn't need more Cement

- Composition of 1 m³ lean concrete:

<table>
<thead>
<tr>
<th></th>
<th>Lean concrete with 100% natural gravel</th>
<th>… with 100 % RC-granulate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel</td>
<td>1'895 kg natural gravel</td>
<td>1'590 kg mixed demolition granulate, treated</td>
</tr>
<tr>
<td>Cement</td>
<td>200 kg</td>
<td>200 kg</td>
</tr>
</tbody>
</table>

- additional assumptions, e.g. on transport distances
2nd result: LCA of lean concretes

... with 0 and 100 % RC-granulate

<table>
<thead>
<tr>
<th>Granulate production</th>
<th>Cement production</th>
<th>RC-Granulate production</th>
<th>Concrete production</th>
</tr>
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<tr>
<th>Gravel use (t)</th>
<th>Land use (m²-eq * a)</th>
<th>Respiratory damages (PM10)</th>
<th>Acidification (SO2eq)</th>
<th>Climate Change (CO2eq)</th>
<th>Energy use (MJeq)</th>
</tr>
</thead>
</table>
2nd LCA: Fictitious building project (transport model)

V1: Pit + landfill

- C 30/37, 100% new gravel
- demolition waste landfilled

V2: pit + recycling

- C 30/37, w/ 25% RC gravel
- demolition waste is used

Transport distances:
- V1 Pit: 36 km, 14 km, 16 km
- V2 Pit: 19 km, 14 km, 14 km
2nd LCA: Results for the fictitious building project

V2 (25 % RC / Waste to recycling)
V1 (100 % Natural / Waste to landfill)

Gravel use (t)

Land use (m²-eq * a)

Respiratory damages (PM10)

Acidification (SO2eq)

Climate Change (CO2eq)

Energy use (MJeq)

- Production: natural gravel
- Production: RC-gravel
- Production: Concrete
- Production: Cement
- Waste treatment
- Transports: Granulates
- Transports: Concrete
3rd LCA – for a regional construction scenario

- 'Swiss Mittelland' (e.g. larger Zürich area)

- Simplified calculations (e.g. no metals, wood)

- Concrete waste = ca. 1/3 of Concrete demand (1.1 vs. 3.6 mio tons p.a.)

- Construction waste is treated: 15 % final waste to landfill, 85% are re-used – either loosely as granulate, or in RC-concrete
3rd LCA: Regional Building Scenario

Regional Offer

1,1 m t Concrete waste

Landfill

A) RC-Granulate

Regional Demand

2,2 m m3 Concrete
3,6 m t Granulate

Roads
Gravel

Concrete Plant

Gravel Pit

B) RC-Concrete
3rd LCA results: CH Regional Construction Scenario

Use of construction waste for ...:

<table>
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<th>A) loose RC-Granulate</th>
<th>B) RC-Concrete</th>
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<td>A) loose RC-Granulate</td>
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<td>B) RC-Concrete</td>
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</tbody>
</table>

- Gravel use (t)
- Land use (m2-eq * a)
- Respiratory damages (PM10)
- Acidification (SO2eq)
- Climate Change (CO2eq)
- Energy use (MJeq)

Legend:
- Production: natural gravel
- Production: Concrete
- Production: RC-Gravel
- Transports natural Gravel
- Transports Concrete
- Transports RC-Granulate

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### Conclusions of this study

- **Lean concrete** made from recycled gravel is environmentally superior, esp. for resource use (land, gravel).
- A **high-quality concrete** w/ recycled gravel has a **similar environmental effect as a concrete with natural gravel** (except for gravel & land use).
- Concrete using **recycled gravel** is preferrable if construction waste would otherwise be **landfilled**.
- On regional scale it is **important that demolished concrete is used** – either loosely or in new concrete – **and not landfilled**. How it is used is less important.
- Key parameters: **Cement type and amount**, and **transport** means and distances.

All but the 3rd conclusions are based on Kytzia et al. 2011, Ökobilanz rezyklierter Gesteinekörnung für Beton
Literature

- Study published in German by Holcim (Switzerland)
- Article on this presentation on avniR documentation (publication pending)

Thank you!