Recycling EoL concrete: The C2CA project

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Outline:

- Motivation
- Objectives and challenges
- The C2CA project
- Main results
Motivations

- Decreasing demand for road foundation materials

Source: Scenario study Dutch government
Objectives and challenges

Economy
In-situ processing

Quality Assurance
Stakeholders

C2CA

“Turn EOL concrete into recycled cement and aggregate”
Economy
Natural aggregate prices fluctuate, but recycling costs do not grow.

Challenges

Essential to minimize process cost (in absence of regulation/taxes)
Challenges

In-situ processing
Mobile recycling technology (low noise, off-gas, ..)

Dry mechanical processing technologies:

• Dismantling (non-concrete materials, brick, gypsum,..)
• Demolition
• Mobile crushing
• Mobile sensor sorting (for coarse contaminants)
• Mobile milling/grinding
• Mobile ADR  →  Recycle aggregate, 
  Raw material for cement production
Challenges

Quality Assurance

Inline quality control & certification

Applying off-spec aggregate is non-acceptable risk.

Recycled aggregate to be transported to reuse location directly after processing.

Inline quality assurance technology (per truck-load)

- Hyperspectral Imaging
- Laser-induced Breakdown Spectroscopy
## Challenges

### Stakeholders, Transition & Forces

Recycling of building materials

<table>
<thead>
<tr>
<th>Acting stakeholder</th>
<th>Transition</th>
<th>Negative / Positive force</th>
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<tbody>
<tr>
<td>Recycler</td>
<td>Granulate for road &gt; Aggregate for mortar</td>
<td>Unstable prices / Shrinking market for road materials</td>
</tr>
<tr>
<td>Mortar producer</td>
<td>Natural aggregate &gt; Recycle aggregate</td>
<td>Consistent quality / Automated quality control, lower material prices</td>
</tr>
<tr>
<td>Cement producer</td>
<td>Limestone &gt; EOL Cement paste</td>
<td>Quality, Control over input, Ownership of quarry / CO2 reduction, “Green market”</td>
</tr>
<tr>
<td>Construction firm</td>
<td>&gt; Secondary mortar</td>
<td>Image</td>
</tr>
</tbody>
</table>
The C2CA Project

End of Life Concrete

To

Cement & Clean Aggregates

La Sapienza Roma - AGH University - FORTH - BSC – Leiden University - TU Denmark

Challenge the future
In Situ

- Hazardous (asbestos, ...)
- Contaminants (gypsum, tapestry, ...)
- Equipment (heating, airco, ...)

- Large recyclables (steel, wood, brick)
- Rebar steel
- +16mm contaminants
- +16mm aggregate
- 4-16mm aggregate
- 1-4mm aggregate

- EOL Building
- Smart Dismantling
- Selective Demolition
- Crushing

Ex Situ

- Sensor Based Sorting
- Attrition Milling Screening 16mm
- ADR
- Screening 4mm

Legend

- Material
- Quality control
- Process
- Groningen Case
- Being developed

Challenge the future
First case study of C2CA: Materials and Method

Demolishing obsolete governmental buildings
Careful demolition approach: layer-by-layer
Different types of concrete
ADR classification

Removal of fines and light pollutants from aggregate

Challenge the future
- ADR geometry has been optimized for in situ (mobile) application.

- Despite the more compact size, separation performance improved!
ADR products

Rotor fraction

Airknife fraction

Qualified 4-16 mm aggregates

Coarse fraction
Products from crushed concrete by ADR: coarse (left) and fine (right)
Problems associated with lacking quality of recycled aggregate (RA)

- Recycled aggregate concrete must match primary materials in:

<table>
<thead>
<tr>
<th>Workability</th>
<th>Compressive strength</th>
<th>Durability</th>
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</table>

- It is crucial to reduce the contents of:

  - Floating pollutants (light)
  - fines < 2mm
Current routes of concrete recycling and RA usage

- Diluting Natural aggregate with Recycled aggregate
- Removing fines by either fully drying & screening, or directly wet screening

Disadvantages:

- Drying consumes a lot of energy
- Wet methods leave a sludge with high disposal costs
- Both methods are less suitable for in situ recycling
C2CA production of crushed EOL concrete

1) Collecting clean end of life concrete into two 10000 ton batches

2) Crushing EOL applying an industrial jaw crusher (Kleemann:SSTR1400) to <40 mm.

3) Floating test of crushed EOL according to EN 12620

<table>
<thead>
<tr>
<th>Size of crushed aggregates (mm)</th>
<th>floating materials [cm³/ per kg of crushed concrete]</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-8</td>
<td>0.38</td>
</tr>
<tr>
<td>8-11.2</td>
<td>0.09</td>
</tr>
<tr>
<td>11.2-16</td>
<td>0.05</td>
</tr>
<tr>
<td>16-22.4</td>
<td>0.08</td>
</tr>
<tr>
<td>22.4-31.5</td>
<td>0.14</td>
</tr>
<tr>
<td>Total</td>
<td><strong>0.74</strong></td>
</tr>
</tbody>
</table>

Floating materials in crushed EOL is less than 1 cm³/ per kg
Comparison of compressive strength development of Recycled aggregate concrete (brown) and Natural aggregate concrete (blue)
LIBS Quality Assessment
Costs breakdown of Wet vs ADR processes

- **WET:** €8.93
- **mobile ADR:** €5.52

- Capital reservation: €3.23
- Maintenance: €2.22
- Certification: €1
- Site rental: €0.03
- Insurance & others: €0.32
- Energy: €0.76
- Personnel: €1.29
- Material transport: €0.92
- Auxiliary material: €0.02
- Waste disposal: €0.26

Challenge the future
Summary and Conclusion

- A new concrete recycling process is under development in the context of the C2CA project
- Autogenous milling and ADR produces clean 2-16 mm RA
- ADR also efficiently separates moist material into fines and a clean coarse fraction
- RAC show 30% higher compressive strength after 7 days
- The freeze-thaw resistance for RAC is not equal to NAC, but it still fulfils the requirements for class F100
- The processing costs are lower than for conventional solutions
- LIBS shows great potential for inline assessment for RA quality
Thank you

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