Welcome to the first SeRaMCo Webinar
Secondary Raw Materials for Concrete Precast Products

22 June 2020
10:30-12:00 CEST
<table>
<thead>
<tr>
<th>Time</th>
<th>Programme</th>
<th>Speaker/Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:30</td>
<td>Welcome</td>
<td>Christian GLOCK, University of Kaiserslautern</td>
</tr>
<tr>
<td>10:35</td>
<td>Concrete and the challenge of a low-carbon, sustainable and circular</td>
<td>Alessio RIMOLDI, BIBM</td>
</tr>
<tr>
<td></td>
<td>construction: Will precast concrete still be used in 2050?</td>
<td></td>
</tr>
<tr>
<td>10:45</td>
<td>The influence of the crushing production process on the quality of</td>
<td>Julien HUBERT, University of Liège</td>
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<tr>
<td></td>
<td>recycled aggregates</td>
<td></td>
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<tr>
<td>10:55</td>
<td>Availability of recycled material:</td>
<td>Lorenc BOGOVIKU, University of Luxembourg</td>
</tr>
<tr>
<td></td>
<td>• Characterization of the building stock in Luxembourg</td>
<td></td>
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<td></td>
<td>• Assessment of concrete volumes</td>
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<td></td>
<td>• Availability of the future mineral waste stock based on stochastic</td>
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<td>scenarios</td>
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<tr>
<td>Time</td>
<td>Session</td>
<td>Presenter/Speaker</td>
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<td>--------------------------------------------------------------------------</td>
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<tr>
<td>11:05</td>
<td>Development of innovative concrete mixtures:</td>
<td>Gaël Gelen CHEWE NGAPEYA</td>
</tr>
<tr>
<td></td>
<td>• High water demand of the recycled aggregates and the regulating effect</td>
<td></td>
</tr>
<tr>
<td></td>
<td>of the superplasticizer ACE in a mixture.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Effect of the particle size distribution on the workability of concrete.</td>
<td></td>
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<td></td>
<td>• Development of medium to high strength concrete with recycled aggregates</td>
<td></td>
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<tr>
<td>11:15</td>
<td>Concrete containing recycled aggregates from unknown origin –</td>
<td>Anja TUSCH</td>
</tr>
<tr>
<td></td>
<td>Development of new concrete mixes for structural precast elements and</td>
<td></td>
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<td></td>
<td>pavement blocks</td>
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<tr>
<td>11:25</td>
<td>Closed-loop supply chain of construction and demolition wastes:</td>
<td>Nacef TAZI</td>
</tr>
<tr>
<td></td>
<td>Towards a circular economy in French regions</td>
<td></td>
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<tr>
<td>11:35</td>
<td>Discussion, questions &amp; answers</td>
<td>All</td>
</tr>
<tr>
<td>11:55</td>
<td>Wrap-up</td>
<td>Christian GLOCK</td>
</tr>
<tr>
<td>12:00</td>
<td>End</td>
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</table>
Concrete and the challenge of a low carbon, sustainable and circular construction

Will precast concrete still be used in 2050?

Webinar
22\textsuperscript{nd} June 2020
Construction 2050

- Energy efficient

Construction 2050

- Low carbon
- Sustainable
- Circular

Construction 2050

- Sustainable
- Energy efficient

Construction 2050

- ??
Construction 2050
- Low carbon
- Sustainable
- Circular

Green Deal
- Sustainable
- Circular

Clean and circular economy
- Building in energy/resource efficient way

Zero pollution
• Low carbon
  o. business as usual
1. Mitigation

- Low carbon
HOW TO GET TO NET-ZERO

Reach net-zero emissions

In 2050

- Low carbon
  + Removal
  = Net Zero

World Resources Institute
• Low carbon - Mitigation

Designers
Optimisation
High-strength concrete
Digitalisation

Raw materials
Cement
- Energy
- Material/process
Aggregates
- Recycled
- Artificial

Precast manufacturers
Circularity
- Long service life
- Easy maintenance and repair
- Easy disassembly

Innovation

Society
Concrete benefits
- Energy efficiency
- Adaptation to CC
- Healthy and safe places
- Value to local economy
• Low carbon - Removal

(EXTERNAL) Capturing CO₂

- Post combustion capture
- Oxyfuel
- LEILAC

CO₂ (>80% concentration)

- Storage (CCS)
- Use (CCU)

(INTERNAL) Carbonation

- Curing of pre-cast concrete with CO₂
- Sequestration during lifetime of construction
- Recycled concrete fines recarbonate with CO₂
• Sustainable

HOLISTIC

Construction work
Whole life cycle

USER NEEDS & TECHNICAL REQUIREMENTS
Concrete

- High quality
- Long service life
- Fire safety
- Versatility
- Healthy
- Affordable
- Aesthetic
- Thermal comfort
- Acoustic comfort
Respond to societal challenges

Healthy & Comfortable

Social

Safe and resilient
• Circular – decoupling economic growth from resource use

from: Decoupling Natural Resource Use and Environmental Impacts from Economic Growth
2011 UNEP International Resource Panel Report
- **Circular in construction**

Ensure a service life as long as possible

Favour internal processes with lower energy
- Repair
- Maintain

Avoid “exiting”
- Re-use
- Recycle
Circular Economy

MINIMIZATION AND PREVENTION

Durability

Easy maintenance and repair

New Concretes
Circular Economy

REUSE

STRUCTURE REUSE

PRODUCT REUSE
Circular Economy

GEOTECHNICAL WORKS

RECYCLING

RECYCLED AGGREGATES
• Conclusion

**PRECAST** provides solutions to the challenges of construction 2050

- Low-carbon
- Sustainable
- Circular

- Fire resistance
- Adapting to climate change
- Affordable
- Thermal comfort
- Resilient

**PRECAST** provides solutions to other societal challenges
PRECAST will be the backbone for a transition to Construction 2050.
• Conclusion

Providing that the precast industry

3. Fully embraces circular economy principles

1. Engages in a transition towards low-carbon together with stakeholders

2. Keeps on manufacturing with sustainability in mind

Designers
Raw materials
Precast manufacturers
Society

Sustainability
Social
Environmental
Economic
Secondary Raw Materials for Concrete precast products

Please visit us
www.nweurope.eu/seramco
https://twitter.com/seramconwe
https://www.linkedin.com/company/seramco

Alessio RIMOLDI
ar@bibm.eu

Thank you for attention.
Recycled aggregates properties – Influence of the crushing method

SeRaMCo Webinar
22\textsuperscript{nd} of June 2020

J. Hubert, Z. Zhao, F. Michel & L. Courard (ULiege)
Summary of the presentation

- Materials and methods
  - Crushing methods
  - Concrete compositions
- Results
  - Grain size distribution
  - Morphology of the aggregates
  - Cement paste content
  - Water absorption
- Energy consumption study
Materials and methods

Crushing methods

Impact crusher

Production of 0/25

Jaw crusher

Set at 6.5 kW (40% of maximum power)

Jaw crusher set at a 22 mm opening
## Materials and methods

### Concrete compositions

<table>
<thead>
<tr>
<th></th>
<th>1.0</th>
<th>1.1</th>
<th>1.2</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name</strong></td>
<td>Reference</td>
<td>CEMIII</td>
<td>Sandstone</td>
<td>Low Cement</td>
<td>Low W/C</td>
</tr>
<tr>
<td><strong>Aggregates type</strong></td>
<td>Limestone</td>
<td>Limestone</td>
<td><strong>Sandstone</strong></td>
<td>Limestone</td>
<td>Limestone</td>
</tr>
<tr>
<td><strong>Cement type</strong></td>
<td>CEMI 52.5</td>
<td><strong>CEMIII 52.5</strong></td>
<td>CEMI 52.5</td>
<td>CEMI 52.5</td>
<td>CEMI 52.5</td>
</tr>
<tr>
<td><strong>Cement quantity (kg/m³)</strong></td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>320</td>
<td>452</td>
</tr>
<tr>
<td><strong>Cement paste volume (dm³/m³)</strong></td>
<td>351</td>
<td>358</td>
<td>351</td>
<td>282</td>
<td>351</td>
</tr>
<tr>
<td><strong>W/C</strong></td>
<td>0.56</td>
<td>0.56</td>
<td>0.56</td>
<td>0.56</td>
<td><strong>0.46</strong></td>
</tr>
</tbody>
</table>
Results

Grain size distribution

The jaw crusher produces aggregates with a more constrained grain size range.
Results

Morphology

The flakiness index decreases with increasing granular fraction and the jaw crusher produces flakier aggregates

No influence of the concrete composition in the investigated range
Results

Cement paste content

Decrease in cement paste content with increasing granular fraction
No influence of the crushing method
Results

Water absorption

Decrease in water absorption with increasing granular fraction
Results

Water absorption

No significant influence of the crushing method on the water absorption of the recycled aggregates (for all tested composition)
## Energy consumption study

<table>
<thead>
<tr>
<th>(a) Running power (kW)</th>
<th>Jaw crusher</th>
<th>Impact crusher</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,8-2,0</td>
<td>6,5-6,6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(b) Mean net power (kW)</th>
<th>Jaw crusher</th>
<th>Impact crusher</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,9-2,1</td>
<td>0,5-0,8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(c) Mean crushing duration (s)</th>
<th>Jaw crusher</th>
<th>Impact crusher</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>200</td>
<td>252</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(d) Crushed mass of material per hour (t/h)</th>
<th>Jaw crusher</th>
<th>Impact crusher</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2,0-2,3</td>
<td>1,6-1,7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(e) Net specific energy consumption (kWh/t) (b/d)</th>
<th>Jaw crusher</th>
<th>Impact crusher</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0,9-1,0</td>
<td>0,30-0,50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(f) Total specific energy consumption (kWh/t) (a+b)/d</th>
<th>Jaw crusher</th>
<th>Impact crusher</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,8-1,9</td>
<td>4,1-4,5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(g) Percentage of energy consumed for crushing (=b/(a+b))</th>
<th>Jaw crusher</th>
<th>Impact crusher</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>~50</td>
<td>~10</td>
</tr>
</tbody>
</table>
Crushing specific energy analysis

No correlation between jaw crusher specific energy consumption and impact crusher specific energy consumption

No correlation between specific energy consumption and compressive strength
## Conclusion

<table>
<thead>
<tr>
<th></th>
<th>Impact crusher</th>
<th>Jaw crusher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregates geometry</td>
<td>More spherical</td>
<td>-</td>
</tr>
<tr>
<td>Grain size distribution</td>
<td>-</td>
<td>More constrained</td>
</tr>
<tr>
<td>Fine content</td>
<td>-</td>
<td>Less fine content</td>
</tr>
<tr>
<td>Cement paste content</td>
<td>No influence</td>
<td>No influence</td>
</tr>
<tr>
<td>Water absorption</td>
<td>No influence</td>
<td>No influence</td>
</tr>
<tr>
<td>Energy consumption</td>
<td>-</td>
<td>Less consuming</td>
</tr>
<tr>
<td>Crushing duration</td>
<td>-</td>
<td>Shorter</td>
</tr>
</tbody>
</table>
Thank you for your attention

The work was carried out thanks to the financial support of the European Commission in the framework of the Interreg NWE SeRaMCo project
Recycled Aggregates Concrete

Dr. Gael CHEWE NGAPEYA
Prof. Dr.-Ing. Danièle Waldmann
Luxembourg, June 2020
Old mortar attached: the main differences between the properties of recycled aggregates and natural aggregates

Density, Porosity, Crushing index

Interfacial Transition zone (ITZ)

High water demand of RAC

Part. size distribution and workability

Medium to high strength concrete

The higher the mortar content is, the higher the porosity of RA, and the higher the water absorption.

The water absorption of RA is 2.3 to 4.6 times higher than that of natural aggregate, irrespective of the original concrete strength. [3,4]

The high water demand of RA leads to a reduction of the workability of RA concrete.

The high water demand of RA leads to a reduction of the workability of RA concrete.
The adhered mortar content increases with the decrease in the aggregate size.

As the RA gradually crumbles, Cement mortar accumulates in fines RA, Density of recycled fine aggregate decreases.

A proportion of more than 20% recycled fine aggregate results in a large reduction of the workability, a phenomenon linked to the saturated surface dry-density of RA.

The saturated surface dry density decreases with the absorption, i.e. with the adhered mortar content, i.e. with the particle size distribution.

- The interfacial transition zone strongly impact the performance of RA concrete.
  
  Soft interface provides a major interfacial cracking mode, while stiff interface induces a main bulk cracking behavior.

- An enhancement of the ITZ performance results in an improvement of the compressive strength of RA concrete.

  The ITZ enhancement could be achieved by:
  1- A two stage mixing approach for improving the micro structure of old adhered mortar.
  2- A separation of adhered mortar or a treatment with a polymer solution.
Development of medium to high strength concrete

Mixing procedure

- Improve the microstructure of old mortar
- Enhance the performance of the ITZ by producing a thin layer of cement slurry on RA.

Aggregates + total binder (cement + fillers)

- 1/2 of free water
  - 30 sec
  - 30 sec

- 1/2 of free water + superplasticizer
  - 60 sec of mix

- Edges scraped
  - 60 sec of mix
  - 120 sec of mix

Fresh concrete
• It is already known that the **concrete compressive strength decreases** with the **increase of the replacement rate of NA with recycled ones**, irrespective of aggregate type.

**Low performance of the Interfacial Transition Zone**

**Low bonding** between **old attached mortars** and the **fresh mortar paste**

**SeRaMCo**

Developed concretes using 100% of recycled aggregates from known origin

- **High-Strength Concrete**
  - Micro-silica ~ 2% of the binder weight
  - Superplasticizer ~ 3% of the binder weight
  - Binder to aggregate ratio ~ 1:3.6
  - Water to binder ratio w/b ~ 0.35
  - Particle size skeleton reconstructed
  - $f_{c,28} = 58.5 \text{ MPa}$
  - $E = 29500 \text{ MPa}$

- **Open Structure Concrete**
  - Micro-silica ~ 2% of the binder weight
  - Binder to aggregate ratio ~ 1:2.9
  - Water to binder ratio w/b ~ 0.35
  - Particle size skeleton reconstructed
  - $f_{c,28} = 5.7 \text{ MPa}$
  - $E = 1500 \text{ MPa}$

- **Self-Compacting Concrete**
  - Master air ~ 0.15% of the binder weight
  - Superplasticizer ~ 1.5% of the binder weight
  - Binder to aggregate ratio ~ 1:3.1
  - Water to binder ratio w/b ~ 0.35
  - Particle size skeleton reconstructed
  - $f_{c,28} = 32.4 \text{ MPa}$
  - $E = 6700 \text{ MPa}$

- **Medium to high strength concrete**
  - $f_{c,28} = 58.5 \text{ MPa}$
  - $E = 29500 \text{ MPa}$
  - $f_{c,28} = 5.7 \text{ MPa}$
  - $E = 1500 \text{ MPa}$
  - $f_{c,28} = 32.4 \text{ MPa}$
  - $E = 6700 \text{ MPa}$
Villmools Merci!
Concrete containing recycled aggregates from unknown origin

Development of new mixes for structural precast elements and pavement blocks

Anja Tusch
Development of different new concrete mixes containing recycled aggregates from unknown origin
Challenges

Production of concrete containing recycled aggregates from unknown origin causes some challenges:

**Aggregates**
- Great variety of the materials
- Great variety of the properties

**Fresh concrete**
- Workability due to the higher water absorption

**Hardened concrete**
- Strength
- Deformation behavior
- Durability
Concrete mixtures for SeRaMCo

- Mixture for the production of structural elements
- Mixture for the production of non-structural elements
- Rammed concrete
- Salty concrete
Used aggregates

**Crushed concrete**
Type A (except Rₐ)
WA24: 4–5 %
Density: 2.3 kg/dm³
Fractions: 2-6 mm, 6-14 mm, 14-22 mm

**Mixed aggregates**
Type B (except Rₐ)
WA24: 6-9 %
Density: 2.2 kg/dm³
Fractions: 2-6 mm, 6-14 mm, 14-22 mm
Concrete mixtures

Mixture for the production of structural elements

Mixture for the production of non-structural elements/ Pavement
Starting point: Development of a concrete mixture, which can be used for different structural elements

Challenge: The products are not known yet and the mixture has to be very variably

Planned test procedure:

• Design a mixture which is able to match C 30/37 by using a standard CEM I 42.5 and recycled aggregates

• Using two different w/c ratios for the concreting of the mixture $\rightarrow$ w/c: 0.45; 0.55

• Verify the results by using different cements $\rightarrow$ CEM II 42.5; CEM I 52.5
Results test series 1:

The variations of the w/c ratio results in a scattering of the compressive strength.
Results test series 2:

- Crushed concrete, 28d, CEM II 42.5 N
- Crushed concrete, 28d, CEM I 52.5 N
- Mixed aggregates, 28d, CEM II 42.5 N
- Mixed aggregates, 28d, CEM I 52.5 N
- Theoretical strength CEM 42.5, 28d
- Theoretical strength CEM 52.5, 28d
Concrete mixtures

Mixture for the production of structural elements

Mixture for the production of non-structural elements/ Pavement
Development of the concrete mix for non-structural elements / paving blocks

Requirements:
• Slump 0 (earth-moist concrete)
• High early age strength
• The resulting concrete has to fulfill the standards of EN 1338

Challenge: Properties of the product depend on the mixture as well as on the used process technology
Development of the concrete mix for non-structural elements / paving blocks

Test procedure:

Step 1
- Determination of a well graded grain composition with a suitable cement amount and an optimum water content
- Analogous to the determination of the proctor density

Step 2
- Determine the properties of the resulting concrete mixture
- Is it able to fulfill the requirements?

Step 3
- Optimization if needed
- Addition of additives if needed

Step 4
- Testing the mixture directly in the production line
- Optimization of the mixture in combination with the production process
Development of the concrete mix for non-structural elements / paving blocks

First results

<table>
<thead>
<tr>
<th>MV material</th>
<th>1:5</th>
<th>1:6</th>
<th>*</th>
<th>*</th>
</tr>
</thead>
<tbody>
<tr>
<td>f_{c3f,sp} [MPa]</td>
<td>0</td>
<td>5.1</td>
<td>5.0</td>
<td>4.4</td>
</tr>
</tbody>
</table>

Procedure to find a suitable mixture:

- Selection of aggregates
- Determination of average cement content (corresponds to mixing ratio)
- Determination of the optimum water content in the test
- Preparation of samples and determination of strength (applying strength by cement content)
- Calculation of the mixture composition from the ingredients
### Development of the concrete mix for non-structural elements / paving blocks

#### Results green strength

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water content</td>
<td>Most important (optimum = $W_{\text{opt}}$)</td>
</tr>
<tr>
<td>Concrete composition (cement content and specific surface!)</td>
<td>Increasing with increasing cement content and specific surface</td>
</tr>
<tr>
<td>Grading curve of aggregates</td>
<td>Minor influence</td>
</tr>
<tr>
<td>Admixtures/additives</td>
<td>Depends on individual case (mixing ratio, added amount)</td>
</tr>
<tr>
<td>Compaction energy</td>
<td>Important</td>
</tr>
</tbody>
</table>
# Development of the concrete mix for non-structural elements / paving blocks

## Results green strength

<table>
<thead>
<tr>
<th>Mix</th>
<th>Mixing ratio</th>
<th>W</th>
<th>C</th>
<th>FA</th>
<th>QP</th>
<th>Aggregates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1:6</td>
<td>x</td>
<td>x</td>
<td>0</td>
<td>0</td>
<td>Gravel</td>
</tr>
<tr>
<td>2</td>
<td>1:5</td>
<td>x</td>
<td>x</td>
<td>0</td>
<td>0</td>
<td>Crushed concrete</td>
</tr>
<tr>
<td>3</td>
<td>1:6</td>
<td>x</td>
<td>x</td>
<td>0</td>
<td>0</td>
<td>Gravel</td>
</tr>
<tr>
<td>4</td>
<td>1:5</td>
<td>x</td>
<td>x</td>
<td>0</td>
<td>0</td>
<td>Crushed concrete</td>
</tr>
<tr>
<td>5</td>
<td>1:5</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>0</td>
<td>Gravel</td>
</tr>
<tr>
<td>6</td>
<td>1:5</td>
<td>x</td>
<td>x</td>
<td>0</td>
<td>x</td>
<td>Gravel</td>
</tr>
<tr>
<td>7</td>
<td>1:5</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>0</td>
<td>Gravel</td>
</tr>
<tr>
<td>8</td>
<td>1:5</td>
<td>x</td>
<td>x</td>
<td>0</td>
<td>x</td>
<td>Gravel</td>
</tr>
<tr>
<td>9</td>
<td>1:5</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>0</td>
<td>Crushed concrete</td>
</tr>
<tr>
<td>10</td>
<td>1:5</td>
<td>x</td>
<td>x</td>
<td>0</td>
<td>x</td>
<td>Crushed concrete</td>
</tr>
</tbody>
</table>
Thank you for your attention!
Closed-loop supply-chain of construction and demolition wastes: Towards circular economy in French regions

N. TAZI, R. IDIR and A. BEN FRAJ
• The necessity to handle inert wastes from dwellings construction and demolition
• Methods
• Results in nutshell
• Conclusions and perspectives
• Assess the ability of a region to reach a sustainable reverse logistic model in the construction and demolition sector
• Stock deposit
• Assessment of inert wastes from dwelling stock
• Avoided resource indicator
Model Framework

French dwelling data

Extraction & Segmentation

Uncertainties

MFA

EoL management

Sustainable reverse logistic practices
Annual flows from inert wastes
Chronological concrete flows generated in French regions from collective (left) and individual (right) dwellings
➢ Annual recycled inert wastes (regional)  

Vs.  

➢ Regional natural resource depletion (NA)
Sustainability criterion
- Towards circular economy in the construction sector (locks and opportunities)
- MCDA of recycling processes of CDW
- Environmental assessment of the reverse logistic process
THANK YOU
Closed-loop supply-chain of construction and demolition wastes:
Towards circular economy in French regions

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June, 22
Discussion, questions & answers
Save the date:

SeRaMCo Final Conference "Precast Concrete in the Circular Economy"

15-16 February 2021
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Thank you for your attention.

We hope to see you again at our next webinar!

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