# DOCTORAL SEMINAR ON SUSTAINABILITY RESEARCH IN THE BUILT ENVIRONMENT

25 - 26 May 2023, Brussels

HOSTED BY VRIJE UNIVERSITEIT BRUSSEL & UNIVERSITÉ LIBRE DE BRUXELLES

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ABOUT THE THEME

# URBAN ENGAGED RESEARCH TO THE RESCUE!?

In our rapidly changing world, science provides perspective and guidance. The rigorous process of truth-seeking and refutation offers the best answer toward reliable insights and responsible choices.

Yet as researchers and human beings, we do not stay unmoved by today's social and ecological issues. Ideally, we would like to make a positive contribution with our research. But can and should we?

In this edition of DS²BE, we explore the role of "urban engaged research" through your own work. Keynotes testify about their interpretation of that role, we make a site visit around action research, and organise a workshop to define your own role.

DS²BE 2023 is co-hosted by perspective.brussels, situated at the back of the Royal Palace between the central station and the Matonge neighbourhood.

**VENUE**

**Perspective.Brussels**

Rue de Namur - Naamsestraat 59, 1000 Brussels.

perspective.brussels is the public interest body and multidisciplinary centre of expertise for territorial development that provides the Brussels Region with the means to understand itself better in order to prepare its future.

Under the WeKonekt program, VUB and ULB collaborate with public and private actors like Perspective.Brussels to open up our campuses and engage researchers and students for metropolitan challenges in and around Brussels.

# DS²BE PROGRAMME

**THURSDAY 25 MAY**

| | |
|---|---|
| **Registration (location perspective.brussels)** | **8:00** |
| **Welcome & Keynote Testimonial** | **9:00** |
| Dalila Ghodbane (perspective.brussels) | |
| Lene De Vrieze (AWR) | |
| **Coffee Break** | **10:30** |
| **Paper Presentations: Urban Circularity** | **11:00** |
| Chair: Karen Allacker | |
| Lisa Van Gulck | |
| Giulia Verga | |
| Victor Ooghe | |
| **Lunch** | **12:30** |
| **CERL Workshop** | **13:30** |
| **Coffee Break** | **15:00** |
| **Parallel Poster Session** | **15:30** |
| **Session 1A: Adaptability and Timber Constructions** | |
| Chairs: Rafael Novais Passarelli & Niels De Temmerman | |
| Ellen Leemans | |
| Tatiana Chilleto | |
| Esther Van Damme | |
| Simon Bothof | |
| **Session 1B: Urban Mining and Circular Construction** | |
| Chairs: Giulia Verga & Damien Trigaux | |
| Anke Blommaert | |
| Katrien De Vos | |
| Gabrielle Kawa | |
| Jasmin Baumgarter | |
| **Site Visite USquare** | **16:30** |
| Presentation by Victor Ooghe | |
| **Guided tour in two groups** | **17:30** |
| Victor Ooghe & Pamela Domingez (BPC) | |
| **Dinner at WOLF** | **20:00** |

## FRIDAY 26 MAY

**Registration (location perspective.brussels)** **9:00**
**Paper Presentations: Material Innovations** **9:30**
Chair: Paulien Strandberg & Nathan Van Den Bossche
Erik Pelicaen
Nick Adams
Yanaika Decorte
**Coffee Break** **11:00**
**Parallel Poster Sessions** **11:30**
**Session 1A: Demolition and Adaptive Reuse**
Chair: Tim De Kock & Elke Knapen
Louise Huba
Paulien Beeckman
Colm mac Aoidh
Lara Reyniers
**Session 1B: Green Urbanism**
Chair: Maider Llaguno & Ahmed Khan
Eda Kale
Marie De Groeve
Yong Xu
**Lunch** **12:30**
**Parallel Poster Session** **13:30**
**Session 2A: Façades**
Chair: Bob Geldermans & Lionel Devlieger
Esther Geboes & Ruben Van Vooren
Angelica Rota
Bruno Vanderschelden
Kaat Janssens
**Session 2B: Concrete**
Chair: Geoffrey Van Moeseke
Steffie de Gaetano
Zhaoxing Wang
Thijs Lambrechts
Fred Mudge
**Coffee Break** **14:30**
**Parallel Poster Session** **15:00**
Session 3A: Design processes and User Stories
Chair: Jouri Kanters & Griet Verbeeck
Nijs de Vries
Elena Cavallin
Lisa De Roeck
Session 3B: Blue Urbanism
Chair: Frank De Troyer
Elena Kasselouri
Evelien Van den Bruel
**Reflections** **16:00**
**Closing drink kindly offered by perspective.brussels**

# INVITED SPEAKERS

**TESTIMONIAL**

**Lene De Vrieze** (Architecture Workroom Brussels)

Lene has been working at Architecture Workroom Brussels since 2017 on open space and food. In her talk she will give us an insight in how AWB engages policy, practice and academia in transdisciplinary processes of innovation.

**WORKSHOP**

**Brecht Van der Schueren** (COMMUNITY ENGAGED RESEARCH AND LEARNING)

Guided by VUB's community engaged research and learning expert Brecht, we will reflect about our own research questions and methods. Can and should you increase the impact of your research endeavours?

**SITE VISIT**

**Pamela Domingez (BPC)**

Together with VUB-ULB researcher Victor Ooghe and project manager Pamela Domingez of contractor BPC, we visit the USquare redevelopment project.
https://usquare.brussels/en
Required: safety shoes.

**CO-HOST**


**perspective.brussels**

The perspective.brussels Territorial Knowledge department conducts analyses of the urban, social, economic and environmental reality of Brussels districts in order to support harmonious regional development.

# PAPER PRESENTATIONS

**THURSDAY 25.05: Urban Circularity**

How to determine when circular building elements are environmentally better than linear elements?

*Lisa Van Gulck*

Which circularity for Urban Design and Planning? A compass to navigate Circular Economy research knowledge and methods.

*Giulia Verga*

Urban circularity: material stock and flow analysis of urban projects in Brussels.

*Victor Ooghe*

**FRIDAY 26.05: Material Innovations**

*Exploring the reuse potential of earth blocks.*

Erik Pelicaen

Implementation of a newly developed Photonic Meta-Concrete into climate models to estimate the impact on the urban island and climate change.

*Nick Adams*

The environmental impact of one-step deep renovation, reconstruction and step-by-step renovation: single-family case study in Flanders

*Yanaika Decorte*

# POSTER PRESENTATION

**THURSDAY 25.05**

**SESSION 1A: Adaptibility & Timber Constructions**

Reusable building systems: prototyping lightweight and modular temporary structures.

*Ellen Leemans*

Design for Disassembly and Reuse: fundamental research on the potential of mass timber components.

*Tatiana Chiletto*

Mapping Stakeholder Perspectives on Multi-Storey Contemporary Timber Construction – an Actor-Network for Belgium

*Esther Van Damme*

Strong sustainability appraisal for transport.

*Simon Bothof*

**SESSION 1B: Urban Mining & Circular Construction**

Determination of the real life expectancy of materials in buildings.

*Anke Blommaert*

Urban mining: availability of building materials in existing dwellings.

*Katrien Devos*

Reimagining vacancy. Temporary projects in vacant industrial buildings, an opportunity for circular construction.

*Gabrielle Kawa*

Circularity, Construction, and the City: embedding the circular construction economy in urban transitions.

*Jasmin Baumgartner*

# POSTER PRESENTATIONS

**FRIDAY 26.05**

**SESSION 1A: Demolition & Adaptive Reuse**

Qualitative data on large-scale demolition in the Brussels-Capital Region, 1987 - 2021.

*Louise Huba*

Repurposing our built environment: circular design strategies for reconverting office buildings to afforable housing.

*Paulien Beeckman*

(Re)establishing adaptive reuse as a transdisciplinary cultural practice

*Colm mac Aoidh*

Behind the scenes. Demolition of a warehouse to construct the Flemish Theatre (KVS) in Brussels.

*Lara Reyniers*

**SESSION 1B: Green Urbanism**

Mapping Green Infrastructure in Built Heritage Sities by Spatial Attributes: a case study in Antwerp.

*Eda Kale*

The impact of vertical greening on built heritage and its local microclimate: preliminary on-site testing.

*Marie De Groeve*

High-albedo urban surfacing materials for heat-resilient and sustainable urban built environment

*Yong Xu*

**SESSION 2A: Façades**

Reusing façade components as a collective endeavour: a retrospective comparison of pioneering projects

*Esther Geboes & Ruben Van Vooren*

An assessment of the potential for reusing post-consumer glass.

*Angelica Rota*

Spatial distribution of material degradation under realistic wettng and drying of the façade.
*Bruno Vanderschelden*

Does interior insulation damage our heritage?

*Kaat Janssens*

**SESSION 2B: Concrete**

Geologic Architecture and its Extraction Landscapes.

*Steffie de Gaetano*

Robust Comparative LCA of Circular Pavement Designs Using Parametric and Probalistic Approach

*Zhaoxing Wang*

Disconnecting and Reconnecting of Precast Concrete Building elements.

*Thijs Lambrechts*

Design Automation Software for Reused-Concrete Buildings.

*Fred Mudge*

**SESSION 3A: Design processes & User stories**

Unfired earth blocks: Mapping the actor's perspective to increase the base of support of unfired earth blocks in the Flemish context.
*Nijs de Vries*

Interaction between designers and AI: how it can support the complexity of sustainable design process.

*Elena Cavallin*

Performing policy conflict within transformative processes: A dramaturgical analysis of contentious urban climate change policies.
*Lisa De Roeck*

**SESSION 3B: Blue Urbanism**

Resiliency in Mediterranean Coastal Territories: water urbanism for climate change adaptation in the Mediterranean basin.
*Elena Kasselouri*

Leaking cities. Mapping changes in Brussels' urban drainage system.
*Evelien Van den Bruel*

# WHITE BOOK OF ABSTRACTS

## PAPERS

## How to determine when circular building elements are environmentally better than linear elements?

Lisa Van Gulck

Life cycle assessment (LCA) is an important tool to determine whether circular building has a lower environmental impact than our traditional linear way of building. A key question is under which conditions the circular building element is environmentally beneficial. This can depend on the scenarios taking place during and at the end of the lifespan of the building element. For example, is the element transformed over its lifespan? Additionally, the values of key parameters can be important. For example, how many times is the material reused? Considering scenario and parameter variability is necessary to obtain robust conclusions on the environmental impact of circular versus linear building elements. Nonetheless, this is not done in most existing LCA studies.

The goal of this paper is to analyse how scenario and parameter variability can be incorporated in LCA studies of linear versus circular building elements to determine in which situations the circular building element is environmentally beneficial. The research is done for the case study of façade systems. The results show that when including scenario variability, considering transformation scenarios during the lifespan of the building element has a large influence on the environmental impact. In contrast, without module D, there is no considerable difference in impact between the end-of-life scenarios. If module D is included in the results, splitting the module into different submodules helps determine where potential environmental benefits originate from. Adding parameter variability and representing the results in an appropriate way allows to determine if the exact parameter values play a role for the conclusions, and if so, for which parameter value combinations one building element is better than the other. By including scenario and parameter variability in LCA studies nuanced and objective conclusions on the environmental impact of linear versus circular building elements can be drawn.

Keywords: Life cycle assessment; Circular building; Scenario variability; Parameter variability; Module D

Supervisors: prof. Marijke Steeman and prof. Jo Dewulf (Ghent University)

Lisa Van Gulck acknowledges the support of the Research Foundation – Flanders (FWO) [grant number: 1S00221N]. The authors thank the three regional authorities of Belgium responsible for the development of the TOTEM tool for providing the documentation to convert Ecoinvent processes to the Belgian context (“Masterexcel version 17/08/2021” and “Harmonisation_changes_EI36_210629”).

## Which circularity for Urban Design and Planning? A compass to navigate Circular Economy research knowledge and methods.

Giulia Verga

The circular economy (CE) has taken hold among urban development plans and programs, yet research on the application of the concept in urban design and planning is still in its infancy. This paper provides a systematic review of the literature related to CE, urban planning, and design. It investigates how the literature is clustered by subject area as well as the epistemological positioning and methodological approach of different research clusters. Results suggest that objectivist and conceptual approaches are most widespread, although practical and constructivist approaches are emerging. Planners and designers are being called upon to lead more integrative research.

This is a review article that combines quantitative and qualitative analyses of the literature on the emerging field of “circular urbanism”. It provides academics and practitioners with a compass to navigate the multifaceted landscape of CE research at the urban scale. Ultimately, the aim is to provide insights to better understand and take a stand in designing socio-ecological processes that influence landscape change."

The article has been jointly written by Andrea Bortolotti and Giulia Verga, supervised by Ahmed Khan, and has been submitted to a special Issue of the Journal of Planning Practice & Research on ‘Challenges of Applying Circular Economy and Metabolism Principles in Urban Planning Practice, Education and Research'.

Keywords: Circular Economy; Circularity, Urban Planning; Urban Design; Urban Agenda

Supervisors: BORTOLOTTI Andrea, Department of Architecture and Urban Studies, Politecnico di Milano, Piazza Leonardo da Vinci 26, +39 02 2399 5415, andrea.bortolotti@polimi.it
KHAN Ahmed Zaib, Building, Architecture and Town Planning, Ecole Polytechnique, Université Libre de Bruxelles, ahmed.khan@ulb.be

Article submitted to a special Issue of the Journal of Planning Practice & Research on ‘Challenges of Applying Circular Economy and Metabolism Principles in Urban Planning Practice, Education and Research’, undergoing the review process after a first acceptance.

CRediTA. Bortolotti and G.C. Verga contributed to the conception and design of the study. A. Bortolotti and G.C. Verga performed the systematic literature review. A. Bortolotti wrote a significant part of the first draft of the manuscript and performed the bibliometric analysis and its visualization. G.C. Verga wrote sections of the manuscript. A.Z. Khan supervised part of the study. A. Bortolotti, G.C. Verga and A.Z. Khan reviewed and edited the final draft.

## Urban circularity: material stock and flow analysis of urban projects in Brussels.

Victor Ooghe

The Circular Economy (CE) is a concept mobilised by cities and regions to foster their sustainability ambitions, advocating for the implementation of resource efficiency strategies. Nevertheless, this concept is not yet fully established at the urban level, defined as the Urban Circularity. In 2018, the Brussels Capital region defined the main circular ambitions as the reduction of material flows (IN/OUT) in the region and the creation or preservation of economic activities.
This article aims to present a stock-driven material flow analysis tool to evaluate and discuss on the current circularity of Brussels’ urban development by studying the impact of its 13 strategic urban projects (UPs).

On the basis of the different scenarios of the environmental impact impacts (EIR), the tool estimates the flows generated in absolute value (tons) but also in relative value (ton/m²) with respect to urban development units: final gross floor area, gross floor area gain and land area.

The results are then discussed through the lens of circularity: is there a gap between material flows of UPs and regional strategies (e.g. PREC, Brussels Doughnut, Renolution)? The findings underline the great impact that current scenarios represent on the overall yearly regional balance of construction materials inflows and outflows. 9 UPs should induce an outflow of between 1.4 and 2.2 million tons and an inflow of between 3.4 and 6.2 tons. These large deviations are not always justified by urbanistic benefits. The discussion suggests that the path towards circularity in the construction sector involves maximising renovations, and sharply decreasing demolition-construction operations.

Keywords: Urban circularity, urban planning, Material flow analysis

Supervisors: Prof. Niels De Temmerman (Vrije Universiteit Brussel) and Prof. Philippe Bouillard (Université Libre de Bruxelles), co-author: Giulia Caterina Verga (Université Libre de Bruxelles)

This paper is a contribution from the Usquare research project which is funded by the Université Libre de Bruxelles and the Vrije Universiteit Brussel.

## Exploring the reuse potential of earth blocks.

Erik Pelicaen

Earth block masonry (EBM) shows considerable potential as a low-impact alternative to conventional masonry systems. However, research is lacking about end-of-life scenarios with EBM. Practitioners often claim the high circular potential of demolition and recycling, not considering the possibility of deconstruction and reuse. Therefore, this study proposes a first attempt to fill this gap by exploring the reuse of earth blocks. Methods are quantitative assessment of the bond strength and qualitative evaluation of the cleaning process for earth block masonry couplets with different mortar compositions.

The study finds that the bond strength is highly influenced by the earth block and mortar binder types, as well as the moisture content of stabilized earth blocks. Geopolymer-stabilised earth mortar shows the highest labour intensity in the cleaning process, and cement-stabilised mortar the lowest. Wetting the walls before deconstruction may be a potential strategy to facilitate the reclaiming of earth blocks. These outcomes underline the importance of considering deconstruction and reuse as a circular strategy for EBM, although further studies are needed to address the environmental and economic benefits of reusing earth blocks

Keywords: Earth block masonry, reuse, bond strength, separation, cleaning
Supervisors: prof. Elke Knapen and prof. Rafael Novais Passarelli (UHasselt)

## Implementation of a newly developed Photonic Meta-Concrete into climate models to estimate the impact on the urban heat-island and climate change

Nick Adams

Radiative cooling (RC) materials gained interest over the past decades, as these can help mitigating the urban heat island effect, fighting climate change and reducing fossil fuel energy consumption through refrigeration. The existing RC materials are composed out of thin metal and polymer layers, manufactured by energy demanding and expensive production processes. The Horizon 2020 project 'MIRACLE' is developing a new innovative radiative cooling material, that for the first time, is based on conventional concrete.

To assess the effect on the climate when applying this new Photonic Meta-Concrete (PMC) to the existing building stock, the region of Flanders is taken as case study. Modelling such larger area allows to explore the impact on climate change. However, as also the effect on the urban heat island is of interest, a smaller scale assessment also is included, more specifically the urban heat island effect of six Belgian cities with and without the use of PMC in the built environment is assessed. This study uses the COSMO-CLM regional climate model with the urban-canopy land-surface scheme (TERRA-URB).

The photonic properties, i.e. the specific emissivity and albedo, of the PMC are modelled in the climate model by adapting the land surface parameters. The amount of city surface in a pixel is used to interpolate and allocate these properties. The effect of implementing the specific albedo, the specific emissivity and the combination are compared to a baseline scenario without the implementation of the PMC to estimate the full potential of this material.

First results indicate that the PMC has great potential to reduce the temperature in cities. The next phase of the research will focus on assessing the working of the material on a longer time span and allocating the emissivity for each spectral band to assess the effect of emitting in the atmospheric window.

Keywords: Photonic Meta-Concrete; Radiative cooling materials; Urban heat-island; Climate modelling
Supervisors: prof. Karen Allacker and prof. Nicole Van Lipzig (KU Leuven)
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 964450.

## The environmental impact of one-step deep renovation, reconstruction and step-by-step renovation: single-family case study in Flanders

Yanaika Decorte

A sustainable transition of the existing dwelling stock towards carbon neutrality is a key element in tackling the climate crisis. To facilitate this transition, one-step deep energy renovation, demolition followed by new build (i.e., reconstruction) and step-by-step renovation are possible pathways. The choice between these three pathways will depend on many aspects, but how does their environmental impact relate?

Lowering the operational energy use is a first essential step, but the environmental impact related to the material use can become equally or even more important in case of low-energy buildings. Today, a systematic comparison of these three pathways from an environmental life cycle perspective is missing in the state-of-the-art. Hence, this paper compares the environmental impact of one-step deep energy renovation, reconstruction and step-by-step renovation with the conservation of an uninsulated single-family dwelling.

The environmental impact is calculated by means of a Life Cycle Assessment (LCA) over a 60-year study period following a cradle-to-grave approach. For each pathway, identical strategies for the different building envelope components and technical installations are assumed. For step-by-step renovation, six steps in two sequences are considered, corresponding to the highest and lowest resulting environmental impact. The results show that one-step deep renovation has the lowest environmental impact, followed by reconstruction. Their environmental impact is respectively 73% and 69% lower than conservation. Step-by-step renovation has a higher impact than both one-step deep renovation (+26% to +73%) and reconstruction (+7% to +48%), but the impact is still 53% to 66% lower than conservation, depending on the sequence of the measures.

Keywords: Life Cycle Assessment; one-step deep energy renovation; reconstruction; step-by-step energy renovation; single-family case study
Supervisors: prof. Marijke Steeman and Nathan Van Den Bossche (Ghent University)
The first author, Yanaika Decorte, would like to gratefully acknowledge the support of the Research Foundation – Flanders (FWO) [SBO - 1S11621N].

# WHITE BOOK OF ABSTRACTS

## POSTERS

## Reusable building systems: prototyping lightweight and modular temporary structures.

Ellen Leemans

In the event sector, structures are often left behind after use, ready to be thrown away. This leads to increased waste and CO2 emissions. However, if 75% of structures were reusable, waste production would be up to 3.5 times lower (Núñez, et al.).

By designing these temporary structures to be lightweight, modular and reconfigurable, they are more efficient for short-term use and reuse. However, current solutions are difficult to assemble or lack variation to achieve different configurations. When multiple configurations are possible, they usually consist only of beams and do not include walls or provide coverage.

Therefore, this research will focus on investigating a lightweight plate-based building system for temporary, reconfigurable and structural applications. First, a geometrical system will be investigated that can later be translated into a plate-based system. Here, materials and connections are crucial. Finally, all results will be combined in a prototype to show the feasibility of the system.

This research will not only produce a prototype, but also a guide to the operation of this innovative building system that will allow optimal use and reuse. In addition, the results of the geometrical study and the development of a slab system and computational methods will be valuable in both the event and construction industries for future innovations.

Keywords: reuse; modular; lightweight; prototyping
Supervisors: Prof.Niels De Temmerman & Prof. Lars De Laet
(Vrije Universiteit Brussel)
Research funded and supported by VUB Architectural Engineering

## Design for Disassembly and Reuse: fundamental research on the potential of mass timber components.

Tatiana Chiletto

The construction industry consumes 30% of global resources and is also one of the leading producers of solid waste generated during the production of materials, construction, and demolition of buildings. Thus, the transition to a circular economy offers an alternative path to the current linear, high-polluting, and wasteful practices in construction. In this scenario, the recent scientific literature states that mass timber construction is one of the sustainable alternatives to traditional building materials and has led to the recent revolution in the construction sector. In recent years, advances in glueing, fixing, and manufacturing technologies have allowed a new generation of large mass timber products to be used in ever larger and increasingly complex building projects. Nonetheless, their relative novelty implies a lack of practical experience of what happens to the products at end-of-life.

This study investigates the possibilities for prolonging the life cycle of timber construction materials, focusing on Cross-Laminated Timber (CLT) components, from a Design for Disassembly and Reuse (DfDR) standpoint. The research is applied in nature, using mixed methods in its approach. It begins with a literature review, establishing a theoretical basis. This is followed by a series of environmental impact case study analyses to present quantitative data to understand the potential of circularity strategies for CLT building components. Finally, research through design will be used to validate the real-life possibilities of DfDR. The results will qualify the applied strategies by demonstrating the inherent recyclability of the approach.

Keywords: Cross-Laminated Timber; Mass Timber Components; Design for Disassembly and Reuse; Design for Circularity
Supervisors: Prof. Rafael Novais Passarelli & Prof. Elke Knapen
(Universiteit Hasselt)

## Mapping Stakeholder Perspectives on Multi-Storey Contemporary Timber Construction – an Actor-Network for Belgium

Esther Van Damme

Multi-storey timber construction is becoming a key asset for addressing the need of a sustainable construction practice. Despite the immense potential and the numerous promising showcase projects in recent years, there are still barriers to large-scale application. This study starts from the assumption that, besides techno-scientific and economic claims, stakeholders in the timber construction sector pursue diverse, potentially opposing, agendas. A nuanced examination of the production network with its diverse actors and actions plays a crucial role in understanding identical goals, concerns or uncertainties, as well as resulting like-minded or conflicting tendencies to act. This implies that, whereas actors may benefit from certain effects in a shift towards structural timber, others may have diverging interests and pursuing different intentions in the construction sector. Therefore, the paper aims to explore the following research question: Which interests and barriers for multi-storey timber construction identify its stakeholders in Belgium?

In order to establish a preliminary Actor-Network Cognitive map, an in-depth review of current literature on participating actors in timber construction has been conducted. Scientific journals within two academic databases of peer-reviewed literature are reviewed in order to identify the preliminary barriers and interests. Based upon the Actor-Network theory, the cognitive map reflects the perceived barriers and interests for the stakeholder and for the other actors. Cognitive mapping is a graphic technique where concepts (nodes) are organized and structured using arrow diagrams (connections), which can be used to seize and explain stakeholder's perceptions. The stakeholders were selected based upon their previous experience with timber projects of four or more storeys in Belgium. A questionnaire survey will be given to those stakeholders serving to validate them. It includes both general questions and inquiries tailored to each actor's particular role. The Actor-Network Cognitive map is used in this study to serve as a starting point with interviewees, encouraging them to discuss 'hidden' aspects related to the structure and composition of their and other's values. Furthermore, the actors reflect upon their specific agency and potential synergies or disagreement with other actors based upon the same questions as the survey. The methods of information retrieval utilized in natural language processing serves as inspiration for the analysis. A concept's importance to an actor group can be gauged by how often it is brought up within that group. The perceived relevance metric helps to discern between significant actor-specific barriers or interests and non-specific barriers or interests.

Most literature concentrates on a limited number of stakeholders, like academics, policy makers, clients, architects, engineers, contractors or manufacturers. The identified barriers to timber construction or the bio-economy in literature are: public perception, deforestation & availability, legislation, building culture, material properties, construction cost & risk, project management, lack of expertise. The interests mentioned in literature are user comfort & aesthetics, circularity & carbon decrease, publicity, innovation, economic development, financial benefits, digitalisation, fast construction, design responsibility, material properties. In these findings, national or above-actor interests are identified in the Actor-Network cognitive map. The relations in the reported approaches are grouped into conflicting and consenting tendencies to highlight their implications, as well as positioning the actor in the network. These profiles of early adopters, explicit motivations and the Actor-Network cognitive map as a tool, will identify opportunities for innovation and timber network building.

Keywords: Circularity; Timber Construction; Stakeholders; Actor-Network map; Barriers and Interests

Supervisors: Prof. Mario Rinke (University of Antwerp)

## Strong sustainability appraisal for transport.

Simon Bothof

Transport infrastructure is an important driver for modern society, needed for the distribution of goods and for access to jobs, services and (social) activities. At the same time the construction and utilization of transport infrastructure causes many negative externalities and takes up lots of space. Transport infrastructure is increasingly competing with housing, agriculture and nature for available land. The presence of roads and cars in cities create barriers that limit social cohesion and cause air pollution detrimental to peoples' health. Sustainability has therefore become a key tenet in transport planning.

Outcomes, however, are often much less sustainable. Part of the reason for this discrepancy can be found in the goals and criteria against which transport projects are evaluated. Ex-ante evaluation of large transport projects is often done with a Cost-Benefit Analysis (CBA) in many countries around the world, but this method has received criticism from multiple directions. For example issues of social and ecological sustainability receive limited attention and the method does not consider the distribution of costs and benefits over different groups.

The goal of this research project is to integrate sustainability and social justice goals in the ex-ante evaluation of transport projects. To this end concepts of environmental sciences and moral philosophy are currently being reviewed to assess benefits, burdens and fairness. Parallel to that an analysis of transport evaluation guidelines and appraisal reports is in progress. These will form the basis of further development of appraisal methods and will help sustainability thinking permeate to real-world policy and decision making on transport and the built environment.

Keywords: Transport, evaluation, cost-benefit analysis, sustainability

Supervisors: prof. Kobe Boussauw, prof. Imre Keserü and dr. Geert te Boveldt

This research is funded by FWO.

## Determination of the real life expectancy of materials in buildings.

Anke Blommaert

Estimating correct lifetimes of materials is often difficult, and is typically based on theoretical technical lifetimes. This does not take into account use, maintenance, possible damage,… LCA or LCC calculations make use of those lifetimes, and the outcome is highly dependent on the assumed lifetime (because this determines, for example, whether the material needs to be replaced within the period under consideration). Lifespan is also sometimes used as a parameter to gain insight into the reuse possibilities of materials. It is therefore interesting to gain more insight into the actual lifespans of elements/materials.

Databases of building defects have proven to be useful for drawing conclusions on underlying causes of building defects and for identifying potential improvement actions to reduce the occurrence of building defects. The analysis of databases of building pathologies allows to perform risk analyses considering the relative frequency of damage cases, as well as the consequences of typical problems.

This research uses the database from a Belgian insurance company containing 9918 cases of building defects ranging from 1996-2019 as a starting point for identifying patterns and providing insights on the dominant underlying factors that impact building pathologies in Belgium. A deep dive in the expert reports provided by the insurance company gives insight in the underlying causes and the materials affected by certain types of damage.

Keywords: building pathology; lifetimes; statistical analysis; LCA; insurance company
Supervisors: Prof. Marijke Steeman and prof. Nathan Van Den Bossche (Ghent University) The authors would like to thank the insurance company for the access to the database, information and insights, and fruitful collaboration.

## Urban mining: availability of building materials in existing dwellings.

Katrien Devos

The European ambition to aim for carbon neutrality by 2050 encourages to renovate or demolish and reconstruct high energy consuming buildings. As these transformations will be accompanied with large quantities of building materials needed and waste flows generated, developing a sustainable material use will be highly important.

According to the concept ‘Urban mining’, buildings should be considered as material banks which can be dismantled into valuable components. However, current construction companies in Belgium take away only 1% of the building materials from a demolition site for reuse, because the market is not in place yet. In detail knowledge on the availability of building materials in the existing building stock is lacking and is essential to facilitate urban mining on a large scale.

This study therefore investigates the material use of 11 social housing case studies in Flanders, built between 1945 and 2005. A general database, containing information on the material use, is created by consulting primary building information, historical and technical documentation, interviews with stakeholders and site visits. For the materials available in these case studies, technical criteria that impact the reuse potential (e.g. ease of disassembly, exposure, etc.) will be researched. In addition, on the materials with sufficient reuse potential a LCA and LCC -to calculate the environmental impact and financial costs of reuse- will be applied.

Keywords:
Supervisors: Prof. Marijke Steeman and Prof. Lionel Devlieger (Ghent University)

## Reimagining vacancy. Temporary projects in vacant industrial buildings, an opportunity for circular construction.

Gabrielle Kawa

Vacancy is a long-studied phenomenon but remains a complex challenge. One dimension is the transformation of empty industrial buildings, attracting temporary projects. Although these projects reactivate sites, they rarely succeed in transferring their value - including materials, functions, and users - to the final transformation. This contrasts with the responsible resource use and transition to a circular construction economy that many regions aspire. Therefore, this research aims to create practical insights about the opportunities of vacancy periods of industrial buildings in cities, and develop circular strategies for temporary occupation projects. Through close collaboration with practitioners and cases, I will create actionable knowledge, strategies, and practical tools to empower and guide stakeholders towards betterinformed design choices and support material reuse in temporary projects.

Through a quantitative and qualitative analysis of international cases, a typology of productive temporary projects, such as makerspaces, will be developed, revealing strengths and opportunities, as well as pitfalls and hurdles. By reinterpreting these findings in a research-by-design, sustainable scenarios and circular strategies will be developed, which a proof-ofconcept project can validate. Altogether, the application of such strategies, supported by actionable knowledge and tools, could move circular innovation in temporary projects from an experimental niche to common practice.

Keywords: temporary projects; vacancy; circular building; productivity; maker-spaces

Supervisors: Prof. Waldo Galle and Prof. Niels De Temmerman
(Vrije Universiteit Brussel)

This research is funded by VUB Architectural Engineering.

## Circularity, Construction, and the City. Embedding the circular construction economy in urban transitions.

Jasmin Baumgarther

European cities are increasingly transitioning to the circular economy, a novel model for urban development that addresses economic, ecological, and societal objectives. This research investigates the territorial embeddedness of the transition to a circular construction economy in the Brussels Capital Region, thereby providing novel insights into the integrative adaptation and context-specific implementation of circular practices at the urban level.

As a backdrop for understanding the linkages between construction and the city, I start by charting the spatial planning and governance regimes regulating urban construction from the 1980s, a pivotal period of deindustrialization, to the present, to uncover prior conditions shaping circular practices. Consequently, to develop the contemporary analysis of circular construction, a threefold analysis of land, labor, and knowledge is taken. Firstly, in the current context of land pressure and industrial gentrification, the research explores emerging spaces of circularity. Five cases of “circular economy hubs” that function as regional flagship projects have been chosen to assess their role in urban redevelopment visions. Secondly, I investigate the economic climate for circular entrepreneurship. Applying the entrepreneurial ecosystem concept from economic geography, I will assess government policies and map networks of private and state actors, to explain the institutionalization of circular construction expertise in new projects. The third angle answers to the socio-economic polarization in Brussels by investigating the effect of inclusion strategies and re-skilling offers on local employment. The research methodology includes an analysis of statistical datasets and multi-scalar spatial plans, intra-urban case studies, and expert interviews with key stakeholders. The final step aims to develop an integrative framework and policy recommendations for circular urban development in Western European cities. The Brussels case will be compared to other European cities to assess the role of context-specific factors, such as local planning regimes and economic expansion strategies, in influencing the formation of circular city pathways.

Keywords: circular economy; circular development; urban construction; urban redevelopment; Brussels

Supervisors: Prof. David Bassens and Prof. Niels De Temmerman
(Vrije Universiteit Brussel)

## Qualitative data on large-scale demolition in the Brussels-Capital Region, 1987 - 2021.

Louise Huba

In Belgium, the building sector is responsible for over 30% of all waste production, an amount which is increasing yearly. Most of this waste -90%- is generated by demolition. Despite growing environmental concerns, demolition waste has seen a sharp increase over the last three decades in Belgium. To reverse this ever-increasing trend, a better understanding on why demolition took place and what has been demolished is needed. Given the undeniable impact of large-scale buildings on both material flows and the urban city scape within Brussels, they are the focus of this research.

This poster presents the results of inventorying all large-scale demolition projects (over 3000m²) which took place in Brussels since the publication of the Brundtland report in 1987 until today. The constructed database, based on building permits, is the first of its kind in the region and includes more than 600 demolition projects. The general trend shows a constant increase in the number of large-scale demolitions, linear to the increase of the total number of building permits. The database contains information on the location, function, size, typology, construction and demolition year, of the buildings before and after demolition. It allowed to identify spatiotemporal patterns of large-scale demolition in Brussels and bring those in connection to the shifting functions and typologies.
The demolition which Brussels is experiencing today, is from another nature than the common demolitions in the 1990s. While today offices being replaced by housing is common practice, two decades ago offices where mainly replaced by new office buildings. This historic perspective on demolition, can contribute to understanding and acting on demolition in the future. The shifting nature of large-scale demolition demonstrates a certain level of precaution is recommended when policymakers want to act on demolition today. The demolition of buildings is subjected to, and triggered by, urban development projects and zoning priorities. In Brussels, these priorities have changed over the past 35 years and might shift again in the next 35 years to come. Therefore, anticipating on a specific future use of buildings constructed today, might be an uncertain exercise.

Keywords: Large-scale demolition; Brussels-capital region; longitudinal analysis; obsolescence
Supervisors: Prof. Stephanie Van der Voorde and Prof. Ine Wouters (Vrije Universiteit Brussel) & dr. Michael Ghyoot and Lionel Billiet (Rotor)

## Repurposing our built environment: circular design strategies for reconverting office buildings to afforable housing.

Paulien Beeckman

Belgium, as well as other western regions, experiences a significant shortage of affordable housing. Therefore, our cities must play a key role to increase the number of affordable housing. By adapting buildings for a new housing function, reconversion can be an answer to this shortage while thus preventing the confiscation of open space.

In the Brussels Region, reconversion was responsible for 20% of new housing creation (332.985 m²) between 2018 and 2020 (perspective.brussels, 2021). In Flanders, we also see this trend more often. Unfortunately, research has shown that reconversion projects face high costs and often the buildings are entirely stripped which generates large building waste. As a solution, circular design strategies not only avoid building waste but can even lower the costs over the entire life cycle of the project.

This research wants to develop a clear insight into the feasibility of reconversion of office buildings to affordable housing by means of circular design strategies. 150 case studies across Belgium and abroad will be collected, analysed based on their building plans and divided into different typologies. For the most common typologies, two to three case studies will be selected. For these cases, alternative solutions will be developed and tested to identify strategies that protect the adaptability of the buildings and increase the financial feasibility to provide more affordable housing. Further, they can make our built environment more adaptable to support our changing needs.

Keywords: Circularity; reconvesion; affordable housing; offices
Supervisors: Prof. Waldo Galle and Prof. Niels De Temmerman (Vrije Universiteit Brussel)
Research funded and supported by VUB Architectural Engineering

## (Re)establishing adaptive reuse as a transdisciplinary cultural practice

Colm mac Aoidh

While it is widely acknowledged that practices of adaptive reuse offer an alternative to current ecologically and socially unsustainable models of architectural production (1), recent studies reveal that most publications and policy initiatives have so far tended to focus on technical, material and economic considerations at the expense of the equally important social and cultural aspects (2). This has led to a disconnect between the stated ambitions with regard to reuse and its actual uptake and implementation (3).

Faced with a situation in which our societies are actually becoming less circular (4), it is clear that the current approach is not working, failing as it does to recognise the fundamental importance of architecture as a cross-cutting cultural activity that plays a crucial role in building social cohesion and demonstrating an integrated approach to sustainability (5).

This PhD addresses the current imbalance through the development of a conceptual framework that firmly repositions adaptive reuse as a transdisciplinary practice, engaged not only with 'hard' values like technical and material concerns, but also 'soft' values encompassing the integral cultural and social aspects that give places meaning and foster connections to the wider world.

The first step involves the curation an anthology of textual and non-textual sources from within and beyond the discipline of architecture, tracing an emerging theory of adaptive reuse and situating it within broader contemporary discourses as a way to span disciplinary boundaries, strengthen the practice's theoretical basis and arrive at new insights and solutions. The collected body of knowledge will be examined through the critical lens of translation, investigating the acts of translation involved in reconciling different traces, time periods, disciplines, interventions and actors, as a way to synthesise the various findings and suggest how the intimate and reciprocal relay between theory, practice and education might be reinforced.

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1. EC report of online conference Common Ground: Making the Renovation Wave a Cultural Project, 2021
2. Francesca Lanz & John Pendlebury, (2022), Adaptive reuse: a critical review, The Journal of Architecture, 27:2-3, 441-462
3. By way of example, the recently-published EU Renovation Wave Strategy concentrates on technical, material and economic aspects of reuse – e.g. energy efficiency, decarbonisation, renewables and environmental standards - with no mention of a strategy to engage with the social and cultural aspects of the existing built heritage (A Renovation Wave for Europe - greening our buildings, creating jobs, improving lives, 2020).
This is despite the fact that the European Union itself has called on institutions and policy makers to pay particular attention to the cultural aspects of architecture rather than focus solely on technical standards or material innovations (Council of the European Union, conclusions on architecture: culture's contribution to sustainable development, 2008/C 319/05).
4. Circle Economy, (2023), The circularity gap report 2023. Amsterdam: Circle Economy
5. As outlined in the Davos Declaration, 2018

Keywords: Adaptive reuse; transdisciplinarity; cultural practice; anthologising; translation

Supervisors: Prof. Dr. Koenraad Van Cleempoel and Dr. Elke Couchez (Universiteit Hasselt)

## Behind the scenes. Demolition of a warehouse to construct the Flemish Theatre (KVS) in Brussels.

Lara Reyniers

Despite evidence suggesting that material salvage was a common practice in the nineteenth century, its impact on the material market and waste reduction in construction remains largely unexplored. Since material salvage was often carried out by demolition contractors who left few records in the public archives, there is a gap in our understanding of this process. To address this issue, this poster investigates the demolition of a public warehouse in 1884 to construct the Flemish Theatre (KVS) in Brussels. This demolition was exceptionally not part of a public tendering process but was instead coordinated by the Brussels city administration, resulting in a rich documentation in the city archives.

Analysis of correspondence between the city engineer and other parties involved, as well as documentation of material sales, confirmed that the salvage of building materials was a prime point of attention in the late nineteenth century. This is hardly surprising considering the project's financial records, because even though the labour-intensive demolition required many different workers, the sale of salvaged materials easily offset the labour costs. Moreover, the price for old materials was significantly lower than for new materials, which made second-hand purchase attractive to individuals, traders and public services looking to save money. Nevertheless, for the construction of the new state-of-the-art Flemish Theatre mainly new materials and building techniques were used: the on-site reuse was limited, the most conspicuous being the reconstruction of the front façade of the warehouse, using the original materials. Today this façade remains a physical reminder of the warehouse in its form and materials. It is challenging to trace the off-site reuse of the warehouse's materials as substitutes for new ones in different parts of the city. Yet, the fact that most of the materials were sold, indicates the presence of flourishing reuse networks in late nineteenth-century Brussels.

Keywords: Demolition; Salvage; Reuse; Construction History

Supervisors: Prof. Ine Wouters and Prof. Stephanie Van de Voorde (Vrije Universiteit Brussel) This research is funded by VUB Architectural Engineering and Research Foundation – Flanders (FWO).

## Mapping Green Infrastructure in Built Heritage Sities by Spatial Attributes: a case study in Antwerp.

Eda Kale

Green infrastructures (GI), are one of the climate-robust solutions, which are strategically planned networks of natural and semi-natural areas with environmental co-benefits, including urban green on buildings. However, despite their widespread implementation in built environments, built heritage sites (BHS) have been excluded from these practices due to the potential structural and aesthetic damage caused by invasive plants. Therefore, there is no strategic framework for implementing GI at protected heritage buildings that are typically subject to strong conservation principles.

To address this gap, this study aims to build a knowledge base of successful practices by mapping intentionally implemented and carefully designed examples of GI in BHS. Focusing on the Antwerp Historical Center, the study analyses the architectural types of BHS where GI has been implemented, the intentions behind their implementation based on building function, the chosen structural support system for GI, and the location of GI on the BHS. The methodology employed includes field surveys and geographic information systems (GIS), and data summary of spatial preferences.

Overall, this study highlights the importance of incorporating BHS into future GI implementation plans and provides spatial insights to urban planners and policymakers seeking culturally compatible ways of implementation.

Keywords: Nature-Based Solutions, Historic Buildings, Heritage Value, Sustainable Development, Urban Heritage

Supervisors: Marie De Groeve, prof. Tim De Kock and Lena Pinnel (University of Antwerp). The authors gratefully acknowledge BOF Research grants for funding this project (44623) and Research Foundation – Flanders (FWO) for funding this project (43365). We thank all the peers who commented and helped us to develop this poster.

## The impact of vertical greening on built heritage and its local microclimate: preliminary on-site testing.

Marie De Grroeve

Built heritage is seen as an essential part of the urban environment due to its cultural and economic values. It has been the core of development for several years resulting in a dense urban environment exhibiting a strong urban heat island effect. City centres are subjected to higher temperatures and higher pollution levels relative to their less dense surroundings. Consequently, green initiatives are increasingly implemented in city centres to mitigate current climate stressors and improve the health and well-being of residents. Unfortunately, built heritage is often excluded from those mitigation strategies due to the limitation of the dense urban fabric (especially in city centres), the conservation rules, and the uncertainty about the structural integrity and the consequences of this implementation on the historical materials.

This research scopes the impact of vertical greening on the local environment and the corresponding impact on common forms of degradation of historic building materials caused by salts, frost and bio-activity. Vertical greening includes plants, rooted in the ground, growing along a vertical surface by either attaching themselves to the façade or trellising. This green initiative has significant potential to be implemented in city centres due to its small footprint and capacity to cover a large surface area. During this research, several case studies affected by the urban heat island effect of Antwerp (Belgium) will be observed and will monitor the surface and air temperature and the relative humidity of a wall and the amount of solar irradiation and air pollution reaching the wall.

Preliminary results from a test case study in Ghent (Belgium) illustrate that vertical greening is able to reduce the amount of incoming solar irradiation and the amplitude of temperature and relative humidity fluctuation on a wall resulting in a potentially lower risk of salt and freeze-thaw weathering and higher risk of bio-deterioration.

Keywords: Degradation, Microclimate, Built heritage, Vertical greening, Urban heat island

Supervisors: Prof. Tim De Kock (University of Antwerp) and Scott Allan Orr (University College of London)

The authors gratefully acknowledge Research Foundation – Flanders (FWO) and BOF Research grants (44623) for funding this project (43365) and Proef-centrum voor Sierteelt for making this case study possible.

## High-albedo urban surfacing materials for heat-resilient and sustainable urban built environment

Yong Xu

In recent years, with the continuous acceleration of urbanization, the scope of cities is gradually expanding, and the ensuing problems of the urban heat island (UHI) effect have become increasingly prominent. UHI is caused by numerous factors, including the use of construction materials, the complex geometry of the urban environment, the reduction of vegetation cover, and anthropogenic heat emissions. Conventional building materials with a relatively low albedo absorb a large amount of incident solar radiation and can be warmer than natural vegetation during daytime and nighttime.

The past decades have witnessed increasing research efforts devoted to developing and evaluating various UHI mitigation strategies through measurements, remote sensing techniques, and numerical simulations. Among other UHI mitigation strategies, high-albedo surfacing materials have gained increasing attention because they can quickly regulate the energy balance and thermal environment in urban areas.

However, it remains elusive what are the current albedo of urban surfaces across cities, how high-albedo surfacing materials would perform in various urban morphological contexts (e.g., building density, building height, and vertical-to-horizontal aspect ratio), and what are the economic and environmental benefits of implementing different high-albedo surfacing materials.

Keywords: Urban heat island; High-albedo surfacing materials; Urban Weather Generator; Urban thermal environment; Urban morphology

Supervisors: prof. Zhi Cao and prof. Over Cedric Vuye (Antwerp University)

## Does interior insulation damage our heritage?

Kaat Janssens

Heritage buildings often require renovation to obtain better energy performance. Because their exterior walls are preserved, these buildings need to be insulated from the inside. However, interior retrofits drastically change the hygrothermal behaviour of a wall, which is why installing interior insulation is by no means risk-free. By performing Heat-, Air- and Moisture (HAM) simulations on the wall assembly, the moisture-related risks can be analysed. Although HAM tools such as Delphin and WUFI are commercially available, they are rarely used in practice to perform hygrothermal assessment on facades. How can we ensure that the insights and knowledge gained from using these tools are translated to and applied in the building industry?

Keywords: HAM-simulations; heritage; degradation; decision framework
Supervisors: Nathan Van Den Bossche (Ghent University) and Valentina Marincioni (UCL London).
This research was funded by the Research Foundation Flanders (FWO), grant number 1S71922N.

## Reusing façade components as a collective endeavour: a retrospective comparison of pioneering projects

Esther Geboes & Ruben Van Vooren

Circularity is gaining ground as a strategy to realize a sustainable building economy. In façade retrofit projects we observe many circular claims, mainly referring to ‘future’ valorisation of building components (e.g., reversible design and reusable components). However, we experience that the actual reuse and refurbishment of existing façade components is limited to niche practices today. These occur, for instance, in heritage conservation projects. These niche practices might provide insights on how important obstacles can be overcome. Therefore, this research identifies how the recurring barriers in pioneering projects are tackled.

Four case studies are selected – all buildings are located in North-Western Europe and underwent a façade retrofit – of which a retrospective comparison is presented. Through a literature study and additional interviews and workshops with involved actors, the following aspects of the projects are mapped: material flows, steps of the refurbishment process, value network (showing involved actors and their main interactions), and specific solutions to pre-specified recurring barriers. Besides, the interview questions focused on the underlying mechanisms of each case; Why was reuse chosen and how was the collaboration structured? What was the role of each actor in the design and execution process? The project sheets resulting from each case study analysis can be used in practice to increase the perceived feasibility of uncommon reuse.

The themes in which solutions are identified include, for example, the coordinating role of material specialists and their network, the tendering process, take-back logistics and a heritage focus on material preservation instead of pure looks. Altogether the results of this study can be an incentive for a better understanding of reuse practice, allowing buildings owners, architects, contractors, reuse consultants and heritage advisors to increase the actual reuse of existing façade components.

Keywords: decision-making process; advisory; reuse; circularity; façade retrofit;
Keywords: insulated glazing; reuse; case studies; value network map; barriers and solutions
Supervisors:Prof. Waldo Galle and Prof. Niels De Temmerman (Vrije Universiteit Brussel)
This research is funded by Vrije Universiteit Brussel
This research is funded by Fonds Wetenschappelijk Onderzoek (FWO), grant number 1S20722N.

## Spatial distribution of material degradation under realistic wettng and drying of the façade.

Bruno Vanderschelden

There are several causes at the root of material degradation in façade constructions, with moisture being the most dominant. For the Belgian industry, it is known that a large share of damage cases is related to the absorption and infiltration of wind driven rain (WDR).

Therefore, it is important to identify the wetting and drying of material in the façade when assessing the hygrothermal performance and durability of buildings. Heat Air Moisture (HAM) transfer models have proven their added value in the building industry to predict such performance and durability. These models allow to analyze the severity and causes of moisture related problems in a numerical approach and are able to predict the spatial distribution of material degradation. In the traditional approach of HAM-modelling, the WDR and the convective heat transfer coefficient (CHTC) are implemented in a simplified manner, i.e., typically an hourly-average value for one location on the façade. However, WDR has a spatially and temporally discrete modus and the CHTC value varies highly across the windward façade. Therefore, the reliability of the traditional approach for hygrothermal response behavior can be questioned.

Within this study, the spatial distribution of the catch ratio and CTHC are implemented in a response behavior study. For the wind driven rain, both experimental and numerical methods are evaluated to determine the catch ratio distribution. In the numerical approach, a CFD model is applied to understand the wind flow around the building and compute the rain trajectory towards the façade. In parallel, two experimental methods are evaluated. Firstly the traditional determination using rain gauges and secondly, a new method is developed in which reverse engineering of the catch ratio is performed based on a measured moisture content and climate history. This spatial approach could help in mapping deterioration patterns of façades and pinpointing critical areas.

Keywords: Risk patterns; hygrothermal behavior; Wetting and drying, windflow
Supervisors: prof. Nathan Van Den Bossche (Ghent University) and prof. Tim De Kock (University of Antwerp), co-author: prof. Veerle Cnudde (Ghent University)

## An assessment of the potential for reusing post-consumer glass.

Angelica Rota

One of the main challenges in the built environment is represented by the reduction of the building's embodied carbon. Moving toward a circular life cycle of the construction sector is crucial to achieve the reduction of the CO2 emissions. This challenge will not be solved without studies of how we can recover the materials from the existing systems in an effective way.

The reclamation potential of building materials needs to be analysed for assessing the ease of disassembling from systems or components and the environmental benefits associated with its further reuse or recycling. In this study, a preliminary assessment was done for the insulating glass unit (IGU) component. In particular, the reuse potential of the post-consumer glass panels recovered from IGUs has been assessed. The disassembling feasibility of this process was evaluated, along with the necessary quality protocol to undertake for evaluating the performances of the post-consumer glass and assess if it's safe for reuse. Forty-three IGUs collected from residential buildings in Belgium were disassembled manually and the glass panels tested destructively with a Coaxial double ring test. Before sampling and testing the glass, a quality scanner fitted on a glass production line was used to identify the distribution of defects (i.e., scratches or spot faults) on the glass surface and based on the density of defects the glass panels was classified in three different quality levels.

The results shows that the mechanical strength of weathered glass is affected by this quality classification of the post-consumer glass. The glass classified with the highest quality level exhibits a value of characteristic bending strength comparable to the batch of new glass, 53 MPa versus 58 MPa, respectively. As this study only focused on clear annealed glass, future work could apply this framework and perform quality assessment to other types of post-consumer glass.

Keywords: Insulating glass unit; Post-consumer glass; Circular economy; mechanical strength
Supervisors: Prof. Francesco fiorito (Polytechnic University of Bari) and Marco Zaccaria (AGC Technovation Centre)
I would like to thank the AGC Technovation Centre for the financial support provided during the glass collection and testing.

## Geologic Architecture and its Extraction Landscapes

Steffie de Gaetano

Capitalist architecture sits at the top of a massive extraction system, fueled by global supply chains (Wigley, in Grima et al., 2021), which are sustained by the legacies of modernity and coloniality, relying on land disappropriation, exploitation of peoples, and pollution of environments. The field of architecture is often unaware of these underlying practices and therefore fails to recognize its involvement in the creation of unsustainable environments and societies, defuturing the world (Fry, 2020; Vazquez, 2017). While the capitalist industry's ideal of modern futurity manifests itself at sites of resource extraction and the material streams of manufacturing, through the geological turn (Ivanchikova, 2018), this PhD research argues that terraformation (intended as a decolonial, or rather demodern, sustainable architectural practice that ensures human and beyond- habitability of Earth) is a far drifted future possibility.

Through case studies departing from three different industrial sectors in Flanders, namely coal, steel and concrete, this research sets out to unravel the following questions:
RQ1. Given the innate telluric foundations of architecture, how are the socio-environmental impacts of the major capitalist architecture industries spatially entangled and ramified.
To propose a different course set by capitalist architecture and oppose its defuturing, this research is addressed through different scales, both geographical and temporal. Thus, a second research question can be formulated as follows:
RQ2. How is the construction and understanding of this industrial past enacted in the present, and impedes future alternatives? Can a critical understanding of the past contribute to opening the stage to alternative futures?
The doctoral research sets out to respond to these questions through three cycles of artistic research and practice, linking sites to concepts constructed through theoretical frameworks informed by (posthuman) anthropology, postcolonial ecology and decolonial/demodern theory.

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Keywords: capitalist architecture, geologic turn, extraction industry, terraformation, demodern
Supervisors: Prof. Griet Verbeeck and Prof.Liesbeth Huybrechts (UHasselt)
A doctoral research made possible through the Special Research Fund (BOF) allocated through the Flemish government and UHasselt. With the intellectual guidance of the external doctoral committee: dr. Sepideh Karami (University of Edinburgh), and dr. Andy Weir (University of the Arts London).

## Robust Comparative LCA of Circular Pavement Designs Using Parametric and Probalistic Approach.

Zhaoxing Wang

Reclaimed asphalt pavement (RAP) is a typical end-of-life (EoL) material used in asphalt pavements to increase material circularity. Due to the performance loss of using RAP in the asphalt binder layer, a thicker binder layer should be employed, leading to additional material usage, energy consumption, and transport effort.

We developed a parametric and probabilistic LCA model to conduct robust comparisons among several circular pavement designs. Our model is built upon thermodynamic and physical models to reveal the complex relationship among parameters. The pedigree approach and Monte Carlo simulation were integrated into the model to reflect data uncertainty at the parameter level. We applied the model to 66 Flemish motorway segments and the discernibility results show that with an increased thickness, using RAP in the binder layer cannot ensure lower greenhouse gas (GHG) emissions. Unless the binder layer contains 60% or 80% RAP and the thickness is increased by a maximum of 2 cm or 4 cm, in which case there is an 89% and 85% probability that their GHG emissions are lower than the baseline (i.e., 0% RAP, 0 cm thicker). Our parametric and probabilistic LCA model provides granular insights to interpret LCA results from parameters and enables robust decision-making with improved data quality.

Keywords: Road network;Life Cycle Assessment;parametric modeling;probabilistic approach;Circular Economy
Supervisors: prof. Zhi Cao and prof. Wim Van den bergh (University of Antwerp)
This research is supported by the Special Research Fund (BOF) of the University of Antwerp.

## Disconnecting and Reconnecting of Precast Concrete Building elements.

Thijs Lambrechts

The ReCreate project aims to give structural precast concrete elements an extended life span in new structure(s). Within this project, four full-scale pilot projects will take place. For each project, a “donor” building is partially or completely deconstructed. Selected elements are subsequently used to design and build one or more structure(s). Research on each step of the reuse process is organized into ten work packages, which comprise the project. This PhD research falls within work packages 2 (deconstruction) and 5 (redesign and reassembly) and focuses on the connections between precast elements.
The main research questions which have been identified within this topic are as follows: Which types of connections are used most frequently in precast concrete projects? What is the reuse potential for these connections? Is the development of new connections/types necessary to enable element reuse?

The main goal is to define a methodology for disassembling existing structures, to aid the process of reusing the harvested elements. Furthermore, when required, new types of connections to reconnect recovered elements are to be defined, developed and tested. To enable the above, methodologies for assessing the reusability of connections, and design methods for creating retrofit connections, will be developed. This will be done through a comparison of different disassembly and reassembly methods aided by experimental research.

Experimental research is currently ongoing to develop a reusable connection in the longitudinal joint between precast hollow-core floor slabs. The connection employs loose aggregate filling between the slabs, coupled with pre-compression in the transversal direction. Further research will entail testing retrofit mechanical connectors, as well as various other connections between different structural elements. The final aspect of the research will be the creation of a connection database/encyclopedia. This database will aid in identifying the most optimal deconstruction technique for any given connection, providing insights on how to reconnect elements and increase the demountability of new structures.

Keywords: Reuse; precast concrete; connections; demountable
Supervisors: Prof. Simon Wijte (Eindhoven University of Technology) and Ing. Marcel Vullings (TNO), co-author: Prof. Patrick Teuffel (Eindhoven University of Technology), Mike Veenhuis (Eindhoven University of Technology)
EU horizon 2020 - ReCreate: funding

## Design Automation Software for Reused-Concrete Buildings.

Fred Mudge

This research forms part of the ReCreate project, a European Horizon 2020 undertaking aimed at giving precast concrete elements in the EU, originally intended for single use, an extended, “circular” life span in one or more new building structure(s).

This project focuses on design and parametric modelling within this context, examining how the generation of new building designs can be semi-automated and optimized, and connected to all other processes within the overall ReCreate project.The primary aim is to develop a digital object model and software prototype to assist architects and structural engineers in creating new designs for buildings consisting primarily of reused precast concrete elements. Secondly, algorithms capable of automatically generating new designs of buildings or components (e.g. floor slab layouts) will be added. Both phases will employ a selection of parametric design, object interaction and structural capacity calculation techniques, supplemented by more advanced computing methods such as evolutionary algorithms, generative design and/or artificial intelligence. Digital representations of precast concrete elements, including their relevant geometric, material and structural data, will be stored in a database including previously used concrete elements currently on stock, as well as elements currently in use but planned for future disassembly.

The abovementioned object model will gather information from this database, along with relevant user inputs regarding the required building properties and expected loadings. The created/generated designs will be in a standard BIM format which can be used and refined by AEC professionals. Additionally, compatibility with third party structural analysis software and LCA tools will be added. Preliminary findings include a generic building design process for reused elements, formulated based on a combination of design approaches followed by past and present projects. Furthermore, an object model (class library) for representing building components, structural systems and complete buildings has been developed in C#. The class structure of the object model will define the schema of the planned element database.

Keywords: Circularity; Reuse; Concrete; Design; Software
Supervisors: prof. Pieter Pauwels and prof. Simon Wijte (Eindhoven University of Technology), co-authors: prof. Patrick Teuffel (Eindhoven University of Technology), Marcel Vullings (TNO)
Thanks to the ReCreate project and the European Horizon 2020 program for funding this research.

## Unfired earth blocks: Mapping the actor's perspective to increase the base of support of unfired earth blocks in the Flemish context.

Nijs de Vries

Unfired earth blocks can play a part in the transition towards a more environmentally responsible building practice since their raw materials are abundantly and locally available, have low embodied energy, and have a high circular potential. However, implementation in mainstream construction lags behind due to numerous perceived barriers, both well defined (e.g. insufficient building codes, costs) as less tangible (e.g. negative associations, resistance to change).

To make unfired earth blocks accessible to a larger public, it is necessary to better understand these perceived barriers as well as motives of actors involved in the production, assembly, and use-phase of unfired earth blocks. In collaboration with the Living Lab project “Van aarde naar waarde”, initiated by the research group ArcK of Hasselt University, this PhD-research intends to gain insight into the perspective of actors involved through interviews, site visits, and research by design. Through the formulation and application of a mapping method, it will be possible to map, identify, and interpret actor-specific preferences, perceptions, and considerations. The results will be used to formulate strategies that help exploit qualities and overcome weaknesses of unfired earth blocks. The gained insights, subsequent strategies, and guidelines, aim to contribute to increasing the base of support of unfired earth blocks in the Flemish construction sector.

Keywords: Unfired earth blocks; implementation; base of support; actor’s perspective
Supervisors: prof. Elke Knapen (University of Hasselt)
VLAIO – agentschap innoveren & ondernemen

## Interaction between designers and AI: how it can support the complexity of sustainable design process.

Elena Cavallin

This doctoral research investigates how Artificial Intelligence can be integrated into the design process to support and solve the complexities of developing and realizing sustainable industrial products. In order to solve through design the problem of sustainability, it is considered appropriate to introduce AI (Artificial Intelligence And The Circular Economy, 2022; Floridi, 2022;), specifically an Machine Learning model, into the design process and to study the interaction that takes place between this computational tool and designers (Van der Burg et al., 2022).
First, an analysis was made of the AI platforms and software that allows data to be processed through low or no code in order to develop projects. The possible interactions found so far are:
- Continuous flow. Interaction that continues over time through projects;
- Spot Queries. Sporadic interaction with different models;
- Project development assistant. Interaction with a single software with plugins with different IAs inside.

A second step was to develop two workshops with students from the Iuav University of Venice. The students had to use Lexica.art - sporadic interaction - to generate images from their own textual elaborations, developed from group reasoning and consepts. These were useful for developing an initial mapping of the AI - design model of the students' interactions, through a questionnaire and direct observation.
With partner MakarenaLabs, we are developing three prototypes to test the three interaction modes described above. Data will be collected by testing the AI platforms available online and the three prototypes developed, according to these methodologies: semi-structured interviews, questionnaires, and on-site observations. The analyses collected on the successful interventions of the machine learning models will be used to understand how the three types can be used to implement sustainability in projects and how designers interact with them. Understand which aspects need to be implemented to achieve optimal interaction.

Keywords: machine learning; HCI; design process; sustainability: artificial intelligence
Supervisors: prof. Michele Sinico (Università Iuav di Venezia) and prof. Michele Zannoni (Università Alma Mater Studiorum – Università di Bologna)
MakarenaLabs, https://www.makarenalabs.com/

## Performing policy conflict within transformative processes: A dramaturgical analysis of contentious urban climate change policies.

Lisa De Roeck

Policy conflict is an intrinsic component of transformative processes within cities. These processes, such as dealing with climate change mitigation, bring together many stakeholders and are concerned with uniting local, regional, and international needs. Furthermore, they often include large infrastructural works, and thus small as well as large interventions within the built environment, on the public as well as private domain. The policies that shape these transformations are often contested and challenged, resulting in various conflicts regarding the measures to be taken and sometimes ending in stagnation. In recent years, these types of conflicts have become more and more of a focal point in public administration studies. Some authors study the frames and dynamics of conflict-escalation (Wolf & Van Dooren, 2021), as well as the role of storylines and language (Verhoeven & Metze, 2022), while others develop frameworks to look at policy conflicts across cases (Weible and Heikkila, 2017).

Although these approaches pay close attention to the content shaping these conflicts and their procedural and relational dimensions, less attention is being paid to the actual expression of these conflicts, as well as who determines how these conflicts can be articulated. Since the enactment of policy conflict also shapes their outcomes and the way policies are produced, this paper wants to explore how policy conflict is performed by different stakeholders. Following the work of Goffman (1956), Hajer (2005; 2009), and others (Escobar, 2015; Verloo, 2015) we use a dramaturgical analysis to study these conflicts, making use of theatre-associated concepts, such as scripting, staging, and settings. This analysis helps uncover the performative elements that play a role in the expression, escalation, and outcomes of policy conflict, such as how arguments are brought on stage, with the help of what objects and if and how actors succeed in conveying others. This approach thus presents a way of paying attention to aspects of social and political life that are otherwise often taken for granted.

Within this paper, we focus on two cases of existing contentious climate change projects in an urban setting. The first case deals with the redevelopment of an urbanized valley area to make it more climate robust, while the other case concerns the development of a new public transport line as a high-quality alternative to car usage. We employ ethnographic observation of participatory moments and discourse analysis of media coverage and policy documents to uncover different scripts of policy conflict. We also identify the artifacts, words, and staging practices that structure the micro-politics in these scripts. We expect to uncover several different scripts and counter-scripts that various actors use for performing conflict. More insight into how conflict is performed can, finally, lead to a better understanding of the complex and dynamic nature of this phenomenon, as well as more knowledge on whose voices are heard during conflicts, and whose voices are not. ..

Keywords: Policy conflict, dramaturgical analysis; transformations, deliberative policy making

Supervisors: prof. Wouter Van Dooren, prof. Tom Coppens (Antwerp University) and prof. Esther van Zimmeren (Antwerp University)

My PhD is part of a broader interdisciplinary study called CONTRA (Conflict in Transformations), which is a JPI ERANET funded project, involving a comparative study of urban planning law and practices focused on climate transition in 4 countries (Belgium; Netherlands; Norway and Poland).

## Resiliency in Mediterranean Coastal Territories: water urbanism for climate change adaptation in the Mediterranean basin.

Elena Kasselouri

The coastal territories are vital interfaces between water and land. Even though the Mediterranean basin has historically faced climatic challenges such as extreme drought, flooding events and wildfires, the past decades these events have been radically increased as an impact of climate change, which is causing unexpected, in intensity and frequency, extreme events. The latter invade the exposed urban and rural areas resulting in dramatic human losses and major economic and ecological damage. Mediterranean ecosystems are in danger, together with their adjacent and dependent settlements.

Water is seen as the potential landscape-infrastructure to support the transition of the existing coastal zones into a robust condition, while systemic thinking has an added value when looking at the scale of the Mediterranean basin and appears essential in order to address future challenges related to climate. Within the thickness of the coastal area, there is a variety of urban typologies and landscapes as nature, agriculture, and urban elements intermingle in a hybrid composition. Focusing on the coastal territories and rooting on the growing role of landscape urbanism for building urban resilience, this research aims to explore a set of diversified and site-specific water urbanism strategies for climate change adaptation and mitigation.

Under the hypothesis that the reinforcement of natural elements is a necessity for climate change adaptation, as well as a guide to future urban structures, this dissertation is building around the research question: How can landscape reframe the coastal urbanization in the Mediterranean in order to address resiliency under the different climate change scenarios? How can the Mediterranean coastal hybrids transition towards a more sustainable future state, adapting to current climate challenges? Within this framework, this research aims to: (a) define the Mediterranean coastal area as a new geography and its various environments according to climates, land uses, urban typologies, social factors etc, (b) build an assessment tool for policy implementation strategies and influence policy makers and (c) test scenarios and spatial designs acknowledging the potential synergies and trade-offs among the Mediterranean coastal territories.

Keywords: landscape urbanism; water system; adaptation; Mediterranean coast
Supervisors: prof. Maria Chiara Tosi (IUAV University of Venice) and prof. Chiara Cavalieri (UCLouvain)

## Leaking cities. Mapping changes in Brussels' urban drainage system.

Evelien Van den Bruel

This abstract is meant to provide an overview of the research project. It is focused on reinterpreting the temporal and spatial dimensions of historical water-related practices. Next to the preliminary formulation of theoretical frameworks, a critical reflection on the selection of case studies based on their territorial context is described.

Throughout time, the urban landscape has been shaped by its ever-renewing infrastructures that facilitate the daily lives of its inhabitants. Water courses are manipulated in response to changing and growing societal needs. With this transformation, wastewater and stormwater drainage services are put under pressure, which is framed within a growing urgency of finding a response to environmental challenges like flooding, drought, and pollution. Although institutionalized systems are pushing the hand of these changes, ‘water sensitivity’ becomes perceptible in movements in which different alternative actors participate.

In this research, a historical tracing of hidden layers of the urbanized area reveals that non-institutionalized production services have played their role through time in water management. A better understanding of these services (their appearance, disappearance, or persistence) is explored to tackle the current challenges urban drainage systems face. By looking for turning points in history and examining the role of their users, the meaning, strengths, and limitations of citizen involvement can be unraveled. These changes are framed within the transition theory, focused on the asset of place-specificity. The territorial analyses are conducted in Brussels-Capital Region and will later be extended to the urban area of Dakar. A preliminary selection of Brussels' case studies will be presented. The research seeks to better understand how and at what scale the spatial configurations of the city influence the changes in wastewater and stormwater drainage services. This involves determining whether the physical urban space is a cause or consequence of the change in drainage practices.

Keywords: water machine, transition, social infrastructure, co-production, urban drainage system
Supervisors: Chiara Cavalieri and Luisa Moretto

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