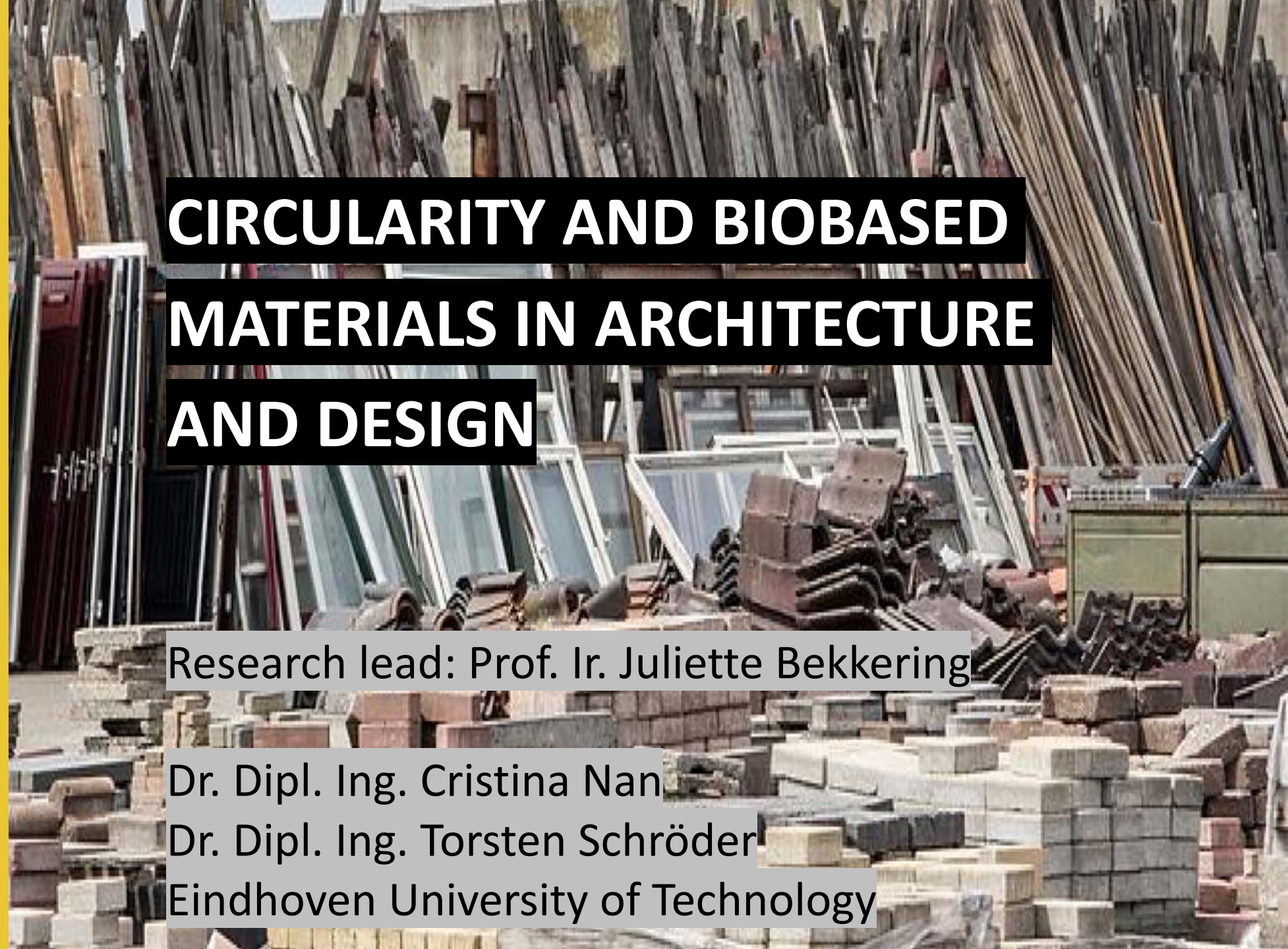

CIRCULARITY AND BIOBASED MATERIALS IN ARCHITECTURE AND DESIGN

Research lead: Prof. Ir. Juliette Bekkering

Dr. Dipl. Ing. Cristina Nan

Dr. Dipl. Ing. Torsten Schröder

Eindhoven University of Technology

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CONTENT

WHY

Global challenges

Translating the 10 r-model to building design

HOW

[Categories of investigation]

1. Material
2. Component
3. Process

WHAT/RESULT

1. Knowledge gaps in industry, practice & academia
2. Relevant challenges
3. Future agenda

(1) Image source

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WHY THIS RESEARCH — DESIGN ALONG THE 10R MODEL

[Global context]

- Paris Agreement, COP 21, 2015
  - The culture of unlimited economic growth has come to an end
- EU Green Deal, 2019
  - Aims for 55% GHG emission reductions by 2030 (to 1990 levels)
- Netherlands Climate Act, 2019
  - 49% GHG emission reduction by 2030 (to 1990 levels
- Netherlands construction industry is responsible for
  - 50% Raw Material Consumption
  - 40% Energy Consumption
  - 30% Water Consumption
  - 40% Construction and Demolition Waste
  - 35% CO2 Emission

[Dutch Disciplinary Context]

- Transitionagenda Circular Building Economy, 2018
  - 2023 Circular Building Economy Base Camp
  - 2030 Circular Building Economy 50%
  - 2050 Circular Building Economy 100%
- Requires a radical transformation of the entire building sector & building design processes This will fundamentally change
  - How to design buildings
  - How to construct buildings
  - Material usage
- Lack of circularity tools, guidelines, measurement systems & data availability for materials, components and buildings

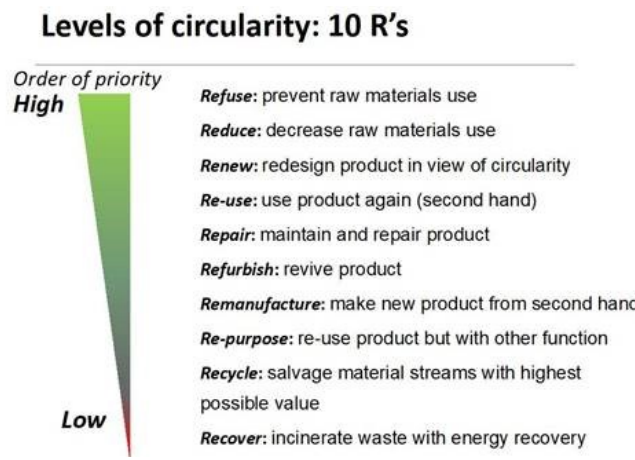

Image sources: 1. Flickr/COP PARIS 2. Level of circularity: 10R's (After Cramer, 2015)
3. theconversation.com

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THE CIRCULAR ECONOMY

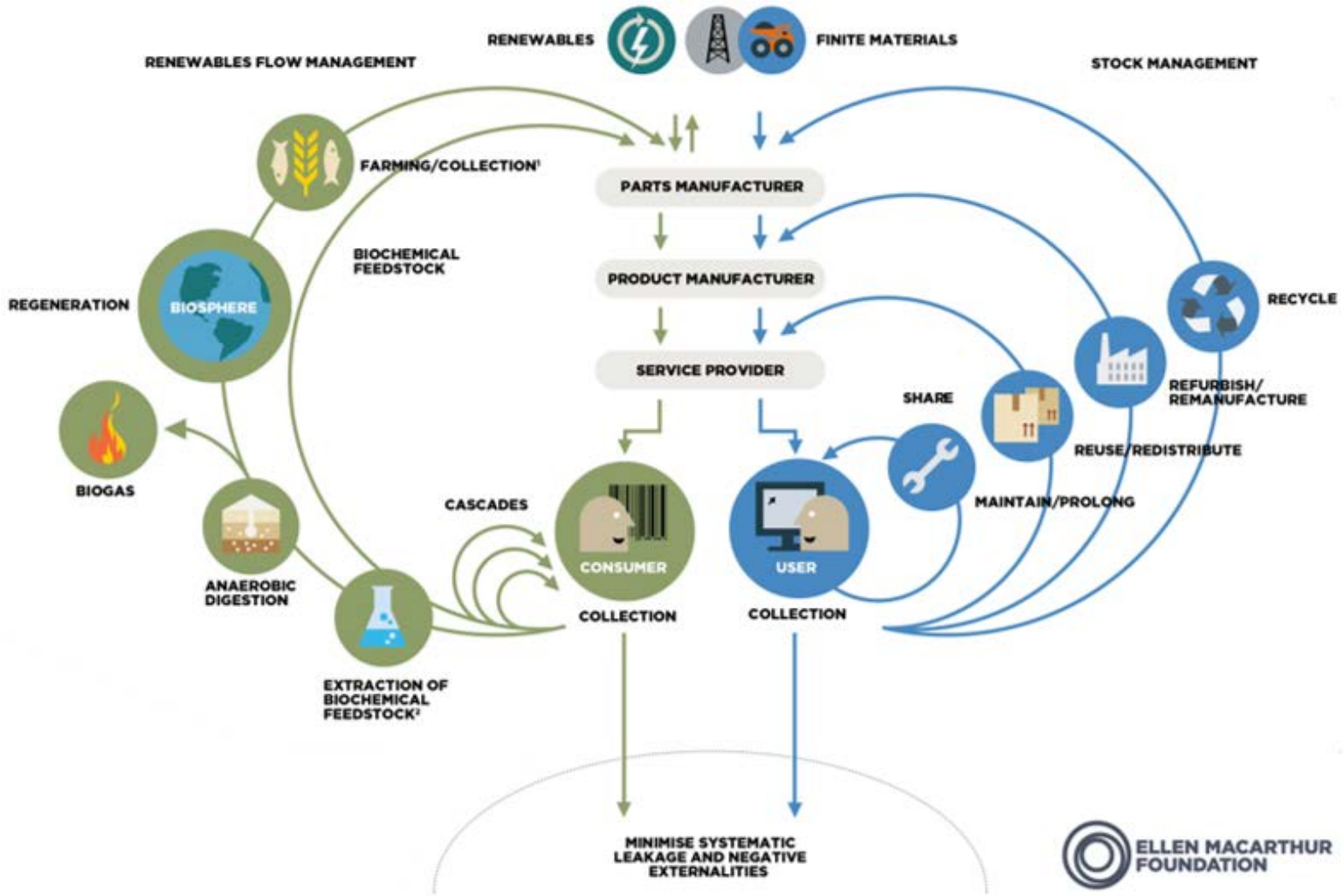

Image sources: 1.Ellen Macarthur Foundation, adapted from the Cradle to Cradle Design Protocol by Baumgart & McDonough

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RESEARCH SET-UP

AIMS

- Identification of emerging challenges
- **Exploration of striking trends in circularity & bio-based materials at the 4TUs & in practice in NL**

HOW

- Identification of current studies
- Q&As with practitioners and researchers
- Evaluation

- *Categories of investigation* in **architectural design** MATERIAL – COMPONENTS – PROCESS.

WHAT / RESULTS

- Identify existing and future challenges
- Relevant research questions
- Agenda for the Future

(1) TUe VIRTUe – Circular pavilion with bio-based materials LINQ at SDME2018

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RESEARCH SET-UP: OVERVIEW INSTITUTIONAL NETWORKS AND RELEVANT ACTORS

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Delft University of Technology

- Prof. Dr. Ing. Tillmann Klein
- Prof Dr. Ir. Vincent Gruis
- Prof. Dr. Conny Bakker
- Prof. Dr. Ir. Andy van den Dobbelsteen

University of Technology Eindhoven

- Dr. Ir. Faas Moonen/ Ir. Tom Veeger
- Dr. Ir. Rijk Blok
- Ir. Jan Schevers
- Prof. Dr. Ir. Jos Brouwers

University of Twente

- Dr. Silu Bhochhibhoya
- Dr. Ir. Marc van den Berg

Wageningen University and Research

- Dr. Daan van Es.

World design embassy circular & biobased building

- Curator: New Heroes:
  Diana van Bokhoven, Lucas De Man
- Marianne Aarnoudse, programme manager of World Design Embassies

Universities of applied sciences

- Avans Hogeschool &
  HZ University of Applied Science:
- Dr. Ir. Perica Savanović

Other organisations/name

- Primum: Ir. Max Drath
- Greenport West-Holland:
  Willem Kemmers
- Superuse Studios:
  Ir. Jan Jongert
- Neutelings Riedijk Architects:
  Ir. Michiel Riedijk
- Popma Ter Steege Architecten:
  Josse Popma.

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STATUS QUO MAPPING OF PUBLIC PRIVATE RESEARCH PROJECTS

ARCHITECTURE CASE STUDIES

- New Heroes — Exploded View.
  Bio-based materials
- TU Delft & Mecanoo: Green village: NONO house
  Experimenting with C02 absorption
- TU Eindhoven, Faas Moonen et Al. — VIRTUe SDME2018
  Hybrid materiality

- Popma Ver Steege Architecten — Biolab Leiden
  Adaptive reuse and bio-based materials
- Superuse — Blue City & Vliegveld Valkenburg
  Adaptive reuse of components
- Neutelings Riedijk Architects — Gare maritime, Brussels
  Refurbishment and bio-based materials
- SLA — Recycled plastic pavilion, Dutch Design Week
  Biobased materials
- Thomas Rau — Townhall Brummen
  Building as a material bank

(1) New Heroes – Exploded View
(2) TU Delft & Mecanoo – NONO house
(3) TUe VIRTUe – Construction LINQ at SDME2018
(4) Thomas RAU – Townhall Brummen

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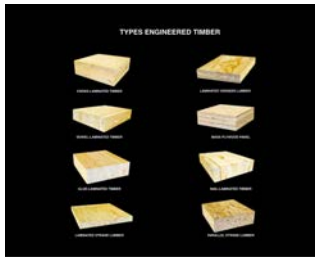
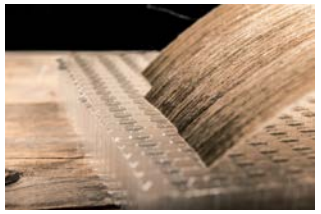
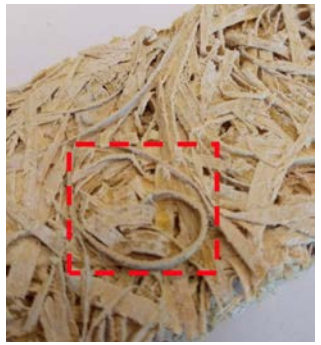
THREE MAIN CATEGORIES OF INVESTIGATION:

MATERIAL

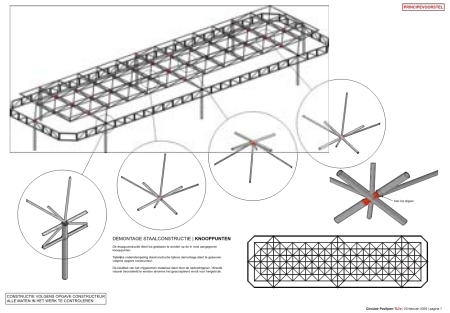


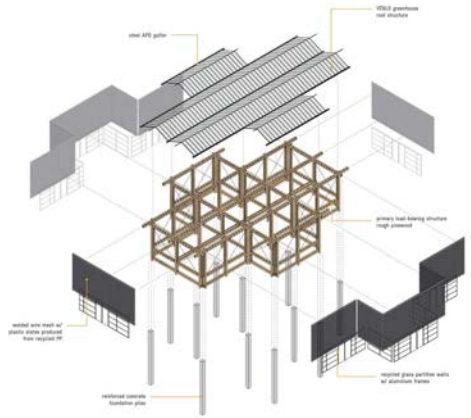




(1) Colouring mycelium, CoE BBE, center of expertise biobased economy, Ilaria la Bianca
(2) Types of engineered timber
(3) printed wood grain, SAL at MIT
(4) Wood Wool, Prof. Jos Brouwers et.al. TU/e

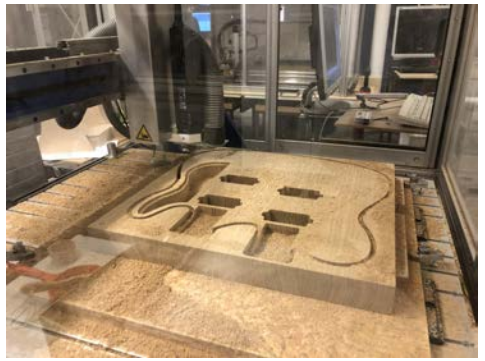
COMPONENT





(1) Reuse material yard
(2) Circular pavilion, rebuilding/reuse, Jan Schevers,Rijk Blok, Juliette Bekkering et. Al. TU/e
(3) People's pavilion Dutch Design Week 2017

PROCESS



(1) KUKA CNC, milling technology
(2) ICD Stuttgart, KUKA wooden pavilion for bundesgartenschau 2019
(3) FABLAB OWL, CNC introduction courses

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MATERIALS - FROM RECYCLED TO BIO-BASED & COMPOSITES

CONCLUSIONS I

MANDATORY BASELINE

Lack of common definition

GENERAL CHALLENGES

- Durability + maintenance + performance
- Availability
- Material options & display
- Non-bio-based fillers + coatings
- Scaling up
  from lab to industry
- Certification

DESIGN CHALLENGES

- Early design stage: involvement of suppliers
- Regulatory and legislative challenges
  eg: fire safety

(1) TUe – Bio-based bridge

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REUSE OF COMPONENTS
CONCLUSIONS II

MANDATORY BASELINE
- Overview of components + availability
- Digitalisation — data banks + catalogues

GENERAL CHALLENGES
- Digital twins & the accuracy of digital materiality
- Uniqueness of components
- Heterogenity + quality consistancy
- Durability + liability + performance
- Refitting
- Storage + maintenance
- Lack of demand from clients

DESIGN CHALLENGES
- Implementation strategies for re-use
- Buildings as material banks
- Oversizing components for adaptive reuse

(1) SuperUse Studios – Afvalbrengstation Den Haag

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PROCESS

CONCLUSIONS III

MANDATORY BASELINE

- New thinking: from design to life cycle
- Computation and digital fabrication
- Client commitment

GENERAL CHALLENGES

- Procurement: logistics + management
- Lack of networks + contact points
- High complexity
- Collaboration with manufacturers
- New expertise for designers + builders/manufacturers
- Labour + time intense
- Overall higher costs

DESIGN CHALLENGES

- Designing manufacturing & production to minimize material use + waste [eg. offcuts]
- Design + fabricate for disassembly + reuse

(1) Studio RAP – 3D printing ceramic tiles

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RESEARCH QUESTIONS FOR THE FUTURE

NEW DESIGN LANGUAGE:
How can designers develop a new & ambitious architectural vocabulary for circularity?

MORE PROTOTYPES & PILOT TESTING:
How to integrate circularity in design thinking & develop more prototypes as applied case studies?
How to develop fast-track pilot testing for bio-based materials in real-life context, for guaranteeing durability and performance?
How can academia, industry & practice collaborate on applied projects to establish design & procedural protocols?

THE MATERIAL QUESTION:
How to increase the availability of certified bb materials & circular components?
How to develop larger material data bases?
How to scale-up: from experiment to large scale application?

PROCESS & LEGISLATION:
How to deal with the high degree of uniqueness of circular building processes?
How can challenges in legislation, building codes and certification be overcome?

OUTREACH:
How to develop meaningful outreach & awareness programmes –educating clients & stakeholders?

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AGENDA FOR THE FUTURE: BOOSTING CIRCULARITY

THE PARADIGM SHIFT: FROM LINIAR TO CIRCULAR DESIGN

INCREASE FAIR PRICING: from linear to circular lifecycle

INCREASE AWARENESS: make circular designs & materials visible and available for a broad audience.

INCREASE VISIBILITY: build prototypes, pilot projects and experiments!

INCREASE APPLICABILITY: design for large scale applications, collaborating with designers+ academia + building industry + suppliers

INCREASE CERTIFICATION & LEGISLATION: introduce control mechanisms, legal assessments and quality assurance

INCREASE AVAILABILITY: develop data-banks and develop systems to make circular products available on large scale

INCREASE THE NETWORK: create a national circularity platform and expand academic networks and research projects

PARADIGM SHIFT IN DESIGNING (ALONG THE 10R MODEL):

develop new design-tools & design-vocabulary with new materials and components
develop new design strategies for buildings as material banks
develop designs that handle the newly arising technical challenges

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RELEVANT LINKS

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https://circulairebouweconomie.nl

https://platformcb23.nl

https://btic.nu/circulariteit/

https://rotordb.org/en

https://opalis.eu

https://www.ellenmacarthurfoundation.org

https://www.circulardesignguide.com

https://www.cleantechdelta.nl

http://www.circulary.eu/project

LINKS PRIVATE PUBLIC RESEARCH PROJECTS

https://companynewheroes.com/project/the-exploded-view/

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