ETH zürich

Informationsveranstaltung am 18.04.2024, 17:00 Uhr

Master-Arbeiten und Master-Projektarbeiten am IBI

Prof. Dr. B.T. Adey, Prof. Dr. Catherine De Wolf, Prof. Dr. G. Habert

IBI is structured along 3 main streams

- Infrastructure Management
  - Prof. Dr. Bryan T. Adey

- Circular Engineering for Architecture
  - Prof. Dr. Catherine De Wolf

- Sustainable Construction
  - Prof. Dr. Guillaume Habert

For an exceptionally good thesis, you can receive an award

Fonds Bau und Infrastruktur-Förderungspreis

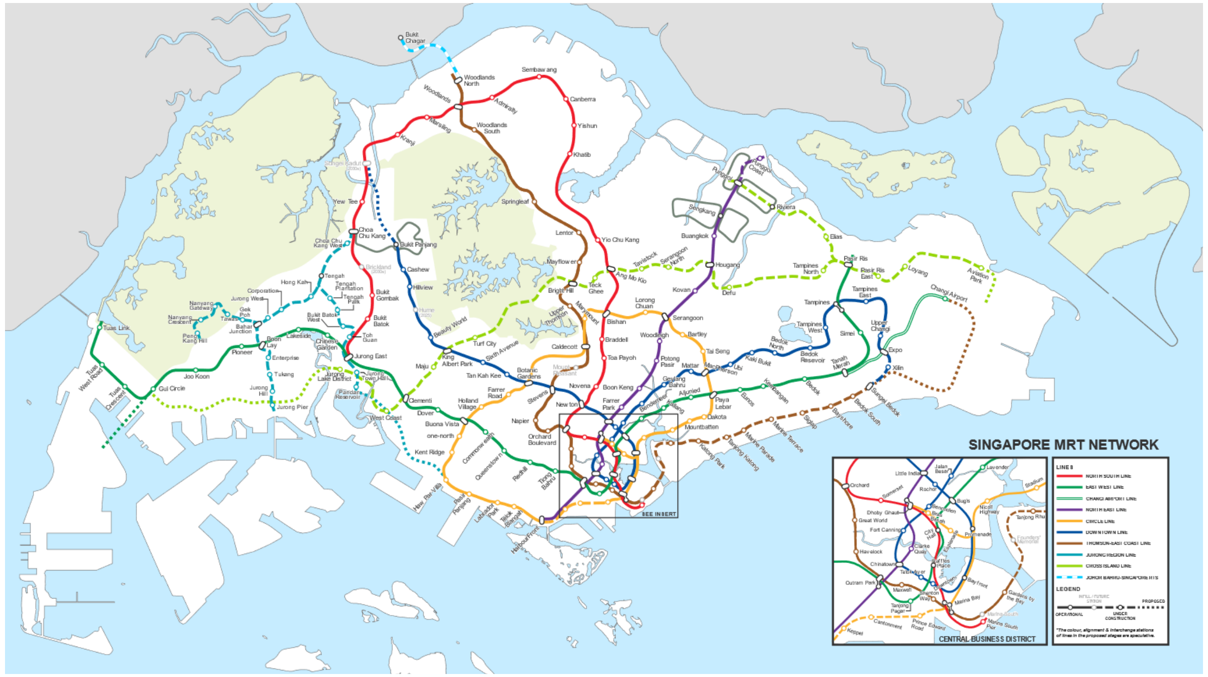
Ziel:

- Hervorragende Master- und/oder Doktor-Arbeiten aus dem Bereich „Bau- und Infrastrukturmanagement“ mit einem Preis auszuzeichnen
- Interesse für Probleme im Bereich des Bau- und Infrastrukturmanagements bei der heranwachsenden Ingenieurgeneration wecken und die Innovationsfreudigkeit für Weiterentwicklung von Bau- und Infrastruktursystemen gefördert werden.

Preisverleihung:

- In der Höhe von CHF 2’000 (Master-Arbeit)

Switzerland



Singapore

Infrastructure Management Group

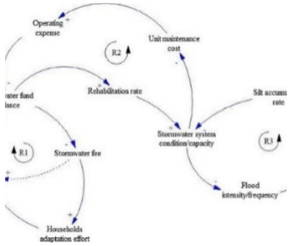
Collaborations

- SBB
- ASTRA
- Scottish Water
- FCL-G (Urban Redevelopment Authority and Land Transport Authority of Singapore)

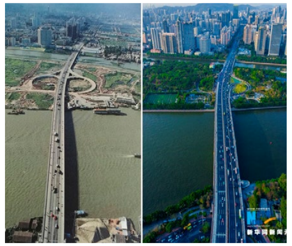
Topics

Master project and thesis

Master thesis

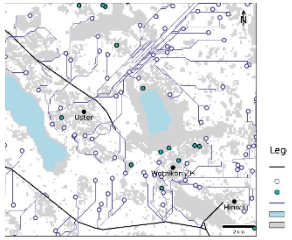


1. System dynamics model to determine funding allocation

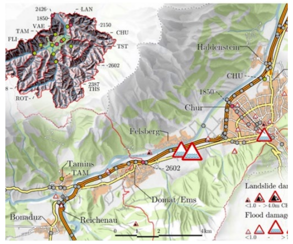


2. Land-Use transport interaction modelling for infrastructure planning

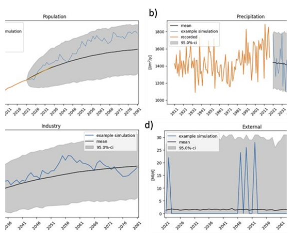
3. Quantifying the benefits of car-lite interventions



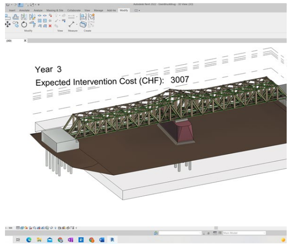
4. Predicting railway development using geospatial tools



5. A real time transport system digital twin to minimize risk



6. Using a digital twin to facilitate planning water system development



7. Connecting future predictions of asset condition and interventions to BIM

8. Estimating missing risk data with Bayesian networks

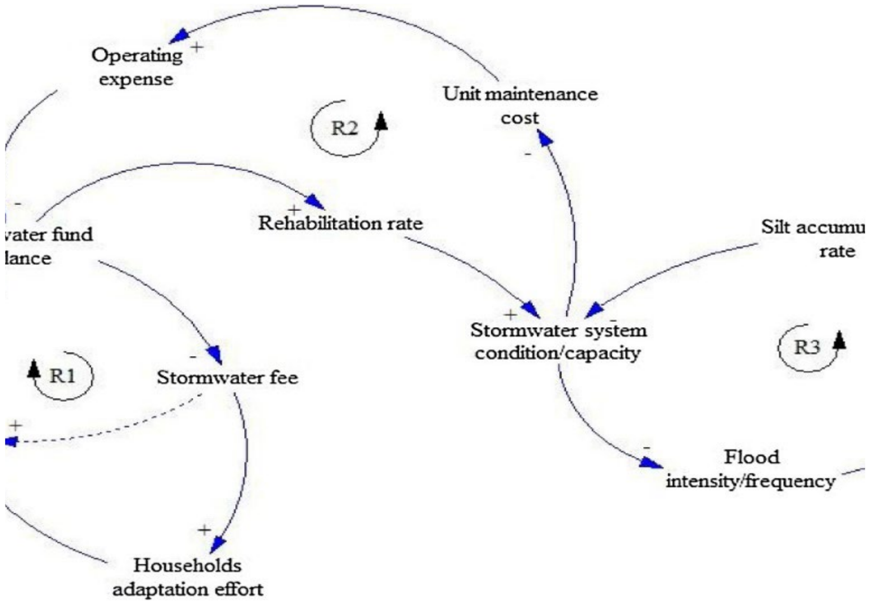
9. Use of extended reality for bridge inspections

10. Asset management approaches to enable resilience

1 – System dynamics model to determine funding allocation

Limited to 1

- **Supervisors:** D. Zani (zani@ibi.baug.ethz.ch), Prof. Dr. B.T. Adey
- **Goal:** To replicate and further develop a model of how a nationwide infrastructure system works to enable the setting of high-level goals considering constraints.
- **Main Tasks:** 1) critically evaluate the key variables to be included in the model, 2) critically evaluate the relationships used in the model, 3) replicate the existing model in an environment in which you are comfortable, 4) test the model for plausibility using sensitivity analysis, 5) discuss the strengths and weaknesses of the model and propose potential improvements.
- **What you will learn:** how to model complex systems at a high-level, the strengths and weakness of such models.
- **What is a successful project?** Reproduction of the model, competent explanation of the model, clear explanation of the strengths and weakness, and clear proposals for improvement.
- **Prerequisites:** Discussion with Prof. Adey. Experience / interest in modelling infrastructure system. Experience / interest in computer programming or knowledge of system dynamics software (e.g., Vensim).



Connected to Scottish Water

2 – Land Use Transport Interactions (LUTI) modelling for infrastructure planning

Limited to 2 persons

- **Supervisors:** O. Roman (oroman@ethz.ch) or J. Yap (jinyap@ethz.ch), Dr. Qiming Ye (qiming.ye@sec.ethz.ch), Prof. Dr. B.T. Adey
- **Goal:** To model the interactions between land use and transportation for a specific case study and use it to inform strategic long-term planning.
- **Main Tasks:** 1) Document / explain the evolution of a region (e.g., Zurich or Singapore) and its transportation infrastructure and land use policies for the previous decades, 2) gather the required datasets needed for the LUTI model (some will be provided), 3) develop/apply the LUTI model to the studied region (code will be provided), 4) calibrate and validate the model, 5) use the model to evaluate potential future infrastructure projects in the region (e.g. changes in travel time, accessibility, urban sprawl, densification).
- **What you will learn:** how to synthesize data collected from different sources, calibration and validation of LUTI models, and how to use models for infrastructure planning.
- **What is a successful project?** Convincing arguments on the use of the model to evaluate infrastructure projects. Identification of the limitations of the work and suggestions on how to use these tools in planning practice.
- **Prerequisites:** GIS and good knowledge/interest in programming with Python, discussion with Mr. Roman and/or Prof. Adey.

Connected to: (FCL) FUTURE CITIES LABORATORY

Limited to 2 persons

3 – Quantifying the benefits of car-lite interventions

- **Supervisors:** O. Roman (roman@ibi.baug.ethz.ch) or J. Yap (jinyap@ethz.ch), Dr. Qiming Ye (qiming.ye@sec.ethz.ch), Prof. Dr. B.T. Adey
- **Goal:** To quantify/model the benefits (e.g. carbon emissions, accessibility, accidents, noise, travel time) of car-lite interventions (e.g., road space reallocation, mobility hubs, pedestrianization) for a specific case study in Zurich or Singapore.
- **Main Tasks:** 1) Review the literature on how the benefits of car-lite interventions are estimated 2) select a case study (e.g. mobility hubs in Zurich) and gather the required data, 3) develop/expand models (code and existing tools will be provided) to estimate selected benefits, 4) calibrate and validate the model, 5) use the model to evaluate potential future car-lite interventions.
- **What you will learn:** how to synthesize data collected from different sources, quantification of benefits/modelling of car-lite interventions, and how to use models for infrastructure planning.
- **What is a successful project?** Convincing arguments on the use of the model/quantification methodology to evaluate projects. Identification of the limitations of the work and suggestions on how to use these tools in planning practice.
- **Prerequisites:** GIS and good knowledge/interest in programming with Python, discussion with Mr. Roman and/or Prof. Adey.

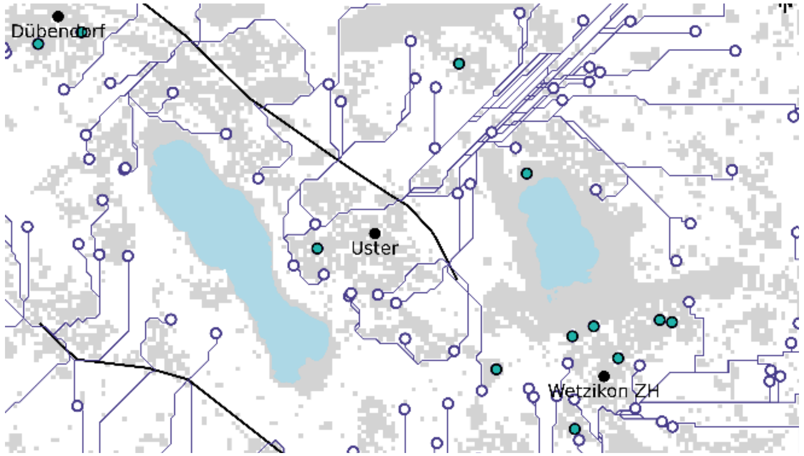
Connected to: (FCL) FUTURE CITIES LABORATORY

4 – Predicting railway development using geospatial tools

Limited to 1

- **Supervisors:** A. Elvarsson (elvarsson@ibi.baug.ethz.ch), Prof. Dr. B.T. Adey
- **Goals:** To generate potential evolution of a rail network considering various influencing factors, such as population growth, shifts in travel demand and land use policies. The study will utilize a case-study rail network and a state-of-the-art algorithm exploiting spatial analysis.
- **Main Tasks:** 1) Gather information for the rail infrastructure system, 2) identify the planning objectives, 3) summarise literature findings on the growth and evolution of transport networks, including recent developments at Chair of Infrastructure Management, 4) develop at least three distinct scenarios that impact rail networks in future, 5) use a novel algorithm to generate changes to the case study rail network, 6) assess the changes to the network considering the stakeholders affected, and 7) identify rail network modifications that can provide societal benefits
- **What you will learn:** Develop programming skills useful for decision-support models, quantitative planning support, how to build solid arguments for decision-makers in infrastructure planning and being able to communicate these to the infrastructure planners.
- **What is a successful project?:** Clear results illustrating a ranking of the rail infrastructure development projects by the societal benefits that they provide.
- **Prerequisites:** Infrastructure Planning, GIS and/or programming skills will be recommended. Discussion with Mr. Elvarsson and/or Prof. Adey.

Example: Generation of many possible highway access nodes

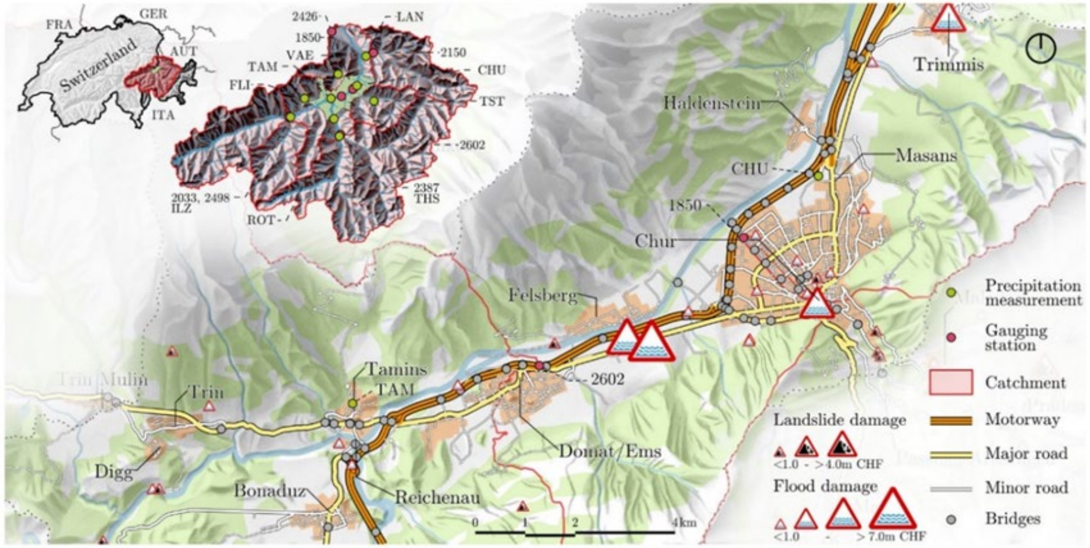


Connected to: (FCL) FUTURE CITIES LABORATORY

5 – A real time transport system digital twin to minimize risk

Limited to 1

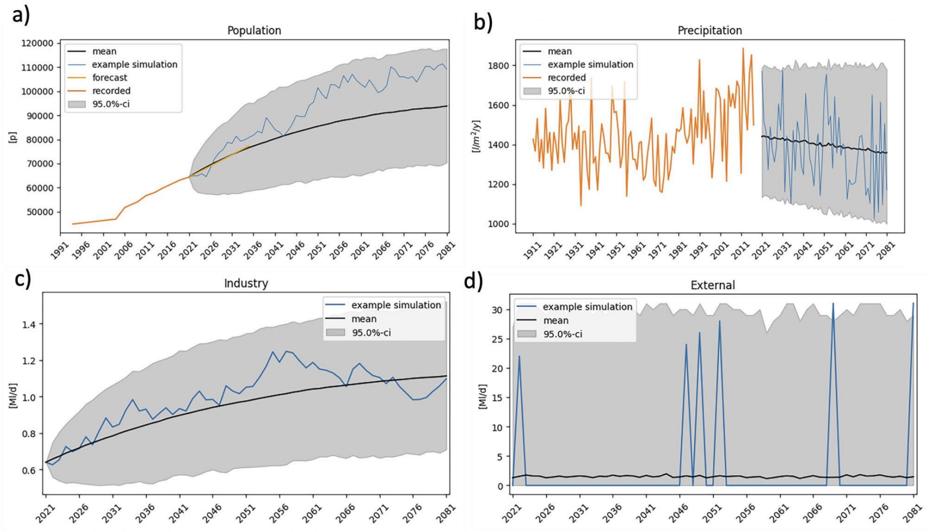
- **Supervisors**: H. Nasrazadani (nasrazadani@ibi.baug.ethz.ch), Dr. Marcelo Torres (gmarcelo@ethz.ch), Prof. Dr. Jürgen Hackl (Princeton), Prof. Dr. B.T. Adey
- **Goal:** To demonstrate how real time information can be used in a digital twin to reduce risk in the region of Chur Switzerland.
- **Main Tasks:** 1) Understand the transport system in Chur, Switzerland, 2) understand/modify the system representation, 3) identify the possible sources of real time information, 4) demonstrably connect the real time information to the system representation or simulations, and 5) demonstrate how the digital twin could be used to reduce risk.
- **What you will learn:** How to use digital twins in the minimization of risk.
- **What is a successful project?** A convincing demonstration that real time information can be used in a spatially distributed digital twin of a transport network to minimize risk.
- **Prerequisites**: Infrastructure Management 1 or Infrastructure Planning; discussion with Mr. Nasrazadani and/or Prof. Adey.



6 – Using a digital twin to facilitate planning water system development

Limited to 1

- **Supervisors**: S. Hässig (haessig@ibi.baug.ethz.ch), Dr. Marcelo Torres (gmarcelo@ethz.ch), Prof. Dr. Jürgen Hackl (Princeton), Prof. Dr. B.T. Adey
- **Goal:** Explain convincingly how a digital twin could be useful in the development of system plans.
- **Main Tasks:** 1) Understand an example water system in Scotland and the decision-making processes of Scottish Water, 2) understand what digital twins are and can be, 3) identify the possible sources of real time information, 4) identify possible sources of uncertainty related to the water system, e.g., rain fall, population, population location, and 5) develop arguments as to how a digital twin could be used including arguments in terms of efficiency and effectiveness of decision making, as well as costs and benefits.
- **What you will learn:** The potential of digital twins in the planning for development of systems.
- **What is a successful project?** A convincing demonstration that real time information can be used in a spatially distributed digital twin of a transport network to minimize risk.
- **Prerequisites**: Infrastructure Management 1 or Infrastructure Planning; discussion with Prof. Adey.

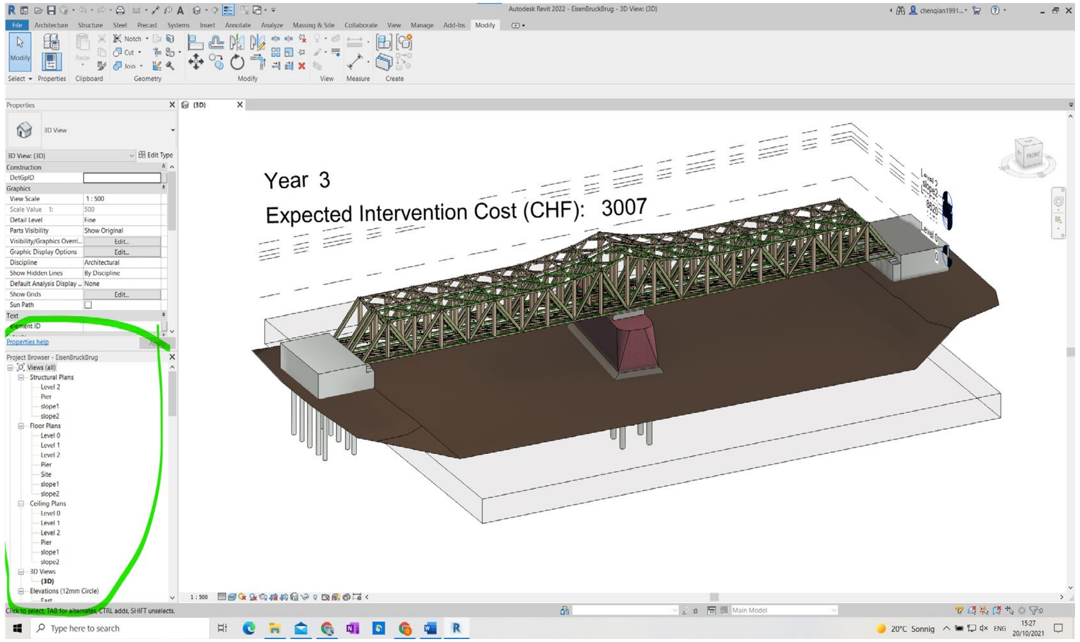


Connected to: Scottish Water

7 – Connecting future predictions to BIM

Limited to 1

- **Supervisors:** S. Hässig (haessig@ibi.baug.ethz.ch), S. Chuo (chuo@ibi.baug.ethz.ch), Prof. Dr. B.T. Adey
- **Goal:** To connect simulation software to BIM.
- **Main Tasks:** 1) Understand how future condition state predictions are made for bridge components, 2) understand how future interventions are predicted, 3) develop a data base which contains this information, 4) connect the database to BIM, 5) illustrate the possible visualisations of the expected deterioration and possible interventions, 6) determine how to best illustrate uncertainty, and 7) develop guidelines for implementation.
- **What you will learn:** How to predict deterioration and failure of bridge components in infrastructure management, how to predict future interventions automatically, and how to connect models to BIM.
- **What is a successful project?** Connection of prediction models to BIM and demonstration of the possible visualization.
- **Prerequisites:** Infrastructure Management 1 or Infrastructure Planning; discussion with Mr. Hässig or Prof. Adey.



Connected to: ASTRA

8 – Estimating missing risk data with Bayesian networks

Limited to 1

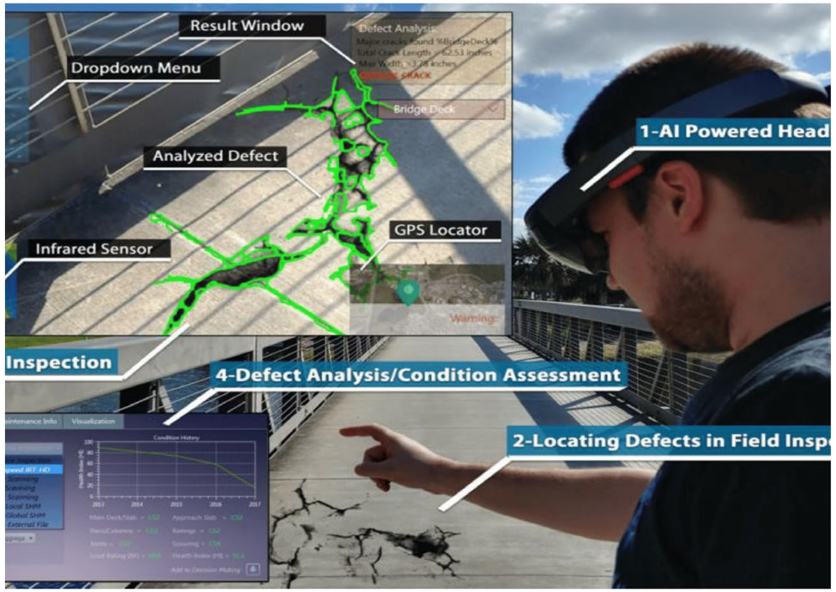
- **Supervisors:** S. Chuo (chuo@ibi.baug.ethz.ch), S. Hässig (haessig@ibi.baug.ethz.ch), Dr. Marcelo Torres, Prof. Dr. B.T. Adey
- **Goal:** To demonstrate how Bayesian networks can be used to estimating missing data for risk estimation for locks and weirs.
- **Main Tasks:** 1) Understand how locks/weirs work, 2) understand how risk estimates are made, 3) develop a tailored risk estimate methodology for the locks/weirs of BAW, 4) identify all information required, 5) adapt an existing methodology from IBI to estimate the required values when there is no data and when there is partial data, and 6) demonstrate how the methodology works on a set of locks/weirs.
- **What you will learn:** How to estimate risk on infrastructure assets, and how to make estimates of missing data using Bayesian Networks.
- **What is a successful project?** A clear demonstration of how good one can estimate missing data using Bayesian Networks to facilitate risk estimates.
- **Prerequisites:** Infrastructure Management 1 or Infrastructure Planning; discussion with Mr. Hässig, Mr. Chuo, or Prof. Adey.

Connected to: BAW, Germany

9 – Use of extended reality of bridge inspections

Limited to 1

- **Supervisors:** Y. An (an@ibi.baug.ethz.ch), S. Hässig (haessig@ibi.baug.ethz.ch), Prof. Dr. Carl Haas (University Waterloo), Prof. Dr. B.T. Adey
- **Goal:** To demonstrate how extended reality and the supporting framework could be used to improve bridge inspection processes.
- **Main Tasks:** 1) Understand how extended reality works, 2) understand how information needs to be structured so that it can be used in extended reality, 3) understand how information needs to be structured so that it is helpful for inspectors and managers to make decisions, 4) understand the different possible ways to display information, 5) learn how to connect information from existing data bases to extended reality devices, 6) determine how current inspection procedures would have to change and could be improved if extended reality was used, and 7) provide an assessment of the advantages and disadvantages of using such a technology.
- **What you will learn:** How extended reality may (or may not) improve bridge inspections.
- **What is a successful project?** A clear demonstration the potential of improvement of bridge inspection processes through the use of extended reality.
- **Prerequisites:** Infrastructure Management 1; discussion with Prof. Adey.



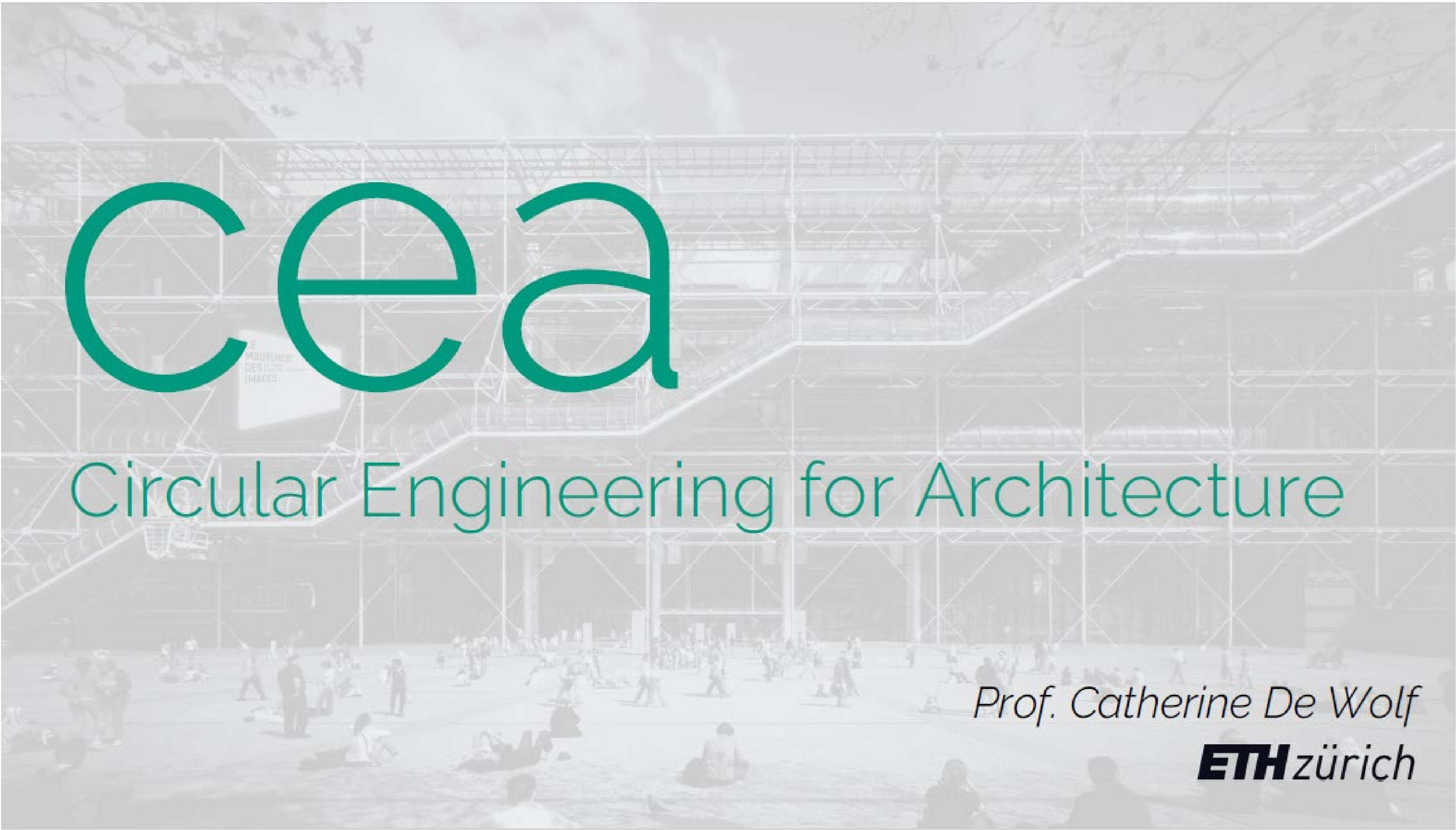
Connected to: SBB

10 – Asset management approaches to enable resilience

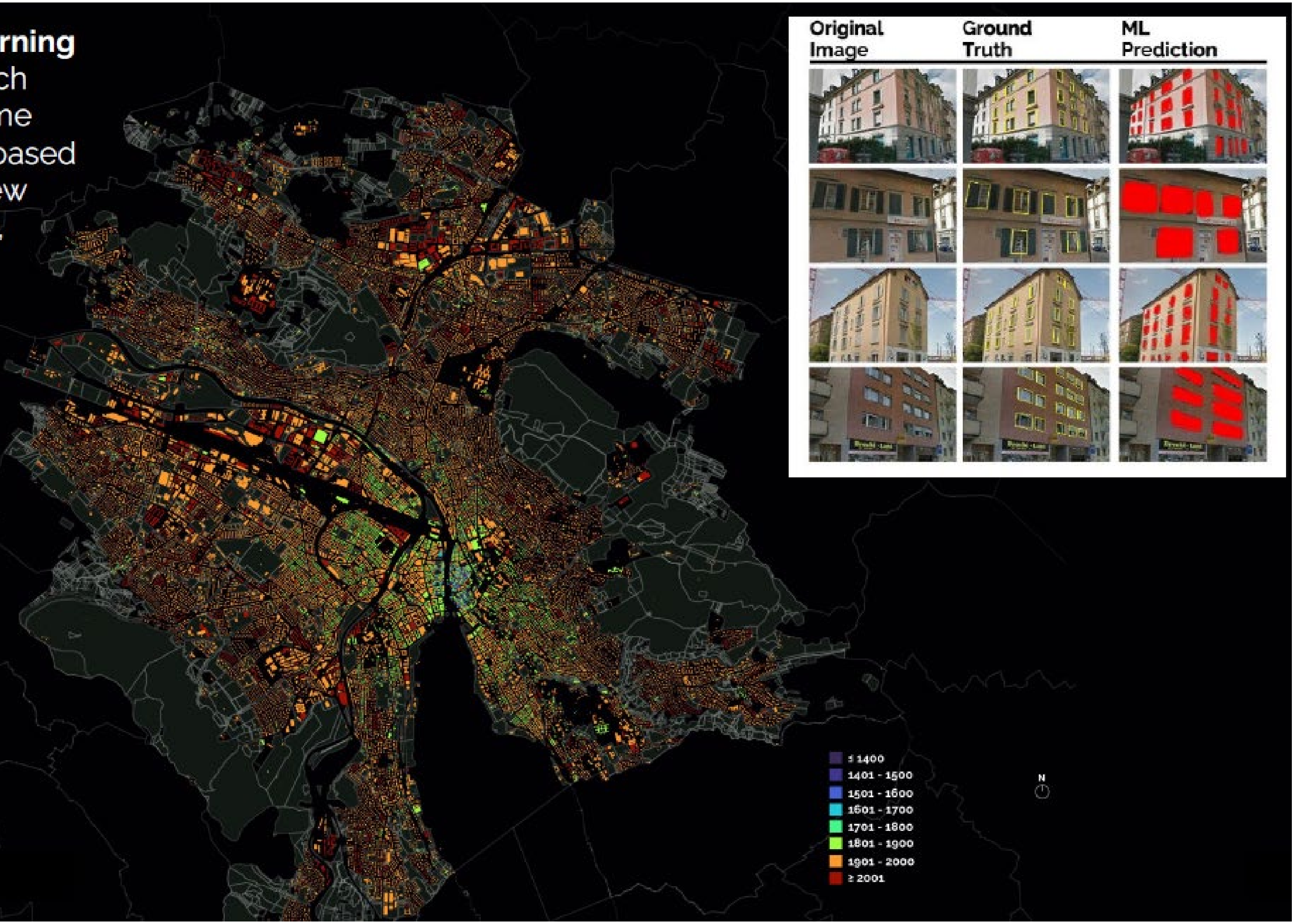
Limited to 1

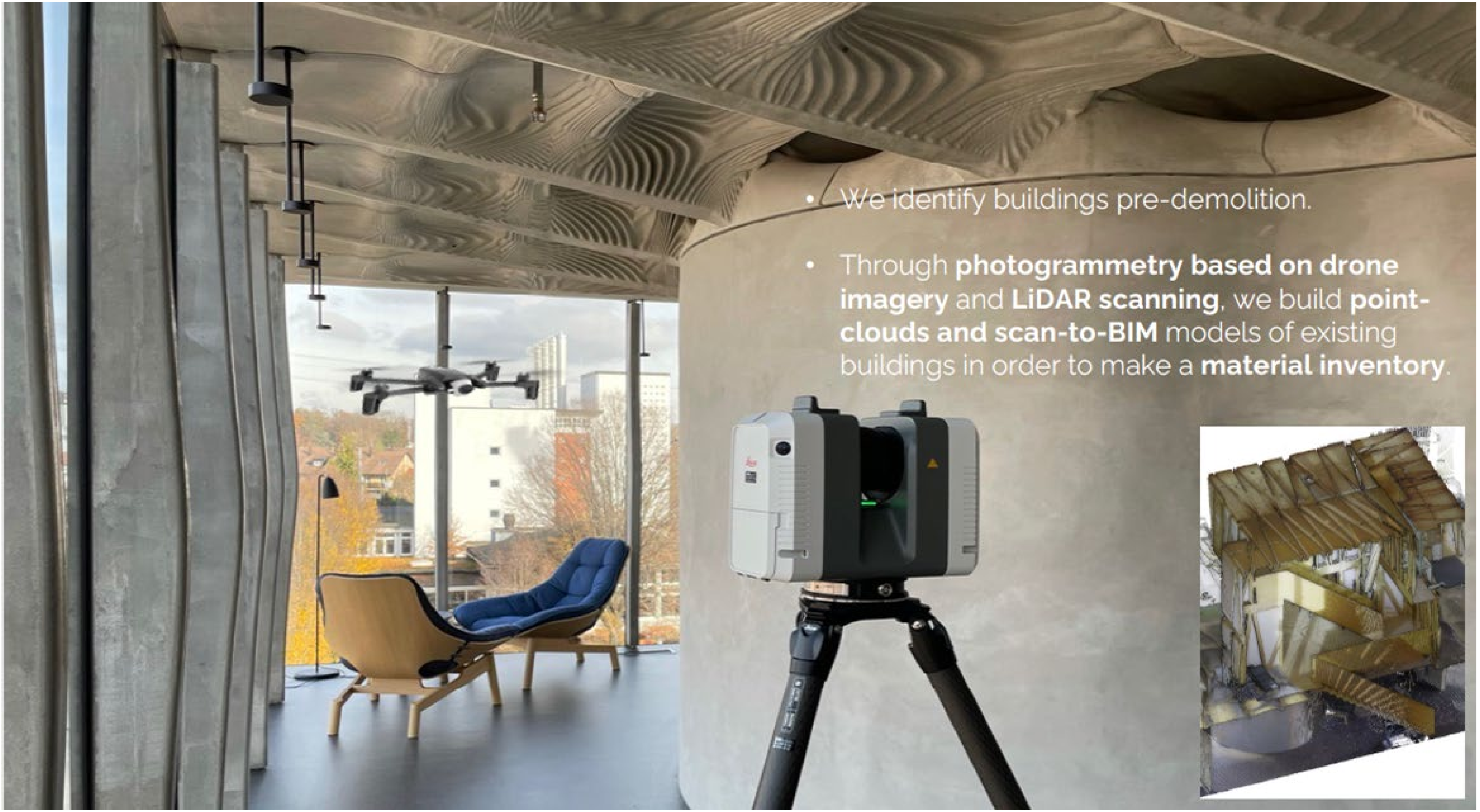
- **Supervisors:** D. Zani (zani@ibi.baug.ethz.ch), J. Meier (meier@ibi.baug.ethz.ch, Dr. Marcelo Torres, Prof. Dr. B.T. Adey
- **Goal:** To provide an example asset management approach that would help ensure network resilience.
- **Main Tasks:** 1) Understand the main components of an asset management approach, 2) understand the main components required to estimate resilience, 3) outline an asset management approach for a railway bridge, 4) collect data to be used to make the asset management approach as realistic as possible, 5) make an asset management approach for a specific type of railway bridge, and 6) make a plan to collect all data required to make the perfect asset management approach and rank the data collection in order of descending importance.
- **What you will learn:** How to make an asset management approach, and how to make an asset management approach to enable resilience.
- **What is a successful project?** An example of an asset management approach to enable resilience that is convincing to bridge managers.
- **Prerequisites:** Infrastructure Management 1; discussion with Prof. Adey.

Connected to: SBB

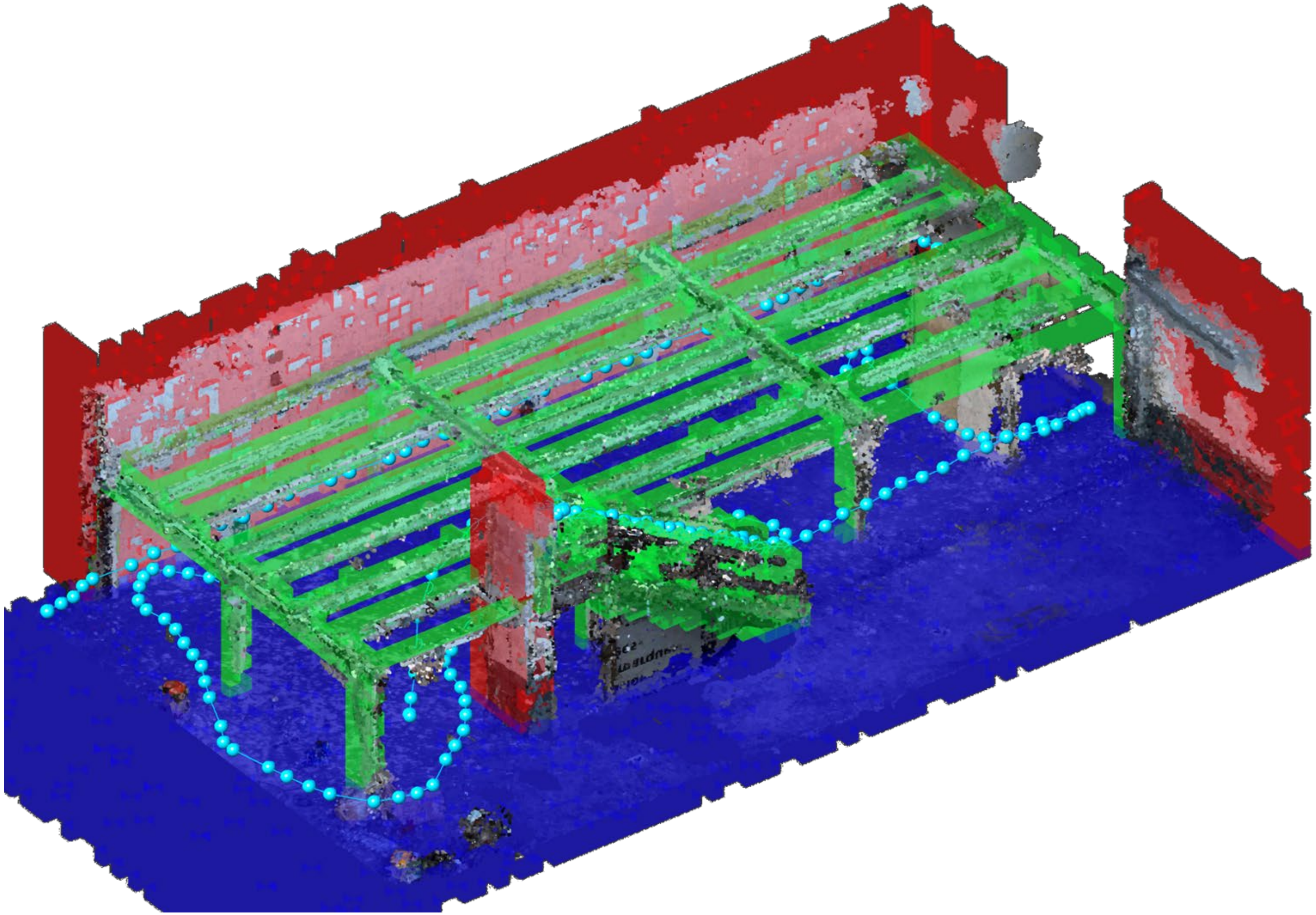

cea
Circular Engineering for Architecture
Prof. Catherine De Wolf
ETH zürich

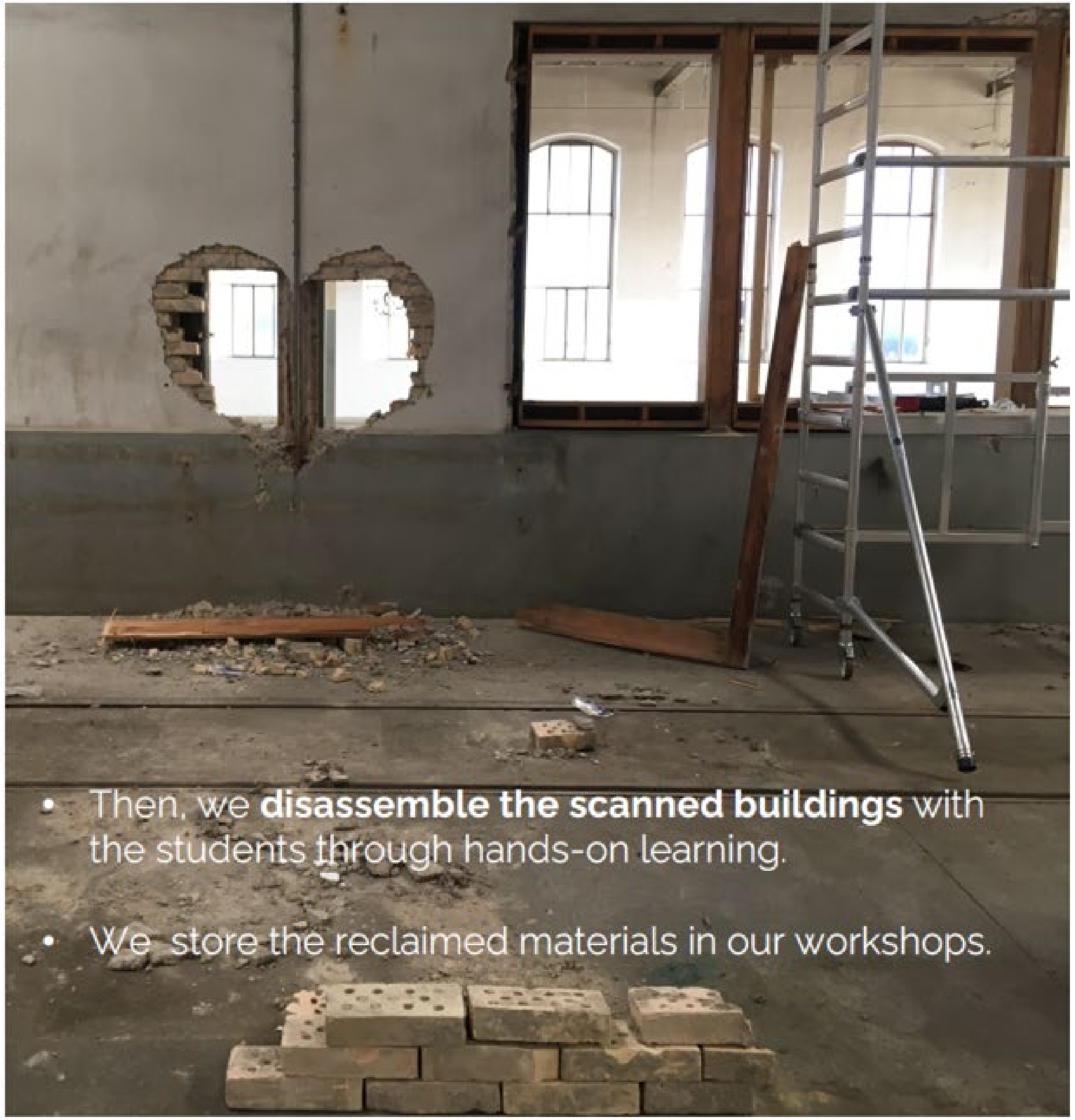
- Using **Machine Learning (AI)**, we predict which materials will become available for reuse based on Google Streetview data, cadastral data, photography, etc.

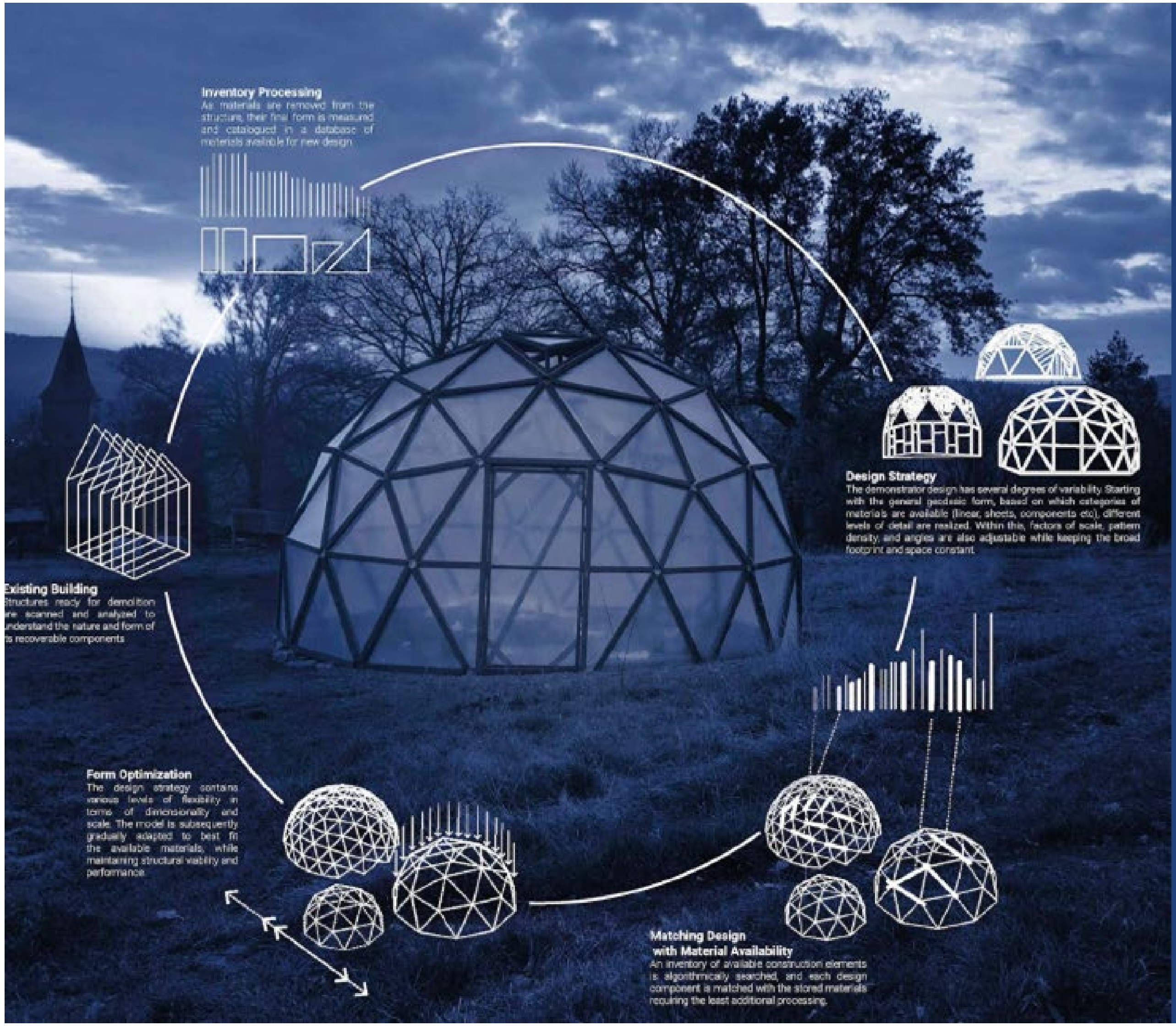




We identify buildings pre-demolition.
Through photogrammetry based on drone imagery and LiDAR scanning, we build point-clouds and scan-to-BIM models of existing buildings in order to make a material inventory.




• Then, we **disassemble the scanned buildings** with the students through hands-on learning.
• We store the reclaimed materials in our workshops.



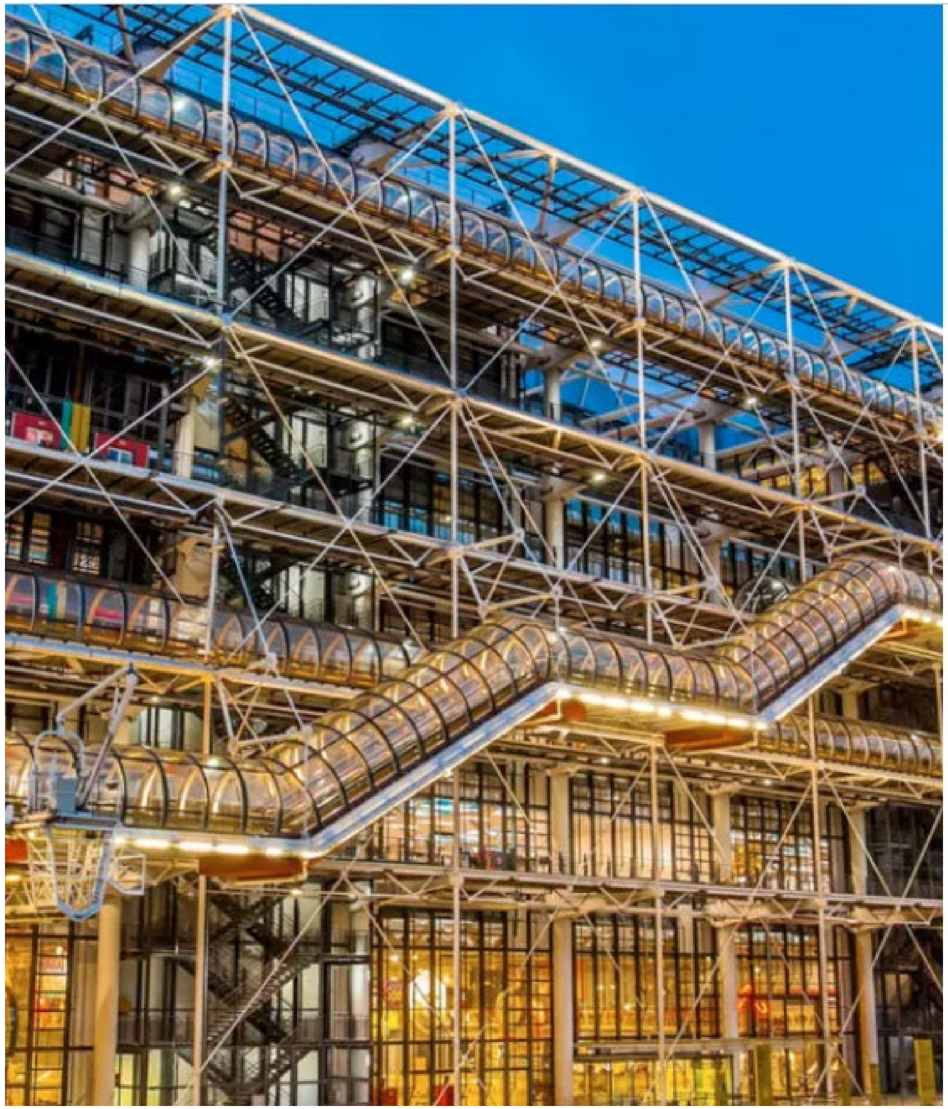
- Next, we use **computational design algorithms to match** our new design with the inventory of available materials.
- Finally, we **robotically assemble** the new structure with the reclaimed materials.

cea

Circular Engineering for Architecture

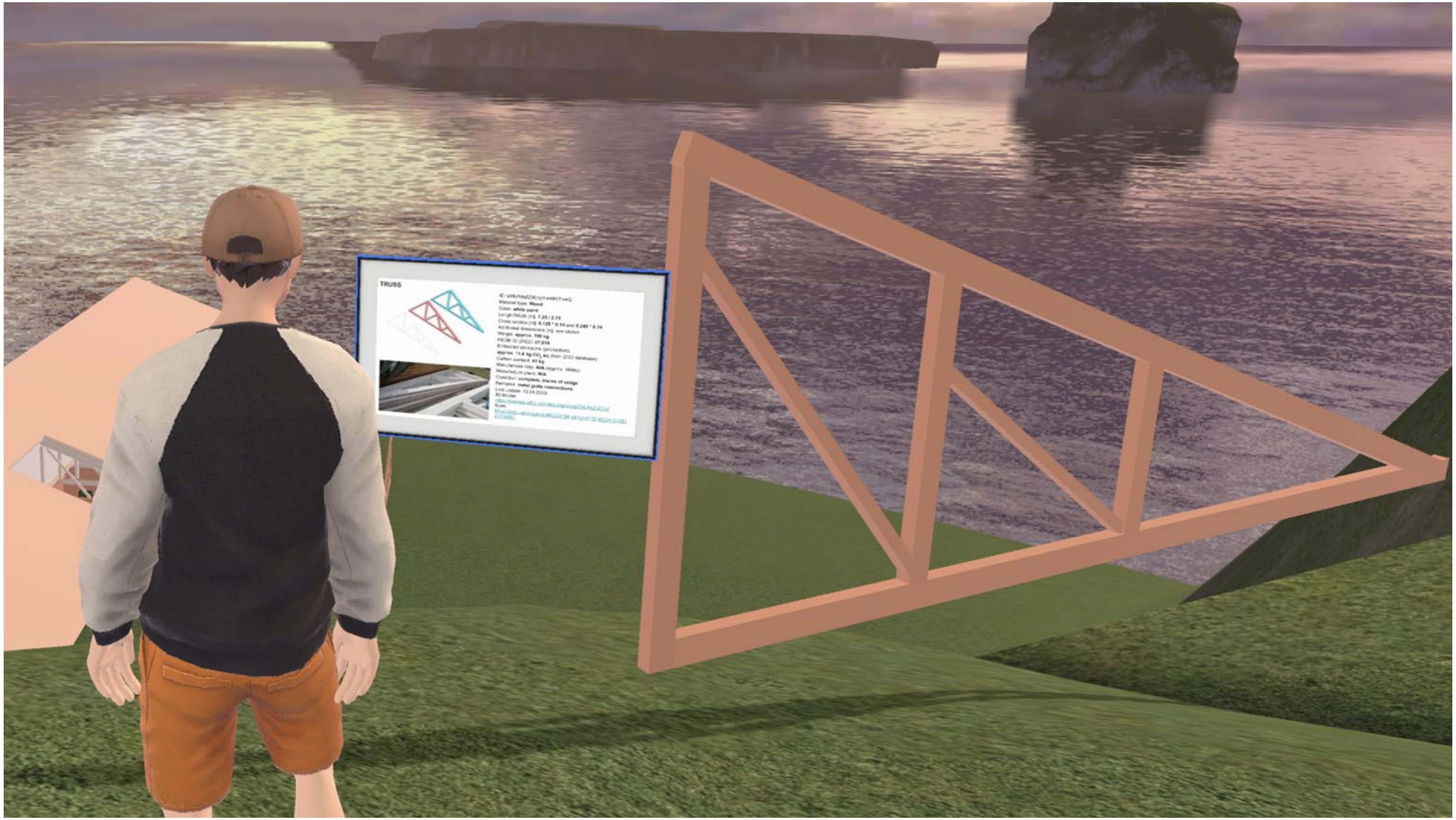
Prof. Catherine De Wolf

ETH zürich




The CEA lab fosters the reuse of **building materials** (such as the glass of the Centre Pompidou) through **digital innovation** to accelerate the transition to **a circular construction industry**

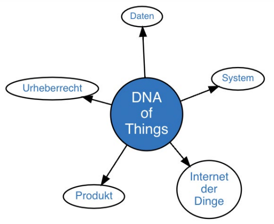
Ariza, Rust, Silvestru, Taras, Gramazio, Kohler, & De Wolf (2024).
"Lost and bound: adaptive detailing with robotic additive joining for reclaimed steel." Robarch


TRUSS

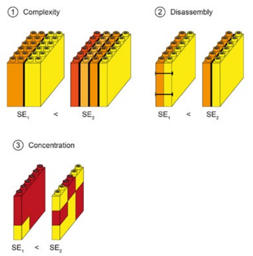
Topics

Master project and thesis

Master thesis



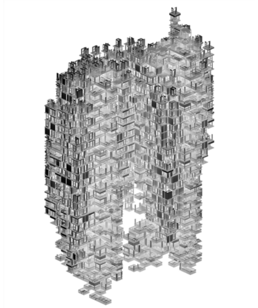
Optimal Integration Techniques of Data Storage via DNA in Setting Construction Materials



Evaluating the degree of reusability of buildings: A case study

Mixed Reality as Digital Tool for Teaching Life Cycle Assessment of Buildings

Validation of Hybrid Reclaimed Timber + 3D Printed Wood elements.



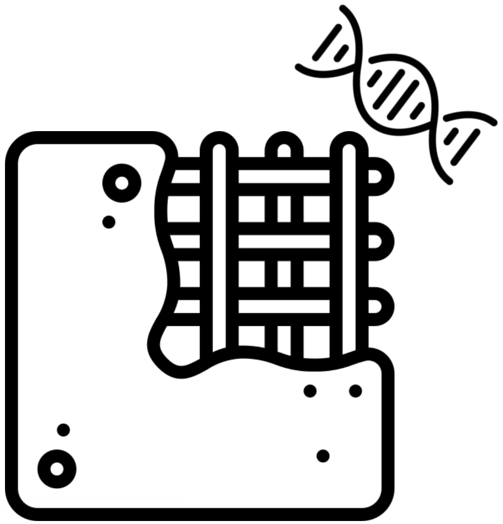
Machine Learning in Circular Design with Reclaimed Building Elements

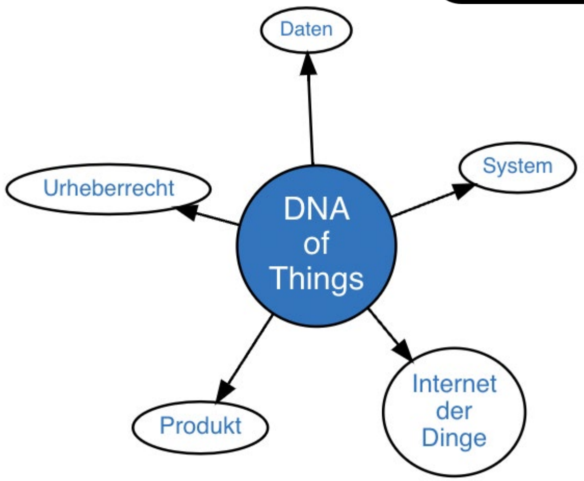
coop

Master Planning Circular Construction with Coop at Wädenswil

Optimal Integration Techniques of Data Storage via DNA in Setting Construction Materials

- **Supervisors:** Brandon Byers (byers@ibi.baug.ethz.ch), Prof. Dr. Robert Grass (D-CHAB), Catherine De Wolf (D-BAUG)
- **Goal:** Determine the best methods for embedding DNA into [paint or concrete] and establish the minimum concentration needed for reliable data retrieval.
  - Which techniques most effectively incorporate DNA into paint and concrete without compromising material or DNA quality?
  - What's the least DNA concentration required in materials to ensure data is consistently readable?
- **Main Tasks:**
  - Sample Preparation: Create paint and concrete batches with varying DNA concentrations.
  - Data Retrieval & Analysis: After material curing, extract/ decode DNA to gauge readability. Assess if DNA concentration affects retrieval success.
- **What you will learn:** Material track & trace for circular construction, state-of-the-art data storage techniques
- **What is a successful project?** A guideline on effective DNA integration in [paint and concrete], including the least DNA concentration required for reliable data retrieval
- **Prerequisites:** Curiosity and interest in biology, openness to collaboration with different departments and labs, experience w/ handling construction materials

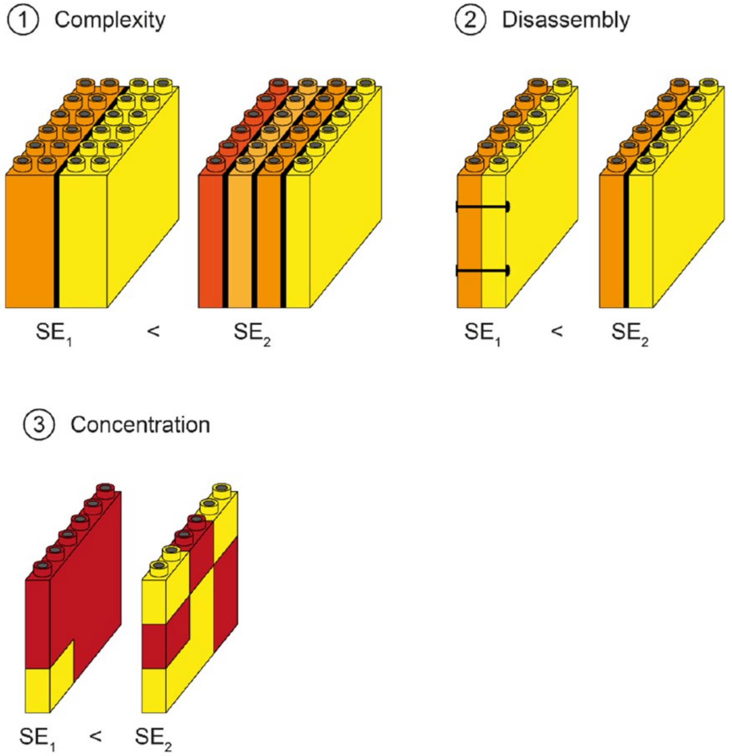




Evaluating the degree of reusability of buildings: A case study

- **Supervisors:** Dr. Katarina Slavkovic (slavkovic@ibi.baug.ethz.ch), Prof. Dr. Catherine De Wolf (ETH), Prof. Dr. Helmut Rechberger (TU Wien)
- **Context:** The relative product-inherent recyclability (RPR) is a robust assessment method for evaluating the degree of recyclability at building assembly scale (e.g. external wall). Researchers at Technical University of Vienna developed and tested the method [1].
- **Goal:** Explore the adaptation of the RPR method to evaluate reusability of an office building, thus introducing an additional tool to the existing building evaluation metrics. If interested, other building types, such as educational, cultural, or industry, could be discussed with the supervisor.
- **Main Tasks:** (1) Analyse the RPR method and review the existing methods for assessing reusability, (2) extend the scope and adapt the method to reuse, (3) apply the new method to a case study, and (4) support dissemination of new knowledge by writing a paper.
- **What you will learn:** Circular economy principles, with a particular focus on reuse strategies in the construction industry. Principles of statistical entropy, notably, complexity, disassembly, and concentration, associated with material composition of buildings.
- **What is a successful project?** Successful project demonstrates the application of the new method, and potential benefits of using the method on an architectural design project.
- **Prerequisites:** familiarity with reuse and recycling; basic academic writing skills, .
- **Extra**: Potential participation in a conference to present your research and join the discussions on circular built environment. Please contact the supervisor: slavkovic@ibi.baug.ethz.ch.

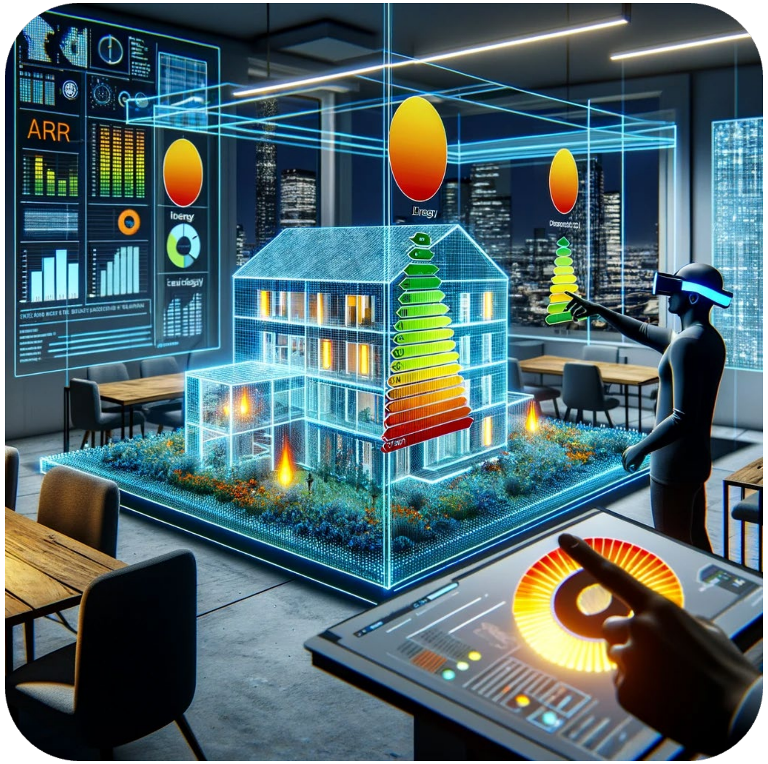
[1] Roithner C, Cencic O, Honic M, Rechberger H. Recyclability assessment at the building design stage based on statistical entropy: A case study on timber and concrete building. Resources, Conservation and Recycling. 2022;184:106407.



Examples of building wall designs described with Statistical Entropy (SE): 1. complexity of assembly structure, 2. disassembly into elements and 3. material concentration in element. Source: [1].

Mixed Reality as Digital Tool for Teaching Life Cycle Assessment of Buildings

- **Supervisors:** Dr. Katarina Slavkovic (slavkovic@ibi.baug.ethz.ch) and Dr. Eleftherios Triantafyllidis (triantafyllidis@ibi.baug.ethz.ch), Catherine De Wolf
- **Context:** Mixed Reality (MR) has the potential to be significantly engaging for users. LCA is a standardised method for quantifying environmental flows associated with the build environment. By combining MR and LCA, there is a notable potential to educate the public about the environmental impact of the circular build environment *(Helamini et al, 2024)*.
- **Goal:** As one of a two-member team, develop a tool that relies on immersive solutions, for educating users about the life cycle environmental performance of buildings.
- **Main Tasks: (1)** Analyze current educational practices on LCA with a focus on MR integration. **(2)** Develop an MR application, showing life cycle environmental impact of a building, quantified with LCA. **(3)** Evaluate the effectiveness of the MR tool in educating users, by conducting a workshop followed by a questionnaire. **(4 - Bonus)** Contrast it with conventional education (e.g. text-books).
- **What you will learn:** Gain insights into LCA and MR, develop an MR educational tool, and contribute to sustainable building practices.
- **What is a successful project?** Engaging and informative MR tool that educates the general public on what constitutes LCA and its concepts, underlining the necessity for circular practises.
- **Prerequisites:** Familiarity with reuse strategies, LCA, MR (ideally have tried it before; but not necessarily), software engineering background (e,g, Unity3D, Unreal, C#, C++) and basic academic writing skills.
- Please contact the supervisors: slavkovic@ibi.baug.ethz.ch and triantafyllidis@ibi.baug.ethz.ch

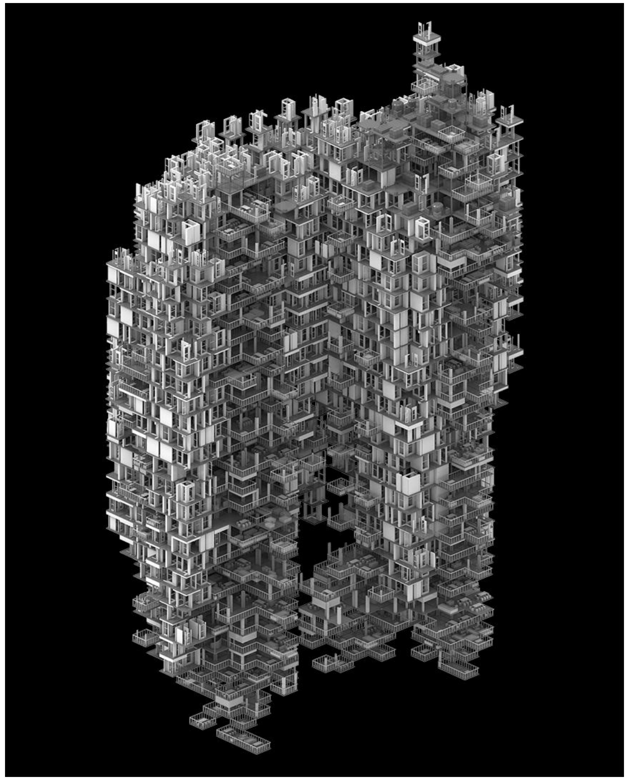


Artistic depiction of using MR to engage users about LCA and understanding the principles of LCA – the impact of our building on the environment. Through immersive visualisations and interactions, users educate themselves about LCA.

Helamini Sandagomika, Safoura Salehi, & Mehrdad Arashpour (2024). Hybrid Life Cycle Assessment (LCA) of prefabrication: A comparison of conventional and mixed reality-based solutions. *Journal of Cleaner Production, 450, 141883.*

Machine Learning in Circular Design with Reclaimed Building Elements

- **Supervisors:** Beril Önalan (oenalan@ibi.baug.ethz.ch), Vanessa Schwarzkopf (schwarzkopf@ibi.baug.ethz.ch), Catherine De Wolf
- **Goal:** The aim is to understand and map out possible Machine Learning (ML) applications for designing from reused materials
- **Main Tasks:** Systematic Literature Review for ML (Generative and Discriminative Models) in digital design and architecture and their potential of application for circular design tasks
- **What you will learn:** Throughout this project, you will gain insights into ML application of computational design methods to circular design problems. In particular you will explore deep learning models (NN,GAN, VAE, CCN, Transformer, …) with an emphasis on using discrete three dimensional reclaimed building material inventories to investigate scalable computational design methods to provide solution to increasingly pressing environmental issues.
- **What is a successful project?** Providing an overview of current research on ML for circular design and identifying research gaps and potentials through presenting your research results
- **Prerequisites:** Interest and curiosity for the research on the digital transformation for circular engineering and architecture, especially in the field of Artificial Intelligence and early-phase design



Housing GAN 2021, Immanuel Koh

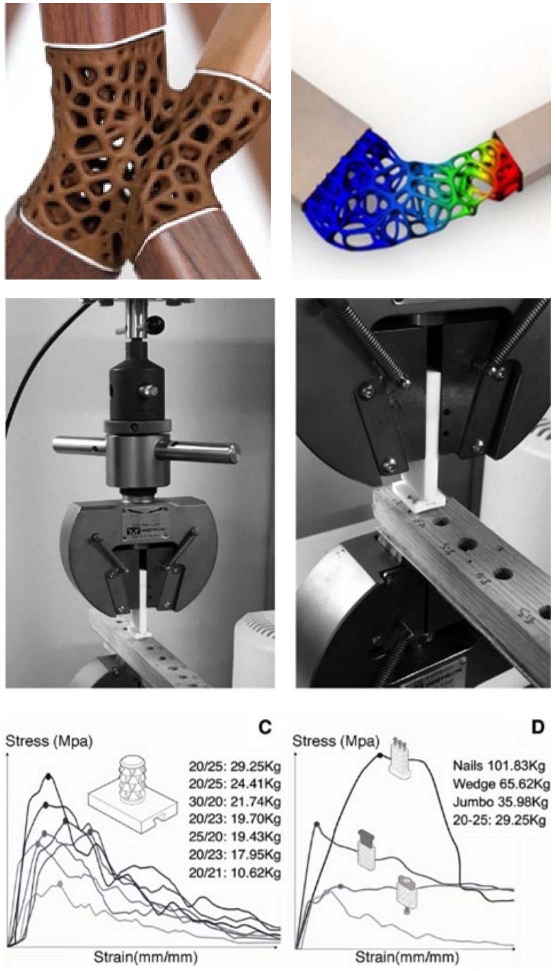
An example of implementing Generative Adversarial Networks with 3D data to a design task

Master Planning Circular Construction with Coop at Wädenswil

- **Supervisors:** Elias Knecht (knecht@ibi.baug.ethz.ch), Arabelle de Saussure (desaussure@ibi.baug.ethz.ch), Catherine De Wolf
- **Goal:** Investigate, quantify and qualify the potential for circular construction for the planned refurbishment of existing houses of Coop in Wädenswil.
- **Main Tasks:** (1) Conduct a comprehensive literature review of existing research on digital innovation, reuse-friendly modern architecture, and circular economy concepts. (2) Conduct fieldwork in Wädenswil and set up an inventory of reusable materials. (3) Evaluate the potential environmental and economic benefits of incorporating digitally innovative techniques for circular construction into the refurbishment project of Wädenswil.
- **What you will learn:** You will learn practical skills in fieldwork and data collection; circular economy concepts; digital innovation; the challenges and opportunities of circular construction
- **What is a successful project?** A successful project demonstrates the potential environmental and economic benefits of circular construction in the Swiss Mill site while incorporating digital techniques into modern architecture design and construction.
- **Prerequisites:** Critical thinking and problem-solving skills; familiarity with digital tools, architecture, (de-)construction processes, and circular economy concepts, experience using excel, photography and CAD.

Structural Simulation and Validation of Hybrid Reclaimed Timber + 3D Printed Wood elements.

- **Supervisors:** Vanessa Costalonga(costalonga@ibi.baug.ethz.ch), Catherine De Wolf
- **Goal:** Create a simulation protocol for Hybrid structures made from Reclaimed Timber and 3D Printed Wood Waste, and validate this simulation with destructive testing.
- **Main Tasks:**
  - Material Testing to define mechanical properties of the hybrid material
  - FEA Modelling of a series of given case studies.
  - Preparation of test samples for destructive testing.
  - Make recommendations for the design refinement based on simulation and test results.
  - Topology optimisation of designs could be explored.
- **What you will learn:**
  - How to simulate 3D Printed structures.
  - Structural Testing protocol: Assess the structural performance of Hybrid Timber/3D Printed elements based on EU regulations.
- **What is a successful project?** A successful project will simulate, test and analyse the given case studies and present structural recommendations for design refinement.
- **Prerequisites:** Familiarity with Finite Element Analysis (FEA) tools and willingness to conduct destructive structural testing. Knowledge of Rhino/Grasshopper is recommended.



Magrisso, Shiran, Moran Mizrahi, and Amit Zoran. "Digital Joinery For Hybrid Carpentry."
In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, 1–11.
Montreal QC Canada: ACM, 2018. https://doi.org/10.1145/3173574.3173741.

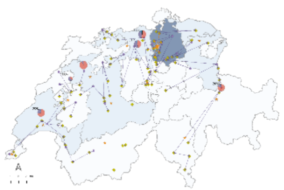
The Chair for Sustainable Construction gathers a group of scientists, engineers and architects who aim to ground sustainability in all disciplines involved in the built environment.

The objective is to identify the relevant parameters that influence the environmental impacts of buildings across spatial and temporal scales in order to implement sustainable practices throughout the development of innovative strategies adapted to each stakeholder.

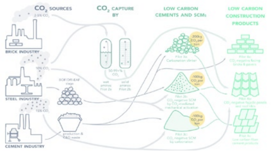
Topics

Master project and/or thesis

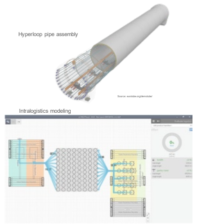
Master thesis



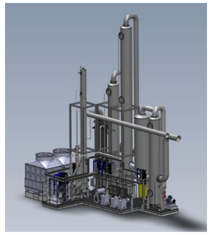
Urban-industrial metabolism within the context of recycling of waste-to-energy residues into construction materials



Estimation of waste streams availability for CO2 mineralization in construction products in Europe

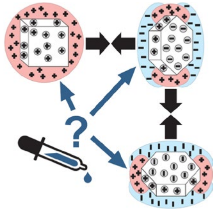


Assess carbon emissions from prefabrication processes thanks to digital twins of factory

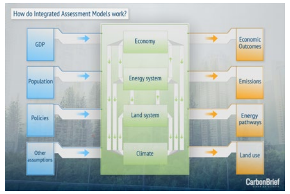


Embodied Carbon of CCUS

Do high-carbon binders reduce the hygrothermal performance of earthen construction?

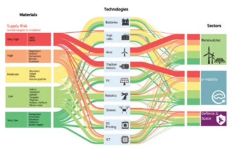


Identifying the dominating sorption sites in Mg-binder stabilized clay based construction materials



Building WLC emissions in IAMs for climate change mitigation

How to model a Global building stock?

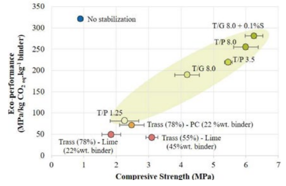


Implications of EU climate policy for urban waste incineration & recycling

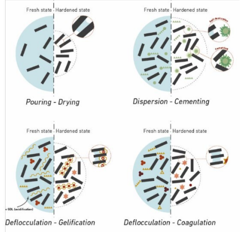
LCA of construction method and material for building project in Zurich

Assessment according to ESGs framework of water pipe maintenance technology

Design for carbonation



Low-tech binder for poured earth stabilization



Poured earth techniques: a systematic performance comparison

MFA

Supply chain, stakeholders, policies

LCA materials & technologies

Materials Development

1 – Urban-industrial metabolism within the context of recycling of waste-to-energy residues into construction materials

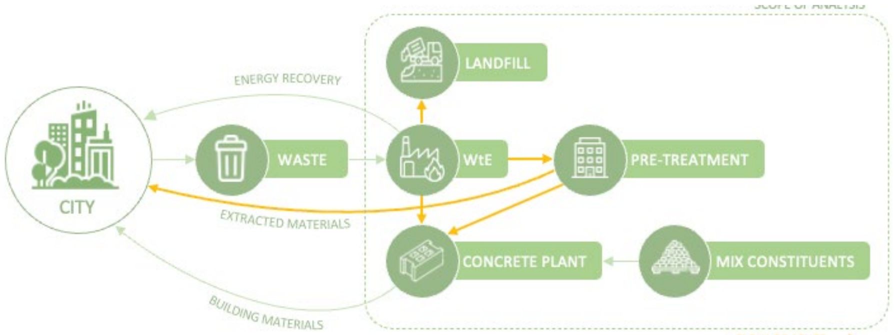
Supervisor: Dr. Anastasija Komkova (komkova@ibi.baug.ethz.ch)

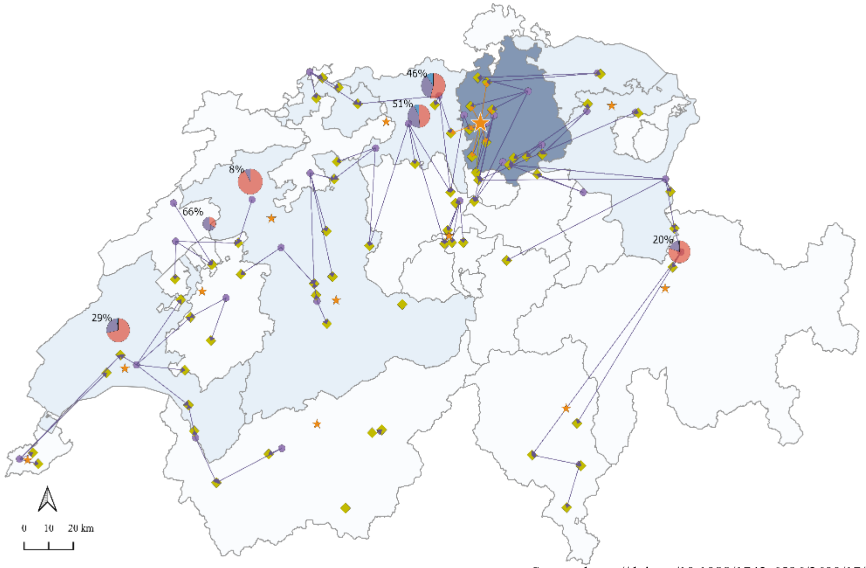
Goal: In Europe, more than 35% of annually generated waste is disposed. But what if waste generated by urban environment can become a resource for construction sector? The goal of the project is to model urban-industrial metabolism within the context of recycling of waste-to-energy residues in construction materials. The case studies can focus on Northern, Central, or South-Eastern Europe.

Main tasks: Further adapt existing optimization model for supply chains within urban-industrial exchanges of waste, minimizing environmental impacts and costs. Match supply of waste and demand for construction materials. Where relevant, examine trans-boundary urban-industrial symbioses. Quantify contributions to national carbon reduction targets.

Prerequisites: Basic skills in one of the programming laguages/softwares: e.g. python, Matlab, R or GAMS. Knowledge of GIS could be useful, but not necessary.

Students: 1





Source: https://doi.org/10.1088/1742-6596/2600/17/172002.

2- Building whole-life carbon emissions in Integrated Assessment Models (IAMs) for climate change mitigation

Supervisor: Dr. Fernanda Belizario-Silva (silva@ibi.baug.ethz.ch)

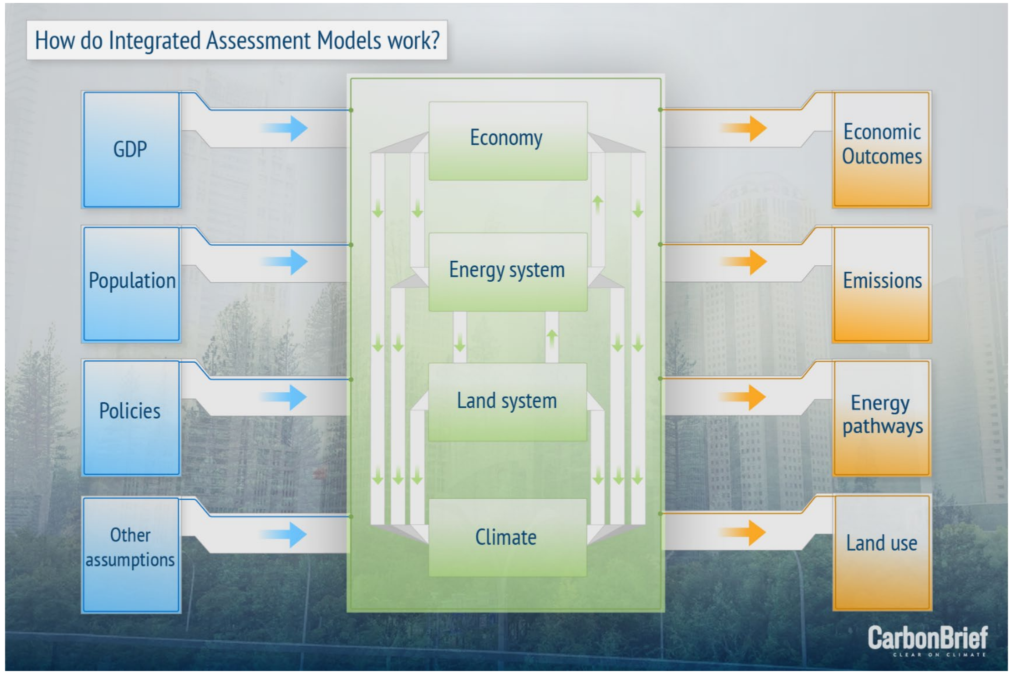
Goal: To understand how Integrated Assessment Models (IAMs), which are used by the Intergovernmental Panel on Climate Change (IPCC) to analyse scenarios for carbon emission and mitigation options at the global scale, model the whole-life carbon emissions of buildings, including the identification of the parameters used to model the evolution of the building stock and corresponding emissions for the different Shared Socioeconomic Pathways (SSPs)

Main tasks:

- Review the documentation of the main IAMs used by the IPCC to identify the parameters used to model the carbon emissions of building-related sectors (buildings and construction materials industry)
- Compile the identified parameters in a systematic way
- Analyse and compare the modelling approach, the underlying premises, and the outcomes of the different IAMs for building-related carbon emissions

Prerequisites: Good analytical skills / Interest in climate change mitigation

Students: 1



Source: CarbonBrief

3- How to model a global building stock?

Supervisor: Dr. Fernanda Belizario-Silva (silva@ibi.baug.ethz.ch)

Goal: To understand the existing approaches and methods to model the current global building stock and its evolution, in order to support the estimation of the resource demand and whole-life carbon emissions of buildings.

Main tasks:
- Review technical and scientific works that model the global (and eventually regional) building stock
- Understand what types of buildings are differentiated
- Understand which methods they use (statistical data, GIS, etc.)
- Identify the required data / data sources
- Analyse the methods and draw recommendations for robust and effective global building stock models

Source: Tuca Vieira

Prerequisites: Good analytical skills

Students: 1

4-Estimation of waste streams availability for CO_2 mineralization in construction products in Europe

Supervisors: Dr. Fernanda Belizario-Silva (silva@ibi.baug.ethz.ch)
Nikhil Kunati (kunati@ibi.baug.ethz.ch)

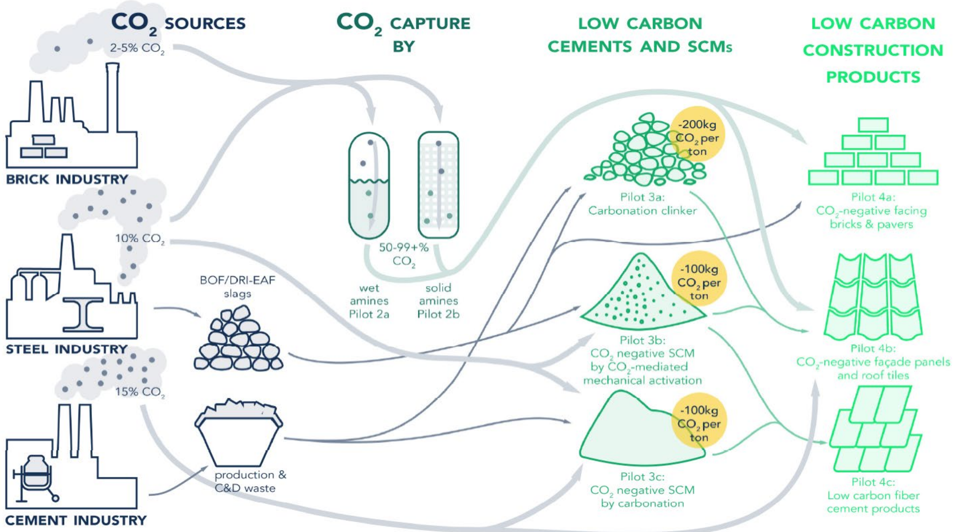
Goal: To estimate the availability and location of various waste streams such as steel slag, CDW fines, fibre cement waste and other relevant sources for CO2 mineralisation through carbonation into construction products

Main tasks:

- Identify waste stream sources in Europe
- Understand the current flow patterns of these waste streams (use/disposal)
- Quantify waste stream availability for carbonation
- Synthetize results in the form of a map

Prerequisites: Basic knowledge about Material Flow Analysis (MFA) / GIS

Students: 1



Source: Carbon4Minerals

5-Implications of European climate policy for urban waste incineration & recycling

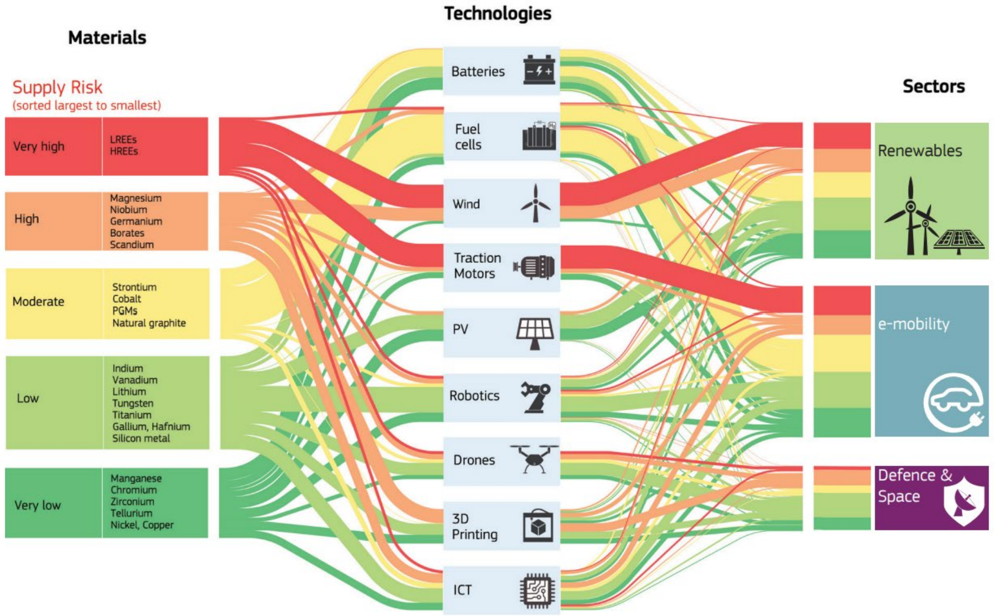
Supervisor: Dr. Anastasija Komkova (komkova@ibi.baug.ethz.ch)

Goal: Identify how European & Swiss 2050 climate targets will affect the municipal solid waste and sewage sludge treatment and incineration practicies. What would be the implications for industrial symbiosis between waste-to-energy (WtE) plants and construction sector that recylces ashes in alternative cement and clay-based construction materials? How extraction of critical raw materials (e.g. P) from ashes can influence such industrial symbioses.

Main tasks: Literature review of policies and legislations. Analysis of material flows between waste producers, WtE, construction sector and agriculture sectors using Eurostat database and national statistics. MFA of current and future scenarios in Europe, considering policy targets.

Prerequisites: Knowledge or interest in material flow analysis.

Students: 1



Source: EC (2020) Critical Raw Materials for Strategic Technologies and Sectors in the EU

Source: https://doi.org/10.1088/1742-6596/2600/17/172002.

6- Assess carbon emissions from prefabrication processes thanks to digital twins of factory

Supervisors:
Jianxiang Ma (ma@ibi.baug.ethz.ch)
Dr. Fernanda Belizario-Silva (silva@ibi.baug.ethz.ch)

Industrial Partner: EuroTube Foundation

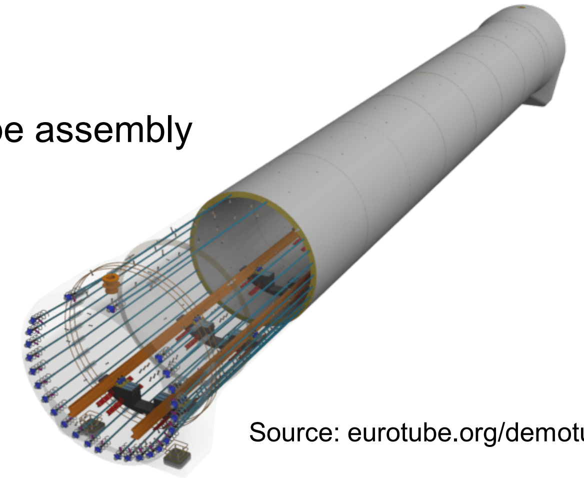
Goal: Evaluate the CO_2 emissions generated during the prefabrication of hyperloop pipes, including an analysis of both **intralogistics** and **manufacturing operations**.

Main tasks:
- Literature review
- LCA modeling of manufacturing operations
- LCA modeling of the intralogistics
- Data analysis for prefabrication processes
- Result interpretation and recommendation for carbon reduction

Prerequisites: Basic knowledge about Life Cycle Assessment

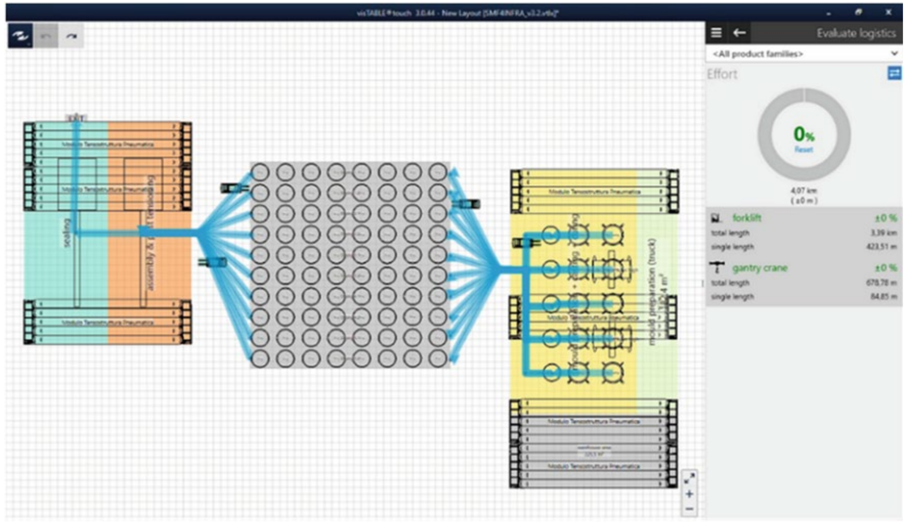
Students: 1

Hyperloop pipe assembly



Source: eurotube.org/demotube/

Intralogistics modeling



Source: www.smf4infra.net/

7- Embodied carbon of carbon capture, storage and use (CCUS) plants

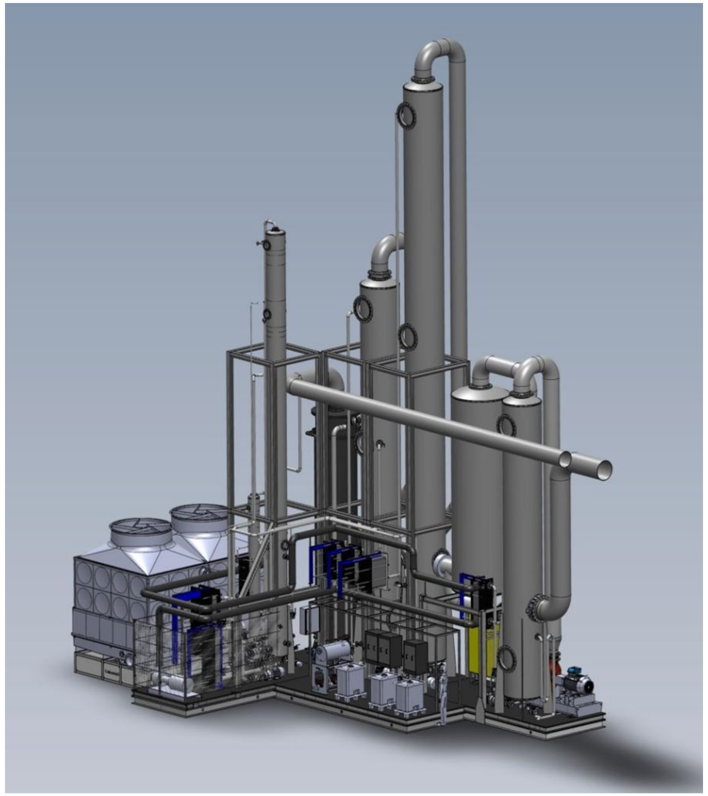
Supervisors: Dr. Fernanda Belizario-Silva (silva@ibi.baug.ethz.ch)
Nikhil Kunati (kunati@ibi.baug.ethz.ch)

Goal: To estimate the embodied carbon of industrial carbon capture storage and use plants (CCUS) including the equipment and the civil infrastructure, and calculate the time of operation required for the CCUS plant to offset its own CO2 emissions.

Main tasks:
- Compile information about CCUS plants for liquid amines and/or solid zeolite-based carbon capture of large point sources
- Develop LCA model for CCUS plant
- Perform LCA to estimate the embodied carbon of CCUS plant
- Analyse the results and estimate the time of operation for the CCUS plant to offset its own emissions

Prerequisites: Basic knowledge about Life Cycle Assessment / Interest in Carbon Capture and Storage technologies

Students: 1



Source: CarbonOro

8-Life Cycle Analysis of Construction Methods and Materials for a building project in Zurich

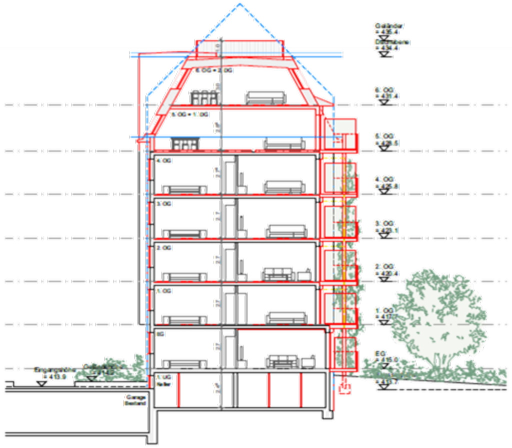
Supervisors: Dr. Fernanda Belizario-Silva (silva@ibi.baug.ethz.ch)
Dr. Verena Göswein (goeswein@ibi.baug.ethz.ch)

Industrial Partner: FREO
Project: Design stage starting September 2024, this project focuses on two Zurich properties within a Swiss bank's portfolio.

Goal: This Master project involves guiding the design phase of two residential building projects in Zurich: one involving deep refurbishment and floor additions, the other entailing demolition and reconstruction. The project aims to quantify embodied and operational emissions across various scenarios, including technical building systems (e.g., mechanical vs. natural ventilation), material selection (e.g., bio-based vs. conventional), and circularity measures (e.g., reuse/recycling of deconstructed elements). The findings will directly inform the construction definitions, offering students practical insights into environmental impact assessment within real construction projects.

Main tasks: Compile and organize data, develop an LCA model, conduct LCA, interpret results, and provide recommendations aligned with the targets outlined in the new SIA 390/1 "Klimapfad - Treibhausgas- und Energiebilanz von Gebäuden.".

Prerequisites: Basic LCA knowledge and willingness to learn LCA software.
Students: This is a groupwork for 2 students.



9-Assessment according to ESGs framework of water pipe maintenance technology (Dipan)

Supervisors: Prof. Guillaume Habert (habert@ibi.baug.ethz.ch)

Industrial Partner: Dipan

Project: Dipan is a company specializing in anti-corrosive treatments and maintenance of sanitary water, heating, sprinkler and cooling networks in the real estate sector. Many buildings in Switzerland are experiencing problems of deterioration of water distribution pipes, linked to the development of corrosion (crevice corrosion for galvanized steel pipes, pitting corrosion for copper pipes). To prevent these pipes from deteriorating, Dipan offers three-step treatments (chemical cleaning of pipes; creation of a protective sodium silicate film inside the pipes; maintaining this film by injecting a low concentration of this product (which is consumable) into the domestic water supply).

Goal: Dipan's clientele consists mainly of institutional clients representing real estate funds, some of which are listed on the stock exchange. As investors are becoming increasingly aware of sustainability issues, indicators have been introduced, such as ESG and energy indicators for real estate funds. For the purposes of this study, we would like to compare three options available to our clients for ESG scores and the environmental indicator,

- Do nothing and let the deterioration of sanitary water systems continue
- Benefit from Dipan treatments and maintenance
- Carry out a renovation

Main tasks: Understand ESG calculation, adapt it for water treatment questions. Compile and organize data from DIPAN. Calculate ESG + LCA results

Prerequisites: Basic LCA knowledge and willingness to learn ESGs

Students: This is a individual work.

DIPAN WATER TECHNOLOGY

10-Design for carbonation

Supervisors: Prof. Guillaume Habert (habert@ibi.baug.ethz.ch)
Dr.Tim Wangler (wangler@ifb.baug.ethz.ch)

Project: 3d Printing is often pushed forward as the new solution. However, it usually brings more cement per cubic meter of concrete leading to actually higher emission. In this project we want to explore how 3DP technology can be used to effectively reduce the emission, concentrating on the unique possibility of fast carbonation due to high exposed surface.

Goal: Model accurately the contribution to climate change a concrete structure is creating when looking at the cement carbonation speed. This can allow to define proper design that would release as less CO2 during production and recapture as fast as possible during life time, minimizing the footprint the carbon structure have on the environment.

Main tasks: Perform LCA once discussing with material expert responsible of the construction and carbonation measure from Tor Alva. Conduct advanced dynamic LCA

Prerequisites: Basic LCA knowledge and willingness to dive into advanced LCA methods. Knowledge of carbonation and concrete technology.

Students: 1

11- Do high-carbon binders reduce the hygrothermal performance of earthen construction?

Supervisors: Dr. Magda Posani (mposani@ethz.ch) / Dr. Rathod Ramawat (sramawat@ethz.ch) and Dr. Yi Du (du@ibi.baug.ethz.ch), Dr. Coralie Brumaud (brumaudc@ethz.ch)

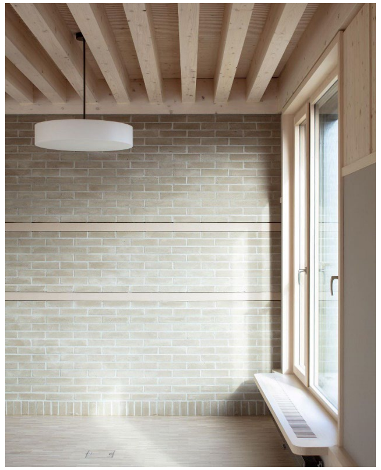
Industrial Partner: TERRABLOC

Goal: Compressed Earth Blocks (CEBs) are becoming increasingly popular due to their significant advantages: they have a low environmental impact and can passively enhance indoor comfort for occupants. However, upon closer examination, the CEBs currently available in the market may not be as environmentally sustainable or effective at ensuring users' comfort as believed. Indeed, to meet the construction industry's requirements for mechanical performance and durability, manufacturers often incorporate carbon-intensive binders into the mix, typically cement. This addition can substantially increase the material's carbon footprint and it is believed to diminish its ability to regulate indoor comfort. There is an urgent need for experimental studies to determine whether the latter concern is valid and to assess its significance relative to the type of binder used. Furthermore, the effect of bio-aggregates addition can be considered for the purpose of maximizing the hygrothermal performance of the material.

Main tasks: Hygrothermal characterization of compressed earth blocks with no stabiliser, cement stabiliser, and an alternative stabiliser. Bio-based aggregate addition can be also considered. Additional tests to clarify the reasoning behind the effect of different binders/bio-aggregates on the hygrothermal behaviour of the earthen product.

Prerequisites: Interest in building materials, sustainable construction, and laboratory work

Students: 2



Institut für Bau- und Infrastrukturmanagement

D BAUG

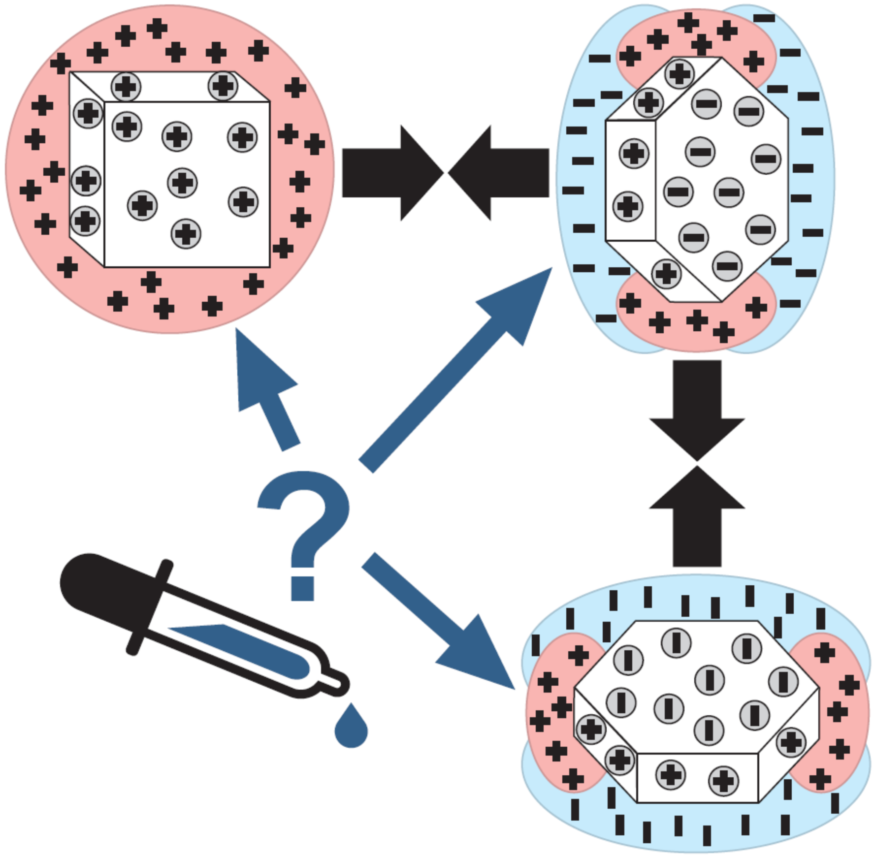
12- Identifying the dominating sorption sites in Mg-binder stabilized clay based construction materials

Supervisors: Raphael Kuhn (raphael.kuhn@empa.ch), Dr. Yi Du (du@ibi.baug.ethz.ch)
Lab work at ETH and Empa (Swiss Federal Laboratories for Materials Science and Technology, Dübendorf)

Goal: Growing attention is being directed towards earthen materials due to their sustainable characteristics. To broaden the scope of earthen construction materials, research is exploring sustainable stabilization methods using Mg-based binders to strengthen its resilience. A critical aspect is enhancing the limiting rheology, achieved through various superplasticizers. However, it remains unclear how and where these superplasticizers operate in suspensions of clay minerals with Mg-binders, and what other factors counteract coagulation. Understanding the mechanisms of these agents is crucial for designing effective building material. The goal is to leverage insights gained from this research to further the application and dissemination of earthen materials.

Main tasks: Identification of how superplasticizers disperse and affect the properties of clay minerals stabilized with Mg-cement and which factors are influenced. Lab work with BET, ICP-OES, pH electrode, zeta probe and rheometer.

Prerequisites: Interest in material development and lab work
Students: 1



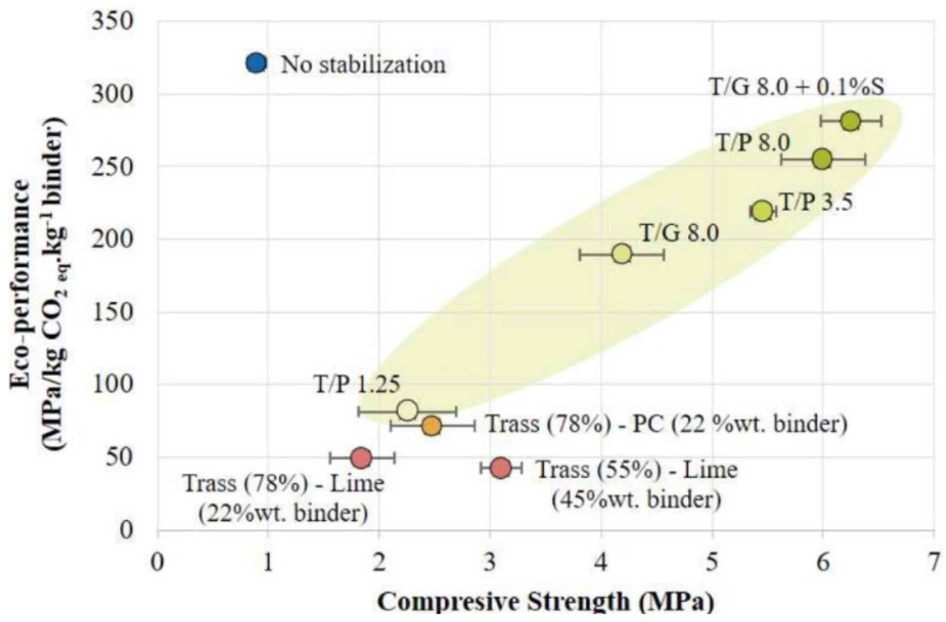
13- Low-tech binder for poured earth stabilization

Supervisors: Julie Assuncao (assuncao@ibi.baug.ethz.ch),
Dr. Coralie Brumaud (brumaud@ibi.baug.ethz.ch)

Goal: Earth is a building resource with many advantages. It is available everywhere, it has the best recycling potential, and its transformation into building material releases low CO2 emission. Despite numerous advantages, this building material presents many weaknesses that limit its use in some conditions. To overcome these difficulties, a mineral (hydraulic) stabilizer such as lime or cement is commonly added to enhance the performances of earth-based materials. However, this method is under debate regarding its environmental impact and recycling potential. Eco-friendly alternative solutions need to be addressed. The aim of this work will be to investigate the use of vernacular CSA binder as stabilizer in the specific case of poured earth application, a recent technique allowing casting earth as concrete via the use of additives.

Main tasks: Poured earth with previously developed alternative binder and dispersant will be prepared and tested. Fresh state properties (rheology) and hardened state properties (strength, setting time, etc) of the different samples will be studied to highlight the influence of additives on stabilized poured earth performances.

Prerequisites: Interest in material development, sustainable materials and lab work
Students: 1



N. Pires Martins et al., Beyond efficiency: Engineering a sustainable low-tech cementitious binder for earth- based construction, CCR, 2022

14- Poured earth techniques: a systematic performance comparison

Supervisors: Daria Ardant (ardant@ibi.baug.ethz.ch),
Dr. Coralie Brumaud (brumaud@ibi.baug.ethz.ch), Dr. Yi Du (du@ibi.baug.ethz.ch)

Goal: Poured earth is a promising technique to develop earth constructions in an urban context. Several techniques were developed over the last decades to get a better control on the rheological behavior of the material, and make possible its hardening in hermetical formwork. However, even if data exist on each poured earth technique, the use of different clay or earth as primal material make impossible the comparison of the techniques. Moreover, some properties that could be relevant for poured earth application are still missing, reducing its possible advantage in use when compared to conventional materials.

Main tasks: Different poured earth techniques will be prepared with the same earth to reduce external variables. The properties of the different samples at fresh state (flowability) and hardened state (hygrothermal properties, strength, shrinkage) will be studied and compared.

Prerequisites: Interest in material development, sustainable materials and lab work
Students: 2