# Biogenic construction

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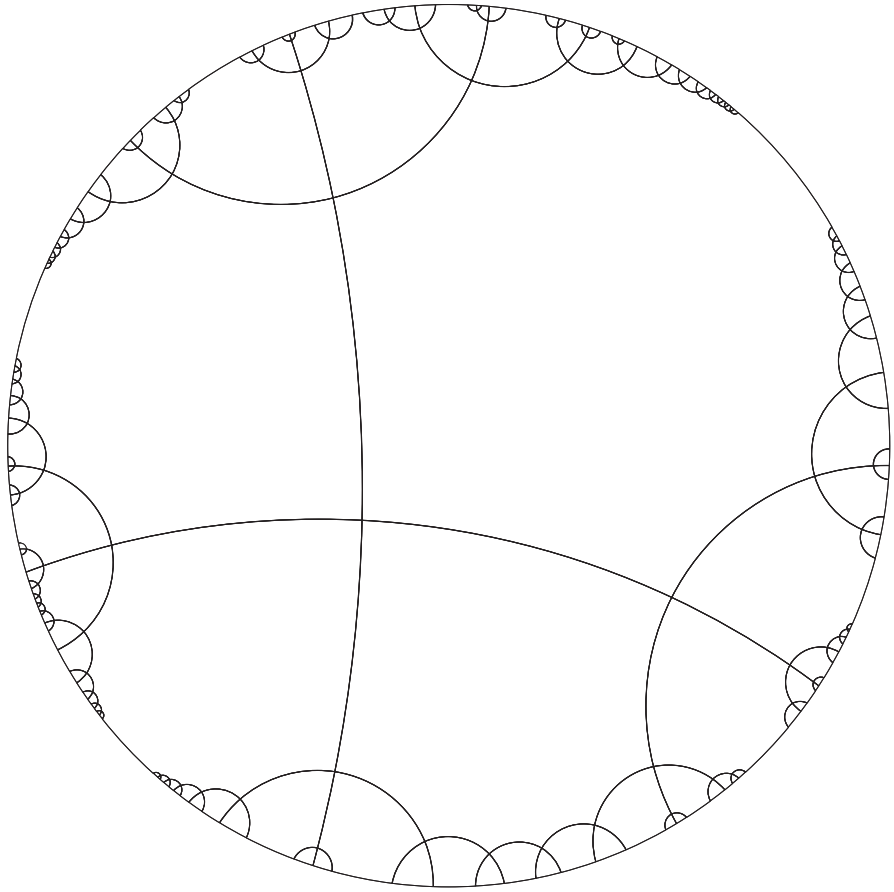
Diogo Burnay [eds.]

# Emerging voices on new architectural ecologies

Trienal de Arquitectura de Lisboa



circodeideias

**Cristina Veríssimo**
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Of Latin origin, the word that titles the 6th edition of the Lisbon Triennale is profoundly polysemic. *Terra* simultaneously means the name of our planet, or its solid part as opposed to the sea. In Portuguese, it also means a space or territory, as in a home country – *terra mãe* (motherland) – or one's birth town – *terra natal* (homeland). In a denser or poetic understanding, it alludes to a place or a *community*.

*Terra* is one of the four classic elements that make up nature – fire, air, water, and earth (*terra*). More literally, it is the disaggregated and loose layer of the terrestrial surface, where vegetation is attached and grows to create essential ecosystems for life with the living beings that dwell above and below it.

As a material, *Terra* has been fundamental to some of the most sustainable building techniques developed by humans since ancient times. *Terra* summons feelings of awareness or security, whether through the phrase *com os pés assentes na terra* (with your feet on the ground), or even setting your feet on *terra firma* (solid ground).

*Emerging voices on new architectural ecologies* is a selection of essays from worldwide researchers who respond to the Lisbon Triennale Millennium bcp Universities Competition open call expanding perspectives on the topics of the four main exhibitions of the Triennale 2022, chief curated by Cristina Veríssimo and Diogo Burnay.

In this edition, the Triennale seeks to research how we can think, design, and build, and how regeneration can be fostered to decisively contribute to environmental and social sustainability and, ultimately, the survival of humanity and Earth itself.

José Mateus
Chairman of the Lisbon Architecture Triennale

# Emerging voices on new architectural ecologies

Cristina Veríssimo & Diogo Burnay

This anthology focuses on seventeen university research projects, all selected for the Lisbon Triennale 2022 Millennium bcp Universities Competition Award and some of which are included in the exhibitions.

This year's Triennale takes the name *Terra* and it addresses how climate cha(lle)nges, pressures on resources, socioeconomic, and environmental inequities are profoundly intertwined and central to architectural concerns. It aims to be an open forum for multiple voices, experiences, and ideas, to help inform the numerous solutions we will need in our diverse world. Understanding these complex situations requires a paradigm shift from a linear growth model of cities as *machines* to a circular evolutionary model of cities as *organisms*.

These projects were selected through a collaborative process between the Triennale chief curators, the exhibition curators, and Ilka Ruby as an external jury member. They were chosen from an open call for ideas which addressed the main exhibition themes, with entries including research projects with a strong visual component, or physical intervention projects, with the breadth of contexts and programmes illustrating the range of academic research carried out globally. These projects explore diverse and emergent voices on architectural ecologies that seek to support shifts in disciplinary paradigms across architecture, urbanism, and landscape from schools all over the world.

For the first time, the award was open to both professional Masters' Degrees and Research programmes from architecture and related fields, including urbanism, urban design, and landscape architecture. Technology is also present, discussed through construction processes and methods as well as experimental material technologies. The humanities feature throughout, prominently with multidisciplinary and transdisciplinary urban sociologies and environmental studies.

Our intention was to create a space for exchange of thinking and making. There is a wealth of approaches, lived experiences, experiment, and research methods to explore architectural concerns, and *Terra* aims to intertwine these playful and critical reflections throughout the four exhibitions themes: *Visionaries*, *Multiplicity*, *Retroactive*, and *Cycles*. Together, this wealth of research questions today's architectural approaches and the *status quo*, proposing circular and regenerative methodologies to support new ecosystems, technologies, and practices.

We were astounded by the quality and diversity of the content and visual representation of all the submitted projects, and inspired by the vitality and relevance of schools from across the world which responded to the open call. It was not an easy process for the curators and jury to narrow the entries down to this selection.

Many universities are researching materials and technologies, developing diverse frameworks of designing to disrupt linear material trajectories and extractive building practices. Research into computational design and robotic fabrication explores possibilities to rethink construction methods and material use. Several projects explore how we source materials, and others propose revisiting traditional construction methods to rethink how ancestral ways of building might support a 21st century circular economy and sustain local cultures.

Research departs from traditional methods and knowledge to propose new ideas using new technologies, *Kinetic snapping skins*, for example, proposes how modern technology might be used to develop dynamic façades that adjust to shifting environmental conditions, saving energy and resources. *Biogenic construction: Thatched building façades for the green transition* questions "How can radical biogenic architecture be developed when integrating

knowledge from traditional building culture/-craft with contemporary efficient building processes." *Flying Earth* proposes the use of earth-based materials alongside computational design and robotic fabrication to explore the precise and complex stereotomies of architectural materials.

Ideas of how heritage and innovation can be understood as a continuous thread were also presented in several interesting projects. *Haegi Wendls*, a pioneer in sustainability, "gives value to the existing building, to its structures and memories, but at the same time demands a high-quality design and a new mix of natural building materials, to create a liveable ambience."

The work of *Architectures of (inter)Action* presents a contribution to the (re)reading and (re)interpretation of how territories are built and inhabited. This is developed with a series of strategies through several developed initiatives that can result in physical applications and offer value to communities. *Landscapes of Care* investigates the forced displacement of populations and "responses to the management, control, and maintenance of forced displacement – the refugee camp."

Participatory design principles advocating for collaborative community work was also a common theme throughout much research and community engagement presented. These projects included strategic proposals at differing scales, dealing with green and public space, social and environmental justice, inequality, and daily life needs of various communities.

*Embd research work* defines strategies of "participatory design that can reactivate abandoned landscapes and building structures in collaboration with the local community." *Intermittent Cities* "explores transformation processes that enable and empower temporary and sharing uses in urban spaces … carried out in three Portuguese universities, promoting each of the different specialisations, yet keeping the common line of thought which focuses on the set of practices and inventive imaginaries that explore the city through an intermittent perspective."

*Drawing at the speed of thought* constructs "new living scenarios upon dystopian present urban views from raw geometry rhythms or initial intuitive sketches." These are presented as visionary ideas that "perceive a future city as a sophisticated living structure, similar to interlinked human tissues."

*Coastal Studio* proposes a transdisciplinary approach to research, bringing together universities of different countries and practices, working with students building 1:1 scale prototypes, designing innovative structures to share knowledge in architecture and those subjects which intersect, not least the climate.

The topic of water as a fundamental resource was addressed by some of the universities, from macro to micro scale, focusing on water preservation and management, and the quality of the ecosystems and drinkable water. A further common theme related to how water and public space can act together for place-making, as mediators between inhabitants and *Terra*.

Universities are critical centres for production of knowledge, experimentation, and innovation. *Terra* creates opportunity for practitioners of architecture and related fields, researchers, academics, and institutions to dialogue and to collate their expertise. Some of these intermittent approaches may lead to new disciplinary and professional paradigms, new approaches which can be fundamentally flexible, focusing on people's everyday needs and aspirations, redefining public space at multiple scales, and working towards a more ecological secure future for this planet *Terra*.

# A community-led research initiative for a productive landscape

Stefan Lengen, Ali Shaw & Mert Özbolat
The Bartlett School of Architecture, UCL (United Kingdom)

ABSTRACT

How can design research endeavour to address the climate emergency with an innovative community-led initiative? The territory our research focused on is Embd, Switzerland, a rural farming village 1450m above sea level and part of the *alpine hinterland* covering a total area of 4000km$^2$ of wood and grassland across Switzerland – the largest continuous hinterland in the Alps. This remote territory formed a local framework of common(s) ownership and land governance that facilitated a natural circular economy for hundreds of years, but sadly it is a landscape – otherwise productive – that has been largely abandoned since the 1970's due to population migration to urban centres with economic, social, and cultural advantages and opportunities. Today, Embd has a population of just 331.

This design research explores strategies to reactivate these productive landscapes and dormant building structures to reverse the trend of abandonment by facilitating a circular economy within the common(s) network in collaboration with local communities, trade, stakeholders, and the planning authorities. This method of work explores participatory design principles, advocating collaborative work, local material sourcing and innovative construction methodologies that address whole-life approaches.

## INTRODUCTION

We have reached a critical point in the climate crisis caused by the Anthropocene. As shown above, with the rising demand for inappropriate construction materials, the construction industry is responsible for approximately 40% of the world's energy related carbon emissions. This led Max Fordham Building Service Engineers to state in the lead up to COP26: "We need to move quickly and join forces to bring about meaningful climate change action. The time is now."[1]

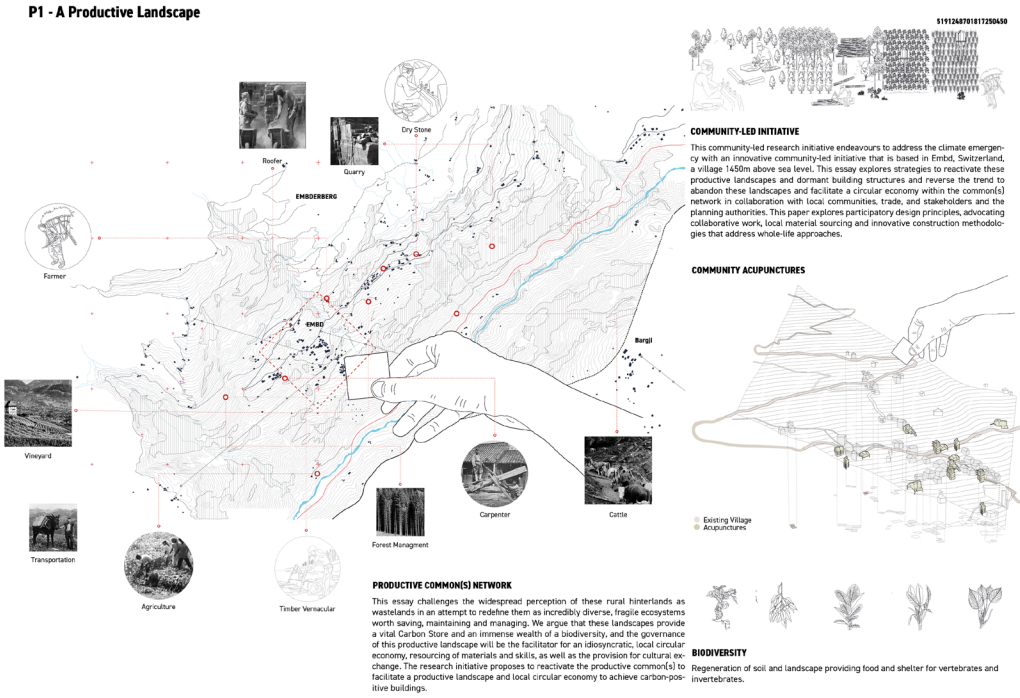
In the context of the global people migration there is a trend of communities moving towards cities, leaving a void in the places of origin. 55% of the world's population live in cities, and it is expected that this number will rise to 68% by 2050. Projections show that as a result of urbanisation, and combined with the overall growth of the world's population, another 2.5 billion people could be added to urban areas by 2050, according to United Nations reports from 2018.[2]

In the construction of skyscrapers, the global construction industry currently relies mainly on concrete and steel, with the associated release of carbon and fossil fumes. However, new technologies are resulting in carbon positive buildings using timber as the core structural material, leading to such architecture becoming a form of carbon sink or store. It is a shocking fact that could offer an opposition to yearly global concrete consumption. Between now and 2050, a 295m thick concrete mass of the area of Switzerland is predicted to be poured worldwide to meet the rising demand for metropolitan living.[3]

1.
Max Fordham (2021). *COP26: Let's tackle the climate emergency together! - Max Fordham.* [online] Max Fordham LLP. Available at: https://www.maxfordham.com/news/cop26-lets-tackle-the-climate-emergency-together.

2.
United Nations (2018). *68% of the World Population Projected to Live in Urban Areas by 2050, Says UN*. [online] United Nations Department of Economic and Social Affairs. Available at: https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html.

3.
Vidal, J. (2019). *Concrete is tipping us into climate catastrophe. It's payback time.* [online] the Guardian. Available at: https://www.theguardian.com/cities/2019/feb/25/concrete-is-tipping-us-into-climate-catastrophe-its-payback-time-cement-tax.




**A Productive Network, UCL The Bartlett**
**Courtesy: Stefan Lengen**

This research explores design and management sourcing and application opportunities for the entire rural hinterland of Embd. The forests grown in this place are hundreds of years old and are excellent stores of carbon from the earth's atmosphere. When cut, the forest carbon is locked into the dwellings which consequently become carbon stores. Forest management is a fundamental component to buildings, architecture, and our environment in the climate emergency.

Although the potential of peatlands is not addressed in this research, they are a type of wetland providing an incredible carbon store capacity.

Gifford states in their essay: "Cold damp climate creates the perfect conditions for peat to form. The land is very saturated, meaning there is very little oxygen in the soil. This makes it difficult for organic material to break down. This partially decomposed plant matter builds up over thousands of years, forming peat.

In areas of the flow country, the peat is 30 metres deep. As this organic material does not fully decompose, it does not release carbon. Peat covers only 3% of earth's land but stores 30% of its carbon. This means it stores 15 times more carbon than forests per square metre."[4]

This makes peat bogs incredible carbon sinks which can store fifteen times more carbon than forests per square metre. Like the alpine hinterland, they are perceived as wastelands within which only moss and small shrubs can grow, making them appear visually desolate. The opportunity to explore the introduction of peatlands in alpine hinterlands would exceed the remit of this paper but is worthy of inquiry.[5]

It is worth comparing steel and cement as primary building materials, and comparing with timber as an environmentally friendly alternative. If all three materials are evaluated on a hypothetical building in the same manner, we observe that timber has a net gain in carbon storage, while steel and cement give a net release of $CO_2$. A net gain means that the building goes beyond achieving net-zero carbon emissions to create an environmental benefit by removing additional carbon dioxide from the atmosphere. Timber also embodies high insulation values that reduces the building's operational carbon impact by 58% compared to steel and concrete counterparts.

After water, concrete is the most widely-used substance on the planet but its benefits mask enormous dangers to the planet.[6] The key to future building in urban and metropolitan areas will be developing and constructing high-rise timber skyscrapers. These inherently maximise the land area to the total floor plate size of dwellings and the use of timber dramatically cuts the embodied and operational carbon impacts of the building.[7]

4.
Gifford, L. (2022). *A Peatland Rehabilitation centre for the Flow Country*. Unpublished undergraduate essay for unit UG6, University College London, Bartlett School of Architecture.

5.
Beaulne, J., Garneau, M., Magnan, G. and Boucher, É. (2021). Peat deposits store more carbon than trees in forested peatlands of the boreal biome. *Scientific Reports*, 11(1).

6.
Vidal, J. (2019). *Concrete is tipping us into climate catastrophe. It's payback time*. [online] the Guardian. Available at: https://www.theguardian.com/cities/2019/feb/25/concrete-is-tipping-us-into-climate-catastrophe-its-payback-time-cement-tax.

7.
The Royal Society (2019). *Sowing seeds for timber skyscrapers can rewind the carbon footprint of the concrete industry*. [online] The Royal Society. Available at: https://royalsociety.org/news/2019/07/summer-science-timber-towers/.

## THE PRODUCTIVE COMMON(S)

Political economist Massimo De Angelis argues that in order to have a system of commons we need to have at least three constituent elements of life-enhancing, socio-ecological, metabolic processes in which cultures of sharing are (re)produced:

"1. Pooled material / immaterial resources or commonwealth.

2. A community of commoners, that is, subjects willing to share, pool, claim, commonwealth.

3. Commoning, or doing in common, that is a specific multifaceted social labour (activity, praxis), through which commonwealth and the community of commoners are (re)produced together with the (re)production of stuff, social relations, affects, decisions, cultures". [8]

In the same book, *Omnia Sunt Communia: on the commons and the transformation to postcapitalism*, De Angelis defines *commoning* as: "... the form of social doing (social labour) occurring within the domain of the commons, and thus is characterised by modes of production, distribution and governance of the commons that are participatory and non-hierarchical, motivated by the values of the commons (re)production, of the (re)production of commoners' commonwealth and of the affective, material, immaterial and cultural (re)production of the commoners and their relations." [9]

Remarkably, the inhabitants of Embd – formed of humble farmers, carpenters, and masons – created a sophisticated form of a local framework of common(s) by harvesting and nurturing the landscape as a community, just as described by Massimo De Angelis for hundreds of years. This loose framework of creative entrepreneurialism is deeply rooted in the history of Embd and forms the basis of this community-led research initiative for a productive landscape for this village.[10]

8.
De Angelis, M. (2017). *Omnia Sunt Communia: on the commons and the transformation to postcapitalism*. London: Zed Books, p.119.

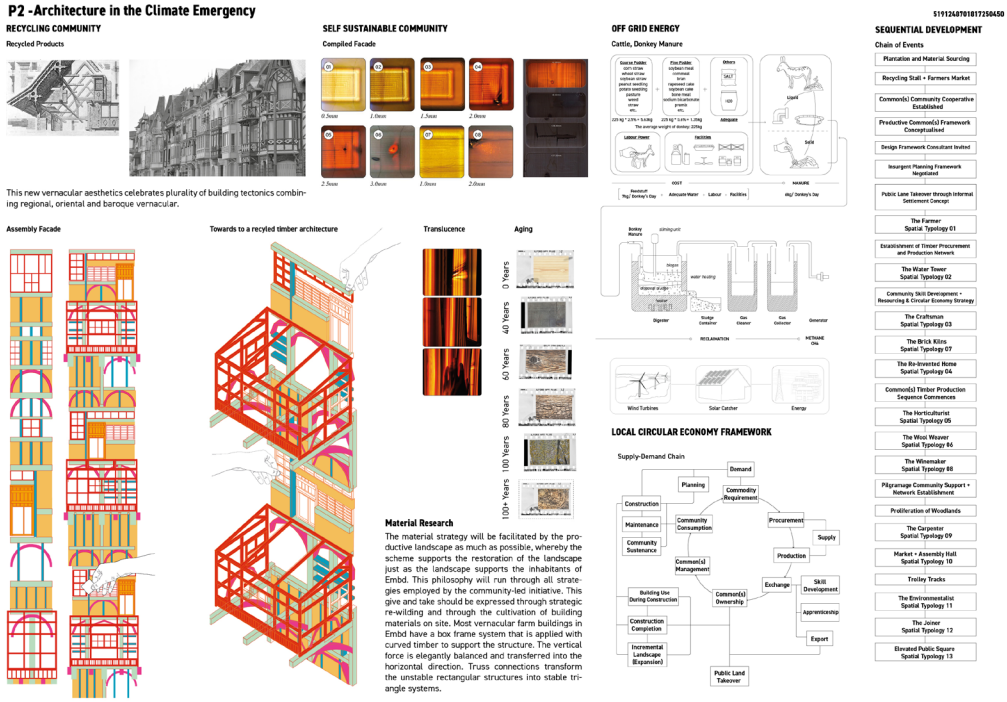
9.
Ibid., p.121.

10.
For a research example of this based in Kashmir, see Arinjoy Sen's MArch project: Sen, A. (2020). *Productive Insurgence. Towards the Automatous (Re) Production of Common(s) Within and Against the State*. Available at: https://issuu.com/arinjoysen/docs/productive_insurgence_asreduced2

There is a widespread perception of such rural hinterlands as wastelands, but they should be redefined as incredibly diverse and fragile ecosystems worth saving, maintaining, and managing. These landscapes provide a vital carbon store and an immense wealth of biodiversity, while the governance of this productive landscape will be the facilitator for an idiosyncratic local circular economy, resourcing of materials and skills, as well as a provision for cultural exchange. Our research initiative proposes to reactivate the productive common(s) in facilitation of a productive landscape and local circular economy to achieve carbon-positive buildings. The productive common(s) network acts as a medium for exploration and development of hybridised construction methods with the aim to maximise the utilisation of locally sourced materials, craft, and social exchange. The focus is not only on ways in which architecture might benefit from the productive landscape but be one of many growing approaches to how this landscape might be governed, nurtured, and restored by this model of productive common(s) network.

In an essay titled *Manifeste du tiers paysage*, the landscape designer and writer Gilles Clément sets out the notion of the *third landscape* to encapsulate "the totality of all those places abandoned by man", such as abandoned transport infrastructure, industrial and rural wastelands, and dormant building sites.[11] For Clément, the *third landscape* was articulated largely in the context of urbanism and ecology, referring to the liminal spatial conditions in the built environment and the exceptionally diverse biological communities they harbour. Clément rejects a romantic reading of places in ruination, with an initiative aligned to Clément's rejection of ruination speculating that when the abandoned hinterland of Embd is understood in relation to the conditions of its abandonment – whether political, economic, or social – and associated human or non-human networks, it can be reimagined as a space for new forms of use and exchange that challenge the market-driven processes shaping much of the built environment.

11.
Clément, G. (2004). *Manifeste du tiers paysage*.
Paris: Sujet - Objet.




**A Productive Network, UCL The Bartlett**
**Courtesy: Stefan Lengen**

## REBUILDING TYPOLOGIES THROUGH CREATIVE COMMON(S)

The vision for the future of this research initiative is that the construction and maintenance strategies are the driving force behind the functioning of the productive common(s) and its circular economy. This strategy will fabricate each element or node of this productive landscape to facilitate the productive network and re-invent traditional guilds and techniques which would in turn drive the circular economy.

The strategy aims to revive a variety of dying local economies and traditions as well as support those communities through the productive common(s) – the farmers, carpenters, and masons thus become incubators of these processes within the common(s) network. The conception of all spatial typologies takes place at the assembly hall and training school.

### EDUCATION AND TRAINING (STAGE 1)

The first building of the productive landscape is the assembly hall and training school for new apprentices in the productive landscape. The assembly hall and training school will act as a crucial hub to facilitate the circular economy with a material reclaiming bank, similar to the Buildings As Material Banks (BAMB),[12] and acting as a fundamental social – and cultural – connector. This facility aims to restore a variety of neglected local economies as well as revive local communities through the means of a productive common(s) network. Being the first building to be constructed within the common(s) framework, it is critical that its tectonics utilise as many local skills, resources, and reclaimed building materials and components from this abandoned landscape as possible.[13] The genesis of the building is explored through tacit knowledge and experimentation, promoting collaboration between the various trades and social groups in a re-invention of the traditional building vernacular, which in turn drives the circular economy. It resembles the symbolic starting point of this process, and facilitates the overarching framework for the productive landscape and emerging common(s) network.

### NATURAL PROCESSES MANAGEMENT PRODUCTION (STAGE 1)

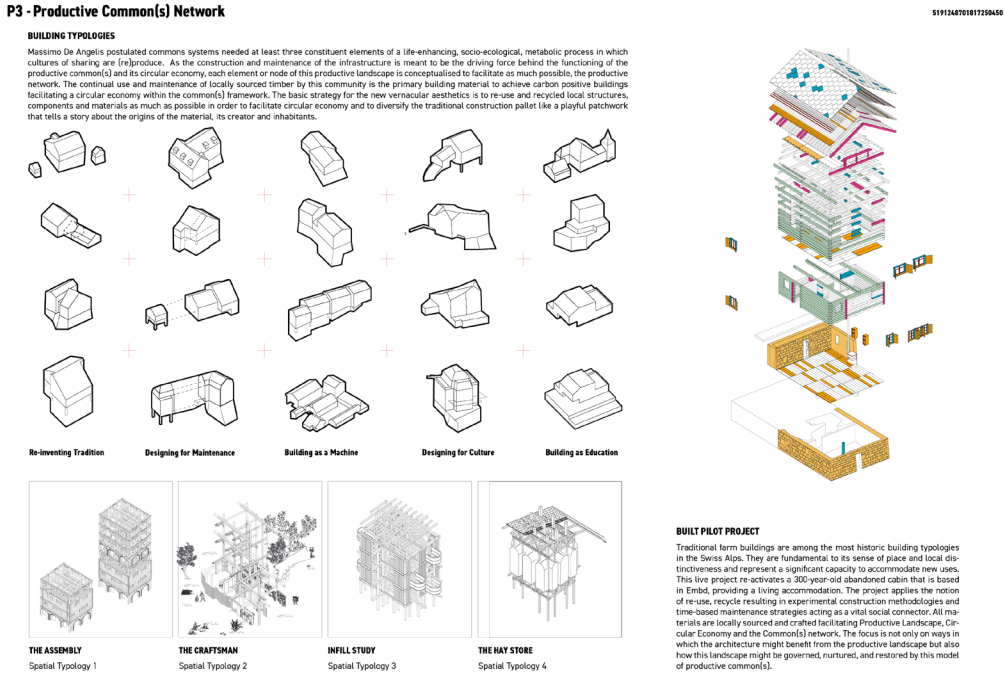
One of the main common(s) networks would facilitate the timber economy of the area. A forest management plan will be established to support the regeneration of the forest, soil, and landscape that provides food and shelter for vertebrates and invertebrates. Locally sourced wood will be processed to provide timber for the built environment as well as the productive landscape of the common(s). These processes aim to bring back and support the forestry community who have the best knowledge of how to maintain and protect the forest while using it for production. The[14] restoring and

12
BAMB (n.d.). *Materials Passports*. [online] BAMB: Buildings As Material Banks. Available at: https://www.bamb2020.eu/topics/materials-passports.

13
For a research example of this based in London, see Yitao Zhu's MArch project: Zhu, Y. (2020). *Collaging Euston*. [online] Collaging Euston. Available at: summer2020.bartlettarchucl.com/pg11/year4-yitao-zhu.

14
Della Valle, J. (2022). *Tethering of Teighs*. Unpublished Thesis for M.Arch, PG16, University College London, Bartlett School of Architecture.

15
Deluo, C. (2022). *The City Farm Revival*. Unpublished Thesis for M.Arch, PG22, University College London, Bartlett School of Architecture.




**A Productive Network, UCL The Bartlett**
**Courtesy: Stefan Lengen**

rewilding of forests would in turn also act as a form of avalanche mitigation strategy for the community and a carbon sink.

### ENERGY CONVERSION TECHNOLOGY (PHASE 1)

Anaerobic digestor chambers break down organic waste and produce biogas that will be converted into electricity, providing essential fertiliser for the productive landscape to grow organic produce. Hydropower energy is available all year round and could be the main energy supplier for this community, with any excess electricity can be traded to the region.

### FROM HINTERLAND TO ARABLE TYPOLOGY (STAGE 2)

Farmers will revive this abandoned alpine hinterland as main protagonists by harvesting and nurturing this territory through agriculture, and farming cattle, donkeys, horses, and sheep. Their practices also involve gardening and beekeeping, facilitating a micro-economy for export (stage 4). This spatial typology provides space for living and working for both animals and humans[15].

### PRODUCTIVE TYPOLOGIES FOR COMMON(S) COMMUNITY (STAGE 2)

A deep-rooted tradition of Embd, hand-made carpentry and joinery has suffered from declining demand due to its high cost against cheaper steel and concrete alternatives. The productive landscape would utilise carpentry skills and facilitate this diminishing economy and tradition in the application of recycling abandoned lumber structures. There is a plethora of opportunities in which timber can be used, recycled, and re-used in a building. Re-using materials and fittings gives a collage-like new aesthetic, with both the material and related memories of the abandoned buildings or structures preserved and communicating a story of the origins and occupants. This spatial typology provides space for living and working for this community, as well as providing training and skill development to the common(s) community.

### WATER TOWER (STAGE 3)

Rainwater is collected in water towers which is then stored in leather vessels, with any excess water fed into circulation troughs to irrigate the landscape. The harvested water is piped into buildings for use in toilets and, if filtered, for the kitchen.

### SEWING AND WEAVING GUILD (PHASE 2)

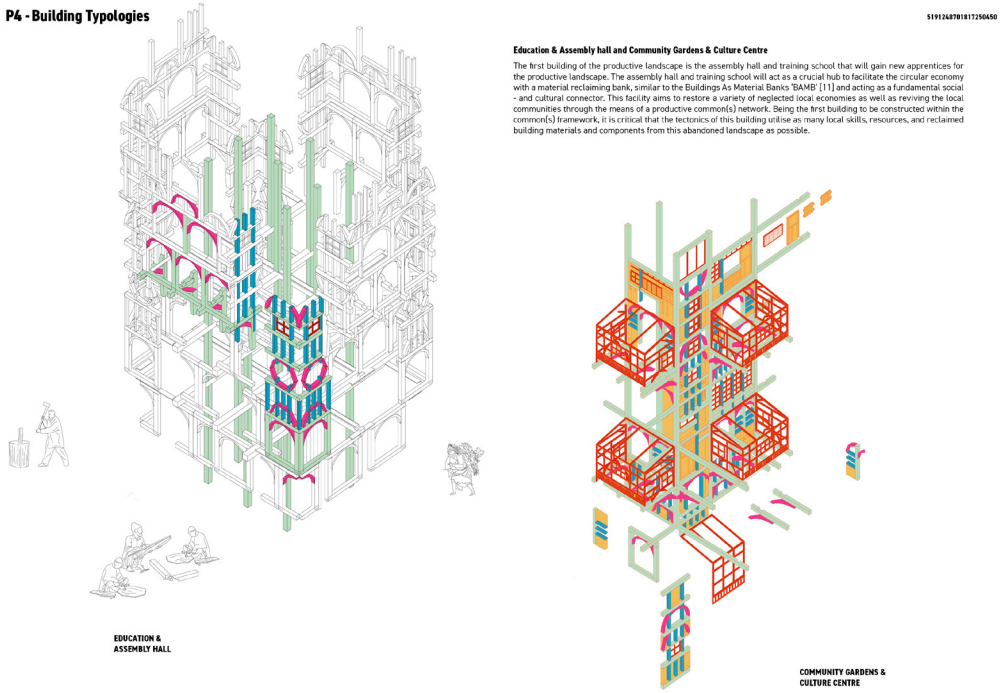
The craft of sewing and weaving of sheep wool and horsehair traditionally to make mats is being utilised for use as a building material providing an alternative insulation. This typology provides space for living and working for this community, as well as providing up-skilling to the common(s) community.

### DRYSTONE – AND ROOF GUILD / QUARRY (PHASE 2)

As traditional guilds of Embd, hand-broken drystone walls and hand-cut slate also have a declining demand due to their cost and cheaper available imported alternatives. The productive landscape would utilise rock and slate as a local building material to facilitate these diminishing economies and traditions.

### THE VINEYARD, EXPORT (PHASE 4)

This dormant landscape has historically been an exporter in the vine and schnaps market. This economy will be tapped into by the




**A Productive Network, UCL The Bartlett**
**Courtesy: Stefan Lengen**

common(s) as a starting point for an alternative income in the circular economy.

### TOWARDS A NEW VERNACULAR AESTHETICS

Traditionally, most vernacular farm buildings in Embd are constructed of a box frame system. A curved timber supports the structure and elegantly transfers the vertical force into the horizontal direction and truss connections transform the unstable rectangular structures into stable triangle systems. Traditional farm buildings are among the most historic building typologies in the Swiss Alps, fundamental to its sense of place and local distinctiveness, and representing a significant capacity to accommodate new uses. The basic strategy for the new vernacular aesthetics is to re-use and maintain such structures, components, and materials as much as possible in order to facilitate a circular economy and diversify the traditional construction pallet – creating a playful patchwork that tells a story about material origins, and the creators

and inhabitants. This new vernacular aesthetics celebrates the plurality of building tectonics, combining regional, oriental, and baroque vernaculars with pitched roofs and wood-carved gable decorations, turrets, and towers.[16] Despite this conceptual freedom of diversity, it provides an underlaying, unifying characteristic of a deep structural, material, and environmental understanding.

### BUILT PILOT PROJECT (STAGE 2022)

This live research project re-constructs a 300-year-old abandoned cabin in Embd to provide residential accommodation. The build applies the notion of re-use and recycling resulting in experimental construction methodologies and time-based maintenance strategies acting as a vital social connector. All materials are locally sourced and crafted with the intention to reactivate the local productive landscape, circular economy, and common(s) network. The focus at this stage is to investigate how this abandoned landscape might be governed, nurtured, and restored by this model of productive common(s).

### CONCLUSION

The construction and maintenance of all building typologies will be the driving force behind the functioning of the productive common(s) and its local circular economy. Each layer of this productive landscape is designed to facilitate the productive network as much as possible. Maintenance has been carefully designed into building tectonics and has often informed the design through a deep understanding of material life cycles and whole life approaches. The choice of building materials with a short life cycle will facilitate the local economy and productive landscape. The practice of maintaining, assembling, and disassembling of building components will be fetishised and is the fundamental, underlying principal to all building typologies, acting as a vital social connector.

16
Cieraad, I. (2018). Bringing Nostalgia Home: Switzerland and the Swiss Chalet. *Architecture and Culture*, 6(2), pp.265–288.

The material strategy will be facilitated by the productive landscape as much as possible, whereby the scheme supports the restoration of the landscape just as the landscape supports the inhabitants of Embd – a philosophy running through all strategies employed by the community-led initiative. This give and take should be expressed through strategic re-wilding and the cultivation of building materials on site. Embd has a large decaying larch forest that can be harvested as construction timber – though unfortunately over the last few decades this alpine hinterland has been abandoned, the local timber economy has declined, and forest management neglected. This essay attempts to reverse this trend by reactivating a deeply-rooted, innate entrepreneurialism and to decompress the predicated pull from the metropolis. The continual use and maintenance of locally sourced timber by this community is the primary building material to achieve carbon positive buildings facilitating a circular economy within the common(s) framework.

# Architectures of (inter)Action

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Centro de Investigação em Arquitectura Urbanismo e Design (CIAUD) (Portugal)

The programme Architectures of (inter)Action aims to promote collaborative strategies between University and Community, in partnership with the public sector and local entities, to explore urban dynamics and architectural solutions with direct application in real contexts.

**Architectures of (inter)Action**
**Courtesy: Rita Ochoa**

Through an approach that brings together teaching, research, and professional practice, it is intended to instill in architectural education the importance of civic participation and interaction with the territories to intervene, as well as to encourage teamwork and the contact with other disciplines in the design processes.

Working the idea of *Architectures of (inter)Action*, these initiatives have been applied in different scales and contexts, from Master's orientations, to exercises in design studio, or open ideas contests with interdisciplinary juries. In parallel, a set of public exhibitions were held, inside and outside the university. More recently, teams of senior students were invited to intervene in vulnerable territories in the outskirts of Covilhã, through two proposals, "Pátio dos 80" and "Pontes", funded by the Portuguese programme *Bairros Saudáveis* (Healthy Neighbourhoods).

Apart from Healthy Neighbourhoods' experience, most of the resulting projects were not built. Nonetheless, we assume that just as important as the results are the dynamics generated. Students leave the *comfort* of the classroom, and the university opens its doors to the community.

Almost fifteen years after the first activities, we believe that a systematisation is required to improve and enhance future projects. Thus, we built this essay in two parts: first, a brief overview of the research programme and an atlas of the (inter)action initiatives; then secondly, a focus on the two ongoing projects that effectively will be constructed, under the collaboration with the Healthy Neighbourhoods Programme.

## ARCHITECTURES OF (INTER)ACTION IN THE CONTEXT OF MIA.UBI

The course of Architecture of Beira Interior University (MIA.UBI) began in the 2003-04 school year, integrated into the Department of Civil Engineering and Architecture (DECA, UBI).

After the start of the course, some local entities began to request of the university solutions to real architectural and urban problems, both in Covilhã and in nearby areas. These covered various scales of intervention, from the urban scale to the detail, including projects as simple as the design of public stairs, but also more complex issues, such as museums, the expansion of schools, urban infrastructures ideas, sports spaces, or memorials.

A large part of these suggestions was incorporated into design studio's exercises, involving collaboration with various local authorities, and motivating – almost automatically – an interdisciplinary approach. In addition to promote interactions between the university and community, these experiences have been developed with pedagogical objectives.

It is no surprise that these dynamics occur in a context of great proximity between the city and the university, integrating five hubs spread throughout Covilhã territory.[1] Adopting the idea of a project in *interaction with the community* (the antecedent of Architectures of (inter)Action), coordinated by Prof. Rita Ochoa, several partnerships were assumed, predominantly with the public sector through municipal and parish councils, often mediated by local entities, associations, or even religious brotherhoods. Different stages of the course were involved, namely the 1st, 2nd, 3rd, and 5th year's final thesis. Adjusting the proposed programmes to the objectives and level of complexity of the subjects, the development of solutions in real contexts through collaborative dynamics allowed both students and teachers to broaden their reflection on architectural practice. Since 2008, the following initiatives have beendeveloped:[2]

1.
The university complex of Beira Interior University resulted on the recovery of ancient buildings of great historic, cultural, and architectural value. During construction, it was possible to preserve some historical landmarks of the city and revitalise them in spaces for teaching and research. The old industrial buildings in Covilhã became, almost naturally, not only a logical solution and of continuity regarding the University physical expansion, but also an option that resulted in a huge benefit to the city, in urban terms and environmental impact, through the recovery of abandoned buildings or ruins that constituted a significant part of the Covilhã industrial heritage. This made the UBI a unique case in the Portuguese University, contrary to the contemporary tendency of a Campus in the peripheral areas of cities. In this process, it must be mentioned the work developed by the Architect Bartolomeu Costa Cabral between 1974 (the first works for the University – previously Instituto Politécnico da Covilhã) and 2004 (the Project for UBI's Library).

2.
Although there have been other interactions with the community in other MIA.UBI subjects, we chose to include in this chronology only initiatives developed in the programme of Architectures of (inter)Action, coordinated by Prof. Rita Ochoa.

2008: Thermal bath in Águas, Penamacor
2009: Thermal bath in Touca, Alpedrinha, Fundão[3]
2009: Space for the Portuguese Association of Disabled People, Covilhã
2012: I. Public space in housing contexts, Covilhã
II. Public exhibition in the Nogueiras neighbourhood[4]
2013: I. Intervention in a viaduct, Boidobra, Covilhã
II. Sports ring, Boidobra, Covilhã
2017: Memorial to the Ancestors, Ferro, Covilhã
2018: Memorial to the 2017 Fire Victims, Castanheira de Pera[5]
2018: Thinking about emptiness, Boidobra, Covilhã
2019: I. Thinking about the museum, space for dyeing plants, MUSLAN, Covilhã
2021: Pátio dos 80, Healthy Neighbourhoods Programme, Covilhã
2022: Pontes, Healthy Neighbourhoods Programme, Covilhã
Playing in urban public space, urban laboratory *Brin-Criar no Bairro*
2022: II. Thinking about the museum and the articulation with Ribeira da Goldra, MUSLAN, Covilhã

## INTER(ACTIONS) IN THE HEALTHY NEIGHBOURHOODS PROGRAMME

The Healthy Neighbourhoods Programme (HNP) is a Portuguese participatory public initiative to improve health conditions, well-being, and quality of life in vulnerable territories. HNP is based on small interventions with the support of associations, residents' collectives, NGOs, and neighbourhood movements in articulation with public entities. Mostly financed by the European Union, HNP was created in 2020 and, in 2022, is finalising its first edition.[6]

3.
Ochoa, R. (2017). UBI, architecture in interaction with the community. In: Constantin, S. (ed.), Local+Global: innovative symbioses in architectural education. Barcelona: Archi.Med.Es/UPC/ETSAV. pp. 72-75.

4.
Costa, J.P., Ochoa, R. and Matos Silva, M. (2015). Enfrentando cuestiones urbanas. La Enseñanza de la Interdisciplinaridad por el Proyecto de Urbanismo. *On the w@terfront*, 5(34), pp. 4–26

5.
Ochoa, R., Lacerda Neto, F. (eds.). (2018). *Memorial às vítimas dos incêndios de 2017. Narrativa de um processo*. Covilhã: Universidade da Beira Interior/Issuu.

6.
Progress of the programme can be followed at: Programa Bairros Saudáveis (n.d.). Bairros Saudáveis. [online] Available at: www.bairrossaudaveis.gov.pt.

7.
There were three levels of funding in HNP projects: €5000 for punctual action or intervention, €25,000 for community services, and €50,000 for small investments and integrated actions.

In the scope of its first open call, in 2020, the local association Beira Serra Associação de Desenvolvimento invited Architectures of (inter)Action to develop the architecture component of two projects, both consisting of public space interventions in peripheral social neighbourhoods of Covilhã. With an increased responsibility in building, the programme integrated as a new member of the team, the Building Technology professor and MIA.UBI director, Prof. João Paulo Delgado.

The first HNP project, Pátio dos 80, focused in the Boidobra's *80 fogos* neighbourhood, in the south of Covilhã. It is a partnership between Beira Serra, MIA.UBI's Architectures of (inter)Action, the residents, the Municipality of Covilhã, the Parish Council of Boidobra, and the public health unit ACES Cova da Beira.

The proposal fitted in the category of €5000 projects,[7] and aimed a development of the neighbourhood's public space for collective and multifunctional use, adopting the concepts of an urban courtyard (*pátio*) and orchard (*pomar*). This application was a continuation of the academic exercise with MIA.UBI's students – the ideas competition Project in Interaction with Community. Thinking about Emptiness – in 2018. It aimed an intervention in a vacant and unused space of about 200m² between two façades.

Three years after this exercise, it was decided to form a team with some of the students who had previously participated in the competition – Flávia Pinto, Hannah Figliolino, Leonardo Ramires, and Sofia Müller who were all now in their fifth year of studies. The team took some of the winning projects to conceive of a new proposal consisting of a pavement, set of shaded convivial areas, and planters with aromatic herbs. We worked on the execution of the project and by summer 2021 the project was completed, led by the parish council in collaboration with students, residents, and members of Beira Serra.

The second HNP proposal, Pontes, focused on Nogueiras neighbourhood in Teixoso, in the north periphery of Covilhã. It was a partnership with Beira Serra, Architectures of (inter)Action, the residents, the Municipality of Covilhã, the parish council of União das Freguesias de Teixoso e Sarzedo, and the public health unit ACES Cova da Beira.

The proposal fitted in the category of €50,000 projects, and was intended to benefit 160 resident families and encourage

non-residents to visit, transforming abandoned common areas into safe places for multiple activities. It was proposed that some community infrastructures would be installed – a bread oven, benches, and vertical planters – and a community centre for several neighbourhood activities would be formed through the re-use of a garage, *Garagem 33*.

Such as in Pátio dos 80, a similar programme had previously been addressed through an academic exercise with MIA.UBI's students – the ideas competition Project in Interaction with Community. Public Space in Housing Contexts – in 2012. It was an exercise for Projeto I Design Studio, in which students designed a barbecue area, playground, space for community gardens, small auditorium, and a community centre as *Garagem 33*. After a set of public sessions – one in the neighbourhood, one on the university – the process culminated in a public exhibition and collaborative lunch in the neighbourhood, the exhibition was also developed and constructed by the students.

A team of five finalist students was formed. One of the students, Ricardo Tereso, worked on the architecture of the community equipment, while another group of students – Flávia Pinto, Hannah Figliolino, Leonardo Ramires, and Sofia Müller again – approached Nogueiras neighbourhood and the HNP programme in complementary perspectives, feeding each and the architectural project through different perspectives resulting in four theses: *Metamorphosis in Common Space, Sew up the fragmented City, Space Interventions in Vulnerable Territories: Healthy Neighbourhoods Programme*, and *Playing in the Public Space*.

In parallel, these experiences integrated a set of collaborative approaches with Nogueiras' residents, such as a Play Laboratory with local children in April, 2022[8] and a set of public sessions with partners and residents to present the project in May, 2022. To implement the project, an *in-situ* construction workshop is planned by the end of 2022.

8.
On April 14, 2022, together with the Beira Serra, a Play Laboratory was held in Nogueiras neighbourhood with children aged 4-10 years, as part of the research methodology, and with the title *Brin-Criar no Bairro*. It consisted in a session of games and playing and aimed to observe and register how children relate to Nogueiras' open and public spaces, pointing out possibilities for the post-design of spaces to play, in the scope of the thesis Playing in the Public Space. In addition, as a transversal objective, it was possible to provide conviviality and interaction with the community of that context.


**Public Space in Housing Context, Covilhã, Portugal, 2012**
**Comic strip: David Oliveira and Francisco Henriques**
**Courtesy: David Oliveira and Francisco Henriques**

## ASSESSMENT OF THE WORK DONE (WHAT ARE ARCHITECTURES OF (INTER)ACTION FOR?)

Almost fifteen years after the first initiatives, a systematisation and balance is required to improve and enhance future projects.

Firstly, it is possible to conclude that, in general, students are perfectly capable of working on this type of register. Working in teams, dealing with real clients, and using the model of an open ideas competition with mixed and interdisciplinary juries – teachers, community members, local entities, anthropologists, sociologists, psychologists, artists, historians, landscape architects, and foresters – clearly motivated students and a led to a qualitative leap in performance.

At the same time, these interactions automatically motivated an interdisciplinary approach[9] to the exercises and link with other

9. Brandão, P. and Remesar, A. (2000). *Espaço público e a interdisciplinaridade.* Lisboa: Centro Português de Design

subjects. The students moved their attention to disciplines including urban design, landscape architecture, public art, and urban sociology. Topics such as public space, citizen participation, or design accessibility were brought into the classroom.

Another relevant idea of Architectures of (inter)Action – perfectly illustrated by the comic strip conceived by two students showing their project in a community session – is the exploration of alternative and expressive ways to communicate the projects, different to those typically employed by architects.

Though these experiences can motivate the students, they also require rigorous planning and preparation for unpredictable situations. To students, it is important to understand all the conditions of their work on the projects, including evaluation.[10] Also, they should not perceive such experiences as *extra work* or *working for free*. It is important that students work in groups, simulating future professional contexts and encouraging discussion. For the works in residential contexts, and particularly those in vulnerable territories, all stakeholders – university, external entities, residents – must be aligned so as to avoid a sense of *space invasion*. In this specific situation, it is an advantage that local associations can act as mediators between the university and focus communities.

Whenever possible, it is important to promote interim presentations and debates to enrich the final outcomes and enhance interaction – in fact we would prefer that *interaction* turns into *participation*.

Finally, it is vital to disseminate the work done as the ecology of shared learning is very important.

## WHAT ARE ARCHITECTURES OF (INTER)ACTION FOR?

With few exceptions, most of the Architectures of (inter)Action's resulted in projects that were not built. Nonetheless, we assume that as important as the results are the dynamics generated and processes developed. Students go out from the *comfort* of the classrooms and make contact and intervene with physical and

10. For example, a work that wins the ideas competition is not necessarily the work with the highest mark, as it must attend the rules of the discipline, and of continuous evaluation.

social spaces. Also, students perceive their work as more *useful*, because there is – even temporarily – a consideration of the issues relating to the city they inhabit. Besides, the university opens its doors to the community and produces useful knowledge. Across the board, we want to give visibility to the UBI's course, developing its identity, which we strongly believe is related to this *modus operandi* that takes advantage of its peripheral condition.

Collaboration with the HNP has made this pedagogical line grow. Through the use of funds to build and develop permanent dialogue with partner entities, an increase in the exigence and responsibility with the community has grown.

In this sense, it is interesting to see how some recent works have already benefited from these experiences, in a ricochet effect. In the current school year, in the context of an (inter)Action with the UBI' MUSLAN (Museum of Wool), part of the exercise was carried out *in situ*, inviting the students to work directly in the place, transforming MUSLAN into an architectural office open to the community through temporary use.

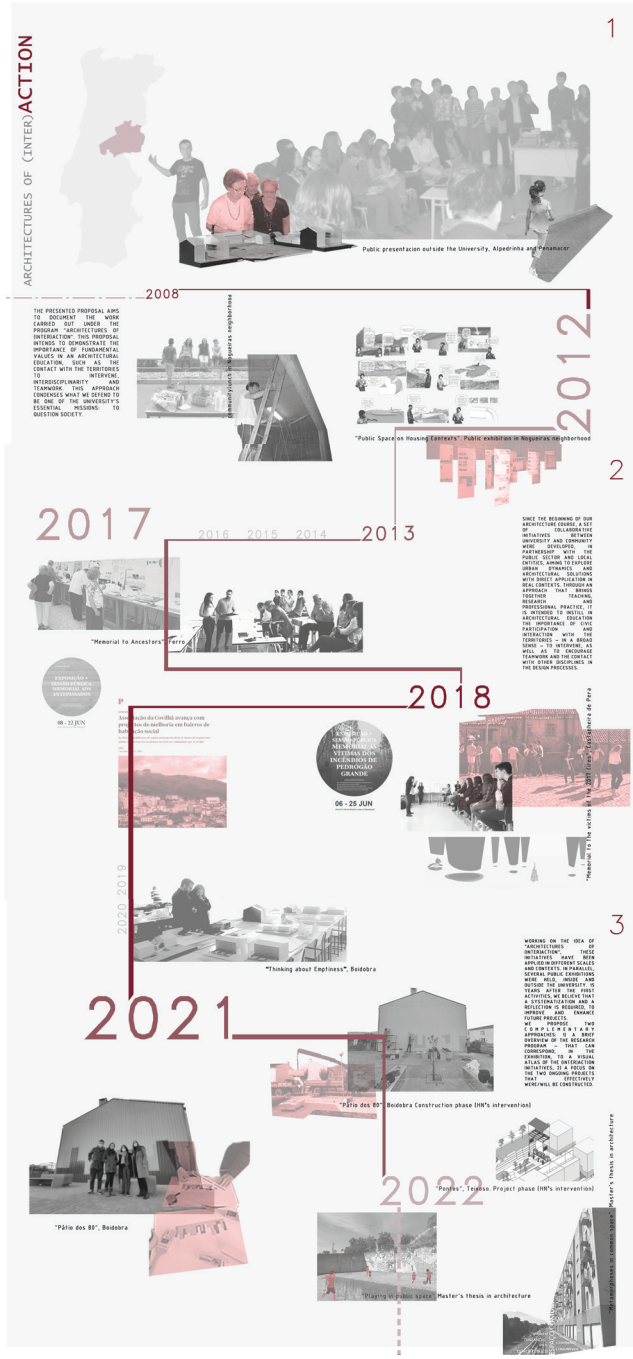
## IMPACTS IN ARCHITECTURE EDUCATION. HOW TO TEACH ARCHITECTURE IN THE 21ST CENTURY?

Developing practical exercises in concrete territories, architecture's teaching requires us to address urban problems with different disciplinary approaches,[11] developing the potentials of the disciplinary training of the course, but also confronting students with the need to seek knowledge to deal with transversal problems.

More complex and dense, the project site is today harder to understand without lengthening the focus. In teaching by project, it is the *place* that summons interdisciplinarity. Thus, it is vital to approach it actively, in all its dimensions: physical and socioeconomic, looking to the present, but also to its future potential in a society in accelerated change.[12] The opposite is also essential: project design studio is a privileged pedagogical space to introduce and consolidate interdisciplinarity.

11. Costa, J.P., Ochoa, R. and Matos Silva, M. (2015). Enfrentando cuestiones urbanas. La Enseñanza de la Interdisciplinaridad por el Proyecto de Urbanismo. *On the w@terfront*, 5(34), pp.4–26

12. Busquets, J. and Correa, F. (2007). Cities X lines: a new lens for the urbanistic project. Cambridge, MA: Harvard University, Graduate School of Design.




**Architectures of (inter)Action in the Healthy Neighbourhoods Program, Chronology of interventions**

**Courtesy: Hannah Figliolino and Rita Ochoa**

Teaching project design studio implies a permanent attention to the societal dynamic. In the complex and multifaceted contemporary city, in which urban problems does not have a discipline, the role of the teacher becomes vital to open interdisciplinary horizons, welcoming contributions from other areas of knowledge, or reinforcing the breadth of problems to be solved, in the context of the classroom.

In this way of working, a useful meaning and an implication in urban problems are called for a project design studio. Also, the produced solutions are tested and confronted with urban actors and with the community. We defend a broader approach to teaching, as we defend that architects can be more than mere constructors of physical and material realities – they can be social agents.[13] [14] Once again, the project design studio can be reinforced as space of debate and for a disciplinary synthesis.

Architectures of (inter)Action becomes demonstrative of a way of *doing* and of a way of *teaching* architecture within contemporary challenges. It condenses what we considered to be one of the essential missions of the university: to question society. In fact, it is up to the teaching a dimension of public intervention and citizenship – informed, responsible, collective, and constructive posture – in which the sense of the community, that we all form, prevails.

13.
Awan, N., Schneider, T. and Till, J. (2011). Spatial agency: other ways of doing architecture. London: Routledge.

14.
Venturini, Gianpiero (2019). ATLAS of Emerging Practices: Being an Architect in the 21st Century. New York/Barcelona: Actar.

# Biogenic construction: Thatched building façades for the green transition

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## BACKGROUND

The project is based on a collaborative ambition across industry and academia to explore and enhance the idea of absolute sustainable architecture based on biogenic materials – under the heading *radical tectonics*.[1] It is funded by the Danish Environmental Technology Development and Demonstration Program (MUDP) together with the involved partners. It is organised as a practice-oriented research collaboration between craftsmen, fire engineers, and architectural researchers represented by two master thatchers, one clay-mason, The Danish Institute of Fire & Security Technology (DBI), The Office of Thatching (*Straatagets Kontor*/Secretariat for ITS - International Thatching Society), and the Center for Industrialised Architecture (CINARK) at the Royal Danish Academy.

1. Beim, A., Zepernick Jensen, J. and Arnfred, L. eds., (2019). *Circular Construction Materials Architecture Tectonics*. [online] Copenhagen: CINARK, The Royal Danish Academy of Fine Arts, Schools of Architecture, Design and Conservation, School of Architecture. Available at: https://issuu.com/cinark/docs/circular_construction_080919_low.

Fire-safety is central when aiming to develop absolute sustainable architectural solutions with biogenic building materials. This project sets out to investigate how material choices and radical tectonic solutions can act as drivers for a sustainable change in the construction industry, building legislation and architectural practice focusing on surface treatments and construction design. The aim is to provide credible suggestions for $CO_2$ neutral construction types with environmentally low impact, *close-to-standard* fire-retardant properties, and a scalability to an industrial level. In this context reed is a very interesting material as it has a fast growth period, can absorb a range of critical greenhouse gases and sustains biodiversity.[2]

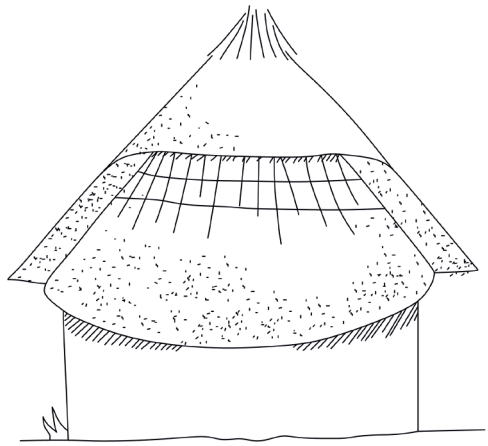
## HISTORICAL DESKTOP RESEARCH

Desktop research shows that clay has been used as a fire-retardant in historic buildings, with the insertion of clay into floor slabs described in the earliest Danish building regulations from 1956.[3] Observations made on chimneys in vernacular architecture constructed with boards cladded with clay also describe how wooden construction persists after many years of use.[4] Although no historical accounts describing a correlation between thatched façades and clay as a fire-retardant have been found, an interesting historical source from Southern Denmark indicates that clay has been used in combination with straw. A building permit from 1889 sets a demand that thatched roofs must be sprayed with an underlay of clay over the doors, indicating that the technique was employed as a fire-retardant to secure a safe escape route. Furthermore, the Danish reference work for applied building techniques from 1949, describes a technique of dipping

2.
Andersen, L.H., Nummi, P., Rafn, J., Frederiksen, C.M.S., et al. (2021). Can reed harvest be used as a management strategy for improving invertebrate biomass and diversity?, *Journal of Environmental Management*, 300, p.113637.

3.
Engelmark, J. (1983). *Københavnsk etageboligbyggeri 1850-1900: en byggeteknisk undersøgelse*. SBI-rapport. Copenhagen: Statens Byggeforskningsinstitut. p.142. (Copenhagen: Statens Byggeforskningsinstitut. 1983).

4.
Kristensen, E.T. ed., (1987). *Gamle folks fortaellinger om det jyske almueliv, som det er blevet ført i mands minde, samt enkelte oplysende side stykker fra øerne*. [online] Internet Archive. Copenhagen: Busck. Available at: https://archive.org/stream/gamlefolksforta01krisgoog/gamlefolksforta01krisgoog_djvu.tx



**Historical Gable Lolland, Copenhagen, Denmark, 2022**
**Courtesy: Henriette Ejstrup and Lykke Arnfred**

the straws in clay and ammonia adhesive before the reeds were fastened on the load bearing structure.[5]

Façade thatching has been commonly used in vernacular architecture, with the use of reed manifested in three different ways:

1) Straw was nailed to the outer wall with battens, protecting the lime washed wattle and daub or adobe stone wall from weathering and functioning as an inhibitor to protect the main construction from tear.

2) The twist gable technique, in which several twists of reed are tied. The twists are held in place in the gable by vertically placed wattles and stacking of twists.[6] This technique was most likely used to provide airflow within structures including pig stables.

3) Finally, the thatched gables of *Lolland*, in which roof thatching is extended onto the gable by a small overhang construction forming a portico.[7] It can be considered that this gable is a refinement of the much older and more provisional twisted gable.

5.
Kjærgaard, P. ed., (1949). *Byggebogen 348.91 Stråtag - marts 1949*. Copenhagen: Nyt Nordisk Forlag.

6.
Kirk, F. (1979). Tre primitive sjællandske gavle. In: *Arkitekturstudier tilegnede Hans Henrik Engqvist*. Copenhagen: Arkitektens Forlag, pp.160–163.

7.
Sebro, L. and Realdania Byg & Byg eds., (2020). *Stines Hus på Lolland - lollandsk egnsbyggeskik*. Copenhagen: Realdania By & Byg.

In the Netherlands, façade thatching has increased in popularity over recent decades, perhaps in part due to the increasing green transition in the building industry.[8] It appears as though the success of the building technique is related to a national narrative of traditional thatched façades, though the research of this project proposes that the only tradition connected to Dutch façade thatching is upon traditional mills, and that other building typologies have never had a tradition of façade thatching.[9] Yet, cultural *anchoring* seems to be the reason of the successful reintroduction of thatch in modern Dutch architecture.

Few modern houses have been built with thatched façades in Denmark. Most spectacular is the *Vadehavscentret* (The Wadden Sea Centre) by the town of Ribe by Dorte Mandrup Architects, illustrating the plasticity of reed in its expressive form. Other projects with thatched façades are cottages, garages, and family homes. A common denominator amongst Danish examples is that innovative sustainable constructions are generally quite conventional, that is apart from the *Vadehavscentret* with an elaborated fire-control plan due to being a public building – fire-retarding solutions are produced through use of a fiberglass membrane and mineral wool within thatched roof constructions.

### FIRE TESTING

Fire tests are based on the Danish Building Regulation (2018) and designed as a function-based approach, used when materials and constructions differ from pre-accepted (standard) solutions and thus requiring testing and documenting individually. Furthermore, the test only focuses on the thatched layer of the façade and not the construction in general.

Initially, it was decided to carry out a broad investigation of mineral based fire-retardants. The decision making of the

8.
See: Vakfederatie Rietdekkers (n.d.). *Geschiedenis*. [online] Available at: https://www.riet.com/riet/geschiedenis.html, and ITS (n.d.). *Dutch Federation of Thatchers*. [online] International Thatching Society (ITS). Available at: https://thatchers.eu/content/holland/.

9.
See: Holland.com (2012). *The purpose of windmills in the Netherlands*. [online] www.holland.com. Available at: www.holland.com/global/tourism/travel-inspiration/traditional/functions-of-windmills-in-holland.htm, and van Hemert, M., van Rooden, M.W.J. and Dijkstra, H.T.D. (1990). Het weke dak: riet- en strobedekkingen. Zeist, 's-Gravenhage: Rijksdienst voor de Monumentenzorg; SDU uitgeverij.

**Mini-SBI Prototype, Copenhagen, Denmark, 2022**
Courtesy: Anne Beim


**Full Scale SBI fire test of profiled version, Copenhagen, Denmark, 2021**
Courtesy: Thorbjørn Lønberg Petersen

variation and combination of the materials and techniques for application had the format of an explorative research study, where the experiences and observations of thatcher, architects, and fire engineers – alongside documentation found in literature studies – were listed and combined resulting in fourteen items. The fire-tests were executed as Mini-SBI tests (Single Burning Item test (EN13823)). The small rig for the Mini SBI consisted of inwards angled corners constructed by calcium silicate plates size 235mm x 15mm and 220mm x 20mm and a thatched layer of approximately 50mm reed.

The reed had to be fixed with metal straps instead of the commonly used metal fixes and screws. In that sense the testing standard happened to be a critical first-hand challenge since the small rig for testing usually is designed for industrialised products which can be cut to measure, not crafted solutions that are formed on site.

The mini SBI-test indicated that sprayed clay, dipped adhesive clay, and dipped clay-ammonia mixture held technical fire-retardant properties equivalent to Class B reference material FIRAX, defined as a fire impregnated MDF board with the properties of a FIGRA-value of approximately 110 W/s.

It was decided to test the three best results as a full scale SBI-test (ISO 13785-1: 2002 (E)). The rig was downscaled to a 1200mm x 2400mm flat construction sandwich comprising elements of calcium silicate and fireproof MDF with a thatched reed layer of 220mm-250mm. The boards were mounted on a wooden frame 400mm height above the ground without any façade openings. Three prototypes were developed:

1) a fully impregnated prototype with plain surface and moraine clay sprayed into the surface layer (50mm-70 mm) of the construction;

2) a fully impregnated prototype with clay sprayed into the surface layer (50mm-70mm) of the construction and integrated clay-boards placed as a firestop every metre to create relief in the surface of the reed; and

3) an un-impregnated plain prototype for baseline readings.

The baseline (prototype 3) showed a FIGRA over a 1000 W/s. The test of prototype 1 was incomplete as it had not been mounted correctly on the rig, resulting in a fire spread on its reverse side due to a chimney effect. Despite this, unburnt pockets of clay and observations of the fire spread suggest that the clay was effective as a fire-retardant, with a FIGRA measurement of 140 W/s. The test of prototype 2 was successful and showed a FIGRA of 25 W/s, with observations indicating that the clay boards as well as the relief profile had a preventative effect upon the fire spread.[10]

## PROTOTYPING

The materials and methods used in the SBI-tests have pointed to new tectonic strategies and fabrication methods that have been elaborated and tested as full-scale prototypes. As part of the next step a full-scale biogenic prototype of a building corner was designed and built to study buildability and architectural character. The architectural design sought to incorporate the data and the knowledge of buildability experienced during the fire test.

10. Beim, A. (2021). Ler som brandhæmmer - det dur. *Tæk*, [online] 2, pp.20–21. Available at: https://straatagetskontor.dk/wp-content/uploads/2021/08/Taek02-2021.pdf.

The load-bearing structure was made of straw filled wooden cassettes (EcoCocon) and the exterior of the straw elements were clad with wood fibre boards (Agapan) and thatched with reed. The reed was treated with clay before thatching and sprayed with moraine clay on the exterior surface. Clay boards were also built into the façade similarly to the test construction. The interior surfaces were treated with clay plaster as well.

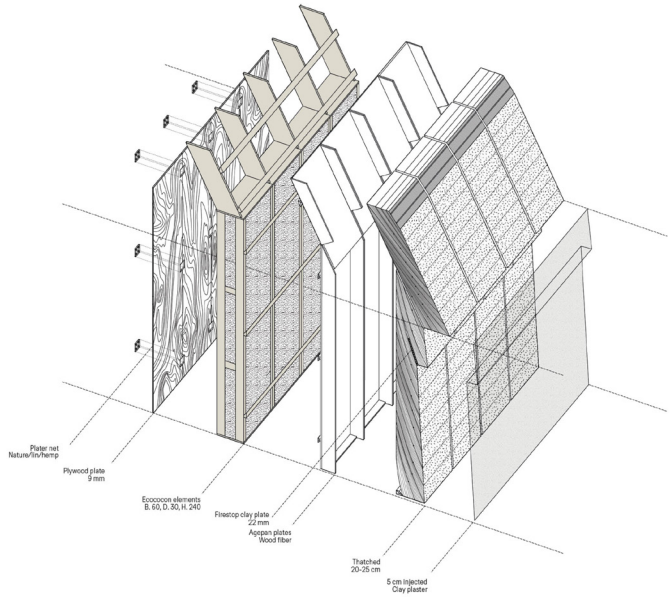
The biogenic construction pointed to tectonic solutions with no ventilation gaps between the layers, as used in conventional wood constructions. This secured a permeable construction with a high performing u-value enabling the avoidance of using plastic vapour barriers. Wooden fibre boards were introduced as both a wind barrier and underlay sheet for fastening the thatch. Discussions on whether the reed must be ventilated or not occurred, but Dutch research indicates that it may not be needed.[11]

The load-bearing elements were screwed together, and their position marked to secure a strategy for disassembly. However, the disassembly proved to be more problematic than expected – the marking of the screws was carried out after the EcoCocon elements were assembled and were found to be marked incorrectly. Furthermore, the screws were fastened on the inside of the wooden cassettes, making access problematic.

The initial prototype – as house corner – was put together in the exhibition hall of the Royal Danish Academy as part of a school exhibition during winter 2021/22, then partially taken down in March 2022. A smaller piece of the house corner was placed outside from March until July for observation of weathering and mechanical tear of the construction and clay impregnation. No severe wash-off emerged during this period, but human interaction did cause the clay to crumble off.

For the next stage of the Lisbon Triennale a new biogenic prototype with thatch has been developed as prefabrication based on Design for Disassembly. The idea is to design the thatched structure as separate elements to fit the structure within the

11.
van Herpen, R.A.P. and Drost-Hofman, M.S. (2012). *Brandveiligheid Rieten Gevels*. [online] Utrecht: Nieman Raadgevende ingenieurs. Available at: www.riet.com/media/vfr/pdf/Brandveiligheid_rieten_gevels.pdf.




**Prefab section, Copenhagen, Denmark, 2022**
**Courtesy: CINARK**

low-ceiling of the exhibition venue and to aid long distance transportation. It is essential that the assembly can be carried out at the exhibition site by two people and handheld tools. Again, EcoCocon straw elements have been included due to the ambition of keeping upfront carbon emissions low and their ability to be stacked, with Agapan wood fibre boards included for similar reasons. The EcoCocon straw elements and the Agapan wood fibre boards have been assembled and the overall buildability tested in a workshop together with thatched façade elements (cassettes) that can be mounted via an interlocking system of bevelled battens. The clay fire retardant will be sprayed to finalise the surface following assembly.

This construction diverges from the previous prototype – there will be a ventilated gap between the load-bearing construction and the thatched cladding element although the reed is still not ventilated. As the prototype is exhibited indoors, some details are not yet resolved. These relate to the tectonic principles of thatch where reed bundles are screwed together with metal wires in continuous assembly, a process which has no technical tradition of disassembly for further reuse without downcycling. Therefore, a Design for

Disassembly principle of thatch points to a radically new tectonic understanding of thatched constructions and the craft of thatching.

Thatching in a small, angled element is a true challenge, although the thatchers involved showed it is possible. For this, selecting reeds with the right properties for the project is highly important. Ultimately, the design strategy points to industrialised assembly of thatched façade elements, where thatchers act as specialists and construction inventors rather than traditional craftspeople. Another point of attention is the wall footing where the thatched façade meets the thatched roof. This detail is quite critical due to weathering of the surface and for technical reasons including needing to shield the load-bearing construction from water. All these aspects need to be studied further as they represent fundamental issues that must be resolved in a larger web of interests and stakeholders to be fully implemented in the construction industry.[12]

## PERSPECTIVES

The challenges ahead are to define technical standards within the framework of the building regulations and fire requirements in the EU, and further development of construction components that can be claimed to be 'radically tectonic', must be tested in the building industry and made available to market are essential for this. The prototypes developed as part of this project have pointed to radical tectonic concepts where many aspects must still be resolved. In this project reed and thatch are set to transition from traditional handheld crafts into more industrialised processes. This will call for novel tectonic strategies in the craft of thatching since it has not advanced at systems level noticeably over the years.

During the construction of the *technical* prototypes for the fire-tests, all involved professional partners/disciplines were involved, enabling an iterative and ongoing discussion regarding buildability, scalability, and technical predictions/development. In addition, for the full scale and more elaborate architectural prototypes developed for the exhibitions, craftsmen and architects worked closely together to advance the designs and developed

12. Greenfield, A. (2018). *Radical technologies: the design of everyday life*. London; New York: Verso.

**Close-up**
Courtesy: Lykke Arnfred

**Exhibition construction opening**
Courtesy: Pelle Munch-Petersen

strategies for construction and industrialisation plausible.

The fire testing (Mini SBI / SBI) suggests that test standards might not currently be adequate for analysing biogenic constructions,[13] and new testing standards and methodologies must be developed to include the totality of construction. Furthermore, the fruitful experimental process across disciplines was essential to develop, elaborate, and discuss both conceptual strategies for the prototypes, but also physical output.

Perspectives on scalability and workflows on actual building sites was also discussed and concluded upon, whether it seemed like a plausible method or not. One improvement, implemented in the final stages of the last prototype, was a fire-stopper consisting of a clay board. The fire-stopper was not a part of the initial ideas, but it increased the fire-safety and combined several intentions and aspects across the involved disciplines, such as protection of the construction by use of architectural detailing.[14]

13.
Dragsted, A. (2022). *Biobaserede byggematerialer kan reducere CO2-udledningen*. [online] Building Green Together. Available at: https://buildinggreen.eu/together/2022/06/02/biobaserede-byggematerialer-kan-reducere-co2-udledningen/.

14.
Beim, A. (2020). Grøn omstilling med lodret tækkede bygningsfacader. *Tæk*, (4), pp.32–33.

# Construction cycles: Towards a new ecology of construction

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**Guaita Baur, Atelier Construction Cycles, JMA, HEIA, 2021, Fribourg, Switzerland**
**Courtesy: Raffael Baur**

Our work focuses on research on architecture through a pedagogy of making.[1] We are interested in exploring the tradition that values experience and the making as origins of knowledge, allowing us to observe our environment in a very specific way. This dimension implies a direct relationship with materials, fabrication and

1. We refer to the pedagogical culture of learning by practice from Rousseau, Pestalozzi, Froebel, Dewey, Montessori, and Kolb.

assembly processes and an understanding of drawing as a construction in itself; an understanding of architecture as a place where human, material and mental relationships intertwine.

Where is the value in the act of making in our present culture? Can we propose a possible recovery or re-enactment of this action?

By rethinking touch and corporeality as a form of active resistance in a context where the making has been drowned out by virtuality, we understand that craft can build up a special concern, interweaving contexts and sensorial human experiences and helping to develop a new integrity and sensibility in the construction of our built environment. We explore a making that moves towards care and concern for the multiple ways of being human.[2]

Reviewing the processual practices of Jean Prouvé (1901-1984) gives us a new way to understand circular economies and sustainability with intelligent low-tech solutions, leading to demountable and transformable structures, a clear message towards a new ecology of construction. This specific methodological practice reveals the experience of the two places: the places of *work* and of the *body*. We conceived the atelier as a series that builds up research about the foundations of architectural construction with the aim to place a cyclical conception of construction at the outset of the design process. We started by analysing a key moment of the history of construction through Prouvé's work and explored its potential to incorporate alterations and future transformations. The basis of our investigation is a direct testing of material and fabrication limits, rethinking the processes of production and use as a cyclical nature.

Supported by physical tools (drawings, models, and prototypes), our atelier[3] explores a conception of architecture transferred directly into the process of making. Learning is encouraged by developing technical and spatial skills, integrating *poiesis* into the construction process, encouraging development of capacities such

2.
According to Boys (2018) a special concern for context, human experience and "the detailed crafting of materials and spaces" can instill a particular attitude in the design process, which can be called "care – full" (full of care): Boys, J. (2018). *Cripping Spaces? On Dis/abling Phenomenology in Architecture*. Log, 42, 55-66.

3.
According to Sennet (2010) the *atelier* is a place where assimilation, in the form of tacit knowledge, unspoken and not verbally codified, became a habit, a thousand small daily gestures that end up constituting a practice: Sennett, R. (2010). *Ce que sait la main: La culture de l'artisanat*. Paris: Albin Michel.

**Guaita Baur, Atelier Construction Cycles, JMA, HEIA, Fribourg, Switzerland, 2021**
**Courtesy: Raffael Baur**

as intuition, imagination, and sensibility, and involving the body in the transmission of knowledge. Spatial propositions are constructed as a consequence of these frictions between the processual body[4] and the material constructions, and the relationship between care in the making and care in the act of design.

This experience can contribute to the development of a particular concern between the context and the human sensory experiences. In a world immersed in a crisis of physical production, we search for other forms of building and explore new formats of learning that reconnect construction to space, place, and to ourselves.

4.
The term used by Erin Manning (2007) relates as an-idea that sensing bodies continually run up against existing political structures: Manning, E. (2007). *Politics of touch: Sense, movement, sovereignty.* Minneapolis: University of Minnesota Press.

### CONSTRUCTION

Performing manual physical tests of the structural properties of a material or element connects students to the work under construction. Detailing develops naturally through tectonic exploration. The slow and tactile nature of the work encourages the development and understanding of detail as a key moment of construction and as a mediator, relating a structure to the body and to the subject perceiving it.

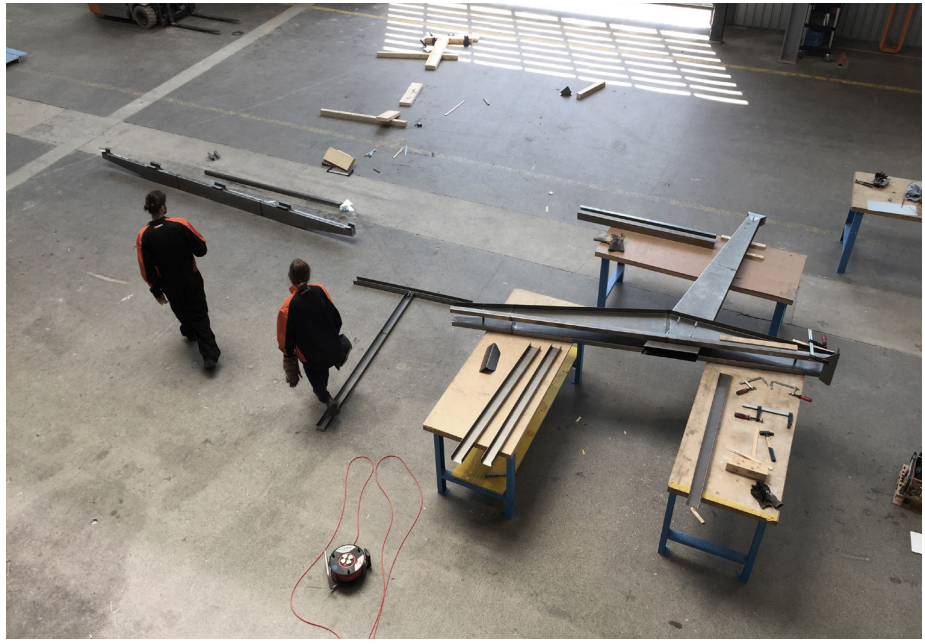
### DRAWING

We search to reveal the temporalities of the building. Made in parallel to the tactile experience of construction, the drawings are places, sites of negotiation that, with their fragmentary nature, transform an idea into a measured reality. The act of drawing can construct 1:1 scale devices where students understand place and scale,[5] so a corporeal way of measuring becomes an integral projective tool.

### CYCLES

In this process we develop a relationship with the work as a body, as a dialogue between bodies, where the constructed fragments become an extension of ourselves, linking the body with place and the act of building with human existence. This thinking in fragments helps students to manage complexity, to develop adequate and innovative solutions, and to conceive design and building processes in a cyclical nature. The work becomes a constructive process that reveals the bodies as itinerant fragments in continuous movement. The development of the project through the accumulation of corporeal fragments, mediating the intimate detail or element and the overall project, exhibits the traces of the construction performance. The students can experience time and memory, activating imagination and material consciousness understood as an extension of thought from the mind to the hand and to the material world.

5.
For Juhani Pallasmaa: "Understanding architectural scale implies the unconscious measuring of the object or the building with one's body, and of projecting one's body scheme into the space in question": Pallasmaa, J. (2012). *The eyes of the skin: Architecture and the senses*. New York: John Wiley & Sons. p.67



**Guaita Baur, Atelier Construction Cycles, JMA, HEIA, Fribourg, Switzerland, 2020**
**Courtesy: Raffael Baur**

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# Designing, building, and social science

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Recently, several prominent architectural educators identified a material turn in architectural education. This new type of design research, they argued, "... supplants drawings, models, diagrams, and all other forms of representation, for the sake of privileging full-scale constructions and installations that are ends in and of themselves."[1] They called this category of research *unmediated practice* or *one-to-one*. For them, design is conflated with construction as a way of working and "... the communicative realm of the representation gives way to the efficacy of the built artifact, and the a posteriori documentation of its construction and occupation." These unmediated practices can be framed as research due to the simple fact that they operate in a controlled laboratory-like environment. In other words, more can be made of one-to-one projects such as those created by educational DesignBuild if they can be structured as university research and/or as study models of architectural practice.

1. Brown, M., Sprecher, A., Weinstein, B., Brownell, et al. (2013). Design Frameworks. J*ournal of Architectural Education*, 67(2), pp. 255–257.

For architectural research, the inclusion of DesignBuild signifies a material turn from research based exclusively in words, drawings, photographs, and already built artifacts. It concerns the social, often ignored in building science. It is part of a larger trend to *new materialism*, a term "... ascribed to a range of contemporary perspectives in the arts, humanities and social sciences that have in common a theoretical and practical *turn to matter*."[2] The new materialism in the social sciences "... emphasises the materiality of the world and everything – social and natural – within it, ... [it] crosses boundaries between natural and social worlds ... supplying social theory with the means to re-immerse itself in a material world..."[3] Thus, there is an alignment between unmediated practices occurring in schools of architecture and the theoretical aspects of new materialism in the social sciences.

Since 2014, this affinity between DesignBuild and the social sciences has been explored in a major interdisciplinary research project, Thinking While Doing. Over the first five years it designed and built and studied a series of gridshells in locations across North America. The voices that follow represent the views of the social scientists and architects and some of our discussions and insights.

1.

As a setting, DesignBuild education includes many activities and specific circumstances that offer interesting data for consideration by social scientists. We – Claire Nicholas and Arlene Oak – are most familiar with how DesignBuild can be considered through the interpretive, qualitative approaches associated with some forms of anthropology and sociology.

As social scientists, we were directly involved in following and recording the activities and communications that occurred during the Thinking While Doing research project (TWD) and its several gridshell structures. The TWD project was organised to include a DesignBuild group and an Insight Group: the DesignBuild group

2. Fox, N. and Alldred, P. (2018). New Materialism. In: P. Atkinson, S. Delamont, M. Hardy and M. Williams, eds., *The SAGE Encyclopedia of Research Methods*. London: Sage, pp.1–3.

3. Ibid.

**Marché de producteurs, Chéticamp NS, Thinking While Doing Partnership, Dalhousie University, 2014**
Courtesy: Julian Parkinson

included architecture professors from a range of different universities who directly designed and built the series of structures, while the Insight group tracked and reflected upon the work of the DesignBuild group.

From the start of the project, DesignBuild education appeared as a rich area to consider through the lenses of the interpretivist social sciences, in turn offering a range of contexts through which to consider the collaborative creativity of architecture education. The gridshell projects involved individuals and groups influencing each other and cooperating across varied activities, from the visualisations required to imagine the future occupants of the pavilions, to the negotiations required to build within a manageable budget. Accordingly, DesignBuild education offers great scope for social scientists who are interested in knowledge transfer and the collaborative activities that allow imaginative concepts to be translated into the physical reality of site, materials, and use.

The social science's recent engagement with how humans are relationally entwined with (rather than distinctly separate from)

**Lafayette Strong Pavilion, Lafayette LA, Thinking While Doing Partnership, University of Louisiana, 2014**
Courtesy: W. Geoff Gjertson

materials, technologies, and spatial settings offers sociologists and anthropologists interesting topics to explore through the activities of DesignBuild education. For example, *micro-level* ethnographic studies might consider how DesignBuild professors and students organise themselves into teams, how students manage the authorship of highly-collaborative projects, and how students and instructors interact with community-based participants to ensure that both client needs and pedagogic goals are met. Other micro-level studies might explore how decisions about materials are negotiated, how the representational technologies of digital drawings and three-dimensional models are more-or-less successfully translated into *real* materials and full-scale structures, and how participants manage failure if a project is not successful. For social scientists who study the situations of everyday life, examining the *real* activities of designing and making structures that will *really* be used offers a great deal, since actual practice reveals the characteristics of projects and the challenges of collaboration.

The activities of DesignBuild are relevant for sociologists who seek to understand the institutional and/or interactional levels of society. That is, sociological studies of DesignBuild could consider the politics and economics of how a DesignBuild programme fits into a school of

architecture (that itself is one component within a larger institution); or they could compare different DesignBuild programmes or projects to consider, for instance, how projects that orient towards Public Interest Design (where the needs of marginalised communities are served) are similar to or different from those projects that emphasise structural, aesthetic, or technological innovation.

2.

An example of our work appears in a 2020 Design Studies paper on the notion of the *detail* – as it features in the architectural imagination – as a focal point for complex social, material, and technical practices on the ground, and as a privileged mode of ethnographic and ethnomethodological writing and analysis.[4] In what follows, we draw attention to the central arguments of that research: "In the imagination of prominent architects and architectural theorists, the architectural detail figures as both a promising and perilous element of built form... As fieldsites, the design-build architecture education programmes we followed drew our attention to the phenomenon of the detail, both as the material practice of joining disparate elements, and as the locus for complex social and professional relations. In short, practices of detailing reveal the integral roles of both social and material tectonics in the *art of joinings*." This opening remark performs the kind of analytical move that we insist upon as a key, but often under-estimated, insight: namely, the interactional, social, and cultural shaping of design, creative, and technical practices, and outcomes. These are not externalities to be controlled for or treated as *factors* to be accounted for and mitigated, but are constitutive of the arc of designing, particularly in collaborative contexts. Likewise, these processes work through productive frictions – social, material, and otherwise.

"DesignBuild education highlights the productive pedagogical and analytical potential of details that resist easy or stable joinings – producing friction and what Chad Kraus has called *salutary failure*"... In the first instance, therefore, DesignBuild education

4.
Nicholas, C. and Oak, A. (2020). Make and break details: The architecture of design-build education. *Design Studies*, 66, pp.35–53. See for references for Section 2.

foregrounds the importance of grappling with the implications of material and technical joinings (and how to allow for or *tolerate* their differences) in a hands-on and embodied manner. In the second instance, it prompts students, faculty, and other stakeholders to negotiate the joining of architecture as a profession and a field of knowledge with other ways of knowing – in practice. In other words, questions of professional ethics, relationships to proximate domains of expertise (such as engineering), and authority over or ownership of a built structure are performed in situated social interactions. These include settings such as design meetings in classrooms and on construction sites, the fabrication of prototypes in university design labs and workshops, the semi-public presentations, and discussions of designs in the juried review or *crit*, and even the ostensibly solitary activity of digital modelling or technical drawing in a studio setting. Very little of DesignBuild education is neat and orderly, as we see in instances where details are managed and enacted as both material and social process."

This quote captures another trademark feature of ethnographic and ethnomethodological approaches: that is, a commitment to holism and the complexity of social (and material) interactions as they unfold in real time, across multiple sites. DesignBuild activities entail a rich and heterogeneous set of contexts, and within these educational settings learning entails productive *frictions* along several axes, whose resolution allows the design (and learning) to proceed, while also generating new frictions in turn which must be addressed.

3.

We've outlined a few ways in which DesignBuild education might be of interest to interpretivist social scientists, but it can be argued that the perspectives of the social sciences offer relevant perspectives to DesignBuild educators. Many contemporary social scientists explore how humans are entwined with materials, tools, and technologies. Studying how DesignBuild participants translate meaning from sketches to models to construction drawings might enable designers or builders to pinpoint occurrences of social miscommunication. Further, social scientists could reveal a range of topics, such as managing a DesignBuild programme within the

**Sonoran Pentapus, Tucson AZ, Thinking While Doing Partnership, University of Arizona, 2015**
Courtesy: Chris Trumble

constraints of an academic schedule; challenging the limited participation by women or persons of colour in architecture education; or studying how members of a local community perceive the presence and work of DesignBuild students. If the participants of DesignBuild education – the architecture students, professors, and community participants – view some of their practices and experiences through social science perspectives, they might more readily recognise, question, and appreciate the social complexities and implications.

As a sociologist and an anthropologist who have closely followed the nuances of DesignBuild education – and who see its relevance as a kind of informal experiment in the socio-technical phenomena of experiential learning – we hope that professors of architecture will engage in similar cross-disciplinary collaborations. Partnerships between architecture and the social sciences are not always easily facilitated, as each has distinct discourses, ways of working, and creative outcomes, but through exploring how the material-spatial and social worlds continuously intersect and engage, collaborations between design build education and the social sciences have much to offer to each other and to wider communities of scholarship and pedagogic practice.

4.

As an architect, with a background in the social sciences, I (Ted Cavanagh) have been interested in the insights various social theories and methods bring to DesignBuild. There is certain comfort in making social processes explicit. For instance, the gridshells designed and built in the TWD project introduced new technologies to architectural students, social scientists, and the public.

Michel Callon is interested in sociotechnical projects in architecture. He studies projects similar to community-based DesignBuild: multiple players, multiple agendas, and real world issues of acceptance and engagement. Callon explains this in terms of a sociology of translation, aligning actors to a common programme of action. His four stages – *problematisation*, *interessement*, *enrolment*, and *mobilisation* – are fluid and depend on the definition and extent of the network.[5]

The *problematisation* stage of a translation process is a time to enrol human or non-human actors and form alliances based on similar interests. Actors position themselves as indispensable resources as a solution to problems they define. The core of the initial grant proposal was to build lightweight shell structures using different structural techniques starting with a grid shell and then others such as cable nets and diagrids. The agreed plan was to build each of the buildings in Canada in three collaborations between the lead university and each of the three other universities in turn. The process of innovation, of teaching, of exploration, and of dissemination would be documented and studied. The first-stage proposal was written by the lead researcher and signed by the other participants. As in many funding proposals, commitment was contingent on success, so the alignment of interests was not (con)tested.

Callon's second stage is *interessement*. This involves convincing other actors that the interests defined by the lead researcher are aligned with other participants' interests. Stage two of the

5.

Callon, M. (1986). Some elements of a sociology of translation: domestication of the scallops and the fishermen of St Brieuc Bay. In: J. Law, ed., *Power, action, and belief : a new sociology of knowledge?* London: Routledge & Kegan Paul, pp.196–233.

gridshell project started with a critique. The successful first-stage proposal came with the funder's suggestions for improvement. A DesignBuild network was added to align the proposal with one in Europe, engaging a new European partner. A face-to-face meeting of the DesignBuild teachers' group served two purposes: to confirm the actual DesignBuild and to align the network with the interests of the organisation of North American architectural schools.

The third stage, called *enrolment*, involves a definition of roles in the newly created actor-network. Initiators seek to convince other actors to embrace the underlying ideas of the growing actor-network, and to be an active part of the whole project. In other words, it is multilateral with negotiations, trials of strength and tricks that enable success. Enrolment occurred after the award. The first meeting combined discussions of organisation, governance and a visit to the first site. The discussions were complex and fraught with difficulty. Large sociotechnical systems needed to be addressed including staking out individual roles with actors aligning people and things to their point of view. Organisational issues competed with an impatience to get on with it. "Everything gets interpreted in the self-same moment as a connection is made in the form of action... Self-appointed *spokespersons* enrol others, especially the silent or silenced, who may be as much mineral as animal."[6]

The final stage, *mobilisation*, saw the adoption of the grid shell for all the built projects and support for the DesignBuild network from a couple of dozen schools. The initial project failed during the design phase after the not-for-profit organisation had escalated the project beyond feasibility. Realignment saw four simple grid shells near each DesignBuild school, with the fifth as a combined project. New local networks were initiated, and each school recommitted to the project reinforcing and modifying the relations between actors. The local networks each added new sites,

6.
Munro, R. (2013). Actor-Network Theory. In: M. Haugaard, ed., *The SAGE handbook of power.* London: Sage, p.134.

climates, programs, publics, university administrators, funders, property owners, and regulations. The diversity and complexity increased due to variations in suitable materials, safety requirements, skill sets, sustainability, maintenance, and other regional influences. Nevertheless, this localisation shored up the weakening commitment on the part of DesignBuild teachers after the failure of the initial project.

5.

In architectural education, conventional studios deal in imaginary processes and representations of material, or don't consider time and material at all. Simply put, time and material are abstractions. In contrast, DesignBuild studios – also known as *Live Projects* – negotiate real time and material. Time becomes a constant companion raising its own resistance and difficulties. Material resists and raises difficulties as well. This happens while designing and constructing.

Material is not just a full-scale property. In the world of computers what is happening is iterative, tweaking the gridshell form by centimetres; repositioning and recalculating every point on the surface. Saving incredible amounts of material with every tweak by improving the total structural performance. In the world of material models, what is happening is that plaster flows to find its own optimal form, interacting with the model maker who constrains the footprint of the mould and allows the rest of the mould to concede to the plaster's will. In the constructed project, the footprint is transcribed on the ground, the optimal form is established, and the optimisation of the material is computed. Each of them contributes to the final form and material distribution. Even the plaster has a predictive quality – for instance, it predicted a dip in the form around large openings that the computer failed to register.

Modelling, scaling up, and scaling down, is affected by the scale being used. Scale is not always a simple zoom of dimension. Often, it is an expansion and a contraction based on a particular parameter. For instance, wood doesn't scale up and down, neither do the connections. If the main purpose was to modify or validate the mathematical models of three-dimensional structural behaviour, then calibrations are made to account for this.

**Cape Breton Highlands, testing quarter-scale model, Thinking While Doing Partnership, Dalhousie University / University of Arizona / University of North Carolina**
Courtesy: Ted Cavanagh

Time is not linear, and it has different speeds. As Albena Yaneva says, "I follow architects as they fabricate models and scale them up and down at different rates of speed."[7] When moving into construction time changes yet again. Materials have a history of their own, a tree grows in a forest, then it is abruptly harvested, seasoned, and processed, wholesaled, then delivered to site. It enters into the critical path of workflow of fabrication and joining other materials in assemblies.

The concept of the *designerly* approach to time is brought into sharp relief in interdisciplinary work. Words like *rapid*, *immediate*, and *layered* describe a *designerly* approach to time; whereas *considered*, *episodic*, *reflective*, and perhaps *patterned* are descriptive of the social science approach. For Claire Nicholas, the issue of time and rhythms of working is almost always present: ethnography is slow, design is relatively fast. Ethnographic insight benefits from *saturation* – a point where patterns emerge, where new phenomena observed tend to align with previous observations

7.
Yaneva, A. (2005). Scaling Up and Down.
*Social Studies of Science*, 35(6), pp.867–894.

and insights. Over time an ethnographer can get to saturation more quickly – for example, if you study designers all the time, insights and patterns from one study might also re-appear and be recognisable in another. There's also a danger though that you'll be more closed-off to surprises and differences if you assume certain commonalities.

Some strategies to deal with many voices and many time frames might be found in the social sciences. Henry Sanoff argued that Participatory Action Research was appropriate for community design.[8] In addition, when extended to construction, as it is in DesignBuild, it is unavoidable. All DesignBuild is Action Research, and frequently it is Participatory Action Research. Moreover, Bruno Latour identifies controversy with two of the three different tasks of the social sciences which, for him, are "the deployment of controversies, the stabilisation of those controversies, and the search for political leverage."[9] Perhaps the experiences of Action Research and, perhaps, the parsing of time by isolating points of controversy are additions to the ways of studying what architects do.

The crossover between architecture and the social sciences is a particularly exciting addition to the processes of design and construction. It comes with huge questions generated by the additional complexity. For architects, materials and time were always complex. Adding social science is adding a partner that makes things at once more complex and more insightful.

8. Sanoff, H. (2000). *Community participation methods in design and planning*. New York: Wiley.

9. Latour, B. (2005). *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press.

# Digital Imperfection

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The imperfection of earth bricks is often understood as a synonym of low-tech construction in deprived communities. However, it is a simple, cheap, and, per nature, circular material to build with. With Digital Imperfection, we wanted to underline that earth is much more than a vernacular material. Our project links state-of-the-art approaches with local traditions by highlighting earth as a post-vernacular, contemporary building material.

## DESCRIPTION

Although Europe has seen a recent trend in using and studying earthen building methods, it is in the Global South that these techniques have developed most widely and achieved widespread use. As a vernacular solution, it has evolved over thousands of years in particular in Africa, South America, and Asia. Even though we can consider that these techniques gradually gave way to other construction methods, there are cases where earthen structures were highlighted by modern movements in architecture, as is the case of Egypt.

Digital Imperfection is a temporary installation made at the German University in Cairo (GUC) combining mixed-reality tools and earth as a sustainable and multifaceted material. The project involved two separate processes that came together during the final montage procedure; on one hand, the design of handmade earth bricks and on the other, the design of a parametric wall and the coding of the montage procedure on the mixed-reality platform.

The project aims to reconnect students and people with the handmade craft of using earth bricks through digital tools. The bricks manufactured by the students are stacked on a wall with the help of a HoloLens that works by overlaying a digital

4-dimensional model over the physical world. Despite the mediation of a digital apparatus, the idea is to engage students – or later the community – in a comprehensive workflow involving handmade production and interactive assembly rather than promoting a mere robotic process.

During the research phase, we analysed the following questions:
– What does *handmade* mean?
– How can we incorporate digital technologies without losing human interaction?
– How can *imperfections* in the handmade bricks be part of a calculative digital scheme?
– How can we bring elements of vernacular architecture to new generations through a technology-mediated exercise?

### MIXED-REALITY-INTEGRATION

The brick structure was developed with parametric design software that generated a real-time procedure directly streamed to the HoloLens, overlaying a digital 4-dimensional model over the physical world. This parametric procedure indicated the worker in a field of Mixed Reality (MR) where to pick up the brick and place it precisely.

In addition, during the assembly process, the height of the bricks had been constantly readjusted to account for the thickness of the mortar. This back-and-forth movement was a crucial point of this collaborative project, as the cycle evolved from the always unique interference of each participant. The main idea of Digital Imperfection was to place humans within the focus of digital assembly.

The benefits of the research are multiple: firstly, by introducing students or a community to the use of sustainable materials in combination with parametric design; secondly, by producing a digitally-designed installation (of relative complexity) without the need of printed documentation; and thirdly, by saving resources in the fact that no framework or printed plans are needed, as the building procedure and instructions are entirely virtual.

The research used HoloLens, a device developed by Microsoft consisting of a smart glass projection system and a complex array of sensors and cameras to *sense* its environment. The result is a device that can interpret its position in a given environment and

**Video of the installation and assembly process**

project information seamlessly into a transparent glass, which gives the impression of a *holographic* projection – that is, the superposition of digital imagery over reality. The HoloLens is Microsoft´s take on "Mixed Reality",[1] a combination of technologies that fosters interactions between real and virtual environments by using instinctual interfaces such as precise motion detection and environmental sensing. Mixed Reality is designed as a blend between physical and digital worlds, by seamlessly locating and positioning both in physical as well as virtual spaces. According to the HoloLens developer, Microsoft,[2] MR is a spectrum that has the physical world on one end and the

1. Speicher, M., Hall, B. and Nebeling, M. (2019). What is Mixed Reality?. In: *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. New York: Association for Computing Machinery. pp.1-15.

2. Wen, Q., Buck, A., Tieto, V., et al. (2022). *What is Mixed Reality?* [online] Available at: https://docs.microsoft.com/en-us/windows/mixed-reality/discover/mixed-reality.

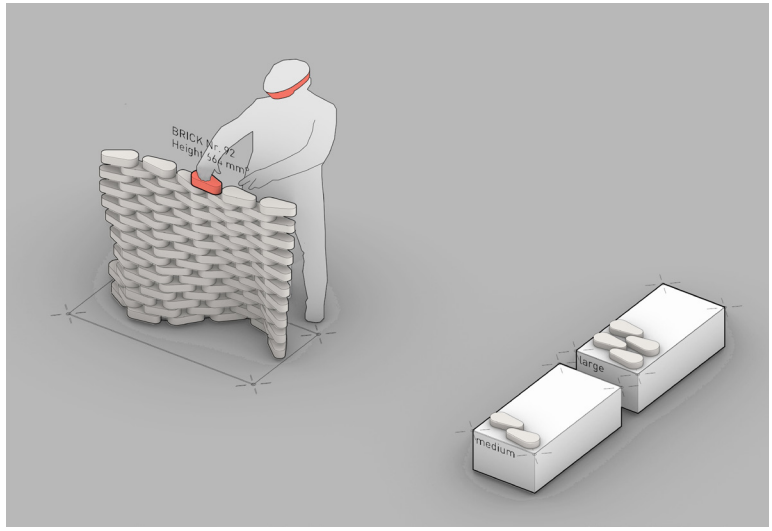
digital world on the other. Inside this spectrum, Augmented Reality (AR) is often understood closer to the *physical world* end and Virtual Reality (VR) closer to the *digital world* node.

## COLLABORATION

As a collaborative work between the elective courses *Unplugged Matter: Earthen Material* (UM:EM) and *Introduction to Robotics in Architecture* (IRA) at the German University in Cairo (GUC), research was intended to combine both core interests (Material Responsible Design and Digital/Parametric Design) in every stage. Regardless of the fact that within contemporary architectural discourse it is almost impossible to avoid digital technologies, the collaboration also proposed to augment not only the capacities of each sub-discipline, but also the perception – and auto-perception – of them by associating low-tech building techniques with hi-tech design procedures. What is interesting in this case was the fact that MR technologies such as AR and VR are becoming ubiquitous in everyday life – such as with real-time image and video filters in social media platforms such as Snapchat and Instagram – but their application in everyday design and construction work is still in rapid development. Besides the *augmented* view, we have been accompanied by a media artist and philosopher (MD) to have a differentiated view and perception about this cooperative procedure. It resulted in a narrative film documentation of the social sculpture by the three authors and the various disciplines involved – UM:EM, IRA, and MD.

The concept behind the collaboration was to hybridise these stages, blending both handmade analogue craft and digital techniques. As previously stated, understanding that most of the contemporary design procedures include more or less a digital component, we intended to maximise this feature by using parametric design or remote sensing instead of just using three-dimensional modelling or CAD drawings. The possibilities of digitalisation allowed us to parametrise a shape of the wall by using the brick as the modular element. By exploring both – the brick and wall – the combined design strategy could develop different dimensions and geometries of forms and their interactions.

In the following detailed design phase, the students of the UM:EM course explored several brick types with different earth




**Assembly procedure**

construction techniques such as mud bricks, compressed earth bricks (CEB), and rammed earth. The shapes of the bricks were diverse, as each student group tested and developed their own ideas, ranging from *tileable* shapes like hexagons, or traditional bricks, to other more complex forms with interlocked shapes and Tetris-like geometries. This stage was entirely designed with analogue tools such as sketches and models, trying to take into account the material qualities and characteristics including resistance, rigidity, overall load bearing capacity, and other visual features.

During this semester the teaching was influenced by Covid-19. During a lockdown we changed the idea from CEB bricks to handmade bricks by a wooden form that could be exchanged among the students. Students *rammed* the bricks by hand out of earth at home then let them dry until the assembly day. This increased and unusual imperfection caused by the distributed handmade procedure forced – or even inspired – us to deal digitally with a new challenge of different heights that had to be implemented into the digital design and build setup.

The design of the construction procedure was carried out in parallel by the students from Introduction to Architectural Robotics (IAR) and consisted of a wall composed of single bricks. The wall could have any shape, both in section and plan, with the possibility of having a slope, inclination, or curvature in any plane.

The solution for the wall definition was quite simple: a surface is defined by two curves or polygons (top and bottom), and if both curves have the same dimensions and are displaced in a vertical axis, the wall will be perfectly vertical, but if they are misaligned, offset, rotated, or scaled in any direction, then the wall or parts of it will be sloped. Finally, the wall was *sectioned* or *sliced* in horizontal lines that formed the guiding lines for the bricks. Each brick was then located over these horizontal lines, either aligned to it or re-oriented according to other criteria.

Lastly, the construction procedure was designed by both teams, while negotiating the particularities of the material and construction technologies and translating them to the digital project. The assembly procedure should also be embedded with the final design of the wall, the brick size, and their unique positions in the wall. Since the procedure would be performed with the HoloLens device, a certain differentiation between the different bricks had to be defined, for example, the bricks on the wall, the bricks on the pick-up area, and the *current* brick, the one that is carried by the user.

The intention was to create a seamless workflow that would allow the user to visualise any change in the design of the wall – either its overall shape or the position or type of bricks – in real-time, one-to-one scale, and superimposed to the actual site. It was also intended to account for different imprecisions such as geometric inaccuracies due to the manufacturing process, or mounting mistakes or discrepancies in the material thicknesses, for example in the mortar. Since these types of errors are embedded in the material and the construction procedure itself, the purpose of this research was also to create a design process that could effectively account for them.

### BRICK AND WALL DESIGN

The design of the earth bricks was an integral part of the UM: EM course. The students were divided into teams and each designed and manufactured several brick types, first in a digital medium, later as model, and finally in real scale with actual earth. Each brick needed to comply with a series of characteristics such as overall dimensions and geometry – that is, each brick should be handled by one worker without any mechanical assistance.

Also, they should have a number of flat sides in order to be stacked or recombined horizontally and vertically, and in any other possible combinations. Similarly, each brick ought to have geometrical characteristics to *lock* to these vertical or horizontal neighbours.

Added to these constraints, several bricks were tested in order to design different types of walls, starting from straight, vertical walls and then trying other combinations such as zig-zag and curved walls. With these particular parameters, the teaching team and the students selected the final design of the brick, an isosceles trapezoid with curved edges. The edges allow *articulation* of the bricks and the ability to rotate them incrementally without exposing edges, which would otherwise be a weakness of the material.

The wall was designed with a parametric design software (Rhinoceros Grasshopper) and at the same time, generated a real-time procedure that was streamed to the HoloLens device in the field. The parametric definition takes two curves – one on the bottom and the other one at the top – and creates a surface between them. If both curves are straight parallel lines, the resulting surface will be a straight surface, if they are not parallel the result will be a ruled surface. Finally, if one or both curves are curved, Rhinoceros will interpolate a surface connecting them, resulting in any number of complex surfaces like hyperboloid or paraboloid patches, among other irregular surfaces.

In the next step this surface is *divided* into rows according to the height of each brick row – calculated as the thickness of the brick and the mortar combined – resulting in a series of stacked curves parallel to the ground. On each of these curves a line of bricks will be laid, separated by a user-defined parameter.

Because of the design of the brick, the relevant characteristic is that the centre of the curved parts is aligned, this way the relative rotation angle between each brick can vary without compromising its structural capacity and the separation between bricks remains constant but the relative rotation might change while adapting to the wall geometry. The position of each brick is precisely defined in a three-dimensional space as well as its angle in the XY plane parallel to the ground.

### ASSEMBLY PROCEDURE

The position and rotation angle of each brick is pin-pointed in space, thus it is possible to stream it to the HoloLens user with precision. Due to fabrication issues, there were two different brick types, with two different thicknesses. This means that each brick row must maintain the same brick height and the user must be able to identify them easily. Since the difference in height was sensible but not easily noticeable, two different piles of bricks were defined, one with each brick type A and B. The parametric procedure indicated the user where to pick up the bricks – either pile A or B – and then where to locate them with precision.

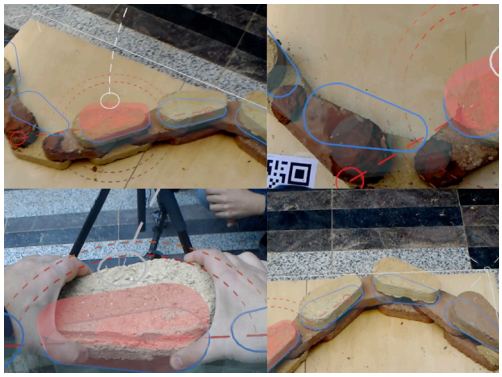
The assembly process required two people: a user or brick layer using the HoloLens device, and an operator manning the computer. The operator should control the overall procedure and select the *active brick*, that is, the one brick highlighted in the wall composition and streamed to the HoloLens device.

The bricklayer will receive the *active brick* location – either pile A or B – and also the final position in the wall. The HoloLens device highlights the location of the brick pile by projecting a dotted line from the brick to its final position on the wall.[3] The final position of the brick is highlighted in red, representing its location in the wall as well as its rotation. The bricklayer must match the physical brick to the HoloLens projection. Once the brick is located in its final position, the operator needs to switch to the next brick, defining a new *active brick*, starting the process again.

### HEIGHT COMPENSATION

One of the key difficulties in this research was to deal with the differences in precision between the three main components of the procedure. The parametric model was obviously the most precise of all, as it is mathematically perfect, but the HoloLens device has a small error due to its positioning sensors, and most importantly, the bricks have manufacturing *imperfections* that produce differences in their geometries. Finally, the application of mortar also adds yet another source of discrepancies.

3.
A video of the installation and assembly process can be seen at: Brum, R. (2022). *Digital Imperfection.* [online] Available at: https://vimeo.com/714403348.



View through the HoloLens

Bricklaying

In order to compensate for these errors, the parametric definition allows the operator to readjust every brick row in order to match the actual position of the physical bricks. This error compensation is performed after each row, with the feedback provided by the HoloLens user via visual aids projected by parametric definition. Once the operator makes the corresponding adjustments, the bricklayer should see the next row of virtual bricks exactly positioned on top of the last real brick row. This feedback procedure proved to be fundamental, and it was used every two or three rows, thus adjusting the virtual brick wall to the dimensions of the real one. Therefore, both walls were built *simultaneously*, each one continuously informing the other one.

## CONCLUSIONS

The benefits of MR devices in the field of construction are mostly related to the display of spatial and geometrical data in order to provide the user of contextual information for example for assembly or maintenance operations. In this case, MR technologies were combined with low-tech construction material – earth bricks – speeding the design process and avoiding the use of traditional construction documentation such as plans or sections.

The research questioned the relationship between high-tech and low-tech tools, measuring, and accounting for variations in manufacturing, montage, and design. It also intended to compensate and/or minimise such discrepancies within the design and its montage by establishing extra parameters and a feedback loop between operator and bricklayer.

The process accounted the different imperfections and heights, sustaining a constant loop with real-time feedback: the physical model updates with new bricks while the digital model is updated with corrected heights.

It is not only possible but exciting to use digital technologies to enhance and promote locally sourced materials. Particularly in countries of the Global South, a *technical* or *digital* enhancement may help communities to identify with their own material traditions and projects, as well as to participate in the planning and construction process.

With Digital Imperfection we underline that earth is much more than a vernacular material, and by involving digital tools, we can augment their use it in a contemporary, elegant way. We emphasise the collective experience of building with sustainable materials, using technology to create a shared understanding of building with the community's hands and to find a post-vernacular narrative for material that is available nearly everywhere.

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# Drawing at the speed of thought

Ilnar Akhtiamov, Rezeda Akhtiamova, Anna Guseva, Timur Abdrakhmanov, Artur Akhunov, Valeria Burkova, Daria Butorina, Artur Gilfanov, Adelina Gubaidullina, Adelina Abdullina, Marat Khafizov, Diana Kalimullina, Dina Kiyamova, Vladislav Krayushkin, Vladimir Obrosov, Olga Sinelnikova, Maria Svetovidova & Olga Yerukova
Kazan State University of Architecture and Engineering (Russia)

As the world changes elusively fast, architects should reflect on it even faster, and put their visions forward. Architectural hand drawing is the most powerful tool for seizing an image of future spaces and engaging audiences to implement them. Thus, teaching architects to draw quickly and intuitively requires a unique methodology, developed at TIArch Studio. The visions of *Terra* by TIArch Studio immerse the beholders in evolving hand-drawn landscapes, unveiling students' perceptions of the changing world through architectural drawings.

The language of architectural drawing speaks right to the heart of the beholder. It is intuitively clear and engaging, unlike more distant, exclusively professional means. In architectural education, hand drawing not only develops spatial thinking, but also allows the students to express their ideas quickly and thoroughly. This is drawing at the speed of thought.

At TIArch Studio, hand drawing is key to every work, from an initial sketch to entire thesis work. The Studio's unique methods of teaching architectural drawing let a student's perception of the world evolve. In a single process, abstract ideas and rhythmic games of geometric volumes turn into meticulous landscapes with tiny characters, their lifestyles, and surrounding urban patterns. Thus, the series of drawing tasks teach students to think from generalities to details, from the critically analysed past and present to the visionary future.

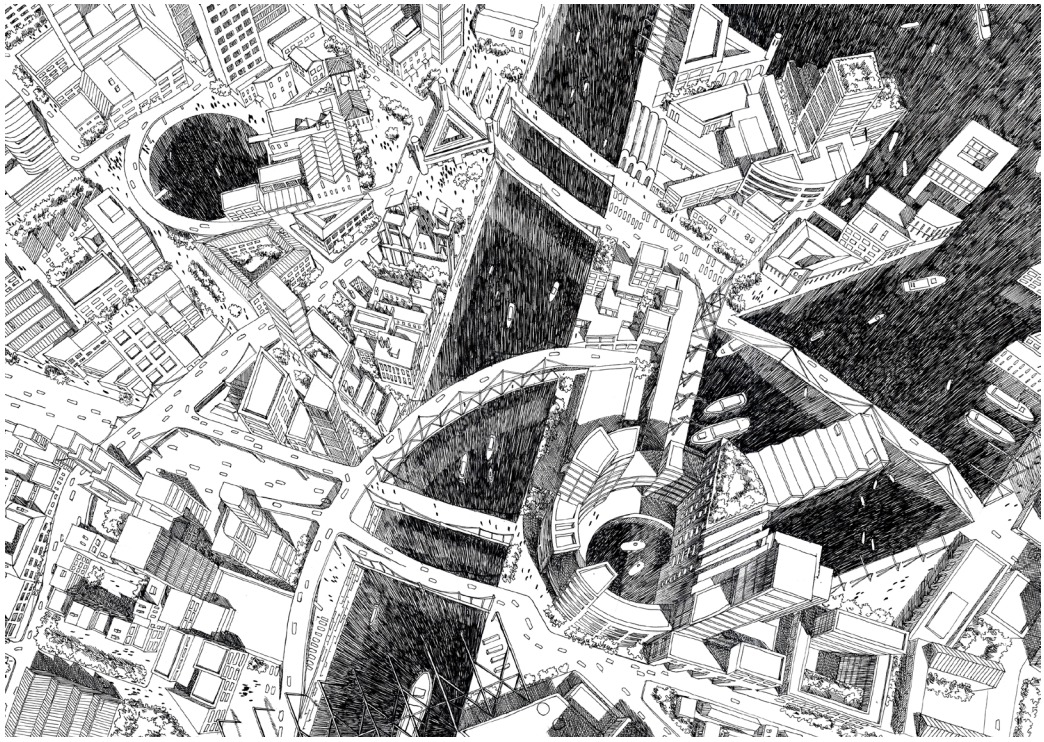
The freedom of thought in a drawing lets architects grasp visionary concepts for the future world, which are later reflected in real-life layouts, and façade patterns. Thus, the students' fantasy drawings help develop thoughtful and courageous architects, who will manage lifestyles in countless territories across their professional careers. Likewise, Steven Holl, the phenomenology practitioner, starts by creating sketches for each of his ideas. This intuitive and *handicraft* practice gives any project a mood, a primary direction, of which Holl has said: "The advantage of watercolours is the freedom to play with the intuition they provide. As a result, they are both conceptual and spatial. They allow you to make discoveries with the help of intuition."[1]

'TIArch *Terras*' have three parts: *Envisioned*, *Transformed*, and *Enlivened*. These graphic works, accompanied with poetic descriptions, immerse the viewers in new world scenarios, invented by the authors. The works are of differing scales, from a watercolour sketch to a detailed fantasy drawing in ink. The unique feature of the drawing method is that all perspective images are carefully proportioned by the rules of descriptive geometry. Given the meticulous details and elaborate perspective angles, one cannot help but admire the diligence of TIArch students, their incredible imagination, and the depth of the inner worlds, expressed in the drawings.

*Envisioned Terras* by TIArch students are autonomous worlds that follow their own lifestyles. Generally, they appear from raw geometry rhythms or intuitive sketches. The *Mount of Two Cities* has emerged from a 3D orthogonal grid, manually divided using an algorithm. When tectonic layers have been set, they are then animated with the daily life of two cities from contrasting cultures, coexisting in a fragile balance on a single rock.

*A World in the Kettle* has another origin. What at first was a highly proportioned still life with balusters and tableware has later been reconstructed from another – more dramatic – perspective. Then, using ink it was turned into a fantasy drawing

1. Belogolovsky, V. (2011). *A game of reflections and refractions. Interview with Steven Holl.* [online] archi.ru. Available at: https://archi.ru/press/world/34468/igra-otrazhenii-i-prelomlenii-intervyu-so-stivenom-hollom.



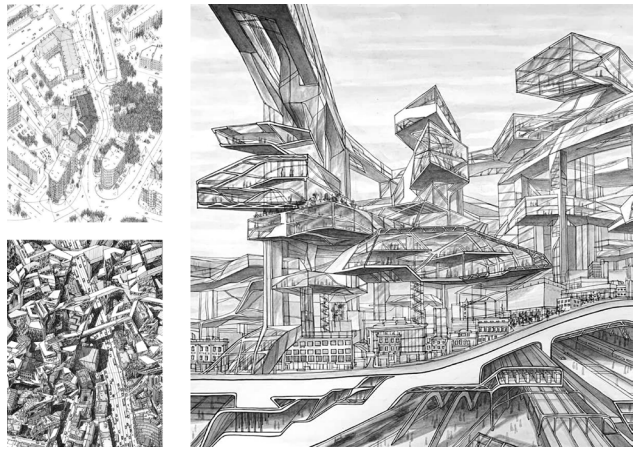
**Dina Kiyamova, "Sea City", Kazan, Russia, 2020**
Courtesy: TIArch Studio, KSUAE

of a bustling high-tech city, erected above the traditional districts. In the end, one finds it hard to distinguish which geometry or sculptural pattern was the drawing's starting point.

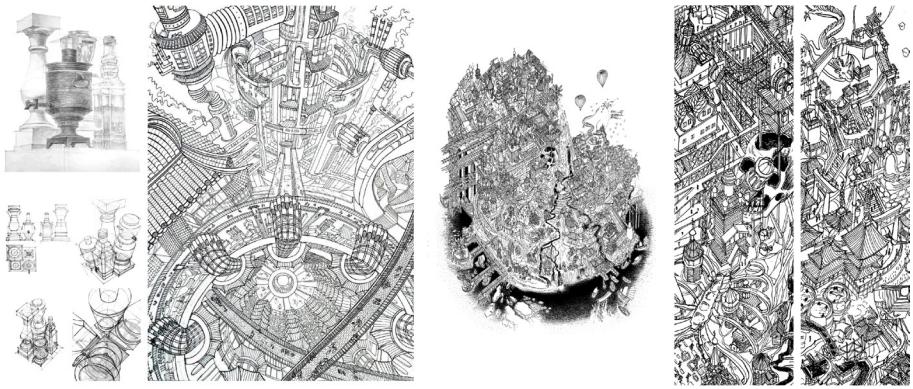
*Transformed Terras* by TIArch students constructs new living scenarios upon dystopian present urban views. They are inspired by plein air sketches, often carried out with a single line of an ink pen, to *feel the proportions first-hand*. Later, the sketches are transposed to become a larger ink-filled image or reconstructed from a bird's eye view. Afterwards, architecture students imagine brand-new scenarios in the familiar scenery, as if film directors. Future transport or space hubs, altered terrain or flooded underwater cities, movie scenes, elevated dwellings, or most daring avant-garde concepts – everything can come to life in TIArch *Terras*. In hand-drawn aerial and cross section drawings, future urban scenarios look credible, thanks to technical details and the author's unique spirit, reflected in the image.

*Enlivened Terras* by TIArch students perceive a future city as a sophisticated living structure, similar to interlinked human tissues. Over their final years of study, TIArch students rethink dense urban centres. How can the familiar city functional zones be joined more productively in the future? Which hybrid or brand-new occupations will future urban dwellers have? What will the city and neighbourhood centres look like throughout the present and coming centuries? Every student carries out their own research and develops a unique concept, constantly updated and later reflected in their thesis work – even if the thesis project is more connected to a present-day concept rather than global futurism.

One of the approaches to the future city that many TIArch students share is an organic structure, resembling the tissues of plants or human bodies. The city, like Earth's crust, reveals the layers of culture accumulated by generations. Yet, the city provokes urban dwellers into building new layers atop, as if growing new strata of living tissues. In future urban landscapes, balanced with natural rules, city dwellers may regain the awe of path-breakers. The city's life support technologies are visually open in some areas, provoking urban dwellers into ecological thinking and hands-on learning. Thus, our urban experience becomes closer to a natural one.



**"Post-City" triptych. Vladislav Krayushkin, "Kazan Street. Axonometry", Olga Sinelnikova, "Altered Kazan Street. Axonometry", "Altered Kazan Street. Section", Kazan, Russia, 2020**
**Courtesy: TIArch Studio, KSUAE**



**“Emerging Worlds” set. Adelina Abdullina, “A World in the Kettle”, final and study drawings, Artur Akhunov, “The Mount Of Two Cities” Kazan, Russia, 2019-2020**
**Courtesy: TIArch Studio, KSUAE**

In our age of omnipresent digital technologies, hand drawing attracts attention of both professionals and the public, thereby experiencing a kind of renaissance. The hand drawing method, developed at TIArch Studio, KSUAE, has been featured in international competitions, magazines, and exhibitions, and celebrating the hybrid of light and shadow in black and white drawings, our TIArch method has graced the 25th ARCH Moscow International exhibition[2] and architecture magazines, like Tatlin.News.[3]

TIArch drawings have been likened to the works of renowned European and American architects by the jury of international competitions, for instance with graphic works by Anna Guseva, Timur Abdrakhmanov, and Karim Shammazov at the Drawing of the Year Competition, held by the Aarhus School of Architecture (2020, 2021). Distinctive thesis works by Egor Orlov, Alisa Silantyeva, Anna Andronova, have been completed entirely by hand, which elevated their ideas and brought several major awards including: LafargeHolcim Awards in sustainable construction (2017), Archiprix International Finals (2015, 2017),[4] and the Tamayouz Excellence Award for architecture theses (2016). Egor Orlov’s hand

2.
Exhibited in the XXV International Exhibition of Architecture and Design ARCH MOSCOW 2020, in the Section of Architecture Education, TIArch Studio, KSUAE Pavilion.

3.
Gilfanov, A. (2018) The Mount. TATLIN, 90/167 Heresy.

4.
Silanteva, A. (n.d.). Alsisa Silanteva about her graduation project Food and the City: Culture and Safety. [online] Archiprix. Available at: https://www.archiprix.org/2021/interviews/interview-alisa-silanteva.

**“Urban DNA” diptych, Diana Kalimullina, “Future City Tissues”, Guzel Khakimova, “Flexible Genetic Code of the City”, Kazan, Russia, 2019-2020**
**Courtesy: TIArch Studio, KSUAE**

drawn concept of Cybertopia was awarded in the eVolo competition (2015) and featured on Dezeen,[5] while students’ drawings of the future of daylight in architecture – by Anna Andronova, Anastasia Maslova, Anna Borisova, and Kamilla Akhmetova – won regional and global tours of International Velux Awards (2016, 2018).

As architects aspire to seize vague perceptions of the changing world, global interest in hand drawing techniques has been reactivated.[6] TIArch’s approach to teaching architectural drawing and thinking has been discussed in professional magazines, including Tatlin[7] and Project Russia.[8] Yet, this is the first time the method itself has been brought to light globally, and it is bound to spark the quest for visions of the changing Earth at the speed of thought.

5.
Frearson, A. (2015). Essence concept high-rise wins eVolo Skyscraper Competition. [online] Dezeen. Available at: www.dezeen.com/2015/04/01/conceptual-high-rise-essence-wins-evolo-skyscraper-competition-2015/.

6.
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7.
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8.
Akhtiamov, I. and Akhtiamova, R. (2017). TIArch Studio. Future Prospects. Project Russia, 1/82, pp.196–201.

# Flying Earth

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## INTRODUCTION

Between the geological earth and the rubble-turned ground, architecture happens. It is in the cycles between that the Flying Earth proposal is developed. Addressing the Triennale challenges, it explores how Earth's most sourceable matter may provide humans with an infinitely available and carbon-free material, contributing to an evolving circular economy paradigm.

Earthen materials – such as adobe bricks, fired clay, or stone – are timeless components of construction with their physical properties including high levels of compressive resistance, thermal inertia, and an index of reusability. With the wit of men, these materials have been tamed to fly under their own weight, shaped into increasingly complex and efficient arches and vaults for millenia, from amorphous to modular design. The Flying Earth proposal aims at achieving circularity and reduce the carbon footprint of construction through a novel building production system encouraging use of earthen materials in architecture. In the age of climate change, it is paramount to give new opportunities of use for such traditional and sustainable materials, thus fighting the disastrous emissions of the building construction industry through its insistence upon concrete and steel-based systems.

## REVIEWING EARTHEN MATERIALS

Earth bricks – or sun dried bricks/mud bricks – are a construction material used since the dawn of building. The first known vaults were built from earth bricks in Mesopotamia,[1] revealing how flexible

1. Oates, D. (1973). Early vaulting in Mesopotamia. In: *Archaeological Theory and Practice*. London: Seminar Press, pp.183–191.

and strong this material is. Earth architecture can be found across the globe, as attested by Houben and Hubert.[2] This traditionally used material has also been the subject of research and application by modern architects, including Hassan Fathy whose two basic pillars of thinking were the use of local materials and the understanding of architecture as a social project. In his book, *Architecture for the Poor*,[3] he wrote that building materials are under our feet, an approach fully in line with circular economy and locality.

Currently, earthen materials are gaining a new relevance to address the urgent needs for a more sustainable and energy-efficient construction. Locally sourced raw earth has a low negative environmental impact, and traditionally used in hot and dry climates, it protects building interiors from overheating. For example, untreated and unfired adobe blocks decompose during the process of erosion, eventually returning to the soil. Recognising these advantages, renowned architects are driving attention to earthen materials – for example Foster + Partners,[4] Renzo Piano Building Workshop,[5] Francis Kéré,[6] and Gramazio and Kohler[7] – to produce either architectural components or an entire building.

## RESEARCH AND INNOVATION AT THE DFL

Building with earth assumes many approaches, all sharing the common property of strong compression resistance. Stereotomic design is one of them, traditionally relying on cut stone to build arches or vaults. A rebirth of stereotomy, or *Stereotomy 2.0*, has been researched over recent years.[8] This interest in discrete,

2.
Houben, H. and Guillaud, H. (2008). *Earth construction: a comprehensive guide*. Warwickshire: Practical Action Publishing.

3.
Fathy, H. (1973). *Architecture for the poor: an experiment in rural Egypt*. Chicago: The University of Chicago Press.

4.
Foster + Partners (2015). *Droneport*. [online] www.fosterandpartners.com. Available at: https://www.fosterandpartners.com/projects/droneport/.

5.
Renzo Piano Building Workshop (2020). *Children's Surgical Hospital*. [online] www.rpbw.com. Available at: http://www.rpbw.com/project/emergency-childrens-surgery-center.

6.
Fernández-Galiano, L. (2018). *Francis Kére: practical aesthetics*. Madrid: Arquitectura Viva Sl.

7.
Gramazio and Kohler (2021). *Clay Rotunda*. [online] Available at: https://gramaziokohler.arch.ethz.ch/web/e/projekte/430.html.

8.
Fallacara, G. and Barberio, M. (2018). An Unfinished Manifesto for Stereotomy 2.0. *Nexus Network Journal*, 20(3), pp.519–543.

prefabricated elements capable of replacing heavy carbon tensile resistant beams is accompanied by a renewed interest in stereo-funicular structures, whose design is now driven by powerful computational tools.

The DFL has been conducting research on this topic at FAUP for more than six years, developing a vision of an increasingly stereo-funicular, discrete architecture[9] while providing an integrated model for the fabrication of these building structures. With the overall idea of waste reduction, a system of reusable and reconfigurable moulds was developed to cast uniquely shaped blocks that, when combined, create compressive working structures. These blocks may be fabricated of any pourable material, and while low carbon concrete mixtures can be used, we suggest earth compositions as raw material. This whole process is fostered by digital technologies from the design and analysis phase to the mould production process. Previous research at the DFL used a robotic arm to inform and fabricate the geometry of these reusable moulds,[10] creating a sort of elision between high-tech digital fabrication and low-tech material making.

While robotic arms have been the larger drive of architectural digital fabrication, other digital technologies are emerging, like Augmented Reality (AR). Being a technology that affords a visualisation experience that overlaps digital and physical information, it has become widespread in many fields including medicine, engineering, commerce, and entertainment. Placing a virtual product in a real environment is becoming ubiquitous practice, with AR technologies harnessed by the end-user without any prior knowledge or skills. Recognising these features and its

9.
Azambuja Varela, P. (2020). *Reconstrução de uma Estereotomia - para uma abordagem estereotómica multi-semântica*. [PhD thesis in Architecture] repositorio-aberto.up.pt. Available at: https://repositorio-aberto.up.pt/handle/10216/129891.

10.
Azambuja Varela, P. and Sousa, J.P. (2018). Reinforced, Reusable, Reconfigurable Molds for Cast Voussoirs. In: J.P. Sousa, ed., *The 36th eCAADe Conference – Volume 1*. [online] Lod University of Technology: CUMINCAD, pp.771–780. Available at: http://papers.cumincad.org/cgi-bin/works/paper/ecaade2018_332. And Azambuja Varela, P. and Sousa, J.P. (2019). Digital Expansion of Stereotomy – A semantic classification. In: J.P. Sousa, ed., *The 37th eCAADe and 23rd SIGraDi Conference – Volume 1*. [online] University of Porto: CUMINCAD, pp.387–396. Available at: http://papers.cumincad.org/cgi-bin/works/paper/ecaadesigradi2019_340.

potential, the DFL has looked into this technology as an opportunity for continuing and innovating research on stereotomy construction with earthen materials.

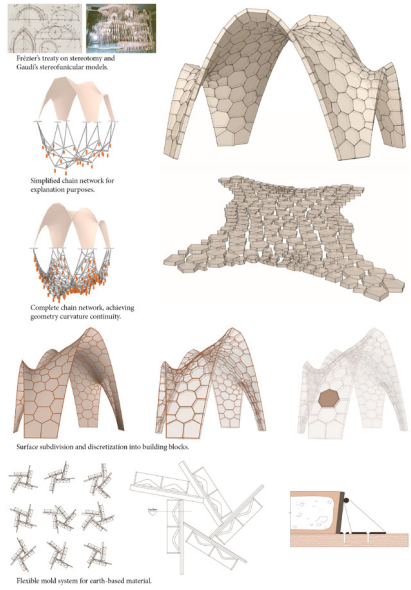
### THE FLYING EARTH PROJECT

The Flying Earth project submitted to the Lisbon Architecture Triennale 2022 explores the innovative potential of earth in architecture by deploying a novel and highly sustainable production process based on AR technology. To demonstrate, the DFL wanted to present a 1:1 scale installation built with earthen components for the University Competition Exhibition. As a complement, various speculative architecture designs would also feature in graphic panels, documenting possible applications of the production system to rethink and envision possibilities for building elements – such as slabs, roofs, vaults, or stairs. These designs would be developed through public workshops in order to engage a wider audience.

### THE DESIGN

The design for the installation consisted of a four-legged vault large enough for people to walk beneath. Featuring horizontal point symmetry, it is composed only of earth voussoirs leaning against each other in a continuous stereo-funicular surface composed of four arches in its perimeter. This sculptural object would showcase the formal and structural possibilities of stereotomic earth construction.

In addition to the proposed vault, a series of other architectural scenarios were investigated to unveil the potential of this construction system. The first example features a building whose façade and inner structure are made of earth blocks arranged in arches, configuring a contemporary expression to the proposed architecture. Another situation features a slab system with a slight curvature, lending a centrality to the room; a system generated algorithmically and automatically adapting to the shape of each room, allowing for a flexible design tool. Finally, a stair system was also devised, following the principle of avoiding heavy carbon materials such as steel or cement. The stair develops along an extended arch, where the steps are actually voussoirs, part of the structure itself.




**Design and fabrication of the Flying Earth project, 2022**
**Courtesy: FAUP-DFL**


**Simulation of the Flying Earth project, 2022**
**Courtesy: FAUP-DFL**

## THE PRODUCTION

For the production of the Flying Earth project, we chose clay as an earth-based material that is easy to mould and unmould. The clay results in smooth surfaces when contacting the faces of the moulding components, and dries when exposed to air without the need for burning or heating. The unmoulded and cured clay blocks also provide strength for the potential compression of vault-like forms.

The stereotomic nature of the Flying Earth project and its variable components required different techniques and technologies in manufacturing and assembly. First, to produce 207 unique voussoirs, it was proposed to employ a flexible mould system that can be customised to produce many different blocks. The flexible mould is constituted of metal plates that can be carefully positioned and angled to prepare different configurations to produce each earthen block. The intended moulds theoretically could be created using blueprints, annotated angles, and a variety of carpentry tools, but it would become time-consuming and potentially have inaccuracies.

**Envisioning stereotomic architectural scenarios, 2022**
Courtesy: FAUP-DFL

So, instead of looking for automated processes through robotic technologies, the Flying Earth project turned to explore the potential of AR technologies to empower human capabilities and complete that task. The fabrication and assembly rely on the HoloLens 2 headset which enables us to deal with complex designs and fabrication tasks. During this augmented fabrication process, we take advantage of the headset's ability to superimpose digital data over physical reality, allowing craftsmanship to handle the design and fabrication processes rather than just visualising.

The use of AR technology coupled with the flexible and reusable mould system allows the production flow of multiple components without generating waste. Together with the earthen nature of the construction materials, this yields sustainable building blocks

which form the basis of our proposed architecture – an architecture inspired by history, rooted in local conditions and human capabilities, and featuring shapes inspired by natural forces and free from a carbon footprint.

## ENVIRONMENTAL IMPACT

Environmental Life Cycle Assessment (LCA) has become a valuable tool to evaluate construction processes and buildings in order to understand their impact on sustainability. One main difference between LCA and previous evaluation methods is a focus on the whole cycle of materials, from extraction to end usage and future application, supporting the concept of circularity, a continuous path of material application that reduces waste to a minimum. Although only a few studies have enumerated the environmental impacts of earthen building materials – including the LCA of adobe bricks,[11] rammed earth,[12] and earthen plasters[13] – a clear idea on the relevance of these materials is postulated by Ben-Alon et al.: "Earthen building materials offer an environmentally sustainable alternative to conventional materials because they are locally available, minimally processed, and waste-free."[14]

## FINAL REMARKS

Although it is understood that building with sustainable materials is a main contemporary challenge of architecture, earthen materials, while being acknowledged as a material widely used globally and spanning civilisations, are yet to enter the list of widely used materials in contemporary construction. This research

11.
Christoforou, E., Kylili, A., Fokaides, P. and Ioannou, I. (2016). Cradle to site Life Cycle Assessment (LCA) of adobe bricks. *Journal of Cleaner Production*, 112, pp.443–452.

12.
Treloar, G.J., Owen, C. and Fay, R. (2001). Environmental assessment of rammed earth construction systems. *Structural Survey*, 19(2), pp.99–106.

13.
Morela, J.C., Mesbah, A., Oggero, M. and Walker, P. (2001). Building houses with local materials: means to drastically reduce the environmental impact of construction. *Building and Environment*, [online] 36(10), pp.1119–1126. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0360132300000548.

14.
Ben-Alon, L., Loftness, V., Harries, K.A. and Cochran Hameen, E. (2019). Integrating Earthen Building Materials and Methods into Mainstream Construction Using Environmental Performance Assessment and Building Policy. *IOP Conference Series: Earth and Environmental Science*, 323.

shows how novel applications with the earth can empower these materials to be used in more contemporary architectural situations than as a standard bearing wall. By looking into the history of stereotomic stone construction, a transfer of knowledge was applied to earth, by transforming this shapeless material into geometric blocks. Future architecture can benefit from this approach by using earth in structural elements such as load-bearing façades, slabs, or stairs while benefiting from the exposed finish of such natural material.

Earth construction must be brought closer to an industrial scale so that the gap between earth construction and contemporary architecture can be continuously narrowed. With this general objective in mind, this research still has big challenges to overcome, and a set of actions can facilitate this task. AR, although quickly becoming ubiquitous, is still in its infancy, and new technologies and modes of usage might foster its application, such as collaborative AR-assisted workers working on the same object, or a more seamless flow of data between AR sets and the main model. Earth moulded blocks must be tested within larger scale experiments, to attest viability in real-world scenarios, as well as different typologies of challenges.

Presence in the Lisbon Architecture Triennale 2022 was thus an opportunity to advance this research on more flexible and sustainable modes of design and construction with earth materials. By promoting emergent tectonics, fostering the use of locally sourced materials, and empowering human capabilities, the Flying Earth project can be an illustration of the New European Bauhaus principles of aesthetics, sustainability, and inclusion.

ACKNOWLEDGMENTS

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# Haegi Wendls: Rethinking space and materials

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The way we plan and build not only shapes our settlements and living spaces, but also the lives of future generations. Which spaces can we claim and share as individuals? Which resources do we use and how will we obtain them in the future as raw materials become increasingly scarce? Construction and existing buildings are responsible for more than a third of global $CO_2$ emissions and energy consumption; short life cycles and enormous waste production exacerbate the situation. Change is required, and projects with a focus on reusing spaces and materials, rather than consuming ever more land and other resources, can serve as valuable examples of a new approach in the building sector.

*Haegi Wendls* is an extraordinary story of the conversion of a small farmstead in Vorarlberg, Austria, dating back to 1458. The building, named after its original owner, was transformed into a family home and a cultural venue for the region where gatherings, readings and concerts can take place. Most of the existing building fabric was preserved and sensitively complemented. Only natural building materials were used for the conversion, and as many parts as possible were reused from the existing structure.

The project is an example of how a group of pioneers in the field of sustainable construction joined forces and took action. It is a co-creation and construction-site experiment where university, craftsmen, architects, experts, house owners and students cooperated, bridging gaps between disciplines and areas of expertise. The project is based on a shared vision of sustainability

that gives value to an existing building, to its structures and memories, but at the same time demands high-quality design new approaches on natural building materials to create a liveable atmosphere. Had it not been for this commitment, the old building would have been torn down and replaced by a new one, most likely using conventional materials like concrete and petroleum-based products.

## CHALLENGES IN TODAY'S ARCHITECTURE

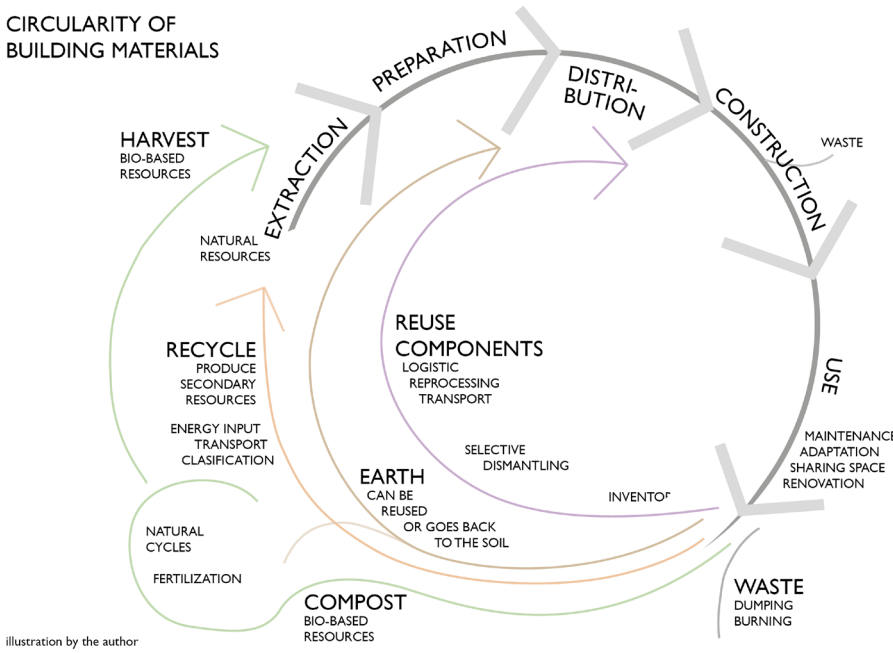
Climate change, and related social and economic problems, probably constitutes the peak of the current ecological challenge. The negative consequences are becoming more and more evident around the globe. Construction activities and existing buildings are main contributors to this fatal change of the climate. At 38%, the major share of global $CO_2$ emissions can be traced back to buildings and construction and this share has been rising significantly over the last years. Ten percent of emissions alone are due to the industrial production of building materials such as cement, steel, and glass, with cement holding by far the highest share.[1]

More than 40% of all resources extracted on our planet are used for housing, construction, and infrastructure. At the same time an enormous amount of waste is caused by this sector. Construction and demolition hold a share of 25-30% of the total waste in the EU, including a wide range of valuable materials like concrete, bricks, glass, tiles, gypsum, wood, plastic, and excavated soil.[2] We build resource-intensively on the one hand and produce waste on the other.

Another critical aspect related to construction activity is the consumption and sealing of land. In fact, Austria is on top in the EU in terms of consumed land per capita. Urban sprawl induces traffic which, in turn, leads to increased $CO_2$ emissions.

1. United Nations Environment Programme (2020). *2020 Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector.* Nairobi: United Nations Environment Programme. Available online at: https://globalabc.org/sites/default/files/inline-files/2020%20Buildings%20GSR_FULL%20REPORT.pdf. p.20.

2. Ibid. p.48.




**Circularity of building materials, 2022**
**Courtesy: BASEhabitat and Ulrike Schwantner**

An increase in sealed soil surfaces through the building of new developments and roads has a negative impact on food security, water storage capacity and heat generation. Thus, we should not only rethink the materials we use, but also the space we build on. The best house is the one that is not built.[3]

## CIRCULARITY OF BUILDING MATERIALS

An important strategy to tackle these global challenges is to consider the building and its components in a circular way, so that valuable raw materials do not end up as waste after a short period of use. Basically, the consumption of new and finite materials has to be reduced, avoiding unnecessary demand through the renovation and preservation of existing buildings and by reusing their materials and components.

3. Fitz, A., Mayr, K., Ritter, K. and Architekturzentrum Wien eds. (2020). *Boden für alle*. Zürich: Park Books, p.139–142.

The material cycle starts with the acquisition of resources (extraction). There are alternatives to mining and extractive processes, like bio-based materials or recycled secondary resources. Reusing components from existing buildings is another important source that requires probably more logistics but has to be a future strategy. Our existing settlements should be considered an important and growing raw material storage, especially as we are running out of natural resources.

The energy needed for transforming raw materials into building materials (preparation) should be considered as well as the distances that have to be covered until the materials end up on the construction site (distribution). When it comes to construction, the design plays an important role. We must improve our skills in applying materials according to their properties, and consider aspects such as thermal mass, regulation of humidity, natural light and ventilation. Our buildings should be designed in such a way that they can do without external cooling and heating as far as possible. Importantly, a large amount of waste is already generated during the construction process.

Furthermore, the period of use of the building materials should be extended. This can be achieved if the designs allow for the flexible use of spaces, for example, flats that can be enlarged, repurposed, or divided according to need, and thus vacancies are avoided (adaptation and sharing space). Another important aspect is to design buildings and building elements in a way that maintenance or renovation is easily possible. All this has a crucial influence on the extension of a building's lifecycle. At the end of the use, dumping and burning materials should be avoided as far as possible.

### REUSE, BIO-BASED MATERIALS AND EARTH – SUPPORTING THE RESILIENCE OF THE BUILDING SECTOR

Reuse of building components in new buildings is a promising approach. Reuse should not be understood as a selective refitting of single items, but must be made possible on large scale. For it to work efficiently, components must be developed that are already designed to be reused, standardised, dismountable, and catalogued. In this way, the current effort-intensive process of reusing building materials could be routinised.

Bio-based resources offer considerable potential for the building sector. In addition to well-known materials such as timber and bamboo, these include a whole range of plant fibres like straw, hemp, reed, rice husks, algae, or fungal mycelium. Most bio-based materials sequester $CO_2$ emissions while growing and store it while they are in use as a building material. At the end of the life-cycle they can be composted and help to regenerate soils. Bio-based materials of particular interest are those which are agricultural by-products, so there is no competition for land that could otherwise be used for agricultural food production. Hemp, for instance, can even fertilise soil while growing.[4]

Earth is another building material of particular interest in addressing climate change and resource depletion. It is an affordable building material that can be found almost everywhere in the world, it is $CO_2$ neutral as it can be dissolved after use, taken back to earth, and reused again and again. In most construction sites in Central Europe, the excavated material contains clay, which could be used directly or with little processing as a building material.[5] There are very many different earth building techniques that go back to old building traditions, but which have made the leap into the present thanks to dedicated researchers and pioneers. Martin Rauch was the first to enable new dimensions with the industrial prefabrication of rammed earth elements and to build impressive buildings such as the *Ricola Herb Centre* (CH)[6] or *Alnatura Campus* (DE). Rammed earth can serve as a load-bearing construction; light earth in combination with fibers reaches better insulation values. In addition to clay plasters and earth floors, many new prefabricated earth elements are being developed and research is done on new techniques like poured earth and 3D printing.

4.
United Nations Environment Programme (2020). *2020 Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector.* Nairobi: United Nations Environment Programme. p.53.

5.
Minke, G. (2017). *Handbuch Lehmbau: Baustoffkunde, Techniken, Lehmarchitektur.* Staufen bei Freiburg: Ökobuch Verlag GmbH. p.11.

6.
Sauer, M. and Kapfinger, O. (2015). *Martin Rauch: Refined Earth: Construction & Design with Rammed Earth*. Munich: DETAIL. p.118.

Earth and bio-based materials have amazing properties. They provide a particularly comfortable indoor climate, are breathable, balance moisture and, above all, are versatile in their combination. Furthermore, earth is a material that easily allows for repairs. Despite the multi-faceted benefits, it still often associated with old-fashioned aesthetics and poor quality. *BASEhabitat* shows with its Travel Guide *Earthen Architecture in Central Europe* [7] that earth is an appropriate building material that is compatible with contemporary design.

The transition to circularity can only succeed if different stakeholders are involved in developing and testing new solutions; product developers and retailers, craftsmen, architects, clients, and public entities that support these processes.

### THE STORY OF *HAEGI WENDLS*

"A house has a history and future. While we are still discovering the past, finding wooden beams from the Middle Ages, we are, at the same time, designing the future of the house, without knowing where exactly it is going to take us. We are part of the story." Silvia Keckeis and Johannes Lampert, owners of *Haegi Wendls.* [8]

The existing historical building was mainly made of wood and some stone walls, consisting of crooked small rooms in the living area and a working area with stable and barn. Over the years it has been used by many different people with different professions – up to 14 people lived there at the same time. The current owners of *Haegi Wendls* have a close relationship to the house and its past. Demolition and new construction, which would have been the more common approach, was out of the question for them. They wanted to renovate the building sensitively. At the same time, it was important to them to create an *open house* as a meeting place for cultural activities and people of the community. This is how the vision of combining living in *Haegi Wendls* with an open cultural centre came about.

7.
BASEhabitat ed. (2016). *Earthen Architecture in Central Europe, Travel Guide*. Linz: BASEhabitat.

8.
Haegi Wendles (2021). *#17. Das vollumfängliche Staunen*. [online] www.haegiwendls.at. Available at: https://haegiwendls.at/2021/08/29/17-das-vollumfaengliche-staunen.

**Reinforcement of historic structure, Muntlix, Austria, 2022**
Courtesy: BASEhabitat and Martin Schachenhofer

According to the conversion plans the exterior and volume of the building was to remain the same, only the roof was to be raised slightly to achieve better room heights. A large window was added in the living room. Since the existing building was made of wood, the construction continued with wood, supplemented with earth and lime as well as various fibres – all raw materials from the region.

Preserving an old structure implies many uncertainties and unpredictable challenges, therefore teamwork is crucial. In May 2020 the idea came up to carry out the conversion through a cooperation between the owner, the architects, experts in earth construction, innovative carpenters, and *BASEhabitat*, with other professionals like a structural engineer, a wood expert, and various craftsmen joining the team. Many things had to be thought through, planned, and rethought, and the goal of a construction site without waste, using only sustainable materials as far as possible, took shape.

The possibility of implementing the project together with engaged students was particularly interesting and space was provided for experimenting and mutual learning. In October 2020 the construction site experiment began, until 2021 three groups of students worked on site, in three-months construction traineeships and a summer school under the guidance of *BASEhabitat* construction site managers.

**Building process with circular materials, Muntlix, Austria, 2021**
Courtesy: BASEhabitat, Silvia Keckeis and Bence Szalai

## THE CONVERSION IN DETAIL

Shortly after the beginning of construction it became clear that it was necessary to stabilise the foundation, a large part of the existing building had to be stripped down to its core construction and reinforced. Load-bearing wooden structures had to be protected against rising humidity. The structure was raised at certain points and concrete foundations were poured, single posts and beams were removed and replaced with new ones. Wooden walls and floors that had to be removed were restored where possible and later re-installed in other places.

The new basic interior construction was wood frame infilled with light-loam. The mix of wooden chips and liquid earth, which provides both an insulating layer and thermal mass, was filled into a lost wooden formwork. Two different techniques have been tried out, prefabricated wood-earth blocks, and a liquid mix filled directly into the formwork. Both materials, wooden chips, and earth, were easily available as a waste material of a sawmill and rest material from a gravel plant. The insulation value of light-loam depends on the ratio of earth to fibre, the material can also absorb noise and is fire-protecting. The external walls were built in the same way, and the original outer surface was preserved. By using the light-loam infill and a second wooden wall on the inside,

it was possible to level out the sloping outer walls. The energy pass that has been issued for the building shows very good values.

A rammed earth floor was placed in the main room of the living area. These kinds of floors are very common in vernacular architecture around the world. By modifying the construction, more resistant floors can be created that have a strong, long-lasting, and impermeable surface.[9] The floor was placed on a wooden substructure with a fill of capillary-breaking foam-glass, gravel and clay powder. It includes an underfloor heating system, but otherwise does not consist of anything other than a compressed mix of earth and stones, polished and sealed with a natural wax. A trass-lime floor was installed in the public area of the building – this is similar to rammed earth but more resistant for intensive use. On the upper floor, a lighter construction was required, so an earth-perlite infill and earth slabs with integrated heating pipes were applied under the restored old wooden boards.

The whole house was plastered with clay, basically applied on top of reed mats. To increase the resistance the first rough plaster was mixed with straw and cow dung that naturally contains the right mix of ammonia and casein.[10] For the finishing plaster in wet areas, different additives were tested like linseed oil, carnauba wax or natural soap, improving the water-resistance of the surface. Some walls were covered with original wooden boards.

Old wooden windows and doors were restored and put in place again. The traditional façade of wooden shingles was restored with new ones. The roof covering was not changed. The original roof tiles were cleaned and reused, and some replacement tiles were bought second-hand. The students experimented with discarded roof tiles, designing a bar for the cultural venue.

In July 2022, the conversion was finished, and the cultural centre was inaugurated with the premiere of a documentary film of the whole building process. Entering *Haegi Wendls*, one can feel the special combination of old and new building elements. A light steel staircase with old wooden steps leads the visitors to the event room on the first floor in the former hayloft. The living area on

9.
Sauer, M. and Kapfinger, O. (2015). Martin Rauch: Refined Earth: Construction & Design with Rammed Earth. Munich: DETAIL. p.51.

10.
Minke, G. (2017). *Handbuch Lehmbau: Baustoffkunde, Techniken, Lehmarchitektur.* Staufen bei Freiburg: Ökobuch Verlag GmbH. p.43.

**Interactions between old and new, Muntlix, Austria, 2021**
Courtesy: BASEhabitat, Silvia Keckeis and Bence Szalai

the opposite side convinces with its open design and natural lighting. The materials used have a special haptic and create a particular atmosphere. *Haegi Wendls* already attracts curious visitors who are astonished by the pioneering project, which, furthermore, has encouraged other house owners to use earth and bio-based materials.

## TOWARDS A SUSTAINABLE FUTURE

Coming back to the question of how to organise our built environment in a more sustainable way and which space and building materials to use, *Haegi Wendls* is an extraordinary, visionary project. It is crucial to understand architecture as a process that involves many players, and therefore recognise the need for and opportunity presented by co-operation, from sketching

first ideas to the search for sustainable building materials until implementation. At *Haegi Wendls* the owners were open to adapting their ideas to the options the building was giving them, planners and craftsmen were joining their expertise in using earth and bio-based materials and the cooperation with the university added further know-how and research base to the project.

Creating buildings in a circular way, means giving the next generation the chance to re-use the buildings according to their future needs. Facing the burning global challenges caused by the construction sector, it is not about doing some small changes here and there, but radically re-thinking the way we plan and build including our approach to architecture. Projects like *Haegi Wendls* are an important starting point.

### ABOUT *BASEhabitat*

As a studio of the Department of Architecture at the University of Art Linz, *BASEhabitat* is part of a growing community of organisations which work intensively on the global challenges connected to the built environment and is member of the *UNESCO Chair Earthen Architecture*. *BASEhabitat* focuses on providing young architects with the means to implement more sustainable and socially responsible design, planning, and construction processes. Studying at *BASEhabitat* includes intensive hands-on experience with sustainable building materials.

# Intermittent Cities: Temporary uses and sharing practices to support an adaptive urban space

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The interdisciplinary funded project, Intermittent Cities, led by FCT and CIAUD.ULisboa, explores transformation processes that empower temporary and sharing practices in urban spaces. Specifically, for Triennale Universities Competition 2022, a study was carried out by three Portuguese universities – FA_ULisboa, ISA_ULisboa, and DECA_UBI – promoting each of their different specialisations (Urbanism, Landscape Architecture, Architecture), yet keeping a common line on the set of practices and inventive imaginaries that explore the city through an intermittent perspective. Acknowledging that intermittent approaches can lead to new disciplinary paradigms which are fundamentally flexible, students were invited to focus on: (i) everyday needs or effervescent collective experiments in public spaces; (ii) small initiatives or self-organised *reclaim-the-city* green spaces; and (iii) regeneration programmes for vacant and obsolete spaces.

## TEMPORARINESS AND SHARING AS DRIVERS OF CONTEMPORARY URBAN CHANGES

Over recent past years, patterns of life have changed greatly, with new social power relations, family structures and gender roles, wealth (in)equality, mass migration, and ageing population amongst much more besides. Meanwhile, new technologies have taken over and established new systems of how, where, and when we act, prompting questions around privacy and identity.[1] Alongside these factors, cities have also been under significant changes, incorporating values of temporariness and sharing in urban processes, disrupting traditional relations between space, time, and use.[2]

The vacant, shrinking, or obsolete spaces that punctuate dense contemporary outskirts have been re-activated with temporary uses. Likewise, traditional, and well-kept public spaces of historical cities seem to be incrementally occupied with unusual and transient activities. Scattered permeable areas around the city – from small planters to blocks – have been transformed into self-managed productive or leisure gardens. Although the replacement of functions is not a new practice, what makes it relevant in these processes is its assumption as an unavoidable contemporary urban issue and spatial experimentation tool,[3] on the fringes of the tradition of architecture and urbanism, whose projects are closed, limited in time, precisely shaped according to contingent needs.

In parallel with temporariness, a variety of sharing practices are emerging in urban processes,[4] driven by a conjugation of social, economic and technologic transformations, which have shifted attention from tangible space to intangible value-added services and a sense of community desired by an increasingly transient population, thus motivating new attitudes towards consumption.[5]

1.
Self, J., Bose, S. and Williams, F. eds., (2016). *Home economics: five new models for domestic life*. London: The Spaces.

2.
Madanipour, A. (2017). Cities in time: *temporary urbanism and the future of the city*. London: Bloomsbury Academic.

3.
Philipp Oswalt, Klaus Overmeyer and Philipp Misselwitz (2014). *Urban catalyst: the power of temporary use*. Berlin: Dom Publishers.

4.
Belk, R. (2010). Sharing. J*ournal of Consumer Research*, 36(5), pp.715–734.

5.
Allegri, A., Benatti Alvim, A., Abascal, E.H. and Sabaté, J. eds. (2021). *Research Tracks in Urbanism: Dynamics, Planning and Design in Contemporary Urban Territories*. Routledge & CRC Press. Boca Raton, FL.: CRC Press.

Also, the drastic reconfigurations of common spaces and activities forced by the recent Covid-19 pandemic has changed many dynamics,[6] evoking for a more adaptive[7] and cooperative city.[8]

Strategies involving temporariness and sharing engage in urban processes, due to: i) sustainability, re-use and resilience of spaces;[9] ii) environmental problems, resource efficiency and circular economies;[10] iii) ability to react ad hoc;[11] iv) local participatory procedures and socially aware practices;[12] v) experimentation and innovation.[13] However, as the use of such strategies increases, some negative impacts arise: i) normalising the precarious and the low cost;[14] ii) becoming a means of urban branding; iii) accelerating gentrification and an uneven distribution of benefits.[15]

In a society where permanence and ownership are becoming less important than with previous generations, the overlapping between temporariness and sharing have expresses itself on dimensions of urban life, giving rise to: new housing models (co-living, co-housing, temporary accommodation); different forms of working (co-working, homeworking, work from anywhere); shared mobility (bike-sharing, car-sharing, pedi-bus); sharing of goods (creative commerce, collaborative consumption, urban agriculture, community food); services shared through digital

6.
Gehl, J. (2020). *Public Space & Public Life during COVID 19*. Copenhagen: Realdania.

7.
URBinLAB (2020). *Challenges, conflicts and opportunities for the City in the time of COVID-19*. [online] Available at: http://urbinlab.fa.ulisboa.pt/images/2020/URBinLAB_COVID_2020_eng.pdf.

8.
Patti, D. and Polyák, L. eds. (2017). *Funding the Cooperative City: Community Finance and the Economy of Civic Spaces*. Vienna: Cooperative City Books.

9.
Bishop, P. and Williams, L. (2012). *The temporary city*. London ; New York: Routledge.

10.
Mclaren, D. and Agyeman, J. (2017). *Sharing cities a case for truly smart and sustainable cities*. Cambridge, Massachusetts: Mit Press.

11.
Esteve, M.B. (2017). *Public Catalyst: Against Indifference*. New York/Barcelona: Actar.

12.
Sidorova, M. and Lammelova, Z. (2016). *How to Design a Fair Shared City? 8 short stories based on equitable urban planning in everyday life*. Prague: Heinrich Böll Stiftung / WPS.

13.
Galdini, R. (2020). *Temporary uses in contemporary spaces. A European project in Rome*. Cities, 96.

14.
Henneberry, J. (2017). *Transience and Permanence in Urban Development*. Chichester: John Wiley & Sons, Ltd.

15.
Tardiveau, A. and Mallo, D. (2014). *Unpacking and Challenging Habitus: An Approach to Temporary Urbanism as a Socially Engaged Practice*. Journal of Urban Design, 19(4), pp.456–472.


**Switch on, Intermittent Cities, Lisboa, Portugal, 2022**
**Courtesy: Alessia Allegri**

platforms (Netflix, Spotify); spontaneous cultural events; unexpected uses in anonymous spaces (parties in abandoned structures; terraces in parking spaces; urban agriculture in vacant lots); and even new kinds of urban policies (soft planning, co-decision).

All these urban dynamics that enable and empower temporariness and sharing in the urban spaces are here named *Intermittent Practices*. Both planned and spontaneous and both in the public and private spheres, Intermittent Practices generate the conditions and/or activate the transformation of the inhabited spaces.

Different operating models, aiming for transitory and collaborative strategies, introducing different concepts and new kinds of design tools, open the path to different ways of defining the roles and responsibilities of architecture – which is much more than definitive and permanent solutions to a given set of problems: it is an unlimited result of an open process.

Thus, we witness a new functional mechanism of the city with the potential to generate new architectures and new ways of living and designing urban space, but whose practices – occurring in a pulverised way, through diverse logics, and not always measurable by conventional architectural discourse – prove the need to evolve more nuanced discussions on the nature of a city and its planning.

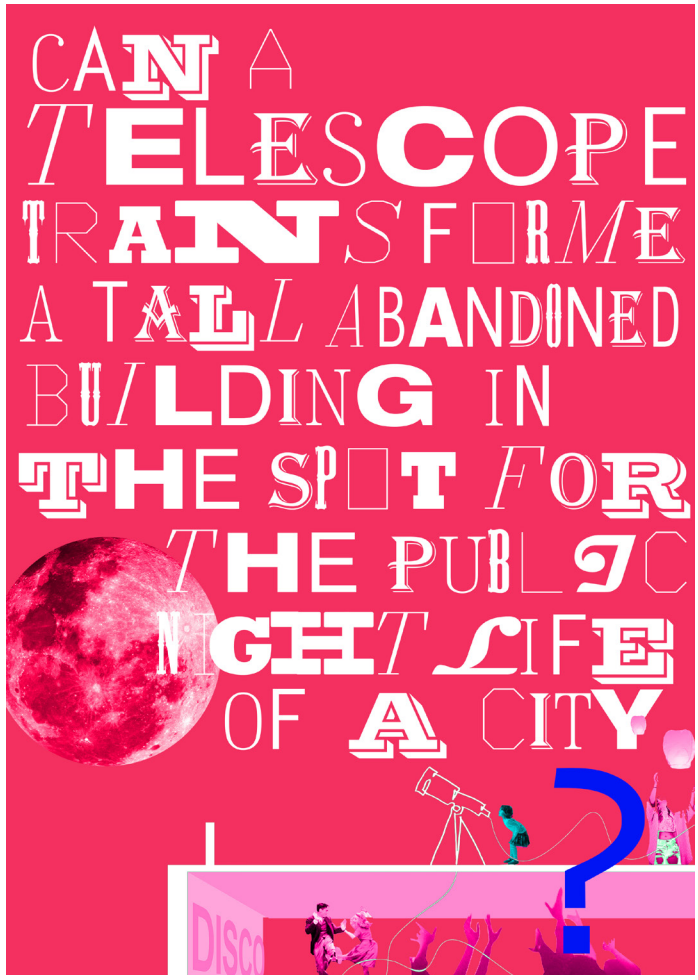
## REFLECTIONS ON A FLEXIBLE PLANNING SYSTEM FOR AN ADAPTIVE CITY

Borrowing the tools typical of a laboratory, cities can be seen as hosting *adaptive* urban projects, that is, transformations that change progressively as the experiment progresses and in which a particular focus can be made on the reactions obtained at each solicitation, probing the possibilities that lie ahead for the subsequent phases. The city is therefore thought as an open system in which all that is unexpected, anomalous, and possible, happens and coincides.[16]

Dismantling and deconstructing the elements of an established praxis is insufficient for the preparation of subsequent steps. To imagine a solid city that constantly balances with an ever-changing open system is likely the biggest challenge of all.

All this informs that it is time to move away from the idea of broad planning and *control*, and instead embrace a logic of actual designing; it is time to think the city as an open project, which can determine its function autonomously and inclusively regardless of macro-planning. But if presented today with the challenge of transforming a street and the city as parts of an open system, how could this be done?

16. Ochoa, R. and Allegri, A. (2021). *Intermittent Practices in the Contemporary City. The Case of Lisbon.* In: J. Charytonowicz, A. Maciejko and C.S. Falcão, eds., Advances in Human Factors in Architecture, Sustainable Urban Planning and Infrastructure. Cham: Springer, pp.249–256.




**Connect, Intermittent Cities, Lisboa, Portugal, 2022**
Courtesy: Alessia Allegri

A paradigm shift is needed, starting in our profession, as architects, designers, urban planners, and decision makers of urban spaces. This shift is already happening, but the role played by urban planners and decision makers needs rethinking too; new roles must be considered such as of *facilitator* or *mediator*. Professionals must adapt to these changes and learn to move from the role of experts who impose decisions, to those who try to understand a space and engage its users (and not just inhabitants). This is the idea of inclusion in the open system (and not only in the street scale), but also in urban processes and urban planning.


**Light up, Intermittent Cities, Lisboa, Portugal, 2022**
Courtesy: Alessia Allegri

This way, emergent forms of planning question the conventional ones that seem to have reached their limits. The conventional tools must therefore change to be flexible and adaptive over time, in order to preserve their usefulness and their strength.

Non-planning enables the possibility of the unexpected, which is a little bit the self-generative form of making the city: the more freedom is left to the new, leaving a modifiable mesh of use, the more that space has the possibility of being a lived space, which can be overwritten, adaptable. This balance is the challenge of the new planning. By hypothesis it is here argued that answers can

come from the hybridisation of more and more portions of projects, overcoming the division and the antithesis between temporary and permanent; increasingly including, whenever is possible, portions of project within experimental tactical urbanism or also, understanding how the same kind of flexibility can be applied to permanent projects.

An Intermittent City is a place where boosting functional arrangements is more important than the construction of an architectonic body, where openness prevails over rigidity and flexibility is valued over rigor and where urban attributes like adaptability and openness seem to be fundamental. In this sense, the Intermittent City is also a sustainable city, whose resilience relies on the city's capacity to disassemble or reconfigure previous situations and relations. For cities to be sustainable, they need to change and facilitate changes, rather than being limited by static and material configurations.

## WORKING INTERMITTENT PRACTICES IN DIFFERENT CONTEXTS AND DISCIPLINES

In the scope of Triennale Universities Competition 2022, Intermittent Cities' inter-university research was developed, highlighting each specific expertise, yet keeping the common line of thought in the set of practices and inventive imaginaries that explore the city through Intermittent Practices. Acknowledging that intermittent methods lead to new disciplinary paradigms that are fundamentally flexible, students explored the concepts of temporality and sharing in different urban scales and contexts, and through different disciplinary approaches.

In FA.ULisboa, the PhD Architecture research *Intermittent Practices as a public space design tool* explores everyday urgent needs or effervescent collective experiments in public spaces, capable of transforming a place and of constructing new relations in space.

In ISA.ULisboa, the Landscape Architecture's Master Thesis *Mutable Urban Space* focuses on small initiative or in self-organised 'reclaim-the-city' intermittent engagements with nature, from Lisbon's city-scale to its parks, gardens, and small planters.

Finally, in DECA.UBI two Architecture's Master Thesis *The forgotten spaces in Covilhã* aim a chart of the several vacant and obsolete spaces in that city – most of them abandoned buildings

or ruins that constituted a significant part of Covilhã industrial heritage. In the view of this survey, the two works explore intermittent practices as tools to (re)activate an impacting abandoned building, the Santo António Tower.

With parallel perspectives, the two first approaches assess the overall premises of the research and are in line with the first two stages of the Intermittent Cities project, SWICH ON (Mapping) and CONNECT (Analysis and Discussion): an open-access archive of Lisbon's Intermittent Practices, followed by an interdisciplinary assessment of the case studies impacts, synergies and potential contributions to transformative actions in the city. Each of the mapped case studies are further explored through cross-disciplinary discussions that highlight the intersections and the complementarities between them, together their capacity to impact the local scale, and to generate transformative actions in view of an adaptive city.

This collection is not meant to be definitive, but rather evolving. A mapping like this, which focuses on the realities that respond to continuous changes, is, by definition, in progress. The idea of this classification that is always open, is paradigmatic of the way this research is understood. Indeed, researching also means experimenting.

The two-last works in Covilhã are in line with the third stage of the project, LIGHT UP (Future Scenarios and Forward-Looking Tools). It is a design-oriented prospect in which future scenarios are tested and incorporated in the creation of urban design tools, encouraging an adaptive city. This stage also reinforces the practical vocation of the project, creating a bridge between Research and Action.

In these works, and in the research project itself, Intermittent Practices are explored as a pedagogical tool, helping students and practitioners to overcome the idea of a static programme by reframing the project as a process of change.[17] Indeed, academia must engage beyond universities. Altogether, these reflections

17.
Costa, J., Ochoa, R. and Matos Silva, M. (2015). *Enfrentando Cuestiones Urbanas. La Enseñanza de la Interdisciplinaridad por el Proyecto de Urbanismo*. On the w@terfront, pp.4–26.

explore grass-rooted actions close to communities that are understood as complementary to the proposed processes.

Finally, and as mentioned, the city is seen as a laboratory – as the scenario of *adaptive* urban projects, where transformations are gradually changing as experiences advance.

## PRE-HYPOTHESES AND PRE-CONCLUSIONS

What do a space for co-working (Ateliers da Penha), a fruit re-use network (*Fruta Feia*), or a bicycle train (Lisbon's Bicycle Train) have in common? What are the similarities between a set of Covid-19 testing containers and an improvised community garden? Partaking values of temporariness and of sharing, all these Intermittent Practices point to ways of doing that are noticeably growing in the contemporary city, where *bottom-up* approaches, packages of small initiatives, and proximity processes seem best suited to unlock the potential of spaces and places, rather than long-term proposals. From the already mapped cases and from the Triennale experiences is possible to formulate some other working questions.

It is clear how flexibility is a main characteristic of studied examples, all constituting the Intermittent City, a place where boosting functional arrangements is more important than the construction of an architectonic body, where openness prevails over rigidity and flexibility is valued over rigour. The Intermittent City is a conceptual instrument that encompasses a range of alternative forms of urbanism, enabling the idea of an open urban approach. It challenges the notion of a city as a stable entity supporting how the way they must be planned would benefit by dissolving the division of temporal versus stable.[18] Considering the long term, temporality emerges as an important condition in the life cycle of every built environment.[19]

The physical space of cities is evolving, mutating, and becoming more malleable, and open to change.[20] These changes are not new

18.
Bishop, P. and Williams, L. (2012). *The temporary city*. London; New York: Routledge.

19.
Henneberry, J. (2017). *Transience and Permanence in Urban Development*. Chichester: John Wiley & Sons, Ltd.

20.
Sennett, R. (2006). *The Open City*. [online] Urban Age. Available at: https://urbanage.lsecities.net/essays/the-open-city.

in a city, but today, urban environments face unremitting flows of human movements as well as an accelerated frequency of natural disasters and economic crisis. As such, in a time in which uncertainty is a new norm, urban attributes like adaptability and openness can be fundamental.

Finally, the Intermittent City aims a fair shared city,[21] addressing the increasingly inequitable economic and social conditions, and exploring mechanisms to combat inequalities. The result improves social connectivity that in turn offers more interaction and a potential for collaboration and sharing. It is often through the collaboration of apparently different parts that emerges a shared empathy that, in turn, increases mutual understanding and supportive actions.[22]

Furthermore, the studied cases demonstrate the ability to promote changes in the places where they occur and the ability to multiply by other contexts, in a domino effect. In similar practices, but also in similar ways of doing so (e.g. the re-use of vacant buildings for community practices). And not least important, they often have the capacity to influence urban planning and public policies. This is visible in how Lisbon's Bicycle Train started to be an initiative of citizens and was later incorporated in a Lisbon Municipality program. This diversity creates a place where *patterns* of occupations, in time and space, determinate an urban landscape's perception.

Thus, it is possible to define the hypothesis that, despite their small initiative character, many of these Intermittent Practices generate others and achieve broader impacts, at an urban level. Implying the participation of citizens, each of these practices has impacts on its surroundings, but also on the city itself. It is therefore important to follow their track, to observe its impacts and synergies, to take advantage of its potential and to consider them in future planning, but also to anticipate their risks. In fact, this is not a phenomenon that has already completed its entire path. On the contrary, as technology and the economy introduce

21.
Sidorova, M. and Lammelova, Z. (2016). *How to Design a Fair Shared City? 8 short stories based on equitable urban planning in everyday life*. Prague: Heinrich Böll Stiftung / WPS.

22.
Patti, D. and Polyák, L. eds. (2017). *Funding the Cooperative City: Community Finance and the Economy of Civic Spaces*. Vienna: Cooperative City Books.

many transformations, various dynamics and societal changes are rapidly taking place, which could be consolidated into new expressions in the coming decades, in all areas of urban life.

In this context, from an action perspective, it is important to anticipate future scenarios resulting from the framework of temporary use and sharing, using speculative but reasoned exercises. This exercise may allow anticipating possible urban transformations that will result from the development of Intermittent Practices, with the objective of encouraging more flexible architectures and a city that is more adaptable to the contemporary societal and urban dynamics.

# Kinetic snapping skins: Envisioning climate-adaptive environments

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Clive Randall & Andrew Smith
The Pennsylvania State University (United States of America)

Natural systems – from sunflowers to trees – dynamically adjust to shifting environmental conditions, saving energy and resources. What if our environments adapted to be dynamic and efficient in the same way? The snapping façades project explores elastic instability as a means to develop kinetic architectural skins for climate-adaptive environments. The project outcome is a prototype of a kinetic skin that draws from recent developments in material science and engineering in smart materials, relying on shape-changing and bistable materials. The geometries and material configurations afforded by this new technology elicit new aesthetics and functional kinetic architectures, envisioning a future with a more efficient built environment.

## INTRODUCTION

Drawing inspiration from nature, kinetic building skins can change their form for optimised functionality and performance. Recent advances in material science have led researchers to propose kinetic envelopes using compliant mechanisms or smart materials. Bistable laminates are a type of compliant mechanism that present two stable states and can transition between them with a small input force. These bistable structures have hardly been explored for kinetic architectural applications.

However, their significant shape morphing capabilities show great potential for adaptive architecture. This project develops and optimises a prototype for a new type of kinetic building skin, designed with bistable flaps actuated and smart materials.

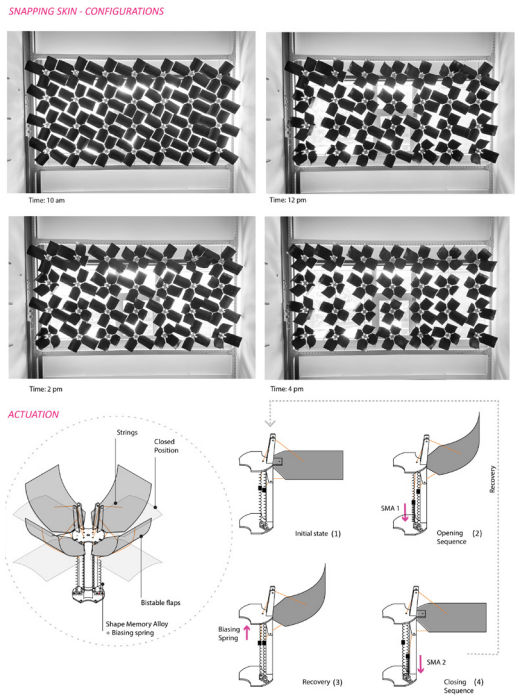
Although kinetic façades are not a novel concept, they have not yet been widely implemented in practice. Some examples of buildings with kinetic systems are the climate-responsive façade of the SDU Kolding Building and the Al Bahr Tower in Abu Dhabi. The barriers to building kinetic systems include the complexity of traditional mechanical systems based on gears and motors and the high maintenance cost. Smart materials have been proposed to replace such mechanical systems, as they have intrinsic sensors and actuators. However, a challenge is the large actuation timescales present in some smart materials.[1] In other words, the actuation times for certain smart materials are typically hours, not seconds. To address these issues, we argue that using bistable materials could lead to fast actuation times, using smart materials to actuate them instead of motors and gear systems.

This project combines a bistable mechanism with a smart material for actuation. In the past decades, researchers have explored using smart materials for various adaptive architecture applications.[2] Smart materials have built-in sensors and actuators that allow them to change their configuration in response to an external stimulus.[3] Shape-changing smart materials present a strain in response to a change in environmental conditions – water, pH, electricity, and so on – which leads to a shape morphing response. This subcategory of smart materials is very appealing to designers and researchers for its potential to construct adaptive environments. Examples of kinetic systems for architectural

1.
Poppinga, S., Zollfrank, C., Prucker, O., Rühe, J., et al. (2017). Toward a New Generation of Smart Biomimetic Actuators for Architecture. *Advanced Materials*, 30(19), pp.1–10.

2.
Vazquez, E., Randall, C., and Pinot Duarte, J. (2019). Shape-Changing Architectural Skins: A Review on Materials, Design and Fabrication Strategies and Performance Analysis. *Journal of Facade Design and Engineering*, 7, no.2, pp.91-102.

3.
Ahmad, I. (1988). Smart Structures and Materials. In: C.A. Rogers, ed., *Proceedings of U.S. Army Research Office Workshop on Smart Materials, Structures and Mathematical Issues*. Virginia Polytechnic Institute & State University: Technomic Publishing Co., Inc., pp.13–16.




**Top: Different configurations of the kinetic system. Below: Actuation mechanism, State College, USA, 2022**

applications include Thermobimetals for dynamic skins[4] and hygromorphic wood envelopes.[5]

Compliant mechanisms rely on the systems' flexibility to achieve motion.[6] Because natural systems are typically flexible rather than rigid, we can see examples of compliant mechanisms in plants such as the Venus flytrap and the waterwheel plant.[7] These compliant mechanisms in plants can lead to bioinspired kinetic systems in architecture, mimicking elastic deformations.[8]

4.
Sung, D. (2016). Smart Geometries for Smart Materials: Taming Thermobimetals to Behave. *Journal of Architectural Education*, 70(1), pp.96–106.

5.
Reichert, S., Menges, A. and Correa, D. (2015). Meteorosensitive architecture: Biomimetic building skins based on materially embedded and hygroscopically enabled responsiveness. *Computer-Aided Design*, 60, pp.50–69.

6.
Howell, L., Magleby, S. and Olsen, B. eds., (2013). *Handbook of compliant mechanisms*. Oxford: Wiley-Blackwell.

7.
Poppinga, S., Correa, D., Bruchmann, B., Menges, A. and Speck, T. (2020). Plant Movements as Concept Generators for the Development of Biomimetic Compliant Mechanisms. *Integrative and Comparative Biology*, 60(4), pp.886–895.

8.
Schleicher, S., Lienhard, J., Poppinga, S., Speck, T. and Knippers, J. (2015). A methodology for transferring principles of plant movements to elastic systems in architecture. *Computer-Aided Design*, 60, pp.105–117.

An example of a bioinspired compliant system for buildings is Flectofin,[9] a kinetic shading system based on elastic deformation. In a similar approach,[10] developed a module for a kinetic system based on the bending of its component. Taken together, these examples show how using flexible materials, kinetic systems can be designed based on elastic deformation principles.

The examples described above show how compliant systems and smart materials can be used, separately, as a basis for kinetic architectural systems. Our research shows the potential of combining compliant bistable flaps and a smart material, a Shape Memory Alloy (SMA), for kinetic shades. Bistable flaps present two stable states and only need input energy to transition between them. One appealing feature of these structures is that they present large shape-morphing capabilities[11] and can remain in either state without additional energy supply. They are, therefore, energy-efficient and can be actuated by Shape Memory Alloys. Shape Memory Alloys are commercially available in the form of wires or springs, such as those used in this research, and they are within the subgroup of shape-changing smart materials. The snapping skin, combines bistable laminates and Shape Memory Alloys for actuation, in a kinetic system that can adopt multiple configurations.

This project aims to show how bistable materials elicit new aesthetic and functional adaptive architectures through experimental prototyping and simulation studies. The research merges digital design, materials science, and engineering expertise in developing a climate-adaptive façade. The snapping skins project also expands architectural agency beyond its conventional disciplinary limits, using design as a catalyst for material innovation. The work shown in this essay forms part of a larger research agenda that envisions climate-adaptive buildings and environments using smart materials.

9.
Lienhard, J., Schleicher, S., Poppinga, S., Masselter, T., Milwich, M., Speck, T. and Knippers, J. (2011). Flectofin: a hingeless flapping mechanism inspired by nature. *Bioinspiration & Biomimetics*, 6(4).

10.
Körner, A., Born, L., Mader, A., Sachse, R., et al. (2017). Flectofold—a biomimetic compliant shading device for complex free form facades. *Smart Materials and Structures*, 27(1).

11.
Emam, S.A. and Inman, D.J. (2015). A Review on Bistable Composite Laminates for Morphing and Energy Harvesting. *Applied Mechanics Reviews*, 67(6).

## METHODOLOGY

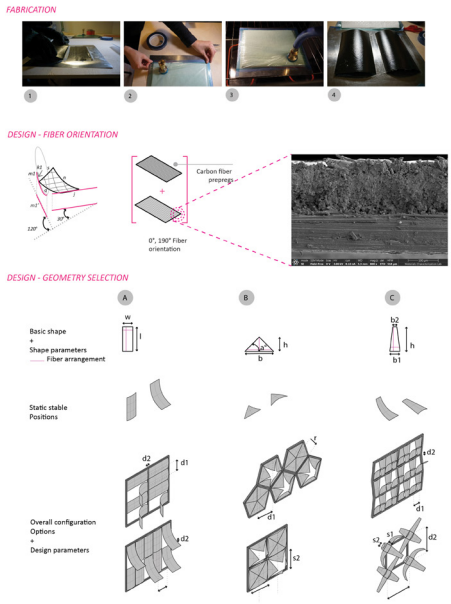
The research adopts a top-down approach with a performance-centred perspective and a bottom-up approach that relies on explorative prototyping inquiries. The method allows the development of a functional kinetic building system balancing aesthetics and functionality while exploring the smart materials' design possibilities. The bottom-up approach focuses on material exploration and characterisation, using experimental testing and Finite Elements Analysis (FEA) modelling. An example of this approach is developing an FEA model that predicts the cured state of bistable flaps fabricated with carbon fibre prepregs. These flaps exhibit a bistable behaviour resulting from differential thermal stresses during fabrication. The top-down approach is concerned with the overall kinetic façade design, proposing strategies for enhanced environmental performance. Daylight simulation studies conducted to assess the performance of different design configurations constitute an example of this approach. These two complementary top-down and bottom-up approaches help in the design of an efficient kinetic system that enhances material arrangements for improved functionality.

## DESIGN AND FABRICATION

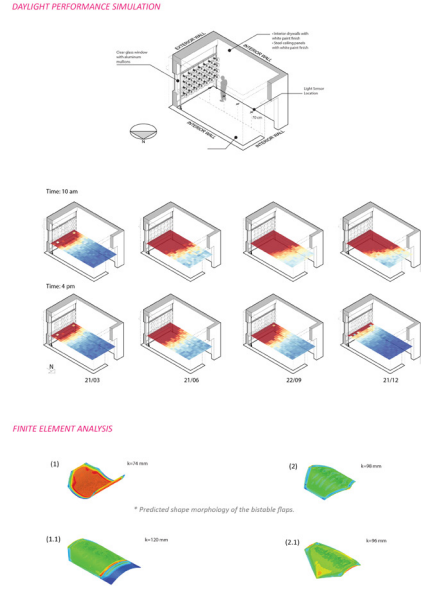
The kinetic snapping skins in this essay have two different material components, the bistable flaps and SMAs. The bistable flaps were fabricated using a process described in,[12] involving cutting and layering unidirectional carbon fibre layers, forming a vacuum bag, and curing the composites in the oven. The heating and cooling process creates differential thermal stresses that imprint the bistable behaviour of the laminates. While the material formation process starts with a flexible fabric with fibres in a single direction, it ends with elastic and lightweight bistable flaps. These materials can be quickly snapped into both positions by hand, as shown in a previous publication by the authors.[13]

12.
Lele, A., Deshpande, V., Myers, O. and Li, S. (2019). Snap-through and stiffness adaptation of a multi-stable Kirigami composite module. *Composites Science and Technology*, 182, p.107750.

13.
Vazquez, E., Evrim, B. and Duarte, J. (2021). Towards a Digital Workflow for Designing Bistable Kinetic Façades. In: Towards a New, Configurable Architecture - Proceedings of the 39th ECAADe Conference. Novi Sad, pp.365–371.




**Top: Fabrication process, Middle: Study of fiber orientations.**
**Below: Design configuration options, State College, USA, 2022**




**Top: Test room for daylight simulation.**
**Below: Finite Element Analysis of the bistable flaps, State College, USA, 2022**

For the final screen design, however, SMA springs strategically placed to actuate the bistable flaps were used.

The snapping skin's modular design comprises units of four flaps supported by a holder that form its entire tessellation. Several geometries were tested before selecting the final one for a full-scale test.[14] The bistable flaps are actuated by SMA springs that pull in strings, which are carefully attached to points in the bistable flap and cause them to snap from one position to the other. Bistable laminates transition between states through snap-through and snap-back motions. The SMA springs contract when they reach a temperature above 55° Celsius as they enter their austenite state. The springs can be actuated on-demand via Joule heating, allowing full control of the kinetic system. An alternative approach would be to use passive solar heating to actuate the SMA springs,

14. Vazques, E. and Duarte, J. (2022) Exploring the Impact of Geometry and Fiber Arrangements on Daylight Control in Bistable Kinetic Shades. *Journal of Facade Design and Engineering*.

but this can only be utilised in scenarios where complete control of the kinetic system is not needed or preferred, which did not fit the current project.

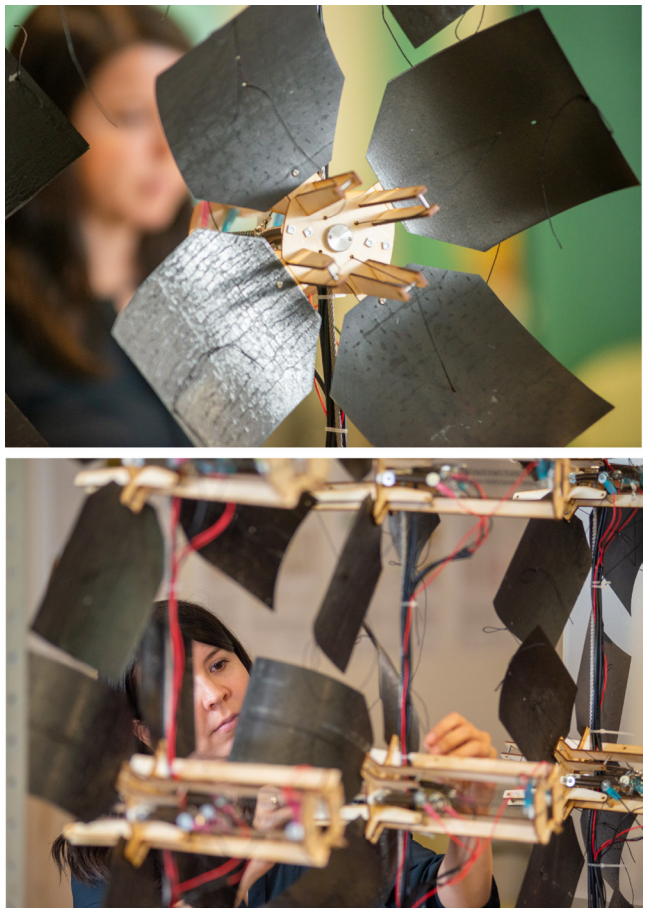
The modular design of the snapping skin allows the system to cover various surfaces, such as skylights, glazed areas, windows, and others. It can also wrap horizontal and vertical planes. In our full-scale prototype, we tested the modular system as a screen placed behind a large window. In this scenario, the screen is utilised mainly for daylight control. However, the system can also be used and programmed for other functions, such as space divider and privacy controller in indoor settings.

### DAYLIGHT CONTROL

One of the goals of this research into bistable skins is to optimise daylight performance in buildings with the screens. The snapping skin can open to allow sunlight to enter the building when needed and close to protect indoor spaces when there is too much light. Since the actuation time of the bistable flaps is around four seconds, a real-time screen adaptation is possible. For instance, the screen can change its configuration throughout the day in response to changing daylight conditions. However, one issue to solve is what design configuration would be more optimal throughout the day, i.e. under different outdoor conditions.

To study the snapping skins' functionality, two simulation models were developed, a daylight model and a Finite Element model. While the Finite Element Model predicted the bistable flaps' shape-morphing movement, the Simulation model tested its daylight performance. To assess the daylight performance, we conducted a series of daylight studies using experimental and simulation research. Using a test room as a case study, we collected daylight data using several light sensors. Once we obtained light data from the test room, we used the results to calibrate a digital model that could predict the screens' performance.[15] In addition, we used optimisation algorithms and design space exploration

15. Vazquez, E. and Duarte, J.P. (2022). Bistable kinetic shades actuated with shape memory alloys: prototype development and daylight performance evaluation. *Smart Materials and Structures*, 31(3), p.034001.



**Details of screen installation, State College, USA, 2022**
Courtesy: Michelle Bixby

to identify the best configurations for specific moments of the day. One of the main findings from these studies is that the bistable screen can help improve daylight control due to its kinetic nature.

## CONCLUSION

Broadly speaking, the research introduced strategies to combine smart materials with bistable laminates, eliciting new aesthetic and functional kinetic structures for kinetic architectural design. One of the many contributions of this project is developing a design language for bistable materials and strategies for integrating smart materials into bistable flaps. The results also demonstrated the feasibility of using Shape Memory Alloys

to actuate the kinetic system and optimise the design for aesthetics and functionality. Finally, we found that kinetic bistable shades can help improve daylight conditions in a full-scale controlled experimental study.

The prototype of the snapping skins introduces not only new aesthetics to kinetic architecture but also new soundscapes. Because the bistable laminates have two stable states, they produce a snapping sound when opening and closing. The elastic nature of their material condition also coupled with the tessellation appears to mimic a knitted fabric. These lightweight structures can wrap and enclose spaces, adding functionality to existing spaces.

Finally, the project has developed what is, to the best of our knowledge, the first prototypes of a kinetic façade using bistable laminates and smart materials. In short, the work expands the field of kinetic buildings by bringing forth a new generation of bistable adaptive façades that are energy efficient and contribute to the design of buildings with improved environmental performance.

# Landscapes of Care. Between spaces of protection and political rights

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Centro de Estudos de Arquitectura e Urbanismo,
grupo de investigação em Arquitectura, Arte e Imagem (AAI-CEAU) (Portugal)

The number of displaced people due to conflict and persecution has grown to the highest number since WWII, reaching 82.4 million, of whom 26.4 million are refugees under the UNHCR-mandate (United Nations High Commissioner for Refugees).[1] This proliferation on a global scale exposes the contradictions and anachronisms of an international refugee regime that continues to operate according to the classic vision of a circumscribed and short-lived conflict, using refugee camps as a medium to reach a permanent solution associated to the 1951 Geneva Convention and its 1967 protocol that, despite being exhausted, are the guarantor of the refugee regime, and in turn feed the creation of more camps. This research argues that this model is increasingly misaligned with 21st century leading to aporias, dilemmas, and chronic dependencies, requiring a new reading and support.

1.
UNHCR (2021) *UNHCR Global Trends 2021*.
Geneva: UNHCR.

Through Kenya, Ethiopia, Jordan, the Gaza Strip in Palestine, Algeria, South Sudan, Mauritania, Uganda, Tanzania, India, Pakistan to Syria, camps vary in shape, density, and (im)permanence. This reality reveals the paradox between the theory related to an exceptional situation limited in time and the practice of humanitarian action with hundreds of refugee camps in protracted situations managed as continuous emergency situations, drawing what we call the *Geography of Vulnerability*.[2]

The refugee camp as a *spatialisation of protection*, thus constitutes a complex and multidimensional reality of deprivation of rights that goes beyond the political and humanitarian dimension, to extend to socio-spatial reflexes.[3] In turn, we realise that the design constraints for the building of these spaces of refuge find their greatest challenge in *manualistics*[4] – part of the regulations that govern the construction and use of these spaces – which ends up reducing architectural practice to a functionalist and instrumentalised science. This is because, when analysing the guidelines for intervention in humanitarian emergency situations for the creation of spaces of protection and refuge – in the figure of refugee camps – we found that, in addition to being manifestly insufficient to respond to the complexity and extent of this challenge, they present operational dilemmas and constraints facing the needs of their inhabitants, exacerbated by the so-called protracted situations,[5] leading to the

2.
For more information about this subject, see the PhD thesis: Neto, M. (2022) *Territórios indefinidos no dilema da acção humanitária. Posicionamento crítico do arquitecto no entendimento dos campos de refugiados em situações prolongadas. Dadaab, Quénia, 1991-2021* (Undefined territories in the dilemma of humanitarian action. Critical positioning of the architect in the understanding of refugee camps in protracted situations. Dadaab, Kenya 1991-2021). Available at: gestion-doctorado.uah.es/tesis/23515. Also see the "instant city" (2021) debate: Agier, M, Herz, M. and Neto, *M. Instant city*, YouTube video, 1:57. Posted by "in conflict" March 28, 2021. www.youtube.com/watch?v=2IckZAhc8sQ.

3.
According to Edward Soja, space and society are co-constituted in a dialectic process, in a turn that assumes human activity, whether its social inter(actions) as readable either in time or in space, thus building a *socio-spatial* dialectic. See: Soja, E. (1980) The socio-spatial dialectic. *Annals of the Association of American Geographers*, Vol. 70, nº2 (6): pp.207-225.

4.
It corresponds to the proliferation of manuals and guidelines of minimum universal standards in essential areas of humanitarian response, in support of humanitarian practice.

5.
According to UNHCR protracted refugee camps are those where at least 25,000 people from the same country live in exile for more than five consecutive years. In fact, the average stay in these spaces is now 17 years. See: UNHCR (2006) Protracted refugee situations: the search for practical solutions. *In The state of the World's Refugees 2006 – Human displacement in the new millennium*, pp.105-197. 1ª edição. Geneva: UNHCR.

degradation of living conditions, chronic dependence and *host-fatigue*. Faced with this situation of total mismatch between what the camps are *intended* to be (spaces of refuge and protection) and what they *really are* (spaces of dependence and insecurity) any intervention plan is recurrently presented as a palliative action that ends up perpetuating the temporary nature of the camps and humanitarian dependency, proving to be insufficient as an effective response.

We also realise that the limitations of living in refugee camps in protracted situations result in informal mechanisms of urbanisation, and that the right to refuge and protection legitimise but do not grant legality to. The right to protection and consequently refuge, despite not being a useless effort, requires expense and is unable to provide lasting solutions *per se*, revealing in practice more of a privilege – difficult to achieve – than a right. This finding reveals that since forced migration has become an emerging challenge on a global scale, with complex social and spatial reflexes, its analysis and response require greater scrutiny not only by so-called *refugee studies*, but also by the disciplines that focus on human occupation in the territory: its forms, processes, and organisation in society. Thus, our contribution to a more thorough understanding of the camp – that of the spaces of refuge – implies the comprehension of both its legal and spatial mechanisms of creation and the management strategies of basic needs over time. Therefore, we understand protection not only in its legal component, but in its *spatialisation*,[6] as a built environment and the corresponding spatial repercussions of the dynamics that take place in it – areas to which architecture and territorial planning are dedicated – linking the discourse of humanitarian aid to architecture and planning.

On this issue, it is important to point out that the work experience with humanitarian agencies leads us to join those who consider that refugee camps should not exist.[7] However, although

6.
Understood here according to Soja's *socio-spatial dialectic*.

7.
In line with the scathing critiques of the refugee camp as a practical, ontological, and ethical problem created by refugee politics, arguing that the ills of refugee camps are inherent in their existence. See: Harrell-Bond, B. (2002) Can Humanitarian Work with Refugees be Humane?. *Human Rights Quarterly* Vol. 24 (4): pp.51-85. Available at:www.unhcr.org/en-in/4d94749c9.pdf.


**Landscapes of Care, Dadaab refugee camps, Dadaab, Kenya, 2016**
**Courtesy: Maria Neto**

we do not defend the camp as an action response, we recognise that managing asylum seekers and refugees depends not only on the economic and social structure of the host country, but also on the flow of requests. Taking into consideration the impossibility of dismantling all refugee camps in protracted situations, and noting that the continued presence of these camps reveals where the main active reception and protection points are located, which unlike other camps contradicts the ephemerality of emergency aid and remains anchored to porous, troubled borders, and chronic conflicts, in the expectation of an integration that although latent does not materialise, we reinforce the need not to deny them, but rather to bring them to the debate for analysing, debating and (re)thinking in the light of contemporary operational tools. How can architecture and urban planning contribute to the (re)reading, (re)interpretation, and (dis)solution of the refugee camp and inform the (re)formulation of this regime?

To answer these questions, we first need to define the camp and understand what activates it.

Thus, we say that the refugee camp results from a forced displacement, in mass, as a consequence of a critical event, revealing the inability of the nation-state to protect and ensure the security of its citizens who after crossing the border inevitably

generate a political problem due to territorial occupation. From this political problem arises a humanitarian problem that requires an "extraordinary response and exceptional measures",[8] given the urgent need to protect and safeguard the rights of a new acquired status – the asylum seeker/refugee. In addition to the citizen's right, which ceases to prevail in the event of a border crossing, there is the natural right associated with the Refugee Convention and its Protocols, which are the legal instruments through which the UNHCR[9] ensures international protection as "(...) temporary substitute for the protection normally provided by States to t heir nationals."

However, despite Refugee Status being defined in the 1951 Geneva Convention and its 1967 Protocol, its operationalisation is not. This means that in practice, despite being based on the same convention, each sovereign state decides the degree of protection and integration to be implemented. It is at this point that the opening of the host country and refugee protection policies diverge, reflected in different appropriations of the space of refuge, extending from the refuge itself as an artifact, to the camp and to human settlements in the territory, substantiating morphologies of precariousness and dependency. Adding to the emergency nature of refugees, both humanitarian and state responses are implemented as urgent, exceptional measures – therefore temporary – and often associated with a grey legal spectrum. It is in these emergency measures that we find the refugee camp, described in the Geneva Convention as the result of the duty of "(...) supervising international conventions providing for the protection of refugees",[10] through the granting of refuge, implemented and operationalised by humanitarian action, through *manualistics*.

We found in the *manualistics* – more specifically in the UNHCR's *Handbook for Emergencies* – the regulations for understanding the granting of refuge in emergency situations, that is, its operationalisation – "since offering a place to live

8. UNHCR (2007) *Handbook for Emergencies*. Geneva: UNHCR.

9. Ibid.

10. UNHCR (1951) *Convention and Protocol Relating to the Status of Refugees. Resolution 2198 (XXI) adopted by the United Nations General Assembly*. Geneva: UNHCR. Available at: https://www.unhcr.org/3b66c2aa10.

is a natural consequence of granting of the right of asylum"[11] – which takes different forms, namely: i) host families/ communities, ii) mass accommodation in existing shelters, and iii) organised camps. Each of these forms has a different impact, predominance, and spatial repercussion. Organised into four thematic chapters, the *Handbook for Emergencies* places the UNHCR's protection mandate in the context of emergency response. It describes the planning, management, and coordination of response efforts; discusses vital emergency sectors in refugee contexts, such as health, community services and sanitation and also describes recommended conducts in field operations.

We also realise, through *manualistics*, that there is an interchange between camp and settlement that intensifies the controversy about its nature and function and makes it even more difficult to define the camp. Given the difficulty of (in)definition of the object itself, we take as a reference the official definitions of organisations whose mandate operates the construction, organisation, and management of refugee camps (and settlements).

The UNHCR[12] defines refugee camps as "temporary facilities built to provide immediate protection and assistance to people who have been forced to flee due to conflict, violence, or persecution. While camps are not intended to provide permanent sustainable solutions, they offer a safe haven for refugees where they receive medical treatment, food, shelter, and other basic services during emergencies."

These guidelines, which are part of the intervention manuals in emergency situations, outline the birth of a space of refuge through an urban vocabulary that is familiar to us, but where the rationalisation of means and the urgency-imposed idea of relief and victim who suffers, are forged on neutrality and independence, that is, based on the logic on which the refugee aid patterns were built.

Humanitarian aid, as Rony Brauman[13] points out, does not have the ambition to transform a society. It does not contain in its genes

11.
UNHCR (2007) *Handbook for Emergencies*. Geneva: UNHCR.

12.
UNHCR (2021) *UNHCR Global Trends 2021*. Geneva: UNHCR.

13.
Brauman, R. (1994, 1997 edition) *A Acção Humanitária*. Lisboa: Instituto Piaget.

a project to transform ways of life, but rather to help its members to go through a period of crisis, in other words, of rupture of a previous balance, supporting the return to normality. We then ask the following question: what about when the return to the normality of prior to the emergency leads to the perpetuation of cycles of poverty and chronic vulnerability, or when the emergency lasts indefinitely and the temporary gives way to the permanent?

This dimension, associated with an ambiguous time and space, leads us to question the type of life that can exist within the camp – without ever forgetting that the camp is the spatial repercussion of the refugee status. Related to the different perspectives on refugee camps, we are interested in highlighting, sequentially, the following thoughts, beginning with Hannah Arendt[14] who links the camp to a perspective of limbo and a space destined to keep all kinds of undesirable elements from society – refugees, stateless, and marginal, to say the superfluous and importunate – deprived of the right to rights; Michel Foucault[15] who understands the camp as a space of discipline and biopolitics; that of Marc Augé[16] who understands the camp as "non-lieux" (*non-place*), so it is understood where there is a life without a place and representation, we would say by analogy, a non-citizen; that of Giorgio Agamben[17] who points to the camp as the *nomos* and its "state of exception" as the dominant paradigm of governance in contemporary times, where the refugee is a naked being with rights – "bare life" – opposing the *zoe* (animal life, without political or social representation) to the *bios* (citizen life, with political and social representation and participation); the camp as a deposit of human waste produced by Zygmunt Bauman's modernity;[18] and the camp as "exception",

14.
See: Arendt, H. (1951, 1989 edition) The Origins of Totalitarianism. Cleveland: Meridian Books; and: Arendt, H. (1968) Men in dark times. New York: Hartcourt Brace.

15.
Foucault, M. (1979) *Naissance de la Biopolitique*. Paris: Gallimard.

16.
Augé, M. (1992, 1994 edition) *Não-lugares: introdução a uma antropologia da supermodernidade*. São Paulo: Papirus.

17.
Agamben, G. (1998) (orig. 1995) *Homo Sacer: Sovereign Power and Bare Life*. Stanford: University Press.

18.
See: Bauman, Z. (1998) Globalization: The Human Consequences. New York: Columbia University Press; Bauman, Z. (2000) Liquid Modernity. Cambridge: Polity Press; and: Bauman, Z. (2004) *Wasted Lives. Modernity and its Outcasts*. Cambridge: Polity Press.


*"Ceci n'est pas une maison"*

**Landscapes of Care, Dadaab refugee camps, Dadaab, Kenya, 2016**
**Courtesy: Maria Neto and Jorge Marum**

"exclusion", "suspended time", "extraterritorial", "incomplete city", or even a space for "managing the undesirables" by Michel Agier.[19]

In fact, the built environment of the camp is witness to the overlapping of emergency operational logics and the mismatches resulting from this practice, revealing in protracted situations a kind of prevarication of the system, where what the organisation theoretically defends is not what it implements and promotes in practice. See the introductory note to chapter 12, "site selection, planning and shelter" of the Handbook for Emergencies: "Aside from a life-saving measure, having a place to live is a basic human right and this should be upheld by providing shelter and a friendly environment."[20] If, in fact, in a short-term exception situation,

19. See: Agier, M. (2002) *Between War and City: Towards an Urban Anthropology of Refugee Camps*. Cambridge: Polity; Agier, M. (2008) *On the Margins of the World: The Refugee Experience Today*. Cambridge: Polity; Agier, M. (2011) *Managing the Undesirables: Refugee Camps and Humanitarian Government*. Cambridge: Polity; and Agier, M. (2014) *Un monde de camps*. Paris: La Découverte.

20. UNHCR (2007) *Handbook for Emergencies*. Geneva: UNHCR.

the norm can be suspended, in the long term the exception incurs a violation of fundamental rights. We can ask at this point, how can UNHCR, an agency that defends human rights, continue to manage spaces where these rights are compromised?

In fact, refugee camps in protracted situations have long since ceased to be the camp that gave rise to them, but there is no other official name to define them. Reinforcing this ambiguous and contradictory character is the mobility inside the camp and between camps, which contrasts with the immobility towards outside the camp. In the opposite movement (from outside-inside), one can see the homogenisation of the camp through universal norms to respond to a universal figure that is also homogeneous – the refugee – that collides with the heterogeneity that forced displacement brought with it. This reading also brings different and contradictory meanings about their built environment, which from the outside reflects a homogeneous *landscape of care*, but which from the inside reveals various appropriations linked to colonised imaginaries by affinity. Alluding to these contradictory meanings is the fact that humanitarian action is linked to a political failure that triggers its activation, but humanitarian action is, by nature, apolitical, therefore incapable of solving political problems.

Since cartography is a fundamental political practice that represents and produces political space,[21] it is perhaps for this reason that none of these spaces of protection and refuge – regardless of their permanence – have been properly mapped, thus denying their existence, similar to the statute that gives rise to it. Denying its representation contributes to perpetuating the invisibility of the camp and who inhabit it. It is through the awareness that not everyone is represented and that there is in fact a *regime of visibility* or a *regime of truth* as M. Foucault[22] called it, where what is not represented by him forms, in opposition to, the regime of invisibility, that we perceive the need to look at the protection system in a disruptive way.

21. Elden, S. (2013) *The Birth of Territory*. Chicago: The University of Chicago Press.

22. Foucault, M. (1994) *Dits et Écrits*. Paris: Gallimard.


*"Ceci n'est pas un citoyen"*

**Landscapes of Care, Dagahaley refugee camp, Dadaab, Kenya, 2017**
**Courtesy: Maria Neto and Jorge Marum**

This critical positioning requires a paradigm shift regarding the way of thinking about spaces of refuge, that is, a repositioning of the architect and the role of planning tools beyond the context of humanitarian relief and emergency situations. For that, we thus question the paradigms of (im)permanence: showing that permanence and impermanence do not represent two opposing and fixed realities, but rather two sides of the same coin, as well as emergency and development, camp and settlement. We disprove an understanding of the camp as a result of a clearly exceptional emergency situation circumscribed in time, which opposes the refugee to the citizen, illegality to legality. On the contrary, we see (im)permanence rather as a porous and complex reality that ends up revealing a desire to make city, which we call *urban by affinity*.

In this context, an analysis of the process of design, construction, and growth of the camp – in its diversity and constant transformation – is fundamental for an understanding of the *socio-spatial* phenomena that occur in it, beyond the homogenising model that gave rise to it. Taking on the vectors of socio-spatial organisations and its expansion over time, is a way of legitimising their existence of being in the world, through

their built environment. Beside cartography, we use photography as a privileged complementary tool for observation, recording an analysis of these territories because we believe that photography can be used to document with critical and poetic narratives about space and the experiences that characterise and identify it, revealing invisible dimensions or those obliterated by the dominant narratives. Photography in this way is a practice and discipline capable of creating innovative and challenging visual discourse that allows a novel gaze to reality.

Indeed, the camp can be seen as a privileged place to challenge the logic of traditional theories of urbanisation and development, through the framing of the individual, as a subject that preceded the social state *apparatus*, allowing one to negotiate the contradictions of this requirement.

Note that many generations in refugee camps in protracted situations, such as in Dadaab in Kenya, were born already under the refugee identity – a non-normative status – even if they have not experienced the escape from their country of origin, which is actually the country that welcomes them, but that treats them as refugees. These generations have not experienced any reality other than exile. What is this relationship that is established with the territory? Despite that, these forms emerging from non-normative social relations were and continue to be understood as marginal to the various fields of knowledge. Nonetheless, the 20th century has been seen as the *century of refugees*[23] and Africa as the *continent of camps*,[24] then these spaces inevitably have an impact yet to be determined, in the process of global urbanisation and the definition of new urban figures and identities. Perhaps because the camp, in protracted situations after decades of permanence, has already metabolised in such a way that it is no longer a camp, but something else, which challenge the exceptionality of humanitarian genetics and threatens the global order. It is not by chance that Dadaab – like most camps in protracted situations – is so difficult to define. Affirming what the camp is or is not, in practice, leads

23. Soguk, N. (1999) *States and Strangers: Refugees and Displacements of Statecraft*. London: University of Minnesota Press.

24. Agier, M. (2011) *Managing the Undesirables: Refugee Camps and Humanitarian Government*. Cambridge: Polity

to this uncertainty not because of the impossibility of defining it, but due to the impossibility of describing it without resorting to linguistic ambiguity.

"Ceci n'est pas une ville", "Ceci n'est pas une maison", and "Ceci n'est pas un citoyen", in analogy to the treachery of images of René Magritte, alludes to the linguistic convention that no longer identifies the object, nor the thing itself, revealing its exceptional and ambiguous condition which is also reflected in its oscillating character between the temporary and the permanent, the legal and the illegal, which defies the norm and our understanding of urban space.

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Kibreab, G. (1991) "The State-of-the-Art Review of Refugee Studies in Africa". *Uppsala Papers in Economic History,* Research Report Nº. 26 (4): pp.351-368.

UN (1967) "Protocolo de 1967 Relativo ao Estatuto dos Refugiados". Geneva: UNHCR. Available at: https://www.acnur.org/fileadmin/Documentos/portugues/BDL/Protocolo_de_1967_Relativo_ao_Estatuto_dos_Refugiados.pdf.

# Repair takes time

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Since our ecological conscience has become prevalent, architects have begun to reconsider the sites on which they build. It is no longer possible to demolish existing constructions and clear a site that has already effected a great carbon footprint. Even if we were to build only biobased buildings adapted to future climate changes, we believe that we should not consider throwing away any existing artifacts on the sole pretext that they would inevitably be replaced by others, even if more virtuous in nature. Therefore, an *architectural project* tends to be less an anticipation of a new closed totality than a continuous process of repair, alteration, and modification of pre-existing situations.

Such a process leads us to reconsider the relationship of architecture with time, for at least two reasons. The first one is pragmatic: most of the sites in which architects are required to build – so long as they agree not to seal new soils – are polluted, and without non-ecological and costly excavations it takes time for decontamination. The second reason is theoretical: since enacting an architectural project no longer consists in conceiving an entirely new work without considering the inherited conditions of existing sites and constructions, our relationship with the past and future is deeply modified. These two changes force us to revise some of our best-established *cultural habits*. It implies a reappraisal of the long-term, whether in the act of soil preparation – now intimately linked to architectural design – or in our relation to history, now less linear and progressive than *anachronistic,*[1] to reveal latent and unexploited potentials within an inherited place or structure. This article explores the consequences of these new temporal conditions on the practice – and pedagogy – of architecture. It attempts to demonstrate not only how architecture can contribute to the repair of the world, but also how this repair implies dealing with time in a renewed way.

## THE LONG PROCESS OF DECONTAMINATION

Whether they are industrial or domestic wastelands, abandoned transport or energy infrastructure, or simply obsolete equipment, most of the sites on which architects will be building are polluted. They have been contaminated by hydrocarbons, heavy metals, chemicals, or volatile organic compounds, all of which have often permeated the water table or spread to surrounding land. The 20th century was not only the period during which more construction took place than during all prior centuries combined, it was also the period that has left behind the most damage.

Thus, a large number of sites are not only abandoned due to lack of proximity to transportation or roads, but also because in their current state the soil is unusable without first implementing significant depollution strategies. However, alternative techniques to simply excavating and relocating the contaminated materials to other sites might involve transformations that require several decades – or even generations. Architecture *as modification* – as initiated by Vittorio Gregotti[2] who claimed that through re-use of existing soil and architecture a revealing of landscapes can occur – now finds a limit that is not so much spatial as temporal. To paraphrase the slogan of May 1968, "the beach beneath the street" is contaminated; the layers of urban palimpsests are infected; our regulatory and aquatic systems are polluted. Faced with impending catastrophe of ecosystems, the will to reveal landscape now engages very long durations. Whether acting upon the horizontal of ground development or upon the vertical construction of a building, architects from the *Gregottian* tradition will have to complete their site's geographical knowledge with a temporal knowledge of the biogeochemical cycles that must be restored. Time has to become an ally and no longer an adversary against which one must fight to ensure the durability of sites and buildings. Time does not destroy everything – and when it comes to polluted soil, it can even revive!

1.
On 'anachronistic' history, see: Didi-Huberman, G. and Mendelsohn, H. (2018). *Surviving image: phantoms of time and time of phantoms: Aby Warburg's history of art*. Pennsylvania: Pennsylvania State University Press, and: Nagel, A. and Wood, C.S. (2020). *Anachronic renaissance*. New York: Zone Books, Cambridge, Mass.

2.
See this special issue of Casabella edited by Vittorio Gregotti: Vittorio, G. ed., (1984). *Casabella: Architettura come modificazione*, 498/499.

**Example of *gradual entropy*, student work from the master program "Transformation", École d'architecture de la ville et des territoires Paris-Est. Transformation of a group of suburban houses in Amiens, 2019**
**Courtesy: Léa Tilly**

## GRADUAL ENTROPY

This recapturing of time is not limited to sites of active development. Since we are less concerned with increasing the building of the world than the simple preservation of it for future generations, repair is also necessary even for sites that remain without planned future use. These sites are numerous. We have inherited an impressive quantity of abandoned places, results of the unlimited devouring of the soil by modernity and a ceaseless globalised economy. We are no longer in the *ordinary* obsolescence of which Françoise Choay speaks in *L'allégorie du patrimoine*, a "universal cycle of creation/destruction".[3] The ratio between obsolescence and usefulness has since been largely reversed. Obsolescence has been gaining ground ever since industrial wastelands were revealed in the 1980s: abandoned transport or energy infrastructure, derelict business parks, shrinking cities,

3.
Choay, F. (2007). *L'allégorie du patrimoine*. Paris Seuil, p.181.

ghost towns and villages, depopulated countryside, buildings without function in the middle of cities or large housing estates, not to mention all the sites that have been exposed to or have recently suffered from natural, human, or war-related disasters. For centuries, the *Western-built* world seemed too small for colonial needs and appetites and it might be that the opposite is happening in the twenty-first century. For even though urban expansion continues on a planetary scale, these abandoned spaces and polluted soil seem too vast in comparison with our real needs in terms of housing, production, and leisure – needs that will prove to be all the more reduced as the ecological imperative should lead us to greater frugality. The care of this huge mass of existing sites with no identified use is no less important than the adaptive reuse of the few sites for which a second built life can be envisaged.

In the uncertain context we are living through, architecture cannot be satisfied with simply responding to present needs. It must also prepare the world for climate change and the upcoming supply crises. The current abundance of spaces of abandonment and contamination paves the way for the deployment of an architecture without immediate programme with a role to re-establish a capacity of repair. In 1966, John von Neumann discovered that what distinguishes the artificial automaton from the living being is that automation stops at the slightest disturbance, aware of its irreversible degradation, while humanity is "capable, up to a certain point, of tolerating, fighting, rectifying the error by proceeding to repairs, regenerations, and reorganisations."[4] We could well be inspired by an idea that the degradable character of humanity is precisely what allows us to survive. We might then recognise with Anna Tsing that situations created by wear and contamination "open the way to transformative encounters, making new landscape arrangements possible."[5] The geographer Caitlin DeSilvey recently proposed the term "Curated Decay"[6] to refer to an organisation

4.
See Edgar Morin on the work of John von Neuman: Morin, E. (2011). General and Logic Theory of Automata. In: *Mes philosophes*. Paris: Pluriel, p.144.

5.
Tsing, A. (2015). *The Mushroom At The End Of The World: On The Possibility Of Life In Capitalist Ruins*. Princeton: Princeton University Press.

6.
Desilvey, C. (2017). *Curated Decay: Heritage Beyond Saving*. Minneapolis: University Of Minnesota Press.

of territories that assumes and integrates different degrees of entropy. She suggests that, for some sites, we might intentionally and carefully "let them go" and see what happens,[7] while for others, it might be better to stabilise their physical permanence so that, for a certain period at least, they are better prepared for an uncertain future.

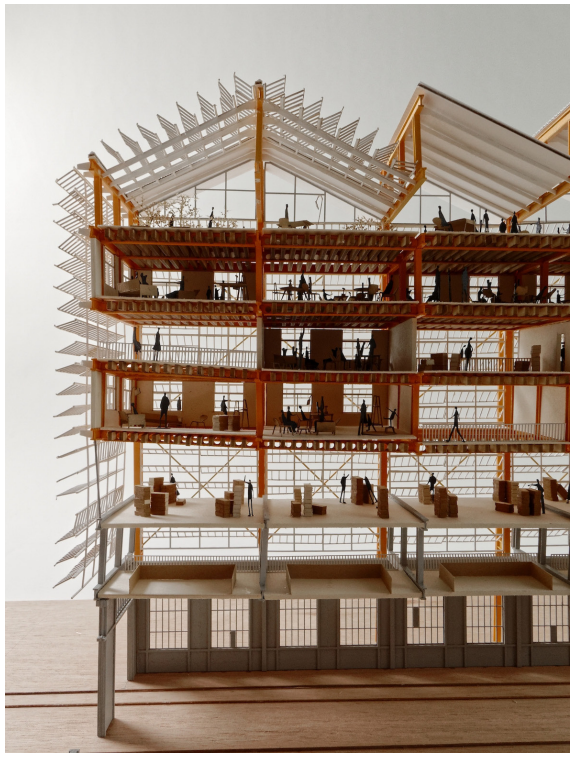
## BUILDING-IN-TIME

In addition to being a concrete and practical response to the urgency of *managing the stocks* of inherited built material, the idea of repair also forces us, on a more historical and theoretical level, to revise some of the principles that no longer seemed to be an issue when talking about architecture. We can classify these modes of revision, in a very schematic way, in four categories.

*FIRST*: the act of repair pushes us to revise our conception of what *heritage* means, a word then displaced from its usual meaning – aesthetically and historically remarkable buildings – to its initial meaning, namely what is transmitted to a community by previous generations. For us, in this case, this means the mass of often polluted built material already mentioned. Repair reanimates the regime of historicity that we have been used to name *pre-modern*, for which the ancient past is a non-problematic quasi-present up for direct manipulation, a reservoir of forms within which one can freely wander and borrow. It induces a relation to heritage that proceeds by returns and rebounds. Without denying invention, it links *architectural history* to the recovery of latent and unexploited potentials contained in any form and any structure.

*SECOND*: repair pushes us to revise our idea of what an architect is. The Renaissance consecrated the idea of the architect as author, a status based on a literary model inherited from Petrarch and now well documented by historians. The corollary, also well documented, is a displacement of architecture towards the stage of conception,

7. This is also what Baptiste Morizot proposes when he claims to "reconnect with the living", i.e. to set up the conditions for rewilding as frequently as possible, in both rural and urban areas. See: Morizot, B. (2020). *Raviver les braises du vivant: un front commun*. Arles, [Marseille]: Actes sud ; Wildproject.



**Example of *interpolation*, student work from the master program "Transformation", École d'architecture de la ville et des territoires Paris-Est. Transformation of a fabric in Amiens, 2019**
**Courtesy: Antonin Delaire**

as a *cosa mentale* that must first be thought out in its smallest details, then built as it was thought out. Of course, all this is not only a matter of the internal history of the architectural discipline, but also of associated financial imperatives and above all a new consciousness of time. A consciousness of time that no longer considers construction as it *was* considered, for example, building a cathedral over several centuries. Now, it seems to us that the transforming architect finds in this old pre-Renaissance consciousness of time their status of architect is modified. The parallel with literature remains enlightening. For example, we recall that medieval literature was accustomed to two practices of great interest to the architect-repairer of today: *continuation*, which consisted of taking up a text written by someone else (or even by several others) to extend it in one's own way, expecting others will also continue; and *interpolation*, consisting of inserting passages

into the course of an existing text.[8] Many ancient works, both literary and architectural, are thus the result of such interweaving. Architect-repairers could thus become these continuators and interpolators.

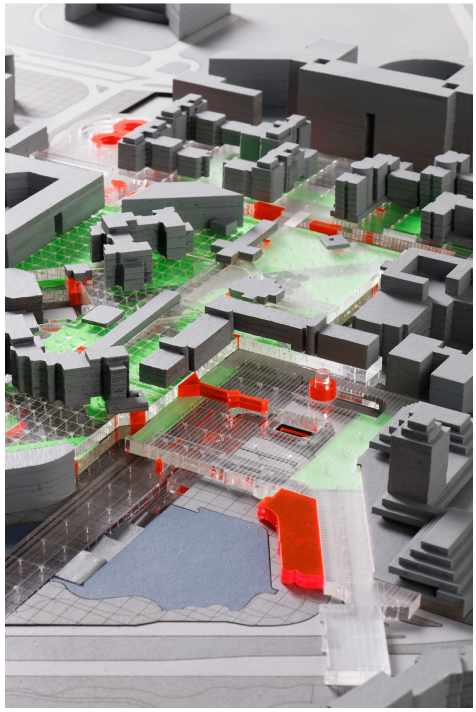
*THIRD*: repair forces us to revise our idea of architectural practice, for it is forced to deal with time in a completely different way. In a book significantly entitled *Building-in-Time*,[9] American architectural historian Marvin Trachtenberg presents an ancient conception of architecture that considers construction to be part of time – and often very long time – writing: "In pre-modern Europe, the architect builds not only with imagination, bricks and mortar, but with time itself".[10] He contrasts this relationship to duration with the gradual emergence of an architectural conception in which time is no longer a material open to the individual and collective reflection of generations, but simply the duration which is necessary for the implementation of what has been thought and conceived beforehand in all its aspects. A duration that must, for reasons of economy – but also so that no one can come and adulterate the work if the author were to fail – be as short as possible. It is worth quoting here some of the theoretical principles from before the Renaissance that, according to Trachtenberg, underpin this relationship with time – at least in his reconstruction, since of course these principles were never stated as such at the time, and as such Trachtenberg is writing what Rem Koolhaas would call a *retroactive manifesto*.

In order not to be too long, we will retain here only two that are of particular interest to us. The first is the principle of *continuous redesign*, according to which any construction, far from being fixed according to the features of a perfection as per Leon Battista Alberti "to which nothing can be added or subtracted", is in fact always open to reworking according to the uses and circumstances likely to give it many new lives. It is useless to underline how such

8.
On these practices, see: Genette, G. (1982). *Palimpsestes: la littérature au second degré*. Paris: Éditions Du Seuil. On quotations, see: Compagnon, A. (1979). *La seconde main ou Le travail de la citation*. Paris: Éditions Du Seuil. On interpolation, see: Rabau, S. (2020). *L'art d'assaisonner les restes, Théorie et pratique de l'interpolation*. Toulouse: Anacharsis.

9.
Trachtenberg, M. (2010). *Building-in-Time from Giotto to Alberti and Modern Oblivion*. New Haven: Yale University Press.

10.
Ibid. Cover flap text.



**Example of *concatenation*, student work from the master program "Transformation", École d'architecture de la ville et des territoires Paris-Est. Transformation of a slab-based infrastructure in Marne-la-Vallée, 2021**

**Courtesy: Terri Champavier, Julie Eymery and Daniel Emanuel Pop**

a principle can concern our current relationship with heritage, in the sense that we have defined it above. The second principle we can cite is the principle of *concatenation*, which "required that every design move be linked to a previous move, or series of such moves, which meant that as a whole, the building formed a continuous chain of design events."[11] What is interesting here is that, by Trachtenberg's own admission, these principles and practices are permanently lost, and his entire book is written to restore their memory. The aim of the architect-repairer is, on the contrary, to prove him wrong, that these principles are very current and now have a critical urgency.

*FOURTH*: repair prompts us to revise our idea of architecture as a discipline largely informed by post-Renaissance conceptions already mentioned. These conceptions have gradually consolidated the idea of architecture as a relatively autonomous discipline,

11.
Ibid. p.139.

and one somewhat focused on its own internal coherence – an idea justified by a long and glorious history, then underpinned by the scholarly tradition of the Treaties and embodied in remarkable monuments. It seems to us, however, that such a paradigm is neither the only one possible, nor the most current, given the mass and state of decay of the heritage that we must now assume. There is no question, of course, of compromising on the formal quality of architecture. But in itself, this quality does not seem to us separable from the external stakes linked to the repair, the maintenance, and the reuse of this heritage.

We will conclude by borrowing a sentence from a recent work of literary criticism whose title constitutes for us a whole programme: *Repairing the World*. Its author, critic and theorist of literature Alexandre Gefen, evokes the appearance of a new consciousness in the literary field, centred less on the paradigm of disciplinary autonomy – which is of course also valid for literature – than on what he calls a "clinical paradigm", made necessary by the situation of the world that we have to face: "I would like to describe this clinical paradigm as a way of asking writing and reading to repair, to reconnect, to knit together, to fill in the cracks of contemporary communities, to reweave collective and personal history, to make up for the vanished mediations of social and religious institutions perceived as obsolete and decaying at a time when the individual is assigned to invent himself."[12]

We would like, without forcing the transfer of the literary domain into the architectural domain, to make this programme[13] our own. Architecture, no less than literature, has real means – means that are its own and which mobilise its history and methods – to tackle such a task.

12.
Gefen, A. (2017). *Réparer le monde: la littérature française face au XXI e siècle*. Paris: Éditions Corti.

13.
The research from which this text is issued is linked to the master program «Transformation» directed by Paul Landauer, with Luc Baboulet, Julien Boidot, Mathieu Delorme, Anne Klepal, Fanny Lopez and Frédérique Mocquet.

# The metamorphic city: Fungal narratives for ecosystemic restoration

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Definitions of metamorphic include:

pertaining to a profound change in form from one stage to the next in the life history of an organism, as from the caterpillar to the pupa and from the pupa to the adult butterfly.

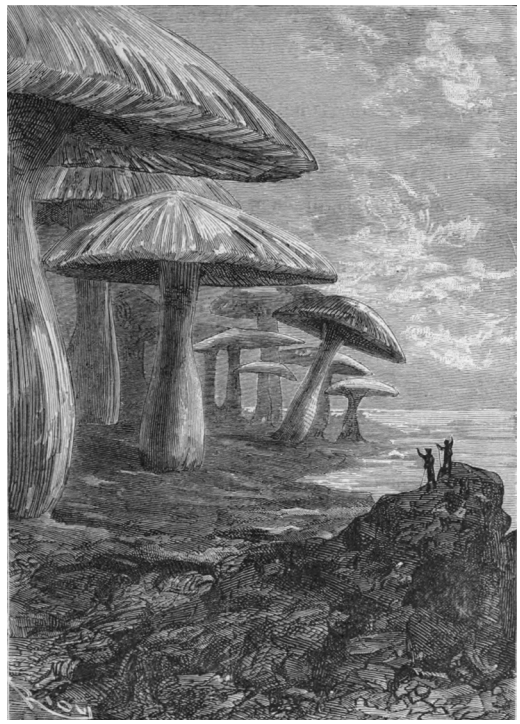
relating to a complete change of structure, or substance, as transformation by magic or witchcraft.[1]

## LIFE OUT OF BALANCE

In the age of environmental exhaustion, the building industry is one of the major sectors responsible for pernicious levels of land extraction and the production of non-valorised waste leading to the loss of biodiversity, habitat degradation, and climate change. The effects of urbanisation have reached unprecedented levels of environmental damage with oversaturated aquatic and terrestrial carbon sinks.[2] Let alone, the building construction, renovation, and demolition residual streams represent roughly one-third of

1. Dictionary.com (n.d.). *Definition of metamorphosis*. [online] www.dictionary.com. Available at: https://www.dictionary.com/browse/metamorphosis.

2. IPCC (2021). *Climate Change 2021: The Physical Science Basis*. [online] www.ipcc.ch. Available at: https://www.ipcc.ch/report/ar6/wg1.



**Édouard Riou,**
**Journey to the Center of the Earth,**
**1864**

planetary waste production.[3] In addition, the harmful effects of human activity on the planet are leaving us even more vulnerable to natural cataclysms, compromising our very existence on earth. Environmental disasters such as flooding, landslides, and wildfires are becoming increasingly recurrent, eradicating built environments and the homes of many.

Concurrently, speculative development and the commodification of cities elevate social inequalities and reinforce disparities for the right to the city. The workings of society are feeding a growing paradox fundamental to contemporary urbanisation. As cities are growing and expanding outwards, they are also consuming their very own foundations.[4] Fed by incessant power dynamics, land privatisation

3.
Government of Canada, P.S. and P.C. (2020). *National Waste Characterization Report: the Composition of Canadian Residual Municipal Solid Waste*. [online] publications.gc.ca. Available at: https://publications.gc.ca/collections/collection_2020/eccc/en14/En14-405-2020-eng.pdf.

4.
Madden, D. (2020). *Housing and the Crisis of Social Reproduction*. [online] www.e-flux.com. Available at: https://www.e-flux.com/architecture/housing/333718/housing-and-the-crisis-of-social-reproduction.

reinforces housing precarity giving rise to more unequal, segmented, and inaccessible conditions for its dwellers, and pushing the most vulnerable populations further out and beyond its urban centres. To inhabit the city today reflects an ever greater economic and political battle against the vortex of speculative development that swarms across any land to inflate its value for profit.

With the urgent need to address our current ways of relating to land and urban fabric, comes the need to reconsider our perception *of* them – from *within* them rather than disassociated from them, as one and the same. Culture, as a body tied to our societal customs, has to undergo ground-breaking change to accept and take on adaptive views and actions. Starting from the challenge to push new boundaries for a paradigm shift, it might be worth revisiting the meaning of *chaos*, commonly associated with a state of disorder and confusion. From Greek mythology to Christian theology, *chaos* has been defined as: the void state of the universe before things came into being or the abyss of the underworld; the unfathomable space at the beginning of time; or, the realm of mass and energy from which much of what is powerful in the world would stem forth in later genealogies.[5] In this sense, chaos can be understood as a temporospatial agent that resets circular life cycles and enables regeneration to take place.

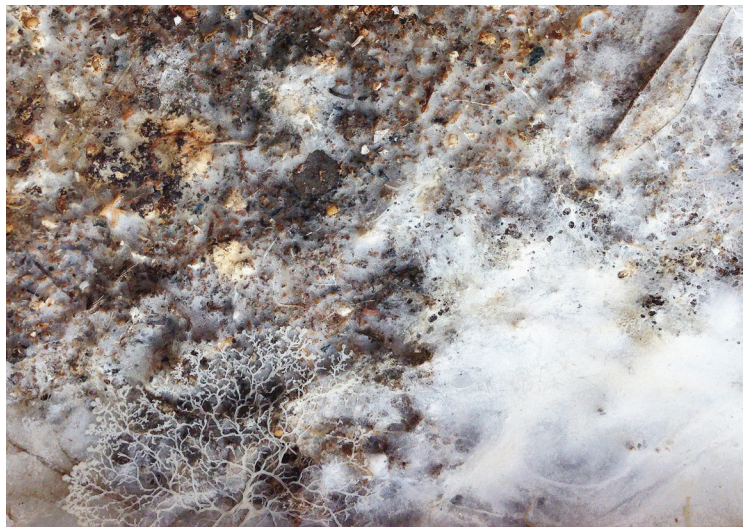
## THE FUNGAL BRIDGE

"Regeneration is not about mitigating harm. Rather, it is about restoring, enriching, nurturing, replenishing, and creating the conditions where ecosystems, economies, and any living agent, including us, could flourish and thrive. Hence, thinking regeneratively means trying to think as a fungus would: with nature, for nature, and as nature."[6]

The proposal explores the entanglements below ground that deal with the transmission of energy enabling life to happen as it does above ground. The vital wellbeing of our plant-based ecosystem is

5. GreekMythology.com (2014). *Chaos*. [online] Greekmythology.com. Available at: https://www.greekmythology.com/Other_Gods/Chaos/chaos.html.

6. Carpenter, W. (2021). *Maurizio Montalti on Design & Nature*. [online] Design Miami/ Shop. Available at: https://shop.designmiami.com/blogs/news/maurizio-montalti-on-design-nature.



**Etienne Issa, Distant Relatives**
**Montreal, Canada, 2021**

largely reliant on a network of fungal organisms in the soil, mostly invisible to the human eye. The underground mediator responsible for creating the complex web that bridges diverse living organisms together is mycelium, the fruiting body of mushrooms composed of an interwoven network of hyphae. Fungi have demonstrated their capacity to remove toxins from the soil and heal deteriorated environments mainly affected by human activity. They restore the biological balance of the soil along with its degraded habitats and pave the way for the rebinding of complex biological communities to gather, contributing to ecological biodiversity.[7] The symbiotic ties formed by mycelia and other living matter can be referred to as a *holobiont* – deriving from the Greek *holos* meaning whole, and *biont* meaning organism – where the result of a composite entity is greater than the sum of its parts. This captures the transformative ability of fungi to mutate along with their organic companions into singular entities, such as lichens (with algae or cyanobacteria), attesting to multispecies biodiversity on Earth ranging from soils, plants, insects, animals, and humans.

7. Stamets, P. (2005). *Mycelium running: how mushrooms can help save the world*. Berkeley, Calif.: Ten Speed Press.

As we look to break away from harmful extractivism, new processes for linking local waste management to biotic material harvest can provide one of many restorative applications for pressing environmental attunement, hampering the mainstream neoliberal industrial model. Fungi represent a drastic shift in the way we think of material life cycle, challenging exhaustive human activity globally. Given the current nature-culture dilemma, the interdisciplinary project studies fungal mycelium as a catalyst for an eco-social reconciliation through emerging biocomposites from collected building waste streams for circular cities, resilient communities, and regenerative materials.

## FERMENTED ARCHITECTURE

How can mycelium alleviate urban waste management and allow residual upcycling of building detritus towards the transformation of cities? How can new alliances between traditional knowledge and novel biomaterials inform contemporary architecture to tackle social inequalities while providing material transparency and access? How can mycelium composites guide us to transcend our cultural perception about the built environment advocating for an ethics of care, sustenance, and maintenance? How can cultivation and fermentation principles set the tone for a time-based climate-sensitive building practice that works in harmony with the change of seasons?

The inquiry focuses on large-scale non-sterile fungal applications for urban transformation, where nature and culture are understood as one for ecological and social justice. The applied research follows a low technology vernacular approach to the development of architectural typologies through load bearing prototypes informed by variable ways of casting, growing, and drying mycelium composites. While mycelium thrives off fibrous lignocellulosic (dry plant matter) waste, the investigation probes the potential gains by adding mineral aggregates from residual building streams – stone, concrete, and clay. The experimental work offers a breaking point for critical alternatives to petroleum-derived products in the building industry using mycelium as an organic binder for upcycling and converting collected building debris into bio-based structural materials. As such, it explores circular and regenerative methods for biological organisms to

**Etienne Issa, Distant Relatives**
**Montreal, Canada, 2021**

disrupt linear material and building trajectories, working towards carbon negative cities. Ultimately, the project explores how mycelium composites can activate new correspondences between architecture and landscape, reorienting the practice of contemporary building to a process of care and maintenance.

The complexity of fungal expression brings up to two complementary processes: dormant works and active works, with dried and animate biological culture respectively. The dormant series consist of precast mycelium composites providing a new inventory of building elements while establishing a tangible bridge for a material transition from fossil-based to bio-based. Conversely, the active series will rely on a scaffold, where the fungal organism will progressively merge with its host, or substrate, to eventually form a singular monolith. The dialectic prototypes speak to the tension that resides between the dead and the living, the geometric and the organic, the defined and the fluid. The explorative project is rooted in the wild fermentation of microorganisms to reflect a time-based process of making that is sensitive to its environmental conditions.

On the one hand, the project offers new horizons by linking local traditional knowledge with biological technology leading to fermented architecture. On the other hand, it creates ties between building waste valorisation and the elaboration of biocomposites. The investigative trail triggers active measures to tackle material scarcity, increase transparency, reduce waste at the source, provide a cleaner production, and empower communities to work collectively towards achieving sustainable frameworks of interaction. Finally, the applied research cultivates the synergies between human and non-human living species striving for ecosystemic change at the collective scale.

## TECHNOLOGY AND ITS SHADOW

"Three hundred years ago, intellectuals of the European Enlightenment constructed a mythology of technology. Influenced by a confluence of humanism, colonialism, and racism, this mythology ignored local wisdom and indigenous innovation, deeming it primitive. Today, we have slowly come to realise that the legacy of this mythology is haunting us."[8]

With modern society came principles of efficiency that underlined the dogmatic link between progress and technology to the point that these two appear to be indissociable to many still today. In the *Reconstructing the Future for People and Planet* conference held in June 2022, organised by Bauhaus Earth and the Pontifical Academy of Sciences (PAS),[9] Edgar Pieterse alluded to the violence of technology as a form of advanced capitalism and a tool for segregation in wealth and accessibility across the Global North and the Global South.[10] Indeed, the development of high technology is subsidised through private/public sources to create new market opportunities and future economic growth, all done in the name of societal progress and advancement. However, the preservation

8.
Watson, J. and Taschen GmbH (2019). *Lo–TEK: Design by Radical Indigenism*. Köln: Taschen.

9.
Bauhaus Earth (2022). *Reconstructing the Future for People and Planet Conference - Announcements - e-flux. [online] www.e-flux*.com. Available at: www.e-flux.com/announcements/472249/reconstructing-the-future-for-people-and-planet-conference.

10.
Edgar Pieterse is the director of the African Center for Cities at the University of Cape Town and is South African Research Chair in Urban Policy.

of low technology is crucial in enabling shared access and the democratisation of methodologies that can be adaptable to various terrain to fit their site-specific conditions. This allows for traditional craft and ancestral knowledge to be passed on from one generation to the next, nurturing polysingularity and ensuring that we remain rooted to the ground. The significance of the project to stay bound to low technology lies in the exchange and the evolution of a discipline to contribute to, and to conversate with the intergenerational multicultures that have influenced nature-based practices across the biosphere. It is to recognise and acknowledge the work of Indigenous communities, the dignity with which they have treated the land that supports them, rather than objectifying it and exploiting it.

From harder to softer landscapes, and from mineral to fibrous matter, some of the oldest civilisations have managed to elaborate dwelling schemes in accordance with nature long before they had modern or sophisticated tools. These vernacular references of *architecture without architects* exemplify land-sensitive innovation responding to human necessity with respect to their immediate landscape through available matter. For instance, troglodytic settlements of the Palaeolithic or Old Stone Age have portrayed distinguished ingenuity through economy of means within a network of carved spaces inside the earth's mass. The excavated material would serve as a complementary resource to complete their construction above ground, where nothing was wasted and nothing was left unused.[11] The constructive or subtractive building logic of the time was already embedded in a sustainable and circular approach, which fed strong regional identities and land ties precisely based on the constitution of the ground.

## THE BUILDER, THE FARMER, OR THE FORAGER

"Know the ways of the ones who take care of you, so that you may take care of them."[12]

Due to their organic character, mycelium composites foster care in all phases of the project: from the cultivation of the mushroom

11. Mastenbroek, B., Mecredy, E. and Baan, I. (2021). *Dig it! Building bound to the ground*. Cologne: Taschen.

12. Kimmerer, R.W. (2013). *Braiding Sweetgrass: Indigenous wisdom, scientific knowledge and the teachings of plants*. Minneapolis: Milkweed Editions.

**Etienne Issa, Built/Found: The convergence of concealing and revealing architecture in Matera's cave dwellings, Matera, Italy, 2019**

spores to the harvest of biomaterials, and from the collective act of building to its maintenance in the years that follow. With the integration of numerous decentralised mushroom farms in the urban fabric, or in annexe to existing community gardens, social groups can create their own material futures through collective autonomy and biocircular economy – weaving the practice of building with that of farming. In one given space, individuals and collectives produce what will simultaneously house them *and* nourish them, blurring the boundaries between architecture and agriculture. If syntropic agriculture is defined through the integration of food production and forest regeneration, then syntropic architecture can be envisioned as the combination of biomaterial production and urban regeneration. Syntropic agriculture follows a process-based model, as opposed to input-based model, which means that one works with nature instead of against it.[13]

13. Gallant, S. (2019). *What is Syntropic Farming?: A Permaculture Perspective*. [online] Porvenir Design. Available at: https://www.porvenirdesign.com/g/2019/7/24/1bufd9zncys2tlph3qmmkz57ncqgsq.

Far before the Green Revolution, agriculture implemented sustainable techniques through transmission of wisdom, which deserve much attention in shaping the pivotal transition within Western *building* culture. For instance, designers and architects can draw from methodologies found in companion planting or intercropping through the cultivation of the Three Sisters, referring to the Indigenous American diet composed of beans, corn, and squash. The symbiotic relationship between the three crops can be observed from how the corn stalks create a trellis for the beans to climb, securing them from high winds; how the bean plant root pulls nitrogen, essential for the growth of both beans and corn; and how the squash plants provide shade with their wide leaves averting the growth of weeds and retaining water in the soil, beneficial to all three.[14] In parallel, an ethics of reverence and land stewardship lies at the core of the *Honorable Harvest*, a traditional bond between humans and the land that governs the exchange of life for life, taking only what one needs and using everything one takes.[15] It is characterised by carrying through an intention from collection to use. This mindfulness forms the basis of acting and making with care, sustaining the comprehensive links to our immediate environment through a multigenerational lens.

Finally, mycelium's binding properties can serve as a metamorphic agent to radiate beyond its natural habitat to impact societies by informing new dynamics of interaction between multiple living organisms. The synergies between mycelium and its biological companions below ground become a model for the social bond that feeds community engagement and empowerment from the ground up. By learning from fungi, we can get in touch with architecture as an extension of landscape, where the ground and its elevation are treated as one. To care for the land becomes to care for the building and to care for the building becomes to care for the land.

14.
Hill, C.G. (2020). *Returning the 'three sisters' – corn, beans and squash – to Native American farms nourishes people, land and cultures*. [online] The Conversation. Available at: theconversation.com/returning-the-three-sisters-corn-beans-and-squash-to-native-american-farms-nourishes-people-land-and-cultures-149230.

15.
Kimmerer, R.W. (2013). *Braiding Sweetgrass: Indigenous wisdom, scientific knowledge and the teachings of plants*. Minneapolis: Milkweed Editions.

# Time form / Form time

Ilnar Akhtiamov, Rezeda Akhtiamova, Anna Guseva, Daria Butorina, Valeria Burkova, Alexandra Chuprina, Dina Kiyamova, Vladislav Krayushkin, Vladimir Obrosov, Olga Yerukova & Diana Kalimullina
Kazan State University of Architecture and Engineering (Russia)

**Time-Form Design Method. Dina Kiyamova, "L'âme. Community Centre in Bordeaux", Kazan, Russia, 2021**
**Courtesy: TIArch Studio, KSUAE**

Humans explore spaces of *terra* through a game designed by nature. Any good design, following nature's game, is adaptive and like a living being. Sarah Williams Goldhagen studies how urban spaces affect people, leaving them enchanted, or indifferent. Following developments in psychology and cognitive neuroscience, Goldhagen reveals that habituation is the main obstacle to improving our lives and habitats.[1] Motionless, non-threatening, and familiar places and environments do not attract our attention, while even proper design elements can dull our senses over time.

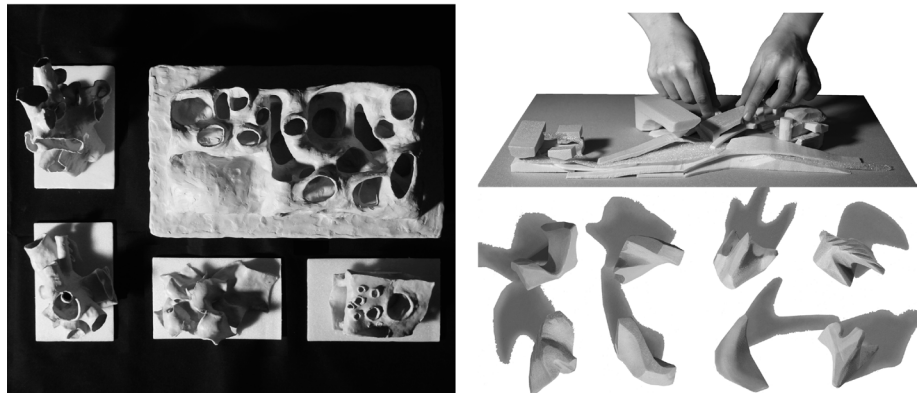
**Stage 1 – Sketches. Vladimir Obrosov, "Community Centre Image", Diana Kalimullina, "Form of the Dance Concept", Kazan, Russia, 2021**
**Courtesy: TIArch Studio, KSUAE**

But designers can prevent *addiction* to the built environment and mitigate its soporific effects if they take advantage of nature's everchanging patterns.

According to the phenomenological approach to architecture, places can be designed to be sensitive to any environmental changes, be it light, weather, temperature, or sound. Changing nature can make the place appear to completely transform, even though it remains the same. Thus, a building can have its own *biorhythms* as temporal patterns leading users to feel a playful spirit of the place through indirect psychological associations. Hence, the more a public building resembles a natural structure with daily or seasonal patterns of *behaviour*, the more engaging this place is for urban dwellers.

The Time-Form design approach, developed at TIArch Studio, KSUAE, allows architecture students to experiment with dynamic physical and social environments of a public space, influencing each other. They seek to discover *invisible* patterns of how living beings or their body parts move, interact, and manage life support resources, later converting them to architectural layouts. The initial natural structures and their biorhythms gradually turn into organic public spaces and their adaptive leisure scenarios.

1. Williams Goldhagen, S. (2019). *Welcome to your world: how the built environment shapes our lives*. New York: Harpercollins. pp.282-291.



**Stage 2 – Models. Valeria Burkova, "Spatial Structure of the Golgi apparatus", Diana Kalimullina, "Choreography Centre Morphology", Kazan, Russia, 2021**
Courtesy: TIArch Studio, KSUAE

Thus, a waterfront community centre has interflowing inner routes, inspired by the daily biorhythms of a human heart.

The Time-Form design method is broadly applied in public space projects at TIArch Studio. Given its versatility, it helps architecture students correlate their sculptural intuition with the natural rules of living beings' behaviour. Here, images are derived from several proposals for a community centre in a waterfront residential district in Bordeaux, designed by Year 4 students. Another example is a thesis work, where a choreography school and a large urban public space in Kazan triggers creativity thanks to elusive body movement patterns incorporated into the centre's spatial structure.

There are three stages which comprise the Time-Form design method. Firstly, sketches are made to gather an intuitive image of the public space. Students develop social portraits of the target users and their habits, and consider possible new activities to bring diverse people together into the neighbourhood. Students also gather the initial architectural image of the public centre, focusing on emotions provoked by the place's natural and artificial lighting, textures, inner mechanisms, and other details, suiting the community and the proposed future activities. In particular, students analyse the structure and biorhythms of a natural system, relevant to their concept, be it a cell, body part, creature, or natural process. Thus, the interlinked parts of a human heart, producing the multi-phase circular blood flow, can be paralleled with the functional diagram of a community centre, and hence

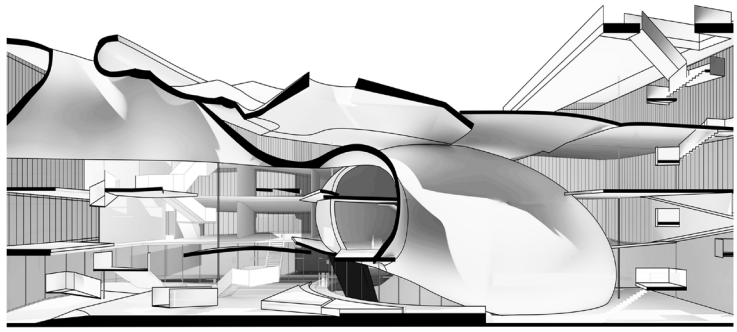
inspire organic and interactive spatial solutions. Likewise, the natural and ergonomic movements of a dance, if systematically analysed, can be *petrified* in appealing spatial patterns, which are later transformed into multi-scale architectural volumes.

Secondly, models are formed to analyse spatial opportunities of a structure inspired by biorhythms. A set of revealed biorhythms is converted into a matrix of spatial patterns, and then these bio-inspired spatial modules are gradually assembled and combined in a sophisticated spatial system, a physical prototype of a future building with an organic structure. Students explore the psychologically pleasant plasticity of natural structures and, importantly, their diverse behaviour at different seasons or times of day. The physical models help architects develop alluring functional inner routes and human-scale design, inspired by nature. In other words, students transfer the discovered natural features to a prototype of an architectural space, which adapts to the users' needs, like a living being.

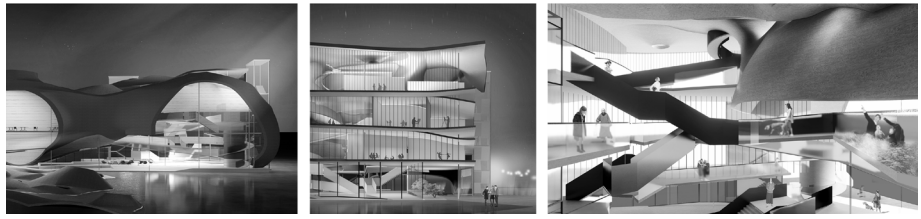
Thirdly, designs are produced using 3D software to elaborate the spatial and functional programmes of urban leisure into a distinct community centre layout. It is designed to fit the local urban context and be developed as a practicable project. At this stage, the engaging nature-based space design, which avoids typical post-and-lintel structures, is supported by modern construction technologies and parametric design software. Thus, the sophisticated interflowing spaces are revealed in multi-layered cross sections and architectural details. Generally situated in potentially vibrant urban environments, such public centres could become neighbourhood dominants, so their organic and elaborate architectural forms suit their role within the community.

Thus, the Time-Form design method involves sketches, physical models, and renderings. Architecture students explore the engaging environment patterns, which will later be experienced by the building users hands-on. It is a quest to bring our urban experience closer to a natural one through a new urban morphology.

The creative and innovative ways of bringing human culture into harmony with Earth's natural systems has been researched by the Land Art Generator Initiative. According to them, regenerative technology and functional land art design can contribute to the sustainable infrastructures of modern public



STAGE 3. DESIGNS



**Stage 3 - Designs. Alexandra Chuprina, "Opportunity Palette. Community Centre in Bordeaux", Kazan, Russia, 2021**
**Courtesy: TIArch Studio, KSUAE**

spaces. A TIArch Studio project, mentioned in the recent LAGI book, devoted to Fly Ranch, Nevada,[2] demonstrates that the nature-based Time-Form design method is applicable not only to public buildings, but also to functional installations.

In *The Nature of Economies,*[3] Jane Jacobs praises biomimetic thinking. Architects can learn from the way that forest ecosystems use the sun's energy: once "captured in the conduit, it is not only converted but repeatedly reconverted, combined and recombined, cycled and recycled, as energy/matter is passed around from organism to organism", (or system to system). The variety of ways in which a system, be it a forest or a building, transforms incoming natural resources, ensures its prosperity. The Time-Form method follows this idea of multiple transitions of temporal and spatial patterns in the design process.

2.
Ferry, R. and Monoian, E. eds., (2021). *Land Art of the 21st Century: Fly Ranch*. Munich: Hirmer. pp.194-5.

3.
Jacobs, J. (2001). *The nature of economies*. New York, Ny Vintage Books. pp.45-51.

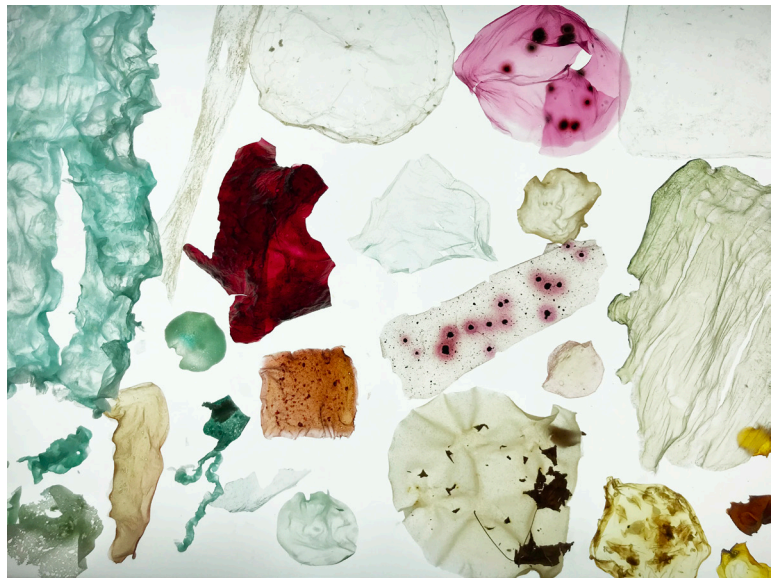
The mutual game of Time and Form has always been rooted in human nature, creating dynamic environments. People and their subtle psyche with natural patterns and urban lifestyle, as well as their craving for inspiring leisure are key to every Time-Form project. The Time-Form design method, applied to multiple projects by various architects, shapes our Collective *Terra*.

# Towards circularity: Subverting a paradigm of waste in the architectural design process

Mary Hale, with students: Mia Arenburg, John Branagan, Anqi Cao, Alexis Connolly, Sana El Halwani, Isabella Greco, Jinhui Gu, Nicholas Hurd, Pedram Keyvani, Sharmeen Khan, Matthew Miller, Soha Mohammed-Eltaher, Dana Murtada, Olivia Ouellette, Jielle Paul, Zeenah Sabbidine, Cristina Sola Sanz, Tu Tran, Rebecca Tredwell, Enya Xu & Daniela Zaragoza
Northeastern University School of Architecture,
College of Arts, Media and Design (CAMD) (United States of America)

Unseen below the surface of the earth, landfills contain sizeable waste deposits for every building built. The United States Environmental Protection Agency (EPA) estimates that 600 million tons of construction and demolition (C&D) debris were generated in the United States alone in 2018. Of this nearly 10%, or 60 million tons, was generated from new construction.[1] However, waste from construction accounts for only part of a building's waste stream. Those familiar with architectural design understand the vast quantity of waste generated before a building breaks ground. Study models, presentation models, prototypes, material

1. United States Environmental Protection Agency (2021). Construction and Demolition Debris: Material-Specific Data. [online] *United States Environmental Protection Agency*. Available at: https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/construction-and-demolition-debris-material.



**A collection of materials experiments from the 2021 Circular Installation Studio**
**Courtesy: Mary Hale**

studies, sketches, test plots, presentation boards, drawing sets, outdated digital equipment, pens, pencils, markers, tape, and more make their way to landfills after their serviceable life ends. Famously documented in the 2002 exhibition, *Herzog & de Meuron: Archaeology of the Mind,* and the accompanying book, *Natural History*, Herzog & de Meuron refer to the vast array of models and physical artifacts they produce as a part of the "immaterial, mental processes of understanding, learning and developing" architecture, and these artifacts are ultimately "an accumulation of waste".[2]

While not all practices rely so heavily on physical artifacts for their design process, one only has to walk into university architectural design studios after final review week to see the waste bins overflowing with models and scraps. The magnitude of the design process' waste stream extends to the study of unbuilt work as well.

2. Herzog, J. and de Meuron, P. (2002). Just Waste. In: P. Ursprung and Canadian Centre for Architecture CCA, eds., *Natural History.* Zurich: Lars Müller Publishers, p.74.

Reducing waste may be possible, but with diminishing returns. A carefully studied design with an accompanying waste stream seems far more likely to result in a successful building than one where the designers eschewed models altogether. Another way forward is to think critically about the materials we use in the design process. Michael Braungart and William McDonough, authors of the iconic manifesto *Cradle to Cradle*, call architects and designers to consider circularity as a fundamental characteristic of good design. Materials fall into "two categories: biological mass and technical – that is, industrial – mass."[3] They further distinguish these two categories as ones containing "biological and technical nutrients", suggesting that the materials from which our products are created should be repurposed after a product's disposal. Biological nutrients should be composted and regenerate nature. Technical nutrients should be harvested and recycled in future industrial products.

Following this logic, if one were to dissect a typical architectural model one would find many materials and methods that do not lend themselves to circularity. Models are often built under the pressure of a deadline, leaving little opportunity for the maker to ruminate on how the model could later be disassembled for repurposing. Equally problematic, many of the common model-making materials such as foam board, rigid foam, and acrylic are persistent and environmentally corrosive. For example, the material at the core of foam board, polystyrene (more commonly known as Styrofoam), is estimated to take 500 years to biodegrade[4] and is known to contribute significantly to environmental pollution. Considering its extreme persistence, the models produced using this material have an ironically short life due in part to how delicate and easily damaged the material is. A designer may use it to study an option or to present a final design to others, but after this short use the model would eventually need to be discarded.

3.
Braungart, M. and Mcdonough, W. (2002). *Cradle to cradle: remaking the way we make things*. London: Vintage, p.92.

4.
Yang, Y., Yang, J., Wu, W.-M., et al. (2015). *Biodegradation and Mineralization of Polystyrene by Plastic-Eating Mealworms: Part 1. Chemical and Physical Characterization and Isotopic Tests*. Environmental Science & Technology, 49(20), pp.12080–12086.

Inspired to address this problem during the summer of 2020 when my practice as an architect, set designer, and installation artist was temporarily on hold due to the Covid-19 pandemic, I launched a research programme into sustainable materials. I worked with an architecture student, Isabella Greco, to research and experiment with homemade biodegradable bioplastic materials and found promise in many, particularly a modification of an agar agar-based film[5] that looked, felt, and behaved much like a polyethylene, a petroleum thermoplastic that I often use in my practice to prototype inflatables.[6]

Having seen this promise, I continued the exploration into biodegradable materials during the fall of 2020 with a small, remote group of architecture students at Northeastern University. I hoped to use the studio environment as a testing ground for these new materials and launched the first *Circular Installation Studio*.

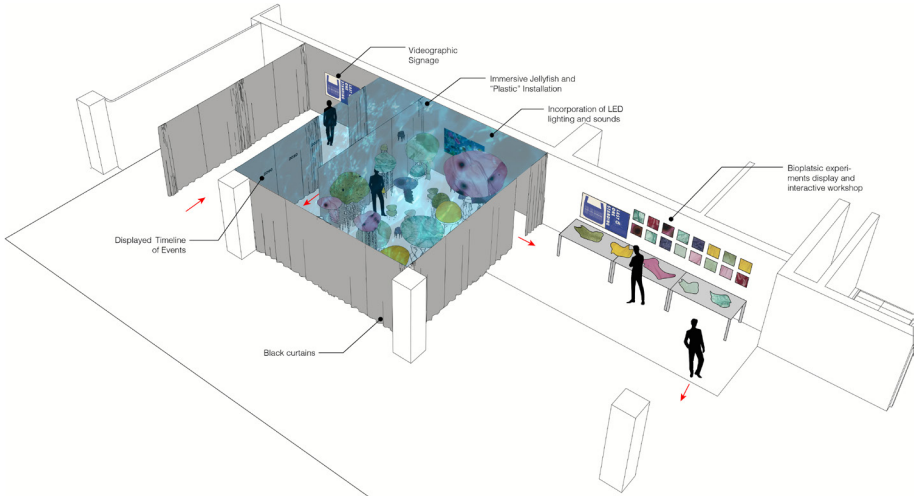
The architectural installation is a perfect, if unlikely vehicle for confronting deep issues of waste in the building industry. Perfect because it enables designers to explore and experiment with radical ideas without risking a client's investment. Unlikely because it is temporary, consuming resources for its very short life in the public eye, before being packed into an energy-intensive storage unit or dumped into a landfill where its parts will last through millennia.

In this studio, students addressed this paradox by researching and experimenting with and even inventing sustainable, biodegradable, bioavailable, and waste materials. Following this open-ended experimentation, students researched the life cycles of these materials from extraction, to manufacturing to disposal. Finally, armed with learnings from physical experimentation and materials research, students proposed circular installation projects.

Because students were working remotely and individually, they lacked the resources to build their work at full scale. Nonetheless, they were all able to fabricate the materials in their kitchens and create prototypes of components at home. Below I will share some of the most intriguing proposals.

5. Garmulewicz, A. (2022). *Agar bioplastic (heated)*. [online] Materiom.org. Available at: https://materiom.org/recipe/41.

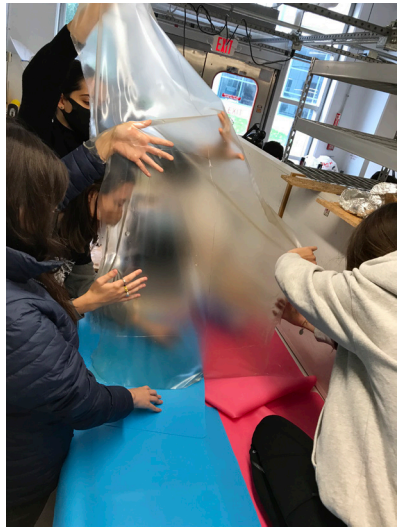
6. Hale, M. (2022). Rethinking Materials Through Remote Collaboration. In: *RAIC | CCUSA 2021 Virtual Academic Summit on Architecture Proceedings*. [online] pp.132–137. Available at: https://raic.org/academicsummit2021.




**A rendering of the final installation and exhibition proposal for the 2021 Circular Installation Studio. Titled "The Last Ones Standing", this installation and exhibition confronted the environmental degradation wrought on our oceans due to plastic waste.**

Matthew Miller's project, *Charnel Meditation*, imagined a spiritual space for meditation on the cycles of life. Sited on an existing ruin in Boston's Franklin Park, designed by Frederick Law Olmsted, his installation took a cylindrical form constructed from mycelium bricks. Visitors would enter through a double-walled corridor at the perimeter and would eventually arrive at the central meditation space. Having spent the semester experimenting, Matthew found that to create functional mycelium bricks one must bake them to kill the fungus before it fruits. Nonetheless, he strategically planned to leave some of the bricks unbaked, so at the interior of the installation mushrooms would fruit on the walls. Matthew argued that the musty smell of the space and the direct encounter with biodegradation by fungus would enhance a meditation on life, death, and life after death. While he intended this to be a spiritual space, this proposal also suggested a new form of temporary community space for sustainable urban myco-culture.

Matthew elaborated on his design in his final book: "I began to think about the circular way in which life propagates itself, through living and dying and living again. The mycelium masonry that makes up the physical form of the eventual installation that I designed became a metaphor for this process. It was grown and



**Students in the 2021 Circular Installation Studio peel a large batch of Carrageenan Iota Leather during their materials experimentation phase.**

fed using the decay of the natural world. After serving its purpose in the enclosure of the installation, the mycelium will begin the cycle anew by decomposing in place and supporting new life that will grow from its respective decay. In this way, given the proper conditions, this cycle can repeat ad infinitum, with new fungal life consuming the dead organic matter of the baked bricks and being harvested to be used or grow additional bricks."

Other students explored the potential for biodegradable algal bioplastics to replace persistent conventional plastic materials. John Branagan envisioned compelling applications for biodegradable bioplastic films on construction sites. He suggested replacing conventional plastic tree guards and construction fences with biodegradable analogues made from kappa carrageenan.[7] Kappa carrageenan is a refined hydrocolloid extracted from seaweed and a common plant-based gelling agent used in vegan cheese.

Also using kappa carrageenan, Mia Arenburg crafted clear, biodegradable hanging planters, reinforced with fibres such as human or horsehair. She filled her planters with soil and native, perennial plants and demonstrated how they could be covertly

7.
Valentina Márquez, L. and Pacheco, C. (2022). *Carrageenan Film Ca03*. [online] materiom.org. Available at: https://materiom.org/recipe/206.

8.
For more on guerrilla gardening, see the blog by Richard Reynolds: Reynolds, R. (2015). *Guerrilla Gardening*. [online] Available at: http://www.guerrillagardening.org/.

deployed to spread pollinators and other beneficial plant materials. This subversive proposal aligned with contemporary eco-activist projects, such as guerrilla gardening.[8]

As Mia writes in her final project, "this installation is a self-sustaining ecosystem encased in a natural fibre enforced bioplastic. These modules are designed to retrofit and adjust to any tree on any site. Inside the modules are small rocks, soil, mosses, various seeds, organic debris such as leaves or sticks, and water – all chosen to serve a purpose for their specific terrarium, as well as for the earth they will fall upon. Like an apple from a tree, these mini ecosystems would inevitably fall to the ground. The sealed module will encapsulate its contents until its contents begin to consume it, the life inside breaking free from the confines of the shape, and spreading over the ground. Because the modules are completely biodegradable, the mini ecosystems will continue to live and grow after they have fallen, while the bioplastic is consumed. The life once held inside the module will live beyond the display, expanding to include more organisms, plants, and animals. The natural fibres inlaid in the bioplastic are to provide tensional strength to the flexible kappa carrageenan and agar bioplastic. The clear bioplastic allows for a window into the layers of the mini ecosystem, as well as a look into the biodegradation process of the shell. A key part of this installation is the concept of time – the progression and growth of the enclosed ecosystem, the progression of deterioration of the bioplastic, the unknown breaking point when the module falls to the ground, and the life of the organisms after the fall. This installation is a gateway into breaking away from the traditional approach to landscape design. The goal of the installation is to expose the process of re-planting areas in a new way, nourished and enriched using bioplastic. It is a process available and doable by anyone willing to invest the time to do it."

Some students applied biodegradable bioplastic materials to intellectual architectural installations, which confronted smooth, clean and environmentally unconcerned modernist architecture. Jinhui Gu's installation, *Bio-Folly*, explored an interplay between Vitruvian firmness and ephemerality. A large inhabitable tetrahedral structure inspired by the three-dimensional kites of Alexander Graham Bell was proposed for a visible part of the

grounds of the Museum of Fine Art in Boston. Jinhui prototyped this tetrahedral structure with found twigs and covered it with an agar-based bioplastic film. This structure would be designed for systematic failure and then decompose on site, playing with the apparent strength of the triangle.

Following their final review, these students were required to document the environmentally beneficial disposal of their prototypes, suggesting a biologically circular disposal for their proposed installation if it were to be built. As the artifacts of their design process were made from biodegradable materials, their design waste could also be composted.

A year later when students could once again convene for in-person instruction, I taught the *Circular Installation Studi*o again, adapted for students to work together on teams and perform material experiments in the studio. Suddenly, we could consider pushing the project to an architectural scale. After an initial research stage, students embarked on weeks of materials experimentation, working with some of the same materials as the 2020 group, but others as well. Students created recycled paper from waste bins in the studio. They explored films using carrageenan iota,[9] another algae based gelling agent, emulsifier and stabiliser. They made dyes in every colour of the rainbow from waste and food products. They also discovered a beautiful bioplastic material using tapioca starch.[10]

After weeks of experimentation and research, students formed groups and made proposals to apply these materials in a final group installation and exhibition. Following a juried midterm review, one proposal was selected, and the students devoted themselves to building the project for public exhibition.

The final project involved an immersive installation about plastic waste and its effect on our oceans. Over several weeks, students collected their own recyclable plastic trash to cover the floor of the exhibition space. They cast massive, organic sheets of a biodegradable bioplastic material based out of tapioca starch and

9.
Powell Best, Z. (2022). *Carrageenan iota 'Leather' Ca01*. [online] materiom.org. Available at: https://materiom.org/recipe/120.

10.
Byju, M. (2022). *Tapioca Starch Bioplastic*. [online] materiom.org. Available at: https://materiom.org/recipe/592.

**Interior rendering of Matthew Miller's *Charnel Meditation* installation proposal featuring a mycelium masonry structure.**

vinegar, which they coloured with blue spirulina. These sheets hung overhead, like the surface of the ocean but also as a counterpoint to the non-biodegradable waste through which the audience moved. Students projected video footage of swimming jellyfish, a beautiful but dangerous creature predicted to thrive in polluted warming seas. Students enhanced the installation with an original soundscape, interspersing advertisements for plastic with presentations from academic conferences and press conferences illuminating the negative environmental impacts of plastic.

In addition to the immersive installation, students created an exhibition about the studio's process. Here visitors could experience a wall of biodegradable plastics dyed from food waste, an open-source cookbook authored by the students, a series of biodegradable housewares and experiments produced earlier in the semester, a large display of bioplastic in the process of curing, a table of samples to touch and feel, and a timeline showcasing predictions for the disturbing evolution of the environmental crisis if we do not change course. This portion of the project was intended to inspire visitors to take action by showcasing non-traditional experimentation and creativity as a way forward.

## CONCLUSION

The *Circular Installation Studio* engages students in developing materials and methods for circular practice through design research and experimentation. In so doing, they learn to critique the current paradigm of waste in architectural design and even develop skills to subvert it. While waste in the architectural design process may be a relatively small facet of our various environmental issues, it is a facet that architecture students can directly tackle in the design studio. In doing so their models and artifacts begin to serve a dual purpose. They are not only meant to study and present a design, but they are also meant to study and critique the paradigms of our material use. Students leave this studio with an elevated consciousness of waste and material flows that they will take into their future studios and beyond into their careers as architects, where they face a responsibility to address the various and significant ways that buildings contribute towards climate change and environmental degradation.

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# Why an architect should be a Naturalist? Organising space by listening and feeling life: The case of the Community Herbarium of Azores, Portugal

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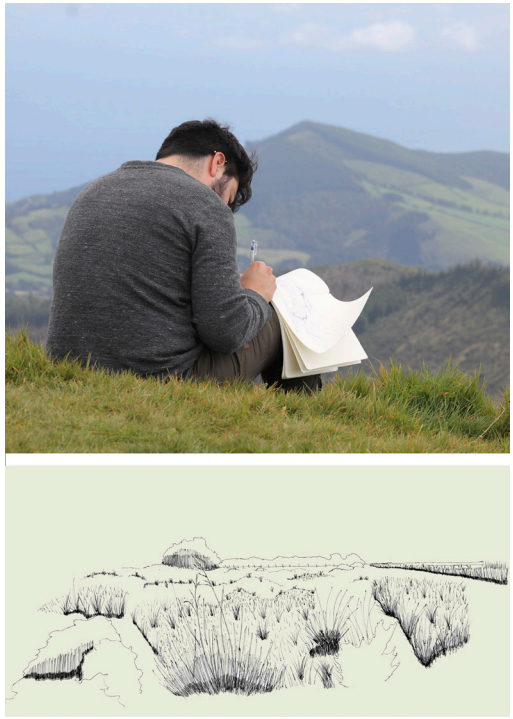
Architecture is a discipline that is thought from projection, that is, there is an organisation proposal so that a space can be inhabited. This research suggests that architects need to study and inhabit space and that knowledge is deepened by slowing down the gaze to allow us to observe and access a more complete understanding of territory. Through the naturalistic work and the creation of the Community Herbarium of Azores, the architect established a dialogue between architecture and other disciplines. By identifying and understanding the natural elements that form the landscape, the architect can also consider them as design materials, proposing a re-signification of the relationship between architecture and its environment. In that way, the experience of



**Inhabiting the territory and stopping to observe becomes a tool for scientific knowledge, but also for creative action.**

space and study of place – in a broader sense and with consideration of the introduction of other disciplines – opens the field of architecture, from an expansion of formal and technical possibilities in architectural design to an improved characterisation and organisation of living spaces.

## INTRODUCTION

Architecture considers space and the lives within it. In this sense, the architect Alberto Cruz says “Architects are those who from life, from living, from intimacy, know how to read, know how to build the face that space has.”[1] This vision coincides with the statement of Fernando Távora when he says that the architect “is a creator of forms, and organiser of space”.[2] There is a similarity

1. Cruz, A. (1959). *Improvisación del Arquitecto Alberto Cruz*. [online] e[ad] - Escuela de Arquitectura y Diseño PUCV. Available at: https://www.ead.pucv.cl/1959/improvisacion-del-arquitecto-alberto-cruz.

2. Távora, F. (2008). *Da Organização do Espaço*. Porto: Faculdade de Arquitectura da Universidade do Porto. p.73.

here between the two architects, each acknowledging the architect's role to build and organise space. In this sense, Cruz states that to know life it is necessary to study and live it, "space is known through space and time".[3] This means that experience of life itself is essential for the comprehension and study of space and, therefore, of architecture. In this way, the time spent in a place, the exercise of taking time in front of things – which is opposed to current models of optimisation and efficiency – enables knowledge, not only rational but also sensorial and corporeal. This means that it is not enough just to read the space, but also to listen and feel it, as Cruz said. It is clear how this relates to naturalist thought and craft, and the relevancy of field work and organismic vision[4] of being in front of entities in action.[5] For example, Humboldt travelled through South America in an attempt to study biodiversity and classify – or *organise* – the different species and ecosystems, which also allowed him incredible life experiences with the possibility of direct contact with the study material.[6] Another case is Carl Linnaeus, who introduced a new way of taxonomic organisation of nature through the scientific binary nomenclature gender-species valid until today.[7]

3.
Cruz, A. (1959). *Improvisación del Arquitecto Alberto Cruz*. [online] e[ad] - Escuela de Arquitectura y Diseño PUCV. Available at: https://www.ead.pucv.cl/1959/improvisacion-del-arquitecto-alberto-cruz/.

4.
Being the study and understanding of the natural order the meaning of this, the focus that unifies the views is the concept of organism as a phenomenological entry and exit point. See: Greene, H. (2005). Organisms in nature as a central focus for biology. *Trends in Ecology & Evolution*, 20(1), pp.23–27.
This irreducible core is connected to fieldwork as a generative problematic dimension and to scientific theoretical conceptualisation to redefine natural history (organism-theoretical framework-naturalist praxis). See: Elórtegui, S. (2015). Historia natural: La discusión. Una revisión del concepto, el conflicto y sus ecos a la educación de las Ciencias Biológicas. *Estudios pedagógicos (Valdivia)*, 41(especial), pp.267–281.

5.
Elórtegui, S. (2015). Historia natural: La discusión. Una revisión del concepto, el conflicto y sus ecos a la educación de las Ciencias Biológicas. *Estudios pedagógicos (Valdivia)*, 41(especial), pp.267–281.

6.
Wulf, A. (2019). *La invención de la naturaleza: el nuevo mundo de Alexander von Humboldt*. Translated by M.L.R. Tapia. Barcelona: Penguin Random House Grupo Editorial. pp.78-128.

7.
See: Stearn, W. (1955). Linnaeus's 'Species Plantarum' and the Language of Botany. *Proceedings of the Linnean Society of London*, 165(2), pp.158–164; and Bennett, B. and Balick, M. (2014). Does the name really matter? The importance of botanical nomenclature and plant taxonomy in biomedical research. *Journal of Ethnopharmacology*, 152(3), pp.387–392.

Naturalists also seek to order space but from the recognition and denomination of ecosystems, that is, how species are organised and relate to each other in a specific territorial system, which determines a certain typology of ecological space that can be characterised. Finally, the various landscapes are also perceptions of space which we evaluate considering culturally produced sensory dimensions. Therefore, there is in fact a direct relationship between the architect and the naturalist, since whether in architecture or in natural sciences, both seek an organisation that can even be taken to tangible spatial dimensions.

The exercise of building an Herbarium activates this lived time in front of things and allows the *dialogue of order and place* between architect and naturalist. For better understanding, an herbarium is a collection of dried plants and their most important parts, conserved and identified, along with information such as the name of the collector, or place and time of the collected samples. These elements are classified and used as material for botanical studies, research, and environmental education.

## CRAFT, DIALOGUE AND PLACE

There is an important relation between the discipline of craft, dialogue, and place, because through these three dimensions it is possible not only to exchange knowledge with other disciplines but also involve the community in their native knowledge. This initial disposition of openness proposes a change of paradigm in how reality is understood, re-valuing and taking the life experiences of the community, not through a critical reasoning, but from a corporeal experience with the place and a direct relationship with the territory.

The contribution that architecture can bring to natural sciences is the possibility of organising aesthetically whether it is the *space* or the *content* of an exhibition. Architecture – understood as organisation – can show and represent a message with plenitude. When the architect works with species of plants and brings in unusual materials, they are blurring the idea of a culturally produced aesthetic and re-constructing it with consideration of a new paradigm to include the ecological sense. That is, importing into the practice of architecture materials and ways that collaborate with ecological dynamics and in turn aid in the

**Herbarium of Pino Sánchez to explore nature/space dimensions of the Open City of Amereida.**

dissemination of a new cultural aesthetic in which a work of art incorporates biology and botany. Thus, the consolidation of place is given by space and community, but also by including nature as part of a process of cultural transformation.

Architecture also brings a structure of order to natural history, which results in a vision of form over standardised botanical curatorship, which normally limits the beauty of an herbarium which will only be stored in a museum for curators and scientific researchers. Architecture brings an openness through the public exhibition of things.

The realisation of an herbarium by an architect is an opportunity to promote the dialogue of craft and transdisciplinarity, where the discipline of architecture – which has certain cannons – is invited to negotiate with another discipline interested in the *doing* of things – meaning both doing and thinking are processes of the hands. In this sense it becomes

relevant to bring the example of Pino Sánchez, a Chilean architect creating formal herbariums over the 1970s, as a tool of expanding knowledge in the Open City of Amereida,[8] where he studied forms and space through the plants.

The contribution of natural sciences to architecture results in the architect engaging directly and with slow contact with the natural world, or in the case of an herbarium with botanical taxonomic science. Although knowledge of the natural territory escapes from the urban reality, it is possible to cross it with other realities in consideration of the city to address environmental issues, such as the loss of biodiversity, excessive pollution, and lack of clean water. These acquired dimensions allow the architect to organise space with more beauty, with more fullness to the extent that they are able to expand their spectrum of understanding about territory, incorporating other dynamic and ecosystem relationships often ignored due to a lack of knowledge but with important implication in the composition and construction of landscape. For its part, an herbarium also displays its own qualities as a sophisticated and key piece for science.

## WHY BUILD AN HERBARIUM?

The construction of a local herbarium is not investment in an obsolete idea or in playful scientific romanticism. Herbaria are critical components of the biological research infrastructure, with plant specimens stored in herbaria are being used to document the impacts of change on humans and nature.[9] In the last decade there has been an increasing number of herbarium consultations by biological, environmental, ecological, and molecular biology

8.
"Idea, utopia, city that is not city (initiated in 1970), a cultural project of architects and designers of the School of Architecture of the Catholic University of Valparaíso (and other related persons)." See: Perez de Arca, R. and Oyarzún, P. (2003). *Escuela de Valparaíso: Ciudad Abierta*. Madrid: Tanais Ediciones. p.166.

9.
See: Lavoie, C. (2013). Biological collections in an ever changing world: Herbaria as tools for biogeographical and environmental studies. *Perspectives in Plant Ecology, Evolution and Systematics*, 15(1), pp.68–76; Rocchetti, G., Armstrong, et al. (2021). Reversing extinction trends: new uses of (old) herbarium specimens to accelerate conservation action on threatened species. *New Phytologist*, 230, pp.433–450; and, López, A. and Sassone, A. (2019). The Uses of Herbaria in Botanical Research. A Review Based on Evidence From Argentina. *Frontiers in Plant Science*, 10(1363), pp.1–10.

sciences, among others,[10] even anthropological and ethnographic.[11] The planetary collection – *the Index Herbariorum* – of specimens is now immeasurable. The USA alone has 686 active herbaria that together contain over 78 million specimens,[12] and of the plant species that science estimates have yet to describe (over 70,000) probably more than 50% are found in herbaria and not in the natural environment.[13] Regarding local community, national park, or island herbaria, studies indicate that their value is very high as many of them focus their attention on species that scientists and the community consider important. A wide-ranging study of local herbaria in the United States indicates that these types of small banks are the ones that provide the greatest record of species that are vulnerable or at serious risk of extinction.[14] All this information places in the hands of the architect a sensitive scenario with serious implications for the development of a community's knowledge and how this architectural action is part of a global effort to understand the natural cohabited environment. The architect sensitises the community to certain issues, but they sensitise themself at the same time. Thinking by doing – and lingering over doing – allows a deeper reflection as a bodily experience. There is here a retrospective exercise of reimagining architecture to its minimum expression, to know what architecture means at the most basic level of the human and what this *thinking by doing* entails.

10.
Funk, V. (2004). *100 Uses for an Herbarium (Well at Least 72)*. [online] Division of Botany, The Yale University Herbarium. Available at: https://www.cvh.ac.cn/public/uploaded/files/support/20200519pvG1KBPN.pdf.

11.
Márquez, F. (2022). *Ruinas Urbanas. Réplicas de memoria en ciudades Latinoamericanas: Santiago, Quito, Bogotá* [project]. Santiago de Chile: Universidad Alberto Hurtado. Available at: https://ruinasurbanas.cl.

12.
Thiers, B. (2020). *The World's Herbaria 2019: A Summary Report Based on Data from Index Herbariorum*. [online] Available at: http://sweetgum.nybg.org/science/docs/The_Worlds_Herbaria_2019.pdf.

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Bebber, D., Carine, M., Wood, J., Wortley, A., et al. (2010). Herbaria are a major frontier for species discovery. *Proceedings of the National Academy of Sciences*, 107(51), pp.22169–22171.

14.
Marsico, T., Krimmel, E., Carter, J.R., Gillespie, E., et al. (2020). Small herbaria contribute unique biogeographic records to county, locality, and temporal scales. *American Journal of Botany*, 107(11), pp.1577–1587.

## THE CASE: COMMUNITY HERBARIUM OF AZORES, PORTUGAL

To clarify this approach, the case of the Community Herbarium of the Azores is presented, starting from the imprint and desire of an architect to study local biodiversity, specifically flora and fauna. It progresses to consider how architecture is capable of raising awareness of environmental problems, not through great technological advances as today, but through the mere fact that we share a habitat with other species – or co-inhabitants – that have different ways of inhabiting.

Based on this commitment to deepen and at the same time to disseminate the natural heritage of the archipelago, the project of the Community Herbarium of Azores applied to the pilot projects *Mão em Mão* of Azores2027, within the application of Ponta Delgada and Azores to the European Capital of Culture. The project consisted of a set of activities whereby a scientific exercise was carried out for deeper understanding of the *Laurissilva* forest, which made allowances to involve the community and make them aware of native and endemic flora within the Azores. In this way, an herbarium was created through naturalistic observation, field work, drawing, and collection of specimens as a way to build knowledge based on experiences and relationship with the territory. The particularity of this initiative is that the community was included as part of the process, transforming them into authors of works of art and creators of collective knowledge. This allows increasing inhabitants' sensitivity and knowledge about nature, creating a sense of belonging with their common heritage, in which they are participants by observing, organising their space, and creating relationships with their territory.

39 participants collected over 100 specimens comprising 31 different species: recalling their contact with them, the traditional uses of the past, and creating new memories from their own experience. A new way of looking at and reconnecting with nature was established. Beyond the herbarium product, it is important to highlight that the way the process took place was fundamental, since it was developed with the community and had a great effect on the final result.

In order to increase the impact of the project, an exhibition was held. It allowed the rest of the community to have access to the

**The content of the exhibition shows the plants but also photographs and drawings of the process of the project.**

information gathered through the herbarium, proposing a new framework to re-signify and re-value the relationship with nature. Here, the role of the architect became fundamental, since their view and projection allowed them to contribute to the development of the project through different aspects. For example, conscious of the necessary sustainability, the architect favoured biodegradable, recyclable, and locally produced materials such as paper, twine, or Japanese cedar wood (an exotic plant produced locally). In addition, in the creative process of the structures and supports for the exhibition, the proposal sought to minimise waste, with a modular design that facilitated its construction and allowed the exhibition to be displayed in spaces with varying dimensions.

Another important aspect is the attention given to aesthetics regarding how the plants, photographs, texts, and drawings are displayed in the exhibition, helping to communicate the content with regards to beauty. That is to say, the plants and drawings are transformed into works of art. The composition of the exhibition space allowed viewers to observe and compare details to better understand and discover the unique beauty of each species. The exhibition also sought to highlight the process of collecting and community participation. To include it, the exhibition had a selection of photographs and drawings that reflect part of the work done.

Here smiles are part of new narratives: the connection with biodiversity and the drawings are a conscious way to convey and represent this re-signification of the relationship with nature. In addition, the underlying rigor and aesthetic care allow the plant samples to fulfil their function as materials for the divulgation of natural heritage, environmental education, and botanical study by academics and researchers.

The main objective of the project was to reconnect the local population with the native species of the Azores, while including the architect in this process. These species are seriously threatened by the presence of exotic and invasive species often better known by the locals themselves. Therefore, by (re)bringing the community closer to these native species, the awareness of the importance of biodiversity in general and the conservation of severely vulnerable habitats in the habitats are promoted.

## CONCLUSIONS

Today, architects have lost a diversity of readings and materials, and the figure of the architectural office has become predominant. That is why, in the search to reconnect architects with inhabited space – and recognising that it is not only inhabited by human beings – the herbarium emerges as an opportunity to incorporate architecture into socio-ecological and scientific contexts of the Azores community. This tool, nowadays strongly revalued by science, becomes a fundamental initiative, since it generates transdisciplinary dialogue with specialists, allowing the architect to increase the breadth of the field of architecture.

Taking the architect to a frontier zone of their discipline allows them to import new visions in ways of organising space and practising architecture. This acquired sensitivity grants the possibility of incorporating nature and re-signifying the relationship between architecture and its environmental context, not only through a translation to form and materials, but also through the incorporation of territory as a living system. Therefore, architects are invited to go out and explore the city, but also nature, so their works can be a projection of this way of living: a sensitive way because they know, understand, and feel in a biological, cultural, aesthetic, and transcendental relationship with the territory.

TERRA

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O Presidente da República

The architecture of the future will be immensely different to that of the 20th century, and the ideas now brewing in universities will form the built fabric of our future cities and landscapes. These seventeen essays draw from some of the most progressive ideas across architecture schools today to explore how designers of the future will be working. In that future, there is a deep reflection of the past and processes that we may have forgotten: thatched buildings, biogenic construction, earthen bricks, and approaches to working with nature and communities towards new architectural ecologies.

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