Week 3

Digital design practice and research groups

This week we will look at dialectics between digital design practices and research. This is relatable to the shift of think-draw-make in recent digital turn.

Outline

01

Computational design research groups

Six research groups worldwide.

02

Architectural practices

Computational design offices worldwide.

03

The dialectics: academia and practice

Discussion will be shaped around designing through making.

Photo by Muhd Asyraaf on Unsplash

Aims and objectives

- To exemplify leading research groups in computational design.
- To elicit different approaches exhibited by architecture design studio which practices computational design.
- To discuss the dialectics between academia and architectural practices.

Learning outcomes

Students will be able to..

01 Draw **differences** in current computational practices compare to mainstream practices.

02 Illustrate how new way architects **think-draw-make** affect practices.

03 Discuss the importance of **design through making.**

(module) Overarching skills

Software skills

Rhino, Grasshopper, etc

Research skills

Designing through extensive research

Personal interest

Exploring a preferred scope of design to be developed further

Theory, history and current debate

Understand historical background of this notion and relevant debates.

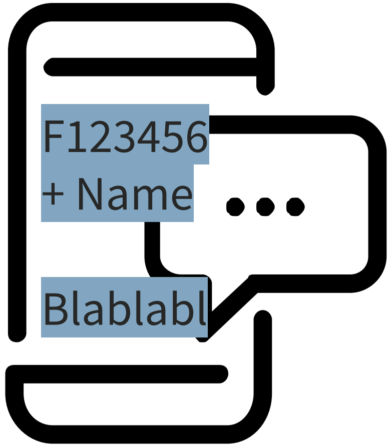
Important concepts

Digital fabrication and construction
Digital design cognition
Human-computer interaction
Digital craftmanship
etc

Design precedents

Learning through analysis of completed project

Week 3 Discussion



THE ROLE OF ROBOTIC MILLING IN THE RESEARCH AND DEVELOPMENT OF THE CORK CONSTRUCTION KIT

OLIVER WILTON
THE BARTLETT SCHOOL OF ARCHITECTURE, UCL
MATTHEW BARNETT HOWLAND
CSK ARCHITECTS
PETER SCULLY
B-MADE, THE BARTLETT SCHOOL OF ARCHITECTURE, UCL

How does dialectics between academia and industry exhibited in this project?

How did the conversation between academia and industry in design stages contribute to advancement of the project (and design field)?

https://miatedjosaputro.com/2022/03/08/dg-week-3-2/

Previously in Week 2..

- **Co-dependency relationship**
- **Man’s monitoring job**
- **Simulation**
- **Humans helping electronic advancement**
- **As of today it has surpassed**
- **Main factor of changes: interactions, computer hardware**
- **Fifth Generation of technological evolution → hardware based on AI**

BRYAN F18511025 · 4 days ago

From this article there are few reasons to this symbiosis is to help humans such as to bring computing machines effectively into the formulation parts of technical problems, to bring computing machines effectively into the processes of thinking that must go on in real time time that moves too fast to permit using computers in conventional ways but as of today with this technological development that keeps on improving it has come to my attention that the computer has exceeded the main objective of the symbiosis. Instead of helping it's even replacing and other places its processing for itself and presents the result to men. So in my opinion as of today it has surpassed what was written in this symbiosis given the development of human(artificial) intelligence.

The key factors to this changes mainly is technological advancements from one decade to another has catalyzed this changes. More computer man interactions such as display wall changes etc,

Reply · Share ›

Dikra · 5 days ago

Week2-F18511013-Dikra

My reflection on Man-computer Symbiosis is the work of Licklider that he describes his vision for a complementary symbiotic relationship between humans and computers at a potential time of the future For me, the current era in which we live now has a close connection between human minds and computers machines. We see the efforts made to achieve this vision and push computing technology forward and develop it. So far, Licklider noticed that he focused his vision on the idea that the human mind must be completed by machines, and this point is very important, for example, to see the architects after thinking and planning their ideas and developing their innovations, in the end, they resort to the computer and applications like Sketchup, AutoCAD, ArchiCAD, rhino... to clarify the project more accurately to facilitate the work of all concerned parties. Routine, pave the way for ideas and decisions by humans, because technology is a complete ambush for human decisions, but this does not prevent us from setting humans against machines .

I think increasing the availability and use of data and one of the most useful benefits of technology for architects the increased computing power allows for large amounts of information and data and software too will help architects save time and effort as it can make communication quick and easy in support of building information flow throughout the installation life cycle.modern technology and tools advance in facilitating the design of buildings as they intervene at each stage of the architectural process. in summary architecture is one of a variety of industries that are constantly improving and changing

From previous lectures we have learnt that..

Collaboration between man and machine has been imagined from 1960s.

Potentials of digital tools for better architecture.

Design practice has gone through important changes due to the proliferation of technology.

What are the drivers of these advancement in digital tools?

What are the drivers of these advancement in digital tools?

Symbiosis of design research and practice, closing existing gaps between the two.

Computational design research clusters/groups

A handful of examples

R1

Block Research Group (BRG)
Institute of Technology in Architecture
At ETH Zurich

Led by: Prof. Dr. Philippe Block and Dr. Tom Van Mele

R2

Institute for Computational Design and Construction
University of Stuttgart, Germany

Led by: Univ.-Prof. Achim Menges

R3

Centre for Innovative Structures and Materials,
RMIT University, Australia

Led by: Prof. Mike Xie

Photo by Szabo Viktor on Unsplash

Computational design research clusters/groups

R1

Block Research Group (BRG)
Institute of Technology in Architecture
At ETH Zurich

https://block.arch.ethz.ch/brg/project/knit-candela-muac-mexico-city

out people research teaching projects publications equipment tools

Photo by Mariana Popescu

KnitCandela - A flexibly formed thin concrete shell at MUAC, Mexico City, 2018

KnitCandela is a thin, sinuous concrete shell built on an ultra-lightweight knitted formwork that was carried from Switzerland to Mexico in a suitcase.

Keywords

There are no keywords.

Files

Computational design research clusters/groups

A handful of examples

R4

Design + Make

Architectural Association, School of Architecture at Hooke Park

Led by: Martin Self

R5

Computational Design and Material Systems Innovation

Taubman College at University of Michigan, USA

Core Affiliate: Wes McGee

R6

Digital Design Research Center (DDRC)

Tongji University, Shanghai

Led by: Prof. Philip Yuan

Photo by Szabo Viktor on Unsplash

Computational design research clusters/groups

R4

Design + Make
Architectural Association, School of Architecture at Hooke Park

Computational design practices

With in-house research unit

A handful of examples

P1 **ZHA (Zaha Hadid Architects)**

ZHA Code, London

P2 **Fosters + Partners**

Applied Research and Development, Material and Research Centre, and Specialist Modelling Group

P3 **Herzog & de Meuron**

Digital Technology Group at Basle office

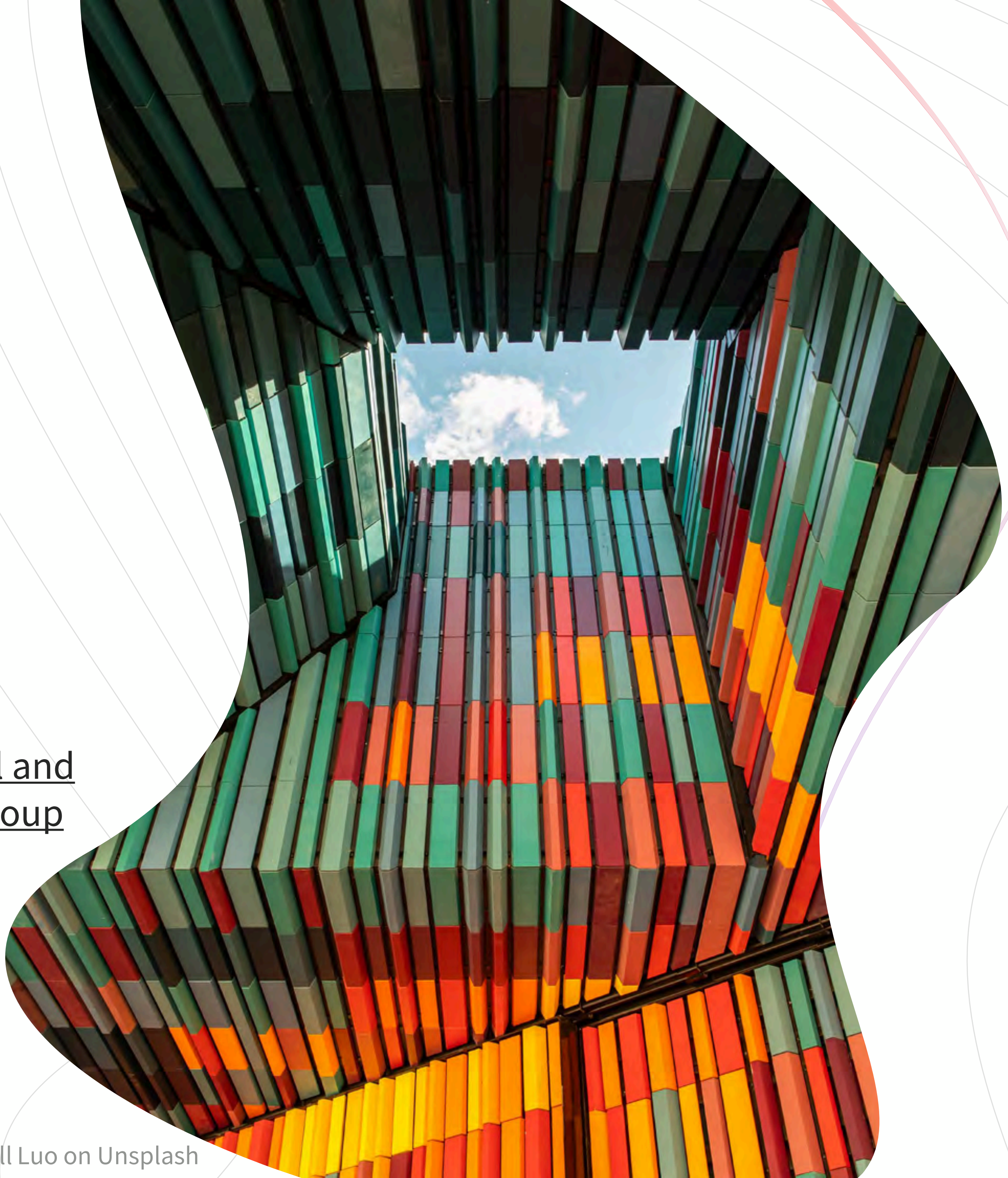


Photo by Mitchell Luo on Unsplash

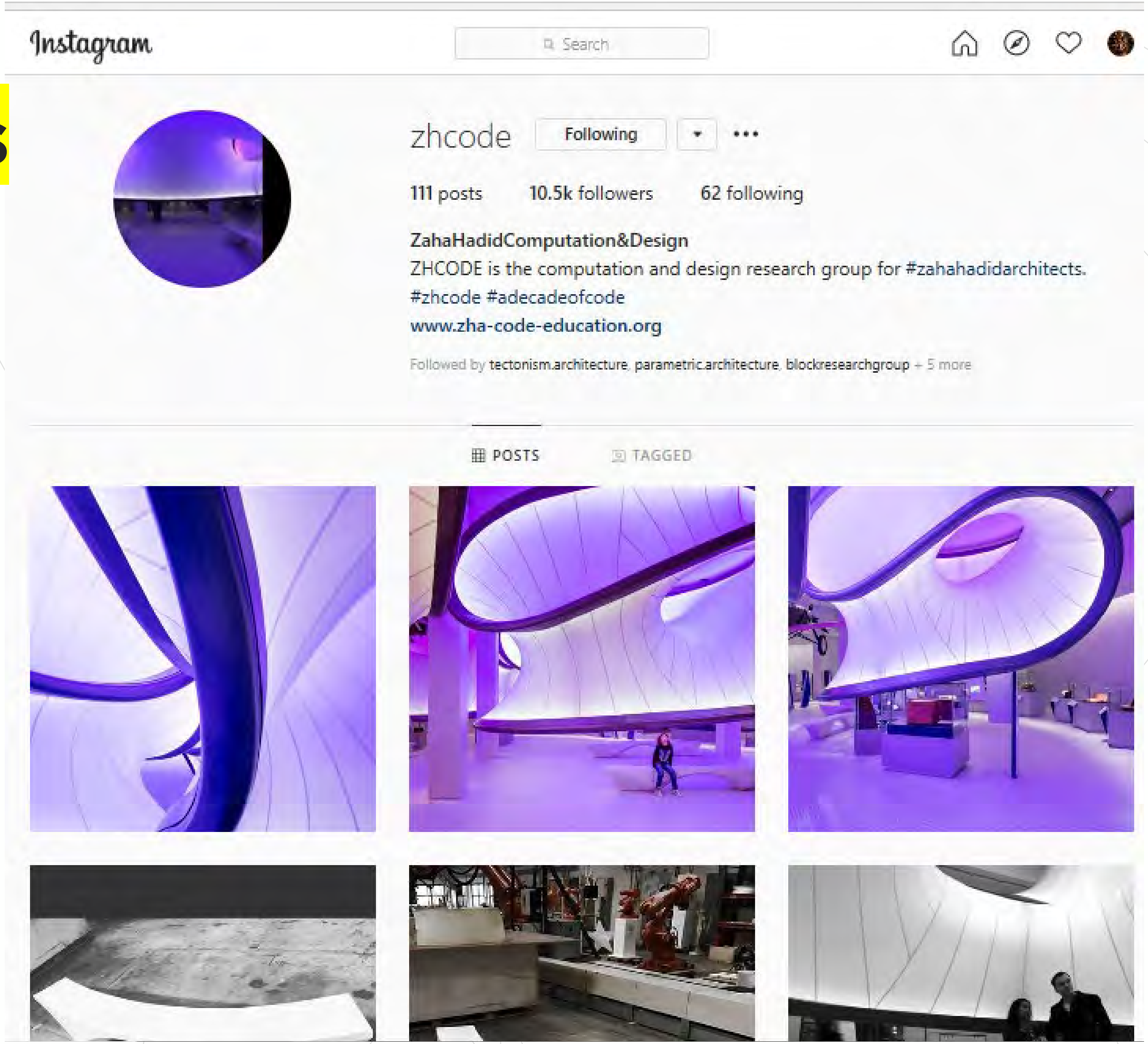
Computational design practices

With in-house research unit

P1

ZHA (Zaha Hadid Architects)

ZHA Code, London



Computational design practices

A handful of examples

P4 **BIG (Bjarke Ingels Group)**
Copenhagen, New York, London and Barcelona

P5 **AL_A (Amanda Levete and partners)**
London

P6 **NaJa & deOstos**
London

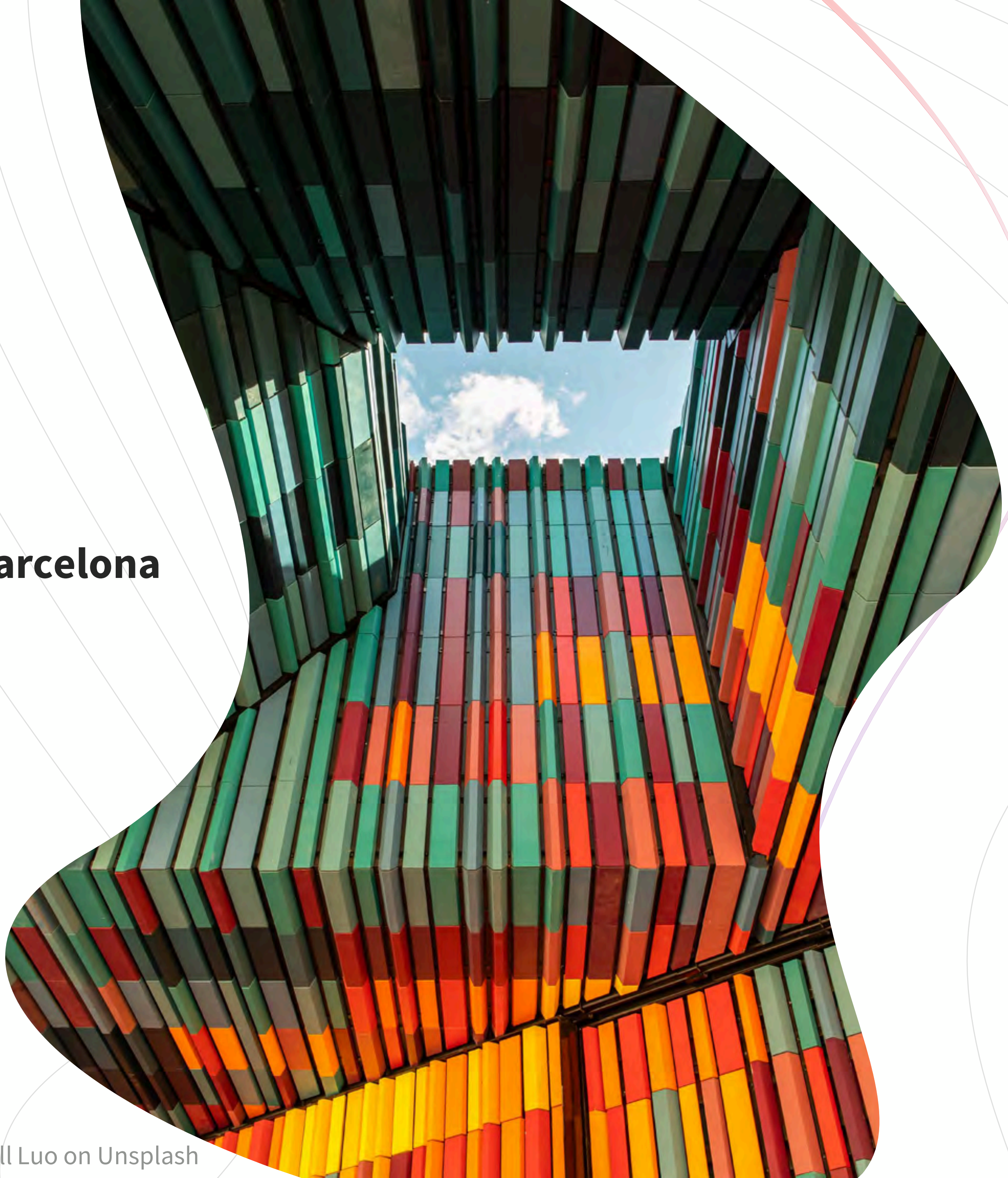
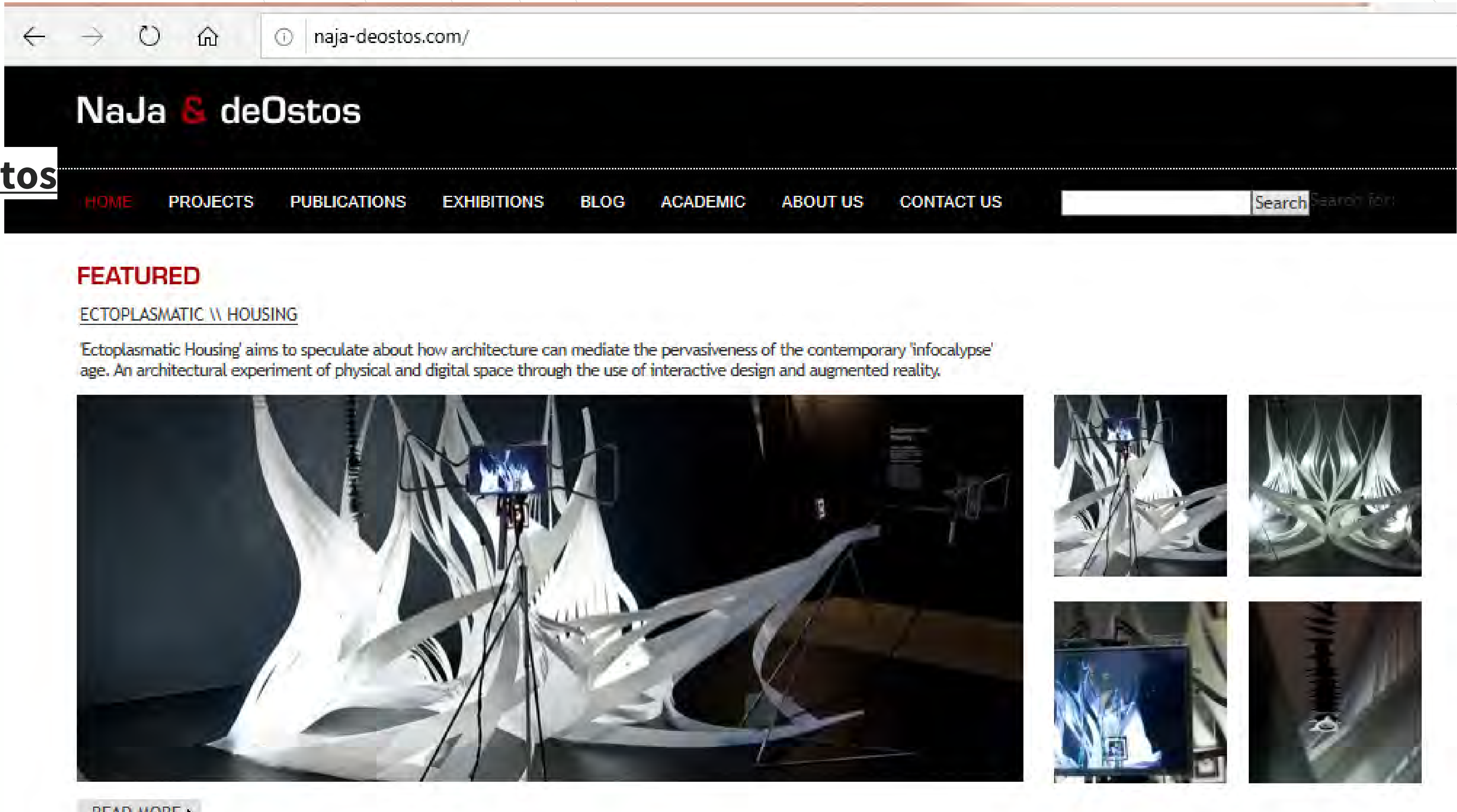


Photo by Mitchell Luo on Unsplash

Computational design practices

P6

NaJa & deOstos
London



Computational design practices

Led by design academics

A handful of examples

- **P7** **Archi-Union and Fab-Union Shanghai**
  Prof Philip Yuan, Tongji University
- **P8** **Philip Beesley Architect**
  Prof Philip Beesley, University of Waterloo
- **P9** **Menges Scheffler Architekten PartG mbB**
  Prof Achim Menges, University of Stuttgart
- **P10** **SoomeenHahm Design**
  Soomen Hahm, SCI-ARC and AA Visting School

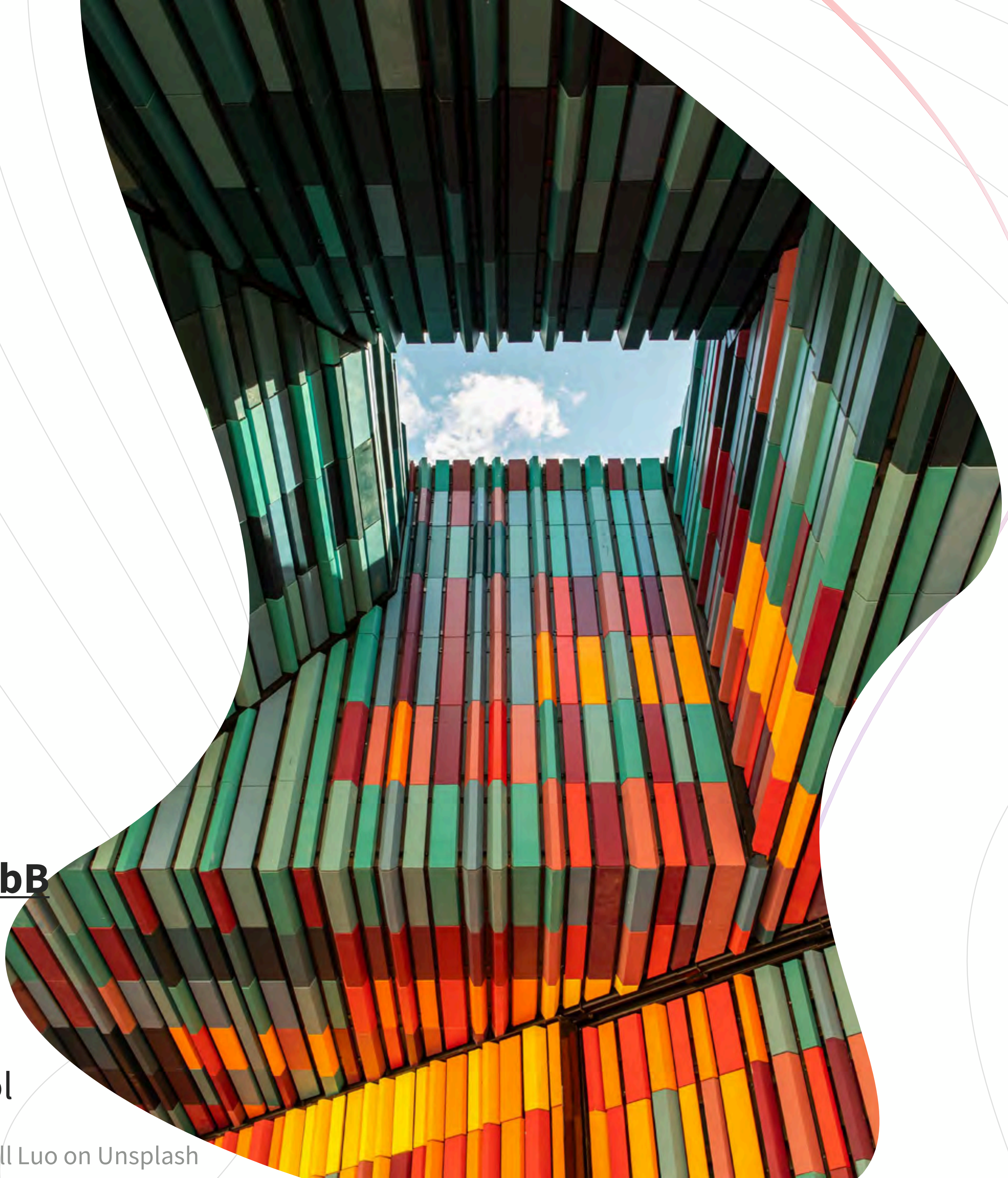


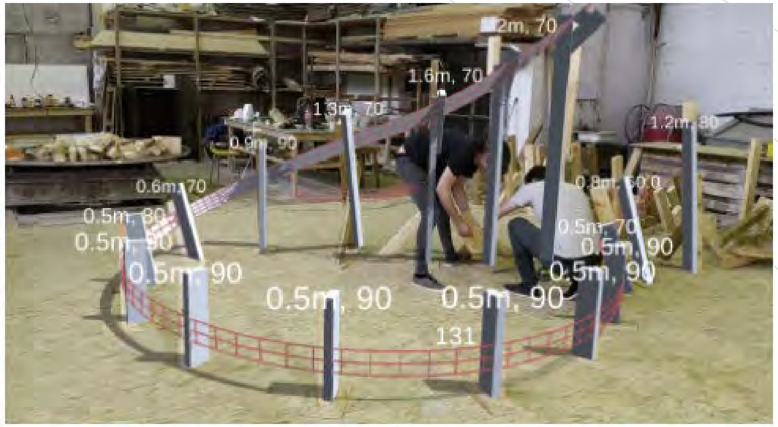
Photo by Mitchell Luo on Unsplash

Computational design practices

P10

SoomeenHahm Design

Soomen Hahm, SCI-ARC and AA Visting School



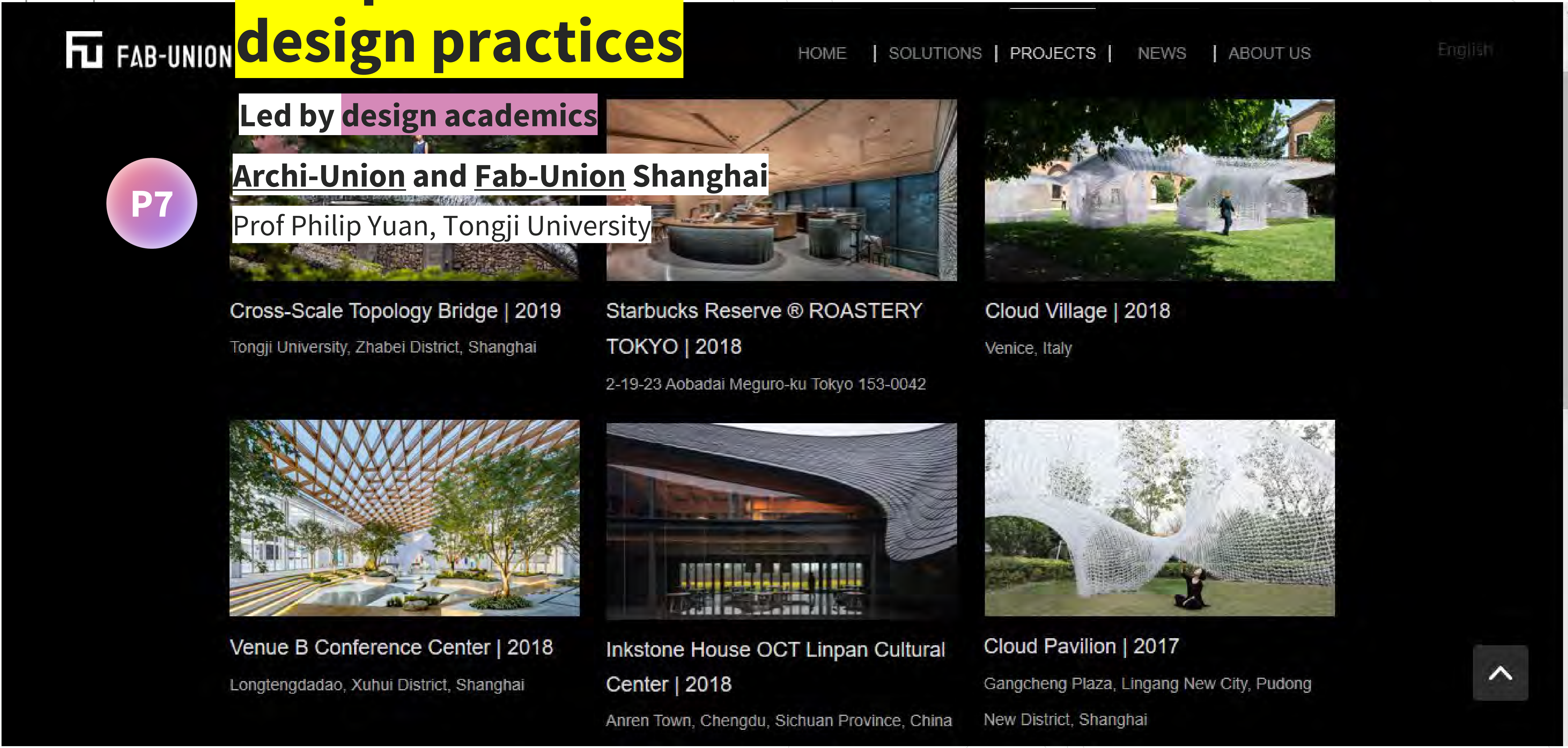
Computational design practices

Led by design academics

P7

Archi-Union and Fab-Union Shanghai

Prof Philip Yuan, Tongji University



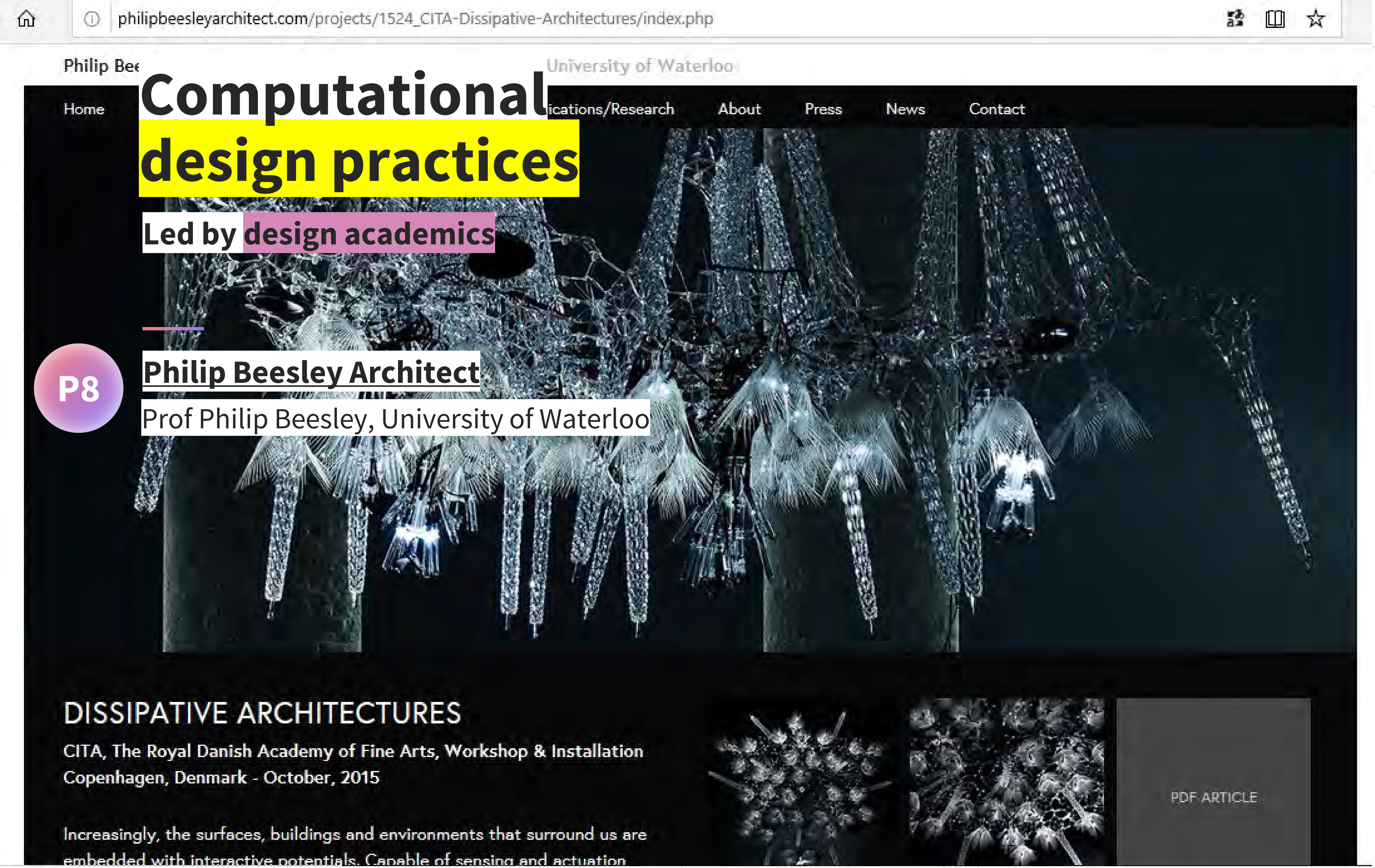
Computational design practices

Led by design academics

P8

Philip Beesley Architect

Prof Philip Beesley, University of Waterloo



www.menges-scheffler.de/?page_id=19876&lang=en

MENGES SCHEFFLER A

Projects Office Contact English

Computational design practices

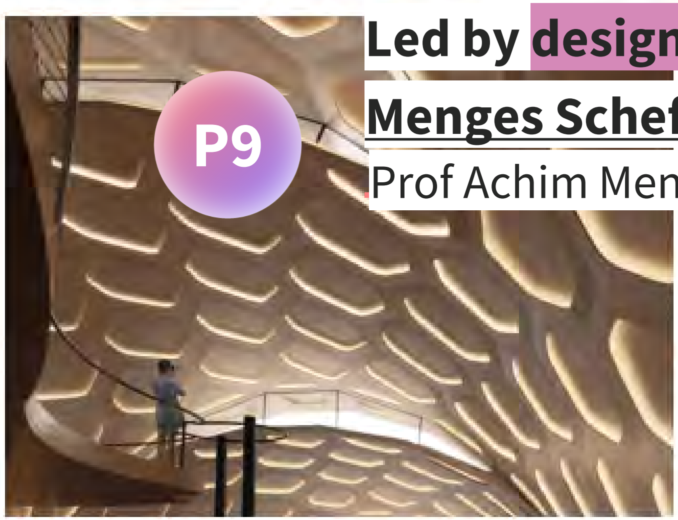
Research buildings

Led by design academics

P9

Menges Scheffler Architekten PartG mbB

Prof Achim Menges, University of Stuttgart



Baden-Wuerttemberg Haus, World Expo 2020, Dubai

2. Preis

2017 ICD (A. Menges) & ITKE (J. Knippers) Uni Stuttgart

Vitra Campus

Elytra Filament Pavilion, Vitra Campus

FABRICATE 2020

Burry, J., Sabin, J. E., Sheil, B. & Skavara, M. (2020). *Fabricate 2020*, UCL Press.

Link to download the book (free): https://www.uclpress.co.uk/products/154646

FABRICATE 2017

Sheil, R., Menges, A., Glynn, R. & Skavara, M. (2017). Fabricate 2017. UCL Press.

Link to download the book (free): https://www.uclpress.co.uk/products/89026

Sheil, R., Menges, A., Glynn, R. & Skavara, M. (2017). Fabricate 2017. UCL Press.

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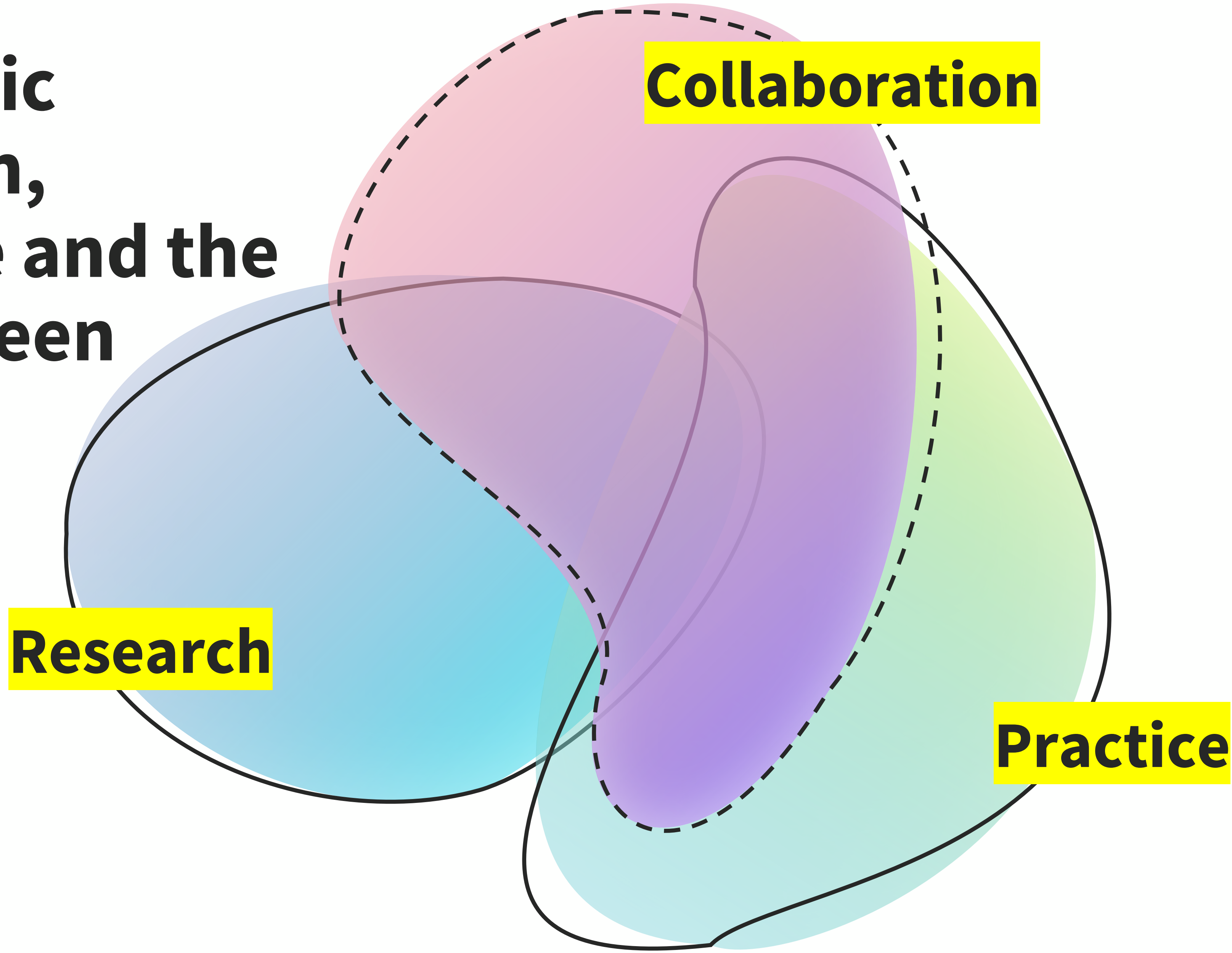
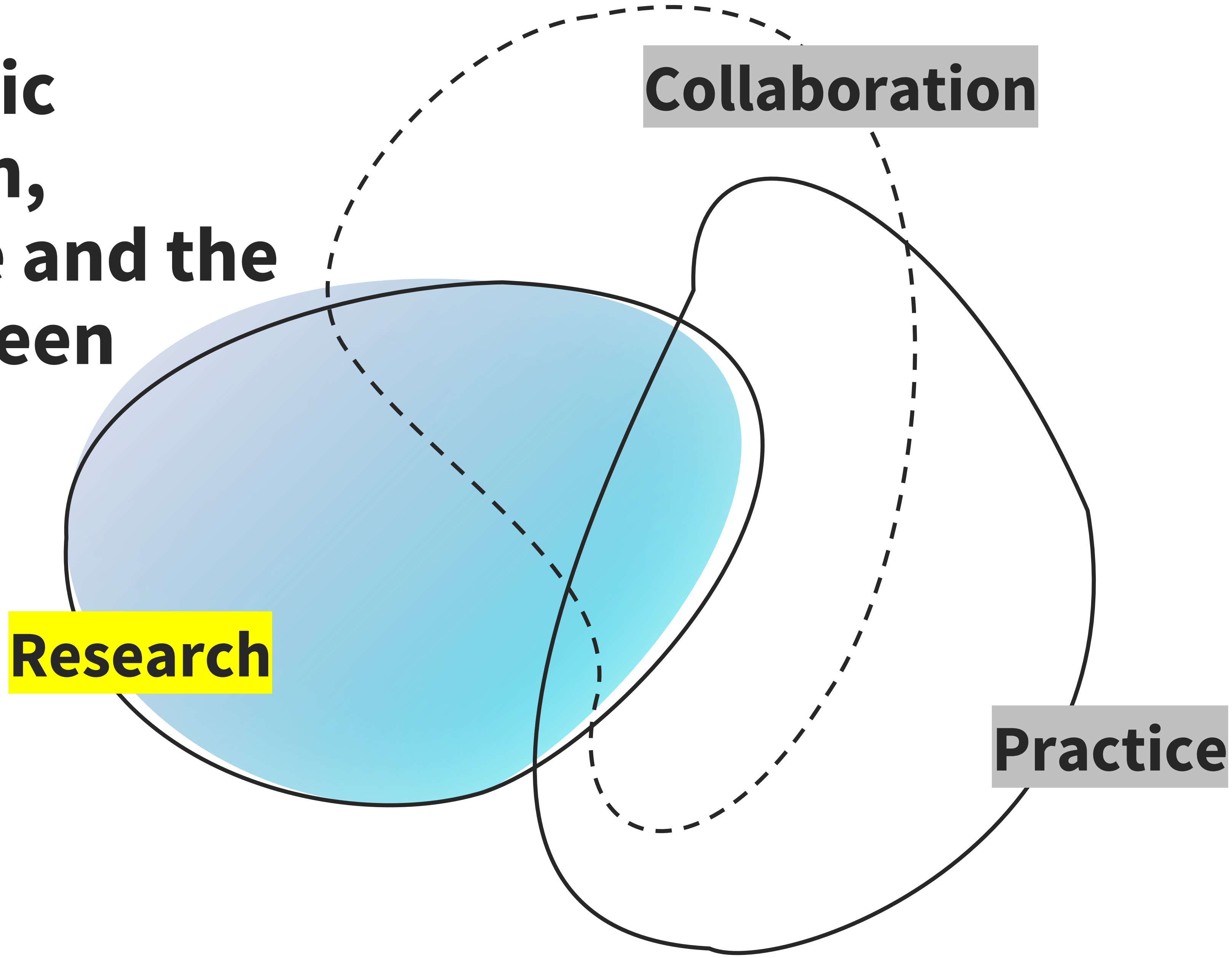
Academic research, practice and the in-between



Academic research, practice and the in-between



P30

Academic research

Architectural Association, London

INFINITE VARIATIONS, RADICAL STRATEGIES

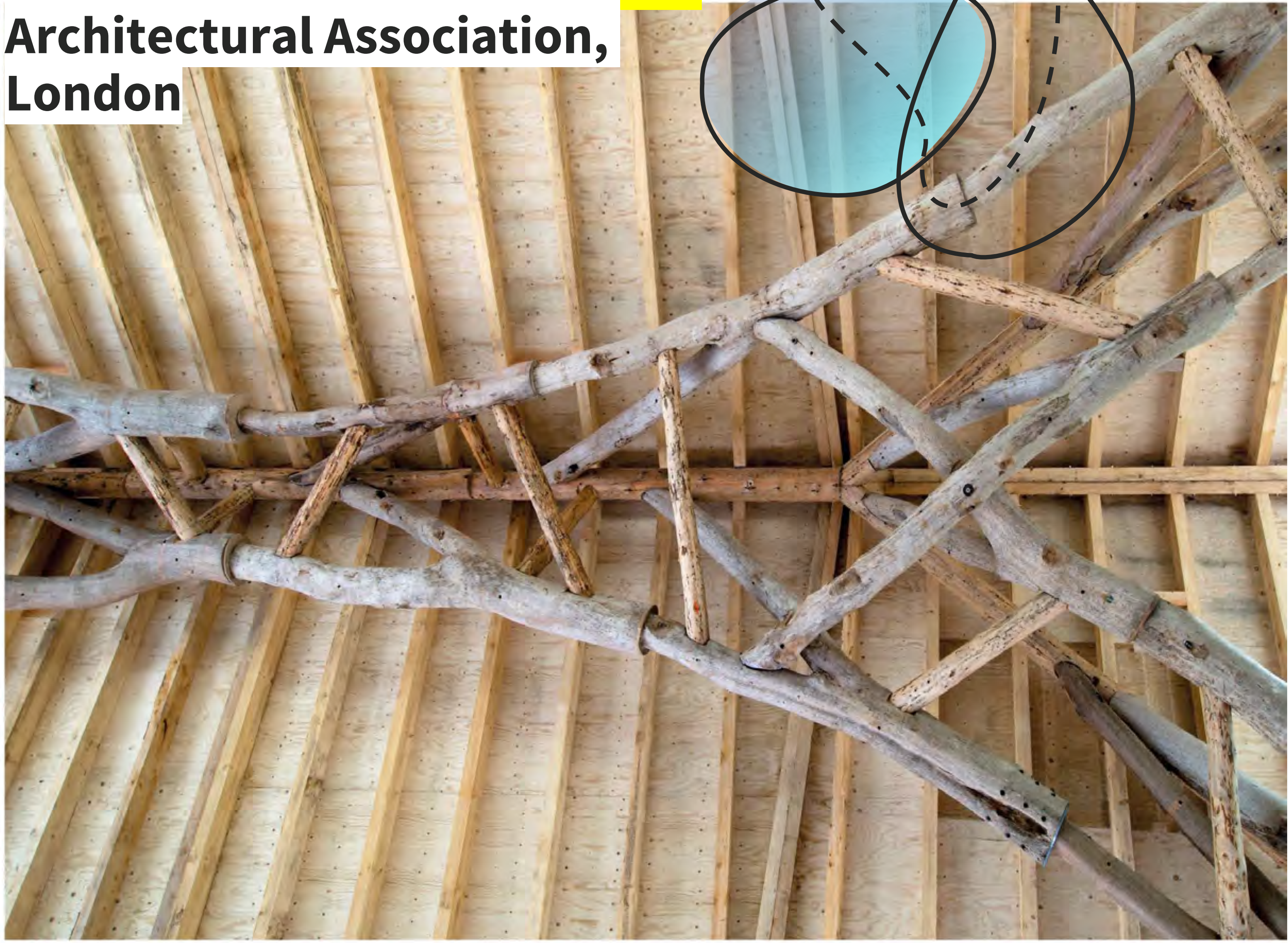
MARTIN SELF / EMMANUEL VERCRUYSSE
Architectural Association, London

The AA's satellite campus out in Hooke Park, Dorset, is the headquarters of its Design+Make programme and operates as a laboratory for architectural research through 1:1 fabrication. In an environment that combines forest, studio, workshop and building site, the large-scale fabrication facilities act as a testing ground where students devote time to advanced speculative research through a hands-on approach.

Designing and building architecture in the woods: within an idyllic forest ecosystem that is both material library and site, the programme explores how natural materials, craft knowledge and new technologies elicit exciting and unpredictable architectures while implying a deep connection between site, construction and tree species. It provokes a critical approach to designing and manufacturing – one which encourages a symbiotic relationship with the variability found in nature.

Design+Make's position, embedded within the forest, nurtures the students' attitude towards design, imbuing it with an expanded sense of material implications. They are exposed to the long-term investment of time and energy required for timber growth and the forestry processes required to manage it. This living material is formed by its spatial and environmental conditions, and the management of a forest is in many ways an act of design where it is possible to guide the structure of the trees it contains. In this way, design thinking begins under the canopy of the forest itself. The forest's delicate experiential qualities are due in no small part to its infinite variability and, rather than merely being a context for the work, the forest itself, with its material and structural diversity, becomes the inspiration for a way of working.

Digital design and fabrication tools are often used to develop non-standard series of components from standardised materials. Timber is usually considered as a rectilinear material, often reduced to sheets, planks or beams before having a complexity returned to it by milling procedures. And yet trees already present a naturally formed non-standard series – each is wholly unique. The Design+Make programme provokes an alternative conception of material form in which inherent irregular geometries are actively exploited by non-standard technologies.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Academic research

University of Michigan

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SENSORIAL PLAYSCAPE
ADVANCED STRUCTURAL, MATERIAL AND RESPONSIVE CAPACITIES OF TEXTILE HYBRID ARCHITECTURES AS THERAPEUTIC ENVIRONMENTS FOR SOCIAL PLAY

SEAN AHLQUIST
University of Michigan, Taubman College of Architecture and Urban Planning

Computational design commonly focuses on the synchronisation of advanced manufacturing technology and material behaviour. This allows for technical specificity, or instrumentalisation, to be achieved in material, structural and architectural performance. The research discussed in this paper extends such a material-based practice by utilising aspects of sensorial experience to drive the design and engineering of material performance and architectural responsivity. This is explored as a part of the *Social Sensory Architectures* research project, through the articulation of textile hybrid structures and their application to the development of skills in motor control and social interaction for children with autism spectrum disorder (ASD). The research is developed at the University of Michigan, through a collaboration between the Taubman College of Architecture and Urban Planning, the Department of Psychiatry and the School of Kinesiology. This alignment of disciplines integrates material research with methodologies for assessment of social function and kinesthetic activity.

This interdisciplinary research is described, in this paper, through the development of the *sensoryPLAYSCAPE* prototype. The prototype, as a malleable multi-sensory architecture, seeks to unravel associations between deficiencies in motor planning and processing of sensory stimuli with limitations in social function for children with autism. Defined as a spectrum disorder, a hallmark of autism is the highly unique and specific sensory and behavioural issues related to each individual. This is captured in the commonly used phrase: "when you've met one person with autism, you've met one person with autism". Accordingly, a significant criterion for the prototype is to enable the child to instrumentalise the sensorial experience of the architecture to suit their particular preferences. The intentions are to develop skills in motor planning that will assist social functioning through collaborative play. Navigating through the tactile architecture simultaneously reinforces such physiological and social activities through the sensorial adaptability of the architecture.

Academic research

Multidisciplinary:
School of Civil Engineering and School of Architecture University of Queensland Australia

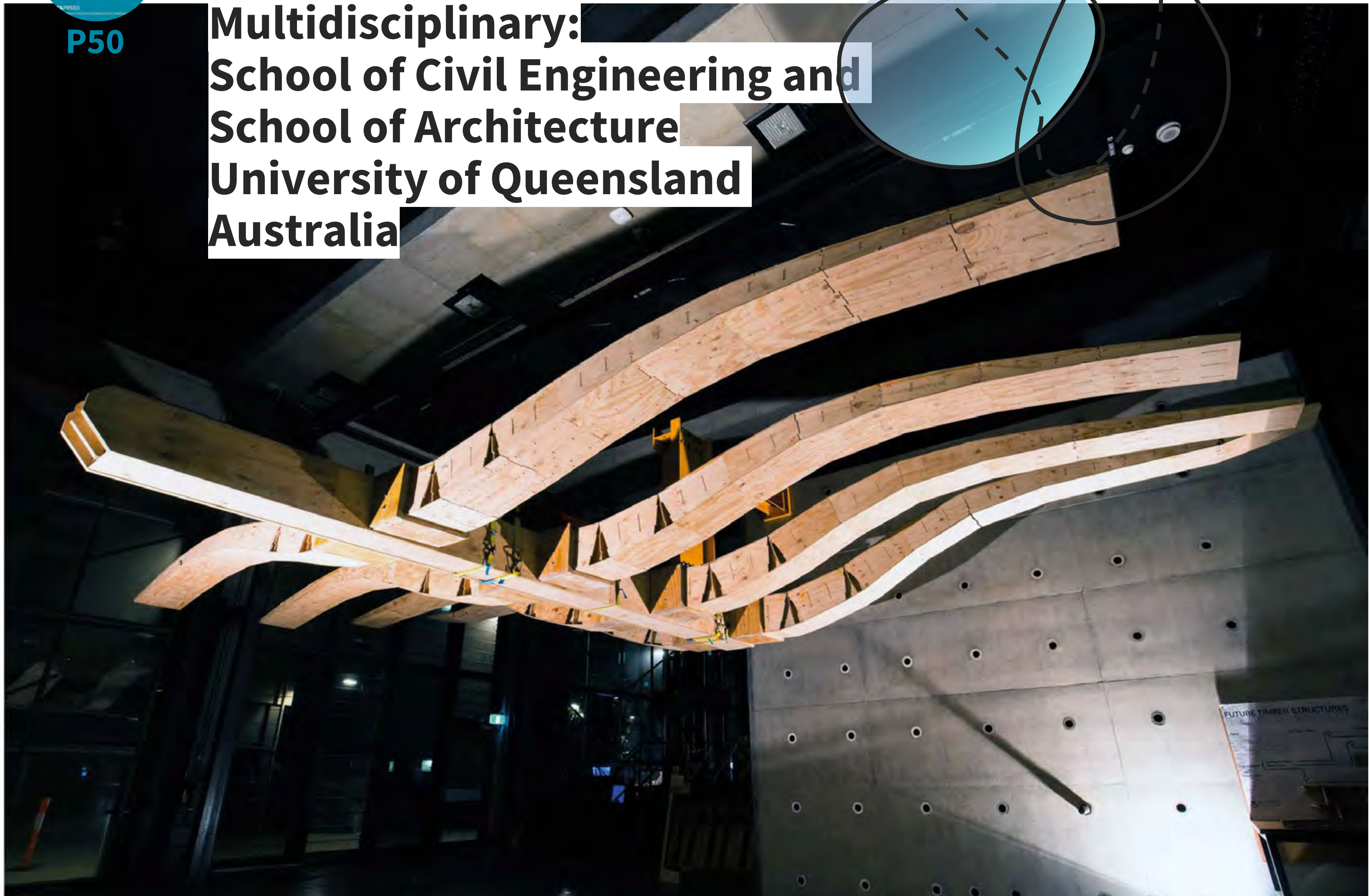
P50

RAPID ASSEMBLY WITH BENDING-STABILISED STRUCTURES

JOSEPH M. GATTAS / YOUSEF AL-QARYOUTI / TING-UEI LEE
School of Civil Engineering, University of Queensland, Australia
KIM BABER
School of Architecture, University of Queensland, Australia

This project seeks to enhance press-fit fabrication techniques through the use of hybrid material construction technology and bending-stabilised forms. It overcomes certain press-fit limitations and undertakes a systematic improvement to connection design, which in combination with material and form enhancements allows for an increase in spanning capacities and robustness of press-fit structures, an increase in the reliability and precision of assembled geometry and retention of the critical press-fit benefits of lightweight, high-speed and uncomplicated construction.

Press-fit connection techniques streamline digital construction methods through elimination of mechanical fixing components and thus enable rapid construction of complex three-dimensional geometries. However, the reliance on dimensional tolerance and oversizing, in lieu of mechanical fixing, causes an inherent instability in press-fit connections in the direction of component insertion. This can be partially abated with increased tightness between parts and/or a 3D interlock, but such measures can also offset the ease of assembly and



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Academic research

Multi institutions:
University of California and University of Stuttgart

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BENDING-ACTIVE PLATES
PLANNING AND CONSTRUCTION

SIMON SCHLEICHER
University of California, Berkeley, College of Environmental Design (CED), Berkeley, United States of America
RICCARDO LA MAGNA / JAN KNIPPERS
University of Stuttgart, Institute of Building Structures and Structural Design (ITKE), Stuttgart, Germany

Bending-active plate structures

In 2015, researchers at the University of California, Berkeley, and the Institute of Building Structures and Structural Design (ITKE) at the University of Stuttgart collaborated with the aim of contributing to the current research on bending-active plate structures. They placed particular emphasis on the further development of the formal and structural potential of this relatively new structural system and construction principle. In general, bending-active structures are fascinating because they take advantage of large elastic deformations as a form-giving and self-stabilising strategy. Previous research has mainly focused on a bottom-up form-finding approach, in which typical characteristics of plates or strips were predefined first and the global shape of the structure resulted from the interaction of assembled parts. In contrast, the main emphasis of this work will be on demonstrating a possible top-down approach that is based on form-conversion.

For bending-active plate structures that implement

FABRICATE

P92

Collaboration

Multi institutions:
École polytechnique fédérale de Lausanne (EPFL)
ETH Zurich

ROBOTIC INTEGRAL ATTACHMENT

CHRISTOPHER ROBELLER / YVES WEINAND
Laboratory for Timber Construction IBOIS – EPFL
VOLKER HELM / ANDREAS THOMA / FABIO GRAMAZIO / MATTHIAS KOHLER
Gramazio Kohler Research, ETH Zurich

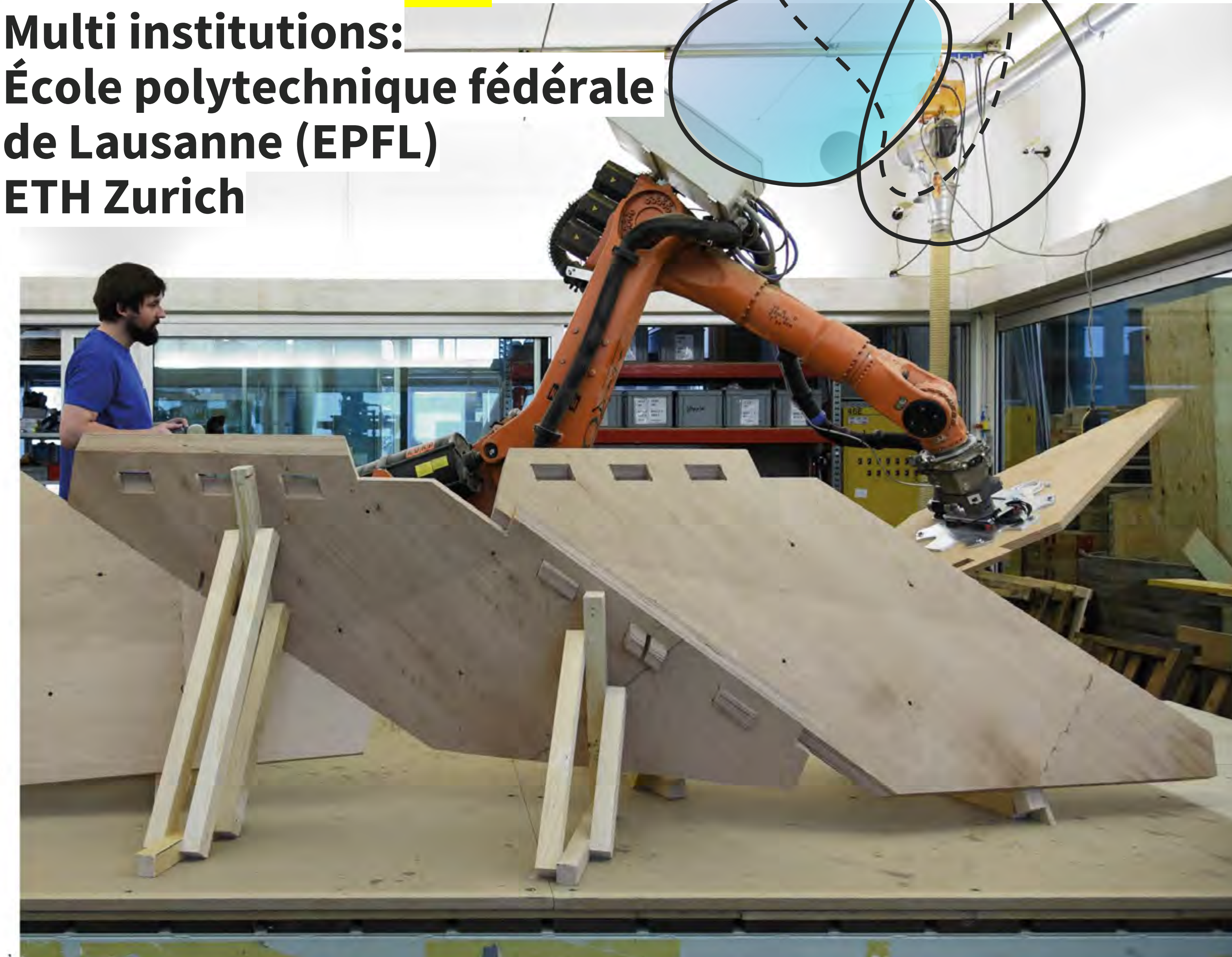
Integral joints provide a rapid, simple and mechanically strong connection between parts. Our investigation focuses on the assembly of cross-laminated wood veneer plates, where previous studies have shown that the strength of through-tenons is equivalent or superior to state-of-the-art fasteners such as screws or nails. This mechanical behaviour is highly dependent on a precise fit of the joints, where no gaps are left between the parts.

However, the manual assembly of such tight-fitting joints can be complicated. Thanks to its rectangular cross-section profile, a single through-tenon joint is a sufficient assembly guide for an entire plate, but multiple through-tenons are required to establish a mechanically strong connection. This results in a kinematically over-constrained assembly motion (Mantripragada et al., 1996). Additionally, due to fabrication- or material-related tolerances, the joints can be too tight-fitting and manual assembly motions deviate from the precise insertion path. So-called 'wedging' occurs during the assembly of tight-fitting joints, especially with larger parts at a building scale (Fig. 1). This requires high forces to be overcome.

Rather than leaving gaps between the parts, which presents one solution for the manual assembly of such systems, we investigate the idea of assembly using an industrial robot. The robot allows for a more precise assembly motion and the application of higher forces in the direction of assembly. The aim of this research is to use these benefits along with the compressibility of wood for the assembly of oversized tenons. While in regular through-tenon joints the width of the tenon is equal to the width of the slot, the oversized tenons in this paper are slightly wider than their slot parts. This assembly will require a certain insertion force, squeezing the tenons into the holes, but the resulting connection will be tight-fitting without any gaps.

Robotic assembly

Robotic integral attachment demonstrates the advantages of combining robotic assembly (Helm et al., 2016) and integral mechanical attachment, such as through-tenon joints. Both methods are used to facilitate the assembly of complex architectural designs, such as freeform shells and space frames. While integral



Collaboration

Bamboo Pod 1

Hosted by Mia and Matt Wallwork

25-28 June 2020

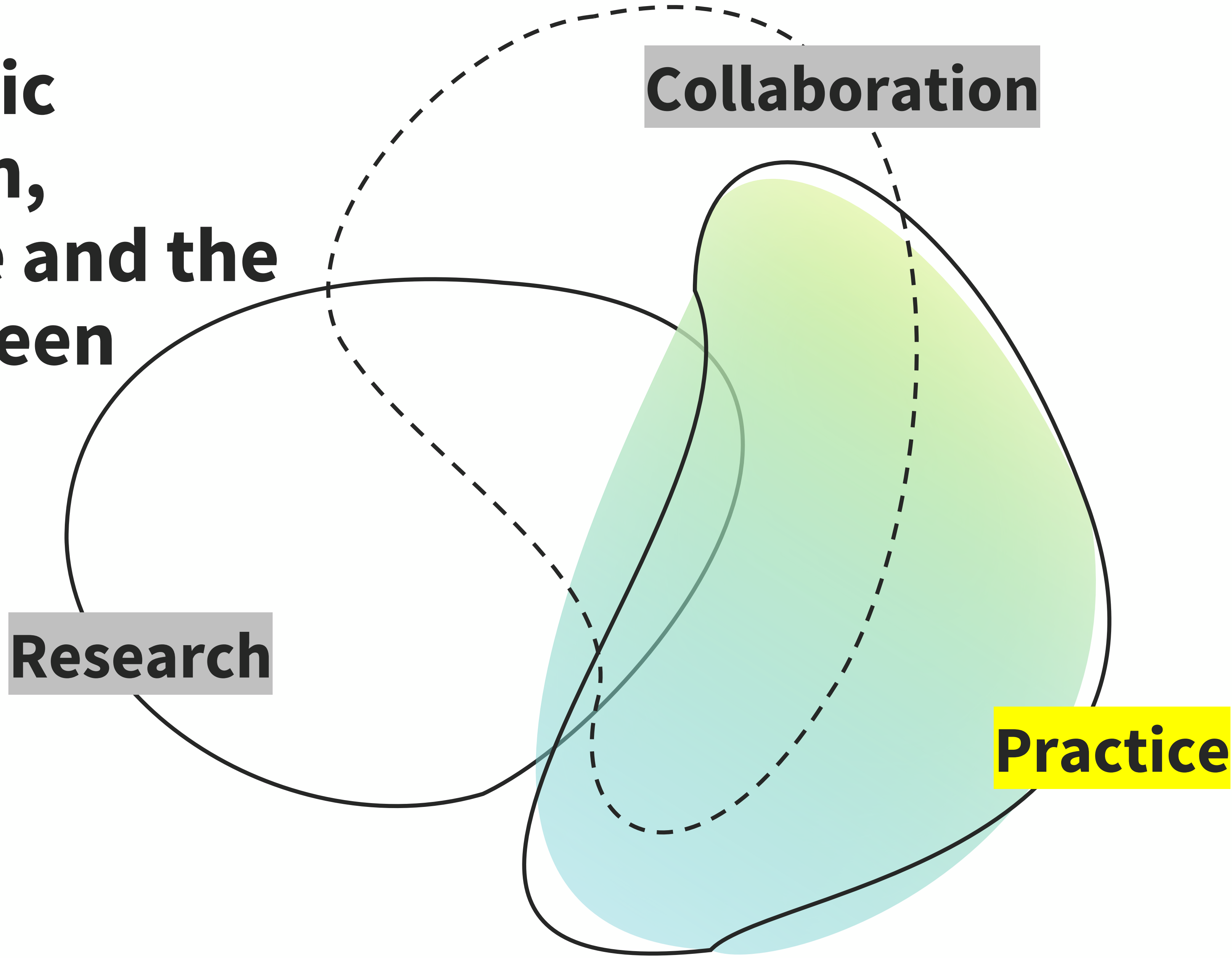
Collaboration

Design team was led by Weishun Xu, Zhejiang University

Hosted by Mia and Matt Wallwork

BAMBOO POD #2

Academic research, practice and the in-between



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Design practice

Ball-Nogues Design Studio

OPEN CAGE-SHELL DESIGN AND FABRICATION (HEALING PAVILION)

BENJAMIN BALL / GASTON NOGUES
Ball-Nogues Design Studio

Breaking boundaries in CNC steel tube rolling

Healing Pavilion, completed in December 2016, explores the boundaries and possibilities of CNC steel tube rolling. Inspired by the prowess of thin structural shells, this project translates the robust double curvature inherent in such forms into a dynamic cage-like array. By delving into the nuances and challenges of bending and rolling tube steel, the design adopts the surface form of a shell while introducing a level of transparency and controlled irregularity only possible through working with a network of individual components. Each tube has a unique three-dimensional curvature and is located at a fixed distance relative to its neighbour.

The pavilion balances structural load paths and assembly considerations with a rigorous exploration of patterning and layering. In addition to creating a space for shade and respite, the porous, shifting grid of steel tubing allows the reading of the complex form to fluidly adjust in relation to its background. The double curvature of the form demonstrates the physical limits of the CNC steel bending and rolling technology. That double curvature allows for structural shape efficiency, which creates natural rigidity through non-planar arcs. With just five construction details for the entire project, this final incarnation isolates and streamlines the design and construction process to tackle structure and the interstices between structural components simultaneously. The five structural details consist of:

1. Where the curved tubes meet the anchor plate at the base;
2. Where the tubes are mitred;
3. Where the tubes are spliced;
4. Where the tubes are capped; and
5. Where the tubes are spaced.

The successful translation of the digital design into a physical fabrication workflow without substantial variation from a digital ideal stands as the key driver defining the success of the project. *Healing Pavilion* combines a commitment to meaningful place-making with a deeply experimental fabrication goal.

Design practice

Foster + Partners

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MAGGIE'S AT THE ROBERT PARFETT BUILDING, MANCHESTER

RICHARD MADDOCK / XAVIER DE KESTELIER / ROGER RIDSDILL SMITH / DARRON HAYLOCK
Foster + Partners

A home away from home

Located across Britain and abroad, Maggie's Centres were conceived as a place of refuge where people affected by cancer could find emotional and practical support. Inspired by the blueprint set out by Maggie Keswick Jencks, they place great value upon the power of architecture to lift the spirits and help in the process of therapy. The design of the Manchester centre aims to establish a domestic atmosphere in a garden setting.

The building is arranged over a single storey, the roof rising in the centre to create a mezzanine level, naturally illuminated by triangular roof lights and supported by lightweight timber lattice beams. The beams act as natural partitions between different internal areas, visually dissolving the architecture into the surrounding gardens.

It was vital to create an atmosphere that would make visitors feel at ease, as if they were at home. The use of exposed timber for the structural elements enabled the creation of a homely, domestic ambience throughout the

Using the practice's expertise in digital modelling and analysis, the structure is the protagonist – a cantilevered timber wing 'tiptoeing' lightly over the site. To that end, much work was undertaken to assess how the design intent could be realised with contemporary materials and digital fabrication methods. Investigations were carried out to explore the structural optimisation potential in minimising the material used. For the construction, an Airfix™ (Airfix, 2016) analogy was deemed desirable – a kit of parts fabricated offsite and assembled onsite, facilitating quick erection.

The result is an innovative use of a traditional material, taking advantage of a complete file-to-factory process to provide the driver of the building aesthetic.

Making design match function

Functionally, the building is laid out to provide accessible open spaces along either side of a central zone: public spaces to the west, with the more private cellular spaces on the east. The centralised horizontal core houses the

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Design practice

AL_A

MPAVILION 2015

AL_A

Responding to climate and landscape

MPavilion is a unique architecture commission and design event for Melbourne, Australia.

A new temporary pavilion is commissioned each year from a leading international architect by the Naomi Milgrom Foundation.

Each structure takes shape in the downtown oasis of Queen Victoria Gardens to accommodate a free programme of talks, workshops, performances and installations from October to February. Building on unexpected collaborations, MPavilion is a catalyst and a meeting place – an intriguing form, a temporary landmark, a spontaneous detour, a starting point and a base to explore design's role in the creative city.

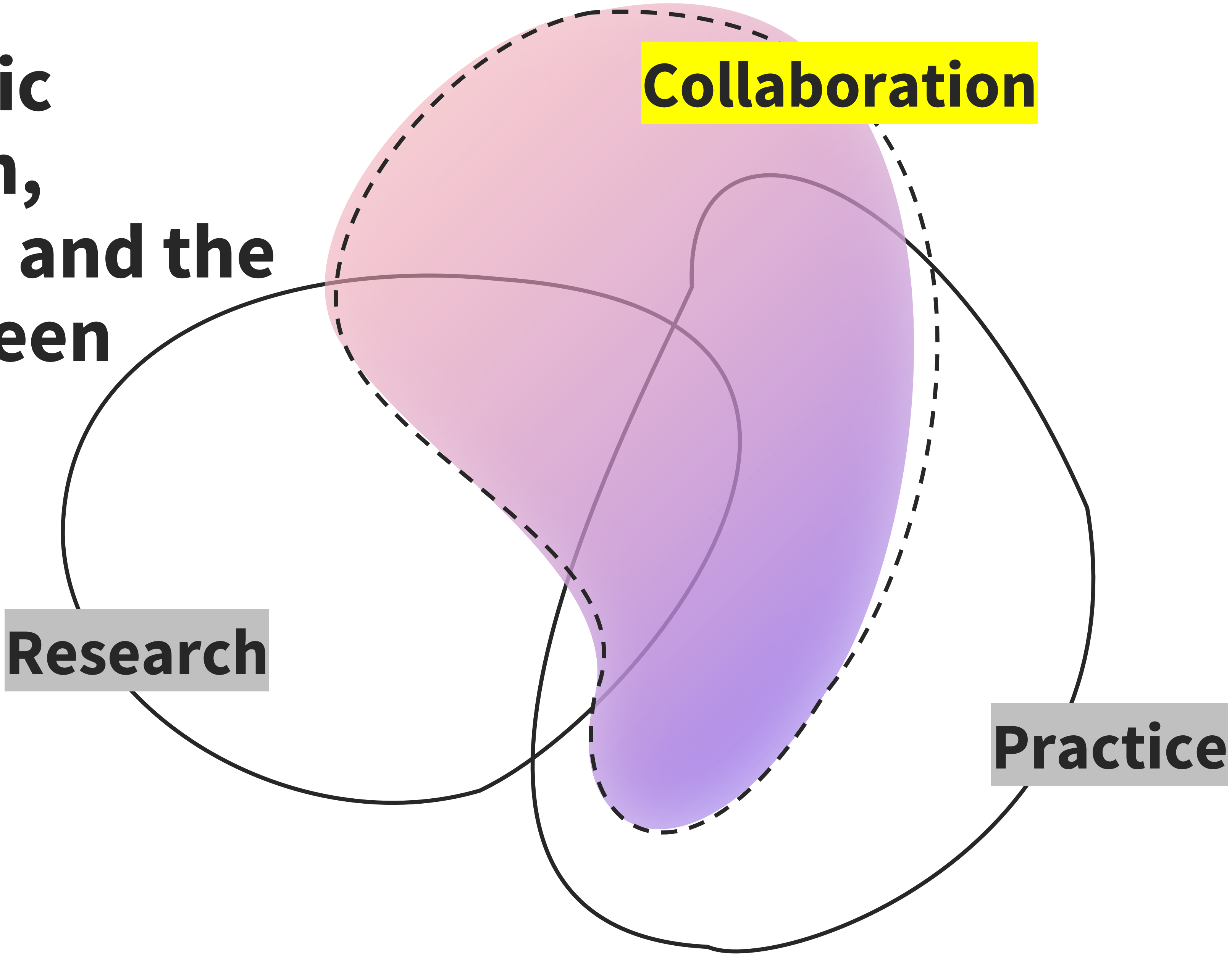
At the conclusion of its lifespan in Queen Victoria Gardens, the pavilion is demounted and gifted to the City of Melbourne for reassembly in a permanent location to create an enduring legacy.

The brief was an opportunity for a structure that responds to its climate and landscape, exploiting the temporary nature of the pavilion form and producing a design that speaks in response to the weather.

Rooting the pavilion in its parkland setting, the vision for MPavilion was to create the sensation of a forest canopy, with beautiful dappled light where visitors could see the sun and the sky – a dreamy atmosphere that could inspire a diverse programme of events for four months.

The design was driven by an ambition not only to integrate the pavilion with its parkscape environment but also to involve the wind, and sometimes the rain, as part of the experience. And so the structure needed to balance a degree of flexibility in its response to the atmosphere with subtle movements, with sufficient stability to safely host thousands of visitors over the summer. The pavilion would be a celebration of those natural shelters where people come together: an exceptionally light, open structure that sits gently on the land while affording protection from the unpredictable weather of Melbourne.

Academic research, practice and the in-between



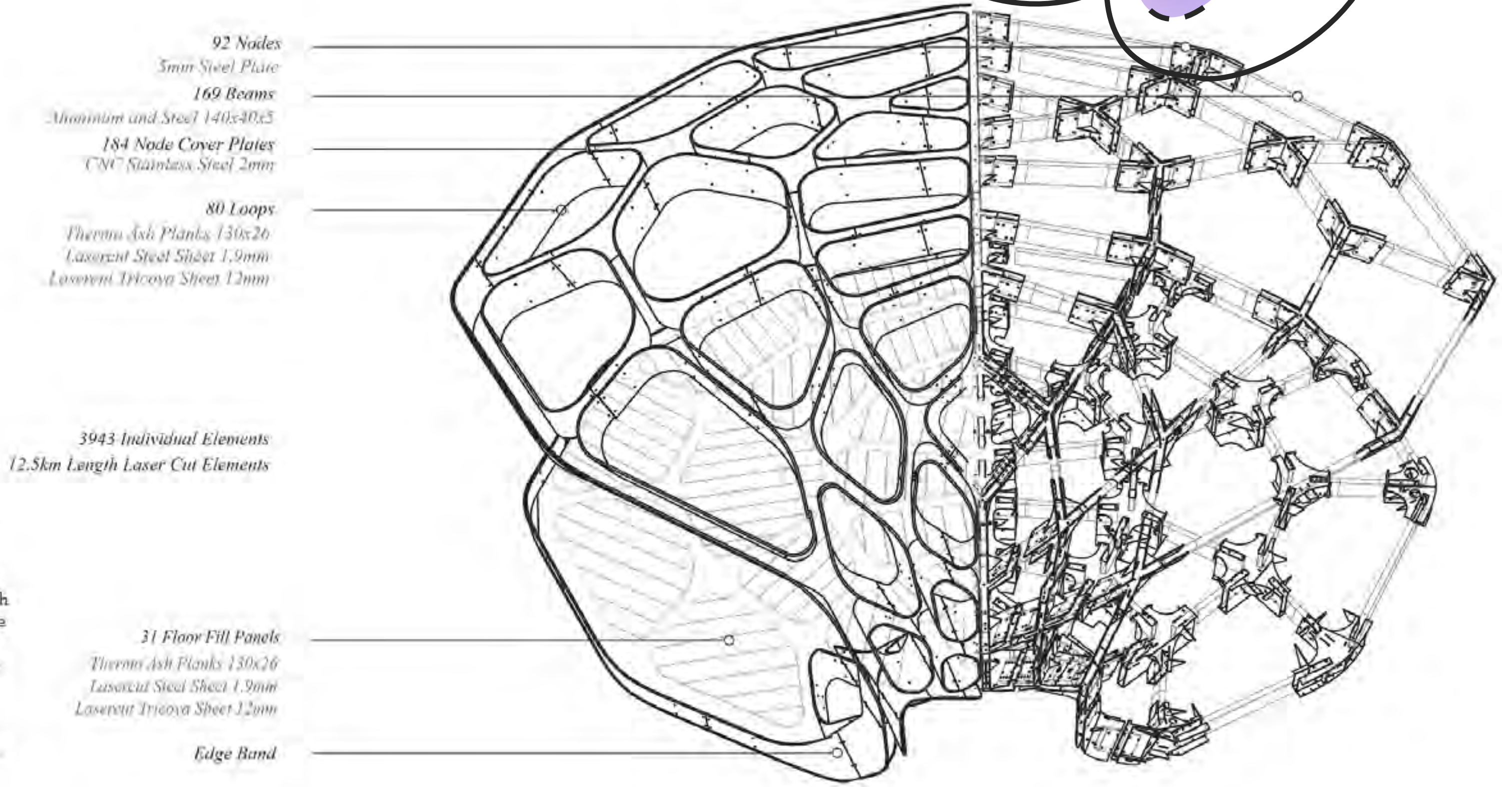
P58

Collaboration

Industry collaboration: Zaha Hadid Architects and One to One

A PREFABRICATED DINING PAVILION USING STRUCTURAL SKELETONS, DEVELOPABLE OFFSET MESHES AND KERF-CUT BENT SHEET MATERIAL

HENRY LOUTH / DAVID REEVES / SHAJAY BHOOSHAN / PATRIK SCHUMACHER
Zaha Hadid Architects
BENJAMIN KOREN
One to One



This project focuses on the role of computational geometry within computer-aided architectural design and construction workflows, i.e. computational geometry as a mediating device between architectural, engineering and construction logics. While the scale of a dining pavilion is relatively modest, the intention is to utilise this research for wider application in larger construction-scale projects. In this regard, the project operates within a tight time-bound, multiple-stakeholder, collaborative and bespoke production pipeline, as typically necessitated by architectural projects.

Digital workflows

Workflows in architectural design can be characterised by two paradigms – one drawing-based, the other model-based. The drawing paradigm is popularly known as Computer Aided Design (CAD) and the model paradigm as Building Information Modelling (BIM). While both drawings and models encode 2D and 3D geometry, a model also contains meta-information about the encoded geometry – its material specification

paradigm, especially Computer Aided Geometric Design (CAGD), can support the creation of a wider range of (arbitrarily) complex geometries and their processing for Computer Aided Manufacturing (CAM). An essential aspect of CAGD, as used in disciplines such as automotive or product design, is the abstraction of the complex physical phenomena and machine parameters associated with manufacturing methods into geometric properties and constraints. Famous examples include the automobile, aircraft and shipbuilding industries motivating the development and use of Bézier curves and surfaces, physical splines and developable surfaces (Bézier, 1971, Sabin, 1971, De Casteljau, 1986, Pérez & Suárez, 2007, Pottmann & Wallner, 1999), etc.

This project aims to apply these operative principles from the automated fabrication industry in architectural design and assembly. Thus the project primarily focuses on developing structural and construction-related meta-information for complex geometries – in other words, augmenting complex CAGD objects with construction-specific information, thus enabling the

Collaboration

Academia and industry collaboration: Massachusetts Institute of Technology University of Michigan Quarra Stone Matter Design

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ROBOTIC FABRICATION OF STONE ASSEMBLY DETAILS

INÉS ARIZA[1,3] / T. SHAN SUTHERLAND[2,3] / JAMES B. DURHAM[3] / CAITLIN T. MUELLER[1] / WES MCGEE[2,4] / BRANDON CLIFFORD[1,4]
[1]Massachusetts Institute of Technology
[2]University of Michigan
[3]Quarra Stone
[4]Matter Design

This research follows an important body of work from the past decade, which focuses on the design of global surface geometries for compression-only structural behaviour. For example, studies in thrust network analysis have made possible the design and computation of complex unreinforced freeform shell structures that work purely under compressive forces once they are completely assembled (Block, 2009). Recent built projects have shown that while it is possible to construct these structures with standard CNC fabrication tools and for them to demonstrate efficient structural behaviour with minimal bending as expected, a major challenge of building these structures is the development of effective assembly strategies during construction to handle tolerance (Rippmann et al., 2016). A second key challenge is the management of falsework, which is structurally necessary to hold individual voussoirs, or compression blocks, in place until the structure is stable, which is sometimes not until the final stone is placed.

These challenges are important to address in order for efficient, geometrically expressive masonry shell structures to play a larger role in the contemporary architectural fabrication landscape alongside conventional steel, concrete and timber structures. In response, the research presented here offers a new approach for the fabrication and assembly of freeform masonry shell structures that can be built with less error and less falsework. Made possible through a computational workflow that simulates structural behaviour during assembly instead of only after a structure is completed, the approach employs cast-metal joining details that bring ancient stonework techniques into the digital age with customised, mechanically responsive geometries.

New agendas for stone carving

Correlating forces (physics) and form (geometry) in 3D, thrust network analysis and accessible physics simulation environments based on dynamic relaxation have extended historical structural form-finding methods into new versatile digital design workflows (Block, 2009, Rippmann et al., 2011, Piker, 2013). One of the results of the availability of these new geometrical exploration approaches has been a renewed interest from designers

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Collaboration

Academia and industry collaboration:
Block Research Group
The Escobedo Group

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THE ARMADILLO VAULT
BALANCING COMPUTATION AND TRADITIONAL CRAFT

PHILIPPE BLOCK / MATTHIAS RIPPMANN / TOM VAN MELE
ETH Zurich - Block Research Group
DAVID ESCOBEDO
The Escobedo Group

This paper describes the development and fabrication of the Armadillo Vault, an unreinforced, freeform, cut-stone vault, which embodies the beauty of compression made possible through geometry. Specifically, the paper provides insights on how a highly interdisciplinary team managed to bridge the difficult gap between digital modelling and realisation by learning from historic precedent and by extending traditional craft with computation.

The vault is the centrepiece of *Beyond Bending*, a contribution to the 15th International Architecture Exhibition – La Biennale di Venezia 2016, curated by Alejandro Aravena (Fig. 2). Wrapping around the columns of the Corderie dell'Arsenale, the shell's shape comes from the same structural and constructional principles as stone cathedrals of the past, but is enhanced by computation and digital fabrication. Comprising 399 individually cut limestone voussoirs with a total weight of approximately 24 tonnes, the vault stands in pure compression, unreinforced and without mortar between the blocks. It spans more than 15m in multiple directions,

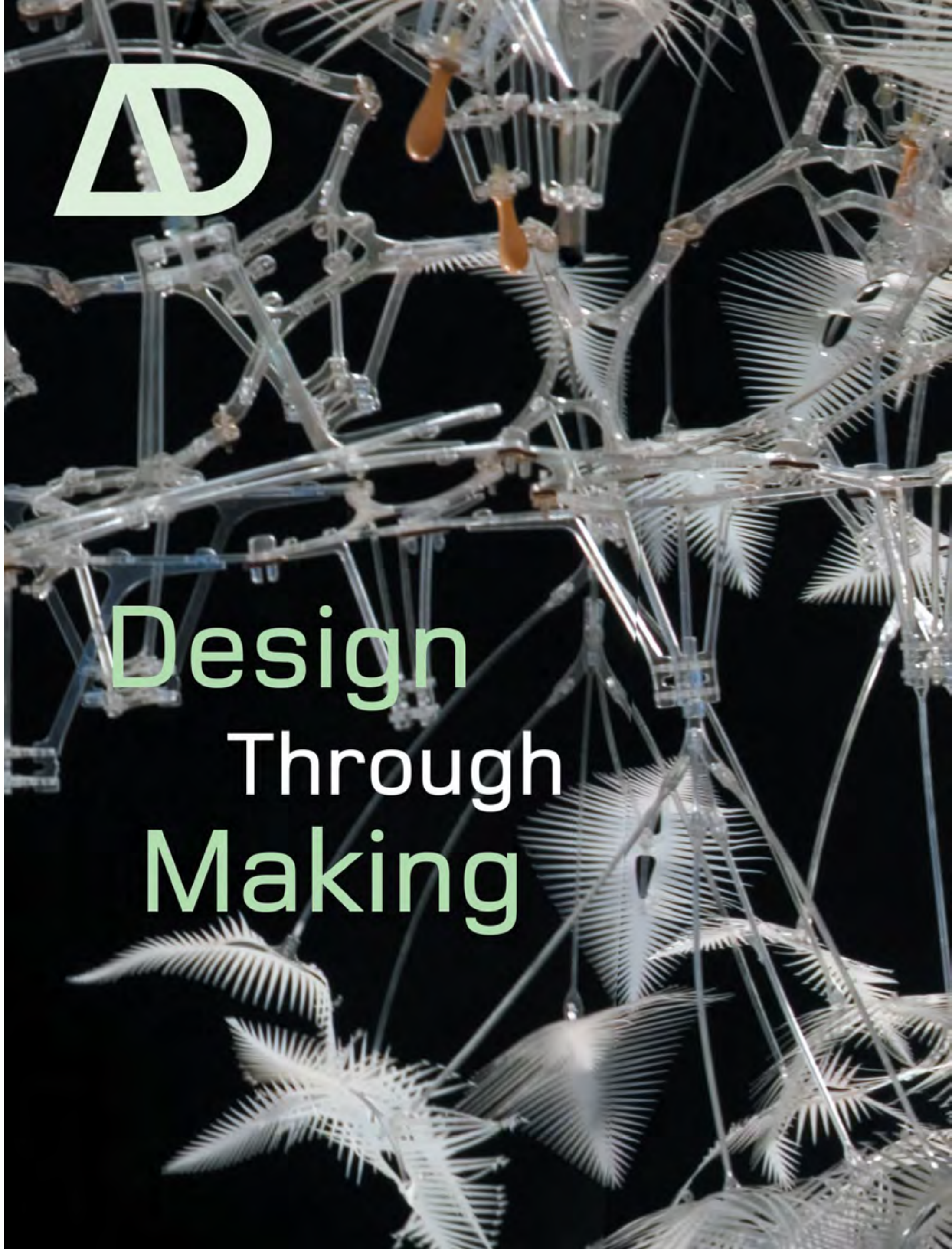
The collaboration became more common and pertinent, between academia and practices

How does approaches exhibited by the mentioned architecture studio compare to mainstream architecture studio?

Design Through Making

Repositioned centre of architectural practice by the expertise of making.

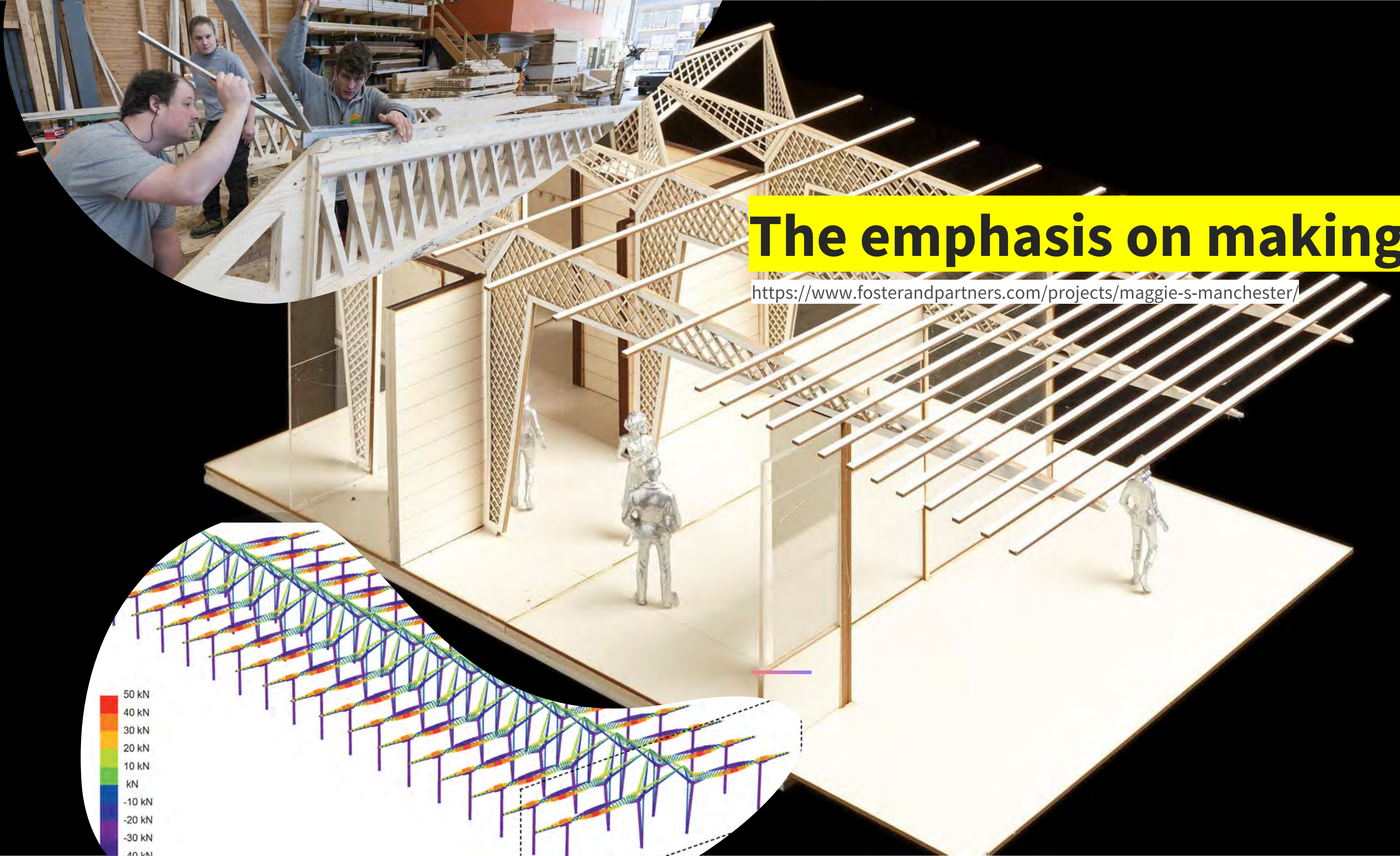
Gap between information and making has been bridged.



Sheil, B. (2005). Design through making: An introduction. *Architectural Design,* 75**,** 5-12.

The emphasis on making

https://www.fosterandpartners.com/projects/maggie-s-manchester/



The emphasis on making:

Making prototypes

Making information

Making data/analysis

Drawing through making*

"If design is to draw, it means drawing through making"

*Jonathan Hill

In my craft and sullen art of sketching the future by drawing the past.

Stacey (2005)

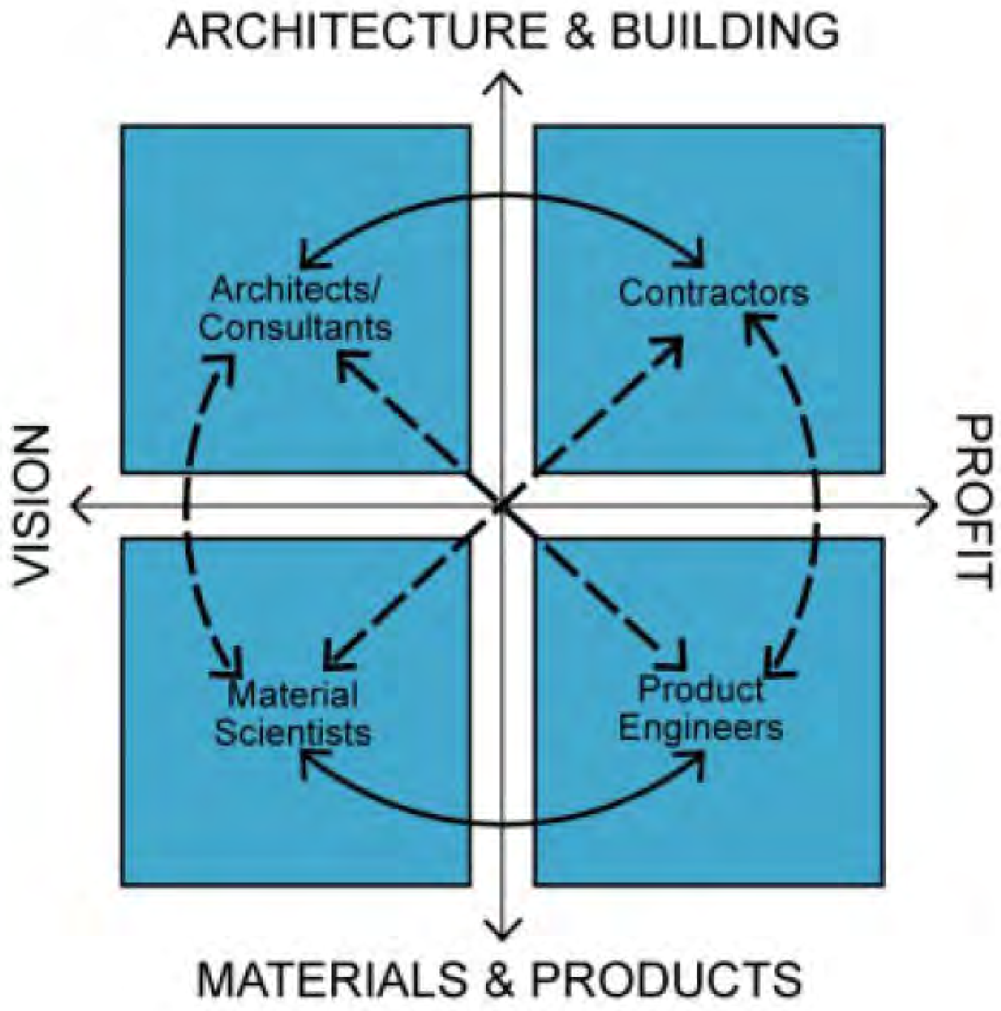
"The use of digital design tools has the potential to position the architect in the centre of the construction process, controlling the flow of information and, critically, the generative geometry"

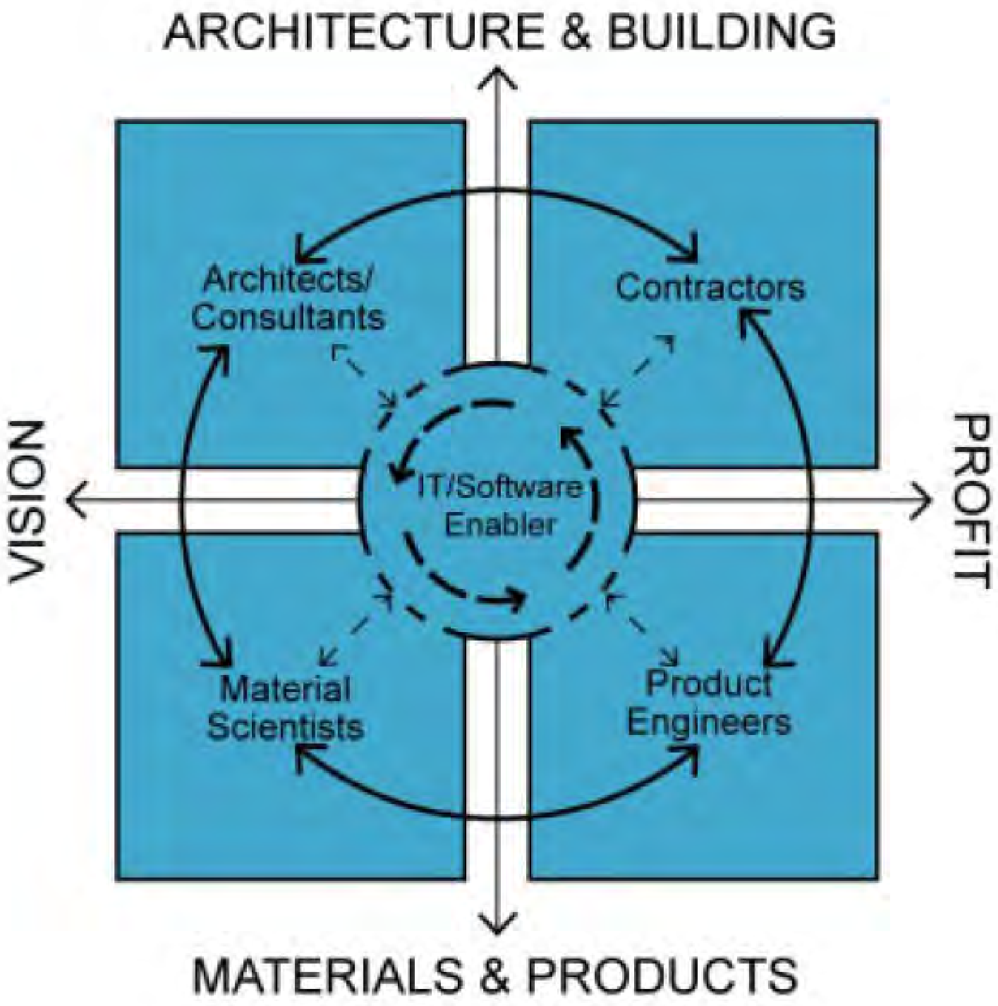
Stacey, M. (2005). In my craft and sullen art or sketching the future by drawing on the past. *Architectural Design*, 75, 38-45.

Digital fabrication and the management of electronic information can place architects at the centre of the construction process. Comparative diagrams: the current isolated conventions of recent construction and the potential of digital fabrication, prepared by James Timberlake and Stephen Kieran.

Kieran and Timberlake (2004), illustration by Stacey (2005)

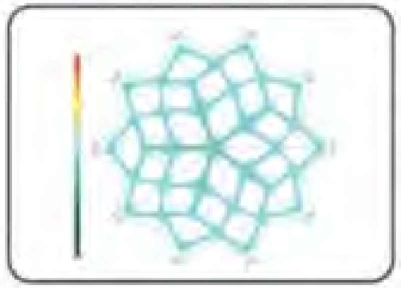
Kieran, S. & Timberlake, J. (2004). *Refabricating architecture: How manufacturing methodologies are poised to transform building construction*, McGraw Hill Professional.

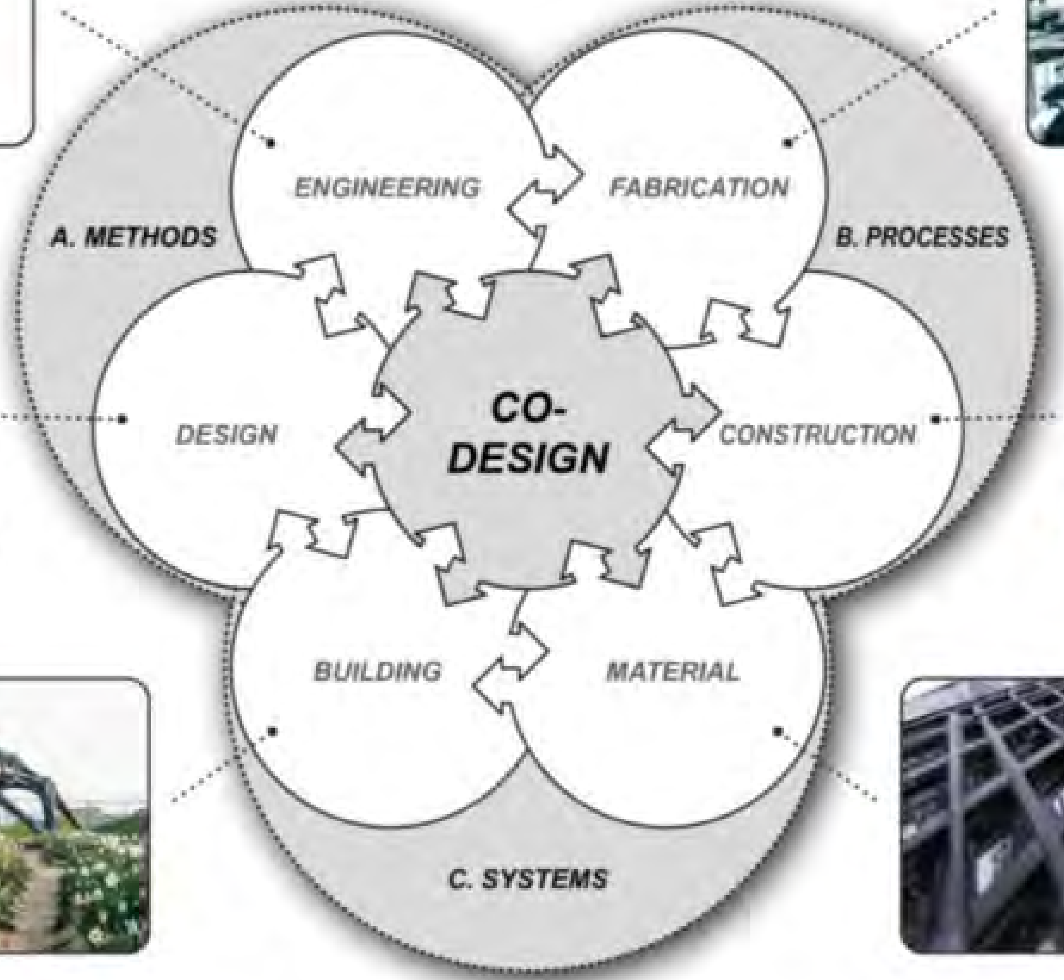




‘Cyber-physical’ approach BUGA Fibre Pavilion 2016 ICD Stuttgart

Co-design approach: Architectural design, structural engineering and robotic fabrication are developed in continuous computational feedback.





https://www.icd.uni-stuttgart.de/projects/buga-fiber-pavilion/

Dialectics between academia and practice

1. Expert knowledge for specific area such as materials, construction method from particular research groups.

2. … **Discuss** based on input texts (see next slide). And post on the forum.

3.

Collaboration

Academia and industry collaboration
(p36-41)

THE ROLE OF ROBOTIC MILLING IN THE RESEARCH AND DEVELOPMENT OF THE CORK CONSTRUCTION KIT

OLIVER WILTON
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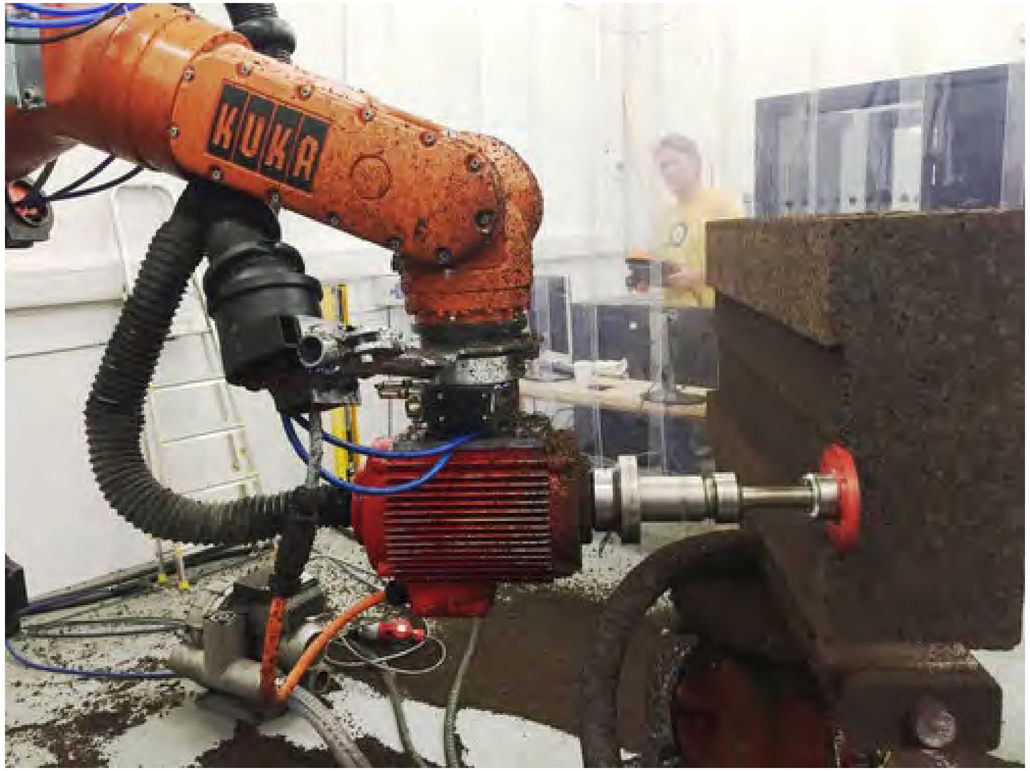
MATTHEW BARNETT HOWLAND
CSK ARCHITECTS
PETER SCULLY
B-MADE, THE BARTLETT SCHOOL OF ARCHITECTURE, UCL



1- https://www.matthewbarnetthowland.com/cork-research

Collaboration

Academia and industry collaboration
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2- https://youtu.be/t76Wjw1ZVkQ

Collaboration

Academia and industry collaboration
(p36-41)

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PETER SCULLY
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Discuss:

https://miatedjosaputro.com/2022/03/08/dg-week-3-2/

How does <u>dialectics</u> between academia and industry exhibited in this project?

How did the <u>conversation</u> between academia and industry in design stages contribute to advancement of the project (and design field)?

Re-iterated aims and objectives

- To exemplify leading research groups in computational design.
- To elicit different approaches exhibited by architecture design studio which practices computational design.
- To discuss the dialectics between academia and architectural practices.