Civil and Architectural Engineering

Yearbook 2020

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SDU

March 2020

Dear Reader...

Welcome to the inaugural issue of the Civil and Architectural Engineering Yearbook. I am delighted to share with you an overview of the Section's activities and accomplishments over the past year or so. The section is well-established in terms of its BEng programme and a MSc in Structural Engineering, which we are expanding as a strategic initiative by the Faculty of Engineering and the Department of Technology and Innovation. We are in the process of significantly broadening our research capacity and at the same time developing a new BSc/MSc programme.

We live in a time of immense changes and formidable challenges. The combination of globalisation, urbanisation, digitalisation, climate change and the broader environmental agenda provides the backdrop as we set out to redefine the direction and the scope of our activities. At SDU's Faculty of Engineering we are fortunate to be in a position to proactively define our research and educational programmes to address current and future challenges in a quest to educate the talent of the future and contribute with relevant research and innovation as significant parts of a sustainable development.

We have defined a series of research focus areas which are also outlined in the yearbook. These research areas all address different aspects of technological advances and explore how novel construction and design methods will facilitate gains in productivity, performance, and sustainability. The research areas are reflected in cross- and transdisciplinary education, providing the skills needed for the green transition of the built environment and the construction sector. I am pleased that we are starting to clearly see the contours of a design-oriented and highly interdisciplinary section with regional presence and international reach.

Enjoy the read!

Professor Mikkel K. Kragh
PhD MSc(Eng) CEng
MCIBSE MASHRAE FSFE

Head of Section for
Civil and Architectural Engineering

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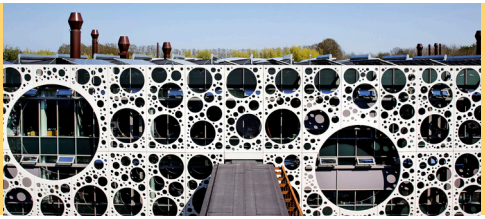

The Section for Civil and Architectural Engineering provides education and conducts research in the design, construction, and use of the built environment. We are a section of engineers and architects, working together following the concept of total design, which implies a comprehensive understanding of the complexity of building projects and the need for building engineers to collaborate across disciplinary boundaries.

About the Section

The Section for Civil and Architectural Engineering brings together an international team of researchers and lecturers with academic and professional trans-disciplinary backgrounds, with the common goal to advance our understanding of the built environment. We develop and teach from a position of deep technical expertise on a physical scale ranging from urban systems to material microstructures. Our work acts upon international and national policies and technical standards.

Design and design thinking inform our research and education following the philosophy of total design. This was an idea put forward and practiced by the Danish and English engineer Ove Nyquist Arup. In his Key Speech from 1970, he explained total design as an ambition for building designers with different expertises to work closely together to produce results that are more than the sum of their parts.

The significant impact that buildings, infrastructure, and cities have on our environment, makes our activities central in contributing to United Nations Sustainable Development Goals, and the university commitment. The goals are considered at a fundamental level in our research and we teach students to critically assess the impact of design decisions. Moreover, as a product of our time, and to prepare students for the workplace of the future, we adopt and emphasise the use of appropriate digital practices in our research and education.

The section has a strong technical focus on four key areas: structural engineering, facade engineering, computational design and digital fabrication, and urban resilience.

Our section is managed by head of section Professor Mikkel K. Kragh. The section can be found on the first floor of the TEK building at the Odense campus of SDU.

We also have a presence at BLOXHUB in central Copenhagen.

People

External Collaborators

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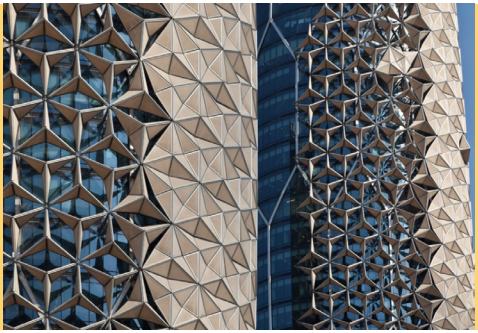
Research Areas



Facade Design and Engineering

Facade Design and Engineering is a research area in the Section for Civil and Architectural engineering. Research in this area is led by Assistant Professor Nebojša Jakica and explores the connected domains of facade design and engineering. The research is clustered within the context of Facade, Architectural Computation, Engineering, Technology, and Systems (FACETS).

The research is focused on the transition towards sustainable, cost-optimal, and resource-efficient buildings, employing data-driven computational processes.

A special interest area is the design and performance of adaptive facades, seen from a human-centred design perspective. Human-facade interaction serves as a basis for creating adaptive and personalised indoor environments that improve human-comfort, experience and well-being.

Research in Facade Design and Engineering includes adaptive facade design (smart glass, kinetic shading systems, led systems), solar design and Zero-Energy Buildings (daylighting, energy generation from building integrated-photovoltaics, whole building energy), facade information modelling (artificial intelligence methods for predictive control and optimal behavior of adaptive facades and buildings), facade virtual prototyping (Physically-Based Visualization for Immersive Environments), and collaborative facades (Human-Centered Facade Design and Operation).

Structural Engineering

Structural Engineering is a research area in the Structural Group that is part of the Section for Civil and Architectural Engineering. Researchers working in this area investigate load-carrying and deformation capacity of structures.

This involves traditional and innovative structures, and the assessment of the structural safety of existing structures. Within these domains, the research group is currently active within concrete and timber structures. Research in this area is led by Associate Professor Henrik Brøner Jørgensen.

The research area is characterised by a focus on developing design models and assessment methods that can be used in practice. This approach requires experimental and theoretical research in tandem, where models are evaluated and confirmed through physical testing. The group is internationally recognised for its work on developing plasticity theory, and is active in the following domains of concrete structures: behaviour and design methods for structural concrete, design of innovative structures, shear in structural concrete, shear in prestressed beams, design and strength of connections, serviceability design of connections, strengthening of existing structures, and residual load-bearing capacity of damaged existing structures.

The experimental research is conducted in the Structural Engineering Laboratory, which is equipped with state-of-the-art equipment for experimental research on concrete structures.

Computational Design and Digital Fabrication

Computational Design and Digital Fabrication is a research area in the Section for Civil and Architectural Engineering. A group was established to coordinate work in this research area: Computational Research in Emergent Architectural Technology (CREATE). The group is led by Assistant Professor Roberto Naboni.

The research area focuses on systematic and creative exploration of novel architectural processes and solutions at the intersection of the fields of computer science, advanced manufacturing, and emergent material technologies. By exploiting a fast-evolving landscape of emerging technologies, CREATE develops projects and concepts as answers to the challenges of today—from the effects of climate change to the well-being of city users.

Within the high-tech context of SDU, the group undertakes research and teaching activities in the fields of Industry 4.0, Additive Manufacturing (AM), Architectural Robotics, and Virtual and Augmented Reality. CREATE develops interdisciplinary research and projects with a team of highly skilled design researchers, and a network of academic and industrial collaborators.

The group's physical infrastructure is CREATE Lab, where future scenarios of construction are studied.

Urban Resilience

Urban Resilience is a research area in the Section for Civil and Architectural Engineering. Research in this area investigates urban resilient transition, and addresses the causes and effects of climate change in cities, including climate change mitigation and adaptation, and risk reduction of climatic, environmental and man-made disaster. Urban Resilience is led by Professor Nicola Tollin.

The objective of the research is to inform policymaking at international and national level, and to support science-based urban planning and design for local action, both in the Global North and South.

The research group actively contributes to the joint implementation of the United Nation's Sustainable Development Goals, the Paris Agreement, the New Urban Agenda, and the Sendai Action Framework for Risk Reduction. The specific areas of competence include urban resilience (theory and practice, operationalisation, monitoring and evaluation), urban climate adaptation (risk reduction, loss and damages, cost of non-action, maladaptation), urban climate mitigation (carbon budgets, generation of co-benefits, low-carbon transition), multi-level governance (vertical and horizontal integration of national policies and local actions), process design (co-design and co-creation, stakeholders' participation, evaluation and monitoring), and circular urban metabolism (circular economy, design for system transition, waste, water and air quality). The activities of the research area in education, training, and capacity building are clustered in the International Urban Resilience Academy (IURA).

Education Programmes

Education Programmes

Education that is provided by the Section for Civil and Architectural Engineering is research based. This means that students are taught the state of the art, by the people that do the research. A critical sustainable approach, digital practice, and transdisciplinary design form the DNA of our teaching.

Our section currently offers two Bachelor programmes. One programme is tailored for those who want to focus on professional development and enter the job-market after 3.5 years. The students also have the possibility to enter the current MSc programme in structural Engineering.

A new BSc programme is developed specifically for those who want to pursue an MSc level education and prepares students for any of the five profiles in a new MSc programme that will start in 2022. The profiles are structural engineering, computational design and digital fabrication, facade engineering, urban resilience, and indoor climate. The governing course language is Danish with English teaching in several courses.

- → BSc in Civil Engineering
- → BEng in Civil Engineering
- → MSc in Civil Engineering
- → MSc in Structural Engineering

During the summer break, in August, two summer schools are offered as intensive 2-week programmes:

- → Computational design and digital fabrication
- → Urban resilience

BEng
Civil Engineering

As a civil engineer you develop, plan and manage projects when bridges, harbour facilities, factories or houses are built. You are also capable of managing projects such as waste water plants, roadworks or technical installations.

As a civil engineer you participate from the very beginning of the project till the finished construction stands ready. You will be taught how to go about tendering, contracts planning and managing a project within the given legal and administrative framework.

Four Education Elements

The first three semesters of the civil engineering programme comprises a basic part for all four specialisations. You acquire your competences by working with four education elements: load bearing structures, technical installations, road and construction work, and production technology.

Specialisation

In the fourth semester you choose between four specialisations:

- Building construction techniques
- Indoor climate, energy and environment
- Road and civil works
- Planning, economy and building project management

Project work

You become part of a project based and problem based study environment where you work in project groups together with your fellow students. In the project group you and your fellow students:

- are responsible for planning and carrying out the project
- will cooperate and meet the deadlines
- will solve problems for companies
- will have access to project rooms

Internship and final project

In the sixth semester you must complete the engineering internship in a company in Denmark or abroad. Through the internship you acquire relevant work experience of great benefit to you in your following career. In the final semester you carry out the final project – usually also in cooperation with a company.

Career Paths

With a degree in civil engineering you will have a range of job opportunities – in Denmark and abroad. Among other things, you could work in planning, quality control and carry out building and construction projects in technical administrations, engineering consultancies or with a contractor.

MSc
Structural Engineering

During your studies you will learn about materials for and construction of machines and buildings. Moreover, you will learn about different construction techniques and complex design methods. This provides graduates with specialist knowledge and exciting job opportunities.

Master of Science in Engineering

The master degree is a two-year programme on top of a relevant bachelor degree such as Mechanical Engineering or Civil Engineering. During the master programme it is possible to specialise in your specific field of interest.

Project work

You become part of a project based and problem based study environment where you work in project groups together with your fellow students.

In the project group you and your fellow students:

- are responsible for planning and carrying out the project
- will cooperate and meet the deadlines
- will solve problems for companies
- will have your own project room

In your last semester you will carry out your master thesis project.

Career Paths

With a degree in Structural Engineering you will have a range of job opportunities – in Denmark and abroad. You could work at, for example, consulting engineering companies, contracting companies or manufacturing companies. Graduates often work in construction, design, project management, supervision or management.

It is also possible to continue your studies with a three-year research programme leading towards a PhD degree.

New BSc and MSc Programmes in Civil Engineering

We live in a world where globalization, digitalization and the technological development are moving rapidly, while climate change and environmental challenges are omnipresent and require our attention. With the new bachelor and master programmes in civil engineering, SDU will not only rise to these accelerating challenges but also prepare engineers for future challenges.

The Ministry for Higher Education and Science has approved new BSc and MSc programmes in Civil Engineering. Professor and Head of Section for Civil and Architectural Engineering, Mikkel K. Kragh, is delighted to get this approval, which has far-reaching perspectives:

- When the climate changes, the world changes. We must give our students the best possible qualifications to interact with a world that is constantly changing, and that is exactly what these programmes do, he says.

The aim of the programmes is to enable the students to work in interdisciplinary teams where they can draw on a range of skills, e.g. building design, infrastructure, urban planning and construction processes – always with a holistic approach and with sustainability at the front.

With a BSc in Civil Engineering, you will play a crucial role in developing the climate-friendly solutions of the future for buildings, bridges and cities.

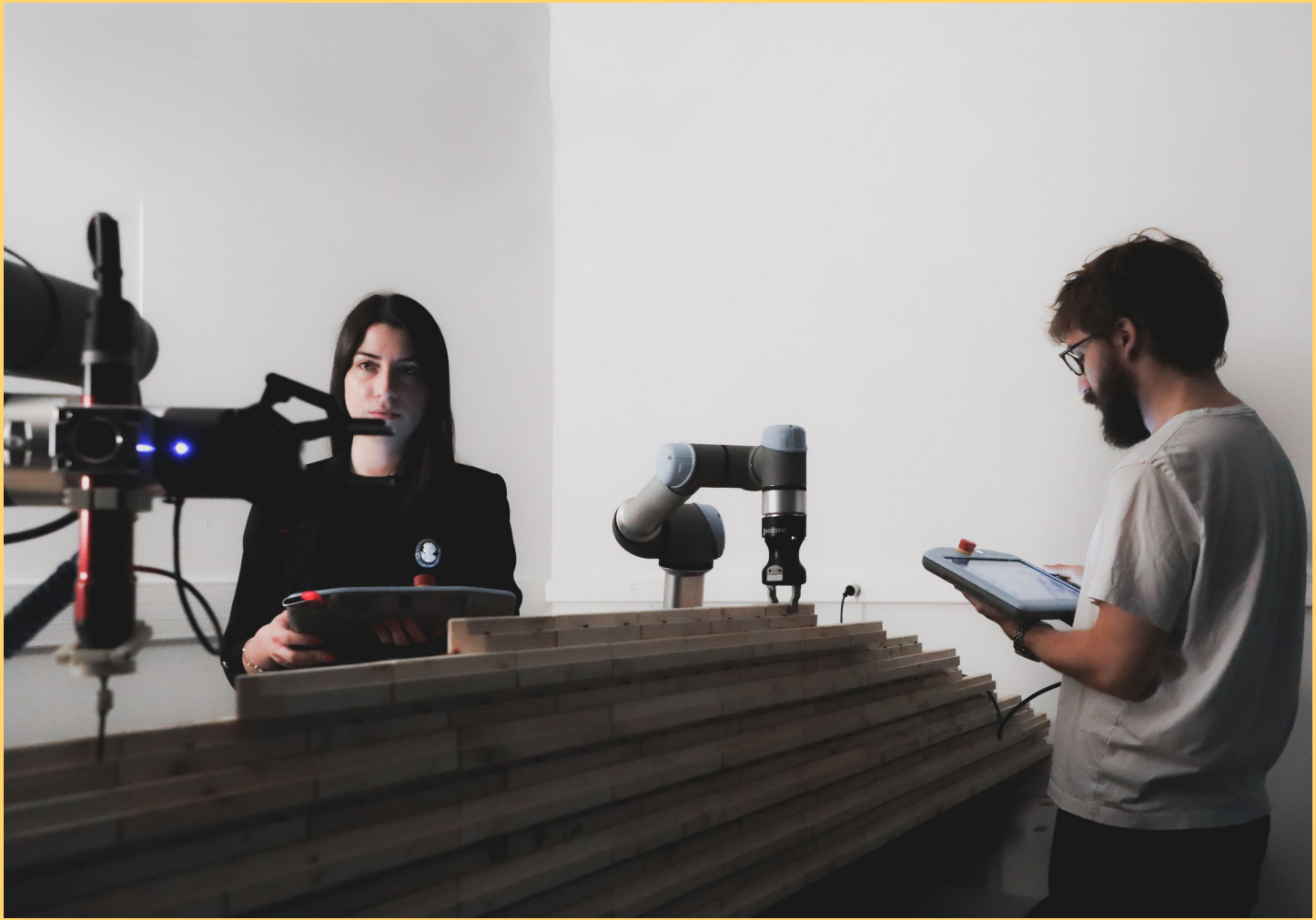
- We live in a world with great challenges and changes. They require engineers of the future to work in new ways. That is why we have created these new programmes, and at the same time they provide an amazing opportunity to build a strong research community, which will be reflected in the teaching and consequently in the engineers who are trained in civil engineering, professor Mikkel K. Kragh says.

At SDU, education and research form an inseparable partnership, not just as two parallels but as a unity with mutual interaction between research activities and teaching of the newest knowledge. The new programmes in civil engineering will draw on several fields where SDU are important players.

- We will be drawing on SDU's strengths in robotics, and the students will also learn about digitalization and urban resilience – meaning the impact of climate and social changes on urban areas – and how this can be transferred to the architecture and building design of the future, professor Mikkel K. Kragh says.

To put it briefly, the purpose of the programmes is to train civil engineers who can combine knowledge and skills in construction with special skills in sustainability and digital construction.

The programmes accept students from fall 2020, and it is expected that around 40-50 people will apply.



Facilities

Structural Engineering Laboratory

The structural Engineering laboratory is a large laboratory with capacity to test large and small-scale structural elements. The laboratory is equipped with state-of-the-art machines and data acquisition equipment.

The laboratory is organised around a large prestressed concrete strong floor. In combination with the strong floor, a flexible system with steel frames and hydraulic actuators enable many different types of structures to be tested. The system includes hydraulic actuators in different sizes and capacities, e.g. actuators with different tension and compression capacity of 250kN, 500kN, 1000kN and 1500kN, for static or cyclic tests.

For measuring displacement, strain and crack development in concrete, a Digital Image Correlation (DIC) System for 3-Dimensional measurements is available. In combination with the DIC system, the laboratory is also equipped with additional state-of-the-art measuring and data acquisition tools.

For material tests, electromechanical tension and compression machines are available. Machines are available in different sizes and with varying tension and compression capacity. The range covers, from 1200 kN in tension to 3000 kN in compression. The largest machine is a special version of the manufacturer's standard machine to enable testing of large specimens.

Associate Professor Henrik Brøner Jørgensen is the scientific and technical laboratory responsible.

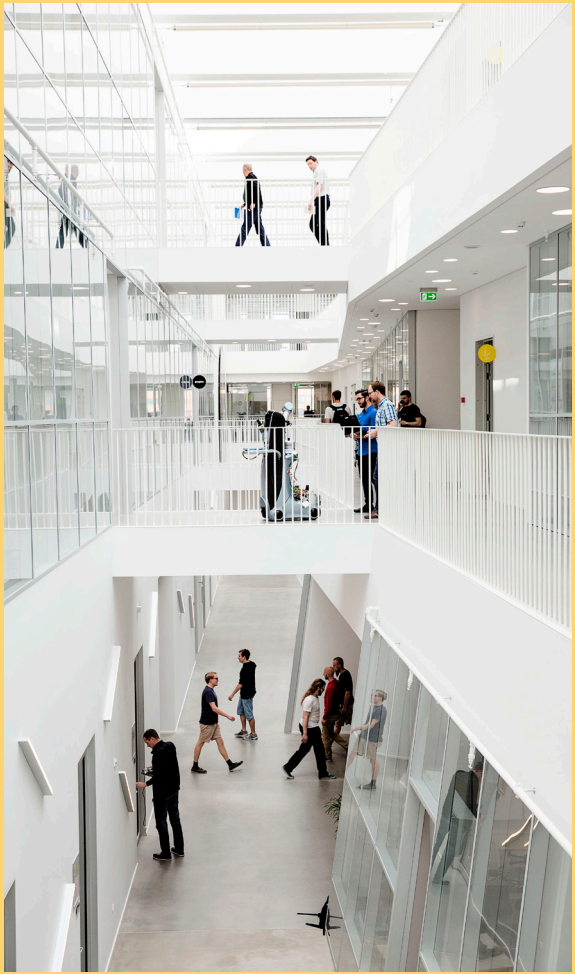
CREATE Lab

The laboratory for Computational Research in Emergent Architectural Technology is a state-of-the-art facility, where the future scenarios of constructions are explored from applied research to visionary concepts, bringing together design and making through digital technology. The focus is on key-research activities, such as:

- Introducing novel architectural systems, with construction techniques derived from the use of computational design thinking, the development of digital workflows, and new fabrication processes;
- Large scale prototyping of new building technologies and their demonstration in operational environments (TRL 1 to 6);
- Studying new models for construction, the fabrication and prefabrication of building systems with the use of cutting-edge digital fabrication technologies.

The laboratory space is organized in different areas that are interconnected through cyber-physical processes: a Computational Design Studio with tools for Mixed Reality design, a Digital Fabrication Area equipped with industrial robots, 3D Printing, and CNC machinery, a Construction and Assembly Setup with construction handling equipment.

The research and teaching activities are held by the CREATE Group. Assistant Professor Roberto Naboni is the scientific and technical laboratory responsible.



Odense Campus: TEK

The new building of the Faculty of Engineering at SDU by C.F. Møller architects and MOE engineers was inaugurated in 2015. It is a shared research and education environment for four different departments.

The building is designed as one big envelope consisting of five buildings connected by bridges at multiple levels crossing the heart of the building, a “piece of furniture” containing common functions and meeting rooms, and giving access to a roof garden/café/lounge area. The many connections allow for more fluid boundaries, and more community and knowledge sharing.

The building is shrouded in an external screen revealing and shading the transparent volume. The elegant and seemingly weightless screen is made from pre-fab panels of white CRC concrete (Compact Reinforced Composite, a special type of Fibre Reinforced High Performance Concrete with high strength) featuring circular openings with an underlying solar screen and natural ventilation. The unusual screen reflects the innovation and creativity that characterises the various departments.

The interior layout creates great flexibility, with the larger laboratories located on the ground floor, for easy access to the terrain and opportunity for outdoor activities.

BLOXHUB

BLOXHUB is the Nordic hub for sustainable urbanization. Founded on the belief, that the challenges of global urbanization and climate change require partnerships and new ways of collaboration.

BLOXHUB is a Nordic launchpad for future urban solutions and a gateway to Danish and Nordic partners and markets for international companies.

In short, a global community for connecting, sharing and scaling businesses that helps shaping a better future.

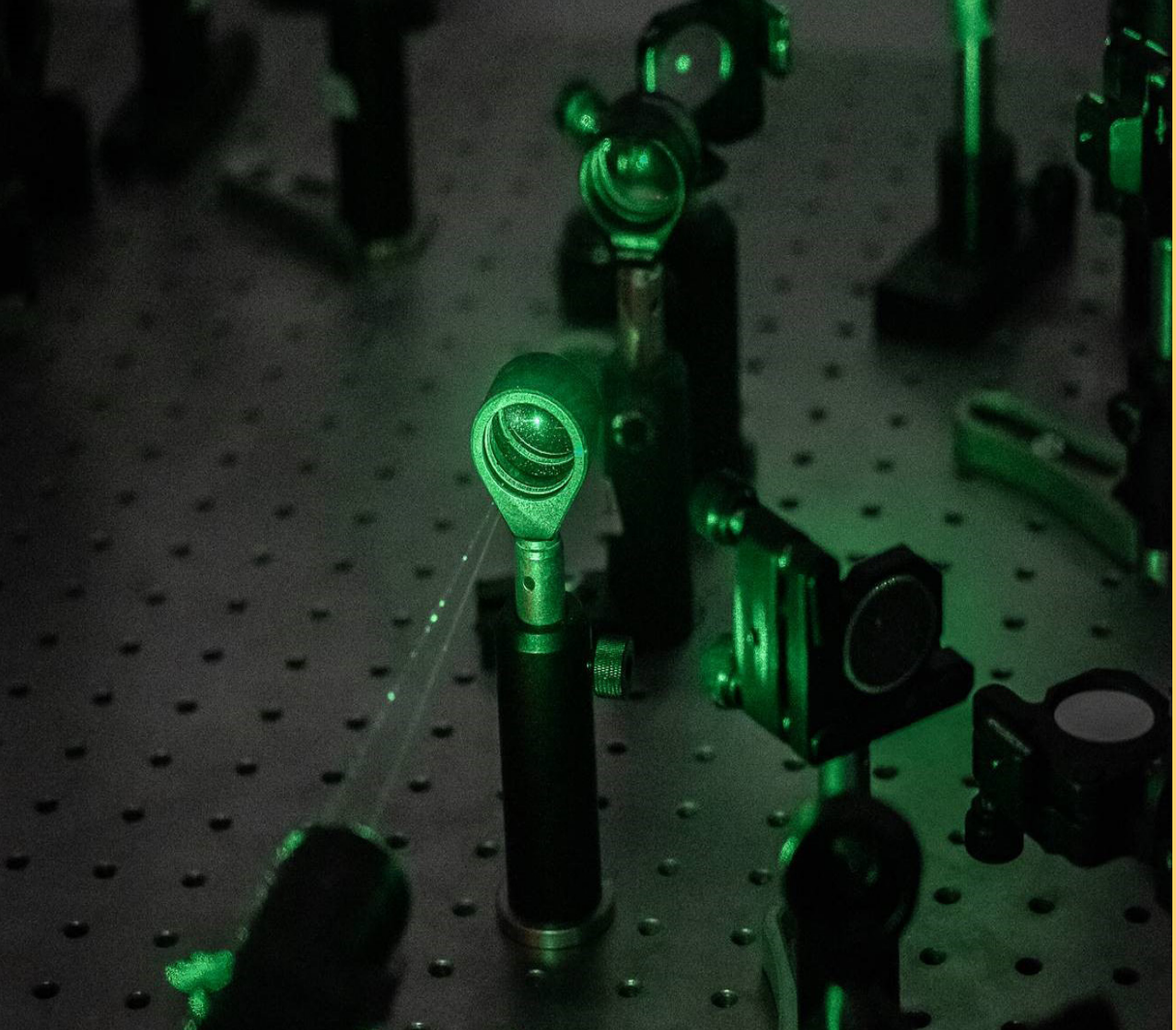
BLOXHUB is focusing on eight themes within sustainable urbanization defined by the member community:

Livability, Urban Mobility, Urban Resilience, Sustainable Buildings, Design DNA, Circular Economy, Digitalisation, and Governance.

BLOXHUB was founded on June 3, 2016, by Realdania, the City of Copenhagen and the Ministry of Industry, Business and Financial Affairs. It is a non profit member association for companies, research institutions, organizations and municipalities.

The BLOXHUB association is agile and comprises a board, a secretariat and two categories of membership: the once who reside there and the community members.

Activities



Research

Glass Virtual Prototyping

Glass selection represents one of the core aspects in decision-making process and planning of glass curtain walls for architects, engineers, and clients among others. Wide variety of advanced coatings and surface treatments along with innovative smart glazing technologies such as switchable glazing and solar control systems offer a multitude of options for reaching design and performance goals. This brings a challenge to architects and engineers to choose between two opposing criteria, energy performance and clear vision. The research goes beyond previous tool and company-specific workflows and proposes a generalized approach for physically-based glass visualization of advanced glass across industries, especially focusing on building facades. It discusses practical-based approaches for virtual prototyping with main objectives: (i) to demonstrate design workflows for photo-realistic virtual prototyping of IGUs containing advanced glass technologies such as smart glass, spectrally-selective coatings, media glass, photovoltaic glass, etc., (ii) to bridge the gap between architectural and engineering glass design process and facilitate their integration, (iii) to demonstrate advantages and limitations of proposed workflows concerning speed, accuracy of color representation, as well as optical effects such as multiple reflections and optical distortion, (iv) to discuss workflows and their respective accuracies and quality levels as a function of glass material optical characterization and glass geometric LODs, (v) to establish a foundation for immersive virtual prototyping façade mock-up pipeline to provide valuable responsive feedback on glass selection throughout the design process in Virtual and Augmented Reality VR/AR.

Enactive Architecture: Villa Girasole

For the work on Enactive Architecture, a study was performed of the Villa Girasole near Verona in Italy. The Villa Girasole is a prototype kinetic architecture built as a holiday home for and by the Italian engineer Angelo Invernizzi in the 1930s. The Villa rotates and, like a sunflower, tracks the sun. The research results outline a framework for enactive building cognition which is relevant for a new type of building that is digitally augmented and autonomous. It is based on an embodied view of cognition, a view that is shared by philosophers, biologists, and roboticists. The framework might serve a complementary approach to integrating building cognition in the overall building design. The research proposes that architectural movement might enable an interdependency between building, occupant, and environment that is critical for establishing a form of highly specific building cognition.

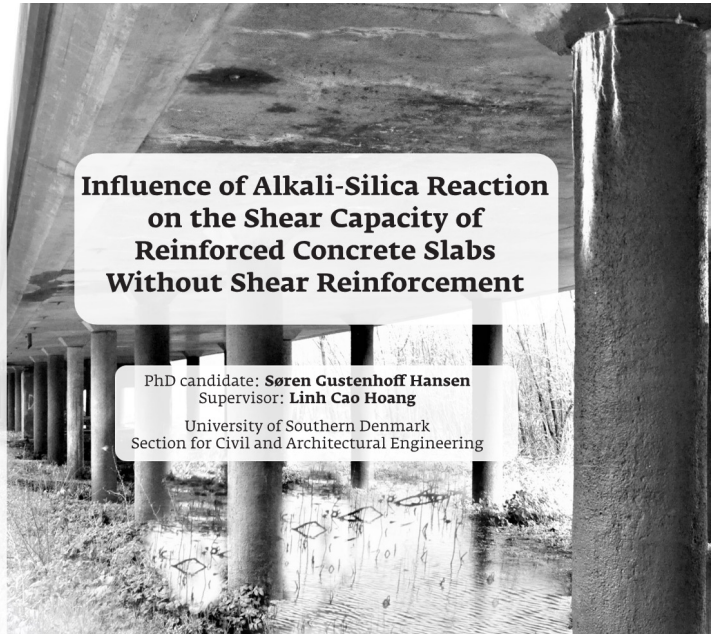
Influence of Alkali-Silica Reaction on the Shear Capacity of Reinforced Concrete Slabs Without Shear Reinforcement

Alkali-silica reaction (ASR) is a well-known deterioration mechanism that can occur in concrete structures. It is a chemical reaction between alkalis, silica minerals and water. The Danish Road Directorate has estimated that more than 600 Danish road bridges have the potential to develop ASR in the future. The majority of these bridges has been constructed as slabs without shear reinforcement. Unfortunately, there exists no satisfactory method to assess the residual shear capacity of ASR-damaged slabs.

The aim of this PhD project is to develop an approach that can be used to determine the shear capacity of ASR-damaged slabs without shear reinforcement. The approach includes a shear model as well as recommendations and descriptions of how the relevant strength parameters should be determined by simple tests on samples taken from the structure.

The investigation includes a large shear testing campaign with specimens cut out from two ASR-damaged bridges. The material properties are investigated by means of standard test methods and state-of-the-art optical measuring techniques. By a critical examination of the results and an optical investigation of the underlying mechanisms, recommendations of testing methods to obtain the anisotropic residual compressive- and tensile strength are formulated.

A model based on the upper bound theorem of plasticity theory is proposed, where the specific solutions are derived with inspiration from the failure mechanisms observed in shear tests with the ASR-damaged slab bridge specimens. The calculated shear capacity correlates well with test results.

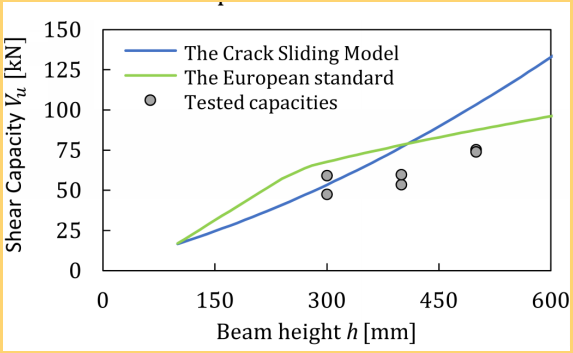


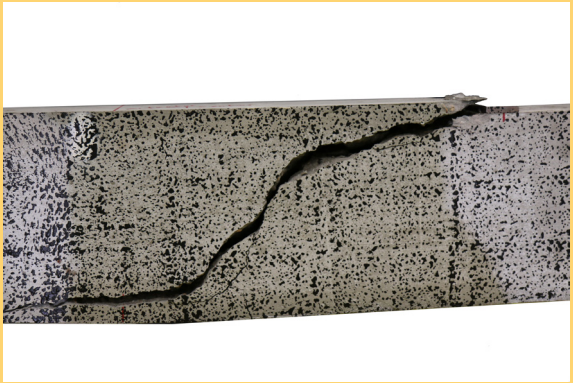
Shear Capacity of Reinforced Concrete Beams

The shear behaviour of concrete beams is complex. The failure mechanism involves several individual mechanisms each contributing to the shear capacity. Several different models have been developed that include each of these contributions when determining the shear capacity. However, in a recently published scientific paper from The University of Southern Denmark it was shown that some of these highly recognised models and standards overestimate the shear capacity of some relatively simple concrete beams with up to 30%.

The objective of this research project is to investigate how the shear carrying mechanisms contributes to the shear capacity in beams with and without shear reinforcement. From this investigation a mechanical model will be developed for determining the shear capacity of reinforced concrete beams. The mechanical model will cover designs with and without shear reinforcement and the transition between. Thus, the objective can be summarised as:

- Develop mechanical models for the shear carrying mechanisms
- Develop mechanical model for the shear capacity of reinforced concrete beams with and without shear reinforcement
- Produce experimental research in order to establish experimental evidence for the developed mechanical models.





Shear Capacity of Prestressed Concrete Beams

The project deals with the shear capacity of post-tensioned concrete structures. In this initial project a simple structure is studied; a single-span post-tensioned beam without shear reinforcement.

When designing such structure, different models for the shear capacity is found in the literature and it is shown in this study that there is a large difference of the load bearing capacity found from the different models that are available in the standards today.

Post-tensioned concrete beams are often used in structures, both nationally and internationally, and enables structures with larger slenderness (i.e. long spans with low height) than conventional concrete structures. Many slab bridges are designed as single span post-tensioned slabs without shear reinforcement. When assessing the load bearing capacity of such bridges, the shear capacity is often governing for the capacity. It is therefore important that the models used for the shear capacity is reliable. The experimental programme in this study is designed to be comparable to standard bridges found in practice.

Reversible Robotic Timber Beam

R2TB is a structure prototype which looks into Circular Construction aided by Human-Robot Collaboration. It is a four-meter long beam prototype, composed of 696 universal building blocks made of wood, and embedding reversible connections. The project fuses advancements in performance-driven combinatorial design, timber building technology and smart robotic production. The structure is manufactured through a participatory effort of collaborative robots and humans, in which machines and people help and integrate each other. The work builds upon principles and robot technology developed in the Industry 4.0 Laboratory of the University of Southern Denmark.

The beam has been assembled out of a discrete set of reversible building blocks, creating a structure which has a capacity to update and evolve its configuration in time. It is developed through computational methods for structural optimization, voxel-based tectonic and structural discretization.

The project presents a novel approach to wood architecture, starting from the conceptualization of a new process for robotic layered manufacturing. The aim is advancing construction through complex tectonic configurations which are informed by logics of robotic assembly, topology and material optimization, and combinatorial design. With the integration of a universal construction kit and human-robot interaction, structures gain higher efficiency, reversibility and capacity to update and evolve their configuration in time.

HORTUS_XL
Astaxanthin.g

In H.O.R.T.U.S. XL Astaxanthin.g, a digital algorithm simulates the growth of a substratum inspired by coral morphology. This is physically deposited by 3D printing machines in layers of 400 microns, supported by triangular units of 46 mm and divided into hexagonal blocks of 18.5 cm.

Photosynthetic Cyanobacteria are inoculated on a biogel medium into the individual triangular cells, or bio-pixel, forming the units of biological intelligence of the system.

Their metabolisms, powered by photosynthesis, convert radiation into actual oxygen and biomass. The density value of each bio-pixel is digitally computed in order to optimally arrange the photosynthetic organisms along iso-surfaces of increased incoming radiation.

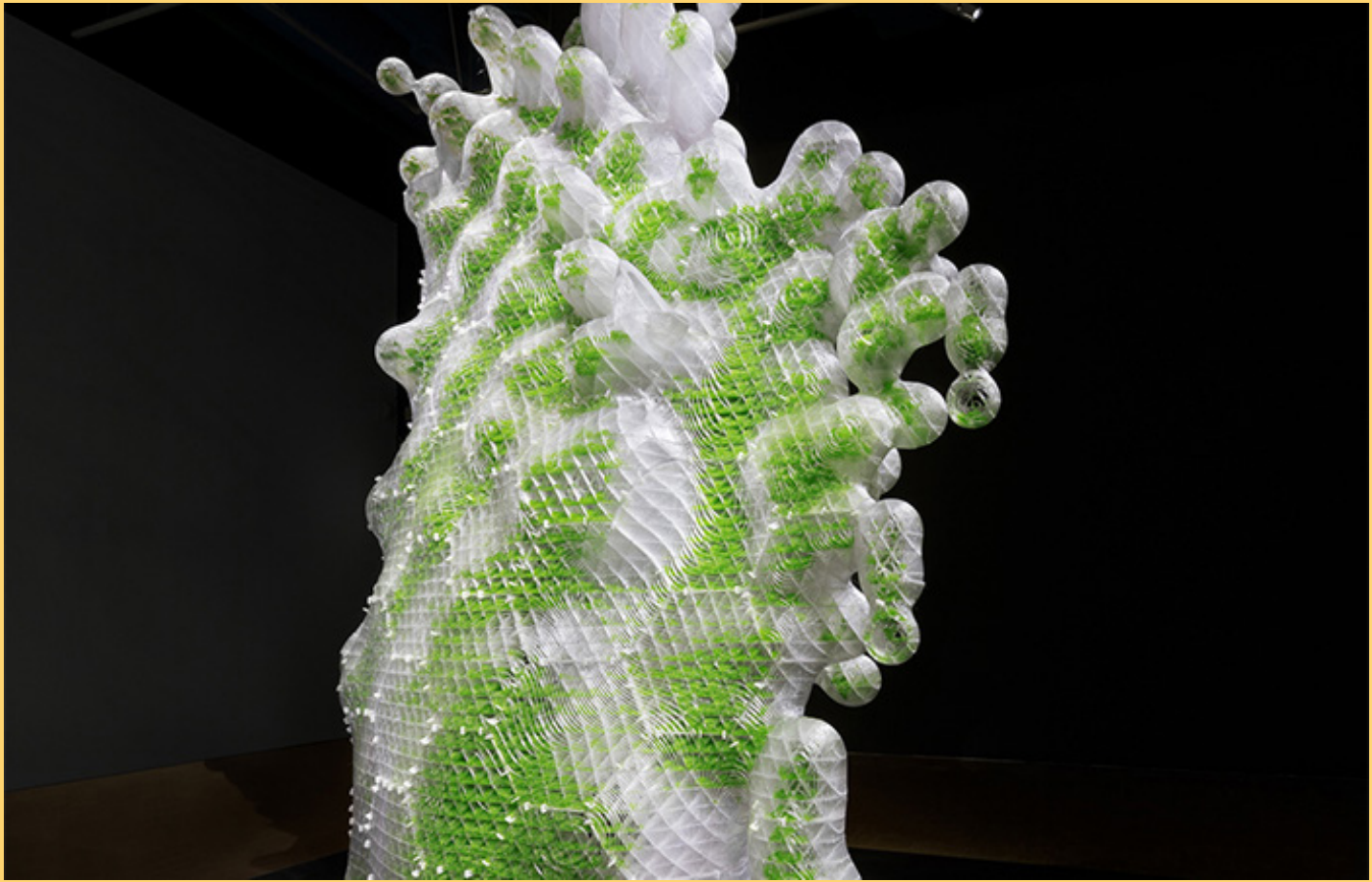
Among the oldest organisms on Earth, cyanobacteria's unique biological intelligence is gathered as part of a new form of biodigital architecture.

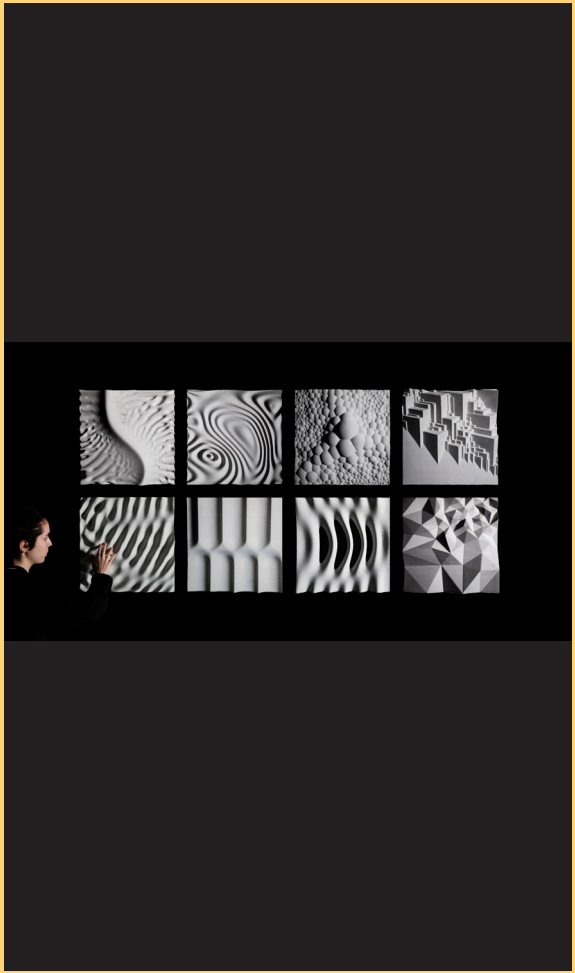
The CREATE Group and WASP Hub Denmark from SDU have contributed to the development of the 3D printed system and the digital fabrication of the structure. I

n this joint research, biological and digital strategies are fused together to conceive a novel model of architecture, able to contribute positively to the urban environment.

The experimental structure is composed of 185 different construction components which are entirely produced by Delta WASP 3D Printers for a total of 1780 hours and 271 kgs in weight.

H.O.R.T.U.S. XL Astaxanthin.g was exhibited at the Centre Pompidou in Paris and at MAK – Museum of Applied Arts in Vienna.





Additive Formworking for Concrete Construction

The project Additive Formworking for Concrete Construction challenges the conventional methods of concrete construction by rethinking the manufacturing process of the formwork. Despite the large impact of digital fabrication, the construction industry still relies on archaic methods for producing formworks: very limited in terms of automation, demanding a large quantity of labour-force, geometrically constrained, mostly made of temporary timber or steel structures that are expensive to customize. Already impacting for more than half of the overall costs of construction, conventional formwork technologies are becoming more and more obsolete and inefficient with the increasing demand for non-standard and complex design solutions.

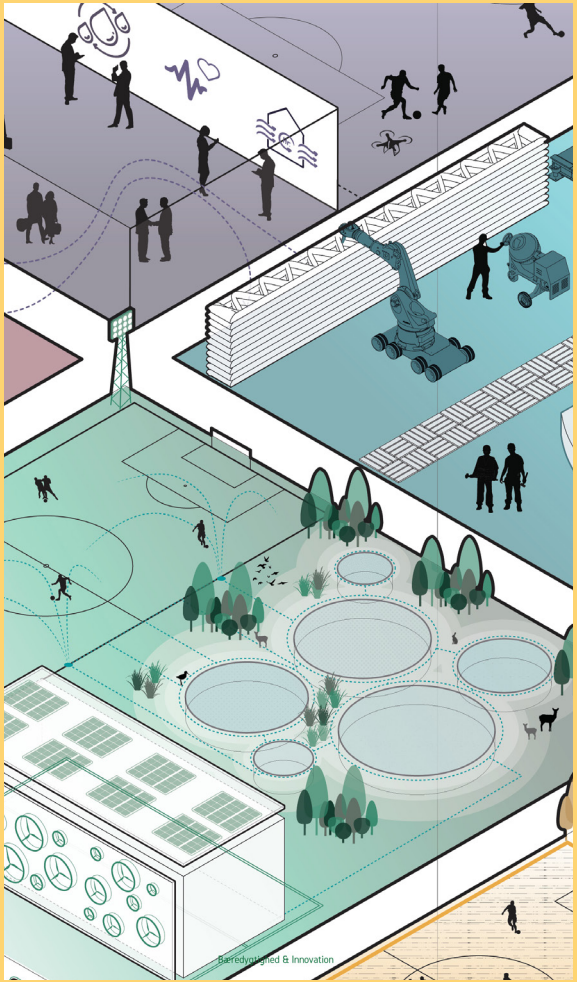
Starting from the simple principle that concrete in its liquid state can fit almost any container, unexplored potential can be found in shell design based on non-standard high-performance geometries. The rapid development of digital design tools is currently supporting modelling and analysis of complex architectural shapes, which are currently limited in use by the existing gap between the digital environment and the modes of production mentioned above. In our research, we focus on developing an approach where Additive Manufacturing (AM) is tested for the sustainable realization of complex and highly detailed construction elements to be used in freeform shell structures.

The research encompasses design, manufacturing and material developments. A range of construction applications is currently tested through a design/making research approach.

Circular Concrete Construction

Circular Concrete Construction is an ongoing research of CREATE on the use of additive manufacturing to realize accurate concrete reversible elements. Given the impending need to limit the consumption of non-renewable resources, the experimental project makes use of Cradle-to-cradle design principles, investigating design for disassembly and the reduction of material usage.

On one hand, the design of a reversible system of a modular struts-and-nodes system offers an optimal solution for the end-of-life of a concrete structure, as well as guaranteeing flexibility and opportunities for upgrades, repairs, and expansions. On the other hand, the manufacturing of reusable formwork through 3D Printing allows for the mass customization of special structures and a reduction in the use of construction materials. The project aim is to design and manufacture spatial structures, taking advantage of the use of Ultra-High-Performance Fiber Reinforced Concrete (UHPFRC).



Strategy for Innovation and Sustainability in Construction

This research activity develops a strategy for sustainable and innovation-driven construction, which is applied to a specific case of Hele Danmarks Fodbold Center, an initiative for the development of new football infrastructure in the city of Odense. The work aims to provide an added value to otherwise a conventional sports facility, by introducing a range of design solutions, sustainable and advanced construction technologies, and programs which would enhance the healthy lifestyle and wellbeing, social inclusion, and sustainable actions in different fields.

Due to its closeness to the University would make the Center not only a generic set of sports fields, but research headquarter for cross-disciplinary work in the areas such as Sport (Football) Science, Health Science, Architecture, Landscape Design, Robotics and Automation, and much more.

Driven by the UN Sustainable Development Goals, CREATE developed a Catalog of Technological Solutions to promote construction innovation, sustainable built environment, augmented and inclusive design.

Six areas of innovation have been studied: (1) Energy and natural resources, (2) Experimental construction, (3) Innovative materials, (4) Advanced facilities, (5) Good health and wellbeing and (6) Social inclusion. Within each group, a set of technologies and activities is proposed and described in relation to their impact and added value to the Center.

Health Assessment, Communication and User Involvement

Health and Wellbeing Assessment, Health Communication and User Involvement is a cross-disciplinary research program under Human Health, funded in 2019, involving interdisciplinary team from the University of Southern Denmark.

This research program explores notions central to current health care practices and initiatives with a specific focus on user involvement, health communication, person and personalized (medicine). The overall aim is to investigate communication about values and personal matters, both in one-on-one health care interactions and when it comes to implementing new health technology. The intention is to contribute to improving or supplementing existing indicators and methods for assessing health and wellbeing by developing methods that take into account factors like patient experience, moods and atmosphere, experience of meaning, the impact of human interaction and physical environment, and the balance between safety and autonomy and privacy. The work is divided in WP1, WP2, WP3.

Work package 1: New indicators and methods for human health assessment.

The overall research question of WP1 is: What are the limitations of existing health and wellbeing indicators, and how can new indicators be developed that are both sensitive to a wider range of factors and still readily applicable to actual health practices and concerns? The work package will be led by Prof Nicola Tollin (TEK), and carried out by a post. doc and a PhD-student (supervised by Lasse Nielsen (HUM), in collaboration with Birgitte Nørgaard (SUND), Diane Bastien (TEK) and Søren Harnow Klausen (HUM).

Development of the Resilience Model of Istanbul, Turkey

University of Southern Denmark assisted the research leading to the definition of a resilience model for Istanbul Metropolitan Municipality. The role of Prof Nicola Tollin as an expert consultant in the development of Istanbul Model, was to follow on the outputs of the project that has been developed by Project Technical Team in Istanbul (the acute shocks and chronic stresses of Istanbul and selected world cities), coordinated by for ADBA Consulting Innovation.; provide support in constructing the holistic approach of Resilience Model of Istanbul and in defining city resilience index.

The holistic approach to develop Resilience Model included the following steps: preliminary research, the data collection, further the analysis and the strategic examinations of resilience frameworks and examples, plans for improving the resilience of the city in face of probable acute shocks and chronic stresses. This served as a background to develop of Resilience index, Key Performance Indicators and Resilience Model. The process was participatory through the direct involvement of stakeholders.

Preliminary findings depicted the factors and processes building resilience of Istanbul city, including consulting the actors involved, that are the government and the Istanbul Metropolitan Municipality (IMM) and the partnerships with NGOs. The city of Istanbul is facing following challenges: Disaster risk, waste management, traffic, migration, climate change, lack of urban identity, urbanization, that were addressed in developing the resilience city model of the city.

Understanding Urban Resilience Research

Understanding Urban Resilience Research is a joint qualitative research by researchers from:

University of Southern Denmark coordinates the research in collaboration with researchers from Imperial College London, IUAV University of Venice, Massachusetts Institute of Technology.

Research objective is to investigate the knowledge – implementation gaps as experienced by urban resilience researchers, practitioners and policy makers. The research is carried out in order to support informed decision and policy-making in liaison with: UNFCCC and Paris Agreement, UN-HABITAT and the New Urban Agenda, UNDRR and the Sendai Framework for Disaster Risk Reduction.

Through the research the following research hypothesis are tested:

- There is a gap between the knowledge and implementation of urban resilience.
- Different knowledge and practice communities lack common ways of validating and constructing knowledge (academics, practitioners, policy makers), which are key for understanding current gaps between the theory and implementation of urban resilience.
- As urban resilience is an interdisciplinary challenge, by understanding the ways in which people relate to interdisciplinary working environments and lifelong learning, we can better understand the barriers and opportunities for bridging the knowledge – implementation gaps

So far 20 semi-structured interviews were conducted, and more than 45 structured surveys completed. The aim is to conduct more than 100 semi-structured interviews and 200 structured surveys.

UNESCO IHP
Water and Human Settlement

UNESCO – United Nations Education, Scientific and Cultural Organization is supporting the process of strengthening water security for sustainable development. The UNESCO Intergovernmental Hydrological Program (IHP), is currently implementing its Eighth Phase," Water Security: Responses to Local, Regional and Global challenges," during the period 2014 - 2021, which began one year prior to the launch of the 2030 Agenda.

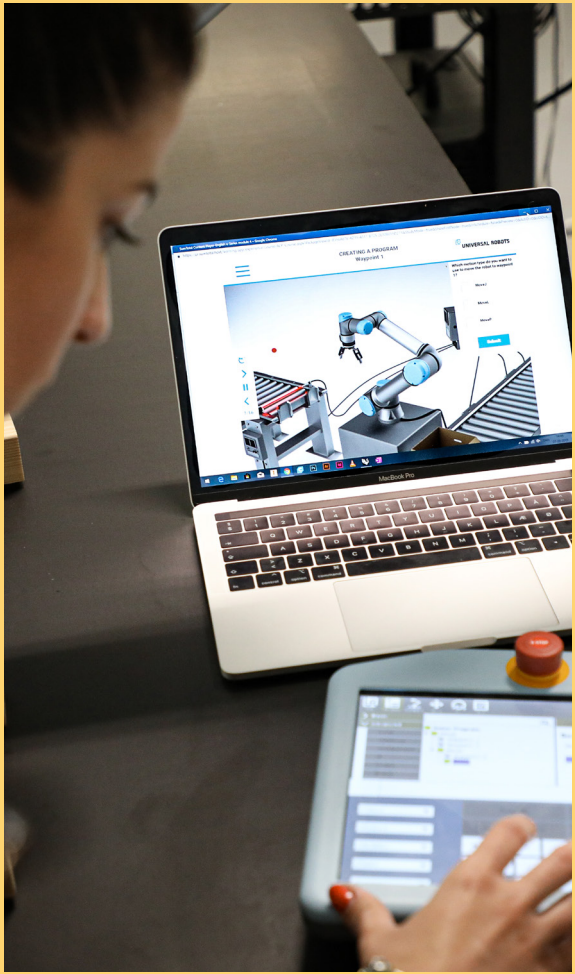
SDU is contributing to deliver the Intergovernmental Hydrological Programme VII world program on the theme of Water and Human Settlement of the Future. The International Hydrological Programme (IHP) is the only intergovernmental programme of the UN system devoted to the scientific, educational and capacity building aspects of hydrology. Based on the priorities and needs of Member States as identified at the Nairobi meeting of the Working Group, the eighth phase of the IHP focuses on six thematic areas to assist Member States in their challenging endeavor to better manage and secure water and to ensure the necessary human and institutional capacities.

United Nations
Educational, Scientific and
Cultural Organization

Intergovernmental
Hydrological
Programme

Water and Human Settlement Research focuses on the cities worldwide that are facing a range of pressures resulting from population growth, climate change and deterioration of urban infrastructure systems. As water demand continues to increase in the future, an increasing number of cities will face challenges of managing scarcer and less reliable water resources in an efficient way. Realities on the ground and the challenges of future pressures have made it obvious that business as usual is not the way forward.

Capacity Building and Training



SDU Summer School: Experimental Architecture with Robotic Timber Construction

Digital Fabrication technologies have the disruptive potential to revolutionize the way we conceive and shape our environment. Through the use of novel fabrication techniques, designers and engineers are challenged to explore innovative structures that benefit from the capacity to produce performative and sustainable architecture with, up to now, unreached levels of complexity and strategic material organization.

The Summer School focuses on exploring ideas and producing design artefacts as an answer to some fundamental driving questions: what kind of tectonic configurations can be enabled by means of digital fabrication such as additive and robotic manufacturing? How do we realize high-performance architecture with it? How can we build bespoke architecture in a sustainable way?

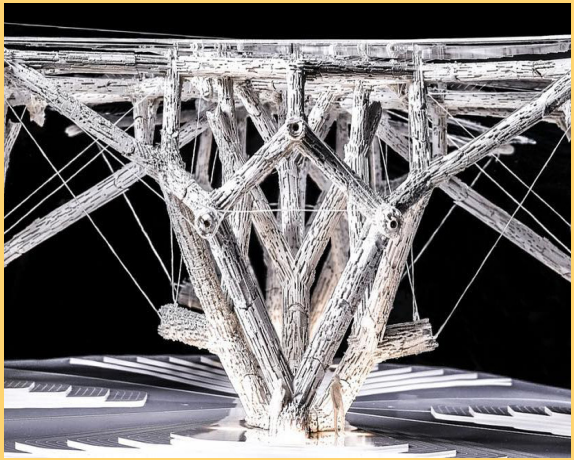
Adopting a design/make approach, catalyzed through tailored computational techniques, various structural configurations are investigated. The school outcomes are contributing to the creation of an atlas of digitally fabricated tectonic prototypes: experimental architectural configurations where material/form/structure are developed in a coherent design approach which takes full advantage of the potential of emergent fabrication techniques.

AA Visiting School Dubai: Additive Stereotomies

Additive Stereotomies was the topic of AA Visiting School Dubai 2019. Stereotomy is the art and science of cutting three-dimensional solids into particular shapes. Typically this involves materials such as stone or wood which is cut to be assembled into complex structures.

The Stereotomic AEquilibrium is a project developed within the topic, which focuses on designing a branching drone port system with interlocking parts that can be deployed on the rooftops of the towers in Dubai.

Stereotomic AEquilibrium emerges from the geometrical manipulation of polyhedra, which intrinsically balance external and internal forces, and generates a related dualism between forces and form, synthesized in two reciprocal diagrams. This approach supports very diverse explorations, culminating in a final design proposal for a lightweight stereotomic system to be used as an infrastructure for drones. A discrete architectural piece takes place on the roof-top of high rise buildings in Dubai and is assembled from components manufactured additively. This design is made to host drones, provide logistics for aerial transportation and offer shelter from the sun for people.

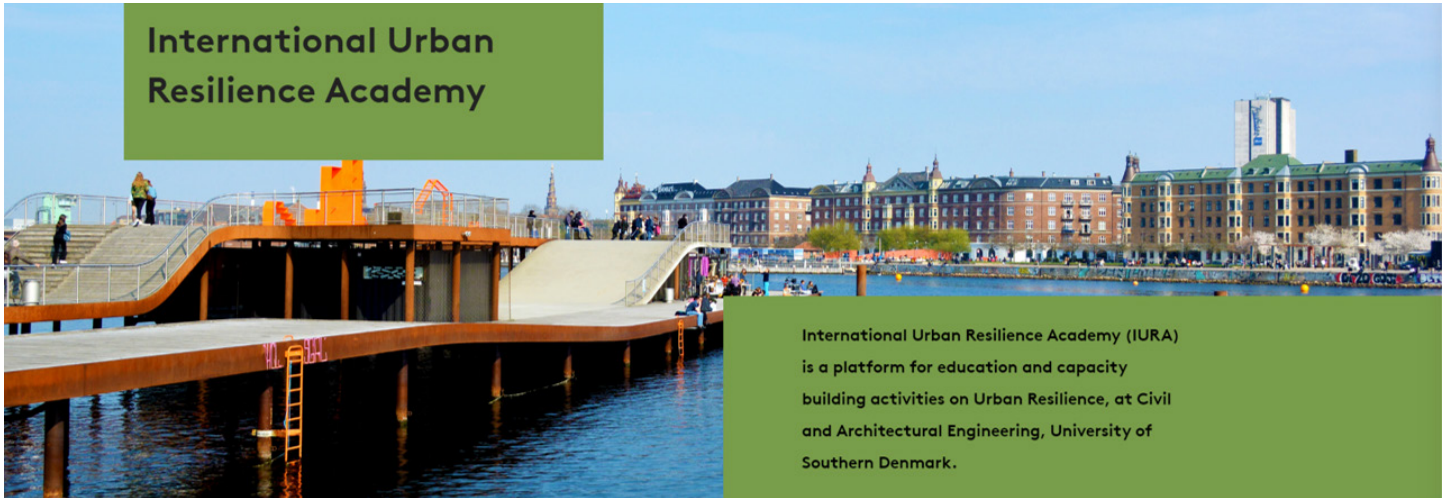


International Urban Resilience Academy (IURA)

The International Urban Resilience Academy (IURA) is a platform for research, education and capacity building activities on Urban Resilience, at Civil and Architectural Engineering, University of Southern Denmark.

IURA includes following activities:

- BLOXHUB Summer School on Urban Resilience (for practitioners, policy makers and researchers) running yearly, from 2019
- SDU Summer School on Urban Resilience (for BSc and MSc) running yearly from 2020
- Short Courses Urban Resilience, half a day or one day, (for practitioners, policy makers and researchers) to be organized on demand from 2020
- World Summer School on Urban Resilience, same as BLOXHUB but organized on demand, lead/co-organized with partner organizations worldwide.



Ministry of Planning and Urban Development Edo State, Nigeria

Delivering training: ‘Processes and indicators for preparing resilient urban master plans’ with guiding and reviewing the Group work on Envisioning Benin City in 2040 during the Technical Assistance Consultancy for the Restructuring of the Ministry of the Physical Planning and Urban Development (MPPUD), EDO State, Nigeria. The entire training aligned with the vision of Edo State as economic & environmental competitive location as well as meeting the provisions of African Urban Agenda, New Urban Agenda, Sustainable Development Goals & PACC Policy.

The training delivered by Prof Nicola Tollin provided an input to the understanding of Urban Resilience as a transformative process through which an urban system aims at dynamically building adaptive capacities at fostering innovation processes. The training session included key findings of the IPCC Climate Change Report (2014), the importance of systemic and integrated approaches able to generate co-benefits and responding with policies, plans and action to the challenges set by the Sustainable Development Goals, the New Urban Agenda, the Paris Agreement and the Sendai Framework of Action, example of cities working toward resilient future. The presentation included the process design methodology, it’s phases for the development of the informed plans, strategies and action for resilience transition, as well as enabling conditions. The participant took part also in the practical exercise on Envisioning Benin City in 2040.

BLOXHUB Summer School: Urban Resilience

BLOXHUB Summer School on Urban Resilience was organized by the University of Southern Denmark, in collaboration with BLOXHUB and Aalborg University, BUILD Department of the Built Environment, and in partnership with multitude of organizations: UN-Habitat, UNDRR, UNESCO-IHP, GERICS, ICLEI, WWF, CTCN, RECNET, ICCCAD, IUAV University of Venice, Polytechnic University of Catalonia, TU Delft, RC3 at Polytechnic of Turin, NURI, and with financial support from: RELDANIA, Grundejernes Investeringfond.

BLOXHUB Summer School was organized responding to the Cities-IPCC call for fostering dialogue between practitioners, policy makers and researchers; to develop and promote peer-to-peer learning across regions, sectors and disciplines. It gathered 26 participants, including 7 policy-makers, 14 scientists and researchers and 12 practitioners from 20 countries and 4 continents, coming for capacity building on & per to peer learning during an intensive eight days course in Copenhagen. The objective of the summer school was to provide multi-disciplinary knowledge and perspectives on the different global and local challenges in cities of the Global South and North, and build capacities to develop informed policies, strategies, plans and solutions for urban resilience, through lectures and involvement in problem-based workshops using Copenhagen's real-life experience and challenges, as a living laboratory.

The lectures provided overview for major international policies in relation to urban resilience, practices, the latest developments and perspectives for research, as well as cross-sectorial and thematic issues, including: multi-level governance, finance, nature-based solutions, appropriate technology, urban metabolism, circular economy, planning and design, participatory processes and stakeholders involvement, generation of co-benefits. Following process design methodology during the workshops 4 groups of participants develop resilience strategic and action plan for Copenhagen and Sydhavn site, tackling systemically challenges of heat-waves, water scarcity, cloudburst and storms in Copenhagen. The resilience plan included the principle of integrated and systemic solutions, though the use of inter alia nature-based solutions, tackling both causes and effects of the 4 urban global challenges, creating various co-benefits for the health, energy and food sectors, as well as focusing on enabling conditions to make the strategies and action come through. Resilience plans had 20 years of timeline, integrating multiple temporal and spatial dimensions.

Quote from a participant :

*Learning the skills required to collaborate across disciplines and backgrounds is equal to if not more important than 'hard' skills, e.g. systems analysis or risk mapping. *

https://tinyurl.com/tp8ztkl

BLOXHUB Summer School on Urban Resilience

12th -19th
September 2019
Copenhagen

Organizers:

SDU University of Southern Denmark

AALBORG UNIVERSITY DENMARK

BLOX HUB

Partners:

UN HABITAT FOR A BETTER URBAN FUTURE

UNDRR UN Office for Disaster Risk Reduction

ICLEI Local Governments for Sustainability

WWF

recnet.

TU Delft BK Bouwkunde

Università Iuav di Venezia

United Nations Educational, Scientific and Cultural Organization

UNESCO Chair on Sustainability

United Nations Educational, Scientific and Cultural Organization

International Hydrological Programme

GERICS Climate Service Center Germany

CTCN Climate Technology Centre & Network

ICCCAD International Centre for Climate Change and Development

POLITECNICO DI TORINO

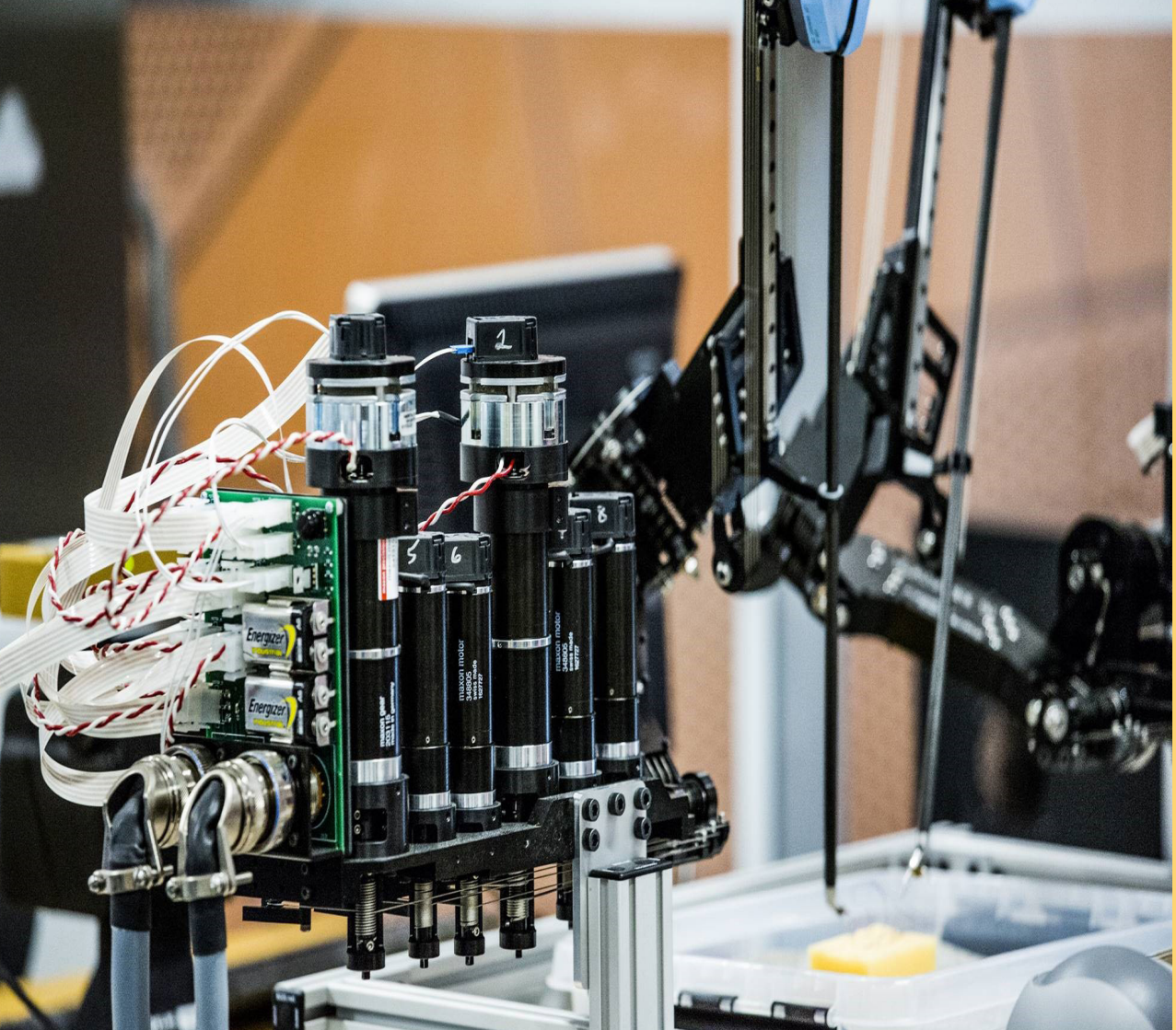
R3C

NORDIC URBAN RESILIENCE INSTITUTE

With financial support from:

Realdania

GI Grundejernes Investeringsfond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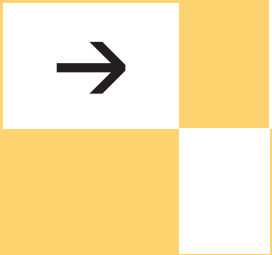
Knowledge Transfer



Organiser of Danish Concrete Research Day

SDU Civil and Architectural Engineering organised the Danish concrete Research Day 2019. The event is established to network and share research ideas across the universities in Denmark. Currently the structural concrete research groups from three universities participate: Aarhus University (AAU), Technical University of Denmark (DTU) and University of Southern Denmark (SDU).

In 2019 the following was presented at the event:

Shear Capacity of post-tensioned concrete Structures, by Ass. Prof. Henrik Brøner Jørgensen, SDU

Modelling of beams in Serviceability Limit State with the crack distance as a central parameter, by Ass. Prof. Annette Beedholm Rasmussen, AAU

Full-scale Experiments of Wall Panels Conducted in the Laboratory, by Post doc. Jesper Harrild Sørensen, DTU

PhD Project on Massive Concrete Structures, by PhD Student Mads Emil Møller Andersen, DTU

Modified Crack Sliding Model, by PhD Student Frederik Autrup, SDU

Presentation on Current Status of Eurocode 2 standardization work, by Prof. Linh Cao Hoang, DTU

Experiments and Modelling of Coupling Beams, by Ass. Prof. Jakob Fisker, AAU

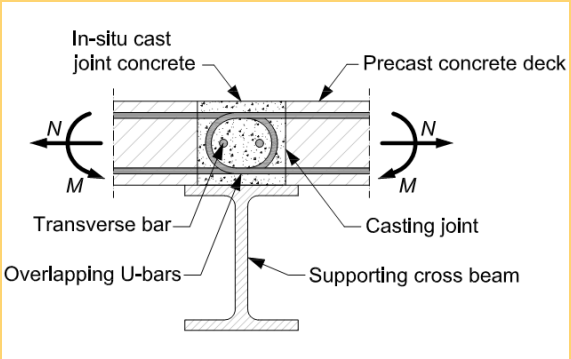
Influence of Alkali-Silica Reaction on the Shear Capacity of Reinforced Concrete Slabs Without Shear Reinforcement, by Søren Gustenhoff Hansen, COWI A/S, former PhD student at SDU

Proposal for Updating the European Standard on Structural Concrete

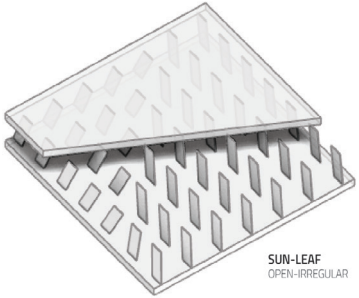
A proposal has been submitted to the working group for the new European standard for concrete structures, Eurocode 2. The authors have previously proposed a design model for calculating the tensile capacity of loop connections between precast concrete panels (bridge decks and wall elements). Loop connections are established by overlapping U-formed reinforcement bars from each of the connected elements. The connection is reinforced with so-called locking bars before casting the connection with concrete.

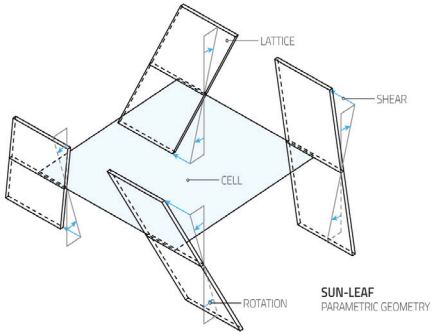
The updated proposal is, similar to the first proposal, based on experimental and analytical research from the University of Southern Denmark. The updated model includes also a proposal for the moment capacity of connections between precast concrete panels.

The proposed models for both the tensile and moment capacity of these connections are now included in the current draft for the new European standard. The new revision of Eurocode is expected to be finalised in 2021 and implemented in 2023.



Activating Optical Behaviour of Cellular Lattices in Glass Sandwich Facades





SCellular lattices (CL) are known for their high structural and mechanical properties, clearly noticeable through the superior stiffness-to-weight ratio. This research goes beyond the structural behaviour of CL and explores the idea that they can be advantageous in enhancing other performances, especially as a core in Glass Sandwich Facades (GSF). Based on the potential for a high variability in spatial configurations and consequently performance, the main research aim is to establish performance-based design methodology of functionally graded CL activated through structural, optical, thermal, visual, occupant comfort and clear view parameters, among others.

This research focuses on optical and visual gradients of façade interface and tests the potential of the structural core to articulate light behaviour passing through the CL medium of GSF. In particular, this research uses computational design tools to define complex geometrical configurations of CL to control solar heat gain, when maximizing clear views. Additionally, the paper explores functional gradients as a mean to explore future structural and multi-physics optimisation.

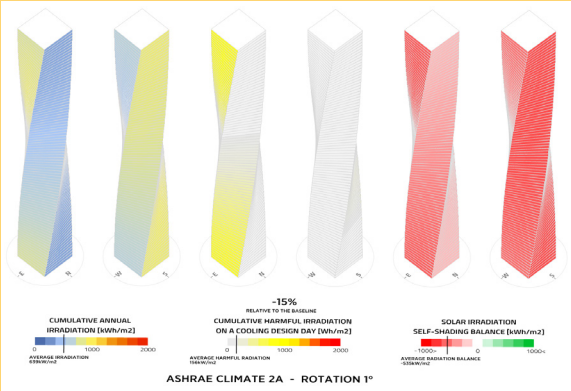
Results suggest that methodology is able to address complex climatic loads simultaneously with structural requirements, thus leading to a substantial improvement of optical properties by functionally grading geometrical configuration. Furthermore, the research provides insights on gonio-apparent aesthetic qualities expressed through complex light interactions with cellular forms, producing nuanced transitions between optical effects of transparency and translucency, reflections and refractions, clear and obstructed views.

Report IEA-PVPS. BIPV Design and Performance Modelling

The given state-of-the-art review of BIPV design and management tools presents recent developments in BIPV modelling concerning design and management processes with different levels of detail, targeting various stakeholders and their requirements in the BIPV value chain in relation to geophysical, technical, economic and environmental aspects. It goes beyond focusing only on PV modelling and gives an overview of the BIPV tools from the perspective of BIPV integration in design and multi-performance modelling and planning. The report examines features and functions, as well as potential development and limitations of currently available tools used in BIPV planning process, including tools specifically designed for BIPV and PV tools with capacity to simulate certain BIPV cases. Moreover, report provides information on limitation and reliability of these tools in different settings and for different BIPV categories, indicating pathways and tools' selection that would provide the highest confidence and fidelity of results as well as positive user experience throughout the process.

The findings of this review showed none of the examined software and apps can cater to all the factors pertaining to PV project design and management. Results have shown that majority of tools used in BIPV modelling come from PV domain and consequently still lack important features regarding BIPV integration, especially for vertical or externally mounted BIPV.

Assessing Self-Shading Benefit of Twisted Towers



Over the last decades, tall building geometries have been shifting from predominantly straight rectangular boxes towards shapes defined through geometrical transformations such as twisting, bending, shearing and tapering, or their combinations. Twisting geometries, defined by the Council on Tall Buildings and Urban Habitat (CTBUH) as ones that progressively rotate their floor plates or their façade as they gain height, are a prominent expression of this trend.

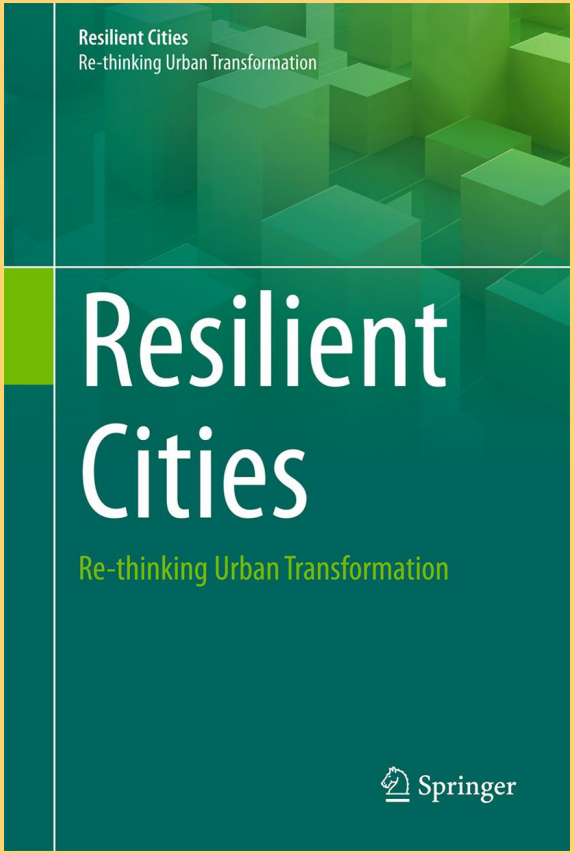
From an aesthetical point of view, these twisting geometries make the tall buildings appear fluid and contemporary, hence defining architecturally distinctive character and identity. From an environmental point of view, however, the benefits are not straightforward and may vary greatly based on climatic loads and urban conditions. While some cases have proven through simulations and testing that twisting may lead to reduced wind loads and consequent savings on structural weight and costs, other environmental aspects such as energy savings, daylighting potential, glare control and views are less well documented neither in academic non-practitioners' domains.

Therefore, this study aims to assess the self-shading benefits of twisted geometries by finding a correlation between floor-to-floor rotation and façade solar irradiation in hot climates. The study differentiates between beneficial and undesired solar irradiation during Hot and Cold Degree Days in order to quantify the overall impact of floor-to-floor rotation as a passive solar design strategy. The results show the sensitivity of solar irradiation benefits, revealing positive, negative, and neutral scenarios across different hot climates and various floor-to-floor rotation angles.

C40 World Mayors Summit Side Event Urban Resilience

The side event was organized by the University of Southern Denmark in partnership with BLOXHUB, Aalborg University, UN-Habitat, UNDRR, UNESCO-IHP, GERICS, ICLEI, WWF, CTCN, RECNET, ICCCAD, IUAV University of Venice, UPC Polytechnic University of Catalonia, TU Delft, RC3 at Polytechnic of Turin, NURI.

The side event was an opportunity to reflect and discuss on the urban resilience challenges and the need to build capacities for its operationalization. The presentations and debate drew on the outcomes of BLOXHUB Summer School on Urban Resilience (12-19 September) during which 30 practitioners, policy makers and researchers from 20 countries in collaboration with 30+ international lectures, elaborated proposals responding to a climate real-life challenge conceived in collaboration with the City of Copenhagen. The strategy and actions proposed for the City of Copenhagen were based on an integrated approach fostering the generation of co-benefits through the use of eco-system services and nature-based solutions. The event also served to present and discuss the preliminary results of research aiming at identifying key knowledge gaps, capacity building needs and operationalization barriers and opportunities for urban resilience.



Springer Book Series. Resilient Cities: Re-thinking Urban Transformation

The Resilient Cities Series aims to analyse the contemporary challenges faced by cities and provide an up-to-date body of knowledge, including a systematic collection of global cutting-edge best practices, fundamental to managing the urban transition towards resilience. Series Editors in Chief: Nicola Tollin and Jordi Morato.

The Resilient Cities book series will be a unique and fundamental resource for practitioners, policy makers and scientists involved in planning and govern¬ing the transition of cities. It presents the latest and up-to-date systematized information on research, practices and policies development, defining clear means and pathways for replication and up-scaling.

The distinctiveness of the Resilient Cities book series is its international dimension, coupled with a multidisciplinary and a cross sectorial approach. Best practices will be collected and analyzed following a common format, enabling the reader to understand the solutions adopted and clearly high¬lighting the parameters and possibilities for replication and up-scaling. The best practices are taken from a global city base including, Barcelona, Medellin, Adelaide, Copenhagen, Seoul, and Accra.

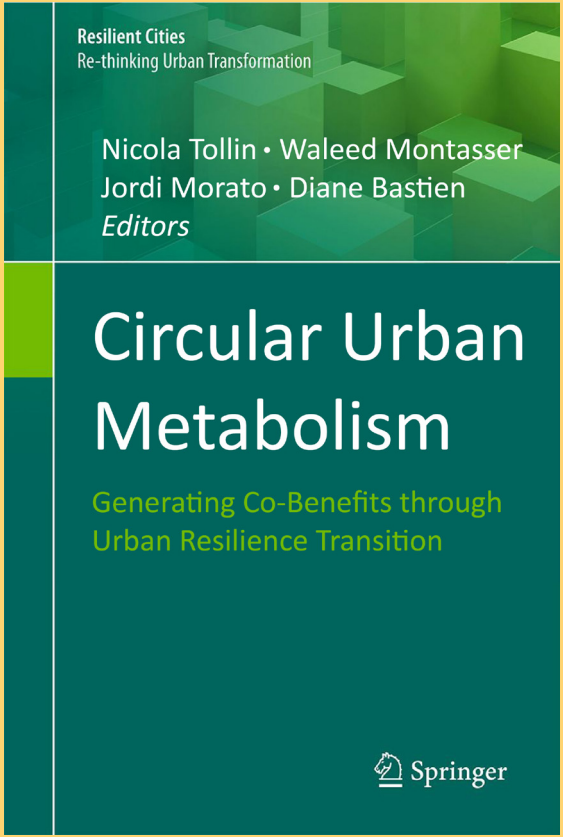
Circular Urban Metabolism

This book give examples and potential frameworks and approaches to design, planning and evaluation, as key enabling factors worldwide, depicting challenges and opportunities within a Circular Urban Metabolism, within e.g. waste and resources and water and wastewater; with differences based on their location and how legal and planning context impact the urban metabolism. Main parts of the book:

• Definitions, approaches and frameworks for Circular Urban Metabolism, including reference to: transition and innovation, circular economy, urban metabolism, low-carbon development, de-growth, decoupling, etc. This topic aims also at discussing approaches on how a circular metabolic system can support urban resilience transition and the challenges related to data collection.

• Case studies collection Sectorial approaches for circular urban metabolism, fostering more systemic and integrated policies, strategies and actions, within topics: 1) water and blue infrastructures; 2) material and waste management; 3) biodiversity and agriculture.

• Case studies collection related to Cross-sectorial approaches for circular urban metabolism, including issues of multiple flows and sectors, including water, waste, biodiversity and agriculture and also energy, knowledge infrastructures, biotechnologies, social economy and the construction sector.



United Nations Climate Change Conference COP25

Side event "**City-level: Capacity-building for Resilience**" was organized and chaired by SDU (Prof Nicola Tollin) and in partnership with UNESCO, GIZ, WWF CITIES, GERICS, UN-Habitat, ICLEI World Secretariat, ICCCAD.

The side event was hosted by the Paris Committee on Capacity-Building (PCCB) in the frame of the Capacity Building Hub, during the Local Governments and Cities Day, coordinated by UNFCCC, UN-Habitat and ICLEI at COP 25. The session aimed to discuss challenges and opportunities for building capacities for urban resilience; respond to the Cities-IPCC call for fostering dialogue between practitioners, policy makers and researchers; lastly, to develop and promote peer- to-peer learning across regions, sectors and disciplines, to support climate action at local level, contributing to raising ambition of national policies.

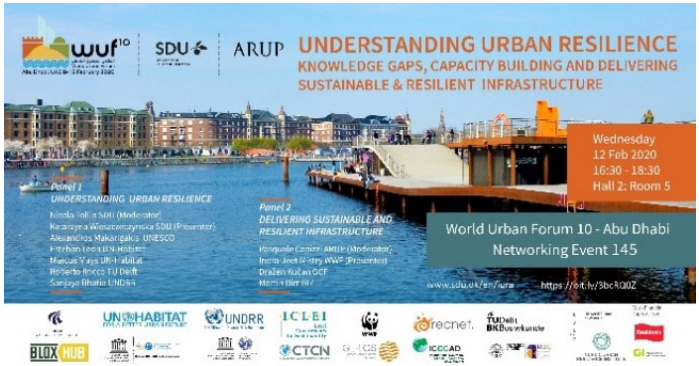
The main highlights from the discussion are; the need for further research on bringing climate information and models to a level useful in cities; integration of finance and national policy as key for building back better; the need for tool integration and navigation to create platforms for learning across mitigation, adaptation and resilience; the need for resilient people by building capacities and educational institutions; the need for more evidence-based decision making, the importance of local context specificities and the importance of community-based measures.

Organised and Chaired Side Events

During COP 25 Urban Resilience Research Group participated in other two side events. "**Improving resilience of key infrastructure in Central America and the Caribbean**" site event was organized by SDU and UN-Habitat, in partnership with ENEA (Italy), CTCN, Ministry of Forestry in Honduras, OECS, IFC (Honduras), and was hosted by the Italian Delegation at COP 25. The panel discussion chaired by Kasia Wieszczeczynska (SDU) focused on debating on how to build resilient infrastructures and support a resilient transition in Central America and the Caribbean. A particular focus was on climate change adaptation in the education sector, given the high importance of education for national development, the centrality of schools as learning and development centers, and their frequent use as emergency shelters during climate disasters.

The side event "**City-level: capacity-building for climate action**"organized by UNESCO. The side event sought to discuss alternatives for climate resilient urban development in small and medium-sized cities, establish a multi-sectorial dialogue to propose ways of reinforcing the capacities of local water actors in city, and also discuss how a city to city knowledge exchange can be facilitated by a cooperation mechanism such as MAWAC and trainings for Cities resilience; Prof Nicola Tollin presented International Urban resilience Academy (IURA) as a capacity building training for urban stakeholders.

UN-Habitat
10th World Urban Forum WUF10



Side event "**Understanding Urban Resilience: knowledge gaps, capacity building; and delivering sustainable & resilient infrastructure**" was organized by SDU, ARUP in partnership with UN-Habitat, UNESCO, GCF, GIZ, WWF Cities, UNDRR and TU Delft.

The side event aimed at discussing key challenges for urban resilience, focusing specifically on knowledge gaps, capacity building and skills development needs and operationalizations through innovative practices in planning, designing and delivering infrastructure in a city.

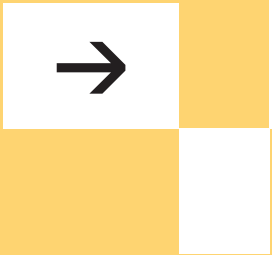
The presentations and Panel 1 discussion drew on the outcomes of the research Understanding Urban Resilience. The main highlights; the knowledge gaps in urban resilience are data accessibility and data relevance; that is fundamental for evidence-based and informed decisions; capacity building needs are: strengthening science-policy interface, multi-sectoral systems thinking, cross-fertilization; and operationalization can happen through: design thinking, horizontal integration, governance (integrating national and local levels). The presentation and Panel 2 discussion drew from a review of innovating practices integrating eco-system services and climate change projections in planning and design, conducted in 2019 by WWF with funding from GIZ, and technical support from Arup. The main highlights: the need to produce a paradigm shift faster: practices of more integrated approaches to eco-system and climate change analysis informing projects, the risk is to have 'too little too late'.

Organised and Chaired Side Events

The special session "**Enhanced resilience of the built environment and infrastructure** " organized by Un-Habitat, with partners: EC-DEVCO, 100 Resilient Cities, Medellin Collaboration for Urban Resilience. The aim of the session, chaired by Prof Nicola Tollin, was to discuss how can the New Urban Agenda be implemented with a focus on integrated urban resilience, and how can the international community support cities build the resilience required to achieve the Sustainable Development Goals, with focus on UN-Habitat's City Resilience Profiling Tool and City Rap. The main highlights of the session: there is a need for integrating climate action in the frame of SDGs; importance of cultural heritage and use of nature based solutions with participatory design, in a face of multiple challenges.

Networking event "**Scaling up finance for transformative climate action in cities**" was organized by Green Climate Fund, with partners: SDU, UN_Habitat, Climate Policy Initiative, EBRD, Moody's Investors Service. This event discussed access to urban climate finance: the innovative development, including the obstacles that impede investment, cutting-edge approaches to addressing key obstacles, a multi-country approach to scale up climate action in cities, and unlocking private capital for urban climate action. Prof Nicola Tollin addressed the need for development of frameworks and tools to integrate climate considerations into fiscal and financial decision-making at the city scale and explore how public budgets can be strategically used.

Networking



Member of Sustainable Concrete Initiative

Sustainable Concrete initiative is about creating a future where the CO_2 footprint from concrete construction is 40-50 percent lower than today. More precisely, the future is called 2030, and improvement must be made without compromising quality, comfort and economy.

In the Sustainable Concrete initiative, more than 50 key players in the Danish concrete and construction industry have come together to achieve an ambitious goal. The reason is that construction - including concrete construction - accounts for a large part of society's climate and environmental impact in the form of resource and energy consumption, CO_2 emissions and waste. In the Danish part of the industry, focus is already on sustainable production, but in many cases it is possible to reduce the environmental footprint further.

SDU CAE contributes mainly to the Sustainable Concrete initiative from a research perspective. Here, the focus is on developing ideas for research projects that can create knowledge that will reduce the CO_2 footprint from concrete construction. However, SDU CAE also contributes with expert knowledge and ideas on the knowledge we already have.

Memorandum of Understanding with Politechnico di Torino

The Politecnico di Torino (POLITO) – Interuniversity Department of Regional and Urban Studies and Planning The Interdepartmental Centre Responsible Risk Resilience (R3C) and University of Southern Denmark, Department of Technology and Innovation has signed Memorandum of Understanding. Therefore, SDU and POLITO established an institutional and scientific partnership for initiatives related to scientific and educational research in the subject areas linked to the fields of urban resilience, climate change adaptation, and circular economy.

The cooperation in training activities, and research in areas of common interest for SDU and POLITO will be implemented in the form of:

• Organising, promoting, staffing and coordinating exchanges for undergraduates and postgraduate students, PhD students, researchers and lecturers (Erasmus+ Project),

• Facilitating and coordinating joint research cooperation and collaborations focused on the fields of urban resilience, climate change adaptation, and circular economy;

• Organising of common bilateral seminars, interactive academic sessions, including special short-term academic programmes, and other professional development activities

• Fostering the participation in tenders and regional, national, European and international research programmes, with a particular focus on the EC Framework Programme;

UNESCO Chair on Urban Resilience University of Southern Denmark

UNESCO Chair on Urban Resilience was established in 2019, under the UNITWIN program, within the Section for Civil and Architectural Engineering, at the Faculty of Engineering, the University of Southern Denmark.

Nicola Tollin, Professor with special responsibilities on Urban Resilience, was be appointed as Chairholder with the mandate to establish a research group on urban resilience operating at the highest international level, as objective for his special responsibilities.

The main objective of the Chair is to actively contribute, through high impact research, education and knowledge transfer activities, to the joint implementation of the Agenda 2030, the Paris Agreement, the New Urban Agenda and the Sendai Framework, primarily through close collaboration with UNFCCC, UN-Habitat and UNISDR, and envisaging further collaboration with IPCC, UN-DESA, UN-Environment and CTC-N.

The Chair is thereby supporting both normative and operational efforts facing major social, economic and environmental global challenges, through evidence-based policy making and empowering participatory local actions, in the global south and north; ultimately supporting the just transition of cities toward urban resilience, leaving no one behind.

Specific objectives:

1. Develop transdisciplinary research and knowledge co-creation at highest international level

2. Support science-based policy making at international and national level

3. Support evidence-based participatory local action globally

4. Develop transdisciplinary education and capacity building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