

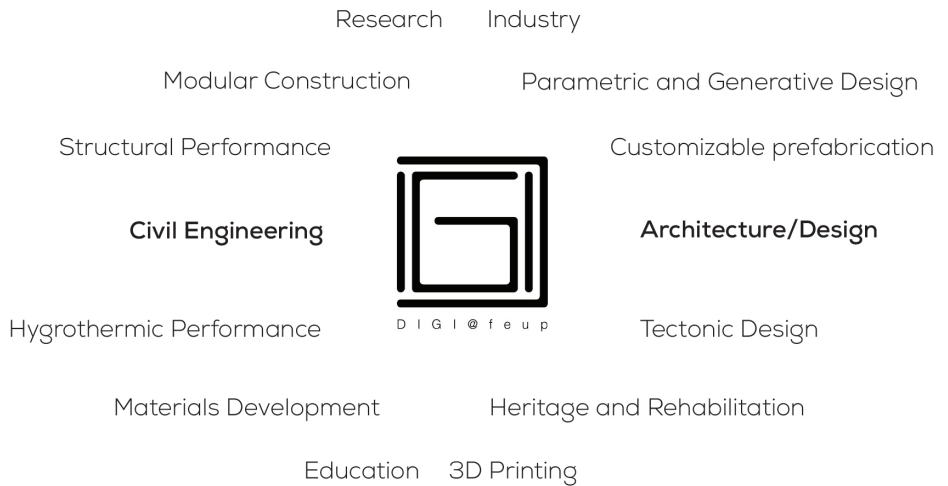
# **CONSTRUÇÃO MODULAR**

**MODULAR  
CONSTRUCTION**



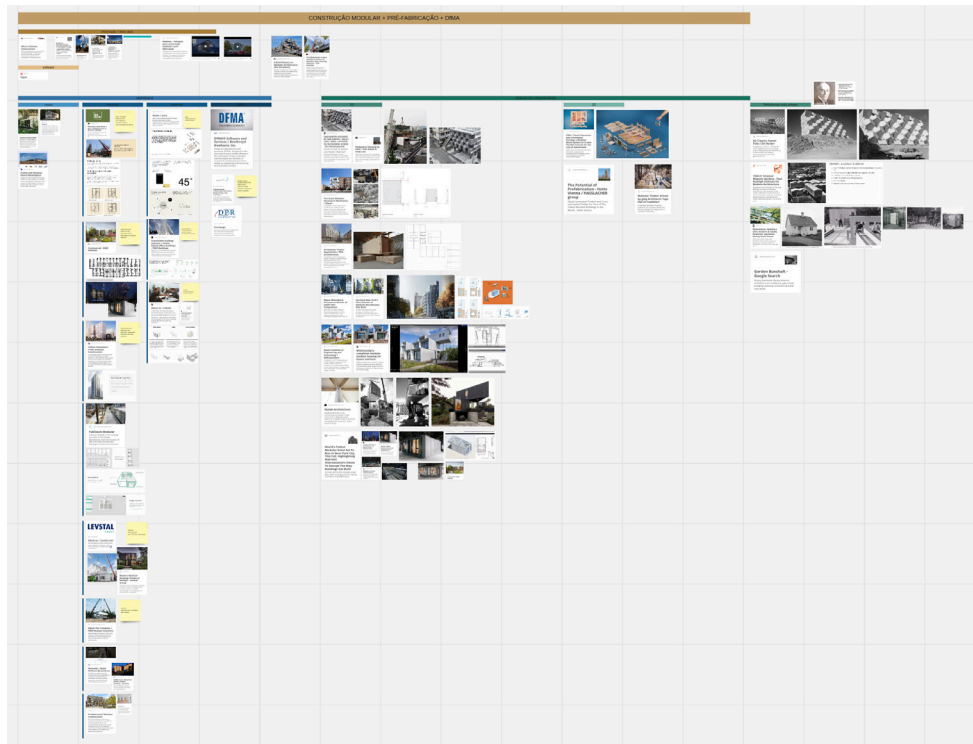
O DIGI@feup é um grupo de investigação multidisciplinar que nasce no Departamento de Engenharia Civil da FEUP com o objetivo de explorar a forma como se pode transformar o paradigma da Construção, sobretudo com a ajuda da Impressão 3D em grande escala e a Construção Modular. Reunindo um conjunto de áreas científicas associadas a estas temáticas não só dentro da Engenharia Civil (como as Estruturas, os Materiais, a Física das Construções e a Sísmica), como da Engenharia Mecânica, da Engenharia de Minas e Materiais e também da Arquitetura e do Design Industrial, pretende-se, neste grupo, estudar de uma forma integrada, a forma como os processos de industrialização e digitalização podem impulsionar o sector da Construção.

No âmbito da impressão 3D, testam-se diferentes formulações de argamassas, avaliando-se o seu comportamento no estado fresco e endurecido; estuda-se o elemento construtivo construído *off-site* e o desempenho do edifício impresso *in situ* nas várias vertentes e as potencialidades formais que esta tecnologia pode oferecer ao desenvolvimento do projeto de Arquitetura. No campo da Construção Modular, procura-se nos processos industriais, formas de otimização do processo construtivo trazendo para a fábrica a produção da maioria dos elementos construtivos e estuda-se a potencialidade da impressão 3D para a customização de produtos pré-fabricados. Para ambas as vertentes, definem-se os parâmetros de desempenho do edifício construído para sustentar o desenvolvimento do projeto integrado entre a Arquitetura e a Engenharia.



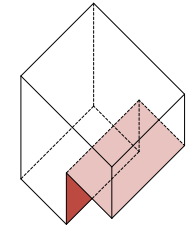
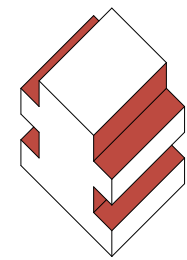
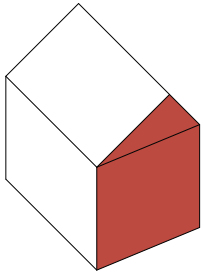
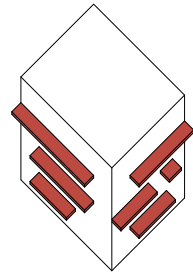
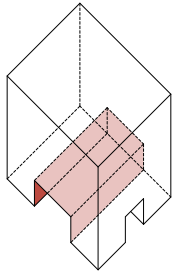
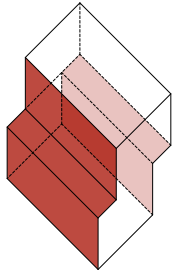
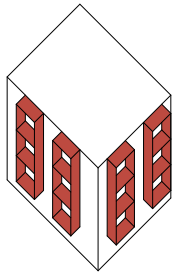
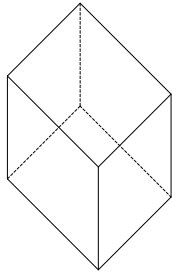
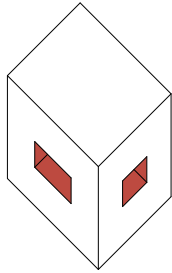
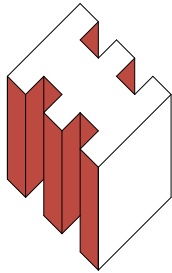
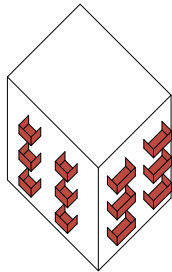
DIGI@feup is a multidisciplinary research group that originated in the Department of Civil Engineering at FEUP, with the goal of exploring how to transform the Construction paradigm, particularly with the help of large-scale 3D printing and Modular Construction. Bringing together a range of scientific fields related to these topics, not only within Civil Engineering (such as Structures, Materials, Building Physics, and Seismic Engineering) but also from Mechanical Engineering, Mining and Materials Engineering, as well as Architecture and Industrial Design, this group aims to study in an integrated way how industrialization and digitalization processes can drive the Construction sector forward.

In the field of 3D printing, different mortar formulations are tested, evaluating their behaviour in both fresh and hardened states; the off-site construction element is studied, along with the performance of the building printed *in situ* in various aspects, as well as the formal potential this technology can offer for the development of architectural projects. In the area of Modular Construction, industrial processes are explored to find ways to optimize the construction process by bringing the production of most construction elements into the factory, and the potential of 3D printing for the customization of prefabricated products is studied. For both areas, the performance parameters of the constructed building are defined to support the development of an integrated project between Architecture and Engineering.



No DIGI@FEUP, a investigação tem-se focado na industrialização da construção em particular na área da Construção Modular. Em colaboração com empresas, têm sido desenvolvidos projetos de investigação, trabalhos e dissertações de mestrado que procuram explorar a otimização dos processos e a utilização de tecnologias avançadas e o seu potencial de aplicação no âmbito da arquitetura, permitindo aos alunos estar em contacto próximo e de forma prática, com os desafios da indústria em Portugal. O projeto R2UTechnologies - Modular Systems, que envolve um consórcio multidisciplinar com várias entidades, procura inovar no campo da pré-fabricação e da Construção Modular em Portugal. A equipa da FEUP contribui diretamente no desenvolvimento de módulos e modelos paramétricos, em estreita cooperação com os restantes investigadores.

At DIGI@FEUP, research has focused on the industrialization of construction, particularly in the area of Modular Construction. In collaboration with companies, research projects, master's theses, and dissertations have been developed to explore process optimization and the use of advanced technologies, as well as their potential application in architecture. This allows students to engage closely and practically with the challenges faced by the industry in Portugal. The R2UTechnologies - Modular Systems project, involving a multidisciplinary consortium with various entities, aims to innovate in the field of prefabrication and Modular Construction in Portugal. The FEUP team directly contributes to the development of modules and parametric models, working closely with the other researchers.



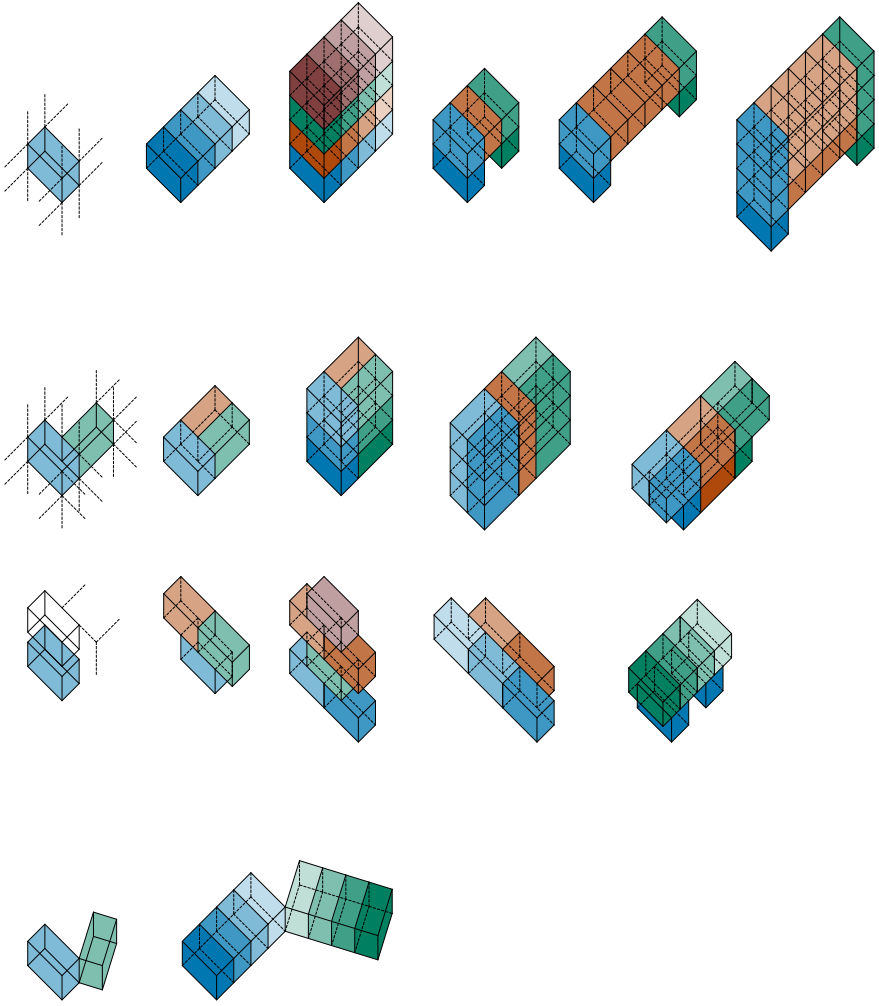


## FEUP - EQUIPA DE PROJETO INTEGRADO

**Bárbara Rangel Carvalho, Caroline Minetto, Leonor Reis**

O projeto R2UTechnologies - Modular Systems reúne um consórcio de empresas e entidades tecnológicas e científicas em Portugal, com o objetivo de desenvolver e industrializar a atividade construtiva no país através da Construção Modular, abordando desafios nas áreas de Design, Sustentabilidade e Construção Inteligente. A Faculdade de Engenharia da Universidade do Porto está integrada na Atividade 1.1, “I&D em Arquitetura, Engenharia e Parametrização”, do Work Package 1, “Princípios da Construção Modular”. A equipa de Projeto Integrado tem como objetivo criar uma metodologia de apoio ao desenvolvimento do Projeto de Arquitetura em Construção Modular.

O trabalho de investigação desenvolve-se em várias frentes. Na vertente teórica, tem como ponto de partida a recolha e análise bibliográfica, bem como o estudo e compilação de sistemas construtivos e edifícios em Construção Modular, com o intuito de compreender os princípios fundamentais desta técnica e os impactos que tem no projeto arquitetónico. Na vertente prática, o projeto envolve o desenvolvimento de um protótipo de edifício em Construção Modular, baseado num módulo tridimensional de um quarto para residência de estudantes. Este trabalho visa testar métricas, formas e escalas, além de desenvolver de forma integrada com as restantes equipas, princípios de parametrização e otimização.



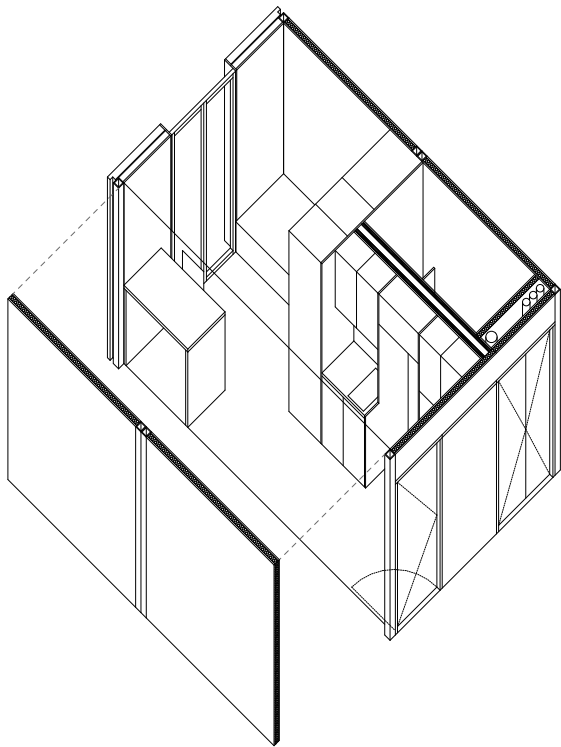
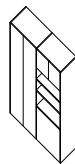
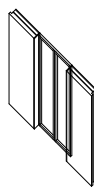
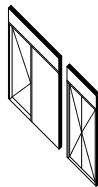
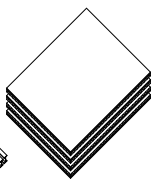
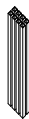
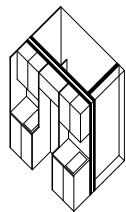
# R2UTECHNOLOGIES - MODULAR SYSTEMS

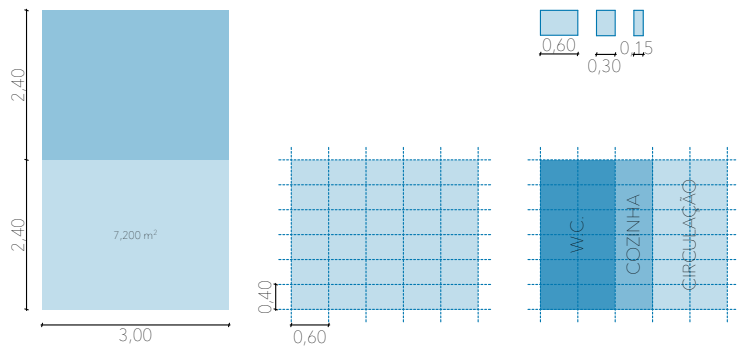
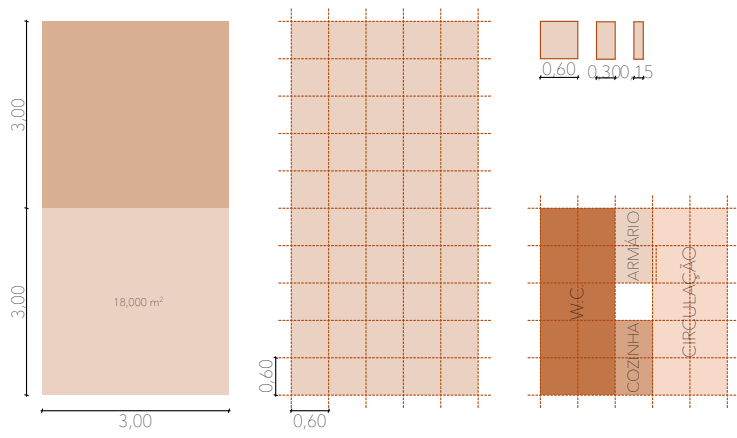
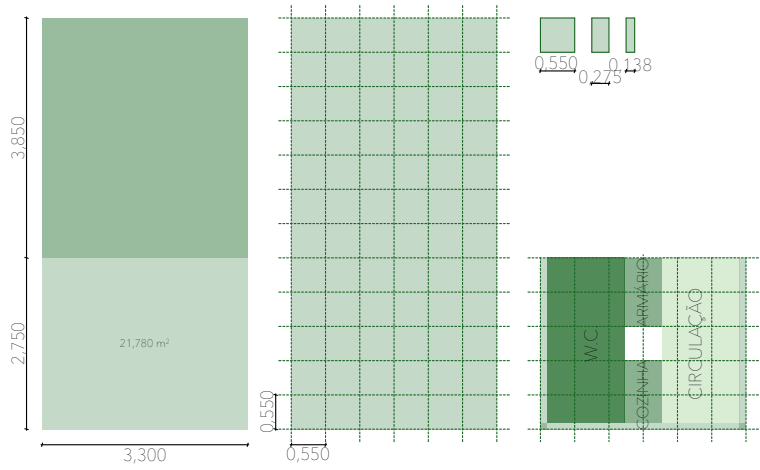
## FEUP - INTEGRATED PROJECT DESIGN TEAM

**Bárbara Rangel Carvalho, Caroline Minetto, Leonor Reis**

The R2UTechnologies - Modular Systems project brings together a consortium of companies and technological and scientific entities in Portugal, with the goal of developing and industrializing the construction industry in the country through Modular Construction, addressing challenges in the areas of Design, Sustainability, and Smart Construction. The Faculty of Engineering of the University of Porto is involved in Activity 1.1, “R&D in Architecture, Engineering, and Parametrization,” within Work Package 1, “Principles of Modular Construction.” The Integrated Project team aims to develop a methodology to support the Architectural Design process in Modular Construction.

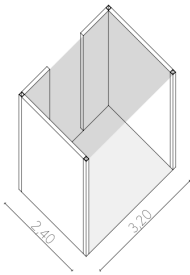
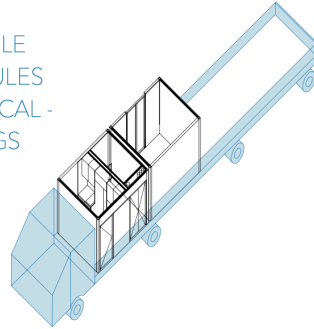
The research work progresses on multiple fronts. On the theoretical side, it starts with a literature review and the study and compilation of construction systems and buildings in Modular Construction, aiming to understand the core principles of this method and its impact on architectural design. On the practical side, the project involves the development of a prototype design for a Modular Construction building, based on a three-dimensional module for a student residence room. This work seeks to test metrics, forms, and scales, and to integrate parametrization and optimization principles into the design process.



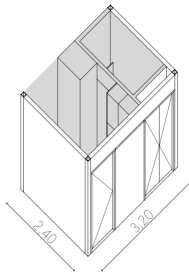


### 3D

TRANSPORT- 3D MODULE  
ASSEMBLY - INTER-MODULES  
- HORIZONTAL AND VERTICAL -  
JOINTS AND FINISHINGS



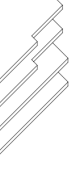
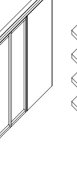
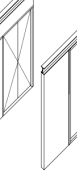
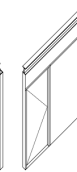
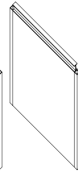
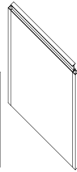
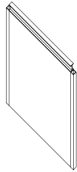
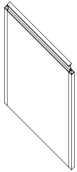
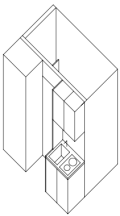
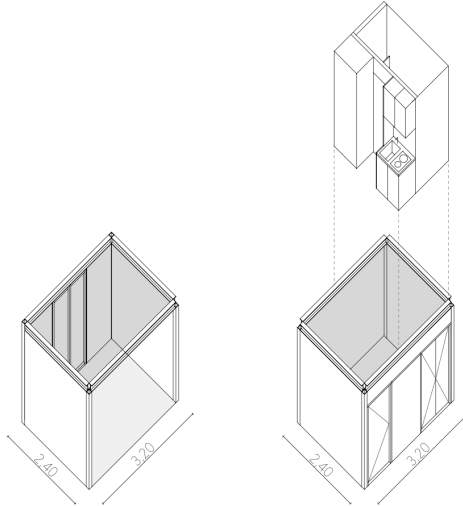
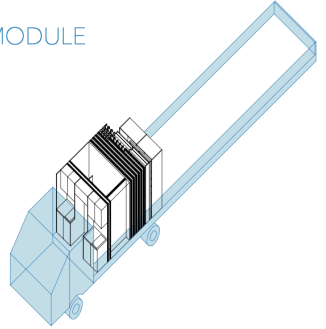
DRY MODULE



WET MODULE

# HYBRID

TRANSPORT- COMPONENS OR 3D MODULE  
ASSEMBLY - COMPONENTS  
- HORIZONTAL AND VERTICAL  
JOINTS AND FINISHINGS

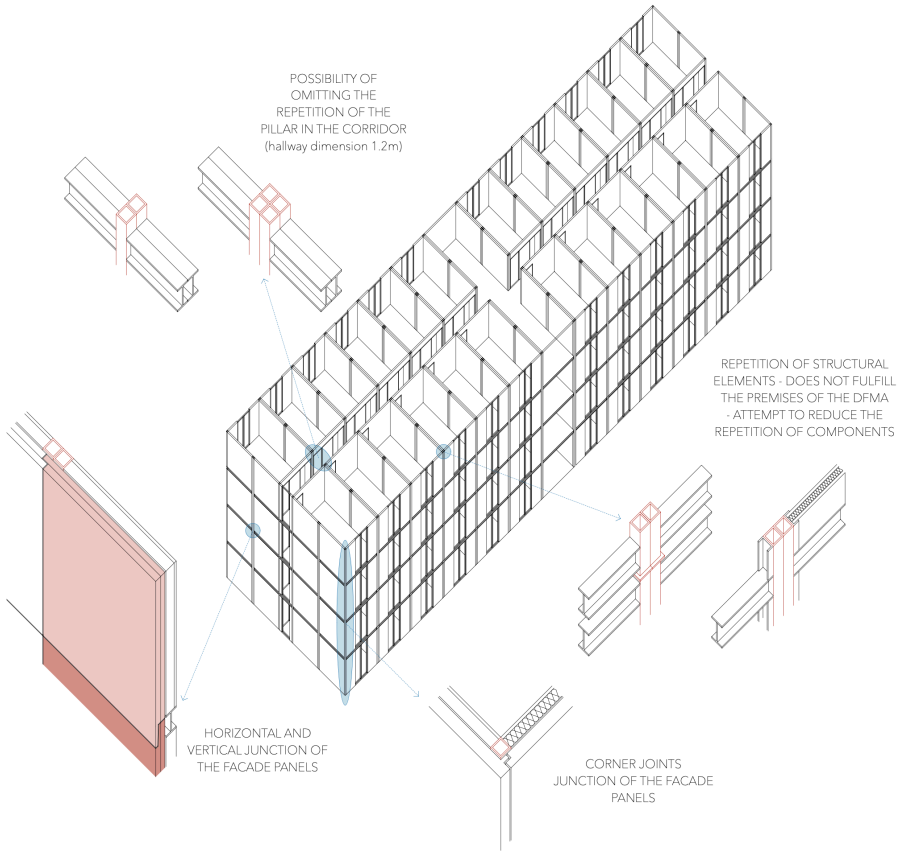


WET MODULE

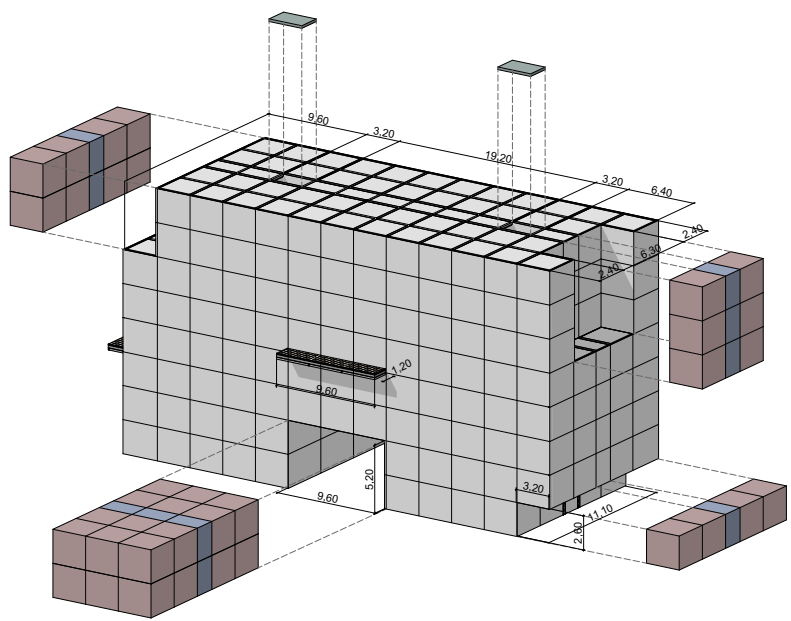
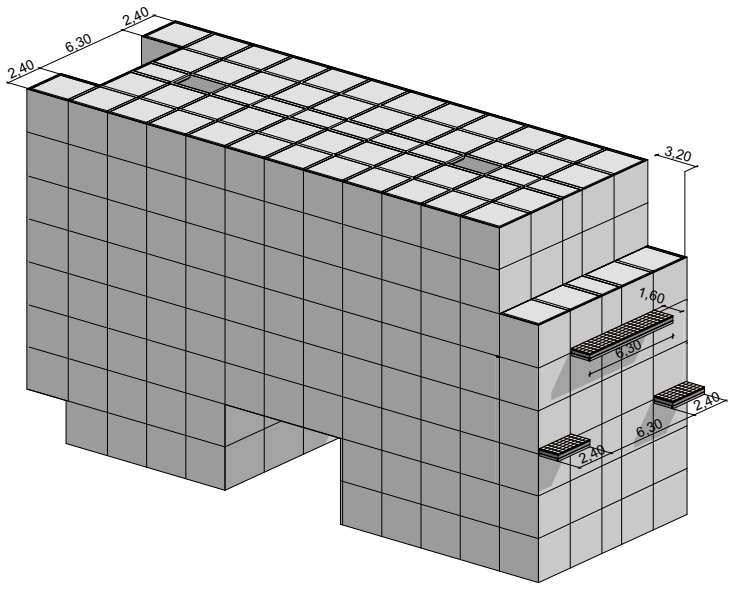
WALL PANELS - A

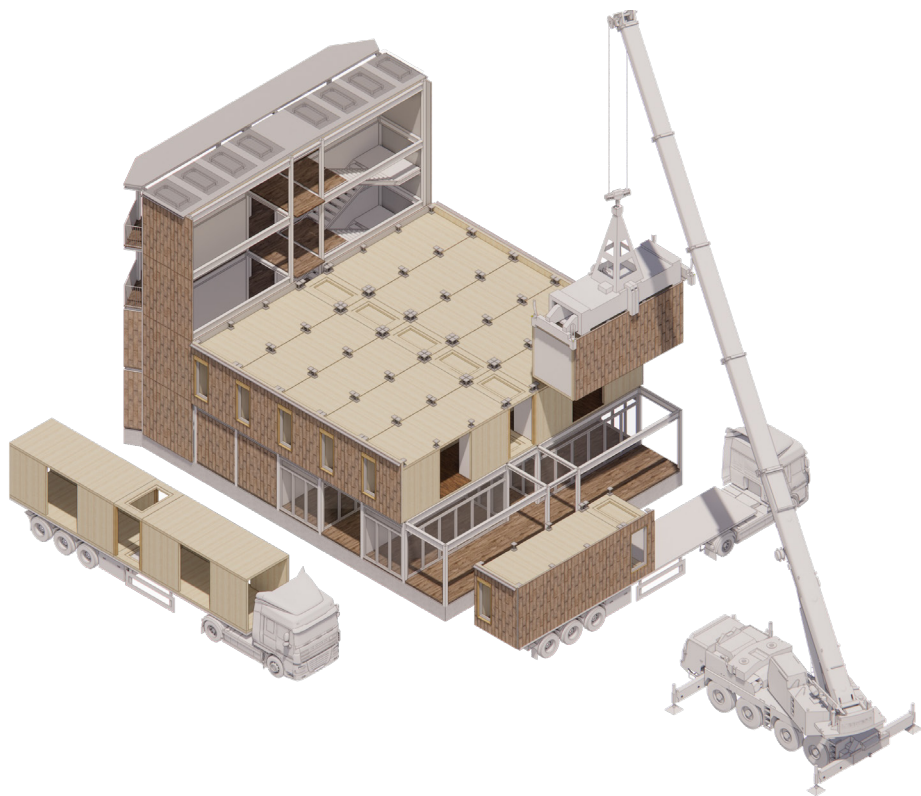
WALL PANELS - B

SLABS - A + B









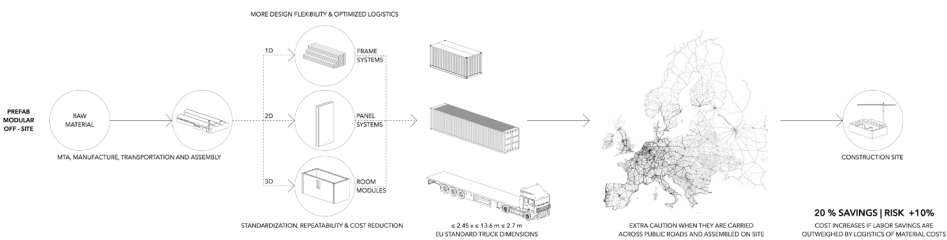
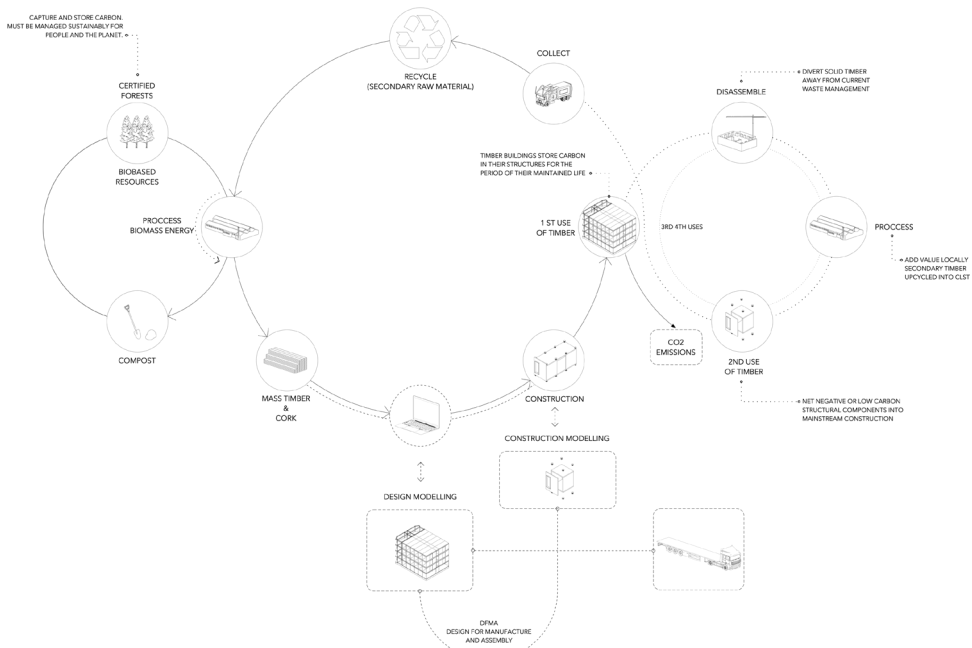
# **MBUILD - MESTRADO EM PROJETO, CONSTRUÇÃO E GESTÃO SUSTENTÁVEIS DO AMBIENTE CONSTRUÍDO**

## **AFFORDABLE MODULAR BUILDING, 2024**

**Ayla Pedron Hajjar, Julia Cojocari, Juan Bugarin**

O MBUILD - Master Degree in Sustainable Design, Construction and Management of the Built Environments - é um Mestrado Conjunto Erasmus Mundus (EMJM) ministrado e certificado pela Universidade do Porto (UP Porto, Portugal), Universidade de Cantábria (UC Santander, Espanha) e Technische Hochschule Mittelhessen (THM Gießen, Alemanha).

O MBUILD tem como objetivo responder às dificuldades identificadas enfrentadas pelas empresas da Indústria da Construção (IC) europeia, especialmente quando trabalham em países em desenvolvimento, na implementação de projetos com soluções sustentáveis e ambientalmente conscientes. A disponibilidade de expertise profissional adequada, em particular a local, é muitas vezes escassa, um problema que este Mestrado Conjunto pretende enfrentar, proporcionando aos seus alunos um conhecimento amplo e competências centradas nas preocupações mais recentes e relevantes para operações de construção mais sustentáveis.



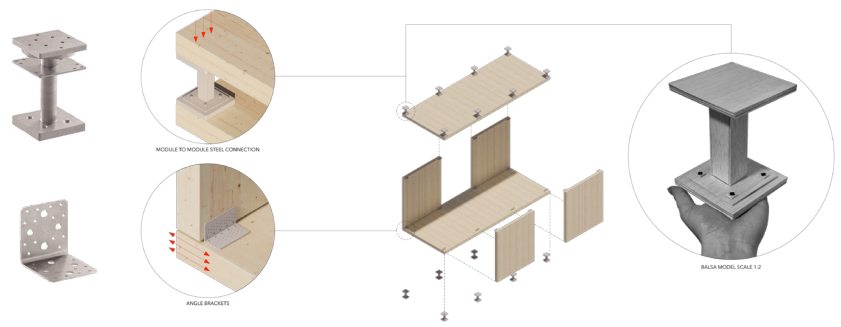
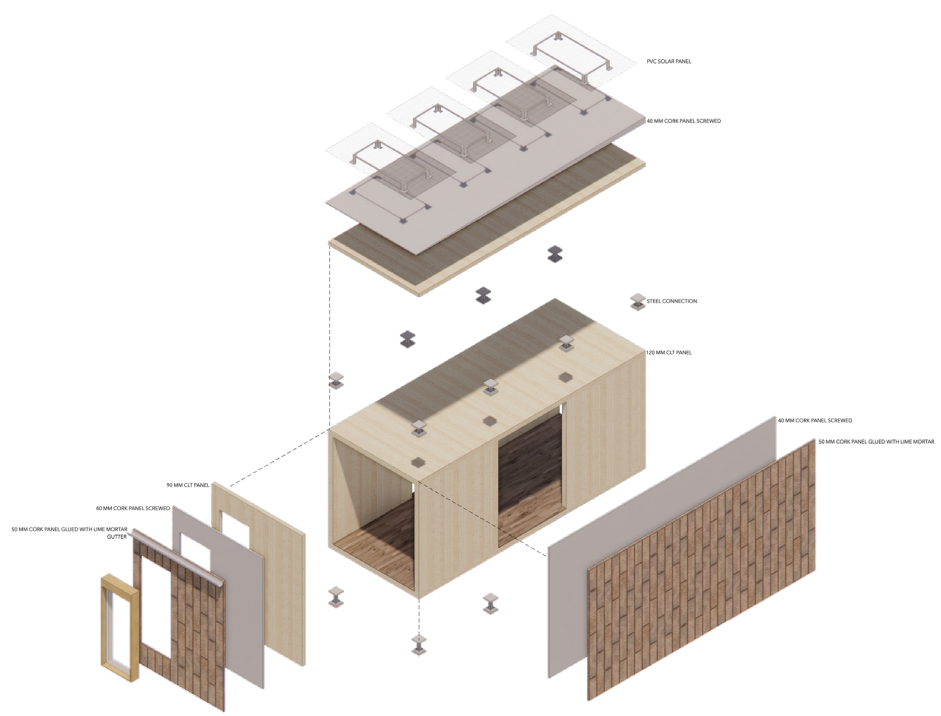
# **MBUILD - MASTER IN SUSTAINABLE DESIGN, CONSTRUCTION AND MANAGEMENT OF THE BUILT ENVIRONMENT**

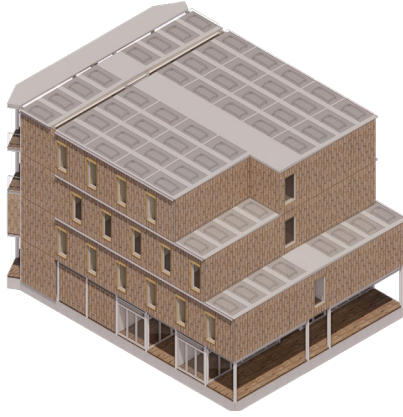
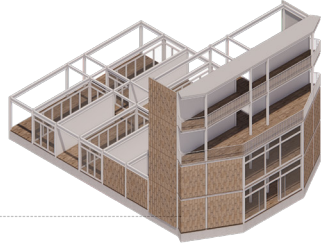
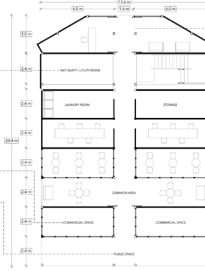
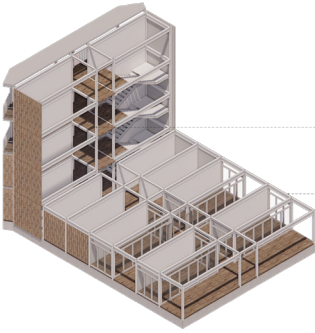
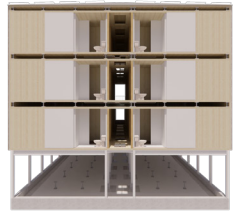
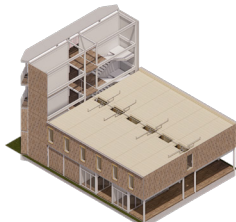
## **AFFORDABLE MODULAR BUILDING, 2024**

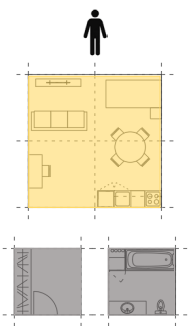
**Ayla Pedron Hajjar, Julia Cojocari, Juan Bugarin**

The MBUILD - Master Degree in Sustainable Design, Construction and Management of the Built Environments - is a EMJM Erasmus Mundus Joint Master delivered and awarded by the University of Porto (UP Porto, Portugal), University of Cantabria (UC Santander, Spain) and Technische Hochschule Mittelhessen (THM Gießen, Germany).

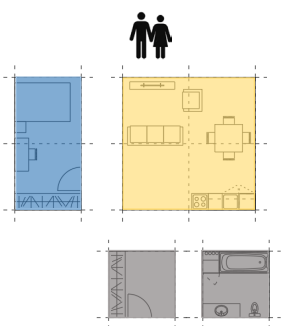
MBUILD aims to give an answer to identified difficulties faced by European Construction Industry (CI) companies, mainly when working in developing countries, in implementing projects with a high level of sustainable and environmentally conscious solutions. The availability of adequate professional expertise, in particular local one, is often scarce, a problem this Joint Master intends to tackle by providing its students with a wide scope knowledge and learning outcomes under the more recent and relevant concerns for more sustainable construction operations.



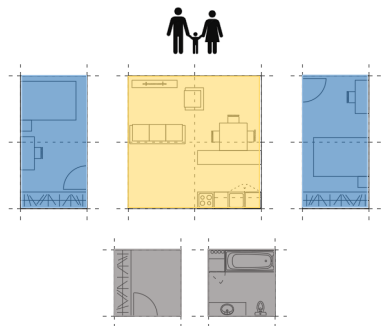




**Type 1**  
Studio Apartment



**Type 2**  
One Bedroom Apartment



**Type 3**  
Two Bedroom Apartment



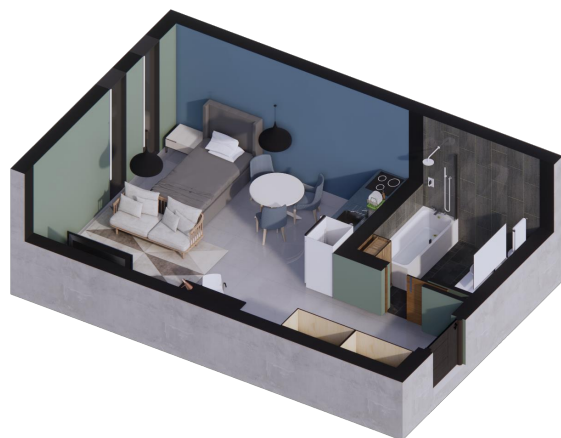
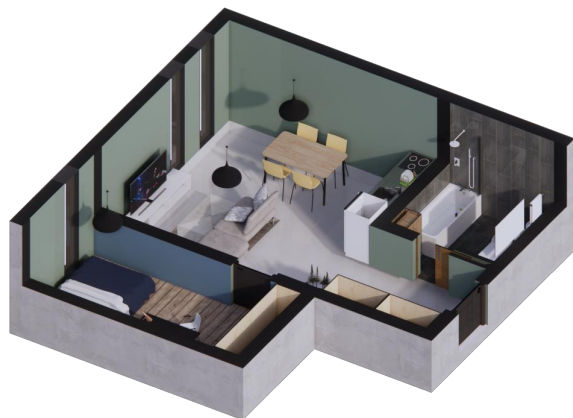
# **MBUILD - MESTRADO EM PROJETO, CONSTRUÇÃO E GESTÃO SUSTENTÁVEIS DO AMBIENTE CONSTRUÍDO**

## **AFFORDABLE MODULAR BUILDING, 2023**

**Imtiaz Ahmad, Jaime Cunha, Zannat Shangi**

Os alunos desenvolveram um alojamento de estudantes baseado nos princípios da arquitetura sustentável e da construção industrializada. A solução proposta é projetada para ser pré-fabricada em estaleiro e transportada de forma eficiente para o local. Incorpora um design modular, permitindo a criação de espaços flexíveis que podem ser adaptados a vários tamanhos e funções, atendendo às diversas necessidades de habitação.

Além disso, o sistema suporta configurações de habitação tanto individuais quanto coletivas, permitindo que funcione como uma unidade autónoma ou como parte de um complexo residencial maior. O processo de construção segue métodos de construção a seco, enfatizando o uso de materiais e ligações que facilitam a montagem como um produto industrializado. Adicionalmente, o design prioriza a futura desmontagem, maximizando a recuperação e reutilização de materiais, alinhando-se assim às práticas de construção sustentável. Este projeto apresenta uma abordagem inovadora, combinando responsabilidade ambiental com adaptabilidade e eficiência.



# **MBUILD - MASTER IN SUSTAINABLE DESIGN, CONSTRUCTION AND MANAGEMENT OF THE BUILT ENVIRONMENT**

## **AFFORDABLE MODULAR BUILDING, 2023**

**Imtiaz Ahmad, Jaime Cunha, Zannat Shangi**

The students developed a student accommodation concept based on the principles of sustainability architecture and industrialised construction. The proposed solution is designed to be prefabricated offsite and efficiently transported to the location. It incorporates a modular design, enabling the creation of flexible spaces that can be adapted to various sizes and functions, meeting the diverse needs of residential living.

Furthermore, the system supports both individual and collective housing configurations, allowing it to function either as a stand-alone unit or as part of a larger residential complex. The construction process follows dry building methods, emphasising the use of materials and connections that facilitate assembly as an industrialised product. Additionally, the design prioritises future disassembly, maximising material recovery and reuse, thus aligning with sustainable construction practices. This project showcases an innovative approach, combining environmental responsibility with adaptability and efficiency.



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