# UNSW / Space Labs VMC Research HUB

As part of Freecity's strategy to lead the growth of Volumetric Modular Construction (VMC) in Australia, we have established a comprehensive Research and Development agenda. Central to this is the **UNSW Engineering VMC Research HUB**, developed in collaboration with Space Labs – Freecity's modular procurement capability designed to support third party VMC projects.

Freecity has entered into a three year agreement with UNSW Engineering to advance research in the following areas:

1. Transforming Construction Practices: A lifecycle and Sustainability perspective on Modular Construction
2. Design and optimization of next-generation Modular Construction systems
3. Digital Twin and Intelligent Lifecycle Management for Modular Construction

The broad research thesis is that engineering has been largely left behind in recent decades and with the development of Artificial Intelligence and Digital Twins we hope to shine a light on new methodologies to optimise steel structure buildings.

The first paper has been issued: Time-variant reliability analysis via advanced most probable point trajectory analysis (AdaVM-MPPT). This paper provides a way to combine structural reliability design with AI-based predictive modeling. If you are not an Engineer, like me you won't understand much of the paper, but the objective is clear – the most probable path to analyse structural performance reduces computational effort whilst maintaining accuracy to get more fit for purpose designs, rather than a 'belt and bracers' approach. By linking AI-based reliability prediction with design choices (thickness of steel, coatings, connection details), engineers can optimize for 50+ year service life while minimising cost.

## *Spotlight: Space Labs Leadership*

Meet Space Labs Director of Operations – Ken Hou. A qualified structural engineer with 20+ years' construction industry experience in both China and Australia. He leads end-to-end delivery from client brief and DfMA/constructability through factory production, logistics (OSOM permitting, cranage and installation sequencing) and site commissioning—aligned to NCC/AS, NSW DBP and SCA CC3 readiness. His portfolio includes high-rise accommodation design, construction engineering analysis and construction implementation on site. Before leading Space Labs operations, Ken built a decade-plus modular track record that anchors today's delivery playbooks—combining early high-rise modular design in South Australia with on-the-ground China procurement and factory governance. He is currently delivering the UNSW–Space Labs VMC Research HUB together with the UNSW Engineering School, to drive ongoing development and innovation in our business.

Leading applied Research with the best Academics in the country is a key to Freecity's Innovation DNA and we will have more to share with you about our Research collaboration projects next year.

**Ken Hou**
*Director of Operations, Space Labs*

Curtin Student Accommodation

## *Collaboration with UNSW Engineering*

I am pleased to introduce Professor Wei Gao who is an Associate Dean International of UNSW Engineering.

Over the past year, UNSW and Space Labs have built a close collaboration, combining UNSW's strengths in structural engineering and lifecycle assessment, with Space Labs' leadership in modular construction. Our joint work follows a problem-driven research method: we take real project challenges, develop advanced structural analysis and design optimisation models, and translate the results into practical tools and certification pathways.

An early success of this partnership was UNSW's support in obtaining EPD and 5-star GBCA green building certification for the company's modular steel systems, where relevant statistics from literature and publicly accessible databases are collected, and our independent structural and lifecycle assessment provided the technical evidence needed to demonstrate lower embodied carbon without compromising performance. UNSW, E-Lab and GBCA, redefined the carbon omission benchmark for modular buildings; under this benchmark to explore and adopt a green-steel pathway, achieving an estimated 30% reduction in embodied carbon intensity for the specified steel grades. The final TÜV audit stage, with certification report expected before the end of the year and this will establish the first green steel contract in both China and Australia, converting theory into verified practice.

Some more thoughts on what we will be looking to deliver together in the years ahead are provided below:

**UNSW & SPACE LABS – HUB Research Projects**

**Project 1:**
**Transforming Construction Practices: A Lifecycle and Sustainability Perspective on Modular Construction**

**Aims**
1. Systematic comparison study between conventional and modular construction methods across the full lifecycle.
2. Develop a quantitative evaluation framework to assess the benefits and trade-offs of transitioning construction modes, covering time, cost, carbon emissions, and sustainability.
3. Provide strategic recommendations for industry and government regarding policies, standards, and technology adoption to accelerate construction transformation.

**Project 2:**
**Design and Optimization of Next-Generation Modular Construction Systems**

**Aims**
1. Develop innovative design frameworks for modular buildings that integrates structural efficiency, functional adaptability, and sustainability.
2. Apply advanced computational methods to enhance module design, configuration, and system performance.
3. Establish digital tools to support design decision-making, enabling rapid prototyping and optimisation of modular systems.

**Project 3:**
**Digital Twin and Intelligent Lifecycle Management for Modular Construction**

**Aims**
1. Develop a scalable digital twin framework for modular buildings that integrates real-time sensing, structural health monitoring, and predictive analytics.
2. Enable data-driven lifecycle management, covering operation, maintenance, retrofitting, and recycling of modular systems.
3. Incorporate advanced models to support fault detection, condition-based maintenance, and optimisation of energy efficiency and occupant comfort.

UNSW SYDNEY

SPACE LABS AUSTRALIA

Professor Wei Gao has been with UNSW's School of Civil and Environmental Engineering since 2008, after serving as a Vice-Chancellor's postdoctoral fellow (2004–2007) and a Chancellor's research fellow at UTS (2007–2008). He is Associate Dean International of the Faculty of Engineering. His research integrates computational and stochastic mechanics with structural engineering, advancing machine learning-based analysis, design, sustainability, and reliability of materials and structures. He has published over 270 widely cited papers, secured 10 ARC projects worth $20M, and built strong industry collaborations. Professor Gao is Editor-in-Chief of Modelling, Associate Editor of Engineering Structures, and serves on editorial boards of leading journals.

**Professor Wei Gao**
*Associate Dean International, UNSW Engineering*