DESIGN

Modern Methods of Construction

Construction Site to Assembly Site

RAMBØLL

EDITION NO. 8
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Prelude

“ Modern methods of construction are revolutionising the construction process and fast becoming an integral method in the construction industry world-wide.”

United Kingdom

1  The Crescent
Plymouth, UK

2  Dalston Works
London, UK

3  Castle Street
Luton, UK

4  Premier Inn
Exeter, UK

5  Aspire SLA
Aldershot, UK

6  Green Park Student Accom
Bath, UK

7  250 City Road
London, UK

8  Abell & Cleland
London, UK

9  Merano Residence
London, UK

10  Citizen M Glasgow
Scotland, UK

11  CitizenM Tower Hill
London, UK

12  Citizen M Bankside
London, UK

13  Park Drive
London, UK

Denmark

14  Lighthouse 2.0
Aarhus, Denmark

Finland

15  Keilaniemen Portti
Espoo, Finland

Norway

16  Mjøstårnet Brumunddal
Norway

17  Sporx Drammen
Norway

Sweden

18  Magasin X
Uppsala, Sweden

Austria

19  HoHo
Vienna, Austria

Middle East

20  LINQ Modular Building System
Dubai, UAE

21  Sindalah Island
NEOM, KSA

Asia-Pacific

22  MRCB Modular Building System
Singapore

23  Lightrus
Singapore

24  JTC Buroh Lane Dorm
Singapore

25  Senja Nursing Home
Singapore

26  Prima Brickfields
Kuala Lumpur, Malaysia

27 Kwasa Plot F
Kuala Lumpur, Malaysia

28  Philippines Modular Building System
Manila, Philippines

29  Student Residence at Wong Chuk Hang, University of Hong Kong
Hong Kong

30  Sampyo HQ
Seoul, South Korea

31  Sampyo Songdo Lake
Incheon, South Korea

Revolutionising the Construction Industry

Re-defining the industry, rather than a solution to the current industry challenges

This is part of a twin publication of the MMC Special Edition. Do refer to the edition for complimentary information.

We are now addressing the most pressing challenges of our time, including the climate crisis, the national skills shortage, a widening productivity gap and increasing concerns around safety.

The development of cutting-edge technology in our industry aims to reduce time to design and build while assuring the highest levels of quality. By combining new offsite construction techniques and digital design capabilities with deep engineering knowledge offers several benefits:

- Time compression
- Improved onsite safety
- Improved productivity
- Improved sustainability

Inspired by Scandinavian heritage and founding principles, a commitment to innovation drives the exploration of revolutionary construction techniques, so we can create sustainable societies where people and nature flourish.

Whether it's designing city centre accommodation, testing existing infrastructure resilience or imagining whole new cities, using advanced digital engineering and offsite construction techniques allow us to address today's real-life engineering and construction challenges.

Conventional construction presents challenges, such as being labour and time-intensive, requiring high carbon footprint and producing significant levels of noise and waste. The use of industrialisation and off-site construction can overcome such challenges, offering a wide range of solutions, from prefabrication of structural elements to the manufacturing of pre-finished components such as panelised, volumetric, MEP (mechanical, electrical, and plumbing) or bathroom pods or hybrid systems.

One of the key advantages of MMC is the reduction in construction time by introducing manufacturing processes and quicker on-site installation. By shifting the work from the site to the factory, most of the work is carried out by highly skilled labour that works in a safer and quality-controlled factory environment. In addition, MMC has the potential to be highly sustainable by selecting materials and techniques that lower carbon emissions and minimise waste production. Furthermore, the levels of noise are reduced significantly compared to conventional construction, which is crucial for developments located in densely urbanised areas or for noise-sensitive. projects.

Space Station (NASA)
An international space station constructed on Earth and deployed out to space.

MMC:
Fast, Sustainable, Innovative Construction

Modern Methods of Construction (MMC) involves the use of off-site manufacturing and industrialised processes to significantly reduce the project execution time, while improving the safety and sustainability.

MMC technologies adhere to the industry's highest quality standards, offering precision-built solutions with adaptability to a broad spectrum of architectural ambitions. Modular building designs are created using an interoperable digital platform including parametric tools, Finite-Element and Building Information Modelling enhancing material optimisation with a minimal amount of waste, designed for quick assembly and flexibility. This design process promotes efficiency and repeatability while preserving the building aesthetics, making MMC technologies suitable even for highly ambitious architectural designs.

Over the past few years, we have seen a rapid increase in interest for MMC particularly in regions undergoing rapid urban development.

In the past decades, areas like Southeast Asia and the Middle East have witnessed substantial urbanisation relying on conventional construction methods. However, there is now a transformative shift towards innovative design and construction.

MMC has the potential to reshape the future of the built environment, promising up to 50% increase in construction speed, reduction in project costs, enhanced design efficiency, improved quality and safety, lower carbon emissions, and the creation of a more resilient urban landscape.

Spacebox, The Netherlands (Mart de Jong)
The Spacebox is a student accommodation. It consists of colorful prefabricated boxes stacked up to 3 storeys high and its 18m² per unit. Each apartment unit fully is equipped with a shower, toilet, bedroom, and a kitchen.

Exploring MMC System Typology

Design for Manufacture and Assembly (DfMA) describes a design approach that focuses on ease of manufacture and efficiency of assembly.

DfMA is the enabler to achieve an efficient implementation of MMC technologies. DfMA is a design methodology that enhances production efficiency, overcome site and environmental constraints and find the optimum solution for the project-specific requirements.

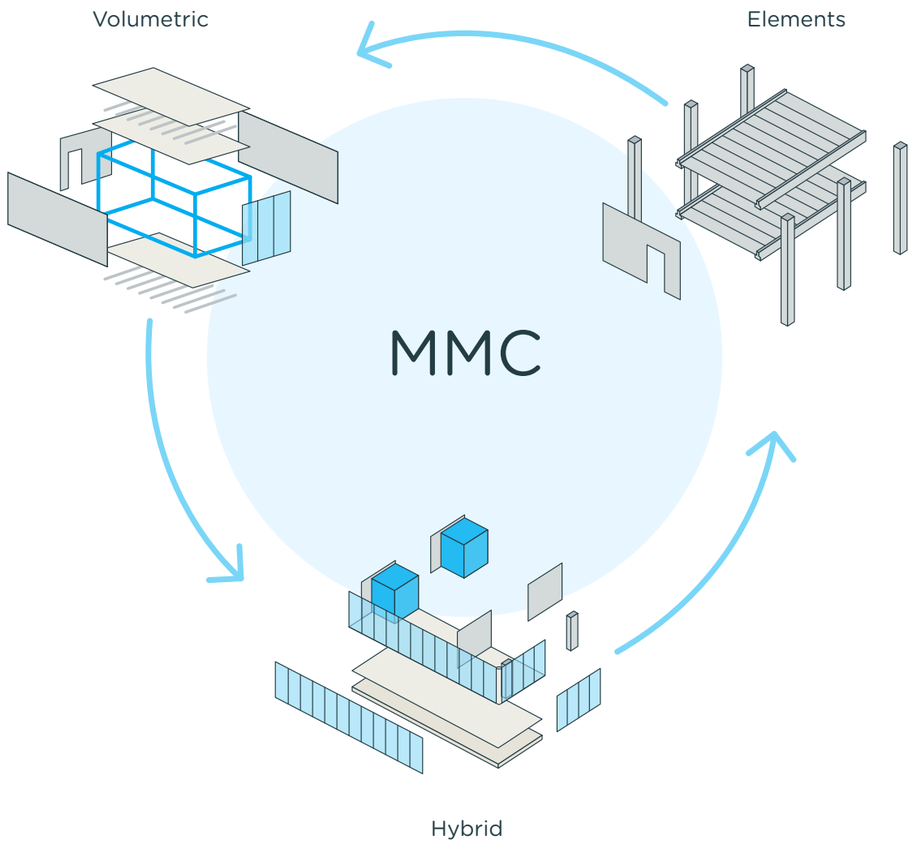
The use of industrialisation in design and construction offers a wide range of solutions, from prefabricated single components to fully integrated assemblies across the structural, architectural and MEP (mechanical, electrical, and plumbing) disciplines. Geometric classification (i.e. 1D, 2D, 3D) prefabricated components is presented in the Special Edition.

To provide a different perspective, an alternative classification of MMC system typologies is provided in this section, focusing on manufacturing and assembly techniques.

Elements:
Consists of single components being prefabricated in a factory or production yard, and then transported to site for installation. While this technique can rely on a well-developed supply chain, it usually requires building services and architectural finishes to be installed on-site.

Volumetric:
This term describes a technology where elements are prefabricated and preassembled off-site to form complete volumes. The module assembly can extend to include the services and architectural fit-outs to form fully prefabricated prefinished volumetric construction (PPVC).

Hybrid:
This technology combines the characteristics and the advantages of the above-mentioned kit-of-parts and volumetric, enhancing speed of construction while enhancing design flexibility.



Digital Design and Industrialised Construction

We shall strive to achieve a balanced design, where the architectural expectations meet structural efficiency, by adopting a holistic approach right from the feasibility studies through the detailed design and construction execution.

The use of cutting-edge technology and software enables a value engineering approach resulting in reliable, robust and yet economical design. We shall seek value engineering through any aspects of design, from the soil-structure interaction and site-specific hazard studies down to element design. Sometimes, a Performance-Based Design can be an opportunity to overcome project-specific constraints and enable an optimum structural design solution.

Modular solutions span a diverse range of projects world-wide, including seismic regions and encompassing hospitality, residential, and commercial projects. The wide range of technologies and systems allow us to successfully adapted modular design to various architectural ambitions, even for projects with highly ambitious designs, going well beyond the conventional `building box' approach.

The Clement Canopy (Bouygues Bâtiment International)
65% of the superstructures of two 40-floor tower blocks were constructed using PPVC making it the world's tallest concrete PPVC building.

We are digital in an analogue industry – we need to embrace digital design for realising client visions and mitigating risks, leveraging on the rapid advances in computational design and the ability to utilise data to create opportunities to revolutionise the process of design, engineering and construction.

The early stages of major projects can be constrained by the lengthy design periods required to develop a concept with robust cost and programme data that shareholders can buy into.

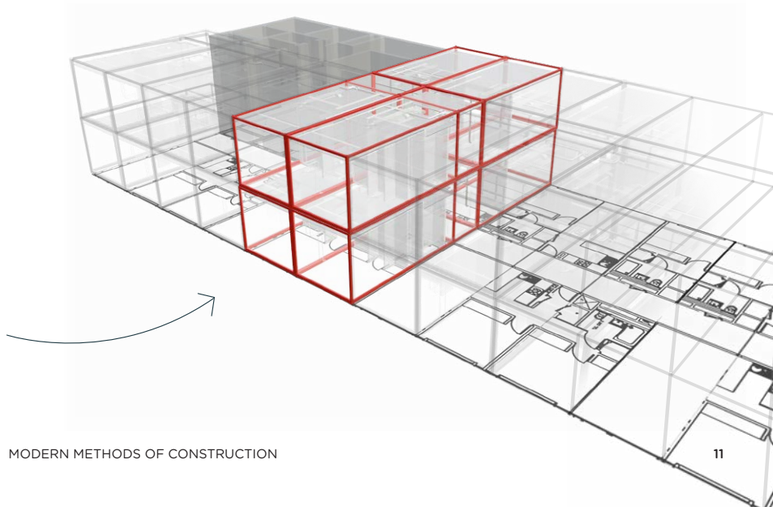
Using the appropriate digital tools enhances the collaboration with architect to rapidly generate building options whilst simultaneously undertaking early engineering analysis to evolve them.

These tools will take into full consideration the site, logistics, access, infrastructure services, MEP (Mechanical, Electrical, and Plumbing) services, buildability, maintenance all the way to tender conditions and reviewing IFC (Issued for Construction) packages to ensure that MMC is implemented and that clients get the full value from their investment in MMC. We're able to run multiple iterations of these, collecting the data and resenting the optimum solution based on any combination of key criteria.

Developers can join the design journey and explore multiple options in real time. They are able to make informed value decisions about where to invest and where to save and to demonstrate the robustness of the proposal in concept, price and programme.

This is a game changer in early-stage design, providing improved transparency and flexibility, leading to better informed decisions earlier in the process.

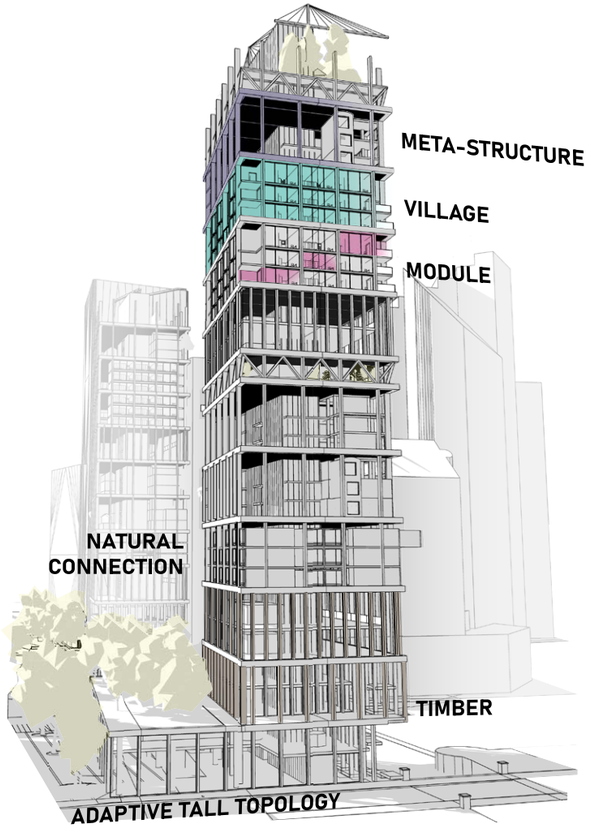
Digital Design with a holistic approach
The use of software packages to enhance collaboration with the design team to rapidly generate building options whilst simultaneously undertaking early engineering analysis to evolve them.

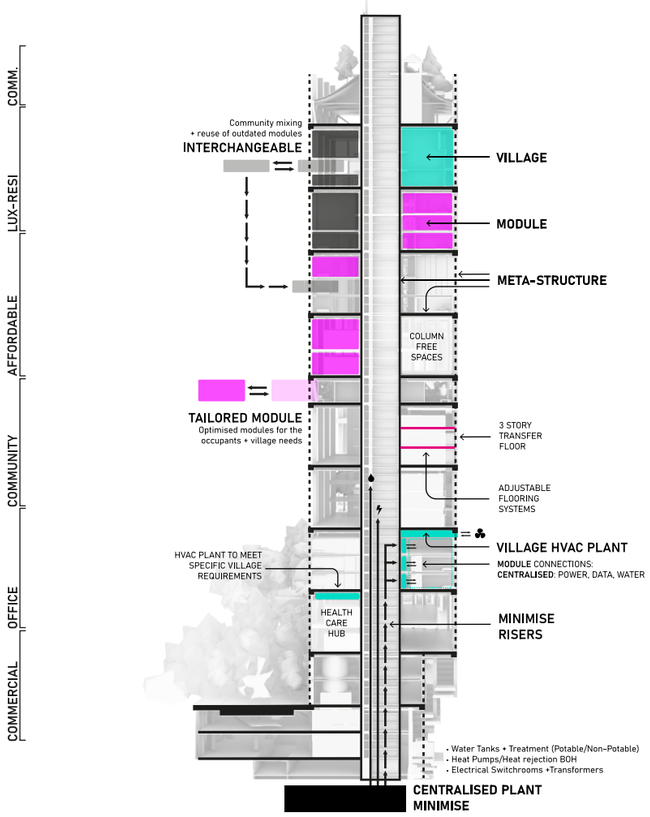


Innovative Modular MEP Design for Bespoke Architecture

Modular building services offer a significant advantage in terms of time and efficiency. These services are installed and fully tested in the factory before delivery to site. Final connections to the central services and drainage through the building are made on site.

Revolutionising building construction, MEP (mechanical, electrical, and plumbing) modular solutions are a game-changer, enhancing efficiency, cost-effectiveness, and sustainability. The off-site fabrication involved in these solutions reduces on-site labour requirements, accelerates project timelines, and minimizes material waste. This results in evident cost-effectiveness through lower labour costs and quicker project completion, ensuring a faster return on investment. Highlighting sustainability, modular MEP systems optimize resource usage and contribute to energy efficiency, aligning with modern environmental standards. The flexibility and adaptability of these solutions allow seamless integration with architectural designs and efficient upgrades.





Ensuring quality assurance is a top priority, with rigorous checks in place to ensure precision and consistency in component fabrication. This approach helps reduce defects and costly rework. As the construction industry embraces innovation, MEP modular solutions serve as a testament to advancing the efficiency, sustainability, and adaptability of contemporary buildings.

The Regenerative High-rise (Haptic Architects and Ramboll)
It is built on a modular logic. It has the main structure frame consisting of three-story-high structural decks. Each deck can support either three intermediate floor plates or three levels of versatile pods.

Student Residence at Wong Chuk Hang

Modular Construction in Hong Kong

The Student Residence at Wong Chuk Hang, University of Hong Kong (HKU), is one of the first examples of the implementation of Modular Integrated Construction (MiC) in Hong Kong.

With a gross floor area of approximately 25,000 m^2, the project comprises two 20-storey modular buildings, featuring two 17-storey modular towers supported on a non-residential three-storey podium. Utilising 952 MiC units with only five variations of module sizes, the Student Residence at Wong Chuk Hang prioritises efficiency, streamlined construction timelines and cost effectiveness.

The MiC units were prefabricated and prefinished at a modular factory located in mainland China and subsequently transported to Wong Chuk Hang for onsite installation. The podium, which consists of a large multi-purpose hall, recreation rooms, library and activities room, serves as a transfer system for the above modules and is designed and constructed using conventional reinforced concrete construction method. Reinforced concrete core walls are located at the centre of these buildings to serve as the lift core, fire staircases and MEP services as well as providing lateral stability.

Citizen M Hotel

Tower Hill UK

Lightweight construction was key. The new load paths from the new modular hotel had to compare favourably with the previous load from the office and the capacity of the existing station structure.

Modular construction was adopted to reduce weight, speed up construction, enhance quality and reduce wastage on site. The modules were manufactured in Poland, stored off-site in the Port of London dockyards, then brought into the City during the night for installation on site.

As part of the development agreement with London Underground, new step free access has been formed for the station. There are two ticket offices, one under the new hotel and the other through a separate building to the south. Each location has a new lift and stair access from platform to ground level.

Epilogue

The construction industry is undergoing a transformative shift as it embraces innovative techniques aimed at enhancing efficiency, safety, and environmental sustainability. Traditional construction practices have long been criticised for their inefficiencies and detrimental impacts on both the environment and site-specific ecosystems. In response, Modern Methods of Construction (MMC) is emerging as a viable solution to address these challenges. MMC not only promise to streamline construction processes but also hold the potential to significantly reduce the ecological footprint of building activities. By focusing on off-site manufacturing and modular assembly, these methods are poised to revolutionize the way we approach construction, paving the way for more sustainable and ecologically mindful building practices.

Bella Sky Comwell Hotel, Denmark (3XN & Ramboll)
The Bella Sky Hotel consists of two towers leaning in opposite directions at a gravity-defying 15-degree angle. The superstructure consists entirely of prefabricated elements.

1. Traditional construction sites are inefficient, unsafe, and destructive to the ecology of the site. More damage is inflicted to the ecological civilisation of some sites during construction, than is the case from the permanent works. This negative dynamic can change for the better if sites are transformed into places of assembly of large pre-finished modular units. MMC goes a long way towards achieving this.

2. Off-site manufacturing of multi-features and layers of construction, from the structure to services, to finishes, facade, etc, can better deal with the waste arising from these activities at source in the factory. This helps shorten the recycling and reuse process in the manufacturing yard under better and well-automated conditions.

3. Studies have been performed on the actual impact of MMC on the embodied carbon footptint of buildings built using the method. Research studies show conflicting data about whether MMC reduces or increases the embodied carbon footprint; further studies are needed in this area. We are currently engaged in one such study with a group of academic researchers, and will share the resulting insight in due course. Current indications from the work done by Team-Ramboll in this space, indicates that carbon savings can indeed be achieved with MMC.

4. Regeneration of the biodiversity and natural features of sites can be better retained and regenerated if construction activities tread lightly on site. MMC can be an agent of change in this respect.

5. MMC also requires modernisation of the Methods of Contract Procurement. Whereas the traditional design and contract procurement processes are linear, and based on the completion of early design stages (concept, schematic, design development, detailed design, and tender documentation). Before a construction contract can be meaningfully procured, MMC requires much earlier engagement of contractors as part of the design and procurement team. Current attempts at modifying the traditionally sculpted contract procurement methods to accomodate some element of design input by contractors (for example in the case of Design & Build contracts), these need to be completely overhauled in a manner that they are bespoke to the essence of MMC.

Ramboll is a global engineering, architecture and consultancy company founded in Denmark in 1945. Across the world, our 18,000 experts create sustainable solutions.

We combine local experience with a global knowledge base to create sustainable cities and societies, driving positive change for our clients, stakeholders and society. We enable our stakeholders to realise their goals and navigate the transition to a more sustainable future.

Bright ideas. Sustainable change.

DESIGN is a periodical publication by the Design Excellence Board (DEB) within the Buildings Market in Ramboll.

The publication promotes and articulates latest ideas on matters relating to design, technology, environment and ethos within the design industry and the built environment, at large. It aims to address key issues facing contemporary design professionals, including our evolving relationship with the natural environment; as well as pressing political and social agendas for the built environment.

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