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CRC#31

**DEMISTIFYING VOLUMETRIC
CONSTRUCTION: A STUDY OF THE
BATHROOM POD**

FINAL PROJECT REPORT – EXECUTIVE SUMMARY



MONASH
University



Australian Government
Department of Industry,
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AusIndustry
Cooperative Research
Centres Program

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CRC#31 Demystifying Volumetric Construction: A Study of the Bathroom Pod

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- University of Melbourne
- Queensland University of Technology

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EXECUTIVE SUMMARY

Part I: The Design-led Overview

The findings of this research project illuminate the many aspects of bathroom pod delivery, in the first steps towards 'demystifying' the approach, as suggested in the project title. Some interesting findings from Part I are summarised below:

1. **There is conflicting information about the bathroom pod value proposition.** Anecdotally there is a long list of benefits to using bathroom pods in construction projects, reflected in the 10 value propositions commonly cited on bathroom pod company websites: high quality; time savings; cost savings; certainty around quality, time, and cost; design flexibility; fewer defects; reduced in situ work; sustainability; simple management; and after sales services. However, there is some contention around whether these claims are true, and little quantifiable data available that considers the costs and cost savings of bathroom pods in light of other indirect benefits that a volumetric approach might bring to a construction project.

2. **Holistic quantification of bathroom pod benefits is lacking.** The research did not find a holistic and empirical quantification of bathroom pod costs and benefits when compared with in situ approaches in the literature. Direct quantitative savings and additional costs should be considered in conjunction with indirect costs and savings, and further qualitative benefits should be factored in.

3. **Multiple and varied approaches exist to business model, design, and production strategies; there isn't a one size fits all.** The research finds varied approaches to the following, each with its benefits and disadvantages:

- Company origination pathways
- Business context (affiliation with other companies and position in construction value chain)
- Product diversification strategies (within and outside of construction)
- Design approach and degree of product standardisation
- Structural material (and regional trends regarding pod characteristics)
- Degree and quality of pod finish
- Installation methodology
- Uptake of digital technologies and automated factory processes

The resulting spectrum of potential combinations is perhaps one reason for lack of empirical and generalisable data on the bathroom pod value proposition.

4. **Standardisation is recommended in the literature, but it is not the most common approach in the industry, and it may not necessarily lead to a cheaper product.** While the literature advocates standardised designs, components, and processes, bathroom pod companies are more likely to offer custom layout and finishes than a standard, pre-designed product, and most companies promote design flexibility as a key value proposition. Interestingly, younger companies are more likely to offer custom layouts and finishes over standard layouts and finishes. Further, the surveyed companies who responded that they offer a standard product design did not always offer the cheapest product for their region.

5. **There are many barriers to broader uptake of bathroom pods in the local context, some of which are related to the nature of current industry skills and structures, and others stem from the impact of bathroom pods on the nature of project delivery.** Regarding incentives for greater uptake, the following are deemed important to consider: (1) the changed scope of work and altered cost / profit margin / benefit distribution; and (2) regulations and clear compliance pathways / inspection procedures developed specifically for off-site construction.

Part II: The Production Strategy

Bathroom pod manufacture comprises four major blocks of work:

- *Design output.* Design freeze is typically 3-6 months prior to production commencing. The manufacturing facility must be tuned with the type of variants, number of variants, volume per variant, and materials in the design variant.
- *Supply chain, procurement and subcontracting.* A multi-faceted problem with direct ramifications on the quality, time, and cost of production. The customer order decoupling points in individual supply chains are found to be crucial in determining the extent of design flexibility that could be offered by the pod company through their existing production facility.
- *Manufacturing.* Can broadly be divided into: factory setup; data management and software; and quality control & defects monitoring.
- *Outbound logistics and site installation.* Can be broadly divided into the following categories: transportation and handling & erection; communication and coordination; and quality control & defects rectification.

The design variations for bathroom pods in a given project and the number of units per design variant are crucial in justifying the costs of off-site manufacturing as low volumes per design variant can prove challenging. The materials and the structural systems of the pod are directly linked to the nature and amount of work involved in the factory. The research highlights the need for close collaboration between the business, design, and manufacturing team to achieve the desired value propositions out of the bathroom pod business. Value offered by the off-site manufacturing of bathroom pods based on published case studies, literature analysis and market review include:

- the cost of producing the bathroom pod;
- construction schedule savings compared to in-situ bathroom construction;
- simplifications of bathroom production tasks in off-site manufacturing; and
- sustainable production.

Schools, hospitals (government-backed sectors), hotels, and multi-storey residential (higher margin private sectors) see the largest uptake of prefabricated bathrooms. Light gauge steel (LGS) framing dominates the structural typology across small, medium, and high-volume production pod companies. Other materials such as concrete, timber, fibreglass, and other composites are also found to be prevalent. Average levels of robotics and automation through modern methods of construction are found to be lower in low-volume producing companies with some exceptions. High volume producing companies are typically found to implement some of the modern methods of construction through BIM-ERP system integration and robotics with fair levels of product standardisations through the catalogue approach.

Part III: The Business Model

The salient features contributing to the viability of a bathroom pod company are:

- *Entering into a partnership* or working with other businesses (suppliers, contractors);
- *Knowledge and understanding of the clients' needs*, and the market segment to determine the types of products offered, and the associated value offerings; and
- *Industrial production* and in particular, automation. This involves high initial investment related costs however, all six (6) case study companies studied claimed to be involved in medium to large-scale industrial production with some degree of automation.

The main considerations or factors influencing the use of bathroom pods in a building project include: (1) certainty in product delivery; (2) management simplicity, consolidated trades and a single point of contact; (3) efficiency in energy use, and sustainability outcomes such as less waste; and (4) product quality.

PROJECT OVERVIEW

This report summarises the research activity conducted in *CRC Project #31 Demystifying Volumetric Construction: A Study of the Bathroom Pod*.

1. Background

Volumetric construction offers the promise of compressed construction cycles, greater quality control, and reduction in waste (material, energy, time). However, increased transportation costs, redundancy of structural components, and increased overheads can dilute the cost savings of volumetric approaches, limiting their viability and therefore uptake.

Within the Australian construction industry, the bathroom pod is one of the few volumetric assemblies which is considered an acceptable method of delivering bathrooms in buildings containing a high degree of repetition (for example, high-rise accommodation, student housing, hospitals etc), however the approach is not yet widespread. This project examines volumetric construction through the lens of the bathroom pod in order to understand:

- the extent to which planning, design, management, production and delivery is rationalised;
- where and how value is generated;
- how the above can be leveraged to increase the viability of volumetric construction.

The industry partner on this project, Lendlease, has extensive experience in the design and delivery of bathroom pods. Bathroom pods have featured in projects that Lendlease has been involved in as developed, designer, and head contractor, and between 2014-2018, the organisation was producing its own bathroom pods in a factory in Brisbane – through a wholly-owned subsidiary called Australian Modular Fabrication (AMF). This project documents and extends some of the learnings from the AMF venture to shed light on the complexities of volumetric construction.

2. Aims and Objectives

The project aims to identify:

- the critical factors affecting the viability of volumetric construction;
- how these factors are related to context and to each other; and
- how they can be addressed through different business models, design, and production approaches.

The resulting framework provides a comprehensive collection of considerations to be investigated and addressed.

3. Research Team and Report Structure

The CRC#31 research team comprises experts from:

- the Future Building Initiative (FBI), Art, Design and Architecture, and the Faculty of Engineering at *Monash University* (MU);
- the Department of Infrastructure Engineering at the *University of Melbourne* (UoM); and
- the School of Economics and Finance at *Queensland University of Technology* (QUT).

The CRC#31 project work was therefore divided into three research streams, each with a distinct focus, presented in this report as separate chapters: *PART I: Design Considerations* (MU); *PART II: Production Study* (UoM); and *PART III: Business Model* (QUT).

4. Research Approach

The multifaceted research approach adopted in this project included:

- *Literature review.* Academic and industry publications about volumetric construction, as well as those specifically addressing prefabrication of bathrooms were reviewed to understand the processes involved in prefabricating bathrooms, commonly encountered challenges, and opportunities for value-add.
- *Market mapping.* A range of Australian and international bathroom pod companies were identified through web searches. Information captured from company websites was used to analyse and compare the spread of business-, design-, and production-specific strategies represented in the identified range of companies (for details, see Part I, Section 03).
- *Online Survey.* A questionnaire was developed to capture high level business-, design-, and production-related information from the companies identified in the market search. Seventy companies were invited to participate and of these, 13 responded (for details, see Part I, Section 04).
- *Case studies.* A select few interesting companies were chosen for further study, to better understand salient features of the varied approaches identified in the market mapping and online survey (for details, see Part II, Section 05).
- *Interviews.* Interviews were conducted with 4 stakeholders in the bathroom pod value chain for further insights to the nature of project delivery using bathroom pods, and the key considerations involved. The interview participants were:
 - A representative from Lendlease's subsidiary *bathroom pod company*, AMF
 - A representative from the Lendlease *development team* with experience of AMF and other bathroom pods
 - An *architect* with experience designing with Lendlease's (AMF) bathroom pods, as well as others' pods.
 - A *head contractor* operating in Singapore, where prefabrication has been incentivised, and to a certain degree mandated by the local authorities.
- *Fortnightly conversations* with industry partner liaisons, Karl-Heinz Weiss and Steven Huang, to capture and reflect on organisational knowledge and experiences.

These core research materials feature in the analyses of the three research streams (see Parts I-III) in various ways, and work together to shine light on:

- Bathroom pod geographic and market trends.
- Which market sectors bathroom pods are currently predominantly being used in.
- Existing spectrum of bathroom pod company size and production volume.
- Evolution trajectories and approaches of successful business pod businesses.
- The different business contexts in which bathroom pod companies are operating.
- Value proposition: how companies are marketing their products and services.
- Standard vs. bespoke design offerings available on the market.
- The kinds of constraints bathroom pod design and delivery are governed by.
- Key challenges in adopting a bathroom pod approach.
- Existing material and production strategies, and factory-to-site ratio of activities.

5. Limitations

Throughout the duration of the project it was necessary for the research approach to change due to the limited direct access to currently operating bathroom pod companies. The initial research plan was to engage a small number (6-10) bathroom pod companies for detailed case study via interviews and workshops, as well as factory visits. This would have enabled deep insight to company design and production operations, and how these have shaped and been shaped by the business model. The idea was to document and compare the vastly different business, design, and production strategies existing in the industry, to reflect on successful combinations and what these could tell us about the reality of volumetric construction viability. However, several months in to the project it became apparent that the research team would not be given this level of access, as no company was willing to participate in such a detailed study. As a result, it was necessary for the research approach to change, working with the limited data that was available: company websites, survey data of 13 companies who participated, a small number of one-off interviews, and literature review.

It is likely that the involvement of our industry partner in this project, Lendlease, hampered external companies' willingness to participate. As the research has identified, some bathroom pod companies are established by larger organisations already operating in construction as either developers, head contractors, or both, making them direct competitors to Lendlease (especially if located in any of the global regions within which Lendlease operates). It is therefore easy to understand the unwillingness of these companies to share details of specific company approaches, or what they might consider to be the secrets to their commercial success.

Further, even if Lendlease were not involved, it is unclear whether access to the research findings would be strong enough incentives for such companies to be involved in the kind of research activities that were proposed in this project. This is something that should be seriously considered in the development of future CRC projects aiming to document and analyse the current state of industry in a detailed way. In these types of research projects, the depth of insight is limited without meaningful industry collaboration, the methods for which have not yet been fully understood, documented, or resolved.

6. Future Research

Please refer to Parts I, II, and III for future research opportunities identified within the respective research.



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