Regulatory barriers associated with prefabricated and modular construction

Briefing Paper

November 2021

Preface and acknowledgement

Swinburne University of Technology (SUT) is undertaking research and development work on regulatory barriers for off-site construction focusing on prefabricated and modular buildings.

The project is commissioned by the Housing Industry Association (HIA) on behalf of the Advanced Manufacturing Growth Centre's Prefab Innovation Hub. HIA are the project sponsors.

This work forms part of series of projects being supported by the Advanced Manufacturing Growth Centre Prefab Innovation Hub.

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1 Purpose of this Briefing Paper

This project aims to develop a report that identifies and analyses the regulatory barriers for off-site construction.

The report will investigate the identified issues in detail and seek to identify recommendations and/or proposals to overcome the barriers to enable more tailored planning and building regime that recognises off-site construction systems.

Recommendations may include: changes to the National Construction Code (NCC), Australian Standards and State planning and building regulatory frameworks.

This briefing paper is part of the **first phase** of the project providing background information and identifying key issues that have been identified by the project team.

It is shared with targeted stakeholders to assist with the consultation phase of the project which involves interviewing and/or surveying the interested parties to further identify and examine regulatory barriers for off-site construction.

The **second phase** of the project will include a final report which will incorporate the findings from the consultation and recommendations for further work and/or proposals for addressing the identified regulatory barriers.

Responding to this Briefing Paper

Interested parties are encouraged to review and respond to this Briefing Paper.

There are various questions posed throughout this paper to assist in highlighting areas that respondents may wish to provide feedback on.

However, if you would like to provide feedback on other regulatory issues not discussed in this paper or would like to provide your own specific feedback on items relevant to this project, this feedback would be welcomed.

There are two choices in responding to this Briefing Paper:

1. Provide a written response to hia_technical@hia.com.au
2. Responding to the survey on the HIA website www.hia.com.au which contains the relevant questions posed herein.

Responses are requested to be provided by COB Thursday 27 January.

For further information on this project or the work in the series of projects being supported by the Advanced Manufacturing Growth Centre Prefab Innovation Hub please contact Simon Croft, HIA Executive Director Building Policy and Building Services at hia_technial@hia.com.au .

2 Introduction

2.1 Background

Australia's building codes and standards, along with the regulatory systems that apply to zoning land and approving the construction of buildings, are written based on traditionally (conventionally) constructed buildings, products, practices and systems.

As a result, they introduce challenges with regulatory acceptance and approvals with respect to off-site construction methods, including prefabricated (prefab) and modular construction.

This can be time consuming and costly and results in inconsistent outcomes for industry and consumers, with the potential for non-approval. This can also result in manufacturers and suppliers being hesitant to bring new products and systems to market given the inconsistency and uncertainty.

The regulatory system for building practitioners is already very complex to navigate for conventional construction and it is even more of a complex web for prefab and modular construction.

In addition, the regulatory requirements for small scale residential construction and financing by home buyers also fail to recognise alternative construction methods (such as prefab and modular construction) and contract arrangements making finance for new homes difficult.

Given the likelihood of a steady increase in fast-tracked building construction, a vast number of construction projects including housing, will move to off-site and modular or systems-based construction methods over the next 5, 10 and 20 years.

It is critical that there is a clear understanding of the regulatory barriers that exist today and that potential solutions are identified now.

These regulatory systems will need to be updated and revised to remove the unnecessary barriers and enable greater uptake and recognition of the suitability and effectiveness of prefabricated and modular construction and facilitate an appropriate and streamlined process for approvals.

2.2 Project objectives and scope

2.2.1 Objective

The objective of this project is to identify regulatory issues that need to be addressed and potential opportunities to facilitate the use of prefab and modular construction in Australia.

This report will form the basis for further discussion with all relevant stakeholders to formulate recommendations to relevant authorities to identify areas of regulatory reform that will need to be updated and revised to remove the unnecessary barriers and enable greater uptake and recognition of the suitability and effectiveness of prefabricated and modular construction.

2.2.2 Scope

The project will examine regulatory barriers for residential buildings (single dwellings) and low- to mid-rise buildings (multiple dwellings).

The aspects of the regulatory requirements which will be explored includes:

- planning and building approvals,
- building codes and standards,
- testing and certification,
- client finance,
- relevant work, health and safety matters,
- transport, and
- other local government regulations (e.g. manufactured homes).

Temporary structures or other temporary or short-term accommodation buildings are not within the scope of this project.

3 The need for a definition

Many terms are used and have been used when referring to modular and prefab construction and similar off-site or pre-manufactured homes and building elements.

Off-site construction, also referred to as off-site manufacturing (OSM) or design for manufacture and assembly (DfMA), refer to a method of construction of buildings with components that have been fabricated 'off-site' or away from the building location.

These buildings typically have prefabricated or modular components and are commonly referred to as prefab or modular buildings.

For the purpose of this paper the terms modular and prefab construction will be predominantly used.

It should be noted within this context the terms modular and prefab construction and within this project and identifying regulatory barriers, construction types such as 'tiny homes', 3D printed homes, bathroom and kitchen pods and multiple purpose/function building elements are all within the scope of discussion for this project.

However, it is likely that different and more nuanced solutions would be needed to the different types of modular and prefabricated construction.

From regulatory perspective, a definition or classification enables appropriate and effective measures necessary for each class of products to achieve compliance and quality assurance.

Classification can be used to determine the level of pre-fabrication. There are three basic types of prefabricated systems (see Figure 1):

- Simple components (1D prefab): most components in construction involve some form of prefabrication for ease of on-site erection, for example steel beams and columns manufactured to be easily bolted on site. The compliance and quality assurance processes for these products are well established.
- Panelised systems (2D prefab): assemblies of components designed for ease of transport and erection. Panelised systems vary from basic system design to serve a specific purpose such as structural panels for roofs, walls and floors, internal/external cladding system to complete panel systems to serve multi-purpose.
  How to assess the level of compliance and quality of these off-site products could become problematical for complete panelised systems.
- Modular systems (3D prefab): this term is often reserved for pre-assembled three-dimensional products varying from single utility units such as bathroom pods or prefab classroom to a full residential unit (an apartment or a house). The technical evaluation of these units is problematical since the regulatory system was not designed for this type of products.

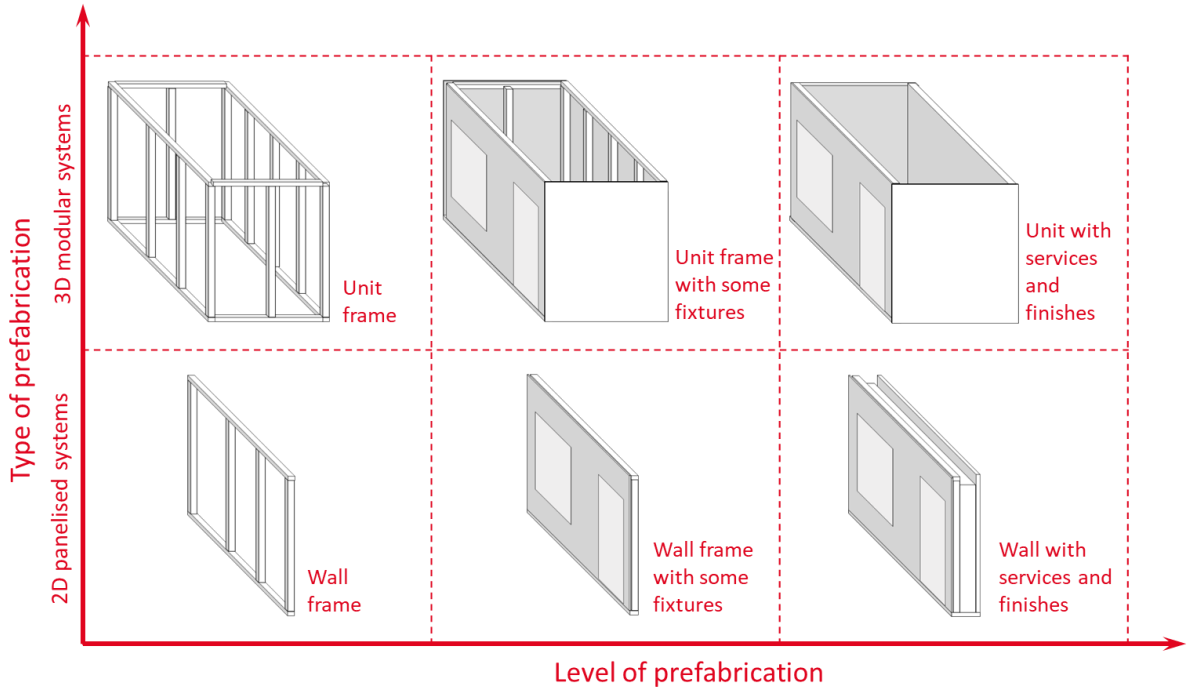

Figure 1: Type and level of prefabrication

The classification in terms of the source of fabrication may also be important.

Products that are manufactured overseas, they face another layer of regulatory barriers associated with imports on top of the usual building control measures which is already difficult to implement for the lack of access.

Issues/Questions - Definitions

- Do you have preferred terms to be used for regulatory purposes?
- Should we promote the use of a fixed set of definitions based on level of prefabrication for technical and regulatory use?

4 Identifying the Issues

4.1 Australian research

The construction of prefabricated and modular housing in Australia has been increasing over the last decade. Multiple initiatives have taken place to assist with the development of off-site construction in Australia, including:

- **prefabAUS:** the peak body for Australia's prefabricated building industry, formed in 2012[1].
- **The Australian Research Council (ARC) Training Centre for Advanced Manufacturing of Prefabricated Housing (CAMP.H):** administered by the University of Melbourne[2].
- **Sustainable Built Environment National Research Centre (SBEnrc):** formed in 2010 acts as a research broker between industry, government and research organisations to provide support to the built environment industry[3].
- **Modular Construction Codes Board (MCCB):** published the first handbook for the design of modular structures in Australia in 2017[4].

Much of the research from the above initiatives and other researchers have focused on general barriers or constraints for the uptake of off-site manufacturing, including:

- Financial challenges
- Capacity limitations,
- Transportation and installation challenges,
- Greater importance for project planning and coordination activities,
- Difficult in applying planning and building codes (developed for traditional methods),
- Insufficient government regulations and incentives,
- Negative community mindset,
- Industrial issues and business politics.

While it has been identified that regulatory systems for buildings in Australia require attention to address prefab and modular construction, a consolidated and specific research approach has not occurred to date.

4.2 Overseas practice

Prefabricated housing has gained great momentum in some countries such as Japan and Scandinavian and Northern European countries, and a fluctuating popularity in other countries such as the United States and United Kingdom since post war period.

For most countries the modular industry is still largely regulated by the same codes as conventional construction. However, significant work has been conducted to improve the quality assurance (QA) and compliance of prefabricated and modular products and construction process. Some of these measures includes:

- Third-party certification of factories, products and processes which often involves surveillance and inspections,
- Manufacture self-certification and quality control procedures,
- Product identification and traceability systems,
- Development of tailored standards and guidelines for prefabricated buildings, and
- Schemes to provide assurance to lenders.

4.3 More regulation, tweaking it or more guidance?

Additional regulations may be necessary to facilitate the acceptance of off-site construction.

Care must be taken so that unintended consequences are not introduced, such as making the process too expensive or too difficult.

The aim should be to harmonise the off-site and on-site activities particularly with demonstration of regulatory compliance and quality assurance.

Issues/Questions - Research

- Are you aware of any research on regulatory issues in Australia as a barrier to the development of prefab industry?
- Are you aware of any regulations from any country specifically designed for prefab industry?
- Are you aware of any schemes from any country that facilitate prefab industry and could be introduced in Australia?
- In lieu of changing or making new regulations – is better use of current regulations and more guidance and supporting tools the answer?
- What level of support does the Handbook for modular structures by the Modular Construction Codes Board provide?

5 Australian practice

Residential construction and all other forms of building construction is subject to a raft of regulations and controls based on the planning and building administrative frameworks in place in each state and territory.

With respect to housing, the planning systems in each state and territory appear to pigeon hole a modular home as a manufactured home and not consider their use as a home on a residential block of land.

Planning agencies will at times say the planning system does not have rules and at other times say the rules apply in the same way as they would to a house built on-site.

Some states and territories perpetuate a separate set of building rules for manufactured homes based on the historical caravan park regimes in place decades ago.

Some suggest the National Construction Code (NCC) does not or should not apply, regardless of where the building is located.

Critically prefab and modular housing design is no different to conventionally built houses.

However, the design and construction stages are managed very differently which can lead to different interactions with the planning and building administration framework including the approvals required.

Prefab and modular housing are generally constructed in two stages, described in Figure 2. These stages must be correctly identified for the regulatory approval and inspection requirements to meet the satisfaction of the regulatory body (council or building surveyor/certifier).

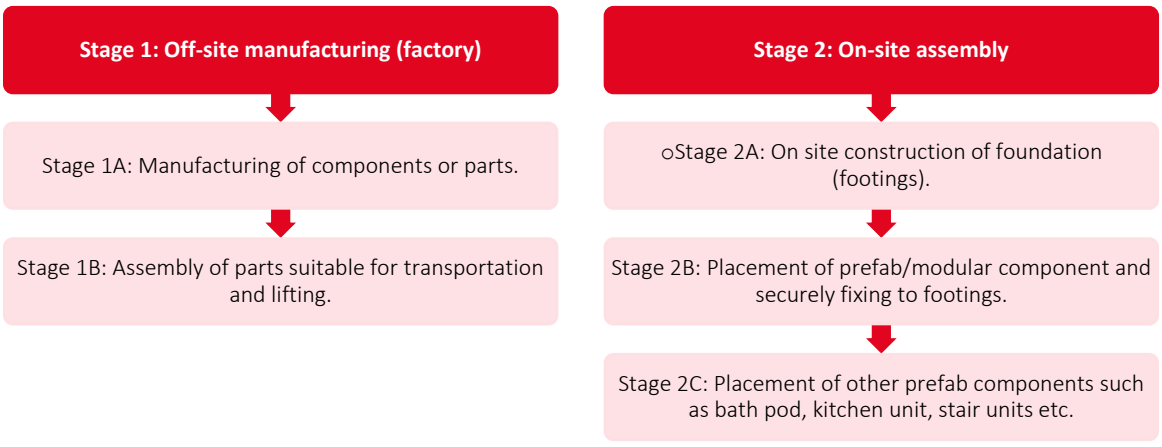

Figure 2: Two key stages of construction for prefab and modular housing

5.1 Contractual issues

Building a home is subject to a raft of consumer laws that impact the contractual arrangement between a builder and a home buyer. These laws broadly assume a home is built on-site and that stages of progress are reached to allow partial payment to a builder.

A prefab or modular home built wholly off-site is treated as a manufactured product with different payment regimes in place, either deposit at the start and full payment at end or full payment before work starts.

Neither of these arrangements suit home lending arrangements in the traditional sense. In most jurisdictions, these same consumer laws will only apply once the work is captured by domestic or residential building law, i.e., most off-site work is not captured and therefore not regulated by these arrangements.

This offers both challenges and flexibility depending on the circumstances of the parties involved.

For example, limits on deposits that apply when carrying out home building work on site will not apply to the manufacture of pre-fabricated building components allowing the manufacturer more flexibility to charge for the works being carried out.

Questions/issues

- Have you had experiences with projects using modular or prefab construction that has been unnecessarily hindered by planning or building regulation? If yes, could you provide details of this.
- Have you had difficulties in obtaining sign off at each stage (e.g., foundations, structure, plumbing, electrical) where elements come pre-assembled? If yes, could you provide details of this.
- Could factory sign off be used as a solution? How about if this factory is not located in Australia?

6 Building Codes and Standards

The planning and building administrative framework in each state and territory calls up the NCC to set the technical standards for the design and construction of buildings in Australia.

The NCC is a performance-based building and plumbing code, meaning the mandatory requirements of the NCC are the Performance Requirements and compliance can be achieved in following the prescriptive Deemed-to-Satisfy Provisions (DTS) or in developing a Performance Solution that can allow for innovative solutions.

Under the DTS pathway the NCC calls up a range of relevant standards (Australian Standards and others) which set benchmarks for the material, design and construction requirements, for example:

- AS 1684 for timber residential construction and AS 1720 for timber structures,
- AS 2870 for residential slabs and footings and AS 3600 for concrete structures design,
- AS 3740 waterproofing of wet areas,
- AS 4100 for steel design and AS 4600 for cold-form steel design,
- AS 4773 for masonry for small buildings and AS 3700 for masonry design.

Whilst a builder and designer could adapt or apply these Australian Standards or the principles contained within them, they have generally not taken into account or specifically designed with off-site and modular and prefab construction in mind.

Similarly, the DTS Provisions of the NCC are written with conventional construction in mind and for products to be generally serving specific purpose to satisfy the NCC rather than a full wall or roof system for example encompassing numerous parts required for NCC compliance.

This leaves builders, designers and manufacturers either trying to make the product fit into the NCC DTS Provisions, developing a Performance Solution specific for the building or some form of a hybrid solution.

This results in inconsistent approaches, uncertainty in approvals and hesitancy to stick with the tried and tested as opposed to bring new and innovative solutions to market.

6.1 Aspects of performance to be addressed and how to demonstrate conformity to requirements

Most issues with prefab are structural issues associated with handling and transport. These can be solved as part of routine design. There are a few more complex issues for high-level prefab (complete panel or modular unit) to be explored.

A high-level prefab product will require multiple aspects of performance to be evaluated, for example a complete wall panel will have to satisfy structural requirements, fire requirements, acoustic requirements, water proofing requirements (if external).

Furthermore, imported products may require specific installation procedure (that may be implicit in the traditional practice of the country of origin), without which it will not perform as expected (example Japanese window units perform badly when installed in Australia/New Zealand).

6.2 Building product conformity

In conjunction with the detailed design and construction requirements of the NCC and Australian Standards, a core component is requirements for building product testing, certification and approval (building product conformity).

The NCC contains building product conformity requirements under the 'evidence of suitability provisions' which lists product evidentiary requirements and ways for which a material, product, design or form a construction to demonstrate compliance with the NCC[5,6].

Many of the Australian standards referenced in the NCC contain testing requirements for products to show compliance with that standard.

Under these provisions the NCC provides a number of ways to demonstrate compliance these are:

- A CodeMark certificate of conformance,
- A certificate of accreditation under a state government certification scheme (where one exists),
- A test report by a National Association of Testing Authorities (NATA) lab,
- A certificate issued by a certification body accredited by the Joint Accreditation System of Australia and New Zealand (JAS-ANZ) – this includes industry schemes such as ACRS and EWPAA schemes,
- A certificate or report by a professional engineer or other appropriately qualified body,
- Another form of documentary evidence such a Product Technical Statement or Technical Appraisal.

Whilst this framework exists and could apply to singular modular elements or full systems there are shortcomings to this. For example, NATA and JAS-ANZ will generally accredit a testing lab or certification body to issue certificates or reports against a scope of accreditation to specific Australian Standards.

Furthermore, the way the NCC and Australian Standards have been designed are generally requiring testing or approval against specific tests for say fire or acoustics not both in the same test. Hence that product requires multiple tests to show full suite of NCC compliance rather than holistic performance of the completed element test.

Similarly, given the NCC and Standards are written generically, many of the modular and prefab construction products and systems differ greatly from manufacturer to manufacturer, so a single standard or specification may need to be developed specifically to that product which is not an approach used elsewhere.

These items highlight some of the challenges associated with building codes and standards provisions with regards to modular and prefab construction that will need to be resolved to facilitate more streamlined set of rules and approvals of these systems.

Issues/questions – Building codes and standards

- ❖ What aspects of the planning and building codes are difficult to apply for prefab and modular buildings?
- ❖ Do any improvements or changes need to be made to existing Australian Standards or should there be specific Australian Standards developed for modular and prefab construction?
- ❖ Should the NCC have a dedicated Section dealing with prefab and modular buildings or should this be left to Performance Solutions?

- Should compliance be left to developing performance-based solutions?
- What method is currently used to demonstrate conformity and quality assurance? (e.g., self-certification, third party independent product certification, factory and production certifications, traceability measures (e.g., product identification methods – barcodes, QR codes)).
- How effective do you think the method to demonstrate conformity and quality is?
- Is it feasible to use CodeMark for evaluating prefab and modular products or should we set up specific body to perform the task for better efficiency?
- Do we need on-site validation as a means of certification as a fully assembled structure?
- Would development of prototypes for testing and certification be a means to overcome certification and testing issues?

7 What is holding us back?

The success or failure of any enterprise is dependent on three factors: motivation, capability and opportunity. The limitations against these three factors are described in Figure 3.

Lack of motivation	Lack of capability	Lack of opportunity
□**Investor**: no money to be made, market not big enough, not familiar with 'modular' buildings; □**Builders:** not familiar with the concept, not prepared to invest on new technology unless there are some incentive; □**Tradies**: not familiar with the concept and threat to some traditional trades, do not want to invest unless there is some incentive; □**Designers:** not familiar with the concept, do not want to invest unless there is some incentive.	□**Builders:** not big enough, require many trades; □**Tradies:** do not want to undertake further training/upskilling, □**Designers:** do not want to undertake further training/upskilling, more factors to be considered (e.g., transport, handling, lifting etc.); □**Fabricators:** require more knowledge and skill for fabrication; □**Regulators:** doesn't easily 'fit' into current regulatory systems - implementing change is difficult and takes time.	□**Regulators:** □***Planning regulatory barriers:*** e.g., limiting height of construction/type of buildings are indirect regulatory barriers to modular; □***Building regulatory barriers:*** e.g., NCC limits specific construction type for fire reasons which becomes a barrier to some and not others, and increasing difficulties in obtaining approval for performance solutions.

Figure 3: Factors holding back the uptake of prefab and modular buildings

Questions/Issues

- In terms of motivation, opportunity and capability, what is the main factor that is holding us back?
- Should we view regulation as a barrier or as an opportunity?
- Do our regulatory and QA systems have the appropriate capabilities for prefab industry?
- Do we need more awareness (recognition) programs of prefab/modular construction (e.g., through schools and universities)?

8 Identification of regulatory barriers

8.1 Chain of custody

With prefab/modular construction the components (parts) are either made in a factory by the builder or it's supplied by a subcontractor and assembled either by the builder or subcontractor in the factory. Hence the chain of custody varies with project to project. In general, the following applies:

- Builder (main contractor): is responsible for planning and implementing all the activities involved in the construction of the building, including undertaking of the on-site construction and installation work. The builder is responsible for everything.
- Architect and design engineer: is responsible for the design of the building and to meet the requirements set by the NCC and other applicable standards/specifications.
- Prefab/Modular manufacturer/supplier: is responsible for the prefab or modular component (product).
- Subcontractor: is responsible for on-site construction and installation work which is outside of the expertise of the builder (e.g., mechanical service workers, electricians and plumbers).
- Building surveyor/certifier: is responsible for providing independent oversight of the building construction process and ensure upon completion the building is safe and meets all necessary requirements. They assess and approve applications for building permits, undertake inspections of building/building work and approve building occupation.
- Government authorities: is responsible for granting planning and building approvals (e.g., local council and state regulators).

Furthermore, the temporary works engineer must be deployed by the appropriate manufacturer/assembler/ subcontractor/builder for the following activities:

- Fabrication and assembly: the builder/subcontractor must ensure all workmanship is certified by engineering representative.
- Storage: the builder/subcontractor must ensure that the storage of components is designed/certified by the engineering representative.
- Transportation: components must be designed to withstand additional loads from the required mode of transportation (e.g., road, rail, sea or air). This must be designed and certified by engineering representative.
- Installation: lifting certificate must be issued by the engineering representative for installation of components in the factor or on-site.

Chain of custody plays an important role especially if issues arise such as damage to components. The type of problems varies with the degree of prefabrication and off-site construction. It is critical that fully assembled modules are checked on-site by certified engineers/architects prior to installation.

If a component is damaged, the responsible party needs to be identified and the components must be returned to the factory for assessment and repair.

If damage occurred during transportation; the transportation company is responsible, however, the engineers must demonstrate that all precautions have been taken to minimise damages due to

additional imposed actions during transportation. It's also necessary to ensure that the component was not damaged prior to transportation, if so, the manufacturer/supplier would be responsible.

8.2 Steps that require regulatory acceptance

The critical stages for the construction of a building that requires regulatory acceptance and the responsible party is shown in Table 1.

Table 1: Stages of construction requiring regulatory acceptance

Construction stage	Regulatory requirements	Responsible party
Planning and conceptual design	Development approval.	Submitted by builder/designer on behalf of the owner and typically granted by local council.
	Funding approval/bank guarantee.	Submitted by owner/developer.
Detailed design	Demonstration of compliance with the NCC performance requirements, including deemed-to-satisfy solutions and approval for performance-based solutions.	Completed by architect/engineer and approved by building surveyor.
Building work on-site	Building approval.	Submitted by builder/designer and typically granted by local council.
Manufacture of off-site components	Manufacturer quality assurance procedures.	Manufacturer and supplier.
	Inspection of components once completed and assembled.	Authorised inspector/supervisor reporting to the building surveyor.
Transportation from factory to site	Approval for transportation, including heavy vehicle requirements.	Temporary works engineer employed by the builder/work safe.
Storage on site	Approval for storage of components on site.	Project engineer representing the builder.
Installation of prefab/modular components	Inspection of modules prior to installation.	Project engineer representing the builder.
	Temporary works.	Temporary works engineer representing the builder.
	Work safe requirements prior to installation.	Temporary works engineer representing the builder.
	Inspection of modules during installation.	Project engineer representing the builder.
Installation of MEP	Certification of products.	Licensed mechanical service worker, electrician and plumber.
Installation of finishes (partition walls, doors, flooring etc.)	Certification of products as necessary.	Licensed trade person as necessary.

Questions/Issues – Regulatory acceptance

- Do you think the responsibilities and roles of stakeholders in the supply chain for prefab is clear?
- What is the current practice with respect to chain of custody?
- Who is responsible for ensuring the quality of the final product?
- Who is responsible for defects (builder, subcontractor, or prefabricator)?
- What are the differences in regulatory compliance between on-site and off-site construction? Are there 'grey' areas that require clarification?
- How long does the regulatory acceptance process take for prefab/modular buildings? And how does this compare with conventional buildings?
- How do you think the regulatory acceptance process can be improved?
- Are the regulatory bodies prepared to accept prefab/modular for housing & residential construction?

9 Summary of key issues for further discussion

Australian planning and building regulations have been written based on traditionally on-site construction and can become barriers for off-site construction, including prefab and modular buildings, due to unintended consequences.

Typically, alternative solutions are necessary to demonstrate compliance which can be time consuming and costly and result in inconsistent outcomes for industry and consumers, with the potential for non-compliance and hence non-approval. The key issues that have been identified thus far are:

- Definitions and applicable regulations: Multiple terms are used for different levels of off-site construction work for buildings. There seems to be confusion about what rules need to be followed during the planning phase, for example whether the building needs to follow the requirements of the NCC, similar to a house built on-site, or separate set of rules specific such as those applicable for a 'manufactured home' which follows the historical caravan park regime.
- Demonstration of compliance and quality assurance: High-level prefab/modular components are likely to require performance-based solution (PBS) to demonstrate performance requirements which can be challenging, especially since there is currently a general problem with PBS for construction products which is not limited to prefab/modular construction.

  Quality assurance is also critical for high-level off-site construction work as it becomes difficult to undertake adequate on-site inspection of prefabricated and modular components. It is uncertain if the current Australian product conformity assessment framework is adequate in dealing with the growing demand of prefabricated and modular construction.
- Project planning and design: Prefab and modular buildings typically require more thorough planning, early completion of engineering design (with less flexibility for design changes after finalisation), and extensive coordinating of activities. These factors can result in different interactions with the planning and building administration framework including the approvals required.
- Chain of custody: It is not clear if the roles and responsibilities of stakeholders in the supply chain for prefab and modular construction is well defined. Chain of custody becomes particularly important when issues arise, such as damage to a component or incompliance, for accountability of responsible stakeholders is necessary.
- Transportation, storage and installation logistics: Careful consideration needs to be given to the transportation, storage and installation of the prefab and modular components and to ensure work safe requirements are adhered.
- Client finance: lenders don't recognise off-site construction methods and are structures based on progress payments of different state of on-site construction making finance arrangements difficult for prefab and modular homes.

Questions/Issues

- ❖ A collection of issues has been identified in each chapter. Are there any other factors that need to be considered? What are the key issues in your opinion?

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