

MARKET ACCESS

*A Cost Comparison Between
Multi-Residential Prefabricated Timber
Frame and Precast Concrete Construction*

Project number: PNA308c-1314

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**Forest & Wood
Products Australia**

A Cost Comparison Between Multi-Residential Prefabricated Timber Frame and Precast Concrete Construction

Prepared for

Forest & Wood Products Australia

by the

**Centre for Sustainable Architecture with Wood
(CSAW)**

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Executive Summary

This report analyses the cost differences between two residential accommodation projects recently completed on Australia's eastern seaboard. One project was built using conventional precast concrete panel construction and the other utilised innovative prefabricated timber construction.

Due to cost and programmatic sensitivities imposed by the developer, the specific project details cannot be released publicly, however, for the purposes of informing industry as to the cost and programmatic differences experienced between the two types of construction, approval has been given to describe the two projects in general terms and for the provision of a percentage based cost comparison.

The design brief and standard of finish for both projects were very similar allowing for an elemental format cost comparison. Both projects were constructed within 18 months of each other by the same contractor and in the same geographical region on the eastern seaboard.

Despite being quite similar, there were points of difference which have been accommodated to allow for an accurate comparison between the two projects. These differences were the timber based project being designed to 5 Star Greenstar guidelines as well as the inclusion of a car park undercroft (making it effectively four storeys high). The geological conditions at the timber buildings location were also significantly more difficult than those at the concrete building's site. Architectural styling between the two buildings was also significantly different resulting in the timber project being considered for an architectural design award.

With the recent adoption of NCC Deemed-to-Satisfy fire provisions for fire protected timber for Class 2(apartments), 3(hotels) and 5(offices) buildings up to an effective height of 25m, this report will provide an accurate comparison between the cost of conventional construction and materials and the types of prefabricated timber construction likely to be considered by industry as it determines the suitability of adopting an increase in timber in large scale commercial construction.

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Context and Preliminary Research

In 2014 a property developer based on Australia's east coast commissioned an analysis of the likely cost differentials for a 120 bed apartment development (circa 4,700m² gross floor area) between conventional pre-cast concrete construction and an innovative volume module timber frame construction to be built using an assembly line method. Both options were assessed on the basis of construction on the same site. EXSTO Management undertook this initial assessment and the overall differences were as follows:

	Pre-cast Concrete Frame (120 units, 4700m²)	Timber Frame (120 units, 4700m²)	Variance
Total Estimated Construction Cost	\$14,315,000	\$15,030,000	+5%
Total Estimated Design & Management Fees	\$860,000	\$1,503,000	+75%
TOTAL (excl. developer fitout)	\$15,175,000	\$16,533,000	+9%
COST / M²	\$3,229 / m²	\$3,518 / m²	

Table 1 - Preliminary Analysis (same site)

It was stated at the time that efficiencies in regard to building modular timber apartments in an assembly line environment could not be assessed but it is reasonable to expect efficiencies in regard to both time and cost.

The developer was aware that a project using a timber frame volume module combined with CLT solution would be the first of its kind to be designed and constructed in Australia. The developer was able to identify potential longer term benefits to prefabrication timber construction and as such, was prepared to incur additional costs and programmatic variations over conventional construction methods.

Both projects were subsequently commissioned and have now been completed. Now that the two projects have been completed, EXSTO Management was again engaged to assist in this research and their original findings have been used to assist in carrying out the comparison of the two completed projects actual costs.

Two Projects – Two Different Approaches

Between 2013 and 2015, the above mentioned developer completed a 180 bed apartment development using a conventional pre-cast concrete panel construction method and a 120 bed apartment development using modular timber frame construction (both projects were constructed in the same area and were of comparable specifications).

The two projects have been used as the basis for this assessment to provide an accurate cost comparison between the two construction methods. Allowances have been made for the differences in the number of apartments, different planning considerations, site, fit-out differences and contractual arrangements.

The resultant aligned data is expressed in summary in percentage format as follows:

	Pre-cast Concrete Panel (120 units, 5,221m²)	Prefabricated Volumetric Timber Frame (120 units, 5,221m²)
Construction Cost		+4%
Design & Management Fees		+72%
TOTAL (excl. developer fitout)		+7%

Table 2 - Aligned Analysis (same site)

The variance of the design and management fees at circa 70% is a combination of the pre-cast concrete solution being developed under a tried and tested design solution with the majority of the design work being done by sub-contractors whereas the timber frame solution was effectively developed on a research and development basis with a consultancy team developing prototypes to prove the concept prior to commencing the formal design process. The elimination of prototype development would have reduced the fee variance significantly but in this instance, the developer was prepared to accept the extra cost of constructing and testing one full scale unit to offset risk associated with commissioning an entire building using a new method of construction. This was considered a one-off cost that allowed all tendering contractors and their sub-contractors to inspect and price accurately based on a thorough inspection of the prototype and to test the construction method and confirm the suitability of the modules to be transported and craned into place.

Comparison of Table 2 results against Table 1 indicates consistent alignment against expectations with the timber frame construction cost being within a 5% range of the traditional pre-cast concrete option.

These costs have included for the one off establishment of an assembly line in a warehouse close to the site. It is anticipated that with the commercialisation of the technology and subsequent setting up of commercial assembly lines, a construction cost reduction of 2% to 2.5% would not be unrealistic placing the timber frame option at 1.5% to 2% higher than a conventional solution.

The design and management fees do however represent a significant variance with a resultant increase to development cost between the options of 3% to 5%. As more projects are constructed using various forms of timber framing, so will the efficiencies from local consultants, builders and suppliers be realised. In their assessment, EXSTO management found no impediments as to why timber frame construction would not be on a comparable cost basis to conventional construction methods albeit with reduced risk on consistency of quality and mitigation of the weather risk on more site intensive works.

Development Specifications

Generally

The baseline project consisted of 120 studio apartments each circa 23m² in size. The apartments were comprised of an en-suite bathroom, kitchenette and combined bedroom / living area that were finished to a medium standard.

The base cost data included for circulation space (corridors, lobbies, stairs 7 lifts), common rooms, administration area, laundry and an under-croft car park (to be noted that this was a site specific requirement as included in the Planning Permit and would typically not be required for a low rise residential development of this nature).

Assessment is based on both construction options being developed on the same greenfield site thereby eliminating any anomalies that may have been resultant from varying site conditions including contaminated soil, existing in-ground services and geotechnical conditions.

Timber piling and a post tensioned ground slab has been allowed for both options which aligns with the actual design that was used for the timber frame apartments. Adjustments thereto for the concrete panel option are noted hereunder.

Prefabricated Timber Frame Construction

The timber framed apartments were constructed in a warehouse complete with kitchen joinery, carpet and vinyl floor finish, plasterboard linings with paint finish, lights and power, plumbing fixtures and fittings. The modules were then transported to site and erected on concrete columns and beams. The modules were stacked on top of each other with 3 apartment levels in total.

The walkways and common room building were constructed from Cross Laminated Timber (CLT) floor panels.

The ground floor consisted of timber piles with a concrete ground slab forming under cover car parking, a laundry, common room space and bike parking.

The timber frame option has been priced using the Final Account from the apartment project but with adjustments made for:

- Extension of time required to design and co-ordination. The full cost associated with this would not have been applicable if the project was built again. We have included part of the extension of time cost as the extra work would have extended the project duration and incurred additional preliminary costs.
- Abortive costs would not be applicable if the project was built again.
- Contaminated spoil removal would not be required for the Greenfield Site.

Pre-Cast Concrete Panel Construction

The pre-cast concrete panel option utilised costs from comparable apartment developments that were constructed on site from pre-cast floor / wall panels supported on steel and concrete beams and columns. The plumbing fixtures, engineering services and fitout i.e. carpet, joinery and kitchen appliances were identical to the timber framed option. All work is carried out on site with no off-site fabrication.

Variations in Options

The main differences in between the two options are:

- Preliminaries:
 - The preliminaries (builder's supervision, insurances, temporary power and water, warehouse rental etc.) were 12.5% for the timber frame option and 8.4% for the precast option. This is due to the pre-fabricated timber option requiring two management teams; one on site and the other at a warehouse manufacturing the apartment modules. Also the hire of the warehouse facility as well as additional crainage requirements as was the shorter construction duration.

- Structural changes:
 - Due to the increased weight of precast compared to timber an allowance has been made for an increase in pile diameter in the substructure and increased column and beam sizes in the main concrete superstructure.

- Pre-cast concrete floor panels in lieu of timber framed floor.

- Precast concrete apartment wall division panels in lieu of timber framed walls with plasterboard lining.

- Pre-cast concrete floor panel to the walkway in lieu of CLT panels with rubber lining.

- Concrete stairs in lieu of CLT stairs.

- Pre-cast floor panels in lieu of CLT floor panels to the common room building.

Cost Comparison

Summary

The following table demonstrates the timber project's cost variance in an elemental format when compared to the precast concrete panel project. Plus figures equal an additional cost and minus figures equal a lower cost in percentage terms. Refer below and to the previous section for an explanation of the areas of variance.

Works/Expenditure specific to each project	Timber Cost Variance to Pre-cast Concrete
Civil Works	Nil variance
Hydraulics & Drainage	Nil variance
Substructure incl. piling	-17%
Steel / Metalwork	-3%
Roofing	+17%
Wall Linings (Plaster)	+23%
Floor / Wall Coverings	+21%
Structural & Internal Walls & Floors <i>(includes pre-cast concrete / CLT / internal timber framing as appropriate)</i>	-7%
Aluminum Glazing	Nil variance
Joinery	Nil variance
Painting	-18%
Electrical Services	Nil variance
Mechanical Services	Nil variance
Lift	Nil variance
Electrical Appliances	Nil variance
Landscaping	Nil variance
Preliminaries	+55%
TOTAL ADJUSTED CONSTRUCTION COST %	+4%

Table 3 – Elemental Analysis based on 120 residential units (5,221m²) built on the same site.

Cost Commentary

Both options have been assessed based on February 2016 costings with no further allowances for escalation in material and labour prices included.

The timber frame option is circa 4% higher than the pre-cast frame option due solely to the increased preliminary costs. These costs include:

- Duplication of management teams required to manage both the warehouse assembly line and the construction site at the same time.
- Renting of the warehouse.
- 1 off setting up of templates and assembly jigs.

The design & management fees represent a further 3% cost variance between the options bringing the total to 7%. The timber frame option includes for circa \$100k of prototype works that was required to prove the concept could be constructed as well as an estimated \$100k of additional design fees in developing the concept and associated design development. If the project was designed again, these costs could be excluded with fees being more closely aligned with other construction solutions.

Supplementary Information

The following information is provided as further background and establishes additional constraints and opportunities that influenced the analysis of the options.

Procurement Route & Form of Contract

The timber frame option was procured under a traditional Fixed Price Lump Sum form of contract with no early input from the preferred contractor in regard to design, materials selection or constructability. Constructability advice was obtained through the design team engaging a small local builder to develop the prototype. This builder had limited input into the final construction detailing and methodology.

The pre-cast concrete panel option was procured under a Guaranteed Maximum Price route with a Design & Construct Form of Contract. This allowed the contractor to develop the material selection and construction methodology with close working of suppliers and sub-contractors thereby maximising program efficiencies and the associated reduced cost in preliminaries.

Program

The timber frame option took approximately 10 months (excluding extension of time) to build while the similar pre-cast concrete panel project took approximately 8 months to build.

Typically, pre-fabricated construction is faster to build than traditional construction but in this instance the timber option took longer. This may have been due to:

- The nature of the building i.e. a frame system rather than a panel system.
- The concept was new to the construction industry in Tasmania with the builder and design team having to work through design and construction issues rather than having a complete design solution from past experience.

In 2012, Exsto Management in conjunction with AECOM carried out an analysis of various construction methodologies and procurement routes on a 180 bed apartment development.

The analysis indicated that a modular form of construction could deliver a development 17% faster than traditional methodologies under a Fixed Price Lump Sum procurement route. This increases to 32% if the project is procured under a more collaborative model with the contractor taking on a larger design responsibility. These efficiencies are based on national benchmarks and assume a developed industry with several years in delivering projects of this nature.

Greenstar Rating

The timber frame option was designed to 5 Star Greenstar guidelines and is currently being submitted to the Green Building Council for accreditation. The pre-cast option would not achieve this rating. Had the concrete structure been designed to achieve the same Greenstar rating, it would have incurred considerable extra cost which would potentially erase much of the overall cost difference between the two systems.

Ground Conditions

The timber frame solution was in part pursued due to the ground conditions of the site. The site was located near a river and had poor bearing capacity and required piling. A pre-cast concrete building would not have been feasible due to the weight of the panels and an alternate site would need to have been found.

Conclusions

In closing, we note that there were wider benefits to the community in selecting the timber frame option, these being:

- Collaboration between academic and private sector in developing solutions.
- Increased local employment opportunities.
- Providing the basis for the establishment of a new business opportunity in Tasmania that could service the wider construction market in Australia.
- Implementing an innovative approach and associated increased brand awareness

This cost analysis has confirmed that pre-cast concrete construction was approximately 7% cheaper overall including design fees and took approximately 2 months less to build. The following should however be noted:

- Timber frame option provides 5 Star Greenstar rating where pre-cast option does not.
- For poor ground conditions, timber framed construction may be the only option due to reduced weight requirements for bearing capacity.
- Combined volumetric timber frame and CLT was the first of its kind in Australia which required greater design co-ordination and construction solutions as a design solution based on past experience could not be used.
- Should the construction industry undertake more pre-fabricated timber construction we would expect the cost and time penalties to reduce as the industry gains more experience in best practice.