Forest&Wood Products Australia
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MARKET ACCESS & DEVELOPMENT

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Strategy for Large Span Second Storey Timber and Wood Products

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www.fwpa.com.au
FWPA Level 4, 10-16 Queen Street,
Melbourne VIC 3000, Australia
T +61 (0)3 9614 7544 F +61 (0)3 9614 6822
E info@fwpa.com.au W www.fwpa.com.au

Strategy for Large Span Second Storey Timber and Wood Products

Prepared for

Forest & Wood Products Australia

by

A. Dunn and P. Forsythe

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Researcher:
A. Dunn and P. Forsythe
Timber Development Association (NSW)

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Forest & Wood Products Australia Limited
Level 4, 10-16 Queen St, Melbourne, Victoria, 3000
T +61 3 9614 7544 F +61 3 9614 6822
E info@fwpa.com.au
W www.fwpa.com.au

Introduction

This document reports the findings and outcomes from a project aimed at improving the awareness and usage of long span timber beams, as an alternative to steel beams, in the detached housing construction market.

The project came about as a response to issues raised by prominent home builders concerning the need for the timber industry to provide a "one-stop" structural solution (i.e. without the need for steel beams) in detached housing construction. A central logic to the issue concerned the increase in Occupational Health and Safety and costs being faced by builders in the erection of steel beams which require cranage, riggers, props and welding. Timber structures do not incur such additional costs therefore this project potentially reduces construction costs whilst aiming to increase the demand for value added engineered wood products.

Given the above aims and current industry needs, a targeted approach was undertaken to executing the project. Specific objectives were to:

- Undertake engineering calculations and analysis and from this produce plywood box beam span tables in limit state format, including the usage of MGP and LVL timbers as framing members.
- Develop a web site containing information about engineered timber and wood based solutions for long span beam situations (including LVL, Glue laminated timber and Plywood box beam options).
- Develop a design guide in the form of a "PDF" document presenting options and strategies for replacing steel beams with timber.
- Develop a Plywood Box Beam span table book in the form of a "PDF" document.

The remainder of the report presents findings and details relating to the above.

Research on Types of Long Span Timber Beams and Associated Market Issues

A review was undertaken of the available long span timber and wood-based beams that exist in the market. A key issue was to determine which ones could realistically be used to replace steel beam applications in single family houses. In addition, various participants in the timber supply chain were contacted and asked about: the typical information they provided to builders and designers about timber beams and how their beam products were typically purchased in the market place. This included a targeted selection of:

- Major timber beam manufacturers (including instances from Western Australia, Victoria, New South Wales and Queensland),
- Wall frame and truss manufacturers,
- Providers of wall frame and roof truss software,
- Beam distributors and retail outlets,
- Builders and architects,
- Timber Associations

The above process served to identify the available timber technology that could be used to substitute steel beams with timber. In essence, this consisted of LVL products, Glue laminated timber products, Plywood box beams and a limited range of specialist engineered timber products produced using metal plate connectors, similar to those used in timber truss manufacture.

The study served to identify the way that builders and designers accessed or interfaced with the timber supply chain. The main conclusion was that all the major timber beam manufacturers have multiple ways of ensuring that builders and designers know about and select their products. This is ostensibly by interfacing with builders and designers through different entry points in the supply chain. For instance, most timber beam manufacturers provide span tables or design software which can be freely downloaded from individual web sites. Even so, builders do not actually buy beam products direct from the manufacturer, instead, they buy through the manufacturer's network of outlets including timber merchants, frame and truss plants and hardware outlets; who also have access to the previously mentioned span tables and design software. These organisations act as the sales interface with builders and designers.

One of the important subtleties in this relationship is that even though builders and designers do not purchase directly off the timber beam manufacturer, they may still deal direct with the manufacturer in obtaining technical advice, guidance on specific design solutions or engineering the structural design in a way that best minimizes costs and maximizes structural performance. This is especially the case where builders and designers buy from timber merchants or hardware outlets as these organisations do not have the technical capacity to assist with complex inquiries. In such cases, builders have what can be described as a "design direct but not buy direct" relationship with the major timber beam manufacturers. The same is less true with frame and truss plants as they aim to provide a more holistic design service to builders and designers. They have technical staff capable of developing a number of beam solutions and are arguably the best vehicle for ensuring engineered timber beams are used to their fullest.

As a result of these findings, TDA has adapted the web site for this project to provide a flexible means for builders and designers to obtain information about proprietary beams products and to link up with various entry points in the timber beam supply chain. In such instances, care has been taken to avoid duplicating manufacturer's design information as manufactures need to manage their information. Equally, the web site provides a means for those in the supply chain, such as frame and truss manufacturers, to interface more smoothly with builders/designers in terms of explaining certain long span beam strategies and related beam products. Finally, the likes of timber frame and truss plants have situations where individual proprietary beam products do not meet the spanning needs of specific projects. Here, the web site has been designed to allow access to box beam solutions which provide a broader scope of spans and are not aligned with individual beam products.

Research Findings on the Calculation of Plywood Box Beams

Considerable research went into the calculation and analysis of plywood box beams for the purposes of developing box beam span tables. As required under the project brief, the calculations were made under limit state design. This proved to be an unexpectedly complicated part of the project. The work was undertaken for TDA by the Engineered Timber Products Association of Australia who has proven expertise in plywood box beam design (having undertaken previous work using the permissible stress method of design).

The main difficulty involved the ability of nails to resist shear (shear flow) forces between the plywood web and solid timber flange members. Requirements also varied according to locations of high shear load in the beam. As a result of this issue, the spanning ability of the beam was limited by nail shear resistance more so than the more common deflection limitations. The effect of this was that:

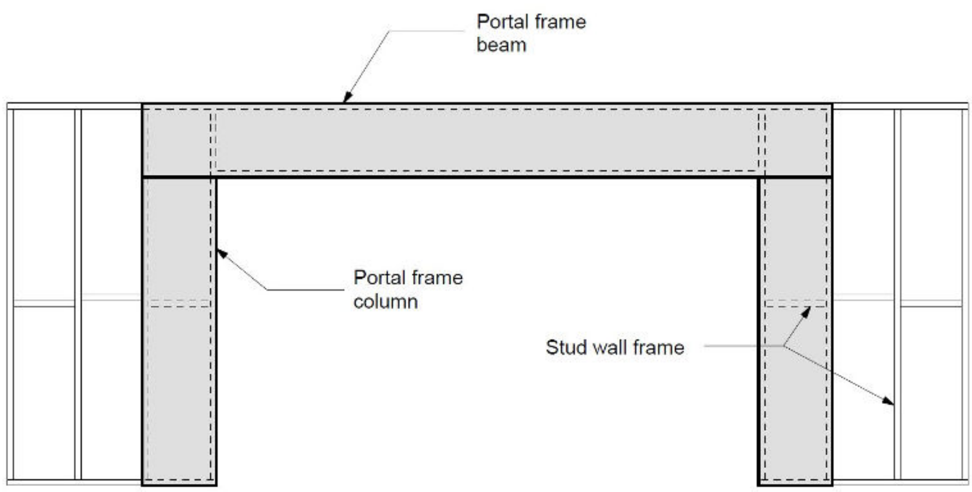
- Beams depths in the range of 225, 300 and even 400mm deep provided relatively poor spans. Because of this, the project steering committee decided it best to omit these depths from the published span tables because alternative timber beam options performed better and at a cheaper price. It was however determined that deeper box beams performed considerably better and so it was decided to add further beam depths including 800 and 1200 mm deep beams. With this in mind, the 400 mm deep beam size was retained because when paired with 800mm deep beam it made efficient use of standard 1200 mm wide plywood sheets.
- It was found that higher stress grade timber and plywood did not necessarily lead to higher beam spans. After making numerous checks of the mathematics involved in the calculations, it was found that the results were theoretically correct and that the anomaly was a bi-product of the formulae used to derive the results. The problem was a function of the way higher stress grades were treated in the formulae when subjected to higher shear loads (between the plywood web and the timber flanges). As the formulae is well established in the timber structural engineering profession it was decided by the steering committee to accept the results albeit disadvantageous to higher stress grade timbers. Given this, the findings suggest that lower stress grade materials may offer almost equivalent value compared to high stress grade timbers and in economic terms, this may be effect the selection and systematization of materials used in box beam fabrication.

Research Findings Concerning Portal Frames

A targeted part of the research concerned achieving extended use from box beams in portal frame construction. Portal frames involve a more advanced application than simple post and beam construction. The connection between the post and beam must be moment resisting i.e. the connection can carry bending forces. On this basis, portal frames improve spanning ability because some of the bending moment in the beam is transferred to the posts. To achieve this, joints must be rigid rather than the hinge joint that prevail in most timber framed construction. The rigidity in the frame also provides a bracing effect (in the plane of the frame).

Here, the main concept was to incorporate portal frames into conventional stud frame construction by sheeting the frame with plywood and thus utilising box beam technology. A drawing of this concept is shown in Figure 1.

Figure 1: Portal frame embedded in stud frame construction



In executing this part of the work, problems were encountered with functional aspects of the portal frame design. The main issue was an inability to confidently ensure, without significant testing and analysis, the ability of a portal to resistant lateral wind loads at the moment resisting joint. The main concern was that any moment resistance at the joint when under gravity load would not surprisingly result in a tendency for the joint to open on one side and close on the other, but the addition of lateral wind loads would add an extra factor where design requirements were unknown.   With regard to this, it is notable that abundant data is available regarding the design of plywood gusseted portal frames, however this information does not directly apply to rectangular timber framed, plywood sheathed box beam systems.

Again this was discussed at the steering committee and it was decided that the risk of an untested system in the market place was not beneficial to the timber industry. The plywood box beam span tables were produced without their inclusion.

Outputs from the Research

Output 1

A key output of the project required development of web pages that demonstrate the use of engineered timber and wood based solutions in housing construction (as alternative solutions to steel beams).

In addressing this, a set of pages have been developed and can be viewed at http://www.timber.net.au/index.php?option=com_content&task=view&id=374&Itemid=336. The opening web page describes the benefits of timber beams over steel and provides a gallery of photos show-casing long span timber beam applications. From this page it is possible to link to other pages covering:

- Typical long span beam situations (this page is driven by strong use of graphical content)
- The types of engineered timber beams that are suitable for long span situations including Glue laminated, LVL, Plywood box beams and timber portal frames. This page includes graphics covering each type of beam;
- Links to beam manufacturers and/or distributors including access to beam design software and links to generic box beam and timber portal span tables.
- Design strategies for dealing with the greater depth of timber beams (compared to steel beams)

Output 2
A second output of the project required development of a PDF version of the web site information. This has resulted in a design guide that reflects similar information to that held on the above web site, and can also be downloaded from that web site.

Output 3
A third output from the project involved the engineering calculation and production of plywood box beam span tables which are conveyed via a PDF downloadable book which can be obtained from the abovementioned web site. The publication begins with a design guide covering issues such as the design parameters used for beam calculations, then assistance in beam fabrication and installation techniques. Following this are individual span tables covering MGP 10, MGP12, F5, and LVL 10 stress grades for flanges and stiffeners. These are provided for a wide range of lintel, bearer, hanging beam and strutting beams situations. With regard to this, a certificate of conformity from a structural engineer is issued as part of the document to underpin the validity of the beam designs.

Output 4
A fourth output from the project involved dissemination of the above outputs. This was achieved by way of a press release (refer Appendix D) sent to various building association, and building design associations, timber industry journals and similar organisations. These included: the Master Builders Association, The Housing Industry Association, The Royal Institute of Architects, the Building Designers Association, Infolink, Timber Trader, The Frame and Truss Manufacturer's Association and Friday Offcuts.

Commercial Implementation of Results

The web site and publications mentioned in the "Outcomes" section of this report have been specifically designed to monitor and encourage uptake of long span timber beams among those involved in the timber supply chain. The web site also provides a means for communication of concepts and products between supply chain members and customers, including builders and building designers.

Intellectual Property

The TDA does not hold any intellectual property rights over any of the parts of the plywood span tables that were calculated and developed as part of this project. This intellectual property is held by the Engineered Wood Products Association of Australia.

Difficulties Encountered in Execution of the Project

The main difficulties in undertaking this project concerned the aforementioned complexities in dealing with unexpected findings about the box beam calculations (i.e. problems relating to nail resistance of shear forces) and portal frame design (i.e. lateral wind loads on moment resisting joints). These issues firstly impacted on time; secondly on the amount of calculation and analysis involved in the project; thirdly on setting a new course of action; fourthly on determining how the eventual findings should be handed in terms of published span table data; and fifthly in terms of determining future research requirements. These factors caused the project to run some 4 weeks beyond scheduled completion date and lead to the identification of further research requirements.

Difficulty was also had with achieving the goal of removal all steel beams from a house. In theory timber could be used to replace most of the steel beams that are encounter in a typical house except for beams used to support brick work. Modern design houses tend to have the upper storey stepped back to reduce street impact which results in brickwork needing to be supported. The steering committee decided that it was not beneficial for the timber industry to support brickwork of timber beams as there was deflection as well as durability concerns. To this end it is not possible to remove all of the steel in a modern design house, but the project has gone a long way in achieving this.

Conclusions and Recommendations for Further Research

In general, it is concluded that there is considerable potential for long span timber beams to offer a viable alternative to steel beams, especially given high current worldwide steel prices. Arguably the best vehicle for implementing this is via frame and truss manufacturers as they are well positioned to create engineered timber solutions customized to suit individual project needs.

Not withstanding the above, current box beam design is currently falling short of allowing such beams to meet their full spanning potential. A key finding from this project was that nail holding capacity (with regard to shear forces between the web and flanges) presents a limiting feature that restricts spanning potential. On this basis, future research should focus on the development of adhesive or even metal plate connectors as a means of more successfully dealing with shear forces than is currently is achieved with nails. In undertaking such work, the project should also address accompanying quality control issues that may differ for onsite as opposed to factory fabrication of box beams. For instance in the past, there have been quality control concerns about the ability to achieve full adhesive strength onsite given the variability and the inability to detect poor onsite work practices.

In addition to the above, the project was unable to address the use of box beams in portal frame construction because of the lack of test data concerning moment resisting joints. Future research should quantify the moment capacity of a range of moment joint configurations for integration with box beam based portal frame design.