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A market assessment and evaluation of structural roundwood products from hardwood pulp plantations

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A market assessment and evaluation of structural roundwood products from hardwood pulp plantations

Prepared for

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Executive Summary

Hardwood plantations comprised of *Eucalyptus* species have been established on a range of sites around Australia for pulp and paper fibre on short rotation management systems. Simultaneously with the increased area planted under pulp regimes, access to natural hardwood forest stands has been reduced, a trend that will continue in most Australian states in the foreseeable future. Plantation owners are interested to know if pulp plantation material has the potential to produce a higher value crop than the original wood chip product and meet the shortfall developing from reduced availability of natural forest resources.

Roundwood structures have always been used for temporary and low cost shelters and other fleeting structures. Novel concepts for the use of plantation hardwoods in roundwood form in construction were developed and circulated along with an electronic questionnaire to stakeholders representing growers, designers and users of hardwood. Responses indicate that there is a high level of interest in developing products from the emerging small roundwood resource and a detailed program of research was supported and recommended by the majority of participants in the survey.

It generally isn't feasible to process pulp logs through traditional sawmilling equipment due to the low recoveries obtained; however this material has the potential to provide high value products in roundwood form. Roundwood products have a range of advantages over sawn boards such as: improved strength attributes for equivalent cross-sectional area; reduced processing costs, lower embodied energy and reduced wastage due to minimal processing activities. Simple steaming technologies can be used to prepare roundwood stems for bending around a form to produce arched structural members providing a wider range of design options to users.

Examples of potential markets include: noise barriers and wind barriers, niche architectural buildings, national park and local authority shelters, ablution facilities and viewing platforms, rural buildings, light footbridges for walking trails, golf course and suburban parklands' infrastructure.

Although roundwood products are widely used in fencing and landscaping applications, their usage in applications such as the concepts listed above represents the introduction of novel and therefore untried systems. The goal of this project was to investigate potential market interest for innovative applications using small diameter roundwood such as pulp logs and thinnings from sawlog plantations.

Senior architecture students from the University of Queensland were presented background information on hardwood plantations, principles of wood science and elements of timber design. Using this information and with support from their lecturer they worked individually and in teams to produce designs and models for roundwood structures.

Illustrations of a selection of these concepts representing small scale (shelters), medium scale (remote housing), large scale (industrial buildings and infrastructure (sound barriers) were included in an electronic survey which was emailed to over 1,200 stakeholders representing a broad cross section of forest growers, designers, specifiers, engineers, timber industry representatives and users.

The results from the survey provided an optimistic view for the potential of small, roundwood, structures with 87% of respondents indicating that they liked the overall impression of the designs and concepts, versus 13% who were neutral. Encouragingly, no respondents disliked the overall impression based on the concepts supplied.

When considering each of the four size class concepts separately, the majority of respondents ranked the general appeal in each case as appealing to very appealing.

The best potential for market uptake was considered to be small shelters and infrastructure, with 80 % of respondents considering the potential for commercialisation of these two construction types to be medium or high.

When asked whether they considered that more detailed research and development is warranted or justified 97% of respondents support or fully support further exploration, with 3% neutral.

An economic assessment was undertaken in relation to the benefit of further R&D and showed that the net present value of R&D investment is high, increasing the viability of hardwood plantations through commercial use of sawlog thinnings and higher value products from pulp plantations. Using a 5% discount rate, the internal rate of return was estimated as 492%, the benefit cost ratio 223:1 and the net present value $100M.

These results indicate a high level of support for further investigation into the use of plantation hardwood for roundwood components. Respondents representing a wide range of stakeholders have indicated that to gain benefit from a detailed project they would require solutions for connection systems and protection from pests and weathering, indications of cost and assurance of ongoing supply for niche applications, data for strength, acoustic dampening and thermal insulation properties, acceptance by regulatory authorities and training for on-site construction.

Table of Contents

Introduction

The development of extensive forest plantations under the "National Forestry Policy Statement" and the "Plantations for Australia: The 2020 vision" have attempted to secure a longer term sustainable industry for construction and other timber products. Though the established end user industries provide growers with some certainty as to the potential yield of plantations at the end of their life cycle, more can be done to leverage extra value from the plantations throughout the management cycle. One important aspect of this cycle is the use of thinnings. Currently this resource is used for lower value applications such as pulp, firewood and low grade timber products. Research around the world has shown that if thinnings can be used in viable higher value applications in the construction industry then the yield from plantations could significantly increase and hence the financial return to the national economy.

Plantation crops of hardwood species have been established under two general management regimes, dependent on final products and markets. The majority of hardwood plantation area has been managed for pulp fibre over a short rotation period, with a lesser area for sawlog over a longer rotation period. In the latter case, it is usual practice to thin to waste a proportion of trees to avoid them competing with superior stems. The age of the trees at the time of this thinning operation may be similar to the final crop harvest age in pulp plantations. This report discusses the opportunities for diverting these thinnings and pulp fibre trees to a higher value application which may increase the economic return from hardwood plantations. It summarises the work of a limited scoping study into the possible application of hardwood thinnings from plantations. It focuses on processes that can both help the seasoning of the wood and the aesthetic and form making potential of steam bending the thinnings into defined curvilinear geometries. Within the limits of a scoping report, this study has focused on the possible end user applications and prototype designs to test market perceptions and desire for further research. A detailed program of research in this domain would likely fast track the benefits to growers.

The report is broken in several main areas. Prior research is outlined in the methodology section. Key projects are themes are identified that have guided the rest of the project. A description of the resource and the approach to developing and assessing ideas has been included in the methodology section also. The main research was undertaken as an inquiry through design. The design propositions were developed by master's level architecture students at the University of Queensland. The reporting on the process and findings from the design exercise is outlined in the results and discussion section of this report. The proposals developed by the students have been catalogued in the appendices 3 to 5.

Designs were generated with advice and feedback from industry experts. Early designs were presented for review and these in turn were edited down and developed through large scale model making. Experiments at 1:1 including the trial bending of some stems was undertaken to widen the perspective of the report across all scales of understanding. Outcomes from the design exercises were summarised in a report that was circulated to industry to gauge opinion via an online survey. A detailed breakdown of the survey results are itemised in the results and discussion chapter with the content of the survey and the full breakdown of responses itemised in appendices 1 and 2. An economical assessment was conducted to estimate the benefit of undertaking a detailed research and development (R&D) project on plantation hardwoods for structural roundwood.

The report summarised key finding and importantly highlights those aspects of the study that require further investigation. One should always bear in mind that this is a scoping study and the aim is to both explore the potential as well lay out the breadth of further study required. We believe that this report more than adequately demonstrates the potential of the resource but equally acknowledges the extensive and broad ranging work that is required to turn great expectations into market realities.

Methodology

Given that the aim of the project was to demonstrate the breadth of design potential for structures that utilised steam bent roundwood thinnings the approach taken was to lead the inquiry through the design of prototypes and to then gauge the level of industry interest in these structures. Consideration of prior research and design constraints were taken into account at the start of the design phase. The project was undertaken by Master of Architecture students enrolled in the School of Architecture at the University of Queensland. The group of 15 students was led by two academics from the school, Mr Michael Dickson lecturer in design and technology and Mr Tim O'Rourke, PhD candidate in the field of Indigenous settlements and construction. Students worked individually and in small groups to collectively generate the material for this scoping study.

Literature review

Prior research focused on the development of timber thinning aim to demonstrate the latent value of the resource as a structural material in order to create a higher value resource. In focusing attention towards higher value products at all steps of the growing cycle the return to the plantation industry in general can be enhanced.

In the context of Australia's plantation industry there is an opportunity to deliver significant increases in yield during the plantation's rotation by diverting just a portion of the thinnings towards higher value products rather than just pulp and firewood. Yeates (1999) demonstrated through simple projections that the pulp market profitability would trend downwards over time as a result of increasing supply outstripping demand whereas the profitability of wood for construction would be tending upwards. At the time of the report the value of pulpwood was \$90/m3 compared to \$200/m3 for construction. If just 20% of the thinning yield were diverted towards viable construction based products then the net increase in profit from national plantations could increase by upwards of 180 million dollars (Yeates 1999). Even if only part of these projections can be realised the latent potential in the market is significant and higher yields during the life cycle of the plantation would make the industry even more attractive to growers.

Though the potential of the market can be demonstrated mathematically the current demand for roundwood structural products is limited. There are many contributing factors to the negative outlook towards structural applications but it is the general perception of roundwood and lack of technical and design guidelines that is preventing a broader understanding or appreciation of the resource (Yeates 1999, Ranta-Maunus 1999).

The challenges to be faced to create greater market acceptance include: grading the resource and the supply of consistent quality, the availability of the resource through conventional building products suppliers, the preparation of the resource to mitigate the issues of growth stresses, the treatment of the resource to enhance durability, the availability of the shelf of connector systems and finally education of designers and engineers as to the potential and good practice in design and detailing using roundwood (Yeates 1999, Ranta-Maunus 1999).

This project is looking at the use of simple delimbed and debarked unshaved thinnings. Part of the rationale of using thinnings in the round is that the embodied energy in processing the resource is quite low, almost 40% lower than processing the material into sawn lumber (TM Chrisp, J Cairns, C Gulland 2003). Processing thinning into sawn logs is problematic as the timber is juvenile and the imbalance of stresses leads to deformities and cracks in sawn boards (Yeates 1999). The yield from a sawn board is also less given the conical geometry of the logs as the greatest dimension is constrained by the smallest log diameter. The combination of log geometry and juvenile wood makes the processing of material into lumber unviable.

The use of roundwood in construction has been typically prevalent in rural or woodland setting where the resource is close at hand and in part of the local tradition. Typically buildings constructed of roundwood have been lower value assets or ancillary buildings such as shed, barns and fencing (Ranta-Maunus 1999). The folksy and traditional image of roundwood construction makes it difficult to find acceptance in more mainstream applications.

A significant aspect of creating a viable roundwood industry is consistency and predictability of the material. Though the consistency of a thinning will never be the same as a sawn log, never the less the structural capacities must be understood so that engineers can calculate structural behaviour. Visual grading and non invasive grading systems need to be developed and design tables issued in the same manner as sawn timber. The broad study of roundwood use in Europe found that there was a reliability and consistency of visual grading techniques that had a high correlation when compared to non invasive analysis and destruction testing (Ranta-Maunus 1999). These results prove that a viable system of grading of roundwood product is possible.

Connector systems are another significant issue that needs development in order for a roundwood industry to develop. There are some systems on the market though these are mainly European systems. Most systems take an embedded approach to connectors, using both steel plates and bolt or threaded rod and dowel connectors. Other systems utilise a cold formed meal nailing plate system similar to those used in softwood framing and truss systems. Both systems have difficulties in that tangential or circumference shrinkage can open large cracks in the timber making undermining the mechanical connection to the timber. Radial shrinkage can also loosen fittings over time as the overall diameter of the log decreases (Yeates 1999, Ranta-Maunus 1999). Sustainable Science.org inc has developed a sleeved connector that overcomes some of the issues associated with embedded systems. Their LPSA (light prestressed segmented arch) structural technology is a systems based approach to roundwood that can be deployed over a variety of construction types including standard houses, bridges domes and towers (Sustainable Science.Org). All systems have their place in roundwood construction though none are easily available in the general marketplace.

There have been a number of prototype structures made and reported that try and flesh out the main constraints utilising the resource. One common aspect is that though the structure and connector systems can be resolved in elegant and structurally sound ways, the irregularity of the main structure creates difficulties when attaching secondary systems and cladding. As a result many of the prototype constructions utilise a “loose fit” approach to sealing the building by using membranes or more traditional approaches such as shingles and sod roofs. The secondary systems need to be able to accommodate both the irregularity of the main structure as well as a reasonable amount of settlement over time.

Demonstration projects illustrate the aesthetic potential of the system and it is through such projects that interest in and knowledge about the roundwood is developed. A project located in Scotland for kids in need and distress (KIND) takes a Scottish timber vernacular as the inspiration for a new guest house (TM Chrisp, J Cairns, C Gulland 2003). The main structure was constructed from conifer thinnings in a triangular form which were bent on site while green. The logic of bending the main structural elements was to maximise the available internal volume and to provide an aesthetic that has been compared to a longboat of a whale carcass. The construction utilises locally available materials and skills so the constructional logic needed to be reasonably straightforward. The use of timber shingles for the A frame structure meant that there was a reasonable allowance for movement and structural irregularities. The authors of the report note that even with a new Eurocode 5 for timber construction, the system feel outside normal conventions and so needed to be prototyped and the structure tested to failure (TM Chrisp, J Cairns, C Gulland 2003). The problem therefore remains that until the number of prototypes increases and knowledge of structural performance can be codified, such structures are still found only in the domain of bespoke or specialist applications.

A series of projects in Hooke Park England takes on roundwood technology through three demonstration projects (R Burton, M Dickson, R Harris 1998). Hooke Park is a demonstration and education facility so the development of the technology has a better chance of development and knowledge dissemination. The utilisation of curved elements and organic forms in all of the Hooke Park projects is in keeping with the current spirit of the age. Contemporary architecture of the last decade is characterised through a series of signature and cultural buildings worldwide that experiment with complex form and space making. Though such complex form making is de rigueur in architectural circles it is usually created through difficult and expensive structural systems using materials with high embodied energy. The potential of using sustainable materials to create complex form as demonstrated in Hooke Park, particularly the training centre, points to a next logical step in the development of such forms.

It can be summarised that the use of roundwood both demonstrates great potential both for financial returns to growers and producers as well as great potential for innovative architectural form. The use of steam bending to generate a language of organic forms will key into the current spirit of the age. Studies have shown though that the development of technology needs to be investigated at all levels of production from the forest to the final structure. Grading, quality control and seasoning to maintain consistency are crucial to market acceptance. The development and wider availability of connection systems and design guidelines are the other aspect of the industry that needs attention in order to encourage wider acceptance and understanding of the resource. All of these aspects can be synthesised in a local context through prototype projects that test various systems and illustrate to the construction and design industries the potential outcomes. A logical extension of such prototypes would be to develop a series of prefabricated building types, demonstration projects could become more widespread and issues of engineering and quality controlled in factory settings.

Resource

The National Plantation Inventory managed by the Bureau of Rural Sciences was consulted to provide current estimates for hardwood plantation areas in Australia.
Data were divided into sawlog regime and pulpwood regime areas, to reflect the different management regimes. Assumptions for potential volumes available and suitable for structural roundwood were derived through consultation with plantation hardwood experts.

Design

Early design propositions were informed by a literature review and input from industry partners. Critical design considerations related to timber use in construction, for example durability in-ground, above ground, corrosion of fasteners, strength, stiffness, roundwood properties compared to sawn wood, and implications of untreated sapwood, were presented to the student architects. Industry inputs came from Outdoor Structures Australia, Queensland Primary Industries Fisheries and Timber Queensland in addition to the inputs from the academics coordinating the student research project.

An inquiry by design synthesised the inputs from literature and industry into a series of preliminary design propositions that worked across building type and scale. These initial design propositions were presented in a poster format for feedback from the project industry partners. Preliminary propositions attempted to present designs in the context of relevant precedent studies, potential applications and viability.

Those proposals that were deemed to have greater market potential or were better resolved were developed through large scale models and 1:1 prototype studies. These developed proposals were collated into a survey document that was distributed to industry for feedback. Financial modelling rounded out the study. Additionally, steam bending of a batch of 8-year-old plantation-grown spotted gum stems was demonstrated to students to provide an indication of the attributes, aesthetics and potential of the resource.

Survey

Representative samples from the range of preliminary design concepts produced by the UQ Architecture student group were compiled into an electronic survey document and distributed to a mailing list of over 1200 range of design professionals, relevant government departments, manufacturers and suppliers. The purpose of the survey was to ascertain the potential support for, and use of, structures fabricated from small diameter plantation hardwood rounds. To simplify the survey process for respondents, the design concepts were categorised into four groups *viz* small, medium and large structures as well as infrastructure such as sound barrier fences.

Economic analysis

An economical assessment was conducted to estimate the benefit of undertaking a detailed research and development (R&D) project on plantation hardwoods for structural roundwood.

Expected returns to the proposed research were estimated using a cost-benefit analysis approach. To account for the time preference of money (opportunity cost), future benefits and costs have been discounted to 2010 values using a real discount rate of 5%. All dollar costs and benefits are expressed in constant dollar terms and discounted to the current financial year. Investment benefits were measured using the following investment criteria:

- Net Present Value (NPV) - the difference between the present value of benefits and the present value of RD&E costs;
- Benefit-Cost Ratio (BCR) - the present value of benefits divided by the present value of the research costs; and
- Internal Rate of Return (IRR) – the discount rate at which the present value of benefits equal the present value of the costs.

Benefits "with" and "without" the project

The Benefit Cost Analysis assesses the change in benefits resulting from the project and compares it with the costs of the research. To assess these changes, two scenarios were created: benefits and costs "with" the project, and benefits and costs "without". The "without" scenario is that the project does not take place, meaning that the R&D costs would not be incurred, and the revenue associated with the new product is not received. However, it can be considered unrealistic to assume that there would be no progress relevant to the research problem in the absence of the project. Industry generated knowledge may generate some solutions to address the problem, although possibly not as promptly or effectively as this project.

New hardwood plantation area established nationally each year is forecast to continue at an average of 50,000 hectares (approximate per annum average based on the period 2004 to 2008). In the analysis this was broken down into 20,000 hectares planted to sawlog and 30,000 hectares planted to pulpwood. Initial planting density is 833 stems per hectare, which allows for mortality of 33 stems per hectare.

Sawlog plantation (20 000 hectares)

The initial planting density of the new hardwood plantations involves a high density of 833 stems per hectare, followed by thinning at year seven to 400 stems per hectare. It is assumed 25 per cent of stems from year seven will be of sufficient size and quality for straight and arched member production from each thinning. The retail price of a length of 7 metre roundwood was $28.00, with the assumption made 30 per cent of this is passed on to the grower. This equates to $8.40 per stem of roundwood at the farm gate.

The remaining 300 stems from the thinning are used in pulpwood production as this in considered to be best practice for industry. The projected farm gate price for pulp stems is $6.56 each.

Pulpwood plantation (30 000 hectares)

The initial planting density of the new hardwood plantations involves a high density of 833 stems per hectare, followed by clear felling at year seven. It is assumed only 100 stems from year seven will be of sufficient size and quality for straight and arched member production. The retail price of a length of 7m roundwood was $28.00, with the assumption made 30 per cent of this is passed on to the grower. This equates to $8.40 per stem of roundwood at the farm gate.

The remaining 700 stems from the thinning are used in pulpwood production as this in considered to be best practice for industry. The projected farm gate price for stems pulped is $6.56 each.

Thinning cost (cut and snig) per stem for either pulp production or roundwood was assumed to be $2.50.

The market will absorb all hardwood straight and arched members produced from early plantation thinning. Straight hardwood members are stronger than their softwood counterparts, and can therefore be used for structures requiring greater strength. The range of uses for hardwood straight members includes sheds, garages, bus shelters, and other light construction purposes. The hardwood arched members are a novel product that will have significant appeal to architects, landscape architects, and artists due to the ability to construct novel shaped structures with aesthetic appeal and suitable strength. Examples of the uses for hardwood arched members include bus shelters, picnic shelters, children's play equipment, and other light construction purposes.

The major parametric assumptions of the model are summarised in Table 1.

Table 1. Inputs/Assumptions for the Cost Benefit Analysis

Inputs/Assumptions	
Sawlog hectares planted per year (Qld, NT, NSW)	20000
Pulpwood hectares planted per year	30000
Initial planting density (stems/ha)	800
Number of stems per hectare from year 7 thin	400
Yield per hectare (cubic metres)	175
Price per cubic metre	$30.00
Price per stem (for pulp) farm gate	$6.56
Thinning cost per stem at year 7	$2.50
Percentage of stems per hectare from year 7 thin suitable for roundwood	25%
Number of stems per hectare from year 7 thin suitable for roundwood	100
Retail price per linear metre of roundwood	$4.00
Length of roundwood stems (metres)	7
Retail price per roundwood stem	$28.00
Price per stem (for roundwood) farm gate	$8.40
Research costs - year 1	-$284,000.00
Research costs - year 2	-$188,000.00
Discount rate	5%

The cost benefit analysis focuses on benefits received privately as a result of new higher valued markets for timber which previously had no value. It must be noted that there may be further benefits associated with the additional value adding processes, but these have not been accounted for in this analysis.

Results and discussion

Within the terms of reference of this pre-study, the results gained from the design inquiry demonstrated that there was a broad application of steam bent thinnings through a variety of building types. At the same time though the process of critically evaluating the designs opened more questions that could not be sufficiently resolved within the pre-study's scope.

Initial design concepts

Initial design ideas and possibilities were generated during a full group brainstorming session. Through discussion it was decided that the range of possible solutions would be best packaged into four defined project types based around scale and use. In simple terms the categories established were as follows:

- Small sized buildings / structures
- Medium sized buildings / structures
- Large sized buildings / structures
- Infrastructure projects, systems and structures.

Within the group each student decided to take on a design within one of the broad project categories so that there was an even spread of designs across categories. These initial concepts are presented in Appendix 3.

During the critical review of these initial schemes a number of common themes emerged. First and foremost the initial designs tended to be quite narrowly focused though in discussing the possible applications it was found that many of the proposals could be adapted to other more general applications. It was found that in order to be viable, design prototypes needed to be sufficiently *generic* so for example a shade structure could become a bus stop which in turn could become a sport stadium.

The *scale* of the design elements was also highlighted as an issue. Small structures such as a bus shelter may be difficult to execute given the scale of the structural elements. Sometimes direct adaptation of a structure type would not work as they would sit outside the bounds of the materials "natural" design and structural properties. There was a view that the material "wanted" to be made into some structures but could not be adapted to others.

Some of the medium scaled structures seemed very well suited to the resource. The clear span of a single log made it appropriate to residential and residentially scaled structures. The clear spanning potential meant that a generic structure could be fitted out in a number of different ways, making it flexible and adaptable. Particularly for houses there was a focus on the speed of erection to stand up the frame which would lend itself both to self build or self finish. This aspect of self build and off grid or remote area housing became an important aspect. Discussions of regional housing options, indigenous housing were discussed, mainly as a way to promote the sustainability of the resources as well as the potential for community engagement and employment opportunities for regional and remote communities.

Many of the schemes utilised the structural elements vertically. The "Umbrella Structure", "Gunyah" and "Woodland Hideaway" (refer Appendices 3.2, 3.3 and 3.6) utilised the elements vertically and integrated in the roof structure. There is a tendency for the elements to be used in similar gridshell or "A" frame type configuration in the students' proposals as well as in many of the examples uncovered in the literature. Perhaps the reasoning is that used vertically, the stems are in a configuration closer to the way they are nature and aesthetically seem to be in character with the material.

The propensity towards "integration" of vertical structural elements points to another trend which was a strong emphasis towards organic forms and a green architecture. For some the issue may be that the folksy aesthetic lends itself only to niche applications however through discussions we believed that a green agenda and returning to nature was becoming more entrenched in mainstream attitudes to the built environment. In the short to medium term though it was felt that it would be easier to market a small to medium scale structure in park like settings and in circumstances where the object was integrated more tightly with a natural environment. This perhaps precludes suburban and urban applications however there are instances in the public realm such as school, sporting facilities and public parks where such structures would find many applications.

Many of the larger scale buildings tended to focus on simple linear shed like buildings. Variations of the portal frame or “Nissen” Hut were the dominant themes explored. Though for most the aim was to create a storage or industrial facility, it became evident that uses such as shade over parking, agricultural applications and community and school sports halls would be a more appropriate fit.

Issues of the consistency of the material became issues when the stems were configured into longer span elemental structures. Most of the student’s schemes made assumptions about the level of variability of the resource with most thinking that the material would be quite consistent and lend itself to prefabrication. When the group started working with full scale elements, this assumption was dismissed and many adapted their ideas to account for the material’s variability.

The steam bending of stems lent themselves to some quite elegant curvilinear forms. Similar forms in materials such as steel would require the use of circular hollow sections which would be at a greater expense both in terms of dollar value and value in carbon. One of the proposals looked at an arched structure that utilised the same bending geometry for all elements so that the manufacturing process is streamlined as well as enabling the structure to be scaled up and down (refer Appendix 3.11). The issue with this approach though was that the conical stem geometry was difficult to resolve due to the differences in stem size and geometry. A universal elemental system would require that the logs be shaved. In practice this would not be viable with thinnings which were intended to span over great distances. The resolution would need to come with the design to ensure that the geometry of the structures were cognisant of the effects of the variable stem geometry and diameter.

Particularly for the larger scaled designs, the ways and means of joining elements became a major issue. There was not a chance to devise 1:1 prototype connectors within the scope of the project so literature research was the main source of solutions. Simple scarf joints with large elements were deemed to be aesthetically unacceptable for anything other than an agricultural building. A variety of large scale biscuit joints and joining plates were used. One solution that was used in a number of schemes was a pipe connector in the end of the log. There is quite a variety of design options with this solution to both join logs to one another in a three dimensional structure as well as connecting to footing structures. Future studies would benefit from a closer investigation of the pipe connector and prototype connectors made.

Some students became preoccupied with the jointing systems as the main focus of their design. The “Universal Roundwood Connector System” (Appendix 3.13) took on the position that smaller straight shaved logs provide more flexibility as a system. Though this position strayed a little from the overall approach of the research project the connector, based on a Dutch prototype, is simple and would allow a variety of structures to be devised from a simple kit of parts. The problem though with the scheme was that it assumed a rectilinear approach to structures and did not have the same aesthetic appeal as the more organically formed structures.

Two propositions looked at the application of roundwood thinning as infrastructure elements. Both schemes (see Appendices 3.12 and 3.14) focused on barrier systems, one for roadside barriers and the other for wind breaks to be used in agriculture and remote communities. The beauty of either of these systems is that there is potentially a large demand for the product and that the existing in ground treatments used for power transmission poles can be utilised.

The “Curvuer” roadside noise barrier system (Appendix 3.12) is especially interesting for two reasons. Firstly the aesthetic appeal of the overall system is in a different league to traditional barrier systems. Traditional barrier systems rely on surface treatment alone as the primary aesthetic component where as the "Curvuer" system looks at surface and form. The overall aesthetic effect is almost like land art with the organic forms more in keeping with the natural environment and the natural flow and curves of the motorway. The issue of cladding such an irregular system is perhaps not as problematic today with the commercial availability of large scale scanning and CNC cutting of plywood sheets. Other than the aesthetic appeal, the curved form may assist in deflecting the sound away from residential areas, reflecting sound over adjacent houses and reflecting it back into the source.

Though the range of student projects was promising there were still some applications that remain unexplored that have significant potential. Children's play structures and shade structures, bridges and towers were not investigated in any of the proposals. In addition there was a focus on the design of the overall form and structure so little investigation into the possible treatments, weathering and footing conditions. It was accepted that these were outside the time frame of this pilot study.

Developed design concepts

Initial designs yielded a good breadth of solutions that were developed though large scale model making and working with the material at a scale of 1:1. Detailed model making provided some insights to the nature of timber and thinking through the process of bending. It also brought the importance of the connection and the balance of structural elements into sharp focus. Given that many of the schemes worked with organic wall and roof forms, the method of cladding over a complex surface also became a major part of the focus.

Not all of the initial designs were developed. Some schemes were rejected and others were conflated into a new proposition. The scale of investigation ranged from 1:50 up to 1:10. There was a scheme developed in each of the categories that were defined at the start of the project.

The material used to simulate the roundwood material was Tasmanian oak (*Eucalyptus* spp.) dowels. Though the material was a consistent diameter and did not have any surface imperfections, it was best in the circumstance as using smaller tree limbs in the experiment did not work as these stems were too irregular.

The dowels were pre soaked for at least two days and were steamed in an autoclave or simply boiled for 10 minutes. Both options had equal effect. Bending rigs were made to set the dowels into bent geometries. The jigs were set to 20% over the required curvature to account for the spring back effect. It was found during the testing that the amount of spring back was consistent at around 20% and that this was in accordance with the anticipated spring back of the actual thinning.


Plate 1: Model bending rigs


Plate 2: Steamed dowels being set in rigs

There were a significant percentage of failures in the dowels during the bending. Many snapped and some that didn't had significant compression failure. On average about 20% of the dowels snapped or had compression failures. The explanation for the percentage of failure could be accounted in some instances due to the variability of the grain in the dowel. Given that they were a dressed product and from different parts of the tree, some dowels had a greater propensity to splitting. It was found that the dowels had a "natural" way to bend and there was a skill in bending the dowels as per the way it wanted to bend. Though this was an issue during the model making phase we felt that this effect would not be replicated in the 1:1 tests.

Two aspects that were of significance though that would transfer between the model and 1:1 production were the effect of the bending jig set out points and the speed with which the stems were placed in the bending jig. The set out points of the bending jig could significantly affect the way propensity for compression failure. The speed with which the dowels lost heat in the time they were placed in the jig significantly affected the success rate of bending. We were all surprised how quickly the capacity for bending diminished even with small changes in temperature.

The difficulties in cladding an irregular structure were revealed both in the model making phase and subsequent 1:1 prototyping studies. There inevitably needed to be a level of adjustability of the fixing between the primary structure of thinning and the secondary structure of sawn or machined material. Structures that utilised fabric or other tensile membranes would inevitably be more adaptable to a bent thinning structure. Therefore building types such as shade pavilions, play structures or simple infrastructure where weather tightness was not an issue would be easier of work with. This is not to say clad buildings are not appropriate to the technology, only that account needs to be made for the tolerances and perhaps a greater level of skill needed to clad such structures.

1:1 prototypes and material studies

Students participating in the pilot study worked with the material through all scales including 1;1 studies. The importance of the engagement with all scales of the material is critical as the hands on experience feeds back into the tacit understanding of the material during the design phase. Though done at the end of the research cycle, the reflections on the experience through all phases of the research project were invaluable.

A pre-designed structure utilizing hardwood thinnings was presented to the group to assess. The design of a "Park Pod" (refer Appendix 5) was developed by the student's coordinator, Michael Dickson. Though the prototype was not completed during the project phase, cladding studies at 1:1 were completed.

Plate 3: Cladding studies for park pod

Plate 4: Cladding studies for park pod

The park pod design is based on a simple circular geometry using the stems in a vertical configuration. The pod can be scaled to perform as a simple shelter all the way to a small bush cabin. The specific aim of the design was to create a cladding challenge hence the structure was presented to students as a structure only with no development of secondary systems to support cladding.

Three bays of the park pod were constructed for students to experiment with. The option of cladding directly to the stems was dismissed as the irregular profiles created too many difficulties. Experiments in weaving flexible material were undertaken and though this was more successful it resulted in irregular and three-way bending of sheet material and required a significant amount of skill in the application.

On reflection of the experience a system of horizontal girts constructed from plywood was decided so that the outer circumference of the ply could be controlled and the inside circumference be adjustable through cutting and trimming.

Bending demonstration

A final aspect of the experiments involved the bending of full sized stems. Thinnings were harvested from an 8-year-old spotted gum sawlog plantation located near Amamoor in south-east Queensland. The stems were selected based on standard thinning rationale to improve the spacing in the plantation. That is stems were removed if they were competing with a superior, dominant neighbouring tree. The range of stem diameters at breast height over bark (DBHOB) was 10 cm to 15 cm. The harvested stems were delimbed, debarked and merchandised to standard lengths of 6 m for transportation.

Plate 5. 8-year-old spotted gum roundwood stems.

Upon delivery to DEEDI's Salisbury Research Centre in Brisbane, the stems were docked to 4 m lengths and received processing treatments to minimise end splitting then placed in a water tank to maintain their green condition. End-split treatments included ring grooving with a hole saw and with longitudinal external kerfing with a circular saw.

Prior to bending the stems were held in a steaming chamber for approximately 24 hours under wet steam conditions of 90°C to 100°C and 100% relative humidity (RH%). Stems were removed from the steam chamber individually and placed in the bending form within 5 minutes, then the tip (small end of the log) was pulled around the form with a forklift and tied off.

As with the experiments during the model phase, it was found that the stems lost heat quickly in the time they left the kiln and were set on the bending rig. Though the bending of the stems did not result in the same percentage of failure, the effect of cooling during the bending process was noticeable. The importance of the proximity between the steaming and the setting in the bending rigs is a major consideration for any future production facility and ideally would form part of future research projects.

The bent stems were covered with a tarpaulin for weather protection during the setting period of 3 weeks.

Plate 6. Steamed logs fixed onto the bending form. Note the ring groove and external kerf treatment used to limit end splitting.

Plate 7. Retained curvature 7 days after release from the bending form.

Survey

The survey prepared by Timber Queensland (TQ) was located on a platform by their external Information Technology resources and emailed to a database of over 1200 people across the eastern states of Australia. The content of the Survey Questionnaire is provided in Appendix 1.

Response

There was a response rate of approximately 5%. Although only a small proportion of those emailed responded to the questionnaire, the 62 people that did represented a broad cross section of designers, specifiers, users and infrastructure owners/managers.

Figure 1 provides a breakdown of the respondents by category. The 'other' category included builders, a veterinarian and sales and marketing. The 'architect' category includes landscape architects.

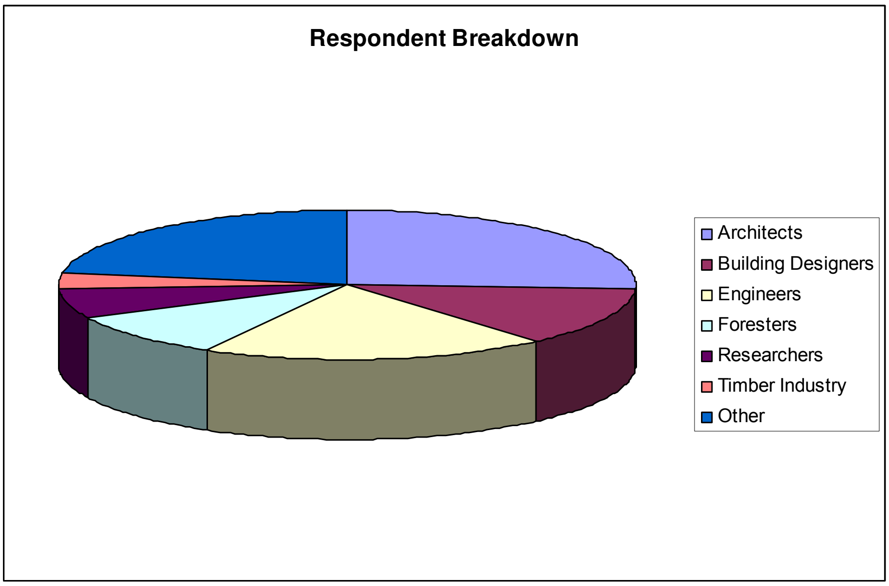

Figure 1. Breakdown of respondents by occupation.

Feedback

In addition to the simple questions in the survey, respondents provided extensive written comments, personal impressions and questions which provide an insight into the concerns and needs of potential designers and users of the material. This valuable feedback is are listed under the relevant survey question in Appendix 2.

For the survey question "Your overall impression of the designs and concepts was…?" 54 respondents or 87 % liked the designs, 8 (13%) neither liked nor disliked, and no respondents disliked the designs as illustrated in figure 2.

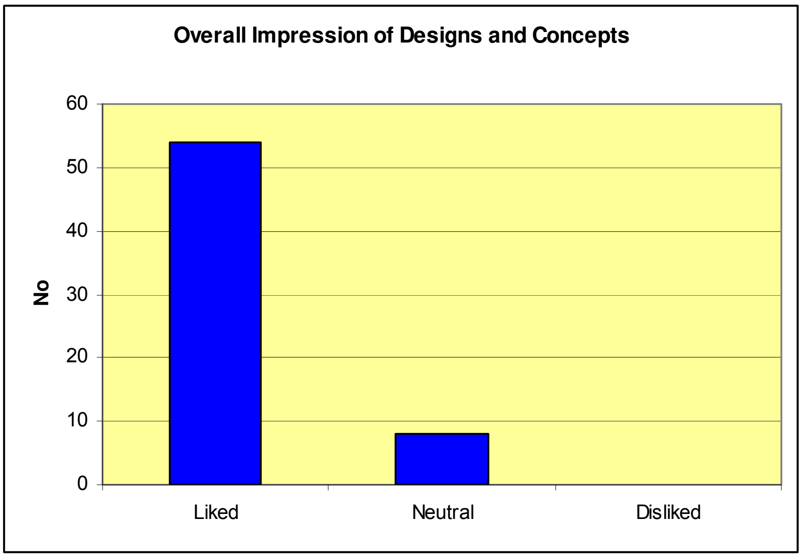

Figure 2. Overall impressions of the designs and concepts (number of responses per 62)

Some recurring feedback responses mentioned the innovative and attractive designs and the potential of curved designs. Another recurring positive comment was that the concepts were not "boxy". The respondents noted that it would be important to make designers and other users aware that the roundwood stems are not regular cylinders and tending to conical in shape. The respondents requested further information on the structural properties of roundwood.

Respondents were asked to rank the general appeal of each concept group (that is: small, medium, large and infrastructure) from 1 highly appealing to 5 forget it. When the results for the two positive scores (highly appealing and appealing) are combined, it can be seen that for each case the majority of respondents found the designs appealing. The rankings for each structure category are presented in figure 3.

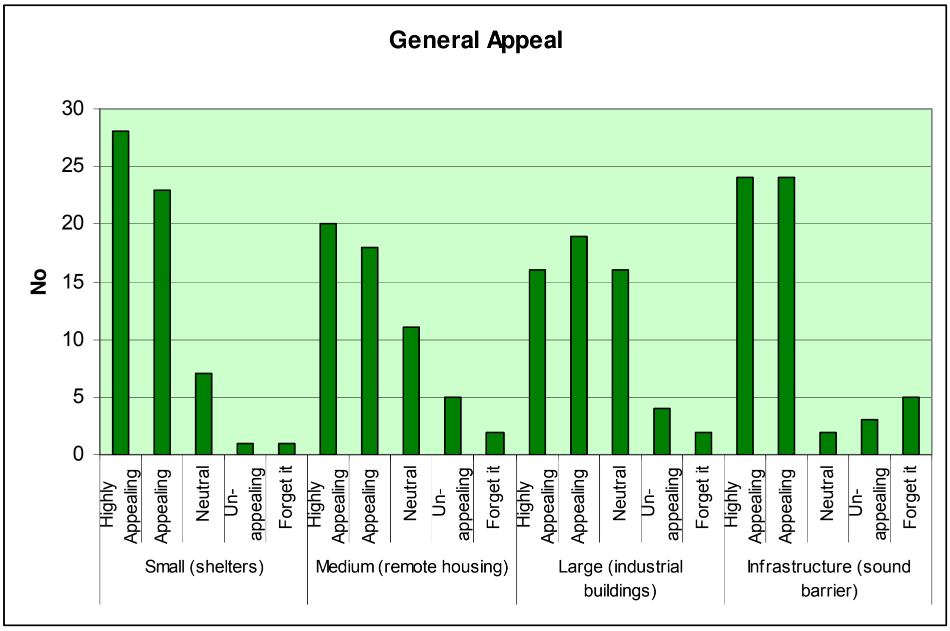

Figure 3. Respondents' ranking of general appeal of design concepts (n=62).

The trend for positive responses to the concepts was further highlighted by data returned for the survey task "For each of the design concepts, please rank their potential for market uptake/commercialisation (1) high (2) medium (3) neutral (4) low (5) very low". Respondents suggested that prefabricated building kits could provide a commercial solution for more affordable structures. Questions raised by respondents were centred around technical aspects such as durability, finishing, maintenance and lifespan.

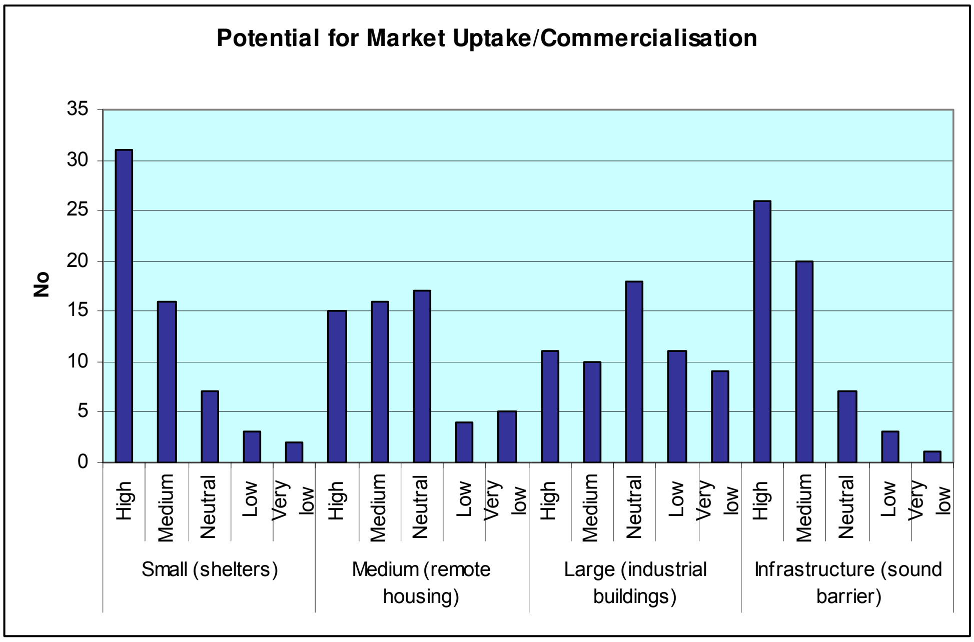

Figure 4. Ranking of the potential for market uptake/ commercialisation (n=62).

When asked whether they considered that detailed R&D towards commercial realisation was justified or warranted, almost all respondents (60 out of 62) said that they support or fully support a project, compared to 2 who were neutral on the point. No respondents suggested that they didn't support R&D on the topic. The development of readily available standard and efficient jointing systems was a common theme in the responses, highlighting the need for this aspect to be covered in future R&D efforts.

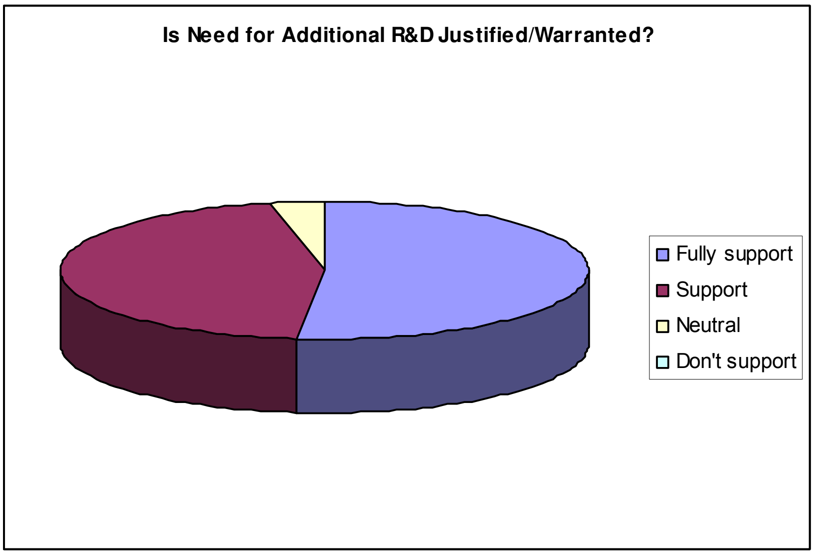

Figure 5. Views of respondents on further R&D on structural roundwood.

In the opinion of the respondents, the main constraints to commercialisation were confidence in durability and lack of suitably priced and available connector systems for rapid construction.

One of the survey questions left unanswered by most respondents was where they were asked to provide an estimate of the potential market size and annual expenditure on the types of structures represented by the conceptual designs. Twenty-eight people provided data for an estimated annual spend (Figure 6) and only twenty-one of the 62 respondents were able to estimate how much material might be used annually (Figure 7).

The breakdown of responses per the four structure categories appear in Table 2.

Table 2. Number of responses regarding potential markets.

Concept category	Number of responses	
	$/annum	Area or lineal m/annum
Small 16		12
Medium 4		3
Large 3		2
Infrastructure 5		4

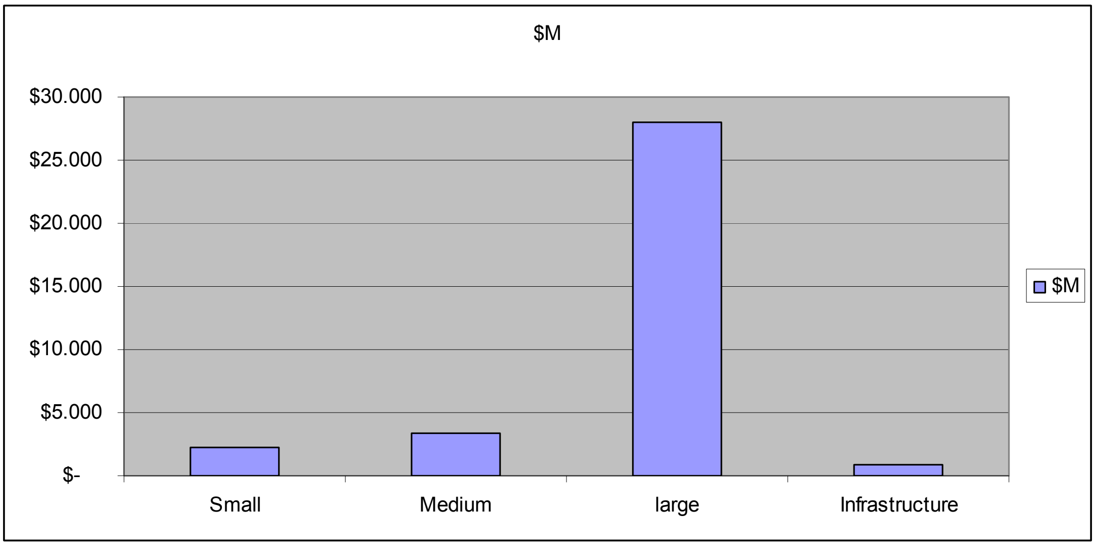

Figure 6. Estimated annual spend on roundwood structures ($million, 28 responses).

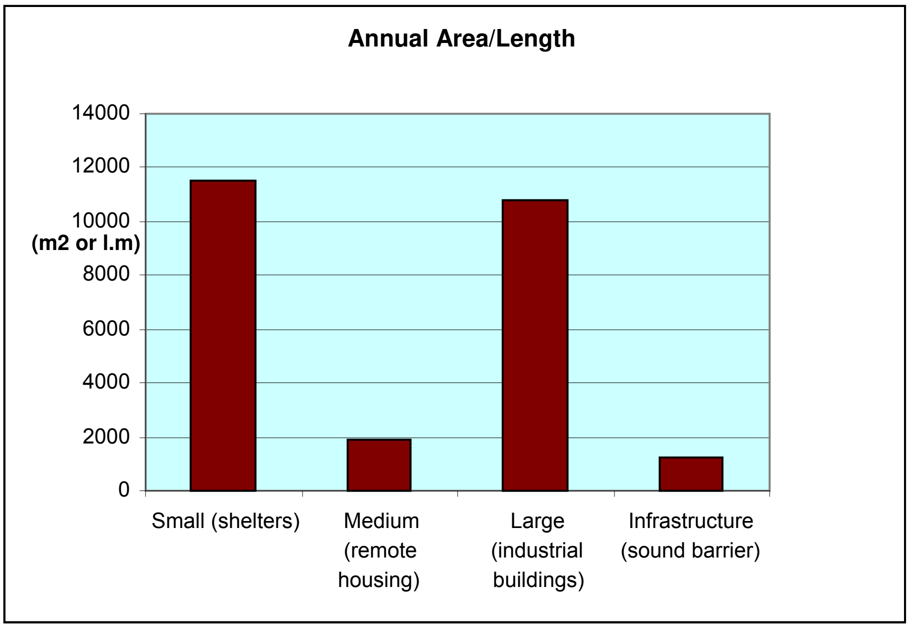

Figure 7. Accumulated size of structures per category per annum (21 respondents).

Economic analysis

The financial benefit cost analysis indicates reasonable expected returns to the proposed project. Using the 5 per cent discount rate:

- internal rate of return (IRR) 492%
- benefit cost ratio (BCR) 223:1
- net present value (NPV) $100.3 million.

Sensitivity analysis

Sensitivity analysis has been undertaken on the key variables, the discount rate and the retail price received for 7-year-old stems sawlog plantation thinnings or pulp logs) for roundwood. The results for this analysis are presented in Table 3.

Table 3. Sensitivity analysis

	Discount rate			Roundwood price reduction		
	5%	8%	10% -1	0% -2	0%	-30%
NPV ($m)	$100.3 $7	5.2	$63.1 $5	4.2	$8.2	-$37.9
BCR	223.2 1	69.1	142.0 1	21.2	19.1	-82.9
IRR	492% 49	2%	492% 34	4% 10	3%	

Discussion

The base-case results and sensitivity analysis indicate that a detailed R&D project *Production of higher value products from plantation-grown hardwoods originally established and managed for pulp production: roundwood structural products* project has significant benefits and presents high return to the project expenses.

Table 3 shows that the net present value of the project costs and benefits is high. The net present value decreases significantly when there is a projected price reduction of roundwood, becoming negative if the projected price received for roundwood timber declines by 30 per cent.

Production of arched and straight light structural members is expected to increase the viability of the hardwood plantations through utilisation of the early thinning timber volume. It must be noted that this analysis was not based on past or current figures, but forecast values.

Conclusions

This project combined interdisciplinary expertise including scientists, engineers, architects, a processor/manufacturer and economic analysts to consider opportunities for commercial uses for small roundwood hardwood products. Interestingly this skills' mix provided the forum for lateral thinking and development of concepts. Scientists and engineers bring ideas to process and assemble materials, the architects expanded on this to explore a range of designs across different scales of construction. The processor/manufacturer maintained a commercial and realistic market potential outlook for the designs and the respondents to the survey provided essential feedback to inform further research.

Despite only 5% of recipients (62) of the survey responding to the questionnaire, important data and information have been obtained to guide future research and development on plantation roundwood structures.

The results from this survey clearly indicate a high level of support for further development and commercialization of the concepts and uses for small diameter round hardwood plantation timber and as well as the necessary R&D to bring this to fruition including:-

- durability
- lifespan
- connections
- structural properties data

- cost
- approvals and compliance with Timber Structures Code and Building Code of Australia
- finishing and maintenance

The economical base-case results and sensitivity analysis indicate that a detailed R&D project has significant benefits and presents high return to the project expenses.

Despite the small scale of this pre-study, the results indicate that it has been a valuable and efficient process to evaluate the need and also the scope for a detailed R&D project. The mix of competencies involved in the pre-study proved to be a productive melting pot, working synergistically towards the development of a future collaborative project.

Recommendations

The detailed R&D project "*Production of higher value products from plantation-grown hardwoods originally established and managed for pulp production: roundwood structural products"* submitted to FWPA in February 2009 should be reconsidered with a greater emphasis on:

- Develop and refine a post harvest treatment: end coring and longitudinal kerfing
- Propose a grading system
- Characterise of minimum acceptable stem geometries
- Resolve durability/weathering/fire performances issues
- Design primary fixing and fastening systems
- Design secondary fixing (panelling, cladding, roofing etc.)
- Design and construct demonstration buildings and noise barrier
- Propose a prefabricated system
- Assess current building code and standards application (technical and design procedures)

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Ted Stubbersfield

Forestry Plantations Queensland

Researcher's Disclaimer

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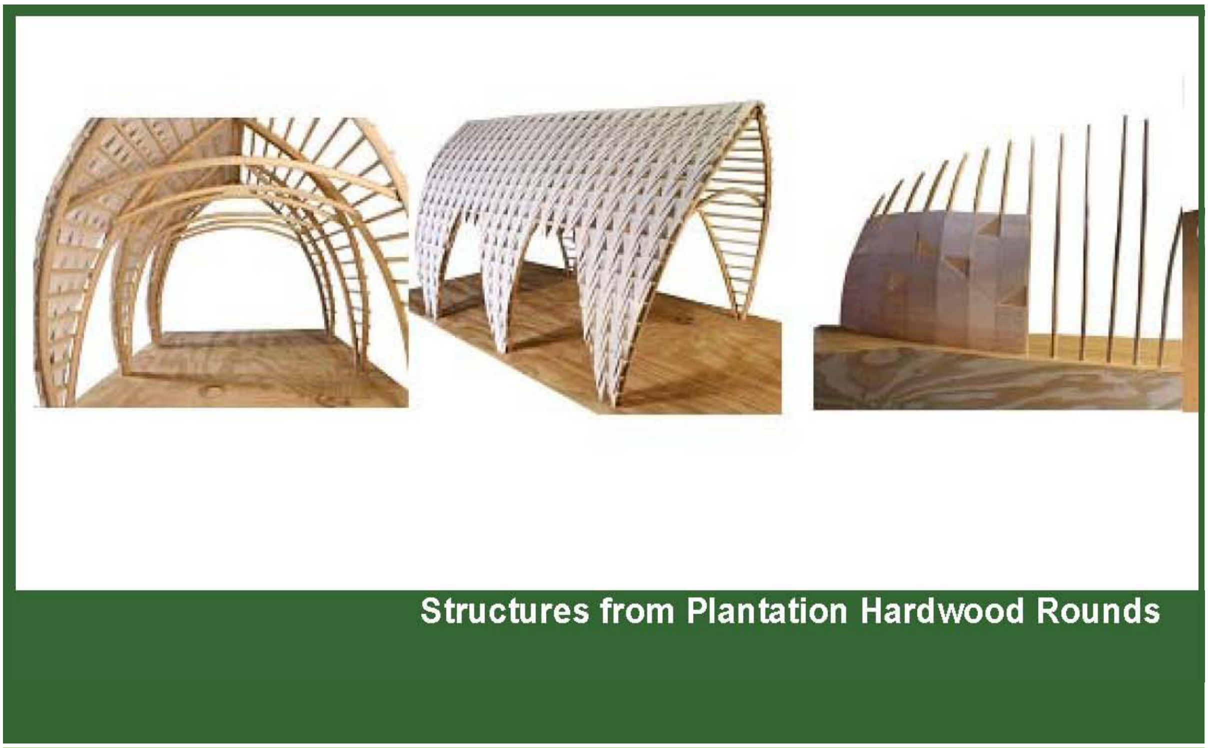
Appendix 1. Survey Questionnaire



Please spend a few minutes reviewing the roundwood design concepts and then complete the survey below. The concepts are grouped into 4 categories – small, medium and large buildings and infrastructure.

In completing the survey, please assume that any issues associated with termites, durability or structural design or adequacy have already been addressed.

Name*

Profession*

Company Name*

Title*

Ph Number

Email

Q1 Your overall impression of the designs and concepts was:*

- Liked
- Disliked
- Neutral

Do you have any comments about your first overall impression of all the designs and concepts?

Q2 For each of the design concepts, please rank their general appeal with (1) highly appealing (2) appealing (3) neutral (4) un-appealing (5) forget it

Small i.e shelters	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Medium i.e remote housing	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Large i.e industrial buildings	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Infrastructure i.e sound barrier or wind break	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Do you have any comments about the general appeal of each concept?	
Q3 For each of the design concepts, please rank their potential for market uptake/commercialisation (1) high (2) medium (3) neutral (4) low (5) very low	☐
Small i.e shelters	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Medium i.e remote housing	☐ 1

	☐ 2
	☐ 3
	☐ 4
	☐ 5
Large i.e industrial buildings	☐ 1
	☐ 2
	☐ 3
	☐ 4
	☐ 5
Infrastructure i.e sound barrier or wind break	☐ 1
	☐ 2
	☐ 3
	☐ 4
	☐ 5
Do you have any comments about the potential for market uptake/commercialisation of each design concept?	
Q4 For the designs/concepts that you most favour, do you consider that it is justified or warranted to undertake more detailed R&D towards commercial realisation?*	☐ Fully support ☐ Support ☐ Neutral ☐ Don't support
Do you have any comments about detailed R&D for the designs/concepts?	
Q5 For the designs/concepts that you most favour, what do you consider to be the biggest constraints or impediments to commercial realisation? Please list.	
Q6 For your organisation, could you please provide an estimate of the potential market size and spend for the types of buildings/structures	☐

covered by these concepts.

Small i.e shelters ($) p.a.	
Small i.e shelters (m2) p.a. of building	
Medium i.e remote housing ($) pa	
Medium i.e remote housing (m2) p.a. of building	
Large i.e industrial buildings ($) pa	
Large i.e industrial buildings (m2) p.a. of building	
Infrastructure i.e sound barrier or wind break ($) pa	
Infrastructure i.e sound barrier or wind break (lin.m) p.a. of structure	
Q7 Please provide any other comments, thoughts or suggestions regarding the above any other potential new uses/applications for small diameter round plantation hardwoods.	

Submit

Appendix 2. Survey Comments

Do you have any comments about your first overall impression of all the designs and concepts?

- Looked like uni projects from architecture students.
- Intricate connection details required. Strength of materials?
- New and outside the square.
- Interesting, good ideas.
- Some appear to be more practical/feasible than others.
- Resembles traditional indigenous forms of architecture i.e. Pacific Islands.
- Lots of potential for creativity.
- Nice to see a different application of material, especially an under-utilised resource, for good design outcome.
- Great animal shade structures, portable and natural.
- The concept will allow for new and exciting designs shapes with a softer aesthetic appeal.
- This is an innovative use of what was once a waste product of the timber plantation industry. The designs however do not show this level of innovation.
- Free form is exciting.
- Very different concept. Good way to utilise smaller timber.
- Unique and creative was my first impression, however, for our purposes we would want to use the materials to make our own designed park shelters.
- I was pleasantly surprised how appealing I found all of them - much better than I would have expected from such a low valued resource.
- Structural design software would be helpful.
- Very good, but most concepts seem to focus on similar curves. There could be a bit more shape variety.
- Structures are light and airy. Purlin fixings on rounds are often clumsy. Will the steamed timber retain its shape?
- I was most interested as to who would take this on as a commercial concept through to marketing, manufacture and erection.
- Good.
- May be suitable as shade structures.
- Quite innovative.
- Impressive! Maybe also be suitable for YURTS-GERS (Mongolian); OZ-Camp (portability easy assembly) subject to anchoring to the ground.
- It sounds like an excellent idea to me with many possible uses.
- AMAZING!!!! PLEASE SEND ME MORE INFO!!!!
- Touchy Feel-y Timber Structures do not seem appropriate in public areas (vandalism, graffiti. arson, old CCA phobias etc., maintenance, weathering) Sad! But true.
- Quite good however I would like to see more innovative solutions and uses with timber...the infrastructure screen seems like a good idea and much more interesting than the solid concrete precast panels you see today...safety is probably another issue...
- Very Innovative. However only one concept addressed the challenging issue of timber connection details.
- Designs were nice looking but not much basic data provided to be able to utilise products in other ways as well.
- I am very interested in the potential of the plantation hardwood rounds. Specifically for use in small structures and play equipment in parks.
- Great flowing shapes.
- Innovative design always attracts attention. Selling the green concept with eye catching designs has to be a winner.

- I believe we need some variety in design particularly for the average home block. Everything seems to be on straight lines. What is available now is very unattractive. I like what I see but this is a limited set. My first thought was cost.
- How do they curve the members and how do they maintain the curvature?
- East Asian in form and shape, very attractive.
- Most of the structures seemed to have very uniform logs, reality is the form is generally poor. Interested to know if there will be any secondary processing of any of the thinnings.
- First impression was that the product would look natural and different at the same time. I like the idea.
- Questioned how practical they would be to get to market. Also there's an awful lot of rounds and probably not that much call for bus shelters!
- I liked the whole concept from both using more wood in place of non-renewable resources and in creating an alternative market for small diameter logs.
- I could see there being a niche for small public amenity buildings.
- Designs looked good with the use of curved surfaces.
- Curved structures aesthetically suit the resource. Small plantation rounds are not regular shapes so aren't suited to recta-linear designs.
- Great potential use for a difficult to utilise product (excluding biomass).
- Some were more practical than others. Large span sheds and infrastructure wall for highway look promising.
- Curved members tend to suit decorative type structures.
- Similar design footprint - linear - a current limitation? Eg meeting hall with cross plan to suit large area plus ancillary spaces.
- An excellent use of small round timber that otherwise would be thinned to waste.

Do you have any comments about the general appeal of each concept?

- 1. Great for parks/ Landscape, 2. Simple for disaster areas, 3. Maybe not to good around heavy machinery, 4. Great change from looking at flat fences on h/ways.
- The combination of modern and traditional technologies holds the most appeal. I like the simplicity of the designs and the idea of using timber rather than steel to create aesthetically appealing, functional and sustainable building forms.
- The general appeal of each concept is considered to be good. The devil may be in the detail.
- The large span structures are the most innovative use of this product demonstrated in the concepts.
- Thermal rating and insulation would be the drawback.
- Design tools will be the issue, and should be investigated.
- The interaction of the rounds with triangular structural shapes is great.
- New and attractive- not 'Boxy'!
- Interesting statement pieces. I like the look of the sound wall in particular.
- Concepts were generally appealing. Further information about structural properties of the timber would be appreciated.
- Curve and flowing lines so much better than standard boxy architecture so commonly seen, particularly for industrial sheds. I don’t like the sound barrier at all.
- I do not like the solid barrier concept of sound and wind barriers, would like to see gaps included that are treed.
- No they look good.
- It is hard to see timber noise barriers making a comeback in the face of concrete and steel.

Do you have any comments about the potential for market uptake/commercialisation of each design concept?

- A kit house developed out of these components could be one commercial solution for more affordable housing and housing those in remote or disaster situations.

- Any system whereby the structure becomes the feature rather than the skin is interesting in commercial terms. Simple and cheap cladding materials may make way for an expression of the structure instead.
- Need to bundle the components into kits for end users.
- I would expect that the industrial shed market might be the hardest to crack. It will come down to cost and how easy is it to design.
- Timber is not a popular structural material in the Queensland construction industry, as it is more time consuming to work with and must be well maintained and treated. Therefore its commercial uptake will be for non-critical structures.
- Climb-ability will be an issue in the public realm. Councils do not like any (minimal) cladding below 2100 high from ground.
- Maybe a recycled plastic or composite cladding would be better than timber.
- Smaller Councils may like the designs ready to use, however, our bushland parks will feature park furniture designs unique to our shire. But I would love to use your materials...give them a trial!
- This will need to be supported by a manufacturer who can follow it through. I would like to see some testing and research on epoxy dowel end connections, as this would ideally lead to innovation in space-frame and truss erection.
- Needs exposure at bdaq and other association meetings.
- Lifespan, maintenance and long term durability would need to be assessed. These would be the first questions a client would ask and to have technical data to support this is very useful.
- Clients are always after innovative products.
- The aesthetic aspect of these structures will be a major selling point. Trying to market these types of structures to clients who do not place high importance on aesthetics will be very difficult.
- More details needed to properly assess commercial opportunity.
- Can the industrial buildings be totally enclosed, otherwise this may limit applicability to keep weather, pests out etc.
- Promote the green credentials/plantation sourced/carbon storage.
- Just the one comment as above I see the best market, biggest market is for the small shelters particularly for the small block. It is where I would start.
- Pre-fabrication of components will assist in success. A building in a box approach.
- This will clearly be the hardest part.
- I suspect the small shelters would have potential because they are not far removed from existing concepts. Similarly with sound/wind barriers there seems to be a desire to give them a natural look.
- Likely to be a niche market. Will require careful marketing. Sustainability a positive factor. Need to make sure structures are durable and will last for at least 20 years.
- Not sure about the commercial uptake of remote housing or the size of its potential market, but they are likely to be responsive to greener options.
- 'Infrastructure' is more a political thing and could be either '1' or '5' depending on what politicians decide.
- Will depend on cost and where they have to come from. I assume you are thinking totally prefab / kit form which would be the go. The killer for me being in WA would be the transport unless you are thinking of setting up factories over here.
- scale of use relevant for loss of vertical space up to 2.0m off Floor level, due to incline, so potential adaptability to integrate a base or plinth, or extend armature longer at lower section

Do you have any comments about detailed R&D for the designs/concepts?

- I thinks all concepts could be explored, and perhaps a design comp for the small projects with the winning schemes being built would be very helpful to get it market tested and taken up
- Investigate or develop locally produced tensile cladding technologies to complement these timber structures.

- Constructability and easy of erection on site.
- Need to consider durability in white ant country.
- R&D must be carried out for cyclone areas/locations. Connections must be simple to design and put together in the field. Flexibility must be built in.
- Consult more closely with influential potential specifiers and users of target structure types prior to finalising the R&D plan for technical/engineering/architectural aspects.
- Jointing- Refer existing manufacturers, world seems to run on milled sections.
- Possibly a return to the old tenon, mill the end at node points and use existing jointing systems.
- R&D will be necessary to develop a simple connection details.
- Why not just do it. Is R&D required? If the product complies with design / building codes then use it. If it does not then R&D is needed to find design structural/ longevity properties.
- Review what is currently available in terms of low cost kit homes and small structures and try to develop cost comparative, yet more beautifully resolved options.
- modular housing and framing options explored more, such as 'e-habitat' type framing perhaps
- Try to get a couple of these structures into prominent public locations.
- Steam bending and then holding that shape is critical.
- Think you need a bigger range of designs to investigate.
- Would need to be sure that timber has appropriate durability. Not sure that we have the technology to deliver timber treatment without serious splitting etc?
- Have you considered the work done in the CRC for Wood Innovations using microwaves to aid in wood bending?
- Need to consider cost side across the entire supply chain as well market research to determine level of demand for this type of product.
- Concerned about the degradation of timber. Is it treated in some way to prevent chewing insects and rot and at what age are thinnings suitable?
- From a structural point of view I can see connections as a tricky issue that would need investigating - especially as no piece is geometrically alike.
- Fixing to the round to be complementary with existing v fast proprietary systems: adaptability to additional live loading from usage.
- Need to consider a wide selection of species as properties of each are likely to be different.

For the designs/concepts that you most favour, what do you consider to be the biggest constraints or impediments to commercial realisation? Please list.

- Design limits, does every structure look the same?
- Changing attitudes to building with wood especially for large structures.
- Comparison of longevity and durability/degradation against other materials.
- connection details and design strength.
- Not convince industrial areas would be strong enough.
- Will depend on the cost.
- Durability/lifespan compared to steel and concrete structures.
- Could be perceived as primitive.
- Assembly.
- replacement of components.
- Cost, complexity of construction methods and longevity of the materials.
- Cost.
- Ease of construction and \mobility, can the structure be moved many times "
- Cost.
- Support, Training, Availability of Supply, Finish.
- Market acceptance. People tend to stick to what they know and it's a 'new' idea.
- Changing perceptions re the geometry and building materials needed for construction.
- Weather proofness, thermal insulation, sound insulation.

- Keeping exposed members looking good. Cost of joining round members has tended to be expensive requiring proprietary connectors.
- Again, finding the right manufacturer.
- Just getting the knowledge of the product out there.
- Financial viability, life of product limitation particularly if sapwood is left on.
- Maintenance, clients question ongoing maintenance with timber products.
- Jointing- Refer existing manufacturers, world seems to run on milled sections.
- Educating builders as to the benefits of using these materials over conventional timber framing systems.
- Concern about weathering and durability, Concern about termite resistance.
- Budgetary issues and conservatism.
- Fire damage, climbing damage from a landscape architecture perspective.
- Finishing/protective coating is significant. Something that will show the beauty of the wood and perform well. Alkyd oil based finish.
- Cost, ease of construction, lasting components.
- Durability and economics and getting the balance between the two right. For example connections need to be efficient cheap and buildable, pre-fabrication of these elements would help.
- Fitting into existing suburbs with similar building forms, the council planners may not like them
- 1) Log form, 2) Suitable feedstock and availabity,3) moisture content – splitting.
- Approval through respective councils.
- The biggest constraint as I see it is acceptance by regulatory bodies and customers and perhaps even the public to a lesser extent.
- Costs associated with harvesting, delivery (small piece size) and processing (high energy requirement, non-uniform shapes).
- Negative stigma around the strength and durability of wood versus steel and concrete.
- Anything new in the building industry has a hard time, but if there is an exception to that, it is with small, decorative 'architectural' type structures.
- Authority and market acceptance: even after all scientific hurdles (and I see many of those) have been overcome
- Cost and I guess getting people to think differently about design and form. Everyone loves poxy project homes which are not at all responsive to the environment or the setting (sense of place).
- Flexibility to suit building / project programme, for Post Occ Eval to demonstrate uses described or proposed.
- Specific training for fabrication on site anywhere necessary, with benefit of speed, to suit community volunteers.
- Current resource availability but this project may promote further planting.

Please provide any other comments, thoughts or suggestions regarding the above any other potential new uses/applications for small diameter round plantation hardwoods.

- Would be good if typical fixing details etc, were available.
- Good idea! I am interested in how this material can have high end specifically detailed interfaces and junctions. Option 4 just starts to touch on the possibility of high tech design with low tech materials. I can see a use for rural and natural areas shelters and general infrastructure, promoting the use of low embodied energy solutions for the community, but in an "arty" manner.
- Our organisation is unlikely to spend directly on the structures but it is likely to support the concept for animal owners in feedlots and intensive situations where they offer a mobile solution to shelter for horses, sheep, pigs and cattle. I would suggest that this product would just about have an endless potential. The potential will be curtailed by cost.

- Interesting work. Longevity issues will need to be addressed to use timber externally for other applications. Appropriate construction detailing may overcome this.
- As it is not shown any solution to the drawbacks or the design data, I can not design or recommend it for any other use than a garden tent. Generally for an architectural structure and for ease and uniformity of construction tolerances you would need to turn the posts (shaved)
- Can they be used as columns?
- Many questions: treatment / durability / stability / [green or dry?] / proposed steam bending - curvature & compression design issues - particularly with tapered column design / lengths / diameter available / why limit concepts? Make the product as a replacement for existing main structural components / issues of radial vs tangential shrinkage and ensuing drying cracking / sleeve coating options? / dry and plastic impregnation options / issues with Timber Users and Marketing Act in Qld and the equivalent in NSW. having already built over 5,000m^3 of structures using plantation roundwood in NSW and knowing this would be illegal in Qld I think the regulatory barriers are the most difficult to overcome. The market will buy if the product is consistently available at known prices and with a reliable [on time and to quality] supply. The buyers will not select the product if it is not cheaper and / or suffers from "quota" shortages imposed by regulation. Regulation will also be needed to allow use as noise barriers but the market for this is enormous and growing. Look at Richter Spielgeraete for potential to develop timber for custom play equipment. www.spielgeraete-richter.de/.
- Not very exciting, but inexpensive bollards might be a good use if the timber strength is there. It is great to see a product use being investigated. A creosote-free preservative treatment may assist with weathering.
- Rain shelter in national parks.
- Build a few and demonstrate them at DesignBuild or similar event. We would be happy to use this product when it is available.
- Not really clear what Q6 is asking for bus shelters and shade structures in public parks and sporting grounds, market them to sporting clubs and associations.
- Great idea for finding some innovative options for timber rounds. My major question would be the availability of the resource. Most of the small diameter timber is from pulpwood plantations and is committed to this purpose.
- Survey a very good idea. Good to keep people informed of progress through this forum.
- Cut into shingles or small wooden tiles to replace CO_2 hungry clay tiles and corrugated tin. Alternately pulp and reconstitute with natural resins into moulded roofing tiles.
- Might be good for beach front projects where steel always rusts.
- Great idea, lots of hurdles, but good on you for giving it a crack. Hope it takes off..
- Form of project unsuited to the residential commercial work predominantly undertaken here, making the application of the system more of a rarer system to incorporate, and more likely in less urban sites.

Appendix 3. Preliminary Design Proposals

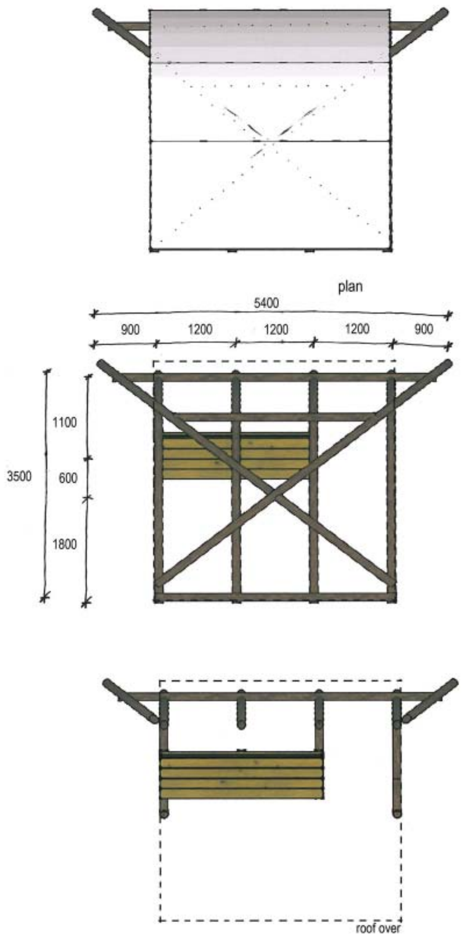
Small Sized Buildings and Structures

3.1 Bus Stop Shelters: Anya Meng

Bus stops are ubiquitous through our cities. Though the quality of shelters has improved in recent years, the materials and technology used in their construction is generally energy intensive. Though the scale of the round wood is perhaps not appropriate as a universal solution to bus stops, it is useful in those locations where there is a larger traffic throughput and a larger community focus. Such structures could incorporate signage as well as other community information and facilities such as public toilets, bicycle storage and rental or newspaper and coffee kiosks.

Sustainability
- Utilises the smallest thinning in the construction
- Utilising a resource with a strength to weight ratio similar to steel
- Utilising a resource that is underutilised and stores carbon.
- Can help create a distinctive community focus and "way-finding" structure.

Competing Technologies / Building Types
The intention would be to replace the medium to larger scale bus stop shelters and to work towards the smaller scale from there. It would not replace the standard Adshell type structure but would reduce the total number of shelters made with high embodied energy materials.



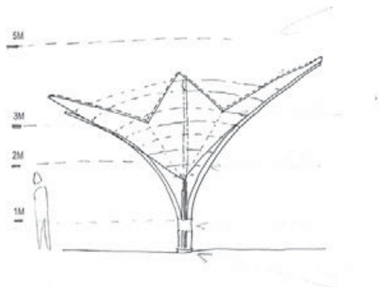
Small Sized Buildings and Structures

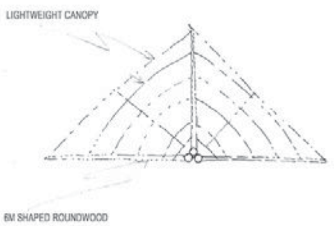
3.2 Umbrella Structures for Transport Interchanges and Public Parks:
Briohny McKauge

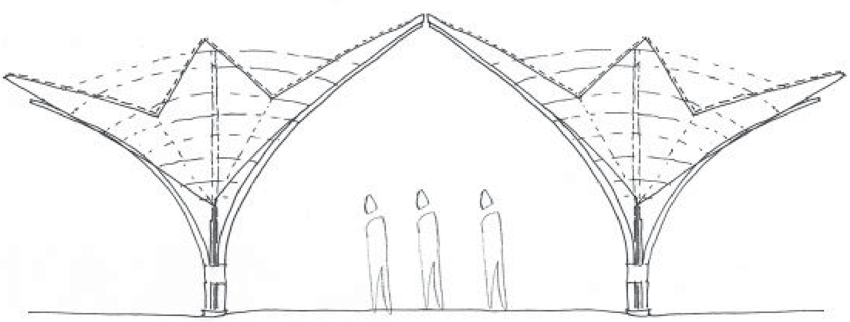
Shade is a critical factor in Queensland. Our outdoor lifestyle coupled with one of the highest incidents of skin cancer in the world makes the provision of shade in our outdoor spaces of important consideration. The proposed design looks at a system that can be deployed as a module to suit the specific location and need. It is imagined that the system could be used for public transport stops, park shelter, playground shelter or any public gathering place. The intention is that the vertical structure that curves out to form the shelter will be sympathetic to a natural tree form making this an ideal application for hardwood thinning as it is the most "tree like" in appearance. The intention is to combine the shelter with solar generation capacity for lighting and advertisements and community announcements as well as the capture and storage of water.

Sustainability
- Design that captures water
- Utilising a resource with a strength to weight ratio similar to steel
- Utilising a resource that is underutilised and stores carbon.
- Creation of attractive tree like structures that blend in with the natural environment.

Competing Technologies / Building Types
Most "umbrella" type structures of a similar scale are bespoke designs and mainly use steel in their construction. As a prototype that can be added to in a modular way, the system can provide shade in a variety of different contexts.







Small Sized Buildings and Structures

3.3 "Gunyah" Shelters for National Parks: Will Gray

Gunyah is based on indigenous shelters that utilise small scale round timber. The shelter is intended for use in nature reserves and national parks where the intention is for the shelter to blend and disappear in the setting. The structure is a modular unit that can be combined in a number of ways to create single or grouped shelters with shared outdoor spaces. Depending on the context the shelter can be used as a picnic shelter or as overnight accommodation for hikers and their swags.

Sustainability

- The design utilises the smallest diameter thinning.
- Utilising a resource with a strength to weight ratio similar to steel
- Utilising a resource that is underutilised and stores carbon.
- The shelter is a discreet element in the landscape.

Competing Technologies / Building Types

The shelter is intended to augment current timber structures used in national parks by being of a slightly smaller scale and used in more remote locations, especially where patrons are walking into locations for an extended hike.

Medium Sized Buildings and Structures

3.4 Off Grid Housing: Andrew Carter

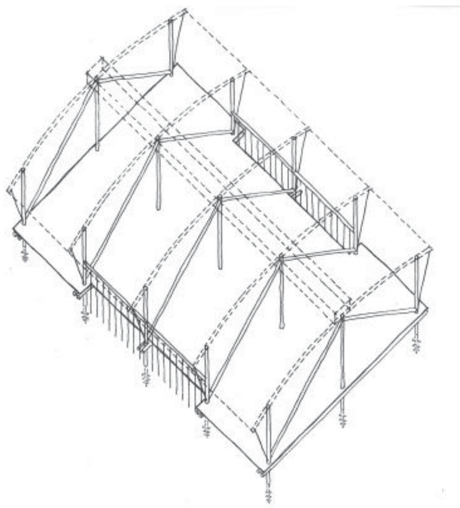
This proposition is focused on the owner builder in remote or outer urban locations. The intention is to try and use the resource as close to the final location as possible to save on embodied energy in transport and log processing. The inherent strength of the round wood system means that a large and simple structure could be erected quickly and slowly completed over time. The system is focused primarily on sharing the technology and knowledge of the resource in combination with specific connectors and foundation technologies.

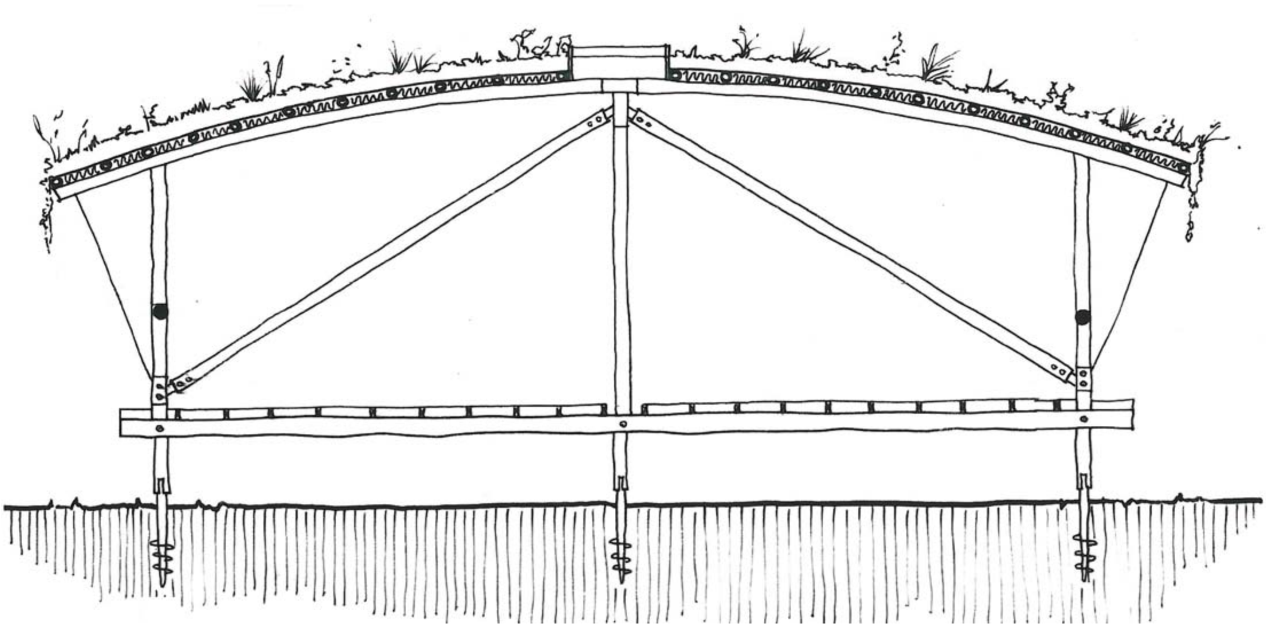
Sustainability

- Leveraged by utilising resources close to the site
- Utilising a resource with a high strength to weight ratio
- Utilising a resource that is underutilised and stores carbon.
- Utilising a material that can be reworked on site with reasonably simple tools

Competing Technologies / Building Types

Though it is not intended to complete with mainstream housing it is aimed at a reasonably sized market that is currently serviced to a greater degree by simple shed technology utilising primarily steel.





Medium Sized Buildings and Structures

3.5 Housing Prototype: Daniel Cocker

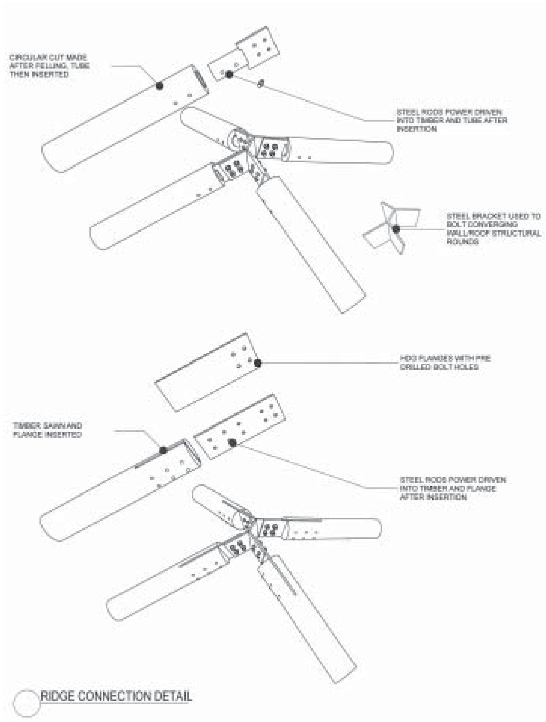
The intention is to provide a house that can be erected quickly and one that is focused on providing large clear span spaces to provide flexibility of layouts. The scale of the structure would work for residential uses as well as small regional offices or holiday accommodation. It is not intended to become a mass market product but will focus on a market that needs flexibility and adaptability, ease and speed of construction as well as final fit out by owners in a DIY approach.

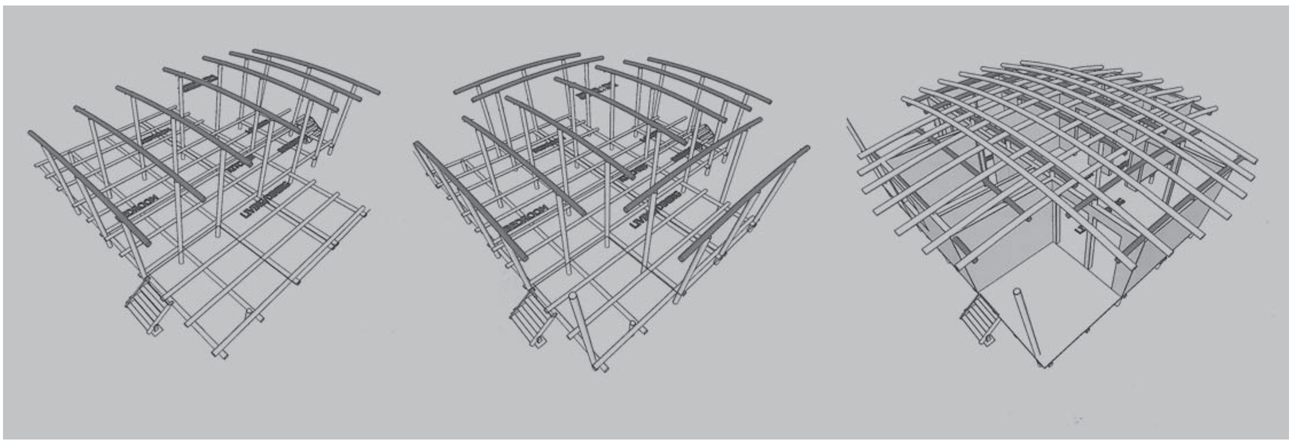
Sustainability

- Niche market could be appropriate for adaptable public housing or indigenous housing.
- Utilising a resource with a high strength to weight ratio
- Utilising a resource that is underutilised and stores carbon.
- Utilising a material that can be reworked on site with reasonably simple tools

Competing Technologies / Building Types

Though it is not intended to complete with mainstream housing it is aimed at a market that demands flexibility and adaptability based on the clear spanning potential of the material.





Medium Sized Buildings and Structures

3.6 Woodland Hideaway: Kerry Martin

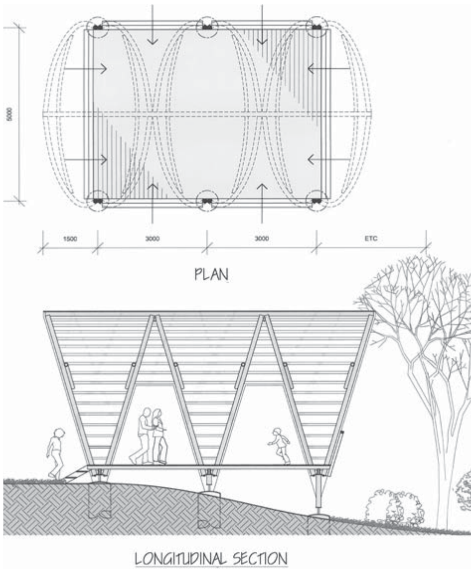
The woodland hideaway is a structure that is intended for medium to larger scale domestic construction. The modularity of the structure lends itself to a range of uses from simple single family houses, guest houses, galleries and studios, rest stops and so on. The unique form and character of the structure would mean it is not aimed at mass market but at a smaller niche that need the flexibility and certainty of a modular system but want a form that is organic and suited to natural environments.

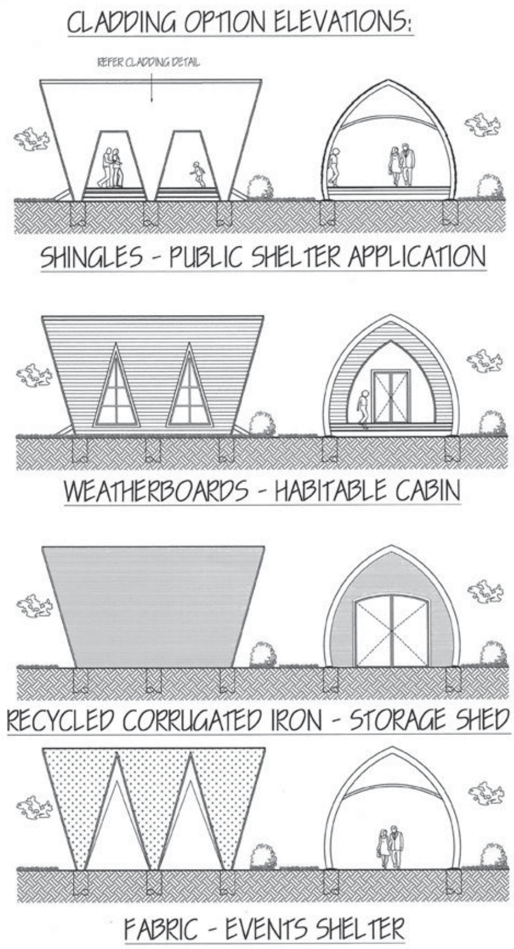
Sustainability

- The scalar nature of the system means it can be utilised in a broader range of building types.
- Utilising a resource with a high strength to weight ratio
- Utilising a resource that is underutilised and stores carbon.
- Utilising a material that can be reworked on site with reasonably simple tools

Competing Technologies / Building Types

Unlike other modular systems that are generally rectilinear and boxy, this system offers a unique and organic solution. Similar roof forms are typically executed with steel at this scale so the timber resource would replace a material with high embodied energy with a low embodied energy resource that stores carbon.





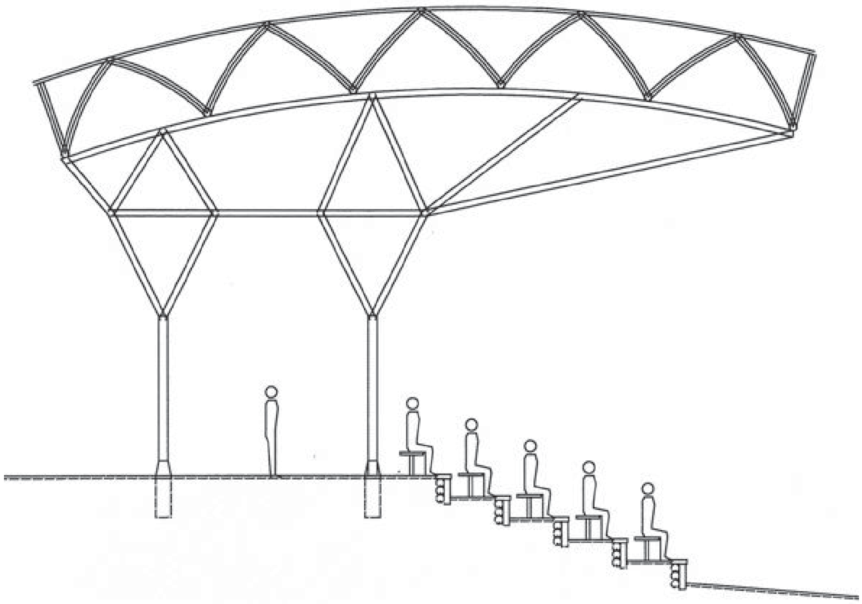
Medium Sized Buildings and Structures

3.7 Community Scale Sports Stadia Structure: Karl Ho

Though the proposition is aimed at providing shade for spectators at community scale sports ovals it can also be adapted to provide shade for more generic applications such as car parks, swimming pools and children's playgrounds. The structure was developed as a truss system with curved top and bottom cords. This was later developed into a simpler structure that utilised the inherent strength of the thinning themselves.
Sustainability

- The application from community stadia to car parks means that the structure is more universal and in turn can use more of the resource.
- The high strength to weight ratio of the material has a good match to the use.
- Utilising a resource that is currently underutilised and stores carbon.
- In combination with a variety of roof cladding the shelters can collect rainwater, generate solar energy and increase vehicle efficiency if used to keep parked cars cool.
- Shade on large areas of bitumen can reduce the amount of radiant heat and cool the ambient temperature in cities.

Competing Technologies / Building Types
Most shade structures used for car parks are steel based. The aim is to directly complete with these systems whilst opening up other applications for shade in outdoor events.



Large Sized Buildings and Structures

3.8 Linear Railway Platform Shelter: Will Downes

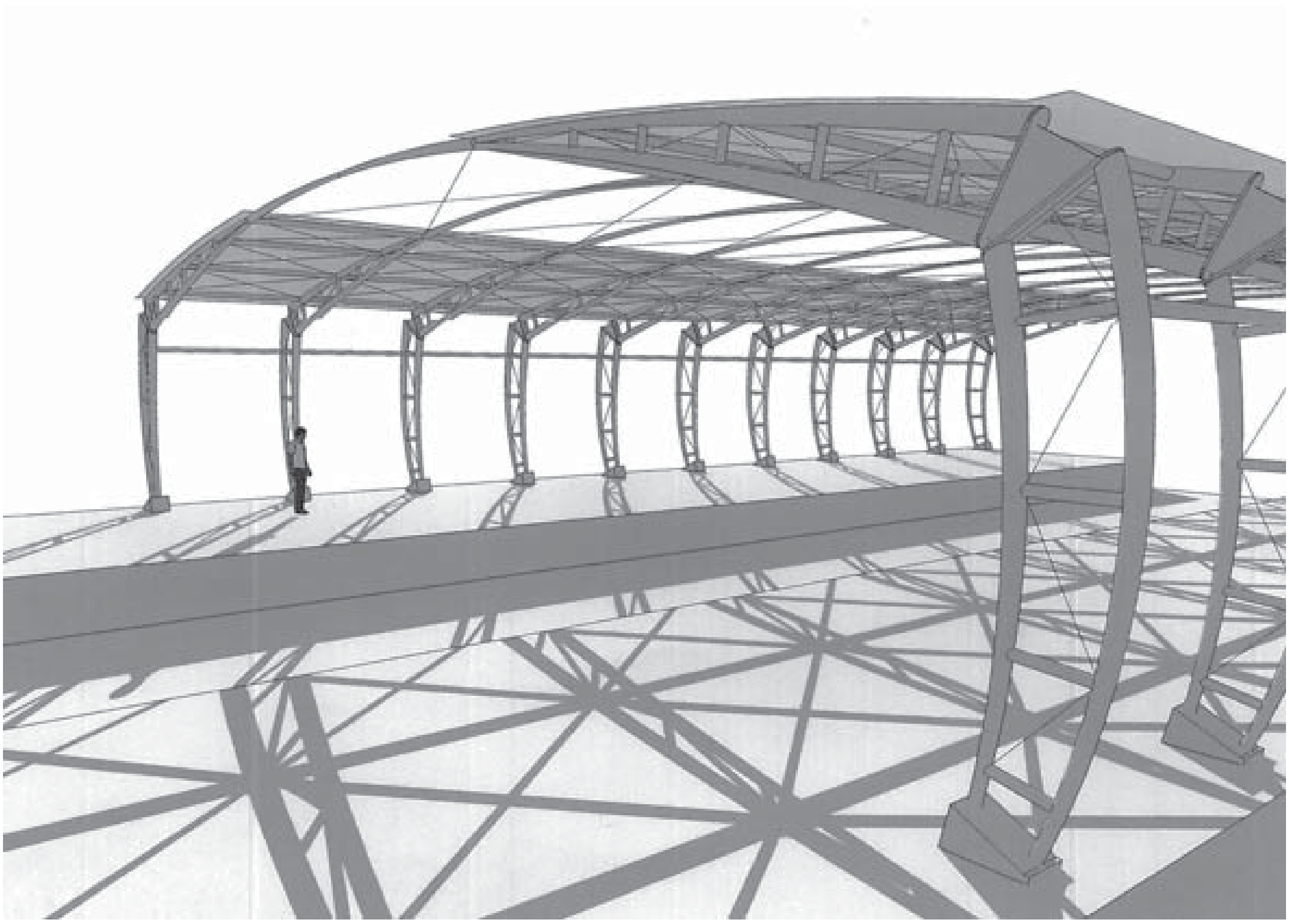
This proposition looked specifically at railway platform shelters. Though such a building type is not a common building project it is generally a bespoke design that involves a high degree of finish durability and aesthetic appeal. Typically such structures are executed with steel however a timber round wood structure with a similar strength to weight ration could equally be considered. Timber in such applications is not unheard of and the aesthetic would provide commuters with a brief contact with nature as part of their everyday routine. The development of such structures would not preclude their application to other more generic building types such as storage facilities, sports halls or industrial buildings.

Sustainability

- Similar high value structures are typically constructed from steel, the aim here would be to replace that with a more sustainable resource without affecting the fire and BCA ratings.
- The high strength to weight ratio of the material has a good match to the use.
- Utilising a resource that is currently underutilised and stores carbon.
- In combination with a variety of roof cladding the shelters can collect rainwater and generate solar energy.

Competing Technologies / Building Types

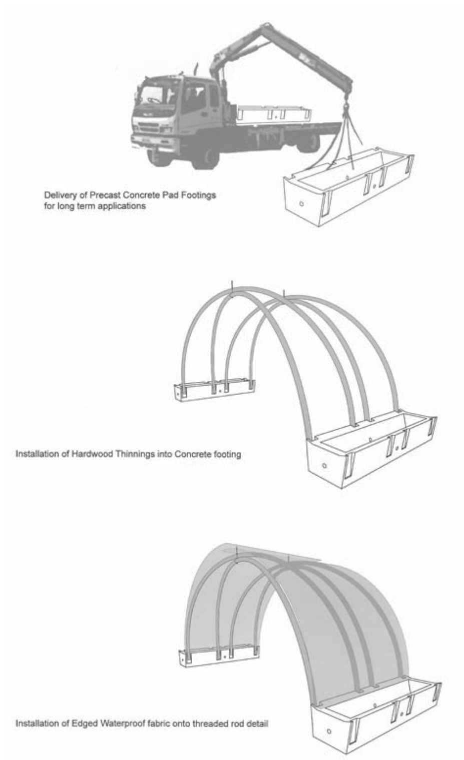
Similar structures are steel based and one would assume that if a system could be devised for railway platforms that other similar linear building types could be constructed using the system.



Large Sized Buildings and Structures

3.9 Quick Assembly Structure for Temporary Applications:
Mathieu Levesque

There are many festivals that need to provide quick and cost effective shelter for people and goods. Such constructions could be in use for some time but at the end need to be dismantled and relocated. Similar applications may be for large construction sites where plant and machinery needs to be kept under cover. The basis of the translocation of structures is that the footings provide adequate tie down but are not permanently fixed into the ground. This design proposes a system of footings that can be weighted down with ballast such as sand, water or rubble.

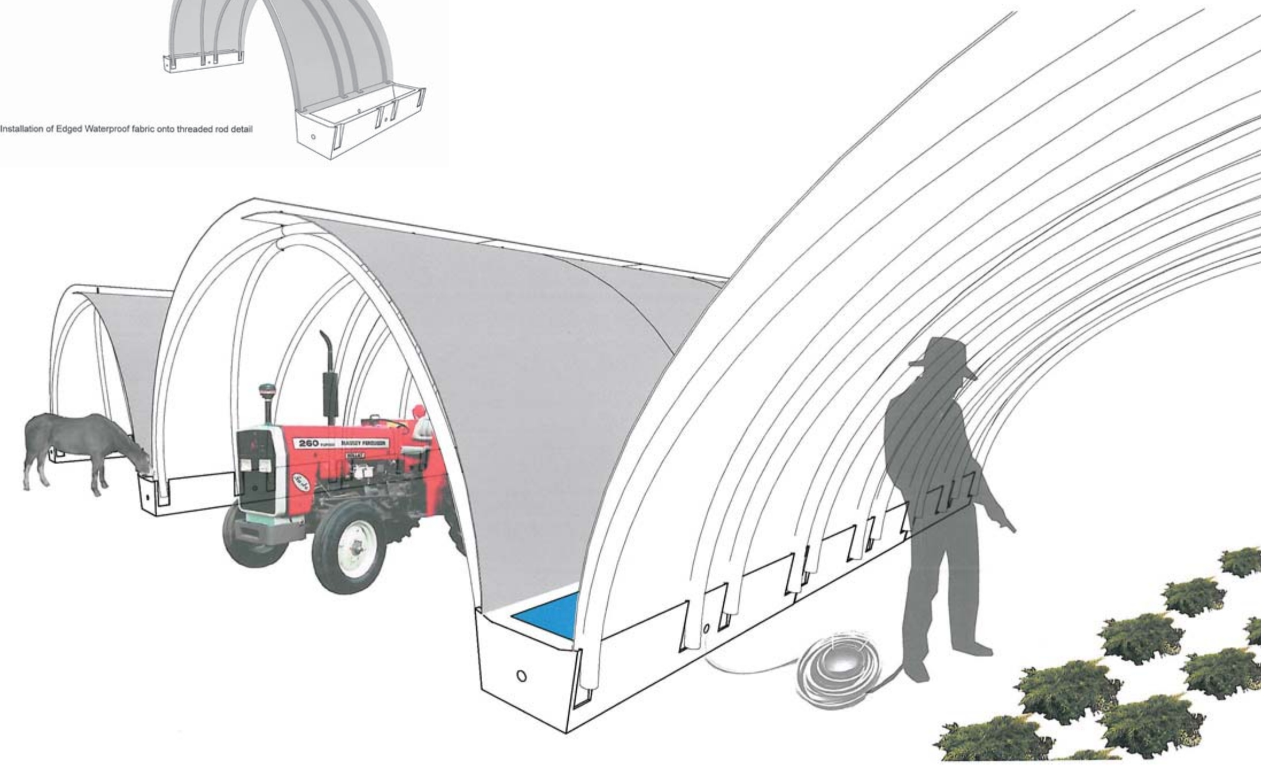


Sustainability

- Similar structures utilise steel.
- The high strength to weight ratio of the material has a good match to the use.
- Utilising a resource that is currently underutilised and stores carbon.
- The intention is that the structure captures rainwater and feeds this into storage tanks to help tie down the structure and provide capacity for general water use.

Competing Technologies / Building Types

Though the demand for special relocatable structures of this scale may be limited, it would find an application in agricultural and remote area mining townships where the structure is on site for an extended period of time but ultimately would need to be removed.



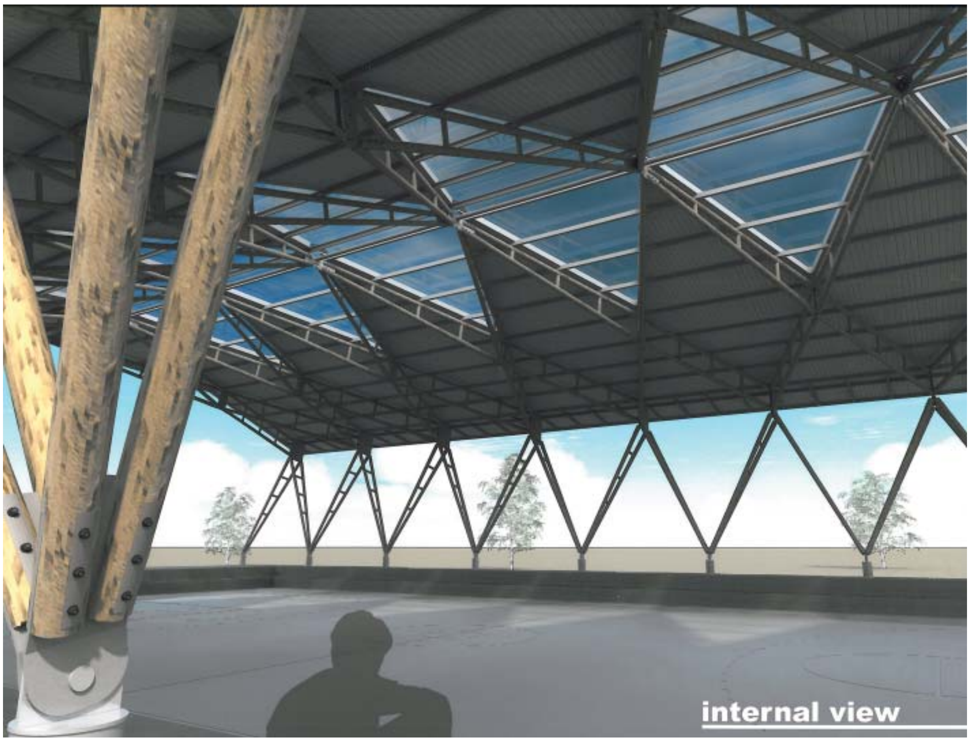
Large Sized Buildings and Structures

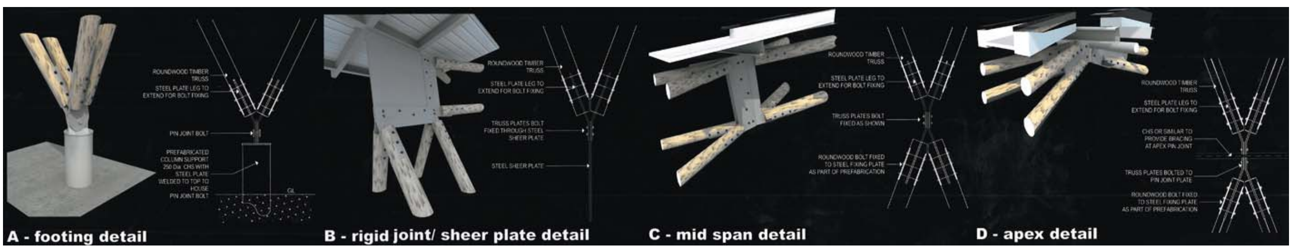
3.10 Large Scale Sheds Utilising Round Wood Truss System: Jeremy Slater

Simple shed structures are ubiquitous in industrial and logistics settings. These structures need to be quick and easy to erect as well as being affordable. Though steel is a dominant material used in these applications, the proposition here is that in a world where carbon capture and storage has a dollar value, then timber construction can be one small way for a company to decrease their carbon footprint. As a pre engineered system it has similar conveniences to steel construction. Typically larger structures are erected by specialist fabricators therefore they can become accustomed to the specifics of the resource. The large span structures are well suited to the properties of round wood and a similar jointing technology to steel fabrication can be adopted.

Sustainability
- Similar structures utilise steel.
- The high strength to weight ratio of the material has a good match to the use.
- Utilising a resource that is currently underutilised and stores carbon.

Competing Technologies / Building Types
If even a small percentage of the market could be transformed from steel to wood then huge savings in greenhouse gases and carbon storage would result as well as a viable market for the resource.





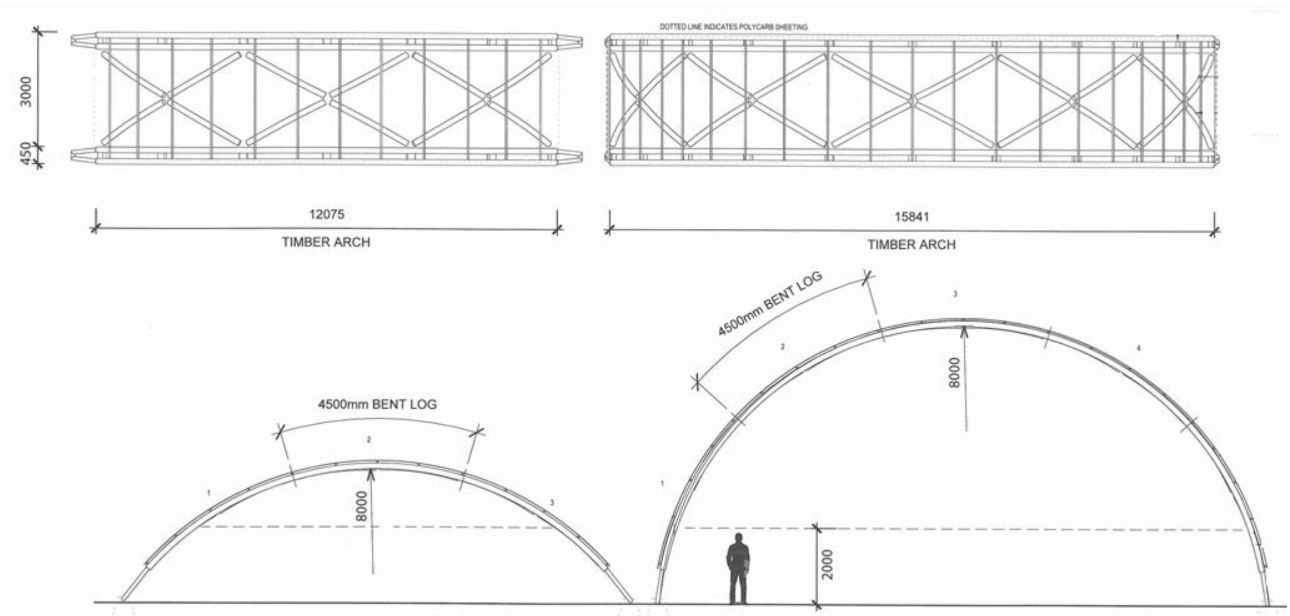
Large Sized Buildings and Structures

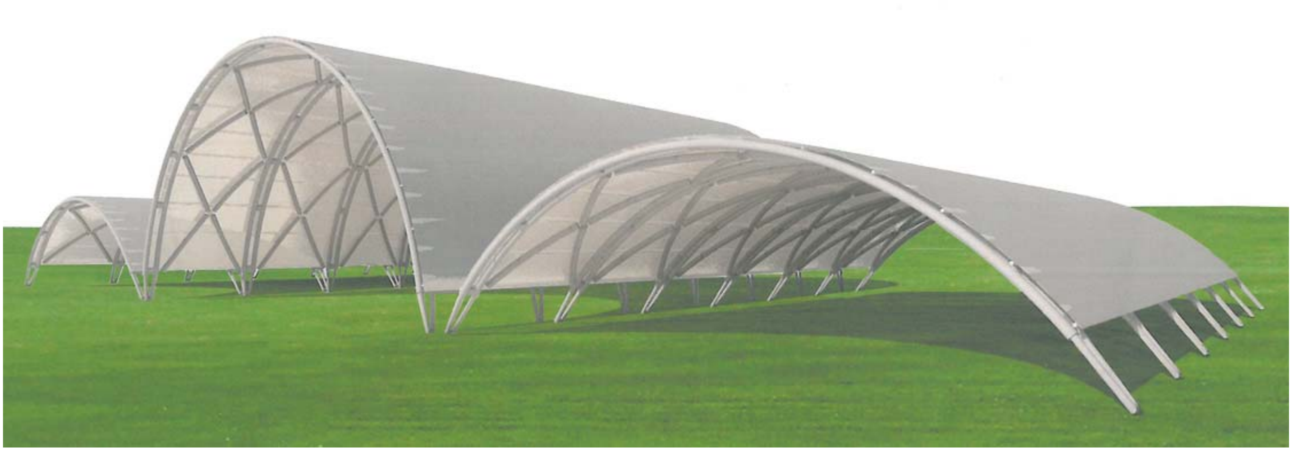
3.11 Large Scale Shade Pavilions: Clare Chippendale

The proposition is for a simple shade structure that can be scaled up or down using the same log geometry. The application is geared towards linear shade structures for swimming pools and sports facilities. Industrial and agricultural building applications also come to mind. The main benefit of this system is the elegance of the resolution and the fact that the geometry is simple and standardised.

Sustainability
- Similar structures utilise steel.
- The high strength to weight ratio of the material has a good match to the use.
- Utilising a resource that is currently underutilised and stores carbon.
- The simplicity of the structures geometry would translate into savings during manufacture.

Competing Technologies / Building Types
Shade structures of this nature are typically constructed with steel. The intention is to compete with these steel prototypes.





Infrastructure Projects, Systems and Structures

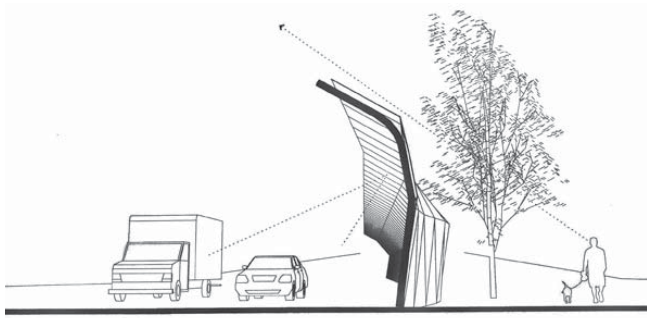
3.12 Curvuer, Roadside Sound Barrier System:
Sean Gill, Michael Lineburg

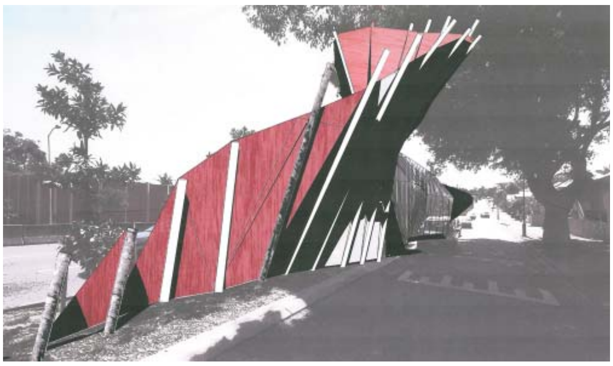
Typical roadside sound barriers are generally simple slab wall construction that can be seen as blight on the landscape. The proposal is to use more organic geometries of the steam bent round wood logs to create a flowing and aesthetically pleasing structure. In simple terms the system works on closely spaced vertical round wood posts with patterns of triangulated plywood acoustic panels to deflect sound. The triangulation is used to help generate the curved geometries. With the use of drive by scanning and CNC cutting technology, the unique surface pattern can be produced using industrial technologies the same as standardised systems, but with a geometry that is better integrated to the natural landscape and specific urban context.

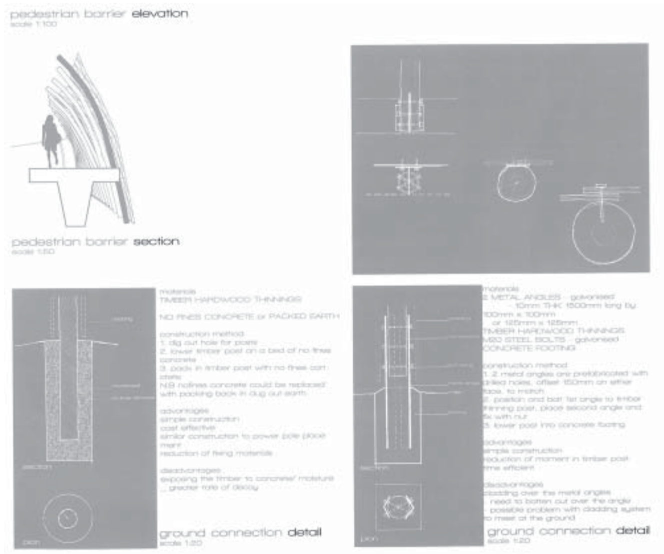
Sustainability

- Similar structures utilise steel structure and concrete panels.
- The high strength to weight ratio of the material has a good match to the use.
- Utilising a resource that is currently underutilised and stores carbon.
- The volume of potential application could result in a lot of the thinning stock to be used dramatically increasing the yield of plantation forests.

Competing Technologies / Building Types
Sound barrier structures of this nature are typically constructed with steel vertical posts with plywood or concrete infill panels. The intention is to compete with these steel prototypes with timber only systems.







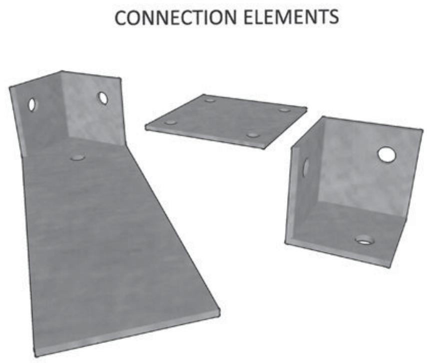
Infrastructure Projects, Systems and Structures

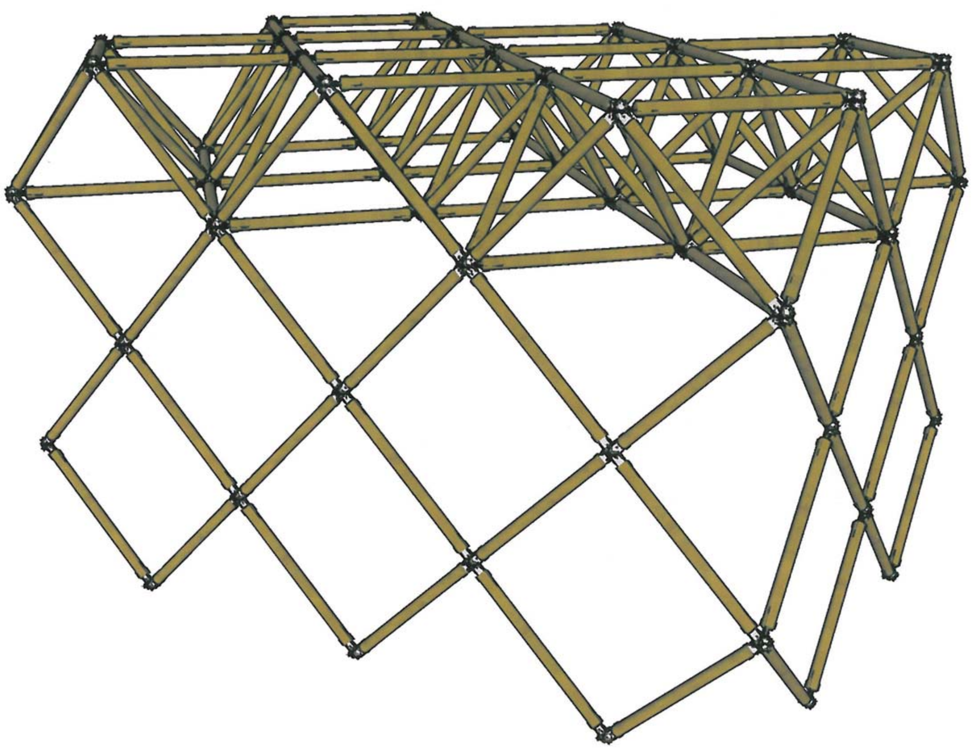
3.13 Universal Roundwood Connector System: Nicholas Vella

This design is pitched as a system of connection rather than as a building prototype per se many round wood constructions adopt a space frame type approach with consistent timber lengths and three dimensional connectors. The proposed system is similar to these proposals but adapts a system that uses simple off the shelf steel profiles to create the three dimensional connectors rather than expensive specially made or cast metal connections. The result is s system approach to building warehouses, towers and bridges utilising a small repertoire of connector types.

Sustainability
- The connectors allow a variety of constructions to be devised, offering modularity and flexibility.
- The high strength to weight ratio of the material has a good match to the use.
- Utilising a resource that is currently underutilised and stores carbon.

Competing Technologies / Building Types
The system is intended to provide an open ended range of applications. Typical space frame structures utilise steel.





Infrastructure Projects, Systems and Structures

3.14 Wind Barriers for Rural and Remote Communities: Lasan Nguyen

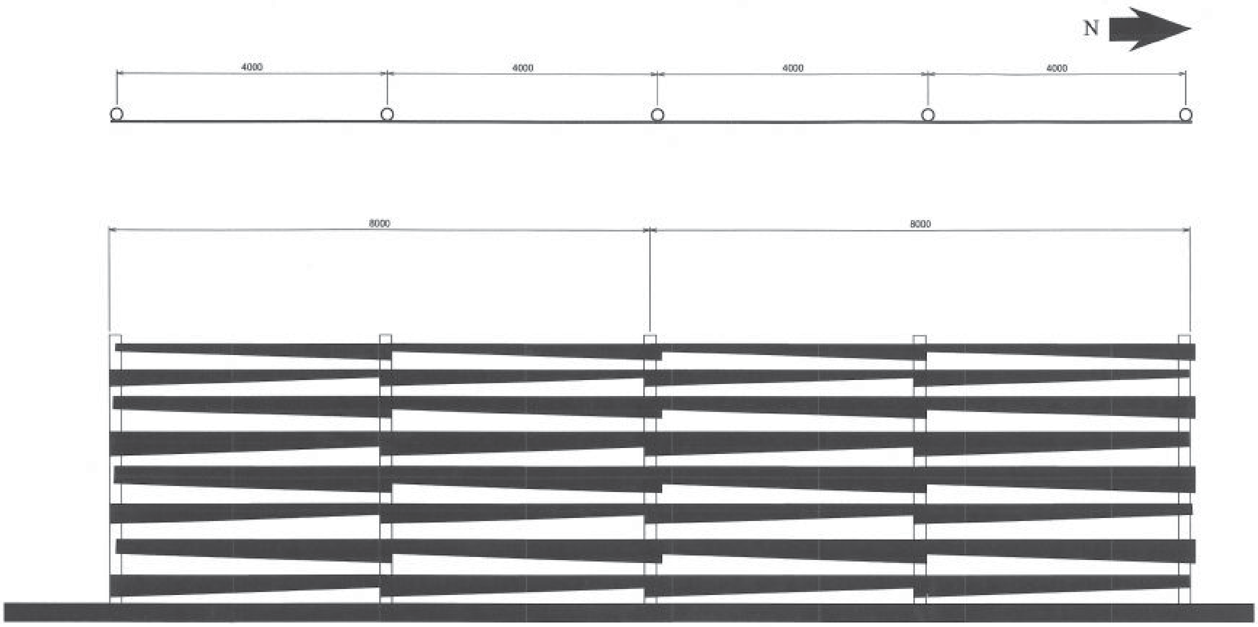
In open rural settings the impact of top soil removal due to the effects of wind can be significant. In addition to the loss of soil, evaporation and the healthy propagation of crops can be significantly increased through the provision of wind barriers. In remote townships that are exposed to winds across open plains would also benefit from a wind barrier to protect common open space between buildings to provide respite and allow shade trees to establish.

Sustainability

- The system is constructed utilising sustainably materials but the effect on the environment in turn helps maximise sustainability.
- The high strength to weight ratio of the material has a good match to the use.
- Utilising a resource that is currently underutilised and stores carbon.

Competing Technologies / Building Types

The deployment of wind barrier systems to not common place in Australia at present, though with changing climate the need for large scale climate controls will become more apparent.



Appendix 4. Developed Design Proposals

Small Sized Buildings and Structures

4.1 Umbrella Shelters: Brihony McKauge, Anya Meng and Karl Ho

Though the preliminary design in principle presented a reasonably simple development phase, in reality the proposal proved more difficult to resolve. The scale of the model was the largest of all the groups and hence the dowel diameter was the greatest. The amount of curvature was difficult to achieve resulting in a significant number of breakages.

The amount of cover provided was also constrained by the natural catenary of the fabric roof. The initial design had proposed a rigid roof cladding such as metal or plastic however the difficulty lay in resolving the position of the ends of the curved members so that a stable secondary roof structure could be set out.

The final aspect that proved problematic was attributed to the scale of the model whereby the four supporting members were intended to be separated to allow a down pipe to pass through the middle, in the final model the four elements were joined too close together. In all the process of model making revealed the construction difficulties of the proposal however it was agreed that these were not insurmountable. Time permitting the model would have been remade and these issues resolved prior to a full scale prototype being constructed.

Above and Left: Umbrella structure. Brihony McKauge, Anya Meng, Karl Ho.
Images by M Dickson

Medium Sized Buildings and Structures

4.2 Woodland Shelter: Kerry Martin, Will Gray

The woodland hideaway proposal translated quite easily from the preliminary poster presentation. The integrated wall roof "A Frame" type structure is aesthetically closer to the nature of trees in the forest and hence appeals to peoples general aesthetic sensibilities.

The unique cladding system relies on a shingle like approach so that the overlap provides adequate tolerance to account for both imperfections in the structural setout as well as settlement over time. Even during the model making phase it was found that the tolerances between the primary bent thinnings and sawn wood purlins needed some kind of adjustablility to ensure that there is an adequate mechanical connection between elements as well as straightness.

The shingle cladding is intended to be a combination of timber and recycled clear plastic. It is unclear how the clear recycled plastic could be easily sourced but the end result is quite pleasing. Further work on both the cladding itself but more importantly on the secondary connection systems between the round-wood and sawn wood purlins needs development that could lead to solving issues of round-wood construction in general.

Above: Woodland Hideaway. Kerry Martin, Will Gray.
Images by M Dickson

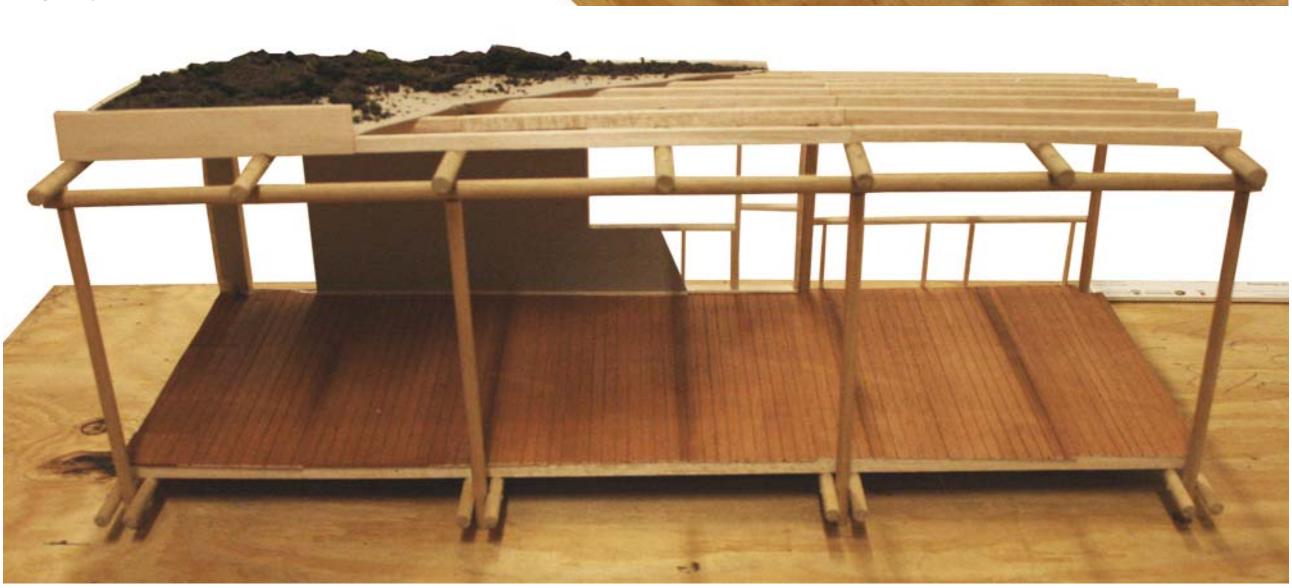
Medium Sized Buildings and Structures

4.3 Off Grid Housing: Andrew Carter, Daniel Cocker

Many of the precedent structures discovered during the literature review were structures that were in rural or woodland settings, often in remote locations. The use of round-wood in these situations is efficient so long as the resource can be easily obtained and worked within a close distance.

The use of an earth roof both helps with natural insulation of the structure as well as providing a solution that can adequately cope with an irregular and moving structure. Other aspects of this developed scheme that need further work is the detail of the floor joist connection to round-wood and the wall panel connections to round columns. In order to get an even and consistent finish specialist fixings are needed that allow a certain level of adjustability. Such systems will need further investigations if this scheme were further developed.

Above and below: Off Grid Housing
Andrew Carter, Daniel Cocker.
Images by M Dickson



Large Sized Buildings and Structures

4.4 Industrial Building: Will Downes, Jeremy Slater, Nicholas Vella

Though the poster and model proposition was aiming towards an industrial application, the final uses for such a structure are perhaps more varied and limited in equal measures. The round-wood structure here has been used without steam bending. The triangulated structure is both elegant to look at but also quite taught with a significant amount of inherent bracing. The diagonal outward cambered columns give another aesthetic element to the overall construction however it is to the detriment of flexibility in an industrial application, for example when installing large access doors for trucks.

The resolution of the end infills has not been demonstrated in the model and the way that the sawn wood purlins connect to the round wood structure has not been shown.

In reality there would be a more limited application in industrial settings with this system however the quality and aesthetic of the structure are well suited to indoor sports facilities or warehouse retail stores.

Right and below: Industrial Building Prototype Will Downes, Jeremy Slater and Nicholas Vella.
Images by M Dickson

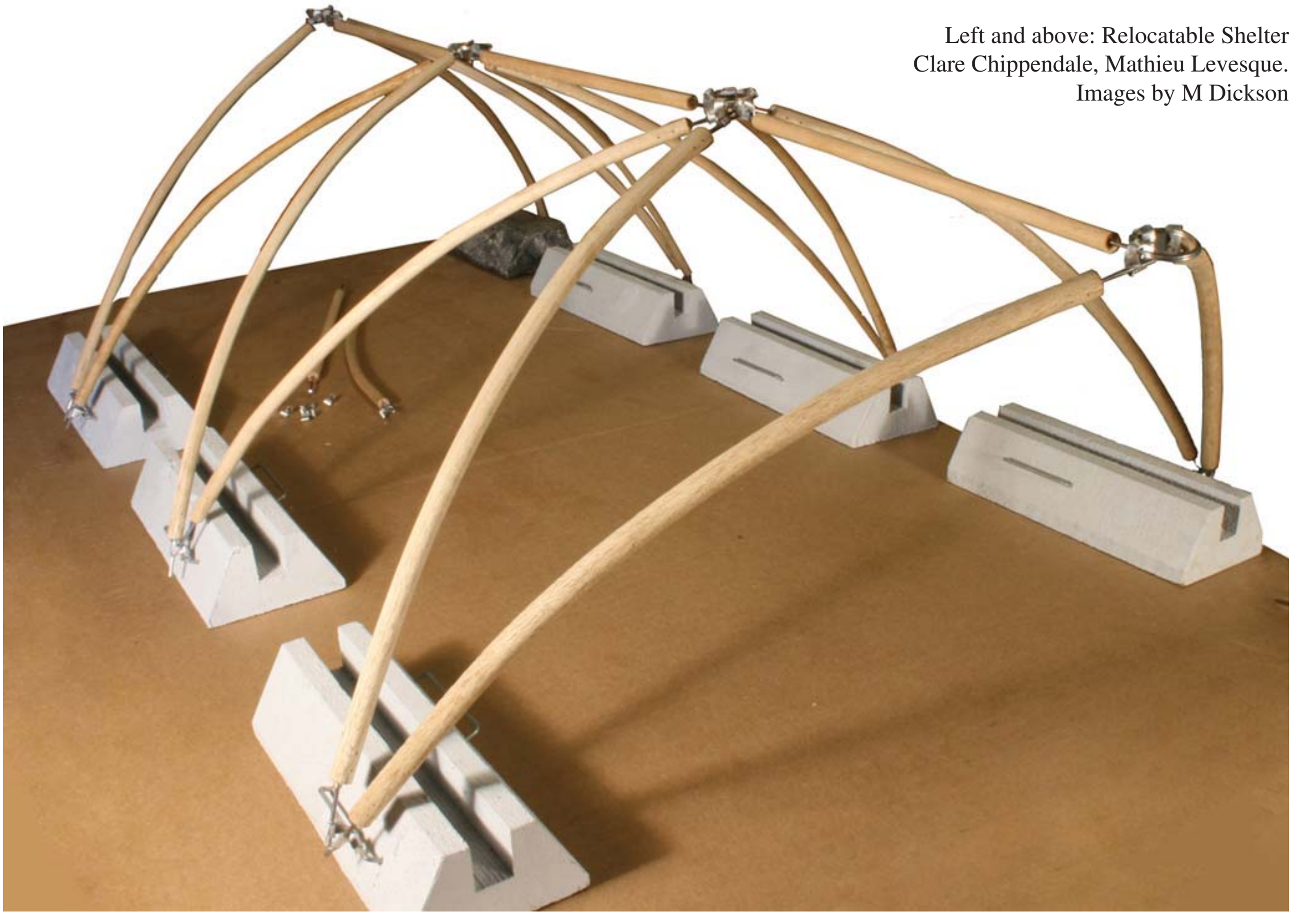
Large Sized Buildings and Structures

4.5 Re-locatable Shelter: Clare Chippendale, Mathieu Levesque

This proposal is also aimed at industrial or storage buildings however it is also intended to be relocatable. This would be ideal for medium term installations for large building and infrastructure sites, festivals or remote community mining towns and so on.

The curved elements are important in this instance as they provide additional usable floor area and volume. The system relies on a simple clamp fixture similar to that employed in scaffolding. The intention was to both make the structure easy to assemble and adjust for varying terrain but more importantly it taps into a pre existing skill set in the building industry.

The footings are intended to be a variety of types. A simple concrete footing is shown here however the intention is that the channel in the footing can collect water for general use and additional ballast during inclement weather. The footings could equally be adapted to a water only design similar to temporary road crash barriers or metal cage gabbion blocks. Though the footing geometry is perhaps not ideal as shown in the model, it has the scope for adaptation and in a refined version could be easily amended.



Left and above: Relocatable Shelter
Clare Chippendale, Mathieu Levesque.
Images by M Dickson

Infrastructure Projects, Systems and Structures

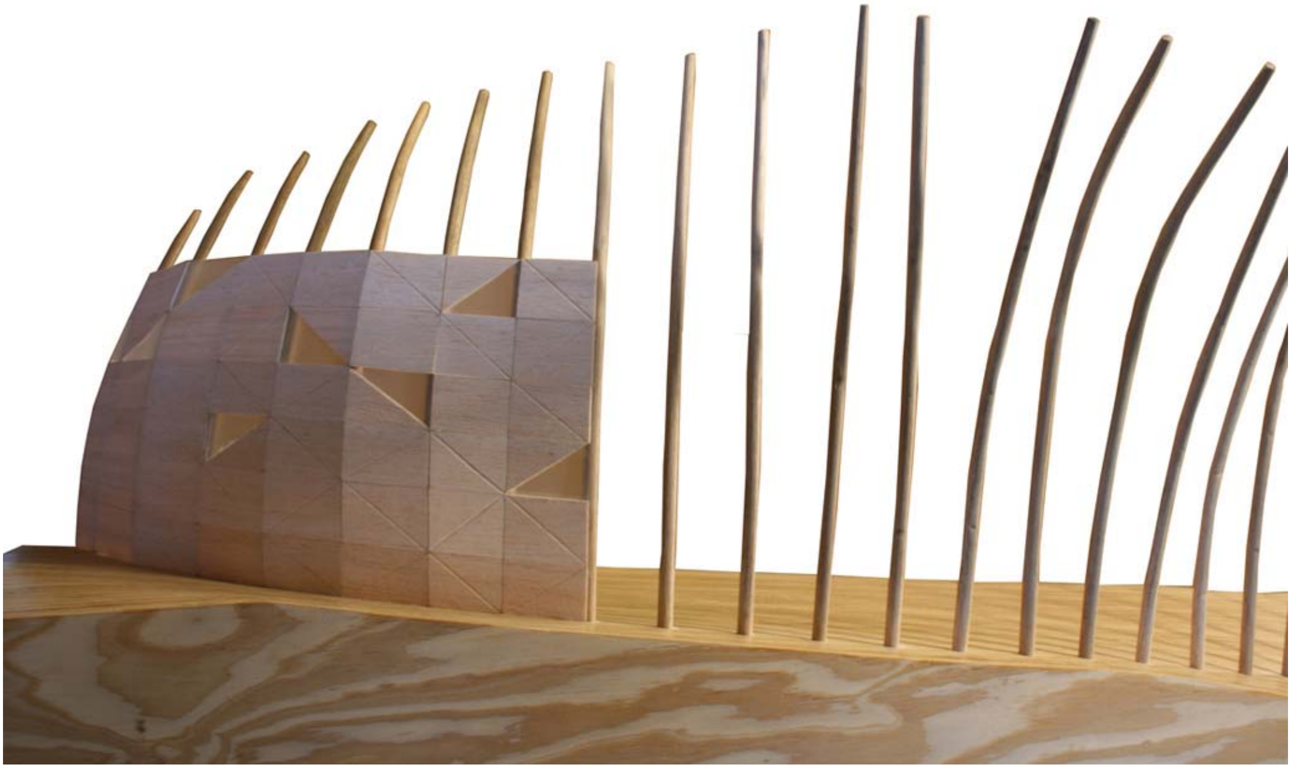
4.6 Curvuer: Sean Gill, Michael Lineburg, Lasan Nguyen

The use of round-wood for road side sound barriers is not necessarily new. Typical designs can be quite dull and most are in a simple vertical configuration. The proposal here is to elevate the humble road side sound barrier to a work of land art, whilst still remaining effective.

The intention is to provide a standard suite of curved vertical elements that can be configured according to the specific location. The technology of establishing the structure can rely on established technology that is used for suspended cable networks. The panel pattern and setout would be developed using drive by scanning technology after the primary structure is in place with automated CNC cutting in the factory. The combination of scanning and automation in the factory means that each installation can be specifically tailored to the structure geometry without being excessively more costly that simple rectilinear components.

This proposal presents unique but not insurmountable technical challenges that has the potential to use of a vast amount of the resource as well as improving the general state of our built environment.

Right and below: Curvuer Sound Barrier
Sean Gill, Michael Lineburg, Lasan Nguyen.
Images by M Dickson



Appendix 5. 1:1 Park Pod Design

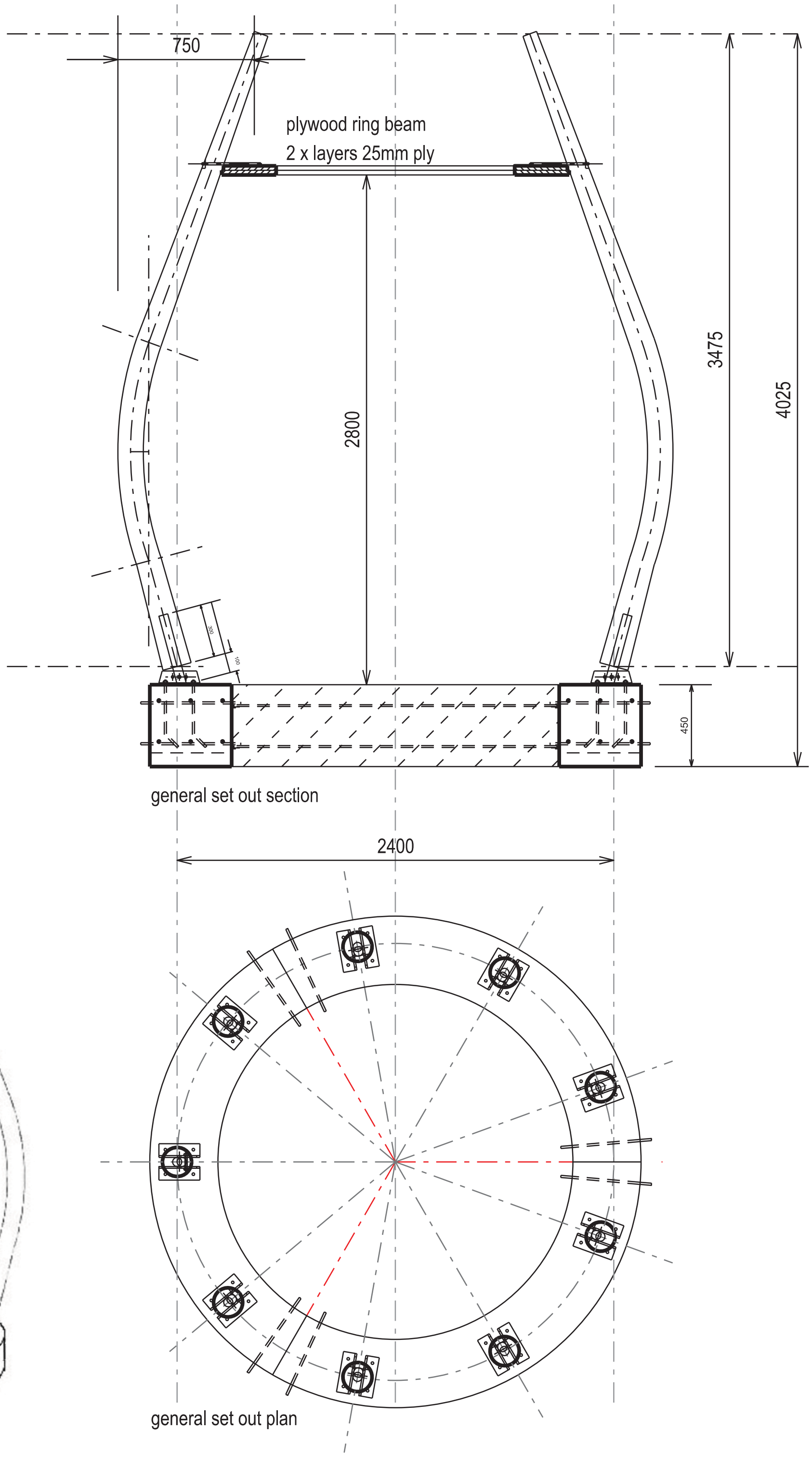
Small Sized Buildings and Structures

5.1 Park Pod: Michael Dickson

The intention of this prototype construction is mainly to test the limits of the bending capacity of the hardwood stems as well as developing cladding systems for a three way complex curve using standard flat sheet material.

The park pod is intended to sit in a parkland or woodland setting to provide shelter for a small group of people. The structure is intended to be prefabricated and mass produced. The elemental nature of the design means that it can be scaled up to provide larger structure for different applications. The structure shown here is a 9 pole park pod however the intention is to develop a 12 pole and a 15 pole structures. Larger structures could be used for small gatherings for say educational or religious ceremonies as well as providing a unique cabin design for woodland settings.

The design shown here is effectively a work in progress and the final design will account for the changes made during the prototyping studies.



Right: Park Pod Construction Set out Drawings: Michael Dickson.
Below: Park Pod Visualisation (Visualisation by Jeremy Slater)