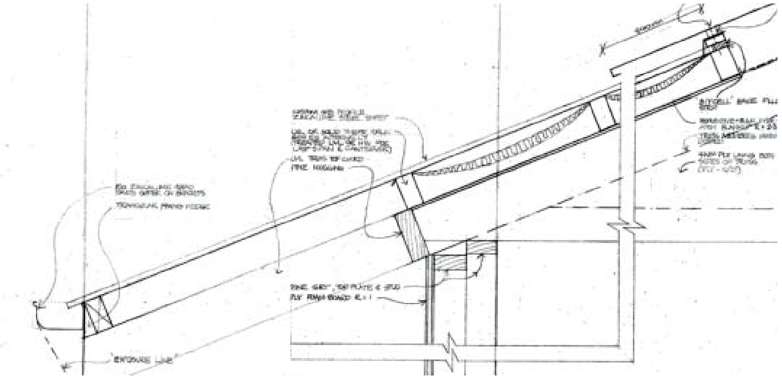
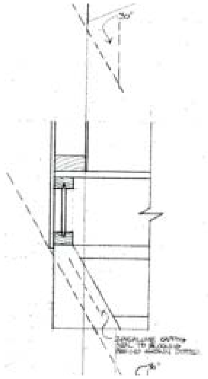
The 'New Queenslander': A Contemporary Environmentally Sustainable Timber House

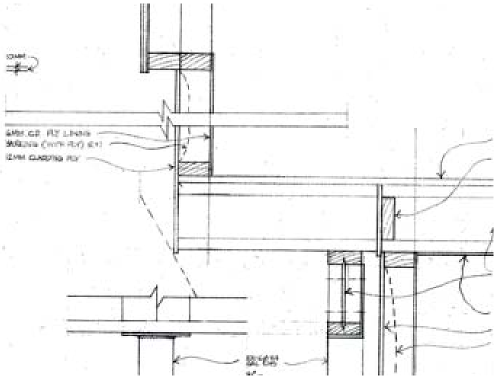
Centre for Subtropical Design
Timber Queensland Ltd
QUT Sustainable Living Initiative

Stage One

Report on the Development of the New Queenslander Construction System







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ABBREVIATIONS

3D	Three Dimensional
ABCB	Australian Building Codes Board
ABS	Australian Bureau of Statistics
AGO	Australian Greenhouse Office
BCA	Building Code of Australia
BCC	Brisbane City Council
BDA	Building Designers Association of Australia Ltd
BERS	Building Energy Rating Scheme
CAD	Computer Aided Drafting
CHS	Circular Hollow Section
CSD	Centre for Subtropical Design
DA	Development Application
ESD	Environmentally Sustainable Design
GFA	Gross Floor Area
HIA	Housing Industry Association Ltd
HERS	Housing Energy Rating Scheme
LVL	Laminated Veneer Lumber
NatHERS	Nationwide House Energy Rating Software
OUM	Office of Urban Management (Dept of Local Government and Housing, Qld)
PAA	Plywood Association of Australasia
PNG	Papua New Guinea
Qld	Queensland
QUT	Queensland University of Technology
RAIA	Royal Australian Institute of Architects
SE Qld	South East Queensland
TQ	Timber Queensland
WHS	Workplace Health and Safety Queensland

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EXECUTIVE SUMMARY

Aim of the Research

The aim of this research is to develop a contemporary, environmentally sustainable housing approach that takes its lead from the qualities and attributes of the original timber housing developed in Queensland. This approach can be widely adopted by the contemporary housing market, and deliver significant benefits in terms of sustainability, affordability and lifestyle.

Project Scope

The scope of this project is to develop a new system for integrating timber products in project homes that embrace market appeal, affordability, environmental performance and design quality.

The timber system developed will be able to be adopted by the residential construction industry with minimal change to the conventional construction process. The research investigates efficiencies gained by utilising timber structural flooring and substructure in lieu of concrete slab on ground. The research also investigated timber cladding instead of brickwork for external walls, and applications for internal timber lining and external shading and screening.

The research examined the effect on construction of a combination of factory fabrication and on-site work, predominantly to supply and install timber floor systems and timber wall framing and cladding systems.

Research Methodology

A design research approach was adopted to establish how standard materials can be used in innovative ways to achieve acceptable housing outcomes. The design research was underpinned by an extensive data collection and analysis phase which focussed on three main topics.

(1) An appraisal of sustainability, affordability and lifestyle issues which are affected by the choice of design and structure of houses was carried out.

(2) A survey of timber and associated building products that are readily available and generally accepted within the industry including a review of the products and information based on manufacturer’s technical literature and a tour of manufacturing facilities operated by Timber Queensland (TQ) members.

(3) A survey of building codes and standards, including local government planning policies and other regulatory issues which impact on the selection and use of timber as a primary material in housing was conducted.

The reviews allowed the researchers to establish objectives for the design and development of timber construction systems suitable for residential construction.

Key Outcomes

- Catalogue of design objectives for a timber construction system which can be readily adopted by the project home market.
- Survey of local products.
- Survey of regulatory issues.
- Generic technical drawings and details of the timber construction system developed for residential construction.
- Recommendations for typologies to be developed as prototypes for Stage Two of this project.

1 Introduction and Overview

The ‘New Queenslander’ project is a collaborative research project between Timber Queensland and QUT (Centre for Subtropical Design) aimed at advancing the construction and popularity of housing that is constructed predominantly of timber and is more environmentally sustainable than housing designs currently produced in the mainstream project home market.

The project involves design-led multi-disciplinary research to develop sustainable, innovative and cost effective timber construction systems that can be adopted by the residential housing industry in Queensland. The primary assumption of the research is that for several reasons, timber is a significantly more environmentally friendly building material than most alternatives currently available, and its use is a credible basis for a better built environment across Queensland and similar warm climates.

This report describes the aims and scope of the overall project, reports on the findings of Stage One, and gives recommendations for residential typologies to be developed as New Queenslander prototypes in Stage Two.

The research used an architectural design approach to identify the optimum housing solution that can be obtained by combining available materials with market affordability, architectural design for lifestyle in subtropical and tropical climates, engineering design, construction project delivery processes, and environmental knowledge. The comprehensive tasks involved in taking this critical approach require the skills of architectural and engineering practitioners; therefore, establishment of the project team itself was critical to the success of the project.

Notably, the architect Rex Addison was engaged to lead the design research. Rex Addison has worked on the design of buildings for SE Qld, PNG, Fiji, Darwin, Sydney, Canberra and Cooktown. In all cases the designs addressed the specific issues of place and climate. Along with this concern for context, his designs show an awareness of the social role the building plays in the course of its habitation. These abstract issues are then brought together with meticulous attention to the material making of the building that produces a well crafted result. Rex Addison received the RAIA Queensland Chapter Robin Dods Award in 2000 for the design of timber residential buildings.

Specialist timber engineering expertise is provided by John Ryder, a consulting engineer with extensive professional experience including 30 years with the international consulting engineers the Arup Group (previously Ove Arup & Partners). Academic leadership was provided by Prof John Hockings, Head of School of Design at QUT, and Director of the Centre for Subtropical Design, and Rosemary Kennedy, architect, research academic and Coordinator of the Centre. Charmaine Kai, a registered architect provided research assistance. Further academic assistance is available to the team through QUT academics. TQ personnel and a stakeholder reference group from industry provided invaluable input and direction to the research team.

1.1 Aim of the Research

The aim of this research is to explore and develop an environmentally sustainable house that takes its lead from the qualities and attributes of the original ‘Queenslander’ house. The objective is to devise a timber construction system for a house which can be widely adopted by the contemporary housing market and deliver significant benefits in terms of sustainability, affordability and lifestyle, while considering market appeal, environmental performance and design quality.

To achieve this objective, the timber system developed must be able to be readily adopted by the project home industry, requiring minimal change to the conventional trade-based process of residential construction which predominates in Queensland. In particular, the research must pay attention to the advantages to be gained by utilising timber structural flooring and substructure in lieu of concrete slab on ground. Applications for timber products to replace alternative materials such as brickwork for external walls, and plasterboard lining for internal walls are also considered important.

1.2 Project scope

The two main stages of the project are:

- Stage One - Data collection and analysis, and development of construction systems using timber, in response to these findings.
- Stage Two - Design of prototype applications.

The scope of Stage One, which is the subject of this report, includes an analysis of regulatory codes, standards and policies, and available timber products, to establish parameters for a timber construction system which embraces environmental sustainability while appealing to both consumers and the project home industry.

Using these parameters the project team would develop a timber construction system to address structure, especially flooring, lining, cladding and external screening/shading applications, depending on the outcome of the reviews. The research would also investigate a combination of factory assembled and on-site work predominantly to supply and install timber floor systems, timber wall framing, timber roof framing and cladding systems. The construction system developed will be described by generic technical drawings and details.

The scope of Stage Two will involve the development of a series of designs for prototypes for residential typologies utilising the generic timber construction system. The range of responses to be developed will be recommended by the project team and confirmed in collaboration with Timber Queensland at the commencement of Stage Two (six prototypes). These will address a variety of solutions for homes which respond to a variety of circumstances including lot size, orientation, household size and so on. Stage Two will also involve the formation of a project team to consider issues associated with the construction of a demonstration house aimed at the first home buyer market, based on one of the New Queenslander prototypical designs. The detailed design and documentation of the demonstration project house will form part of a future project to develop a demonstration house.

1.3 Research methodology and methods

The research combined two main complementary strategies - research by design being the overall method of research, and a literature review with the research fields informed by the design questions. The primary means of data collection was a web-based desk-top survey. This established many variables which the designers interpreted to make sense of the relationship between these variables and subsequently used the knowledge gained in the literature review to problem-solve.

The researchers catalogued sustainability, affordability and lifestyle issues in order to address the underlying question of environmentally sustainable approaches to housing. This work sought to critically appraise the current position of the project home market and to establish reference points for a housing solution based on timber. Typical lot sizes in ‘greenfield’ subdivisions and for ‘infill’ sites were investigated through developers’ brochures and through site visits to a variety of residential development sites.

A desktop review of timber and associated building products that are readily available and generally accepted within the industry, based on information provided by manufacturers’ technical literature was carried out. Further knowledge of products’ attributes was obtained through tours of manufacturing plants operated by Timber Queensland (TQ) members and informal interviews with personnel.

An analysis of relevant building codes and standards, including local government planning policies and other regulatory issues which impact on the use of timber in housing in Queensland was conducted to reveal the regulatory issues to be taken into account in the design of the timber system. The analysis considered the implications of applying the codes to the design of the timber system.

The synthesis of the product and code reviews was the establishment of design parameters for the development of the residential timber construction systems, and the selection of a suite of materials, in standard sizes.

For good design to emerge, and for the design proposal to be implemented, a balance between content and method is required. The timber construction system was developed iteratively throughout the data analysis stage, drawing on knowledge of siting, function, structures, mechanical systems, aesthetics and construction management processes. The outcome addresses timber structure, lining, cladding and external shading applications and the buildability of these, taking into account conventions on site. The system was developed with advice from an array of contributors including individuals on the Timber Queensland Reference Group.

2 Research Background

This section of the report establishes the social, economic and ecological context of the project to develop a new ‘Queenslander’. It briefly describes the tradition of low-density detached timber housing in Queensland, the current position of timber in the project home industry, demographic trends and urban development trends.

2.1 Vernacular precedent

The vernacular form of Queensland housing developed as an empathetic solution to residential design in the tropical and subtropical regions of Australia. High-set timber and tin houses, often set amongst luxuriant vegetation, have enriched the urban fabric of Queensland’s cities and towns. These buildings were naturally ventilated, and provided cool shaded places on verandahs, or beneath the house for a myriad of domestic activities to take place.

Not only was this form of housing suitable for the local conditions, readily accommodating flat sites or hilly terrain, it was also very adaptable and has proven to be lasting (Saini and Joyce, 1982). Many timber houses built in the late 19th Century, and early 20th Century are still in use today, either as housing or reused for an infinite variety of community and commercial purposes. These houses and the neighbourhoods formed by their aggregations are also valued as a particularly important part of Queensland’s cultural heritage.

The high-set timber and tin house typology may provide an appropriate model for a sustainable built environment. Traditionally, timber houses could be obtained at a low cost by using materials which were locally available and which could be used in a structural system which was neither labour-intensive, nor time consuming.

2.2 Current position of timber in the project home industry

Currently, the detached house represents the majority of the built environment in suburban Australia. However, many new project home designs adopt generic designs regardless of local topographical or climatic conditions, resulting in an homogeneous housing stock proliferating across widely varying climate zones. In Queensland, these types of designs have marginalised local design knowledge and building practice, and often result in inappropriate outcomes which require the addition of energy-consuming appliances such as air conditioning to make them habitable. Rules of thumb for orientation are frequently ignored and windows and external walls are left unshaded. House construction is generally characterised by a concrete slab on ground, brick or blockwork ‘skins’ on timber framing for outer walls and metal or concrete tiled roofs without overhangs. Since the 1960’s the majority of houses in South East Queensland and beyond have been timber and brick veneer construction on concrete slab on ground. Concrete slab on ground has been widely preferred over the low set raised timber floor system mainly due to costs and the speed of construction (Williamson and Demirbilek, 2003).

Despite the enduring nature of the ‘Queenslander’, timber has suffered an image problem due to the perceived need for high levels of maintenance, susceptibility to borers, termites and decay, all of which can be avoided with appropriate design detailing and ongoing awareness of owners/occupants (FWPRDC, 2005).

Timber as a primary construction material is now often confined to one-off custom designed new houses and renovations. These homes represent a small percentage of the overall market, but some architecturally designed homes are important in promoting innovation in the residential design sector, borrowing many of the characteristics of the traditional Queensland house without replicating the original aesthetic. These houses use timber structurally, as well as for floors, linings, external wall cladding, window and door joinery, and decorative timber shading and privacy devices. Their design takes advantage of cross ventilation, uses deep shading overhangs, and often includes generous outdoor living areas. Zincalume or galvanised steel roofs are also an important feature, particularly when linked to collection of roof water. Timber is selected by designers and owners because it has qualities that people value including something very intangible but very sought after - character.

The Brisbane Institute (2004) provides insights into the recent direction of Queensland house design and materials based on a Brisbane City Council sample survey of new housing: eighty-eight percent of new houses are project home designs; 60% utilised a concrete slab on ground; 85% used brick veneer for external walls; 60% used tiles or concrete for roofs; 40% had no eaves, or eaves of less than 450mm; 46% had air conditioning retrofitted during the first year of occupation. Timber framing was used in 96% of new houses. The use of timber for external walls increased slightly from 7% in 1999, to 10% in 2001.

Part of the popularity of ‘off-the-peg’ homes is likely to be attributable to the purchase price, particularly when it is related to cost per square metre. (The scope of this project does not include confirmation of attitudes and behaviours of the consumer.) These cost efficiencies are gained through mass production and the subcontractor system employed by volume builders. Currently, little concern is given to the cost benefits to be gained through better designed houses which adopt low-energy strategies, either by the project developer, or prospective buyer. In an increasingly affluent society dwellings have become a status symbol to display personal wealth rather than the basic need for shelter (Sydney Morning Herald, 2003 and ABC Television, 2005).

2.3 Demographic trends

The Australian Bureau of Statistics (ABS) predictions of future demographics indicate that the typical suburban family house will represent only 10% of the new housing units required in the next 20 years (Johnson, 2004).

Over the past 90 years, the number of households in Australia has increased by an average of 2.4% per year, compared with an average yearly increase in population of 1.6%. This is reflected in the fall in the average household size over the same period from 4.5 persons per household in 1911 to the 2001 household size of 2.6 persons. (ABS, 2002a). Queensland reflected the national average. The average size of Australian households is projected by the ABS to continue to decrease to between 2.2-2.3 persons per household by 2026. This means the number of dwellings will continue to increase substantially to accommodate the increase in the number of households (ABS, 2005).

The Draft South East Queensland Regional Plan (OUM, 2004) notes that for the local region:

> *The projected population increase, combined with the continuing trend towards smaller households will require an estimated 550,000 new dwellings to be constructed in the region between 2004 and 2026. There will also be a greater demand for a diversity of housing forms to match the needs of changing household structures, particularly an increase in one and two person households across all adult ages.*

Over a similar period of time since the 1920's, the size of the average house has increased from 120m² to 275 m². In 2001, 47% of all families in Australia were couples with children. The trend of couples without children is increasing and is projected to outnumber couples with children as soon as 2010. In a survey of Australian housing characteristics, costs and conditions (ABS, 2000) the ABS used the Canadian National Occupancy Standard[2], to determine that the average dwelling only requires 2 or 3 bedrooms at the most. The survey found that of the 7.2 million households in Australia, only a small proportion (5%) required one or more additional bedrooms, 23% of all households had the exact number of bedrooms required, while 73% had more bedrooms than were needed to accommodate the occupants.

These predictions indicate that one size does not fit all, and further questions the sustainability of existing housing stock. As household sizes diminish, we are likely to see an oversupply of large suburban houses, many of which will need retrofitting to comply with energy and water efficiency codes. Residential design which accommodates a diversity of housing models through flexibility and adaptability is more likely to be achievable using structural timber products and systems than with inflexible concrete and masonry construction.

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[2] The Canadian National Occupancy Standard for housing appropriateness is sensitive to both household size and composition. The measure assesses the bedroom requirements of a household by specifying:
- there should be no more than two persons per bedroom
- children less than 5 years of age of the opposite sex may reasonably share a bedroom
- children 5 years and older of the opposite sex should have separate bedrooms
- children less than 18 of the same sex may reasonably share a bedroom
- single household members 18years or over should have a separate bedroom

Households living in dwellings where this standard cannot be met are considered to be overcrowded.

2.4 Urban development trends

Intersecting with the desire for larger homes, and the increasing number of households, is the dwindling supply of land. 42% of the land subdivisions in Brisbane City over the past three years featured lot sizes of between 600m2 and 999m2 (Department of Local Government and Planning, 2003). This represents a significant amount of land being cleared and consumed by greenfield subdivision sites. The lot size is also inconsistent with the Draft South East Queensland Regional Plan that indicates an increase in density to 15 housing lots per hectare for efficient use of land (OUM, 2004). This compares to an average of 7 to 8 dwellings per hectare in existing greenfield developments.

As lot sizes decrease, and house sizes increase, the tradition of low density detached housing in Queensland and the desire to live in single family houses with big backyards is translating into something rather different than the familiar open and permeable built environment that encouraged air flow through and around buildings, with abundant space for shade trees and gardens. Recent subdivisions are spawning buildings that have minimum regard for climate and an uneasy relationship with their surroundings. Homes which are currently seeking to provide the largest house on the smallest block leave little room for shade trees to flourish and to provide much-needed tempering of these suburban environments.

According to the 2001 census, there were 1,045,137 detached houses in Queensland. This made up 77.1% of the total housing stock in Queensland. There were 164,424 apartment dwellings in Queensland, which made up 12.1% of the total housing stock in Queensland (ABS, 2002a). However these trends are set to alter radically, particularly in SE Queensland. Only in the past decade has the number of townhouses and apartments approved rivalled that of single detached houses. According to the OUM (2004), the major urbanised local government areas of Brisbane City and Gold Coast City, will require 271,000 new dwellings to 2026, with over 64% of the total (174,500) projected to be provided through infill higher density developments, with apartments likely to make up a greater percentage of total dwellings. These are likely to be in locations which require responses to context, and feature sloping and/or difficult constrained sites.

Over the next decade it is expected that medium and higher density forms of residential development will dominate within Brisbane City particularly close to major public transport nodes. Single detached housing will continue to be the main form of development in many other parts of the region.

Brisbane and Queensland generally, does not have a strong history of higher density housing. A denser urban environment has generally been regarded negatively by the local population, and considered as a sacrifice of living standards due to the apparent diminishing of urban outdoor space and other issues related to the quality of habitation. A general perception is that increasing densities are likely to reduce or block the prevailing breezes. Good examples of locally appropriate higher density development, positive strategies and innovative models for a subtropical or tropical built environment which responds to lifestyle, landscape and climate are vital for sustainable, compact urbanisation.

3 Sustainability, Affordability, and Lifestyle Expectations in the Housing Market

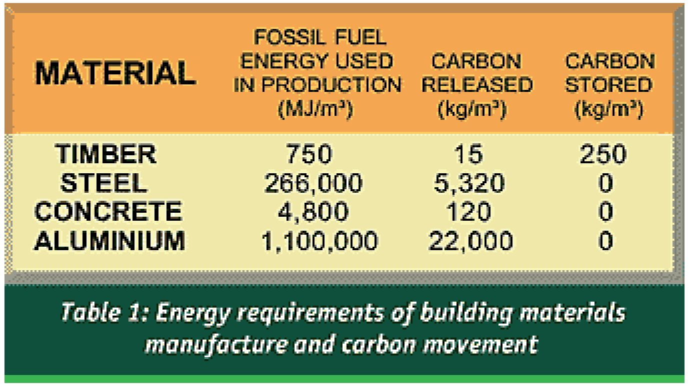
This section appraises sustainability, affordability and lifestyle issues which are affected by the choice of design and structure of houses.

3.1 Timber - an environmentally sustainable product

Timber occupies a defensible position as an environmentally sound material for the construction industry in Queensland. The following summary of issues demonstrates that it should be highly valued as a building material which is renewable, and which is significant in the carbon cycle.

3.1.1 Timber in the carbon cycle

In the context of environmental sustainability, timber is a very important renewable resource. Ideally the largest possible quantity of timber should be grown and used in building, through sustainable resource management. Not only is timber renewable, and a low-energy material to produce, but forests and timber plantations act as ‘carbon sinks’ which absorb carbon dioxide (CO2) from the atmosphere and store it as wood fibre or cellulose. CO2 emitted into the atmosphere is absorbed by trees and remains bound in the timber even when it is converted into building materials (Szokolay, 1992). As well as their role in the carbon cycle, forests and plantations are essential for maintaining soils’ hydrological processes. Table 1 tabulates common building materials and compares them for the amount of carbon released into the atmosphere. It shows that timber is the only product that actually stores carbon.



MATERIAL	FOSSIL FUEL ENERGY USED IN PRODUCTION (MJ/m³)	CARBON RELEASED (kg/m³)	CARBON STORED (kg/m³)
TIMBER	750	15	250
STEEL	266,000	5,320	0
CONCRETE	4,800	120	0
ALUMINIUM	1,100,000	22,000	0

Table 1: Energy requirements of building materials manufacture and carbon movement

Source: Plantation Timber Association Australia website

Table 1 Products and their effects on CO2 in the atmosphere

Local plantations

In 2001, Australia had over 1.6 million hectares of plantation timber that consist of 1 million hectares of long rotation softwoods, 500,000 hectares of short rotation hardwood and 100,000 hectares of long rotation hardwood. The plantations produce 60% of all the timber produced in Australia each year. It is envisaged that by 2010 about 75% of all timber produced will be plantation timber (Plantation Timber Association of Australia, 2001).

For each tonne of kiln dried plantation softwood, about 500kg of CO2 is produced in the drying process. However the CO2 produced is ameliorated by plantation forests acting as carbon sinks which absorbs the CO2. The carbon is stored in the timber’s wood fibres even after the tree is felled, and is effectively stored in timber products for the life of the building or longer if the timber is recycled. The stored carbon is released when the timber is burnt (Lawson, 1996).

There are also advantages in establishing timber plantations on previously cleared agricultural land, particularly where the existing land was in poor condition due to overgrazing, excessive crop cultivation or salinity problems in the soil. Soil fertility can improve through the processes involved in establishing a plantation including aeration of the soil and tree planting. Soil erosion can be reduced once the tree roots take hold of the soil. Loss of soil moisture through evaporation is reduced by the trees shading the ground and also the leaf litter. Chemical fertilisers used on plantations may have ecologically adverse affects in ground water and local streams such as excessive algae and weed growth (Lawson, 1996). According to the Plantation Timber Association of Australia (2001) significant areas of native vegetation are retained within plantations besides streams and in wet, steep and rocky areas.

Transport costs are reduced when building materials are sourced close to the area of demand. This reduces greenhouse gas emissions from the use of road transport vehicles. Hyne is one of the main softwood plantation timber suppliers in Queensland. Hyne sources their timber locally from plantations in Tuan near Maryborough in Queensland or from plantations in Northern NSW.

Maintaining biological diversity is essential to ecologically sustainable development. Plantations are usually mono-cultures and uniform forests with little undergrowth. The mono-culture plantations provide a less suitable habitat to support a variety of native wildlife, compared to the biodiverse native forests that they sometimes replace (Lawson, 1996).

Hardwood
The source of timber and its sustainable management must be a cornerstone of the industry. Some hardwoods are imported, mainly from South East Asia, although the international pressure to limit harvesting to sustainable levels has restricted supplies (Lawson, 1996). Kwila imported from Asia remains popular in Australia for its durability.

3.1.2 Buildings and resource consumption

At each stage of a building's lifecycle, large quantities of materials, energy and other resources are consumed with significant environmental impact at the global, local, and personal levels. The energy consumption of buildings includes embodied energy, which is the energy consumed at all steps in the extraction of raw materials, the manufacture and fabrication of materials and the construction of a building. Timber has a generally low embodied energy compared to other building materials (National Timber Development Council, 2001).

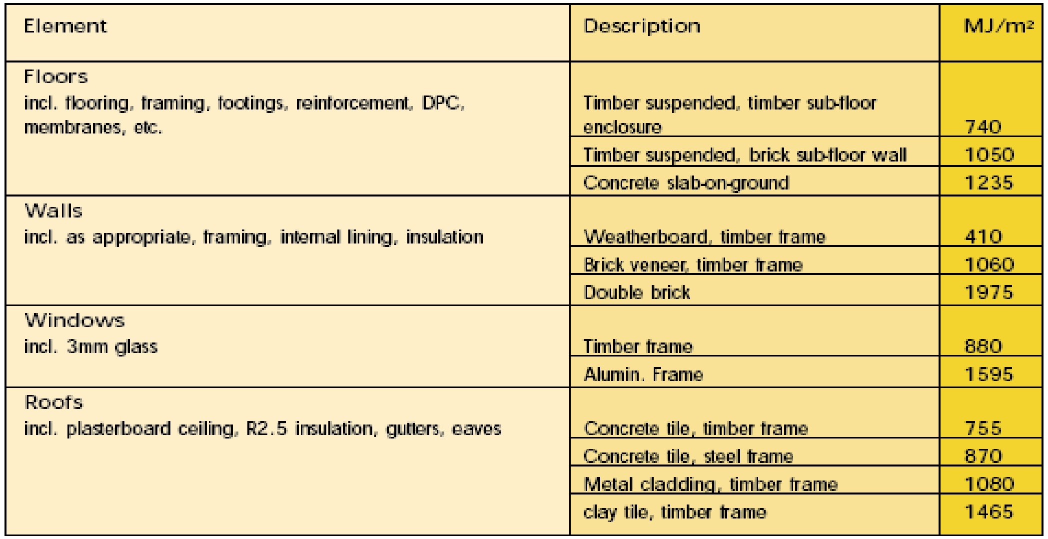
It can be shown that timber consumes much less energy in production than other types of building materials. Sawn timber products are the simplest and most traditional use of wood resources, and they require little processing to form a useful building material (Lawson, 1996).

Wood products other than sawn timber do require considerable processing and forming (Lawson, 1996). However, reconstituted and engineered wood products represent a very efficient use of timber resources. These products effectively utilise material unsuitable for sawn timber application, or timber wastes, to produce a product of predictable performance. Composite products such as glue laminated timber and laminated veneer lumber (LVL) complement structural sawn timber in the market place, and can be used to achieve long spans. Hardboard is an engineered timber product that consists of hardwood wastes combined with water and natural lignins. It does not produce off-gassing as the manufacturing process uses all natural products.

Construction activity can generate harmful environmental wastes ranging from water contaminated with cement, paints, and acids, to offcuts of solid materials, which often end up in landfill. Timber has the advantage of being biodegradable. However, advances in computer aided design and documentation means that timber products can be specified and ordered to within very narrow tolerances with very little waste. Prefabricated roof trusses, wall framing and floor framing, minimises the amount of on site waste during the construction process. The truss manufacturing process produces little waste as timber is selected and accurately cut to minimise waste. Any waste timbers are sorted and reused as noggins and set out pieces in wall frames and roof trusses.

A dwelling that is constructed primarily with timber requires less energy to produce than a dwelling using brick, concrete and steel building materials (National Timber Development Council, 2001). Refer Table 2 below.

Table 1: Indicative Embodied Energy Values for Common Building Elements



Element	Description	MJ/m²
Floors incl. flooring, framing, footings, reinforcement, DPC, membranes, etc.	Timber suspended, timber sub-floor enclosure	740
	Timber suspended, brick sub-floor wall	1050
	Concrete slab-on-ground	1235
Walls incl. as appropriate, framing, internal lining, insulation	Weatherboard, timber frame	410
	Brick veneer, timber frame	1060
	Double brick	1975
Windows incl. 3mm glass	Timber frame	880
	Alumin. Frame	1595
Roofs incl. plasterboard ceiling, R2.5 insulation, gutters, eaves	Concrete tile, timber frame	755
	Concrete tile, steel frame	870
	Metal cladding, timber frame	1080
	clay tile, timber frame	1465

Source: National Timber Development Council, Environmentally Friendly Housing using Timber – Principles, January 2001.

Table 2: Indicative embodied energy values for common building elements.

Double brick and brick veneer homes are becoming increasingly common across Australia. In 1999, 71% of dwellings had walls of either brick or brick veneer, compared to 65% in 1994. In 1999, the majority of homes featured timber frames (64%) and had roof of either tiles (63%) or metal sheeting (33%). These proportions had not significantly altered since 1994 (ABS, 2000).

Maintenance and refurbishment activities also generate hazardous waste when construction materials are consigned to landfill. This can have implications for adjacent waterways or future redevelopment of the land. Timber products are biodegradable and when relegated to landfill is less likely to be toxic or can be reused or recycled, negating the need for landfill.

When a building is demolished, the bulk of materials are disposed of in landfill, where they are effectively irrecoverable and may have a variety of adverse environmental impacts (Lawson, 1996). A timber building may be salvaged as components, or moved to another location to continue its useful life. The potential for re-use of sawn hardwood is also very good. For example, structural timbers and flooring from demolition sites can be recycled in new buildings. A German study that compared dismantling and reuse of building materials with the more conventional practice of demolishing and disposing of wastes found that although it took longer, the recycling of building materials had the benefit of an 18% cost saving (Ruch, Schultmann, and Rentz, 1994). Formalised recycling is not yet a significant part of the materials supply for the construction of buildings.

3.2 Energy efficiency

When energy efficiency is discussed, this generally refers to the levels of energy required to operate a building, whether it be a residence or some other building type, for heating and cooling, lighting, powering appliances, and heating water. The energy consumed in the operation of a house is significant as the life of the house can be more than 50 years (ABS, 2000).

Australians are using increasing amounts of energy in the home. In 2002, 20Gj of energy per person was used, an increase of 2Gj compared to 1980. This increase is despite homes becoming more energy efficient (AGO, 1999), and is highly likely to be related to the trend towards smaller households and larger houses (Ironmonger, Aitken, and Erbas, 1994).

In Queensland, energy used for water heating using electrical hot water systems accounts for the highest proportion of a dwelling’s operational energy. Water heating accounts for about 27% of an average household energy bill (Ballinger, Prasad, and Rudder, 1997) and was responsible for about 28% of greenhouse gas emissions produced from homes in 1998 (AGO, 1999). Consequently, the type of water heating appliance used in a dwelling has a considerable influence on energy costs and greenhouse gas emissions.

The majority of hot water units in homes are electric (60% in 1999). Apart from changes to the method of heating water for new houses (the choice of fittings for water heating is generally made at time of construction and then rarely changed afterwards) the greatest energy savings can be made when a house is designed and built specifically to be energy efficient. The most influential factors are the construction materials used, the building’s design and orientation and the inclusion of insulation. These factors reduce the overall running energy costs of maintaining a comfortable internal environment throughout the year (ABS, 2002b).

Insulation can assist in maintaining a comfortable internal environment. Ceiling insulation installed in a typical brick veneer house, can save about 25% of heating costs and wall insulation can save a further 14% (Ballinger et al, 1997). In 1999, 46% of all Australian dwellings were not insulated. This was represented by 38% of detached houses, 63% of medium density and 85% of high density dwellings. Queensland had the highest proportion of uninsulated dwellings at 67%. The most common reasons given by occupants to explain why insulation was not installed was cost (27%) and climate (16%) (ABS, 1999).

Although technically there are not many days on average that move away from the comfortable range of temperature and humidity, many more people in subtropical regions of Queensland are demanding that their homes, schools and workplaces are artificially cooled or heated, using air conditioning run on electricity from coal-fired power stations which are a major contributor to greenhouse gas emissions in Australia. Over the past few years in SE Queensland, energy use for control of thermal comfort during summer has increased significantly, resulting in surging electricity consumption and a straining power grid. This is in part due to changing expectations in an affluent society, but also in large part due to inappropriate solutions in the built environment in both planning and design terms.

A timber building can be designed to be responsive to climate, that is warm in winter and cool in summer. Timber buildings in warm climates, using correct applications of insulated ceilings and floors, and shading of walls and openings, can be naturally ventilated and comfortable to live in year round (Sustainable Homes, 2004).

3.2.1 Climatic design for tropical and subtropical environments

A considerable body of literature exists on designing for climate including the AGO's Your Home Technical Guide (2002) and the Principles of subtropical design for detached houses developed by the Centre for Subtropical Design (2005). Drysdale's Designing houses for Australian Climates, first printed 1952, broadly classified Queensland's climates as Tropical Humid, Subtropical Humid and Hot Arid, and provided advice specific to the major climatic zones. The most heavily populated regions of Queensland are in the Subtropical Humid zone and experience a kind of 'hybrid' climate (Hollo, 1995) characterised by hot, humid summers and cool winters and which calls for a mix of design strategies. When a climate is predominantly too hot for comfort it is usually recommended to minimise solid enclosure and thermal mass – however a subtropical house will benefit from some thermal mass to store the sun's warmth for winter evenings. The important thing is to locate this mass so that it receives no direct sun on summer days.

Bridgman (2003) describes two fundamental responses to designing for climate as 'climate-interactive' and 'climate-defensive'. The terms were initially used by Zold and Szokolay (1997) in relation to the heat transfer characteristics of a building, but Bridgman uses them more literally to describe the relationship of a building to the natural environment. 'Climate-interactive' buildings are largely open to the environment, relying on passive systems and the use of the building form and fabric to moderate internal conditions. 'Climate-defensive' buildings use the building form and fabric as a means of defence against the climate. Bridgman notes that these buildings rely almost totally on active systems and manufactured energy to modify internal conditions.

Environmentally sustainable housing takes the interactive approach but the hybrid climate of SE Queensland may require a hybrid building model. Lincolne Scott Australia's (2005) thermal comfort analysis conducted during the design development process for the Sustainable Home Brisbane, noted the benign climate of SE Queensland, and used 'forest living' as a starting point for thermal comfort prediction analysis. If an occupant were simply to live 'outside' sheltered from direct sun and night sky by tree cover, the climate of Brisbane would be between comfortable to slightly cool 79.1% of the time and cool to cold 18.7% of the time – the rest of the time (1.2%) conditions would be slightly warm to hot. However, 'outside' living is impractical in this society, and as the 'outside' concept is replaced by enclosure (using timber, masonry, steel, glazing and so on) the range and extremity of thermal comfort experiences alters and often deteriorates. Hence in this climate, climatic design is largely to undo or counteract the effects of enclosure.

Lincolne Scott's findings were that any attempt to provide a whole-of-year solution in a rational manner needs to have a house behave as a 'Queenslander' in summer, and operate with passive design principles in winter. A design checklist for summer conditions includes:

- Well-shielded walls and glazing
- No insulation except in roof to prevent radiation
- No exposed external mass
- Significant exposure to available breezes – that is, a high level of permeability obtained by sufficient openings and arrangement of openings.

A recent workshop conducted in Townsville by Building Codes Queensland (draft report, April 2004) to discuss energy efficient house design for Tropical Queensland also noted other important strategies:

- Ceiling fans are useful for air movement to relieve humidity when breezes are not available.
- Good house design should take into account the airflows which are created and channelled through a house, with inlets and outlets matched with cool and hot sources respectively.

Winter passive climate design principles according to Lincolne Scott:

- Solar radiation through glazing to raise internal surface and air temperatures.
- Sufficient insulation to retain heat at night.
- Exposed thermal mass to assist in dampening winter diurnal swings.

The final design for the Sustainable Home, Brisbane is a hybrid design which exemplifies the qualities of the timber house with shaded walls and windows and uses a low-energy system which combines a thermal chimney and four low static, high air volume fans that move air through the ceiling cavity. According to Lincolne Scott, if the ceiling cavity temperature is beneficial for the living room space temperature, the occupant will be advised and can decide to operate the fans to recirculate the heated/cooled air, and close the thermal chimney. The system can be regulated to either winter or summer conditions. It is a climate-interactive house which uses an active system to modulate thermal comfort.

However, the real test for climatic design which seeks to be energy efficient, is the behaviour of occupants and their lifestyle preferences. The success of any low-energy strategy depends on its ability to be simple to operate, and meaningful to the people who live in the house.

3.3 Housing affordability

In 1999, households in the lowest income bracket spent the highest proportion of their income on housing costs compared to other households in the same tenure group. Low income earners spent 64% of their income on housing costs, while households with high income spent 11-12% of their income. Affordability benchmarks set by the ABS suggest that households spending more than 50% of their income on housing were having severe affordability problems. The low income earners who can least afford accommodation costs are paying the most to upkeep a dwelling (ABS, 2000).

A number of factors contribute to affordability. These will not be examined in depth here as they are beyond the scope of the current project. However, some factors which are directly related to the project should be mentioned. The Smart Housing Design Objectives (Dept of Housing, 2004) notes that an economically sustainable house is cost-efficient over the lifespan of the house. It balances up-front and construction costs against ongoing running costs, living costs, long-term maintenance costs, and the likely costs of future modifications, to provide a clearer picture of affordability.

In practice, the concept of paying potentially higher initial capital costs to reduce future running costs is difficult to embrace, particularly for first home buyers with restricted budgets, and mortgages to repay. Payback time for energy efficient appliances is usually quite long which makes the initial cost seem a larger financial burden, particularly for those with low income. However, if a house is cheaper to operate it is more affordable because the cost of running a dwelling that has incorporated energy efficient appliances and passive design principles will decrease over time, compared to a dwelling without the energy efficient features.

As demonstrated in sections 2.3 and 2.4, over-scaled conventional detached housing dominates the product currently available to homebuyers – designs are aimed at larger houses accommodating fewer people. Larger homes for fewer occupants consume comparatively more resources than a modestly scaled house, both in terms of embodied energy and operational energy.

Part of the explanation for over-scaled housing lies in property economics. A house used to cost twice as much as the land. Now that land prices have increased dramatically, land can cost much more than the price of the house and homebuyers think that the investment in a house should relate closely to the value of the land for better returns. The result becomes a balance between the largest house, on the smallest block, for the cheapest price (SMH, 2003). Homebuyers are extremely price-sensitive, and will choose a smaller block of land to save the many thousands of dollars that a slightly larger block might cost.

The economic argument for sustainable building is compelling, and there are numerous examples that show consumers are willing to pay a premium for ‘green’ homes (for example, Village Homes, Davis, California). Some mortgage lenders are now considering projected running costs (or lack of them) as a factor in mortgage qualification. The reduced costs may make ownership possible for some individuals who might not otherwise be able to qualify for a mortgage. From the homeowner’s perspective it makes more sense to spend hard-won income on a tax-deductible, equity building mortgage than on ongoing power bills (Barnett and Brown, 1999).

3.4 Lifestyle expectations

Ironically it is this lack of ‘fit’ between house and land that contributes to a proliferation of inappropriate solutions that are expensive to run. People choose more floor area over practical solutions which can save them money in the long run. Homebuyers choose to forego eaves, and walls are pushed to the limits of boundary setbacks. This extract from Crowded Land of Giants (SMH, 2003) describes the new suburbia:

> *Big houses on small blocks, with narrow footpaths and narrow roads, allow little space to plant trees, as branches will hit houses, roots get into drains, and leaves drop on manicured lawns. Houses are so close that you must keep windows shut, have tinted glass, or blinds and curtains drawn, and the air-conditioning on, to get visual and acoustic privacy…..*
>
> *The traditional backyard has gone, along with its trees, garden, vegie patch, washing line and shed, where children could let their bodies and imaginations run free and build tree houses, cubbyhouses, billycarts, dig in the dirt and invent games. Now it’s indoor computer games, and given there’s no room for a decent run-up in most McMansion courtyards, children are driven to sport and formally organised activities most days of the week.*

Nevertheless, it is possible to enjoy the outdoors year round, and space for outdoor living is an essential element in Queensland houses, whether it is a detached house on a suburban block, or an apartment in the inner city. In more established residential areas, the subtropical setting of dense vegetation allows the lines between indoor and outdoors to become more blurred as people enjoy the visual privacy afforded by established vegetation.

Negative perceptions of high maintenance of timber houses – particularly tasks relating to painting, borers, termites and decay, are exacerbated by the lifestyle issue of lack of time. People feel they have less time to spend or are too busy to carry out routine maintenance, or are not even aware of the necessity for this, with obvious results. On the other hand, a do-it-yourself home renovation boom has indicated just the opposite, with many people carrying out alterations, particularly on timber houses on weekends and in their spare time.

Other lifestyle issues that are implicated in housing choice are:
- Housing diversity related to demographics.
- Flexibility and adaptability to changing lifestyle needs of occupants.

3.5 Objectives for an environmentally sustainable timber house

The observations in the foregoing sections of this report form the basis of a checklist of objectives for the environmentally sustainable house.

Modify the 'one-size-fits-all' approach to allow for social, cultural, and climatic differences

Adopt more compact housing models. Small may be better than over-scaled. Optimise use of interior space through careful design, so that the overall building size and resource use in constructing and running a house is kept to a minimum. Capitalise on the climate by giving greater emphasis to covered outdoor living spaces.

Pay attention to solar orientation and airflows

Support compact development whilst maintaining openness and permeability, and a strong connection with nature.

Minimise environmental impacts on sites

A majority of sites available for residential projects in Queensland in future, whether Greenfield, or infill redevelopments, are likely to be characterised by significant slopes. One of the main objectives of environmentally sensitive design is to minimise site disturbance and to accommodate for particular site conditions.

Benefit from existing and future vegetation

Vegetation offers many advantages in urbanised subtropical and tropical environments.
Trees and topsoil should be protected during site work, and pesticides and chemicals avoided where possible.

Be adaptable/flexible for a variety of household types

This reflects one of the main objectives of Smart Housing Design, an initiative of the Department of Housing. Dwellings should be socially, environmentally and economically sustainable. One of the main principles is that a Smart House will comfortably accommodate people with a diverse range of needs during all stages of their life. The Smart House is intended to minimise the need for future alterations, maintenance and expense. It is intended to be more comfortable and less expensive to operate as it is more resource efficient.

Design for future reuse

Make the structure adaptable to other uses, and choose components that can be reused or recycled.

Be adaptable for retrofitting as new technologies become available and/or acceptable

Future penetrations and services are easier to achieve with a suspended timber framed floor than slab on ground.

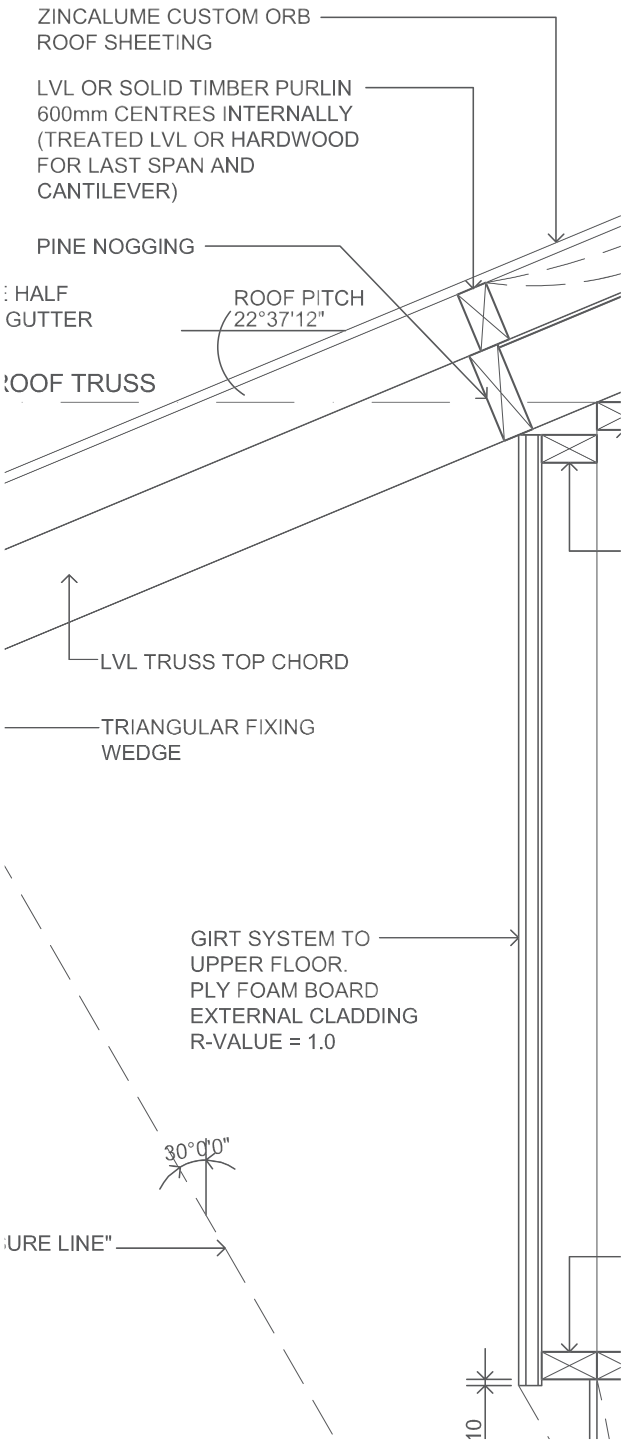
Simplify the construction process

Use standardised and modular elements that minimise onsite construction time and cost.
Minimise the number of trades on-site during construction.
Prefabricate wall and floor frames and roof trusses.
Combination of prefabrication and site work to provide efficient outcome.
Flexibility for changes during construction.

Optimise material use

Minimise waste by designing for standard sizes. Avoid waste from structural over-design.

As will be seen later in the report these objectives are achievable using timber products.



3.5.1 Objectives for selecting materials for an environmentally sustainable house

A companion checklist based on Barnett and Brown’s (1999) Primer for sustainability, has been developed to guide selection of appropriate materials.

- ***Use timber from sustainably managed native forests***
- ***Use locally produced building materials***
- ***Choose building materials with low embodied energy***
- ***Use durable products and materials***
- ***Use building products made from recycled materials***
- ***Avoid materials that will off-gas pollutants***
- ***Minimise long term maintenance***

The following sections of the report describe how these objectives are achievable using locally available products.

4 Survey of Timber Products and Associated Building Materials

In Section 3 of this report, the researchers established a number of objectives that materials in an environmentally sustainable timber house would need to meet. From this list of objectives, an inventory of materials and their applications was developed.

The researchers establish acceptable criteria for the evaluation of timber products and associated building products. Several products were selected for their ability to meet the foregoing objectives, and evaluated according to criteria such as source of product (local or imported), treatments (any glues, resins or other treatments that may be harmful to people), flammability, finishes and applications.

4.1 Engineered timber products

The analysis was based on information and technical data provided by the manufacturers of the engineered timber products. Products included I-beams, hardboards, plywood, glue laminated beams, Laminated Veneer Lumber (LVL), Laminated Strand Lumber (LSL), Oriented Strand Board (OSB). Plywood Association web based brochures were also consulted for information on plywood, glues (formaldehyde emissions), veneers and LVL's.

The products reviewed by desk-top web-based survey include:

- Australian Hardboards – Deco hardboard, Dual bond flooring, Masonite underlay, tempered MR, M4/M6 Braceboard, Readiwall, I-Beam and Smart frame I-Joist.
- Futurebuild (Carter Holt Harvey) – Hyspan/Hyspan H2 LVL, Hybeam H2 I-Joist, Hychord LVL roof truss member, Hypitch LVL pitching beam, Hyplank LVL scaffold plank.
- Hyne – Hyne T2 I-Beam, Hyne Edgbeam LVL Glulam beam, Hynebeam 21C Glulam Beam, Hyne 17C Glulam Beam, Araucaria MGP 12, Hardwood F27, Hyne Poles, Hyne Pine framing, Tru-Pine mouldings, Hyne flooring.
- Norply – Norclad exterior cladding, Norclad interior panelling, Norfloor Plywood floor/ceiling panel, Norbrace Bracing Plywood, Nortest general structural plywood, Preserveply preservative treated plywood, Norform concrete form, Norply LVL.
- Pine Solutions Trus-Joist – Timberstrand Laminated Strand Lumber, e-Rim Rim board, TJI I-Joists, Microllam LVL.
- Tasbeam – Tasbeam 18 Glulam beam, Tasbeam 17 and Tasbeam 17 LOSP
- Tilling Timber – Smartframe LVL

Detailed reviews are available in Appendix A.1.

The following general observations were made:

Structural capacity

Spanning capacity for timber is traditionally low compared to that of steel and concrete. However this has been addressed with engineered timber structure such as Glulam beams, LVL's and engineered I-Beams. Engineered I-Beams used as joists can be designed to span up to 12m and are relatively light compared to a steel member with a similar span.

Stability of material

The swelling and shrinkage of timber members due to exposure to moisture is particularly relevant in hot humid climates. Steel and masonry does not tend to swell and shrink as timber does. This is particularly important for timber flooring where joints open and close depending on the humidity. This can be overcome by sealing the timber floor so that it does not readily absorb and lose moisture.

Sawn timber is vulnerable to defects such as bowing, twisting, knots, checks, splits and cupping. These imperfections are not present in engineered timber products such as plywood, glue laminated beams, LVL's and engineered I-Beams. The engineered timber products still contain the favourable attributes of timber yet it minimised the flaws in the process.

Another deficiency in sawn timber is its reliability of being a consistent strength throughout a member. This has been overcome by engineered wood products where beam strength is uniform throughout.

One-off and mass production
Efficiencies can be gained by manufacturing large quantities of the same product. A prefabricated modular system could save labour costs onsite.

Mass produced prefabricated products have twofold influences on the residential construction industry. It addresses the problems of skill shortages in the short term as prefabricated products require less skill to build on site. The long term effect of the mass produced prefabrication is that onsite construction skills will be lost as the skills will no longer be required.

One off construction can accommodate the peculiarities of every individual site and the design can suit individual requirements. The disadvantage of one off construction is the cost of design and construction as time is required to consider the issues of each particular building.

The gang-nail truss industry is a good example of one off production that can be mass produced. The gang-nail truss industry has its own Australian Standard AS4440-2004 which provides the framework in which the gang-nail truss industry can autonomously work within. This allows the truss manufacturer to manufacture trusses to suit the various house designs for the project home market and still maintain time and cost efficiencies by not requiring a structural engineer's certification for each individual house.

The disadvantage to this type of system is that designs become limited to what can be produced within the AS4440-2004 framework.

4.2 Associated building products

The associated building products were investigated as products to be integrated as part of the proposed building system. The analysis was based on information and technical data provided by manufacturers of insulation products and expanded polystyrene products. As timber has relatively low R-Values, it requires insulation to supplement its thermal properties. Based on the study comparing the thermal comfort of houses with concrete slab on ground and raised timber floors, it seems that insulating the floor of raised timber framed houses may be required.

A summary of the engineered timber products reviewed includes:
Bondor – Flameguard fire resistant sandwich panel, Equitilt

Insulation Solutions – Sisalation 438 Light duty foil laminate, Gladiator breather Extra Heavy Duty wall wrap, Permastop 436 roofing blanket, Pink Batts thermal insulation for ceiling and walls, Pinkpoly acoustic insulation, R-Blanket general purpose building blanket.

Ritek – Ritek Custom Panel, expanded polystyrene panel.

Detailed reviews are available in Appendix A.2.

Window joinery was not investigated specifically but deserves more specific research into the comparative performance of timber and aluminium framed windows. Table 2 of this report indicates the difference in embodied energy between timber framed windows and aluminium framed windows. Aluminium is almost twice as energy intensive as timber; however it is likely to have numerous other benefits.

4.3 Manufacturers' site visits

The desk-top review of materials was supplemented by visits to the plant operations of local manufacturers, Hyne, Australian Hardboard, Boral Hancock, Australian Timber and Truss. This gave first-hand insights into the manufacturing and fabrication processes which define many of the engineered timber products in the marketplace. (Refer Appendix A.3 for more detail).

4.4 Implications of available building materials for a design system for an environmentally sustainable timber house.

The analysis confirmed that timber products meet several of the objectives in the Section 3.5.1 checklist – **selecting products** for environmentally sustainable housing.

Use timber from sustainably managed native forests
Recommended materials are sourced from local plantations, or from Australian eucalyptus hardwood waste (Australian Hardboards).

Use locally produced building materials
Recommended products use locally produced components and local sources of timber.

Choose building materials with low embodied energy
Wood products other than sawn timber do require considerable processing and forming. However, reconstituted and engineered wood products represent a very efficient use of timber resources. These products effectively utilise material unsuitable for sawn timber application, or timber wastes, to produce a product of predictable performance. Composite products such as glue laminated timber and laminated veneer lumber (LVL) complement structural sawn timber in the market place, and can be used to achieve long spans.

Use durable products and materials
Timber is an organic building material, and needs to be protected from the weather (sun and rain) and from biological damage such as insect, termites, borers and fungal attack. The life of timber buildings can be extended by appropriate design, detailing and specification. (National Timber Development Council, 2001). Timber I-Beams or I-Joists are generally not suitable for external use therefore careful and appropriate use of timber products is essential. As long as external timber cladding is protected by eaves or building overhangs so that it is not directly exposed to rain and sun, it is a durable material.

Timber can be also used effectively as a durable internal lining material. Plywood sheets are relatively inexpensive and more durable than plasterboard lining. However plywood is disadvantaged in this application because it lacks the fire resistance of plasterboard.

Use building products made from recycled materials
Reconstituted and engineered wood products represent a very efficient use of timber resources. These products effectively utilise material unsuitable for sawn timber application, or timber wastes, to produce a product of predictable performance.

Avoid materials that will off-gas pollutants
Hardboard is an engineered timber product that consists of hardwood wastes combined with water and natural lignins. It does not produce off-gassing as the manufacturing process uses all natural products.

Minimise long term maintenance
Perceptions of low durability and high maintenance are considered to be timber products' major drawbacks. Appropriate detailing, connections and routine checking ensure a low maintenance outcome. However, ease of replacement is one of timber's advantages in this regard. Any damaged element of the building can be replaced and usually does not require specialised large machinery due to its lightweight nature. Timber's flexibility is another advantage to be taken into consideration. As a structural frame it tolerates some movement. Timber structures are flexible enough to accommodate movement due to reactive soils, whereas masonry and concrete structures do not respond favourably to ground movement or reactive soils. Cracking of masonry and concrete structure can be expensive to repair. A further problem is exposed if the monolithic concrete slab cracks and allows termites to penetrate. This could occur undetected by the homeowner.

The analysis also confirmed that structural systems using timber products can meet the objectives in the Section 3.5. **checklist – objectives** for environmentally sustainable housing.

Modify the 'one-size-fits-all' approach to allow for social, cultural, and climatic differences
Timber framed housing is ideal to accommodate the various affordability, lifestyle and climatic differences presented in an urbanised subtropical environment.

Pay attention to solar orientation and airflows
Timber structural systems and planning with timber lends itself to a design approach which supports openness and permeability, and a strong connection with nature.

Minimise environmental impacts on sites
Slab on ground construction requiring extensive cutting and filling of land is not an ideal solution environmentally, requiring retaining walls and causing loss of habitat, interruptions to overland water flow and dramatically altered microclimatic conditions. The raised floors possible with timber construction are much better able to accommodate slope, and 'difficult' sites without major interventions on site.

Benefit from existing and future vegetation
Timber buildings which are specified and detailed correctly are able to meet this objective, and can incorporate flexibility in their planning to retain existing trees and to accommodate significant future trees.

Be adaptable / flexible for a variety of household types

Raised timber houses offer many possibilities for adaptation. A raised house can be built in under at a later stage. This work can also be reversed with the minimum of fuss. Open space under the house can be used for parking cars, drying clothes, children's play area, workshop area and so on, evolving as the occupants' need change. Timber construction's advantage is the ease of altering or adding to timber framed buildings in terms of time and cost benefits compared to masonry construction. The raised floor platform can provide some difficulties for disabled access, particularly on a flat site, where ramps would have to be used to negotiate the levels. However, on sloping sites where timber has an advantage, access is less problematic if skilfully designed.

Design for future reuse

Timber houses can be altered, or added to with considerably less complexity than may be involved with a masonry or concrete building.

Simplify the construction process

Timber technology makes each of these objectives achievable. Timber's light and easy to handle construction elements minimise heavy transportation and heavy onsite lifting. Point load distribution of posts allow for building over services such as sewer/ stormwater drains, and access to services is not concealed as per slab on ground construction.

Optimise material use

Computer aided design and documentation of construction projects and components means that timber products can be specified and ordered to within very narrow tolerances with very little waste. Prefabricated roof trusses, wall framing and floor framing, minimises the amount of on site waste during the construction process. The truss manufacturing process produces little waste as timber is selected and accurately cut to minimise waste. Any waste timbers are sorted and reused as noggins and set out pieces in wall frames and roof trusses.

5 Regulatory Issues

The following regulations and codes were analysed for issues which impact on the use/choice of timber as a primary construction material for housing. The findings highlight some of the conflicts which occur between various regulatory issues, and between objectives of the regulations themselves.

- Building Code of Australia (refer Appendix A4)
- Brisbane City Council City Plan 2000 (refer Appendix A5)
- Australian Standards (refer Appendix A6)
- Workplace Health and Safety

5.1 Building Code of Australia

The analysis of the Building Code of Australia was based on Class 1 buildings (detached and attached houses) and Class 2 buildings (units and apartments) and the implications of the Building Codes on a timber framed system. The BCA definition of lightweight construction is different to the timber and steel framing concept that is commonly expressed in the construction industry.

The main provisions identified in the BCA as having implications for timber housing are:
- Energy efficiency
- Weather protection
- Termite risk management
- Fire safety, and
- Structural stability and resistance to actions

Other provisions cover health and amenity, sound transmission, acoustic privacy, and fixing of timber cladding.

5.1.1 Energy efficiency and star ratings

Australian state and federal governments are concerned with the production of greenhouse gases by the burning of fossil fuels in electricity generation. The need to reduce greenhouse gas emissions has led to policies directed by Australian Greenhouse Office and the Australian Building Codes Board to increase energy efficiencies in new residential buildings by limiting household energy use in heating and cooling. The AGO and ABCB have worked together to introduce energy efficiency requirements to the Building Code of Australia. The energy efficiency measures encompassed in the BCA include minimum construction requirements which are regulated at the building approval stage of the process of constructing a new home.

The ABCB also recently introduced measures to incorporate energy efficiency provisions into Multi-Residential Buildings, which came into effect on 1 May 2005 (ABS, 2002).

The deemed to satisfy requirements contained in the BCA set out some basic energy efficiency requirements involving insulation levels and window area to floor area ratios. To demonstrate BCA compliance in climate zones 1-3, which covers most parts of Queensland, except for the Toowoomba and Warwick areas, a minimum 3.5 star rating using version 3.2 of BERS[2], version 3.5 of FirstRate or version 2.32 of NatHERS[3] from an accredited energy rating assessor is required.

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[2] BERS Building Energy Rating Scheme

[3] NatHERS Nationwide House Energy Rating Scheme

A description of BERS can be found at http://www.solarlogic.com.au/BersDetail.htm. The following discussion of NatHERS is also applicable to BERS. FirstRate has not been analysed in this report.

Current tools for measuring energy efficiency are not site specific and do not take into account orientation, the effects of adjacent buildings, vegetation, or a broad range of construction materials. The tools are designed to rate the thermal efficiency of the building envelope using predefined thermostat settings. They are not designed to predict actual energy usage of a specific dwelling's occupants and do not take into account regional lifestyle inclinations such as a preference for open windows even when the external temperature is higher than that inside. (CRC Construction Innovation, 2004).

The Building Designers Association of Australia Ltd (BDA) notes that the current focus on star ratings rather than actual energy savings has resulted in the introduction of inefficient regulatory policies. In benign climates like coastal SE Queensland and northern NSW, heating and cooling energy can represent as little as 6% of total household energy consumption. In these climates, strict application of HERS based regulation can divert limited budget away from more effective energy saving strategies such as solar hot water systems, efficient appliances and reducing embodied energy. Building Codes Queensland also notes widespread dissatisfaction with the use of computer modelling for assessing house energy performance in the tropics. Queensland variations in the BCA for Zones 1, 2 and 3 include a minimum R1.0 or shading to single skin masonry walls of not less than 140mm thick. It should be noted that the sealed building model used in FirstRate and NatHERS has little application in tropical climates where opening the buildings for breezes is an important part of the design. As a rule of thumb care should be taken when rating houses further north than Brisbane.

The BDA agrees and recommends that NatHERS is best suited to climates that require heating, and challenges the inbuilt assumption of current rating tools that high thermal mass construction is universally beneficial in improving energy efficiency. The BDA challenges the necessity for thermal mass particularly in climates where there is a low diurnal range (less than 6 degrees) and comments that in these locations, mass has dubious benefit at best. When the additional embodied energy of high mass construction is taken into account, high mass construction will often cause increased energy consumption on a building lifecycle basis (BDA, 2001).

Another flaw with NatHERS is that it does not adequately address solutions for the 40% of sites on which solar access cannot be achieved (BDA, 2001). Further, according to the BDA, the measurement of energy use/m2/annum is also flawed. It rewards inefficient use of space. Typically, a 300m2 home with three occupants will score higher than a 150m2 home with three occupants because it has a lower ratio of external wall to floor area. Yet the larger building will consume around double the heating and cooling energy and contain double the embodied energy.

According to Building Codes Queensland, second-generation computer modelling programs (AccuRate and BERS11) aim to address these problems. The most significant change to these programs has been a greater recognition of the cooling benefits of natural ventilation. On these grounds alone, there is general agreement that the Building Code of Australia needs to replace first generation computer modelling programs as soon as possible (Building Codes Qld, 2005).

A recent study by the CSIRO for the CRC-CI (2004) focussed on energy efficiency and its link between dwelling energy efficiency and subdivisional layout. The main finding from this study is that there is a correlation between the efficiency of the dwelling and the land that it is built upon and that lot-related issues do play an important part in the overall efficiency that a dwelling is able to achieve. The study used AccuRate to model a range of case study dwellings at their presented orientations, using two levels of external shielding (shade protection). The findings quantified and confirmed the importance principles of orientation, external shading and airflow paths for ventilation in SE Queensland. The study mentioned that increased energy loads are the likely impact of increased suburban and urban densities.

The Centre for Subtropical Design suggests that these increases can be avoided if the principles of subtropical design are adopted at all scales of urban development (CSD, 2005).

However, the overall level of energy efficiency in Australian homes will be slow to improve because new houses make up a small proportion of the overall housing stock (ABS, Australian Social Trends 2002). Meanwhile in Queensland, though energy consumption for heating and cooling is increasing, the single biggest consumer of energy in the dwelling is for water heating (CRC-CI, 2004).

5.1.2 Weather protection

The main concern of the BCA with regard to weatherproofing is ensuring resistance to moisture rising from the ground, surface water and water penetration. Timber is susceptible to rot and decay if it is untreated and in a constant damp environment. Timber must be protected from the weather (sun and rain), and ventilated in humid climates to reduce the likelihood of rot and mould to maintain its durability. Constant exposure to direct sun and rain will eventually cause timber to split. Straightforward design strategies which avoid these problems are available. For example, wide eaves and overhangs provide weather protection to walls, openings and decks.

The advantage of a raised house is that it separates the timber from ground moisture which is also implicated in acceleration of the decay of timber. The raised house is well away from surface water and also minimises interruption to natural overland flow.

The raised floor strategy also contributes to keeping the undercroft area dry by providing access to ventilation underneath the house.

5.1.3 Termite risk management

In Queensland where termites are prevalent, slab on ground construction requires a partial or full stainless steel mesh system, graded stone or a full chemical system beneath the slab for protection of primary building elements against termites. However, even with the physical or chemical barrier in place, regular inspections for termite activity are essential for slab on ground houses as termites can enter at any vulnerable point beneath the slab and not be detected until some timber damage has occurred. Internal elements such as pine skirtings and architraves are usually the first vulnerable points attacked. Concrete slabs need to comply with AS 3660.1-2000 as well as the BCA requirements.

The BCA addresses termite barriers for suspended floors. Termites can be managed by a simple termite shielding system. The advantage of a raised timber floor is the ease of inspection for termite or borer activity. Inspections can be done by the homeowner on a regular 6 monthly basis. The BCA notes that attachments to buildings such as downpipes need to be kept clear of structure to allow for visual inspection. The dry undercroft area beneath a raised timber house is also a deterrent to termite activity as termites require a source of water for survival.

Naturally termite resistant timbers include: Australian native softwoods such as cypress and huon pine, and Australian hardwoods such as blackbutt, jarrah, tallowwood, grey ironbark, spotted gum, river red gum and brush box. Refer to AS 3660.1 for the full list.

5.1.4 Fire safety

Fire separation requirements affect the type of construction allowed and the type of materials that can be used. Setbacks defined by the BCA are based on maintaining fire separation between buildings. Fire considerations are required when building close to the boundary, close to other buildings and separating walls in duplex and multi-residential design. Timber framed lightweight solutions are available where fire resistant boards are applied over the timber framing. For external walls, it is possible to have plywood or weatherboard external cladding, timber framing and fire resistant internal lining to achieve the required fire ratings.

Spread of fire provisions apply if a secondary dwelling such as a granny flat was built adjacent to the primary dwelling. The perception is that timber burns easily and therefore spreads fire from adjoining houses quickly, however as stated in AS 1720.4-1990 a typical minimum width of 100mm for hardwood will provide a 60/-/- FRL. This is due to the charring factor of sawn timber. Only a thin outer layer of timber is charred leaving the remaining timber unaffected by the flames, with structural integrity intact.

The BCA also requires external walls including gables to be fire resistant and this property must extend to the underside of a non-combustible roof covering or non-combustible eaves lining. The construction details provided in the BCA incorporate masonry or non-combustible lining such as fibre cement or plasterboard as a method of providing fire protection for the timber frame.

5.1.5 Structural stability and resistance to actions

The aim of this provision is to provide a more robust structure by minimising damage to structure due to excessive deformation, vibration and degradation of materials. It addresses the need for minimising the effects of groundwater action, minimising the effects of ground movement caused by swelling and shrinkage of soil, rainwater action, differential movement, creep and shrinkage, and thermal effects on structure. The following comments describe the suitability of timber construction to resist actions.

- Raising the house above the ground reduces the effects of ground water action on the structure. The flexibility of structural timber can accommodate movement in soil due to groundwater.
- Timber framing is a flexible structure that can accommodate movement in the ground.
- Rainwater action can be accommodated by raised timber floors. Ground water is kept away from the house and natural overland flow paths are not impeded.
- Differential movement can be accommodated due to the flexibility of timber framing; movement due to heat and cold are negligible as timber is a poor conductor of heat.
- Creep and shrinkage is allowed for and considered in timber framed design tolerances.
- Thermal effects on structure are negligible as timber does not readily transfer heat. Contraction and expansion of timber structure is minimal.

5.2 Brisbane City Council City Plan 2000

Chapters 3, 4 and 5 of the Brisbane City Council City Plan 2000 were investigated. The analysis is based on the implications of the City Plan on building new timber framed houses and units in different locations within the boundaries of Brisbane City.

The height limit restriction of 8.5m above natural ground line for detached houses does not consider the undulating topography of Brisbane.

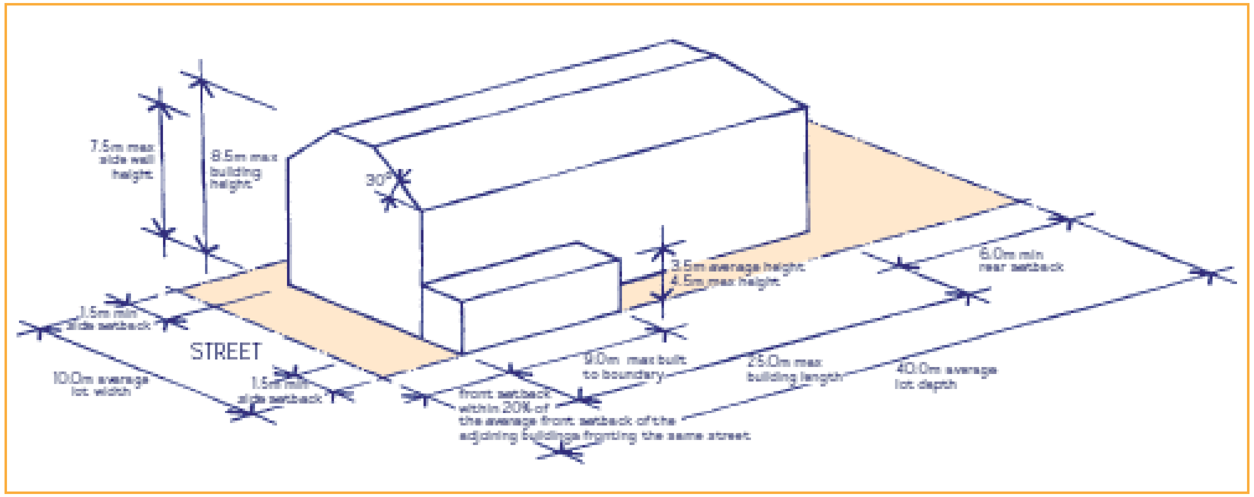


Figure 2 Building envelope for a typical 16 perch (405m²) lot with one street frontage

Figure 1. **BCC Building envelope for a typical small lot with one street frontage.**

The small lot code requires a maximum height of 7.5m above ground level for side and rear walls increasing at no more than 30° to a maximum of 8.5m above ground level. The building envelope does not fully maximise the pitched roof building form. There is considerable space that cannot be used to conform to the 8.5m height limit.

The diagram (Figure 1) provided by Brisbane City Council indicates a flat site. On a sloping site it is difficult to achieve a flat building platform for a two storey house and stay within the 8.5m height limit. One possible solution to overcome this problem would be to build a split level house. However the split level solution has problems with ease of mobility between each floor of the house and additional costs of construction. If the site is extremely steep a split level house would not comply with the height limit requirements.

Another solution to satisfy the required 8.5m height limit on sloping sites is the reduction of ceiling heights to accommodate the allowable building envelope. The BCA minimum habitable room height of 2.4m is too low to install ceiling fans to improve air circulation. The Queensland Development Code Part 22 for Childcare Centres has been used as the basis for the minimum height requirement for ceiling fans heights which is 2.4m to underside of the fan blades. The height of living areas needs to accommodate ceiling fans, with a minimum of 2400mm to the underside of the fan and a minimum of 2650 or preferably, a 2700mm high ceiling. The higher ceiling will accommodate the fan and allow it to effectively circulate the air in the room.

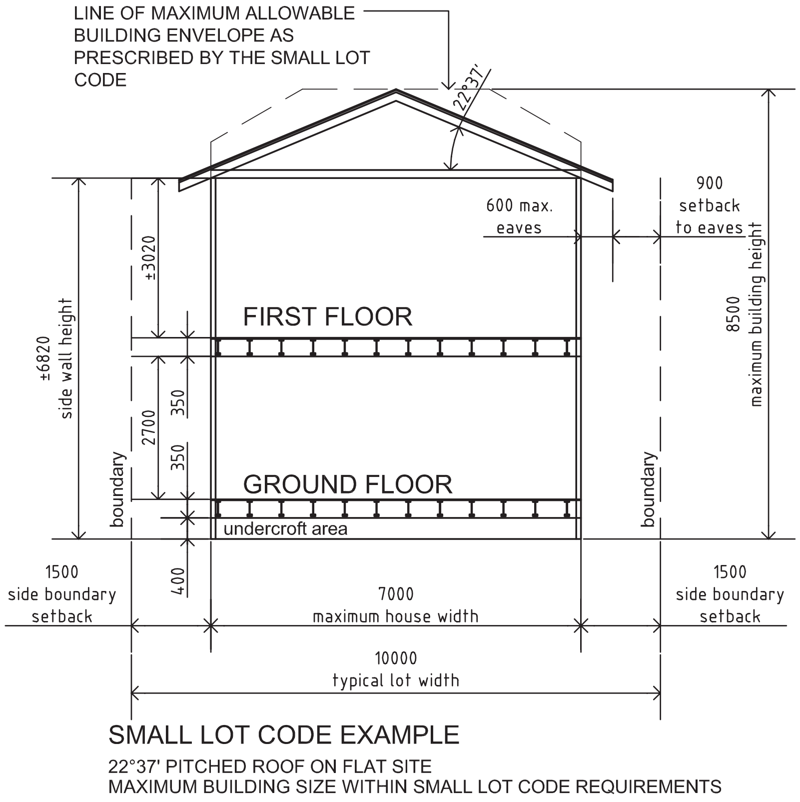


Figure 2 Example of maximum allowable requirements under the BCC small lot code

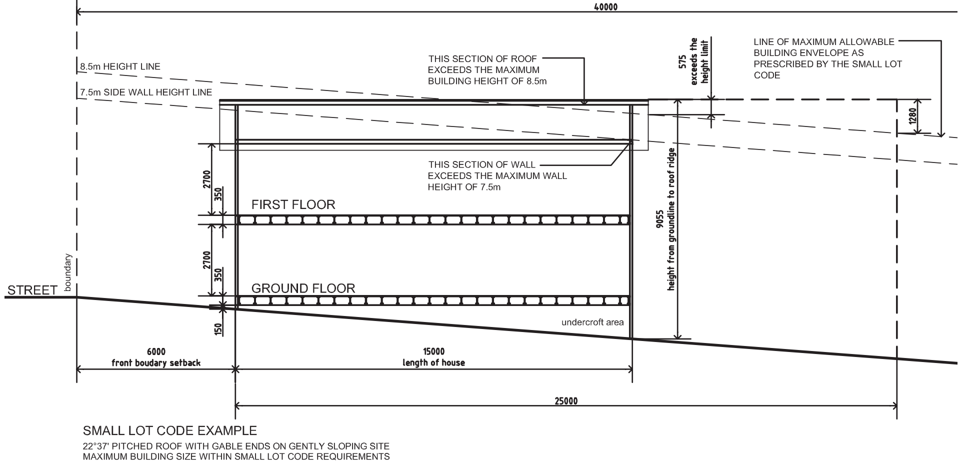


Figure 3 Example of house on sloping site under the BCC small lot code

The following (Figure 2) is an example of building to the maximum allowable requirements of the small lot code. Assumptions for this example are the typical 10m lot width, one street frontage, average lot depth of 40m and a flat site. Based on the some of the design requirements developed in this project a 22º37' pitched roof can have a maximum side wall height of approximately 6.8m. The 6.8m wall height includes the following:

- a raised ground floor timber platform to the minimum BCA requirement of 400mm to underside of bearer
- a floor depth of 350mm for the ground floor
- a ground floor to ceiling height of 2700mm
- a floor depth of 350mm for the first floor
- a first floor to ceiling height of approximately 3000mm, assuming there was a flat ceiling, higher if there was a raking ceiling.

Assuming a typical street frontage of 10m, and applying the small lot code side boundary setback regulations, a configuration that allows the maximum width of 7m for the house creates a 1.5m wide strip down each side of the house. The 1.5m wide spaces are not wide enough to use productively as an outdoor recreation area. The internal layout of the 7m wide house restricts a typical design to two 3m wide bedrooms with a 1m wide corridor. The restriction on the width creates a corridor from which bedrooms come off. The width makes the bedrooms quite small and does not allow for flexibility to cater for other uses. For open plan design areas such as living, kitchen and dining spaces, the width is less restrictive if a corridor if not used. For further reading, refer Skinner (2004).

The eaves overhang of 600mm which is the maximum allowable under the small lot code. If the minimum side setback of 1.5m is used, the eaves seem disproportionate small compared to the rest of the house. The small overhang provides neither adequate shading nor weather protection to the side walls and windows. Thus the site boundary setbacks work against sustainable outcomes of providing adequate sun shading to the walls of the house.

Although the above example seems to fit within the prescribed small lot building envelope, if the site was sloping the outcome would be quite different.

The following (Figure 3) is an example of a gently sloping site at approximately 4º gradient or a 3m fall over the 40m length of the site. Even by reducing the floor to ceiling height to 2700mm on the ground and first floors, the gable end roof still exceeds the maximum 8.5m limit by about 0.5m. Also the distance between the ground and the underside of the bearer at the lowest point is only 150mm, the minimum requirement to comply with the BCA. The building length is only 15m not the maximum 25m allowed in the small lot code. If the building length was 25m, the gable end would exceed the height limit by over 1200mm.

The above scenario is only exacerbated when the steepness of the slope increases or the building's long dimensions increases. Brisbane is a hilly city and sloping or steep sites are not uncommon. The small lot code does not promote the use of raised timber platforms as a construction solution when dealing with hilly terrain. The raised timber platform is an economically and environmentally preferred option to slab on ground as excavation costs are minimal and the footings are only placed in the ground as required rather than covering the entire building footprint. Natural overland flow paths are maintained and the ground is left in a less disturbed state.

5.3 Australian Standards

Including AS 1684 Part 2 Non-Cyclonic Timber Framing Manual and AS 3660.1-2000 Termite Management. Refer Appendix A.6 for details.

5.4 Workplace Health and Safety

5.4.1 Workplace Health and Safety obligations for guardrail systems in Queensland

Section 184 and 185 of the Workplace Health and Safety Regulation 1997 describes the risk and requirements for fall prevention measures used in construction.

There are many different complying forms of rails and restraints that can be used to prevent a person from falling any distance including, edge protection, a fall protection cover placed over an opening and a travel restraint system. If preventing a fall is not practicable, then control measures can be used such as a fall arresting platform, a fall-arrest harness system or an industrial safety net. The fall and arrest harnesses and the travel restraint system are not the preferred methods of fall prevention endorsed by Workplace Health and Safety Queensland.

The requirements for edge protection and the fall arresting platform will be considered as they are the most common and economical control systems in the residential construction industry.

Safety measures such as a guardrail system must be employed when working at height of 3m or more for residential construction work, or on a roof, or partly completed roof surface with a pitch greater than 26º. Guard rail systems can be attached to the roof truss or stud framing for stability.

The edge protection must have a toprail that is at least 900mm higher than the surface, a bottom rail or toe board and a midrail. If the roof pitch is over 26º then a mesh or solid panel needs to be fitted in between the top and bottom rail. This requirement adds to the expense of the edge protection system.

If the roof pitch is not over 26º, a fall arresting platform can be installed at no lower than 1m below the roof edge. The platform must provide an unobstructed landing area that is at least 675mm wide and for the length of the platform. The fall arresting platform must also have edge protection as per the edge protection specification. This makes the fall arresting platform a more expensive option than the edge protection method. The fall arresting platform has the added benefit of being useful for other purposes such as a working platform to assist with external cladding and painting.

During the site visits to manufacturers, the researchers were informed by the roof truss manufacturer that the roof truss spacing at 600mm centres was a WHS (Workplace Health and Safety) requirement to provide some fall protection for the roofing contractors.

However, the Workplace Health and Safety Regulations 1997 do not specify a requirement of 600mm centres for roof trusses. The application of 600mm centres for roof trusses was an example provided in a WHS work method statement, not the WHS Regulations. The example provided by WHS has been adopted as a “requirement” by the project home industry even though it is not a regulated requirement. The 600mm centres example given by WHS has been adopted by the truss manufacturing industry as a construction norm. The 600mm centres are also the preferred spacing for concrete tile roofing. The trend for roof trusses at 600mm centres is contributing to the proliferation of concrete tile roofs in project homes.

As more trusses are required to frame the same roof than trusses spaced at 1200 or 2400mm centres, the average roof requires more timber to construct. Although timber is a renewable resource, it is important to conserve its use.

Another example given by the work method statement is for roof truss spacings greater than 600mm, in which case roof battens at 450 centres would be acceptable provided the battens were installed insitu from gutter to apex, thereby creating a ladder upwards.

The HIA is currently working with WHS to investigate safe working methods for trusses spaced at greater than 600 centres.

6 A Construction System for a Contemporary Environmentally Sustainable Timber House

The transition to a sustainable future will require that the vast majority of people be persuaded to adopt different lifestyles, supportive of sustainability. A construction system for a contemporary environmentally sustainable timber house must simultaneously address the complexities of designing more compact homes on steeper slopes, smaller sites and to optimise solar access and natural ventilation. Meanwhile, the project team believe that timber's main marketing disadvantage is the perception that it is a high maintenance building material. To this end, it was decided that the protection of the timber material and the elimination of the negative perception were central to the success of the design concept. Protecting timber from the weather and thereby increasing its durability is crucial for the system to succeed in the project home market.

When investigating a timber framed and clad construction system for two-storey detached housing, it was considered that for climatic reasons and the prevention of weathering of materials that a timber wall system that stepped out as it went up would provide many benefits. Solar and rain protection for the inhabitants would be achieved at the same time as a suitable protection for the timber materials.

Two systems emerged from the research by design approach. Both systems consist of a timber framed self weathering wall system, a timber framed floor system and a timber framed roof truss system.

Type A is a galvanised steel column/timber beam system that relies on the steel loadbearing column that is external of the lower wall frame. (Refer to Figures 5-16) To address the building codes and wind loading requirements, contemporary timber construction is really timber and steel construction. Both timber and steel are excellent materials which when used together complement each other's qualities. The Type A system uses the material that is best suited for the purpose.

Type B is a strutted and clad system that uses the load bearing properties of the lower wall frame to support the upper floor. (Refer to Figures 17-28) Both types share many features; where they differ will be described below.

The lower floor frame has the potential for prefabrication if planning of the house design is carried out on a modular basis. It is also important that some standardisation be achieved at this level in order to compete with the popularity of slab on ground construction.

Timber floor framing, by definition, will engage height restrictions in the town planning codes before slab on ground construction. In response to the height limit regulations, the system developed attempts to minimise the height above ground (within allowable limits) and to minimise the floor thickness. Many of the new engineered timber products are deep, so to minimise the depth, the timber floor system proposed consists of discontinuous joists between the bearers.

The Type A floor system has a galvanised steel blade column supported at the edge of the floor frame. The Type B floor system is simply supported by a galvanised steel column directly underneath the floor frame. Both systems are simply supported by galvanised steel columns midspan, and would have plywood floor cladding in full sheets to the module.

The lower wall framing in Type A allows a degree of flexibility in construction because the post and beam is the load bearing element, rather than the wall frame. This allows windows and door openings to be sized and positioned where desirable on the lower floor without disruption to the load bearing elements.

The lower wall framing in Type B is load bearing and includes a standard prefabricated sheeted strut that supports the end overhang of the floor above.

The upper floor joists in the Type A system are supported on an engineered beam that is protected at its ends by zincalume capping. In the Type B system, the upper floor joists sit on the walls and strut walls below. The upper floor joists in both systems would be engineered beams at 600mm centres. In both systems, the upper floor provides weather protection to the lower floor with a 600mm overhang. The floor framing system of the upper floor is proposed to be the same as the current industry standard.

From the first floor upwards, both types are the same. The proposed upper wall system is 2400mm wide prefabricated panels with lower studs, top and bottom plates and belt rails delivered onsite. The upper wall is framed onsite with timber girts or LVL's to form a "skin" further out. The girt system assists in providing some weather protection to the lower section cladding below. It is likely that the upper floor of the dwelling will contain bedrooms and this wall system provides niche storage or display spaces.

The roof trusses proposed are spaced at 2400mm centres and have an engineered top chord to allow a 1200mm roof overhang to protect the upper level. Roof purlins between the trusses allow for large overhangs on the gable ends for optimum weather protection. A steel sheeted roof is proposed for minimum heat retention and for rainwater collection. The roof system allows for ventilation at the ridge. The purlins are spaced internally at 600mm centres to provide ceiling fixing on the rake. This offers more generous spaces internally and allows the upper floor to have overhead fans. The roof trusses can be lined on site like the walls, however, the option exists for the trusses to be delivered on site pre-lined with plywood.

The upper section of the first floor wall is clad with a composite plywood sandwich panel to achieve the thermal insulation R value of 1, which is the BCA requirement in Queensland. The lower section of the first floor wall is clad with 12mm of external plywood. The ground floor walls would be suitably clad in a number of materials such as corrugated zincalume or 12mm external plywood. Where plywood is used exclusively as the external cladding, a colouring of the stains is suggested, with the lightest colour on top, down to the darkest colour below to emphasise the layers.

Internal wall and ceiling linings can be either hardboard for a paint finish or plywood for a clear or stained finish. It is preferred that discontinuous sheet materials be used rather than flush set ones that do not tolerate any movement of the timber structure.

The floor lining for the first floor and the prefabricated ground floor is proposed to be plywood. The plywood is particularly suited to the prefabricated floor system as it is light sheet flooring that holds the floor system together. The plywood flooring also provides lateral support and can work as a bracing system.

The raised lower floor, if prefabricated to some degree would be better placed to compete with the slab on ground construction. Benefits of the raised floor system include that it is more flexible in its timing for subcontract fit out, and is also more flexible for its inhabitants if plumbing fixtures require relocation or retrofitting at a later date.

These proposals are an attempt to establish a new house "type". When looking at the page from The "Commonwealth Savings Bank Housing Loans – Acceptable Standards of Construction Queensland" (Figure 4) that depicts the standard details for brick veneer construction, it is obvious the power that a standardised building type has to change the face **of a nation once it is** adopted.

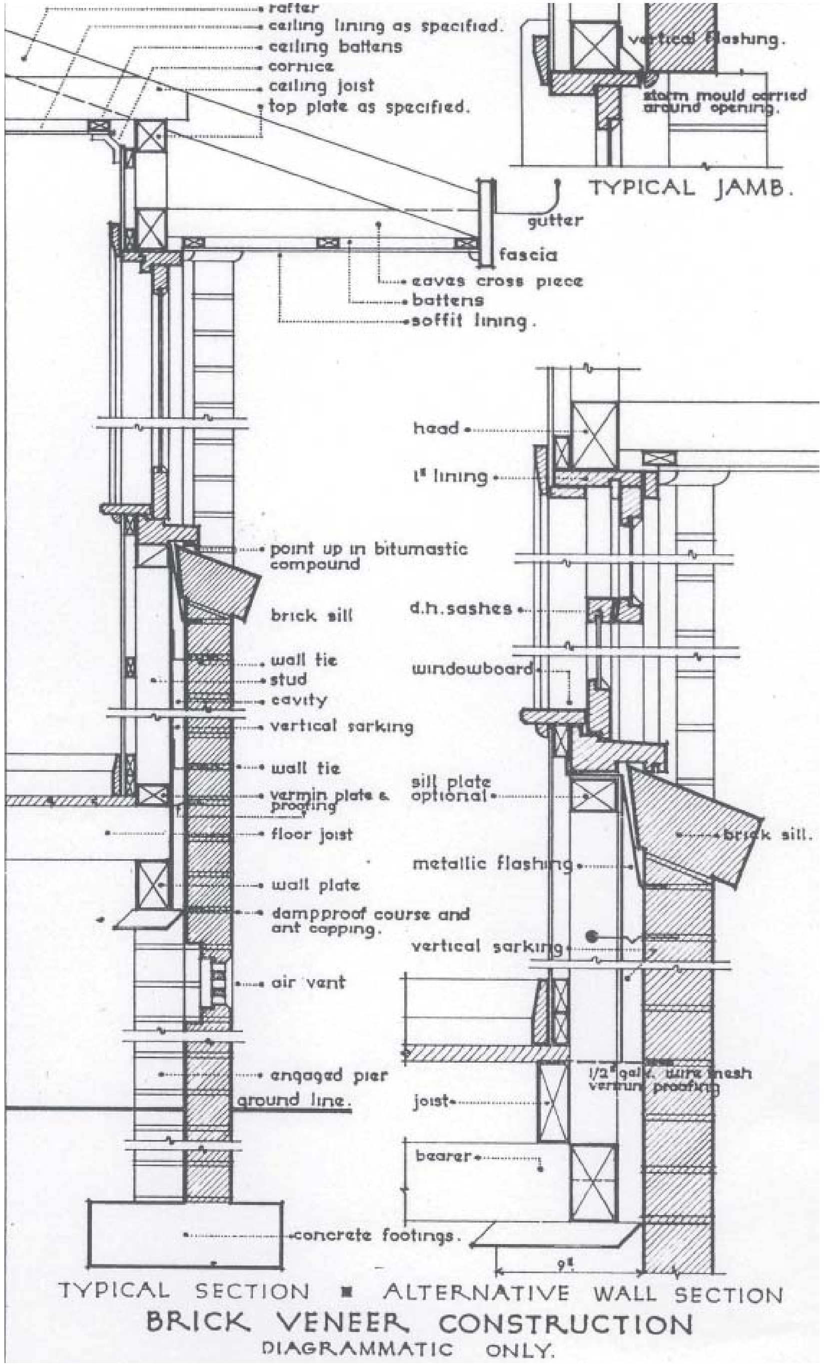
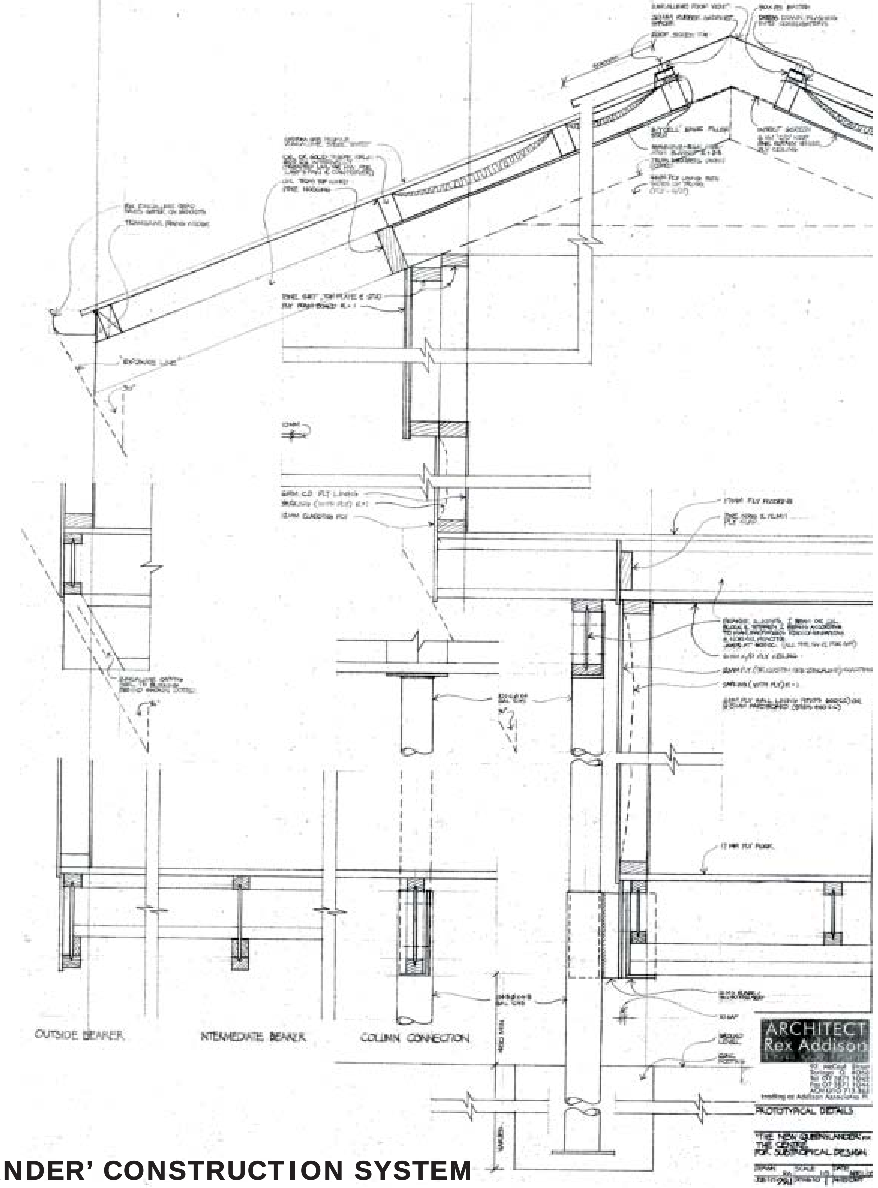


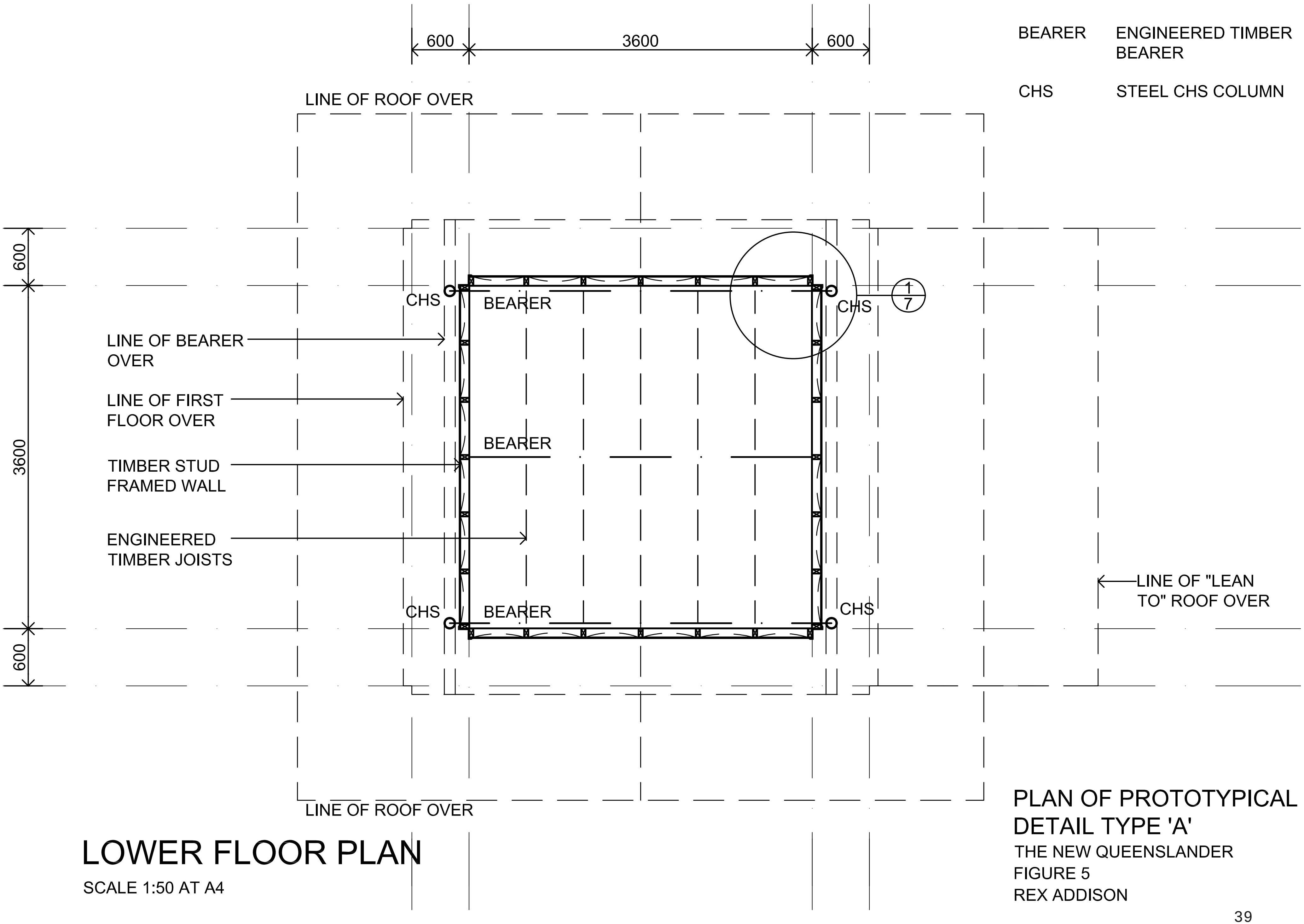
Figure 4 Commonwealth Savings Bank Housing Loans - Acceptable Standards of Construction Queensland

The applicability of the systems will be tested in Stage Two of the project, when six housing types will be planned for various conditions. Applying the timber systems in a house plan may uncover other situations which will need to be detailed to complete the system. The aim of Stage Two is not only to demonstrate the system's adaptability and flexibility, but to check that the system satisfies a whole range of criteria articulated in Stage One, and solves more than one problem while not creating new problems.



'NEW QUEENSLANDER' CONSTRUCTION SYSTEM

BEARER	ENGINEERED TIMBER BEARER
CHS	STEEL CHS COLUMN

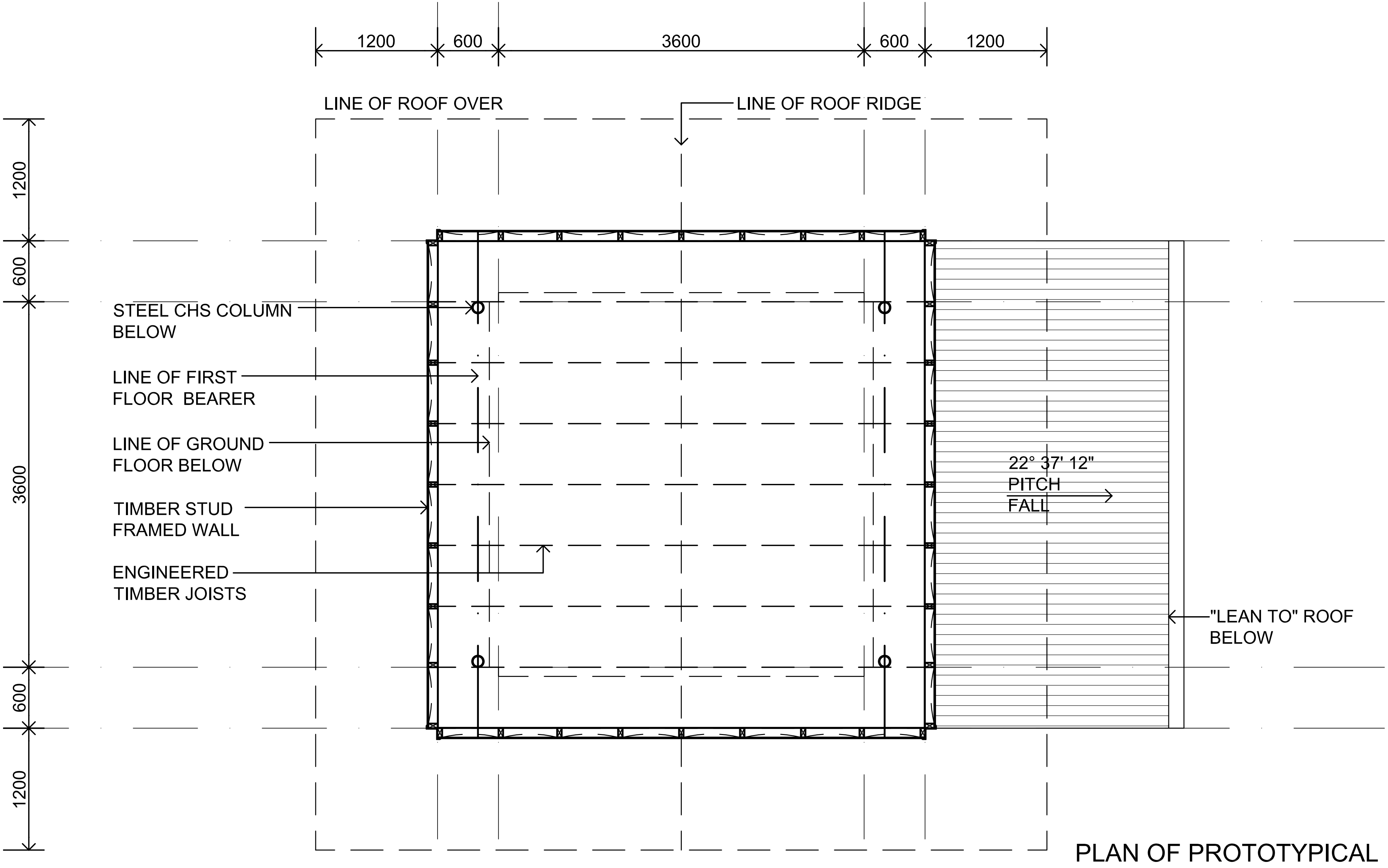


LOWER FLOOR PLAN

SCALE 1:50 AT A4

PLAN OF PROTOTYPICAL DETAIL TYPE 'A'

THE NEW QUEENSLANDER
FIGURE 5
REX ADDISON

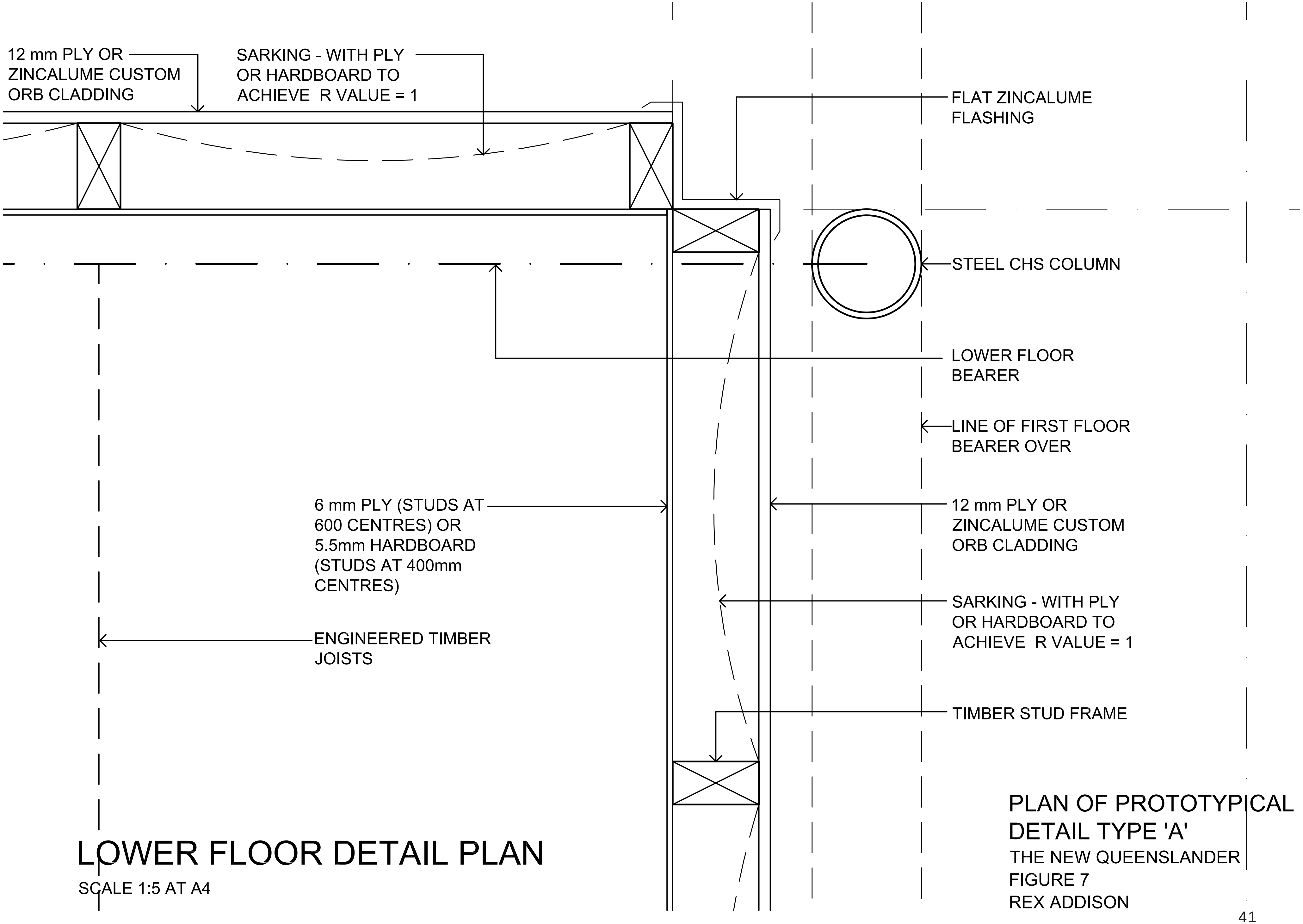


UPPER FLOOR PLAN

SCALE 1:50 AT A4

PLAN OF PROTOTYPICAL DETAIL TYPE 'A'

THE NEW QUEENSLANDER
FIGURE 6
REX ADDISON

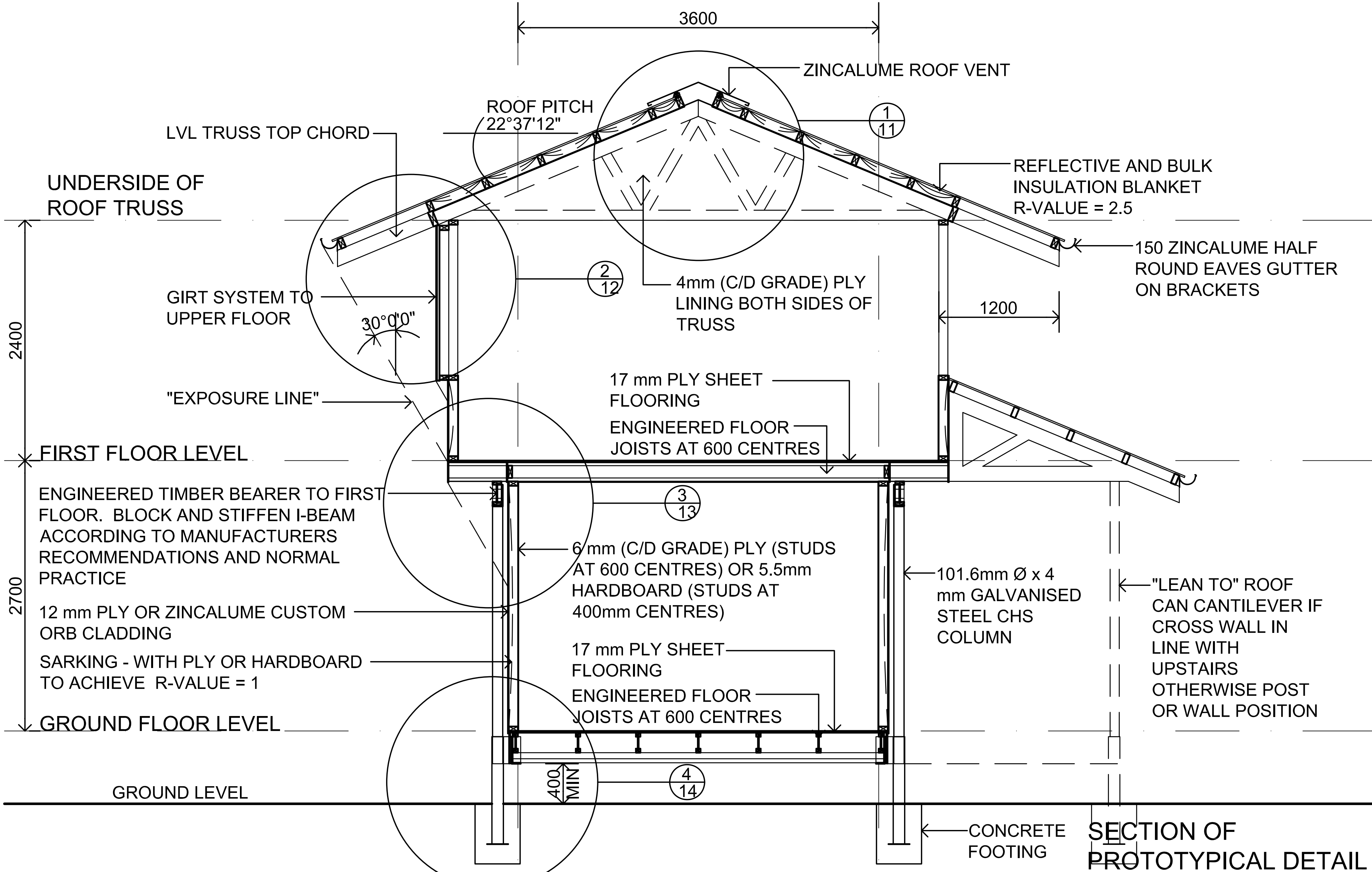


LOWER FLOOR DETAIL PLAN

SCALE 1:5 AT A4

PLAN OF PROTOTYPICAL DETAIL TYPE 'A'

THE NEW QUEENSLANDER
FIGURE 7
REX ADDISON

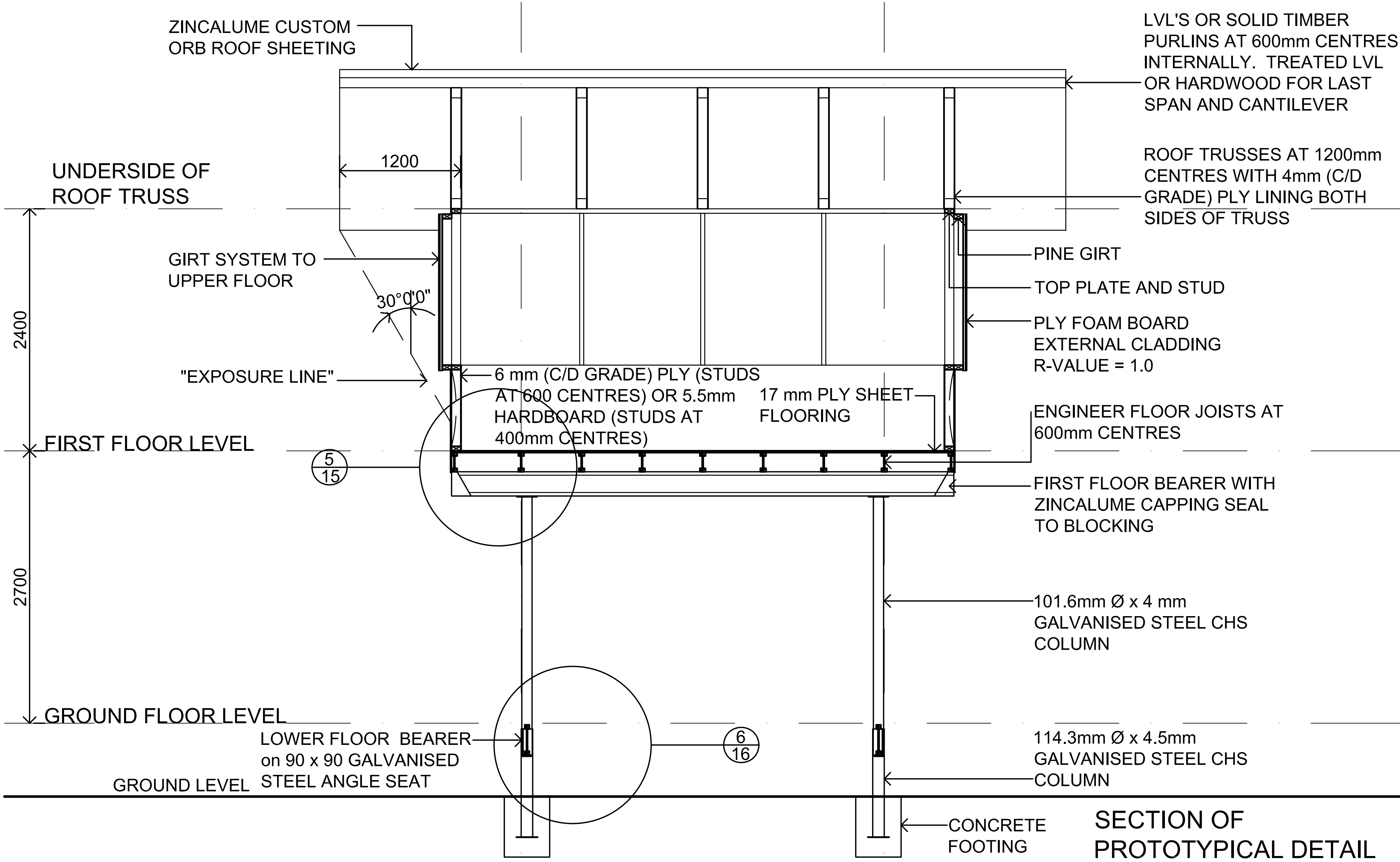


SECTION 1

SCALE 1:50 AT A4

SECTION OF PROTOTYPICAL DETAIL TYPE 'A'

THE NEW QUEENSLANDER
FIGURE 8
REX ADDISON

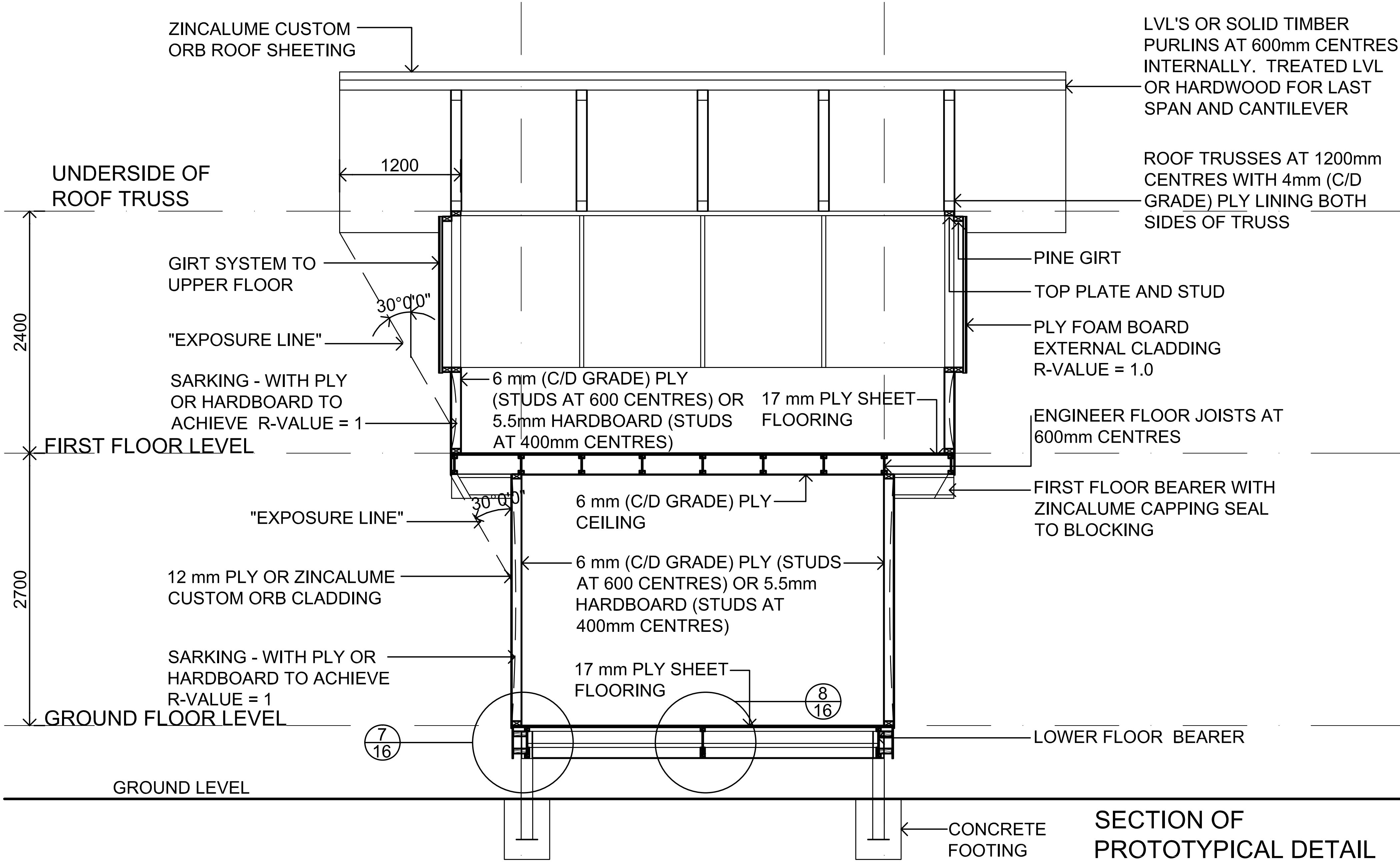


SECTION 2

SCALE 1:50 AT A4

SECTION OF PROTOTYPICAL DETAIL TYPE 'A'

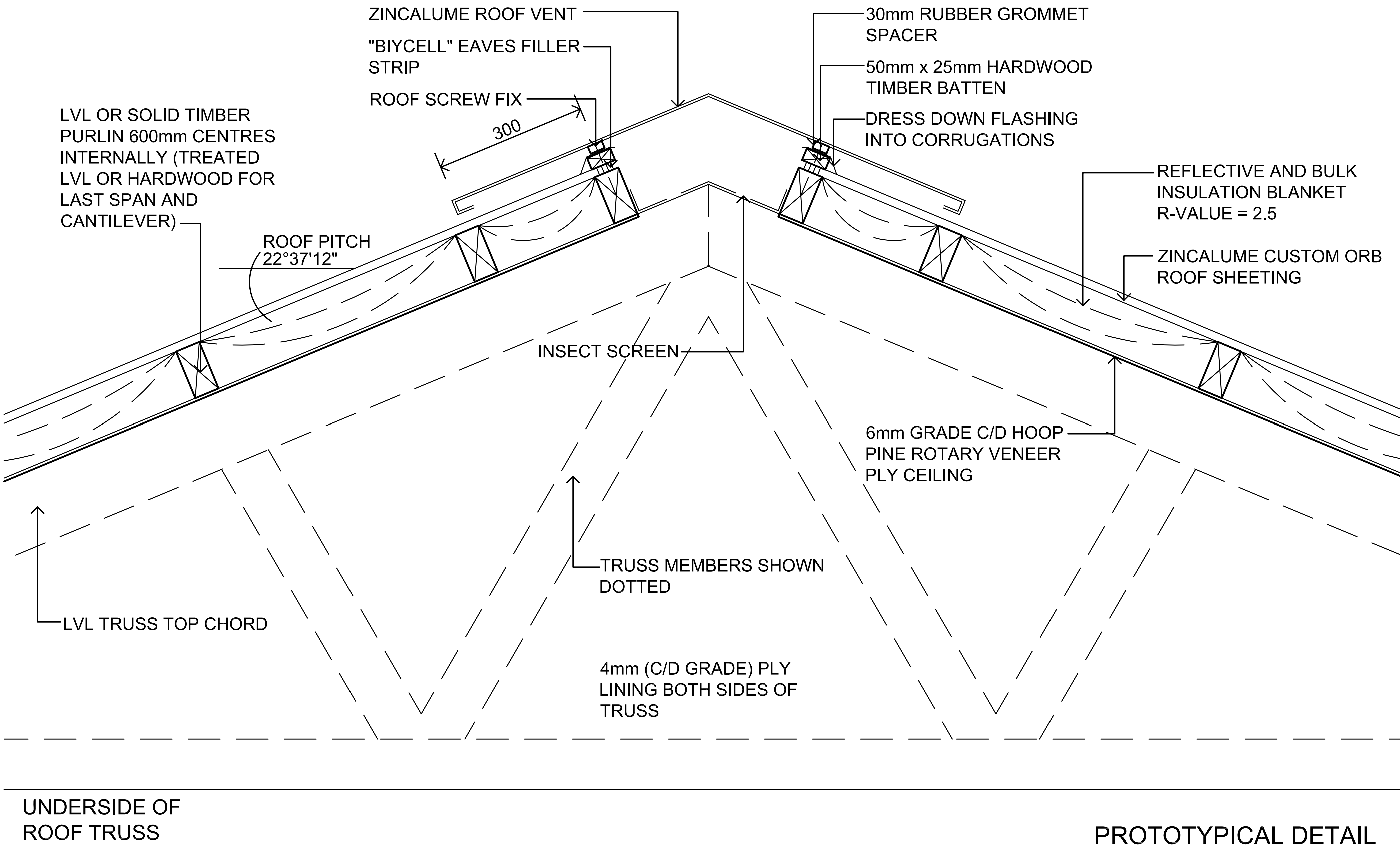
THE NEW QUEENSLANDER
FIGURE 9
REX ADDISON



SECTION 3

SCALE 1:50 AT A4

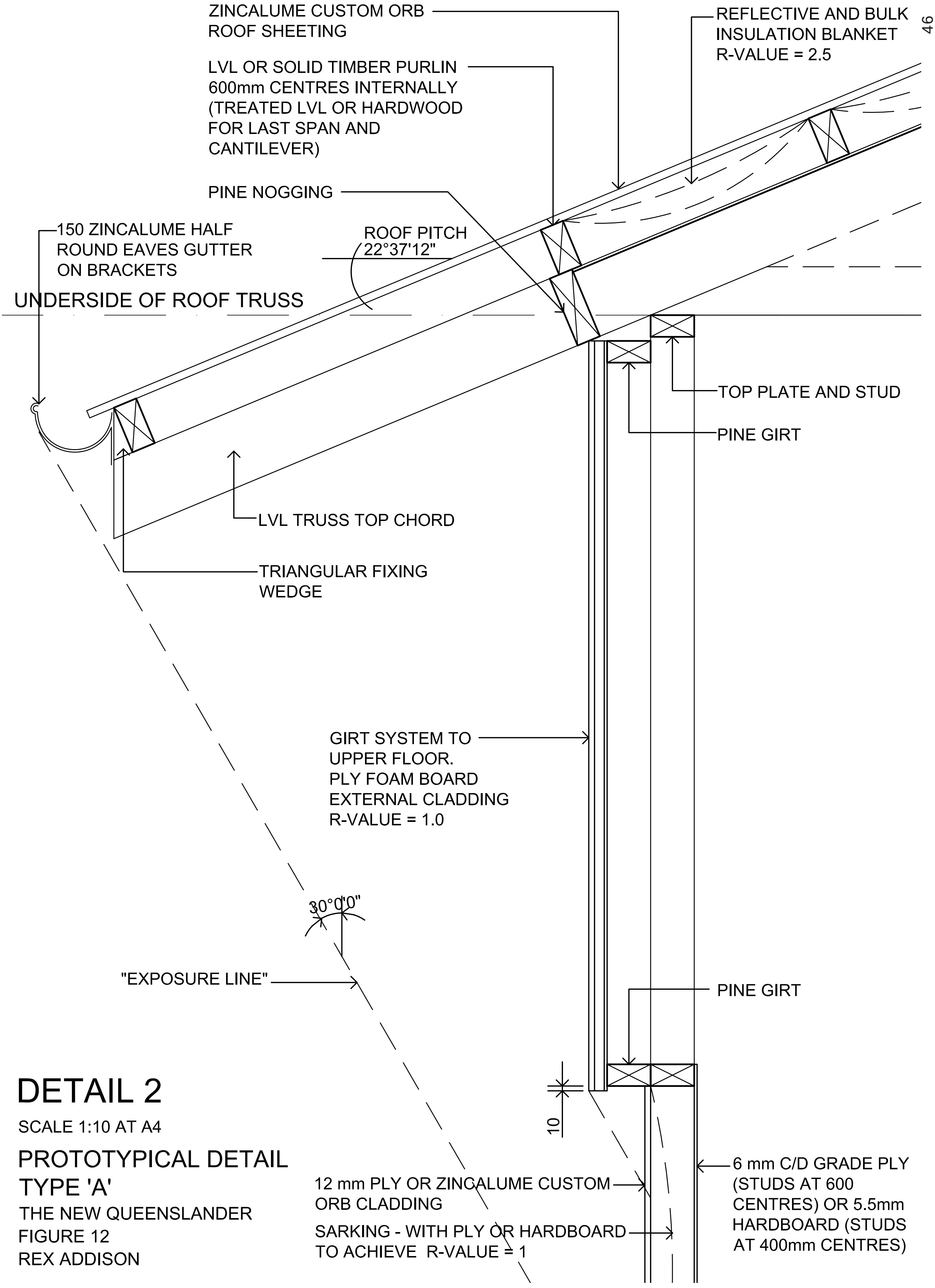
SECTION OF PROTOTYPICAL DETAIL TYPE 'A'
THE NEW QUEENSLANDER
FIGURE 10
REX ADDISON



DETAIL 1

SCALE 1:10 AT A4

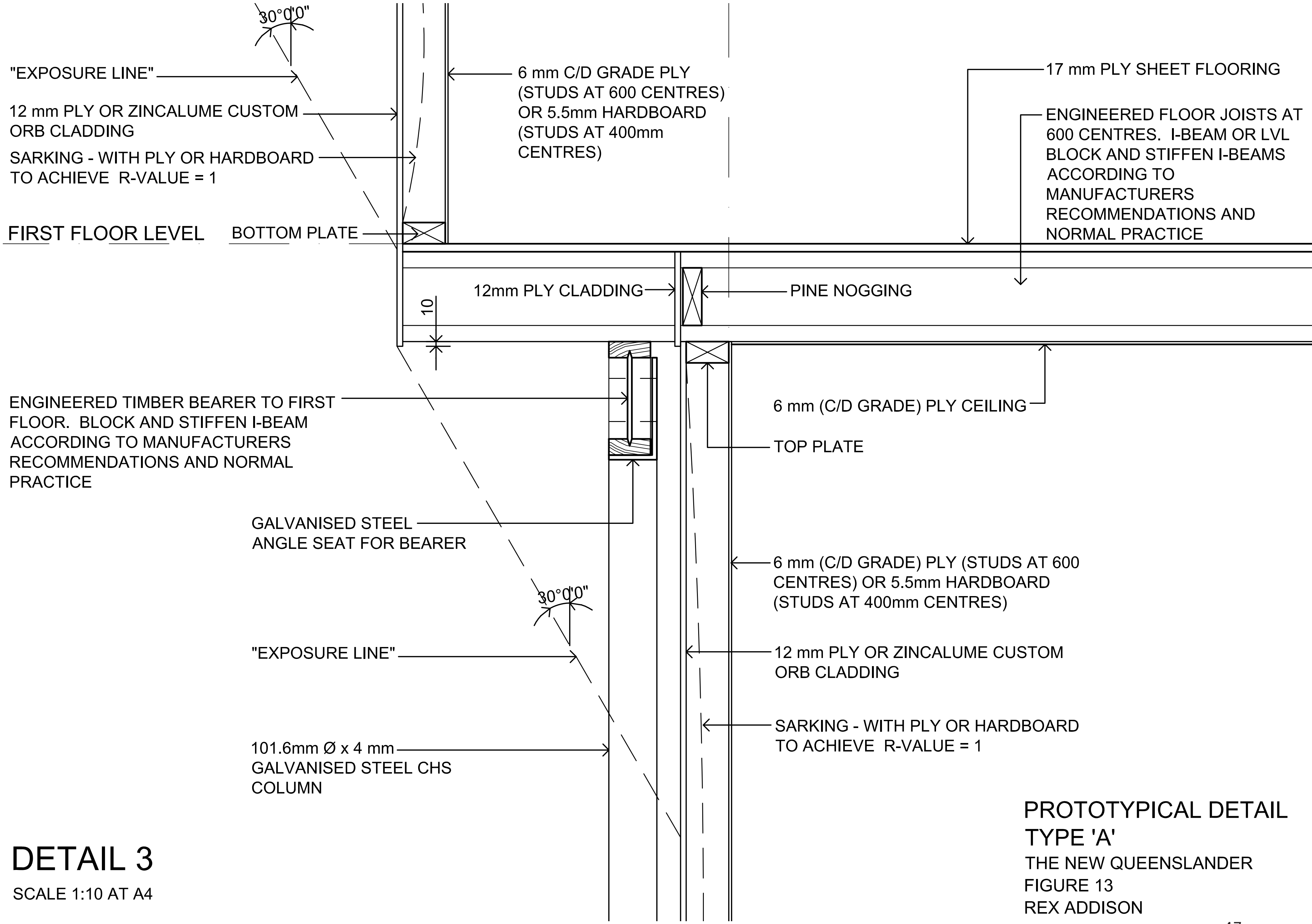
PROTOTYPICAL DETAIL
TYPE 'A'
THE NEW QUEENSLANDER
FIGURE 11
REX ADDISON



DETAIL 2

SCALE 1:10 AT A4

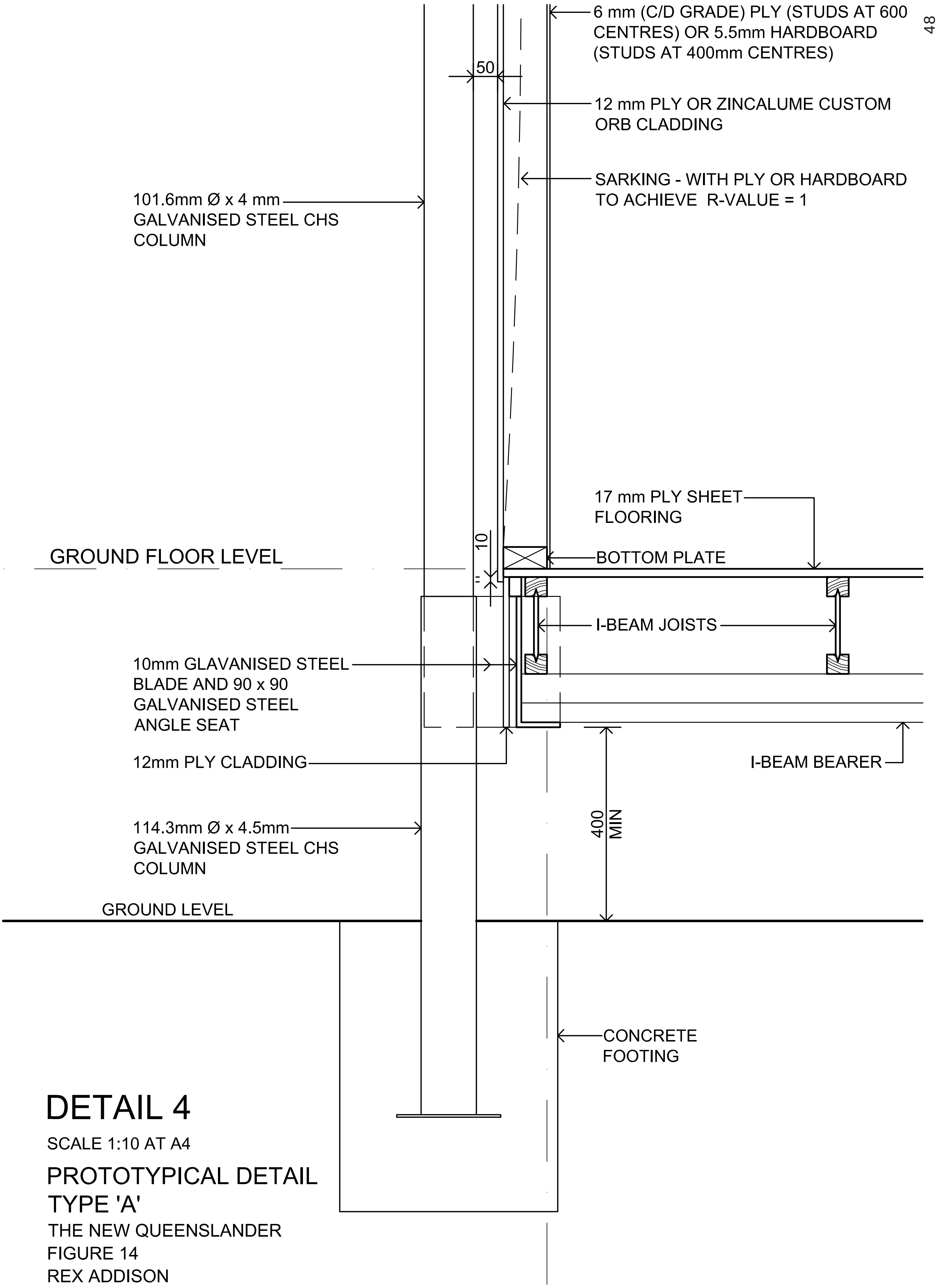
PROTOTYPICAL DETAIL
TYPE 'A'
THE NEW QUEENSLANDER
FIGURE 12
REX ADDISON



DETAIL 3

SCALE 1:10 AT A4

PROTOTYPICAL DETAIL
TYPE 'A'
THE NEW QUEENSLANDER
FIGURE 13
REX ADDISON

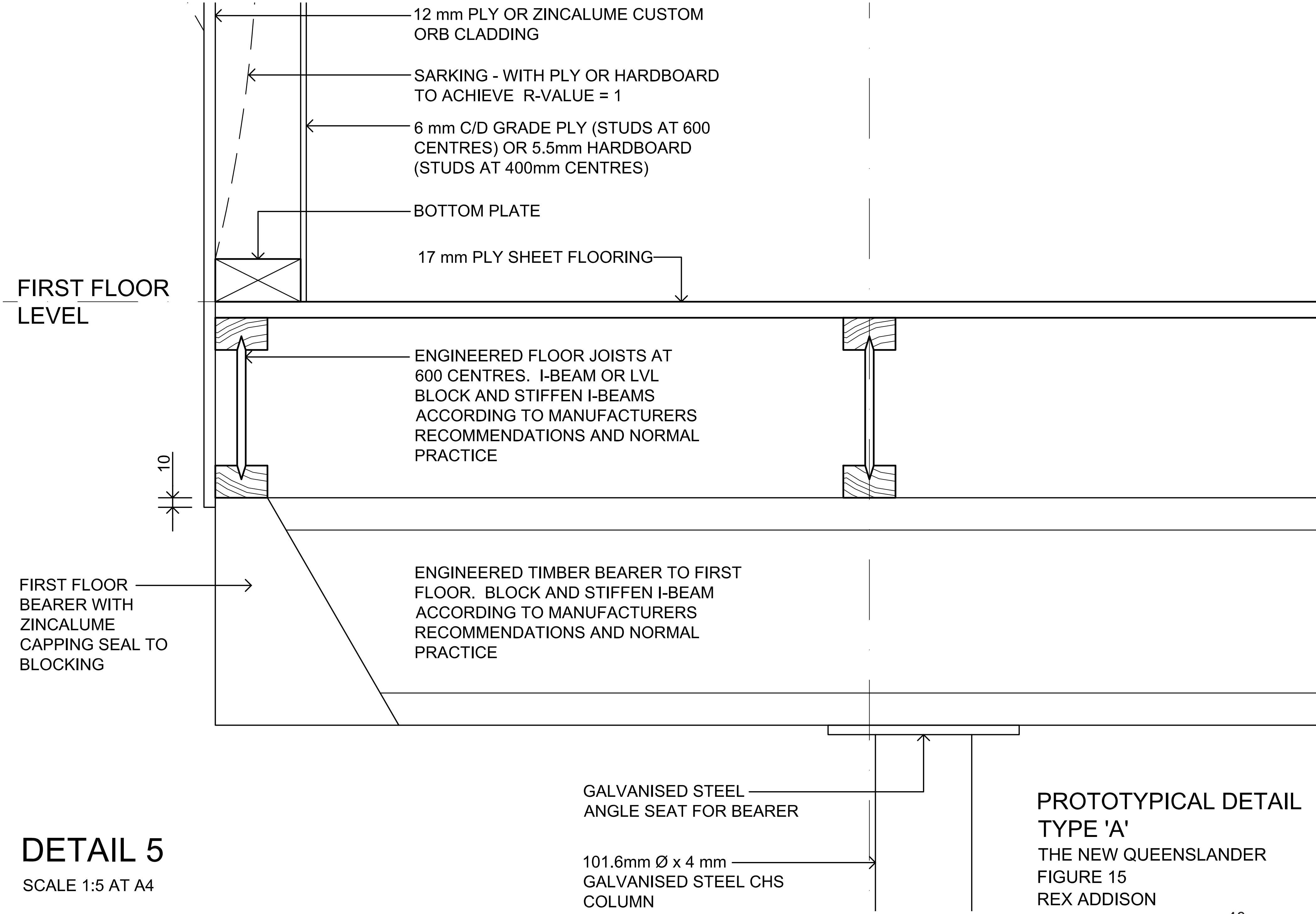


DETAIL 4

SCALE 1:10 AT A4

PROTOTYPICAL DETAIL TYPE 'A'

THE NEW QUEENSLANDER
FIGURE 14
REX ADDISON



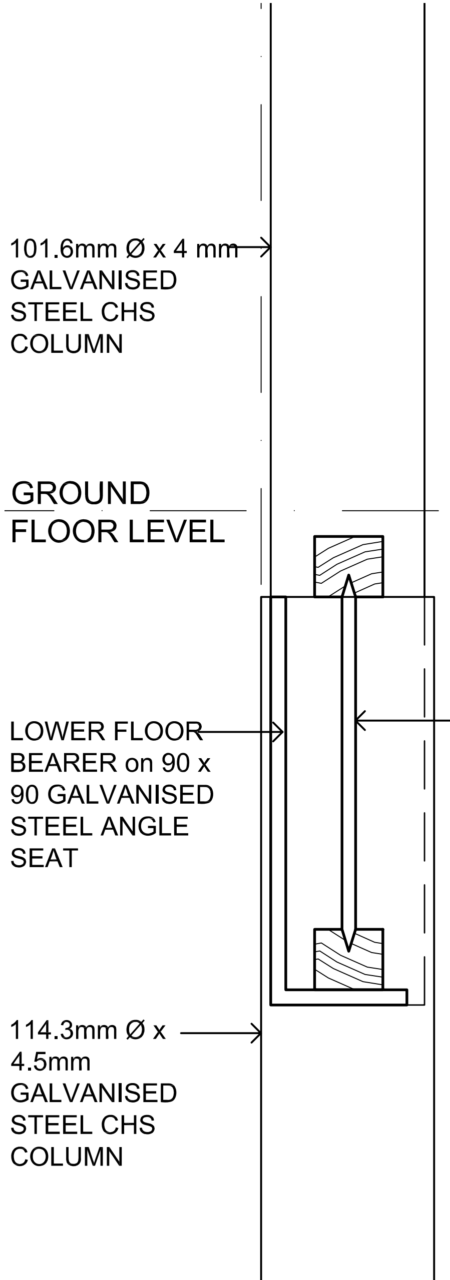
DETAIL 5

SCALE 1:5 AT A4

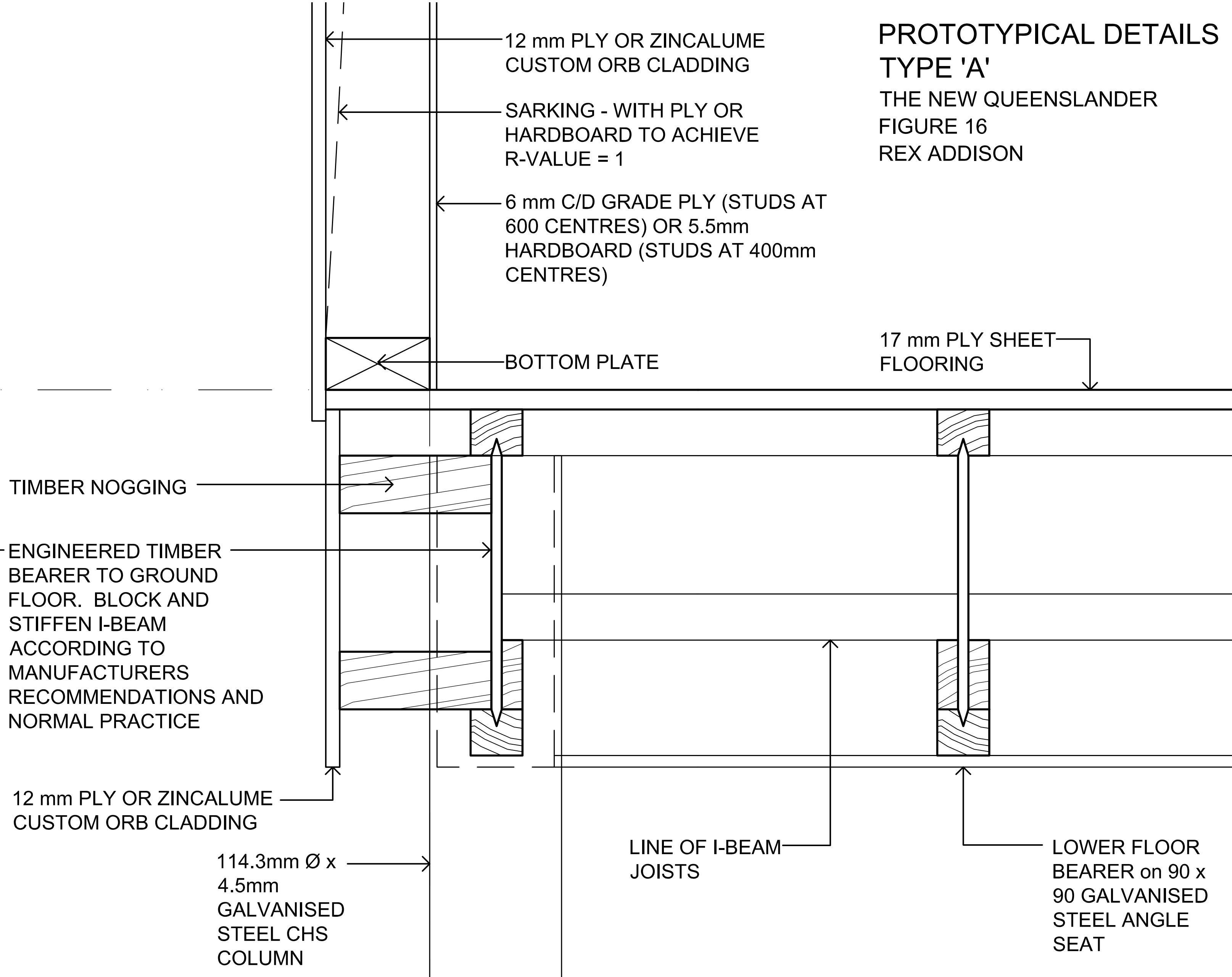
PROTOTYPICAL DETAIL TYPE 'A'
THE NEW QUEENSLANDER
FIGURE 15
REX ADDISON

PROTOTYPICAL DETAILS TYPE 'A'

THE NEW QUEENSLANDER
FIGURE 16
REX ADDISON



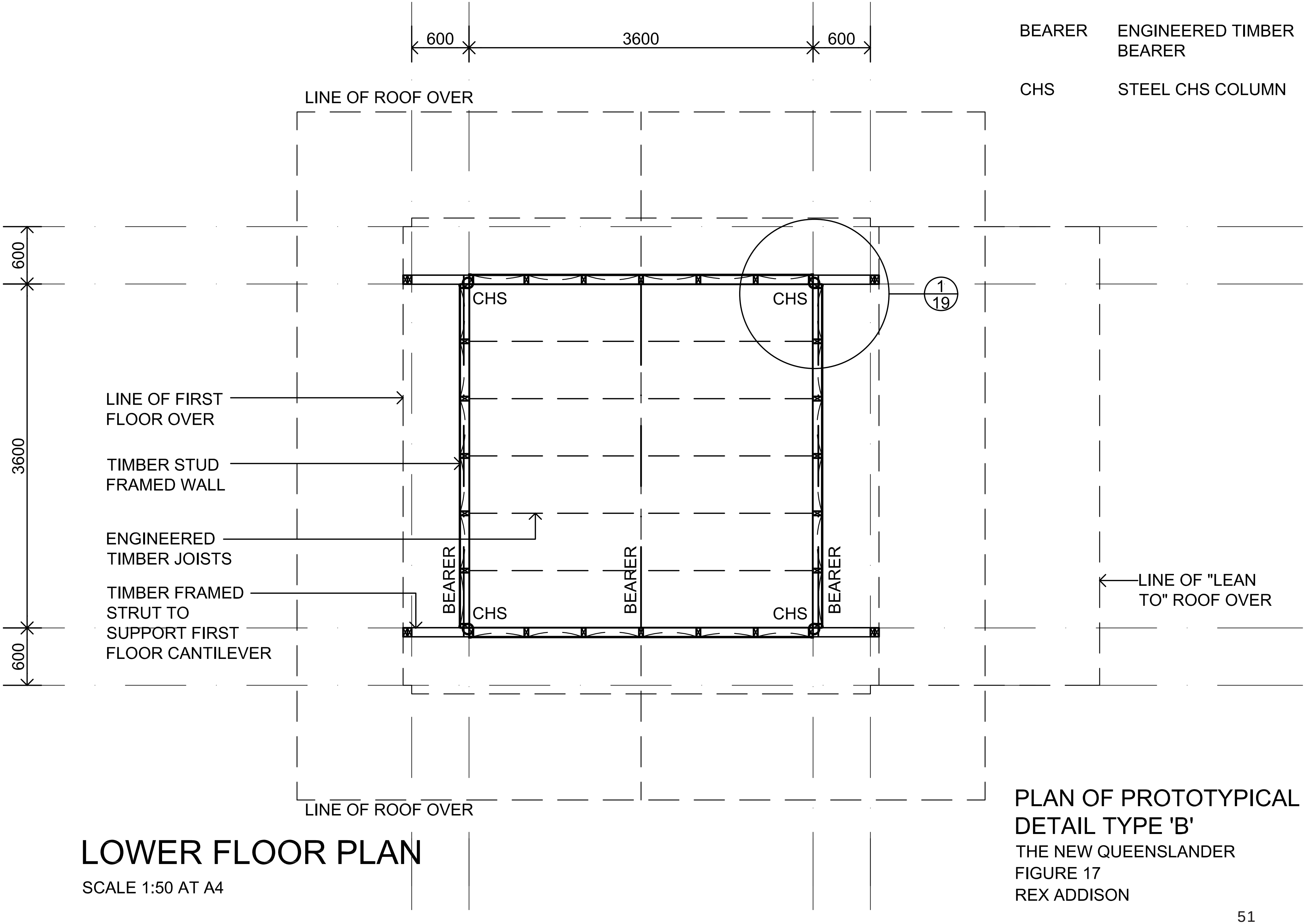
DETAIL 6
COLUMN CONNECTION
SCALE 1:5 AT A4



DETAIL 7
OUTSIDE BEARER CONNECTION
SCALE 1:5 AT A4

DETAIL 8
INTERMEDIATE BEARER CONNECTION
SCALE 1:5 AT A4

BEARER	ENGINEERED TIMBER BEARER
CHS	STEEL CHS COLUMN

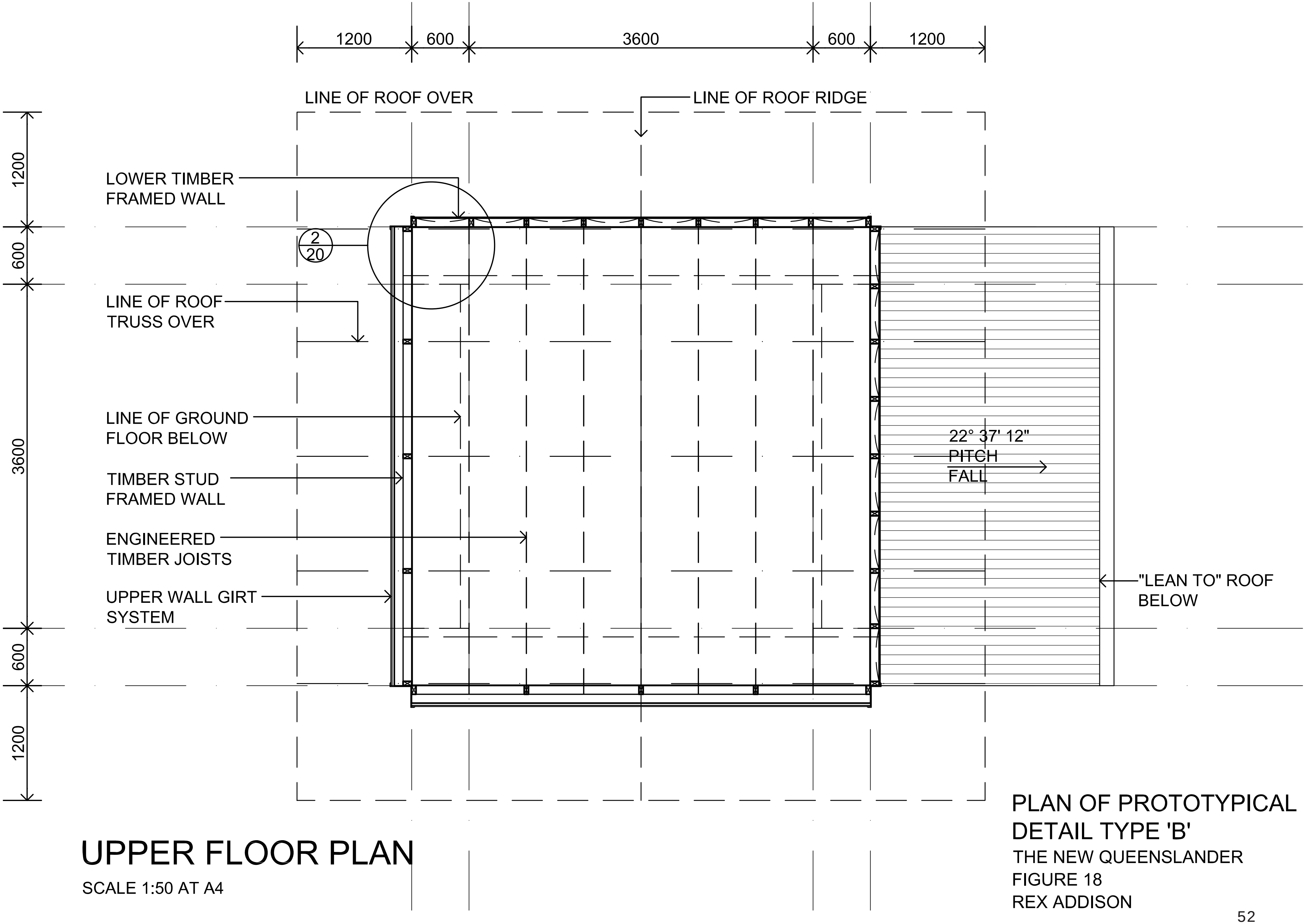


LOWER FLOOR PLAN

SCALE 1:50 AT A4

PLAN OF PROTOTYPICAL DETAIL TYPE 'B'

THE NEW QUEENSLANDER
FIGURE 17
REX ADDISON

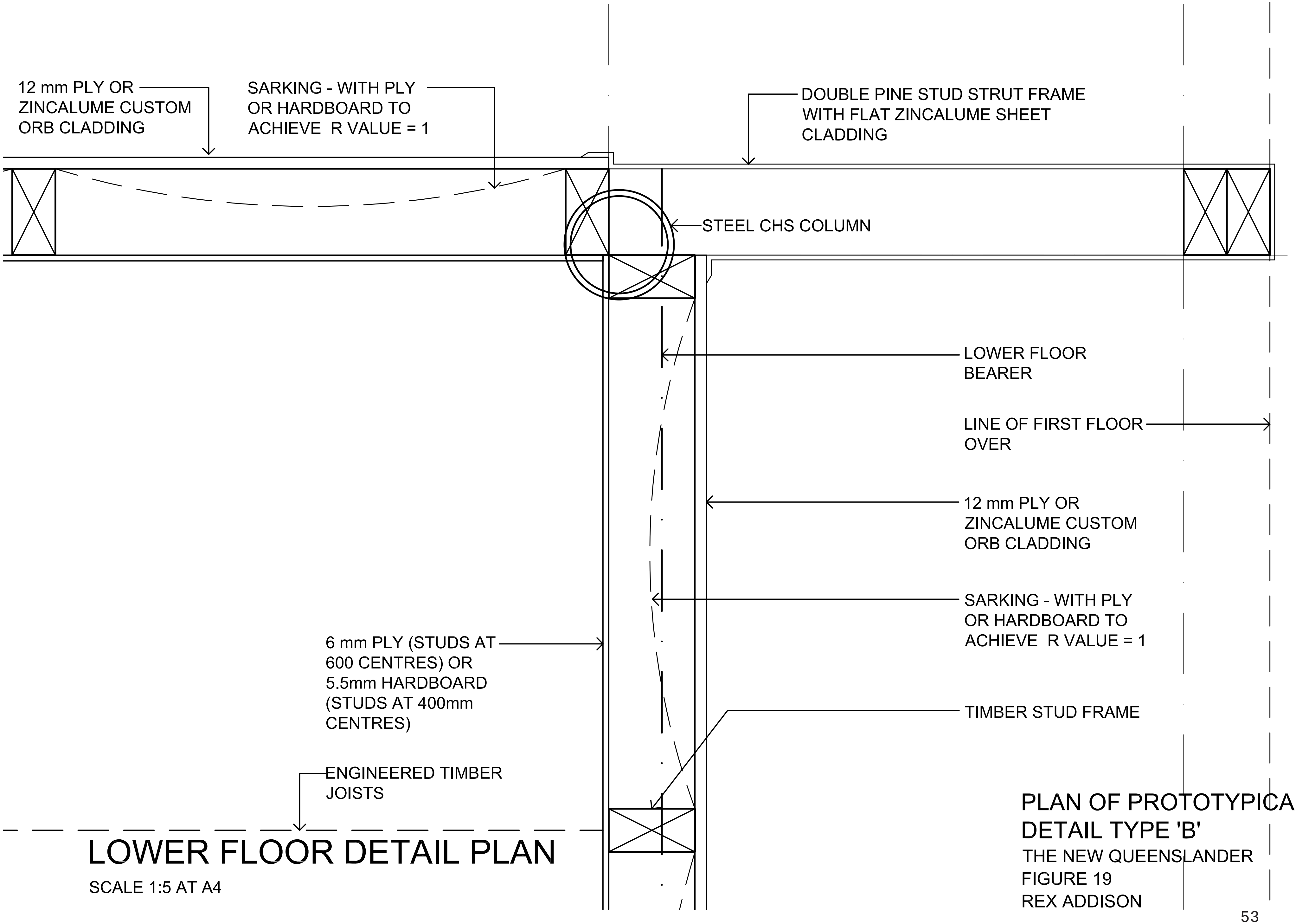


UPPER FLOOR PLAN

SCALE 1:50 AT A4

PLAN OF PROTOTYPICAL DETAIL TYPE 'B'

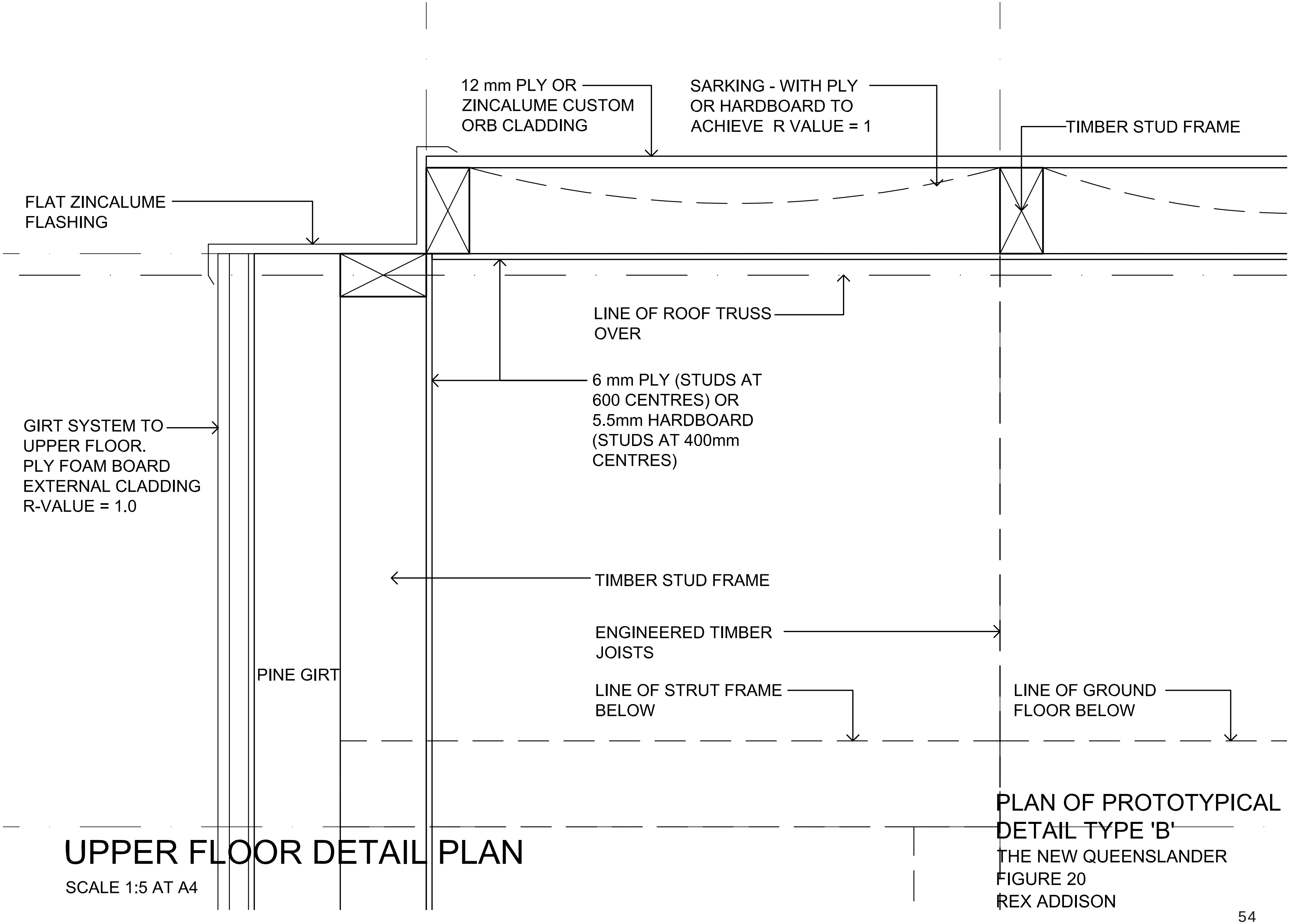
THE NEW QUEENSLANDER
FIGURE 18
REX ADDISON



LOWER FLOOR DETAIL PLAN

SCALE 1:5 AT A4

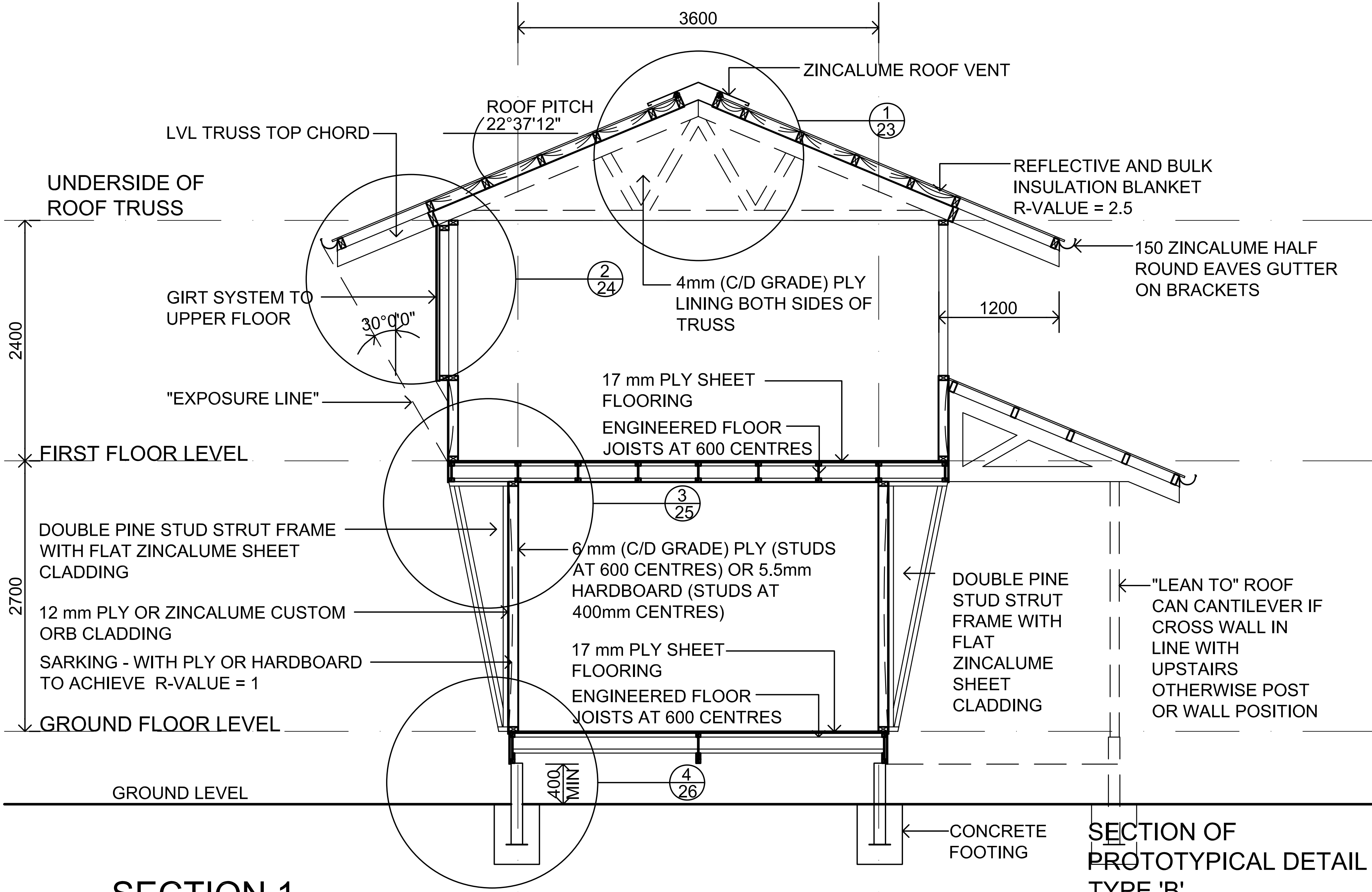
PLAN OF PROTOTYPICAL DETAIL TYPE 'B'
THE NEW QUEENSLANDER
FIGURE 19
REX ADDISON



UPPER FLOOR DETAIL PLAN

SCALE 1:5 AT A4

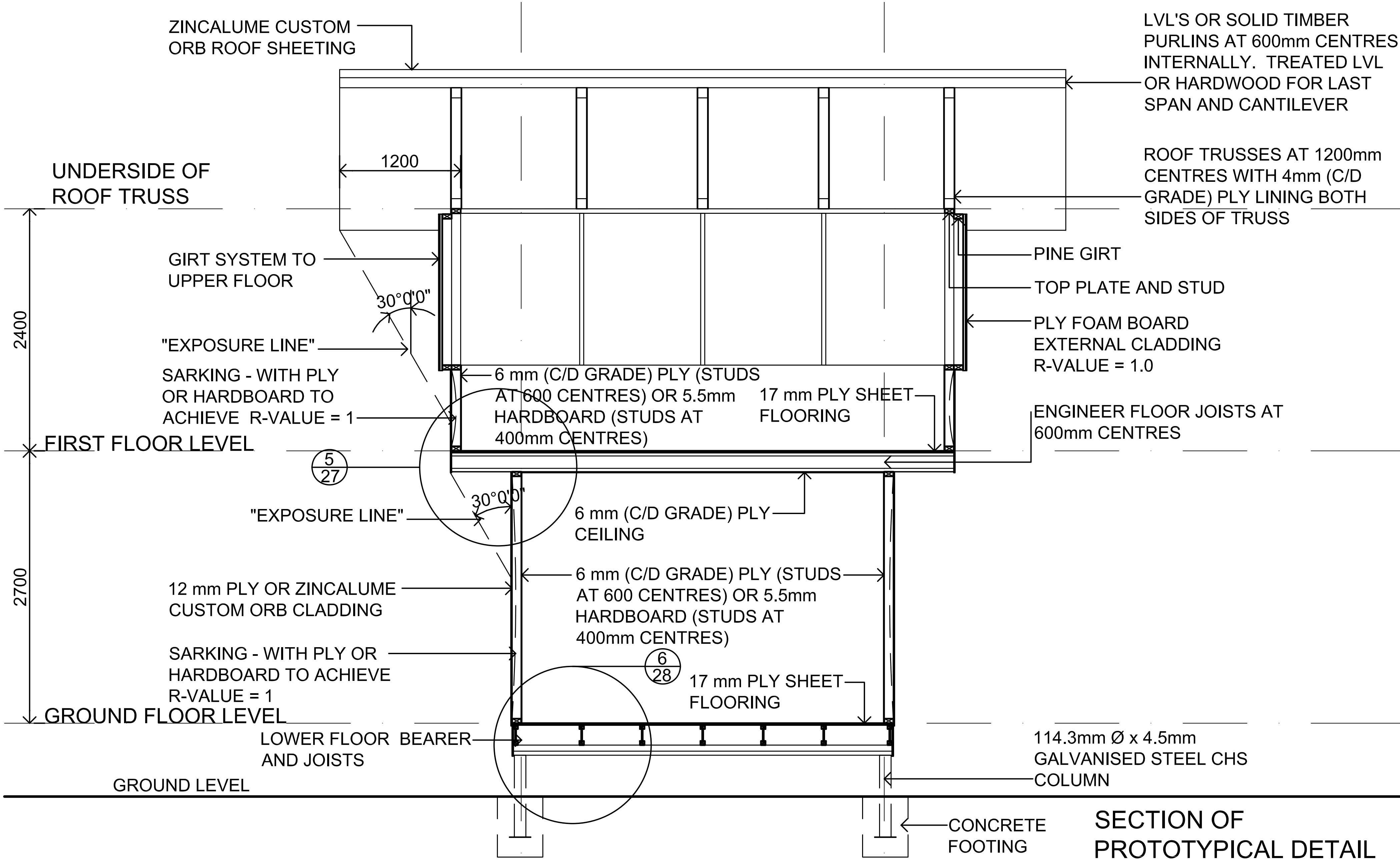
PLAN OF PROTOTYPICAL
DETAIL TYPE 'B'
THE NEW QUEENSLANDER
FIGURE 20
REX ADDISON



SECTION 1

SCALE 1:50 AT A4

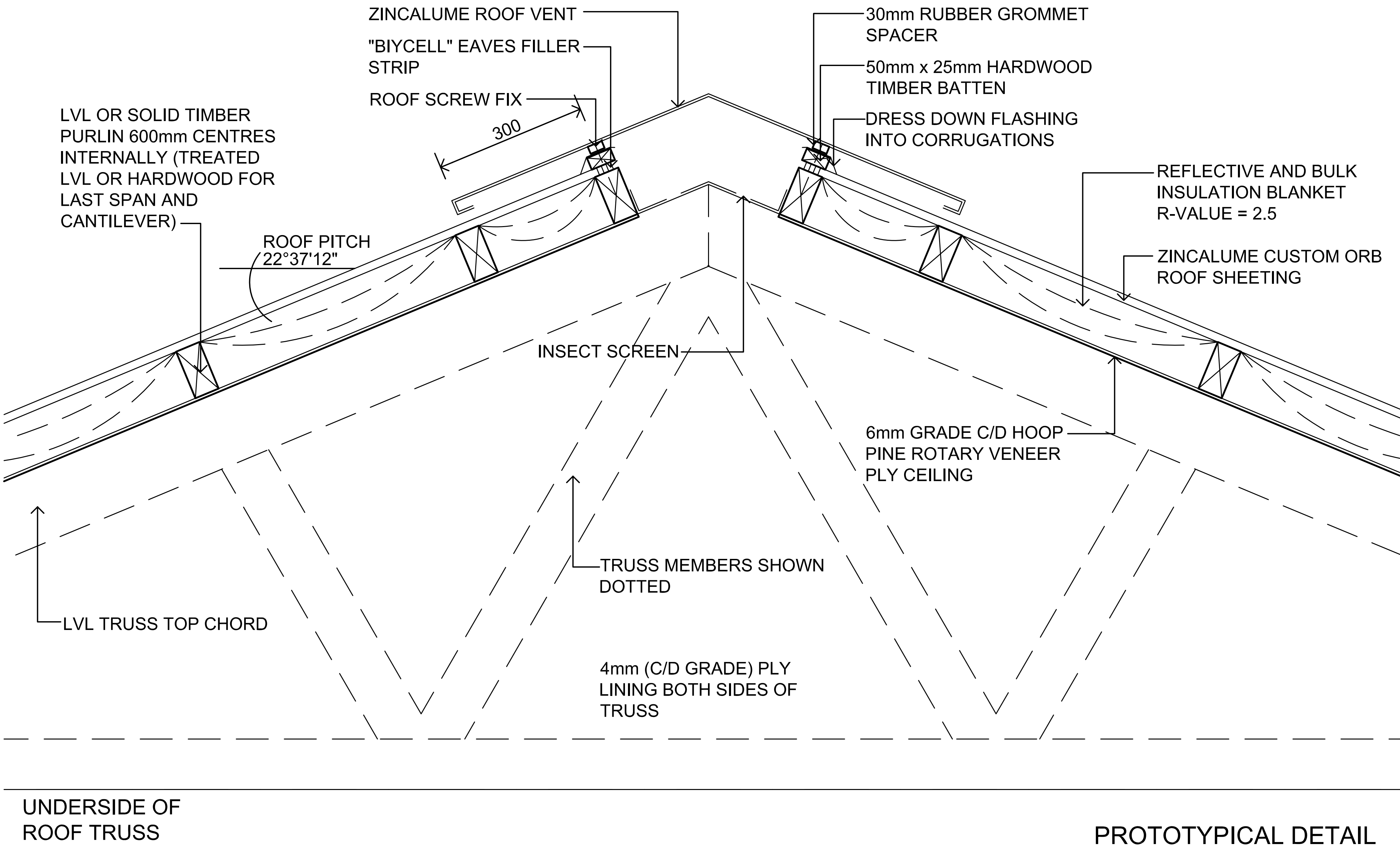
SECTION OF
PROTOTYPICAL DETAIL
TYPE 'B'
THE NEW QUEENSLANDER
FIGURE 21
REX ADDISON



SECTION 2

SCALE 1:50 AT A4

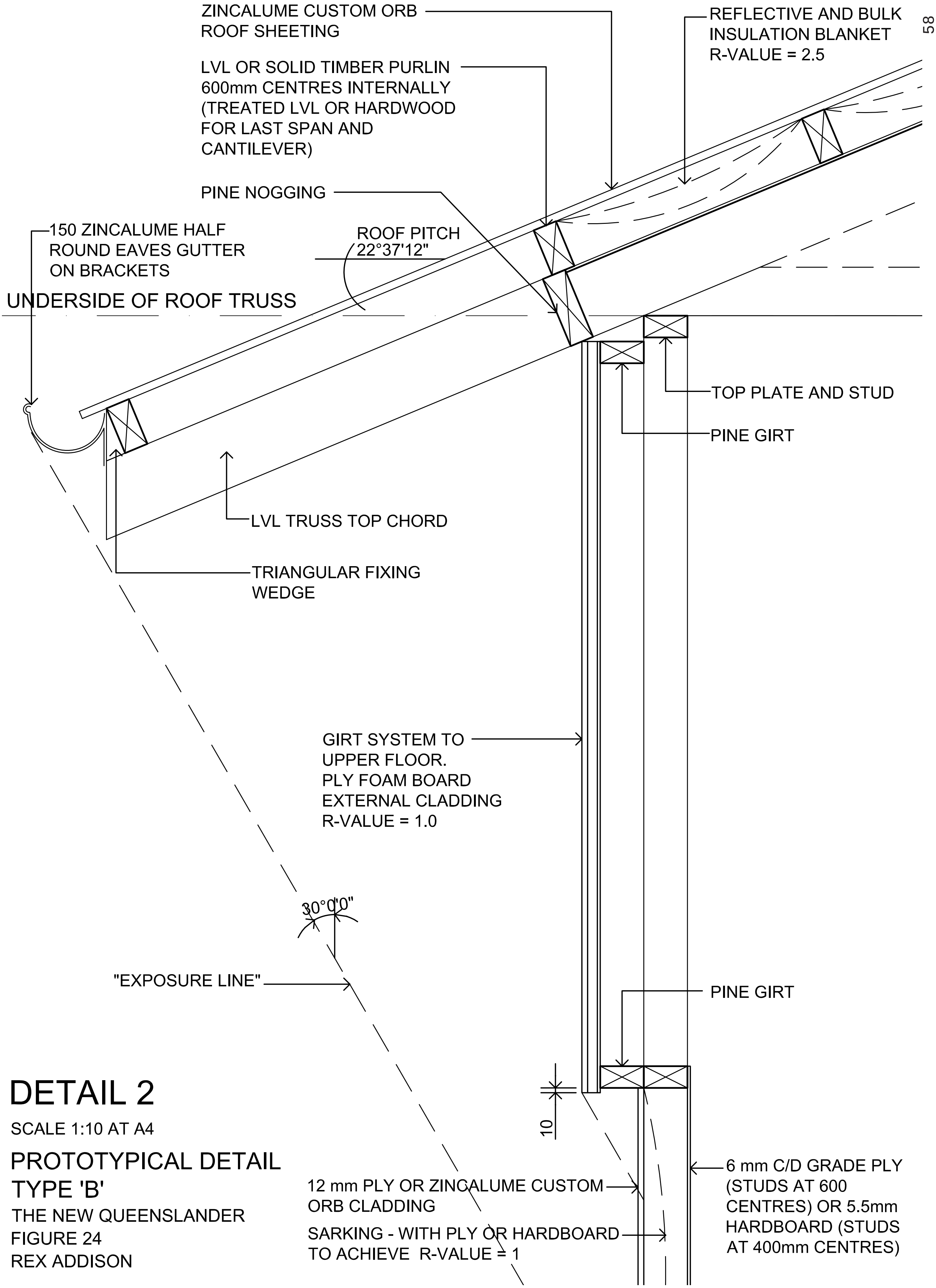
SECTION OF
PROTOTYPICAL DETAIL
TYPE 'B'
THE NEW QUEENSLANDER
FIGURE 22
REX ADDISON



DETAIL 1

SCALE 1:10 AT A4

PROTOTYPICAL DETAIL
TYPE 'B'
THE NEW QUEENSLANDER
FIGURE 23
REX ADDISON

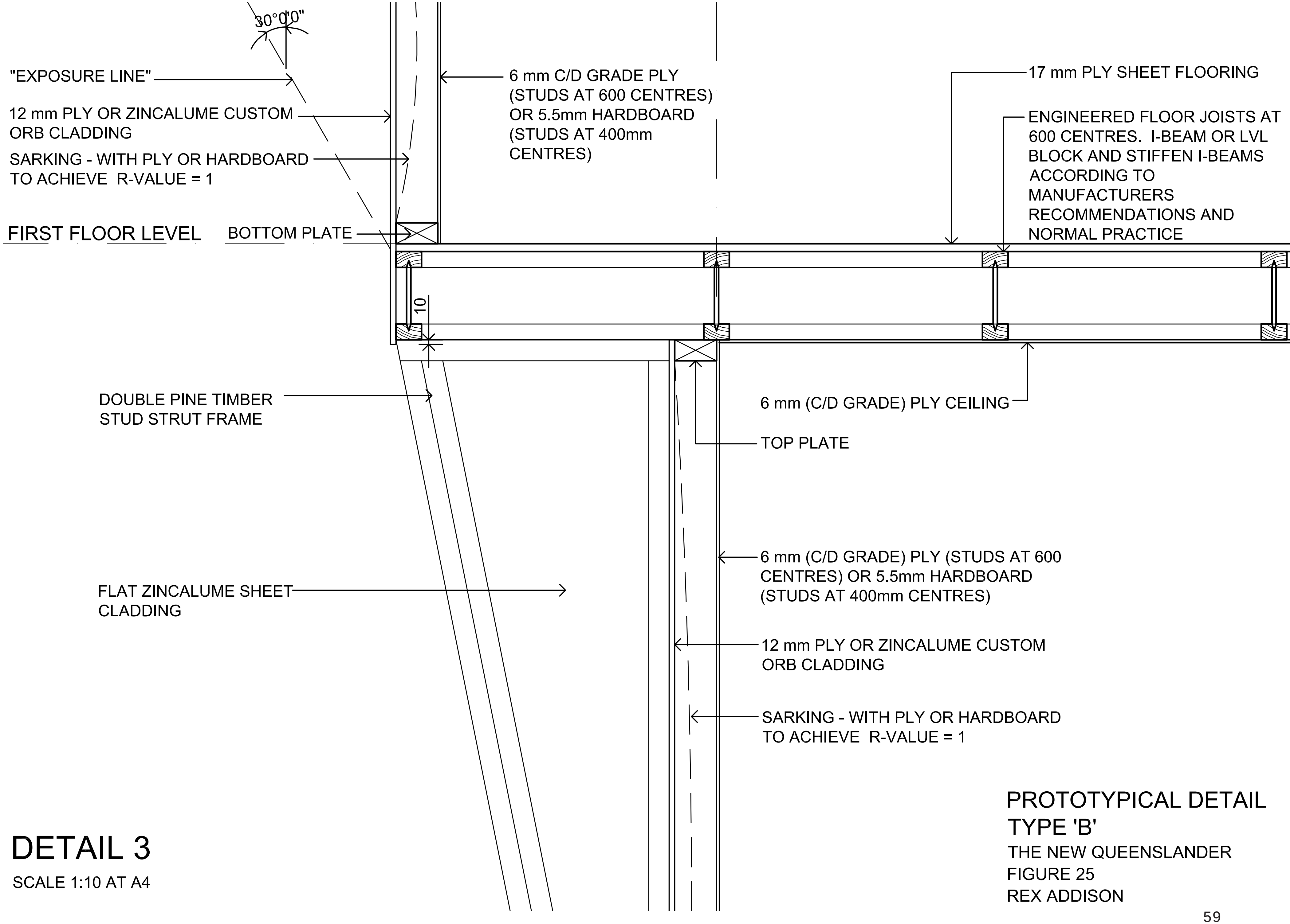


DETAIL 2

SCALE 1:10 AT A4

PROTOTYPICAL DETAIL TYPE 'B'

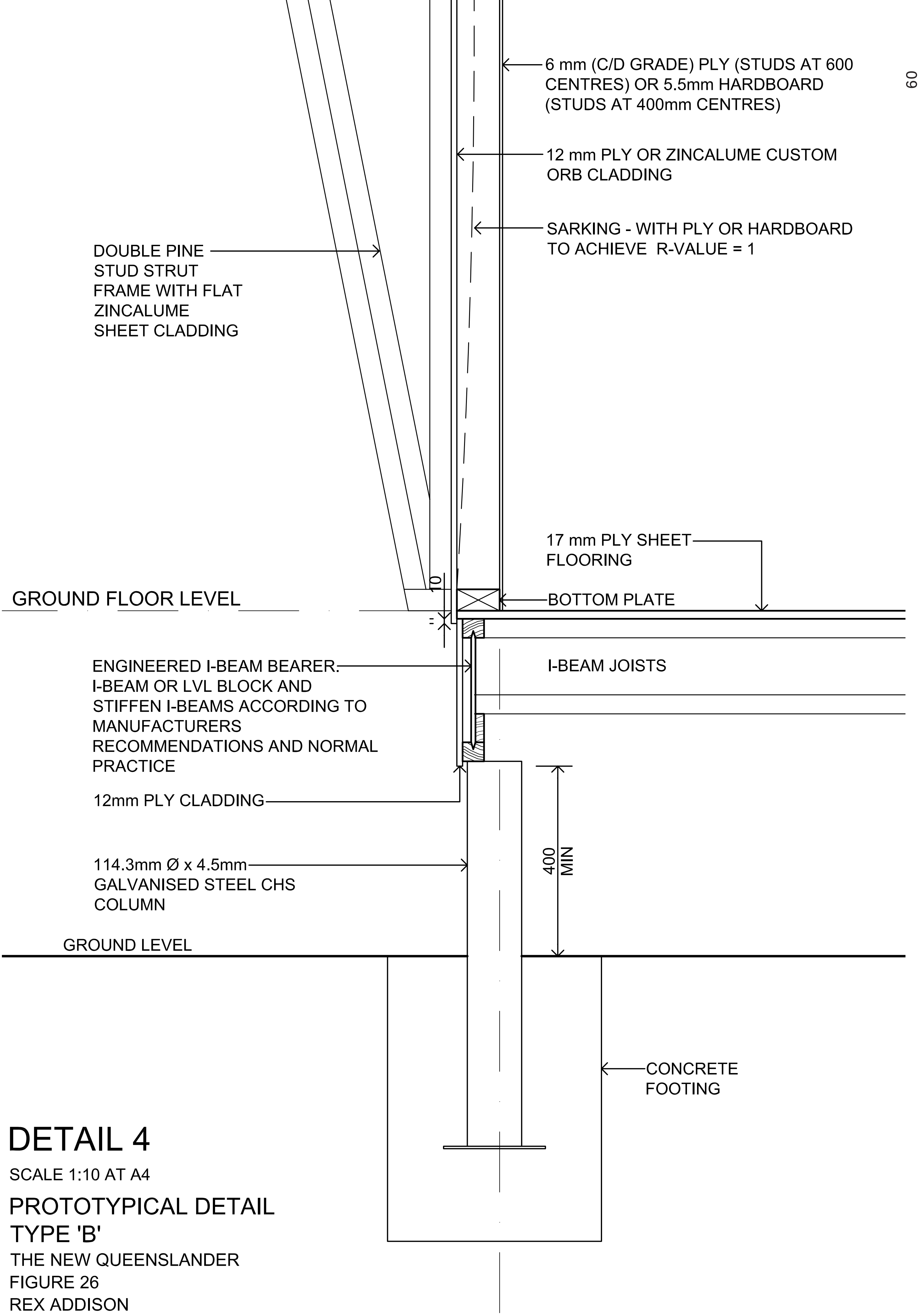
THE NEW QUEENSLANDER
FIGURE 24
REX ADDISON



DETAIL 3

SCALE 1:10 AT A4

PROTOTYPICAL DETAIL
TYPE 'B'
THE NEW QUEENSLANDER
FIGURE 25
REX ADDISON

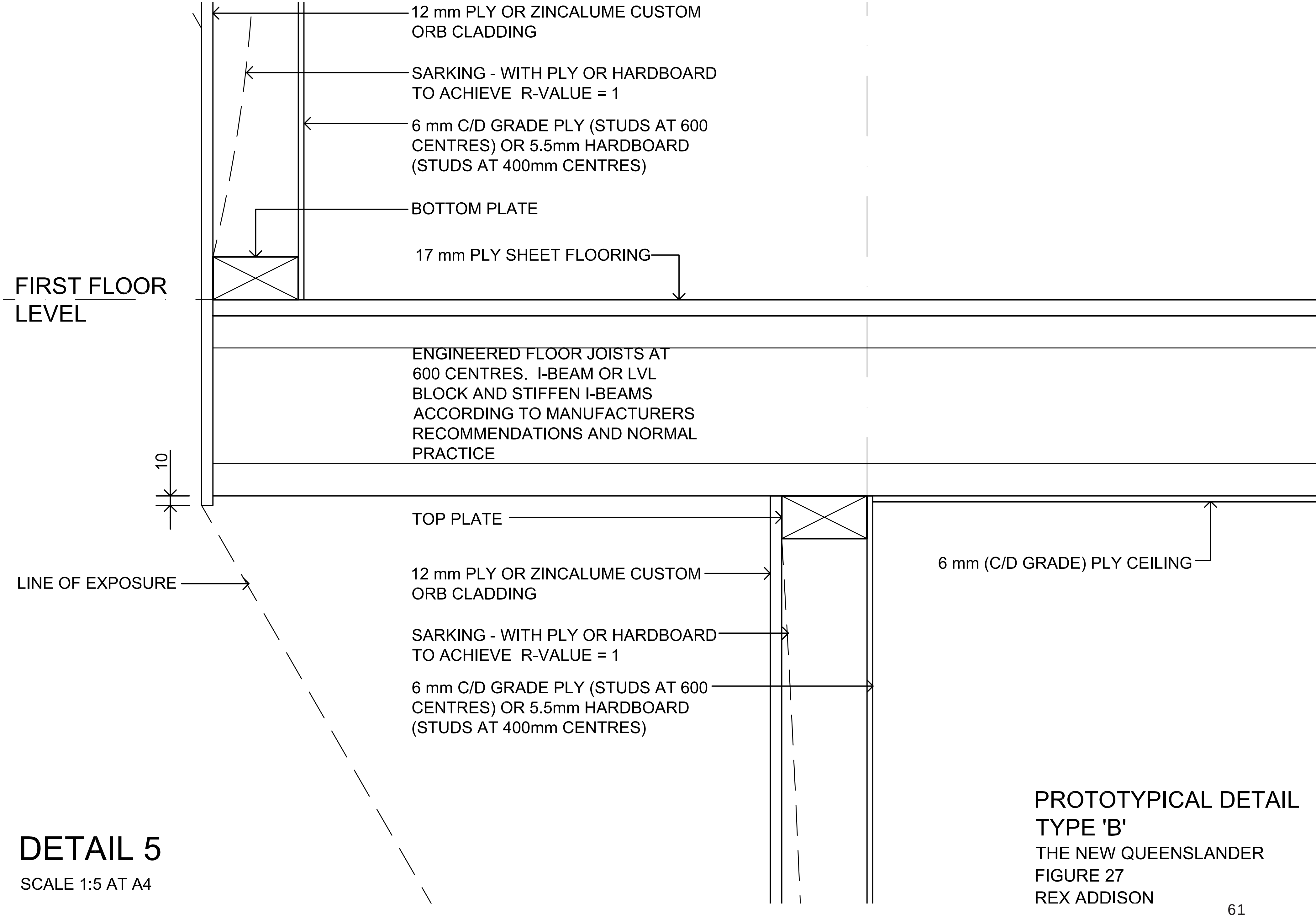


DETAIL 4

SCALE 1:10 AT A4

PROTOTYPICAL DETAIL TYPE 'B'

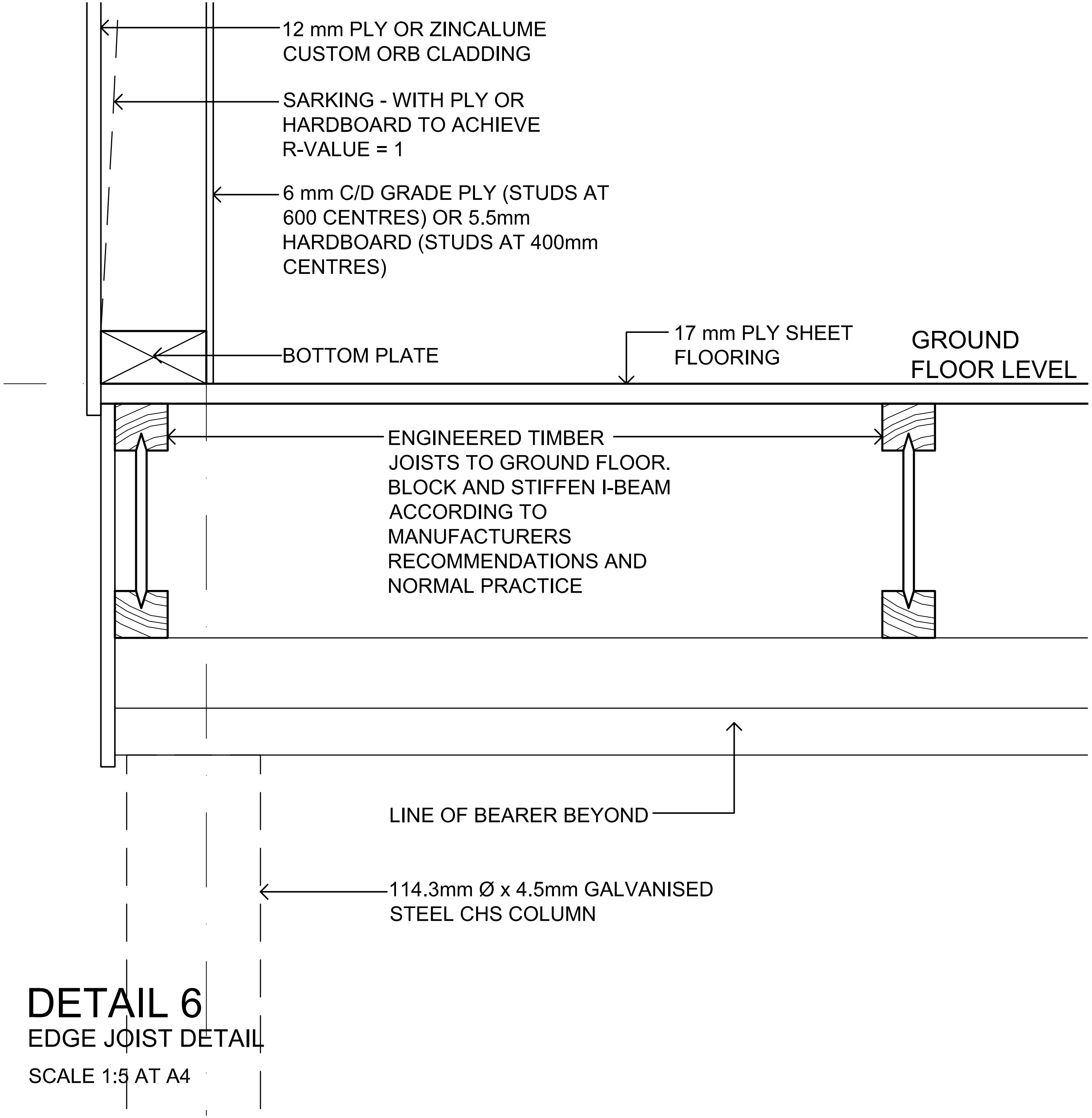
THE NEW QUEENSLANDER
FIGURE 26
REX ADDISON



DETAIL 5

SCALE 1:5 AT A4

PROTOTYPICAL DETAIL
TYPE 'B'
THE NEW QUEENSLANDER
FIGURE 27
REX ADDISON



DETAIL 6

EDGE JOIST DETAIL

SCALE 1:5 AT A4

PROTOTYPICAL DETAILS
TYPE 'B'
THE NEW QUEENSLANDER
FIGURE 28
REX ADDISON

7 Recommendations for Stage Two

The next stage of this project will be the development of a series of six prototypical designs utilising the timber construction system for a variety of solutions. These will respond to a variety of conditions for lot size, orientation, household size and so on. The following range of prototypes was confirmed at the meeting of the Timber Queensland 'New Queenslander' Reference Group on 29th April 2005. Types 1-3 reflect the majority of the current market, and types 4-6 are considered to reflect future models.

1. Detached single storey house on 400m2 lot

- First home buyer's brief
- Narrow frontage 12m x 33m
- Single garage or carport
- Small lots are common in more established areas and will tend to be more common in the future as housing densities in the city increase.
- Sloping blocks are common in Brisbane and more rural sites.
- The prototype system accommodates undulating topography with minimal site works. This saves money and reduces the environmental impact on the site.

2. Detached single storey house on larger lot

- First/second home buyer
- Lot size 600-990m2
- 800m2 blocks are common in new greenfield subdivisions in Brisbane.
- Sloping block are common in Brisbane and more rural sites.

3. Detached 2 storey house on 400m2 lot

- Narrow frontage 10m x 40m
- Small lots are common in more established areas and will tend to be more common in the future as housing densities in the city increase.
- Sloping block are common in Brisbane and more rural sites.
- The prototype system accommodates undulating topography with minimal site works. This saves money and reduces the environmental impact on the site.

4. Dual Occupancy – two houses on 800m2 lot

- Single unit dwellings as per the BCC definition

5. Townhouses

- 800m2 lot
- 2 storeys

6. Duplex

- On 600m2 lot
- Popular in provincial centres
- The duplex allows for greater housing densities to be built in subdivisions, this is in line with the South East Queensland draft regional plan.

7.1 Further research

The intention post Stage Two is to develop one of the conceptual prototypes into an actual demonstration project in an existing, accessible location for new homebuyers and home builders to observe. Demonstration projects are critical in effective knowledge dissemination and give industry and markets the opportunity to ‘try before you buy’ the beneficial features of adopting an environmentally sustainable timber house which responds to subtropical conditions and lifestyles.

The current proposal to the ARC for a Linkage Grant by QUT Sustainable Living Initiative in collaboration with Timber Queensland Ltd is a logical extension of this project. The proposed ARC research will investigate more deeply the affordability issues, lifestyle issues, and perceptions which prevail in the current environment and which may explain the reasons for the under-use of renewable building materials such as timber in the mainstream housing market.

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10 Researchers’ CVs

Rex Addison

John Ryder

Rosemary Kennedy

John Hockings

Charmaine Kai

REX ADDISON

B.Arch. UQ 1970
AA Grad Dip, London, 1972

ADDISON ASSOCIATES PTY LTD - Principal

Rex Addison has worked on the design of buildings for SE Qld, PNG, Fiji, Darwin, Sydney, Canberra and Cooktown. In all cases the designs addressed the specific issues of place and climate. Along with this concern for context, his designs show an awareness of the social role the building plays in the course of its habitation. These abstract issues are then brought together with a meticulous attention to the material making of the building that produces a well crafted result.

PROFESSIONAL AFFILIATIONS

Registered Architect Qld 1978
Adjunct Associate Professor of Architecture, University of Queensland since 2001

PROFESSIONAL EXPERIENCE

Principal of his own practice since 1978.

PUBLIC SPEAKING/TEACHING

2005	Public lecture, ‘Reflections on the Homegame’, University of Queensland
2002	Lecture at ‘Regional Architecture on the Threshold’ Coffs Harbour
2001	‘Light House’ lecture to WA Chapter of the RAIA, Perth
	Appointed Adjunct Associate Professor of Architecture, University of Queensland
2000	Public lecture at UQ ‘A Type of House’
	Lecture on exhibited work in the travelling ‘Light House’ exhibition at the RAIA Qld Chapter in October
1995-97	Conducted a second semester project with final year students at the University of Queensland
1995	Conducted 1 week teaching project at the University of Adelaide
1993	Conducted Master Class at University of Technology, Lae, Papua New Guinea
	International Guest Juror and Speaker, PNG Institute of Architects Awards
1992	RAIA National Housing Conference, Canberra
	inter School “Medium Density Housing Design Issues”, QUT Brisbane
1991	Guest Lecturer - Tasmanian State Institute of Technology, Hobart and Launceston
	Visiting Professor - Second Semester, University of Canberra, Belconnen
1989	Guest Lecturer - Tasmanian State Institute of Technology, Hobart and Launceston
	Address to Tusculum Club (RAIA NSW Chapter)
	Lecture - RAIA NSW Chapter
1988	Address at RAIA/Timber Promotions Council Dinner, Melbourne
	RAIA National Convention, Sydney
1987	Master of Architecture by Design: Led Design Studio Workshop and delivered Public Lecture, University of Melbourne
	Lecture - RAIA Details Workshop, Canberra
1986	A New Urban Architecture for Brisbane, Brisbane
	Lecture at the Arts Council Gallery, Canberra as part of the Australian Built Exhibition which toured Australia

1985	Regionalism and Localism Conference, Hobart
	University of Adelaide, Address to Students
	Maywest Conference, Fremantle
1984	Community Arts Centre, Brisbane
	National Architecture Conference - “Functions of Architects”, Brisbane
1983	Community Arts Centre, Brisbane
	Institute of Architects, Sydney
	Institute of Architects, Canberra
1981	Canberra National Student Conference “Next Wave”

WORK PUBLISHED

2005	Architecture Australia May 2005
2003	Architectural Review (UK) November 2003
	InDesign No.14, August 2003
	Architecture Australia Vol.92 No.3 (May - June 2003)
2002	Eight Great Houses, Pesaro Publishing, Sydney
2001	A Short History of Brisbane Architecture, Pesaro Publishing, Sydney
	Architecture Australia Vol.91 No.1 (Jan-Feb.2002)
2000	Architectural Review (UK) (October issue)
1999	Austral Eden - 200 years of Australian Architecture by Patrick Bingham-Hall, Watermark Press, Sydney
1999/2000	Monument 33
1999	Architecture Australia Vol.88 No.4 (July/August issue)
1998	Monument 20
	Architecture Australia, Vol.87 No.5 (September issue)
1997	The Fibro Frontier - a different history of Australian Architecture published by the Powerhouse Museum, Sydney
1995	‘Thinking Architecture’ - Theory in the work of Australian Architects - a book published by the RAIA
1992	National Trust Queensland Journal (October issue)
	Artlink, Vol.11 No.4 Summer
1990	Australian Architects 5: Rex Addison, Lindsay Clare, Russell Hall
	Architect Designed Houses (Issue 2)
1989	Arkitecktur, Swedish Architectural Periodical (June)
	Arkkitehti, Finnish Architectural Review (July)
	Architecture Australia, (December issue)
1988	Architectural Review (UK) (October issue)
1987	Critiques - a book produced around the work of the architects invited to contribute to the Masters Program, University of Melbourne
	Bannister-Fletcher, A History of Architecture (19th edition)
1986	Australian Built-Responding to Place (Catalogue from National Touring Exhibition)
	Architecture Australia (May Issue)
	Architecture Australia (November Issue)
	UIA International Architect, Issue 4
	Architectural Review (UK) (November Issue)
1985	Architecture Australia (March Issue)
1983	Architecture Australia (March Issue)

1982	International Architect, No.8 Vol.1 Issue 8
1981	A.C. 101
1978	Architectural Review (UK), September issue

LIST OF EXHIBITIONS, PRIZES AND AWARDS

2000	RAIA Qld Chapter Robin Dods Award (Joint Winner) - Addison House & Studio
	Addison House & Studio represented in the ‘Light House’ Exhibition at the Adelaide Festival 2000 and touring Australia after the festival.
1996	RAIA Qld Chapter Regional Commendation - Bus Shelters Herston & Kelvin Grove
1994	RAIA Qld Chapter Tourism Award, Ninderry House, Yandina
1992	RAIA ACT Chapter Certificate of Merit, Tuggeranong Community Centre, Tuggeranong
	RAIA Queensland Chapter, Regional Commendation/State Finalist Multiple Housing Award Privately developed Pilot Project at 60 Hassall Street, Corinda
1990	RAIA Queensland Chapter Commercial Award, Hill House, Spring Hill Office and Townhouse Development
1989	RAIA ACT Chapter C.S. Daley Medal, Government Housing, Corryton Gardens, Lyneham North
1988	RAIA Queensland Chapter House of the Year (Joint Winner) Speculative House, Edgar Street, Newmarket
1987	RAIA ACT Chapter C.S. Daley Medal, Government Housing, Burrundulla Gardens, Kambah
	RAIA Queensland Chapter House of the Year, Manson House, Macleay Island
1985-86	“Australian Built”: an exhibition compiled by the Design Arts Board and James Hardie which toured Australia
1984	Darwin Parliament House Competition - Second Prize

JOHN RYDER
BE (Hons), MIEAust

POSITIONS HELD

2005 – present	Ryder Consulting Pty Ltd. - Director
2000 – 2004.	Arup Group, Australasia. Principal and Leader, Arup Façade Engineering. International Leadership responsibilities in Asia, Middle East and USA.
1988 – 1999.	Ove Arup & Partners, Sydney. Principal – Structures.
1986 – 1988.	Ove Arup & Partners. Associate Director. Manager Canberra Office.
1984 – 1986.	Ove Arup & Partners, Sydney. Senior Engineer – Structures.
1982 – 1983.	Ove Arup & Partners, London. Senior Engineer – Building engineering.
1978 – 1981.	Arup Australia International (Papua New Guinea). Manager Lae Office.
1976	Global Engineering (N.Z.) Ltd. Design Engineer. New Plymouth.
1973 – 1975.	Ove Arup & Partners, Melbourne. Design Engineer

CAREER

John Ryder is a Consulting Engineer resident in Sydney, with over 30 years of professional experience. He has spent most of his professional life working as a structural engineering consultant, engaged on the design of building and civil engineering projects, and more recently in the façade engineering area. John has worked on a diverse range of structures, and his career has encompassed delivery of major projects both locally and internationally. He has worked successfully with architects, owners, project managers, developers and builders. John has lived overseas in Papua New Guinea and the UK, and has worked on projects in SE Asia, Hong Kong, China, the Middle East and USA.

SPECIFIC EXPERIENCE

In the age of rapid and powerful computer solutions, it is easy to lose sight of the fundamental understanding of structural and materials behaviour. John has always approached structural design from a first principles understanding, and from his extensive experience with many structural types, he has developed an innate understanding for structural solutions. He has worked closely with architects, and has always enjoyed the interaction and development of sympathetic design.

His particular areas of expertise include Timber Engineering, Glass Walls, Footbridges, Specialist Analysis and Design Studies, and Specialist Reports, along with general design of reinforced concrete and steel structures. He has worked widely on Commercial, Retail, Residential, and Institutional buildings, and on Civil Engineering and Industrial structures.

John's experience is offered to clients to suit their specific needs, where a highly experienced, or more sympathetic, articulated or specialist perspective is required. John's project experience includes the following:

RELEVANT TIMBER ENGINEERING PROJECTS

1. General

Glued laminated beams for Papua New Guinea Parliament House, Port Moresby, PNG
Glued laminated trusses for Brittannia Leisure Centre, London, UK.
Long Span nail plate roof trusses for several schools, Sydney.
Nan Tien Ssu Temple, Wollongong, NSW. Extensive timber trussed roof system, including detailing to accommodate feature tiling projections.

2. Design of timber framed structures in earthquake and cyclonic zones
Office for Coffee Industry Board, Goroka, PNG
Raun Raun Theatre Building, Goroka, PNG
Three storey offices for Chevron Nuigini, Mendi, PNG
Buka University Centre, Buka, PNG
Office for PNGBC, Kokopo, PNG
Uniting Church, Goroka, PNG
York Island Air Terminal, Torres Strait
Palm Island Housing, North Qld
Sesia House, North Qld

3. Historic Structures
Extensive timber condition studies and reports, Walsh Bay Wharves, Sydney, including termite and other damage assessments, and fire engineering studies.
Refurbishment of Bond Stores 2 & 3, Walsh Bay, Sydney.
Design for Sydney Theatre and Dance Companies in Wharf 4/5, Walsh Bay
Extensive timber condition studies and reports, Woolloomooloo Wharf, Sydney.
Fire engineering assessment of REVY Building Bond Store, Jones Bay, Sydney.
Refurbishment of Bond Store at No1 Kent St, Sydney.
Earthquake report and repairs for Newcastle GPO

ROSEMARY KENNEDY

B. Des St. UQ 1980.
B. Arch (Hons) UQ 1988
Grad Cert. Env Man. UQ 1995

Rosemary is the Coordinator of the Centre for Subtropical Design at QUT.

She studied architecture at The University of Queensland where her interest in design that responds to culture, landscape and climate was nurtured. She established Mulder + Kennedy Architects in 1993 and her professional work has continued to focus on identity and place and embraces contextual climatic characteristics in appropriate design solutions. She is a director of Mulder + Kennedy with a role in design projects. The practice has always been an advocate of timber construction for housing projects, but has also had great success using the material in applications for pubic buildings and eco-tourism projects, notably Lake Cressbrook camping facilities, the award winning ‘Kidspace’ at Chermside, and the Oxley Creek Environment Centre, Rocklea.

Rosemary was recently involved in the Cooperative Research Centre for Construction Innovation as a member of a collaborative research team looking at alignment of participants’ values in construction project delivery.

Rosemary joined the Centre for Subtropical Design at QUT Dec 2003 and is involved in delivery of its program of research and dissemination activities.

JOHN HOCKINGS

Head of School of Design, Faculty of Built Environment and Engineering QUT

John Hockings is an academic, researcher, architectural critic and author, and maintains a design practice. Research specialisations are Architectural Design, Urban Design and Vernacular Architecture in the Asia Pacific region. He is an active researcher with numerous publications in the fields of architecture and urban design.

From 1981-85 practised architecture as Senior Associate with Noel Robinson Architects, which included work on a large range of award-winning mixed-use, commercial and residential projects throughout Australia. In 1985, John joined the Department of Architecture at the University of Queensland as a Lecturer, appointed Senior Lecturer in 1987, and Acting Dean in 1996 and Acting Head of Department in 1998. Became Head of Department in 2000 and served as Acting Head of School for periods in 2001.

John has maintained a design and research practice since 1985, undertaking residential works and major urban design consultancies for State Governments, Local Authorities and various national private practices including Bligh Nield and Hassell and Lindsay Clare. He has been the recipient of a number of architectural awards and prizes including first prize in the Sydney 2000 International Olympic Village Design Competition, first prize in the BDA Southbank competition and first prize in the Lang Park Football Stadium competition.

Recent major publication is a new book: Grose Bradley: The Poetics of Materiality L'arcaedizioni New York 1999. John was recently Chairman and Lord Mayor's representative, the BCC Urban Design Advisory Panel, and member of the University of Queensland Site Planning Committee. Major current research projects are focused on Architectural Design through project work. In addition, current research concerns vernacular architecture, particularly in the Asia Pacific region. There is an ongoing project in the nation of Kiribati involving the complete redesign of the country's government housing programme and involves a period of fieldwork there each year.

CHARMAINE KAI

B. Des St. UQ 1996
B. Arch (Hons) UQ 1999

Charmaine is a researcher with the Centre for Subtropical Design. She established 8i Architecture in 2004, a professional practice engaged in furthering sustainable design principles in the built environment. The practice is currently undertaking several timber framed residential projects.

She was recently an Associate Architect with Husband Leith Architects. Project experience includes residential renovations of timber houses in Brisbane, multi-residential developments, commercial and industrial developments. Charmaine is skilled in investigation and research on technical standards, sustainability and social requirements for problem-solving by design.