

# Guide to Wood Construction Systems

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## Authos

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## Guide aim and approach

### Aim

- To assist practicing structural engineers and other building design professionals confidently develop conceptual structural designs for timber-rich buildings and structures.



## Guide aim and approach



### Approach

This guide takes a whole-of-process approach to the selection of timber-rich structural systems.

- It explores:
  - Available structural systems.
  - Connections and material options.
  - Design approaches.
  - Performance requirements and material properties.
- It includes
  - *Regular* options for systems and materials.
  - Two worked examples.



## Guide structure

The guide sections align with the stages of the conceptual design process.

Icons and graphics are widely used to demonstrate available options.



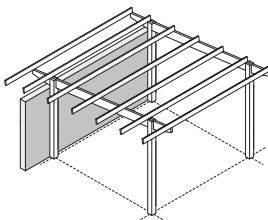
Design brief formulation	Why wood	S1
Information search	Material basics	S7
	Material properties	S8
	Performance requirements	S9
	Aspects of AS1720	S10
	Worked examples	S11
	Glossary	S12
Conceptual design	System options	S2
	Connection options	S3
	Element options	S4
	Construction options	S5
	Design approaches	S6
Detailed design and Design documentation		
	Other WoodSolutions guides	

## Section overview



### S1: Why wood

The significant environmental, design and construction edge that timber and wood products have over alternative building materials in environmentally responsible buildings.

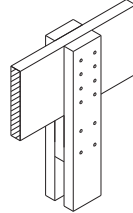


### S2: System options

Regular options for the spanning, support and lateral restraint systems used in a project's structure. It includes materials available for each option.

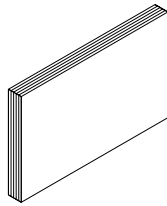


## Section overview



### S3: Connection options

Major options for making reliable structural connections in timber elements in the workshop and on site.



### S4: Element options

Major material options for timber-rich building elements, their applications and standards, and likely means of supply

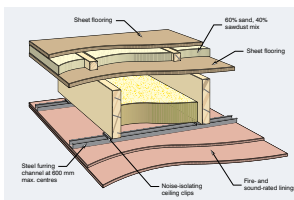


## Section overview



### S5: Construction options

Construction process options for timber-rich buildings and structures, including options for element prefabrication.

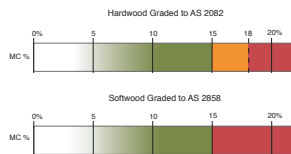
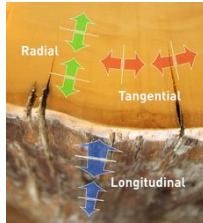


### S6: Design approaches

Considerations and design approaches required to address the performance requirement of timber-rich buildings and structures.



## Section overview



MC requirements for structural  
hardwood graded to AS 2082 and  
softwood to AS 2858



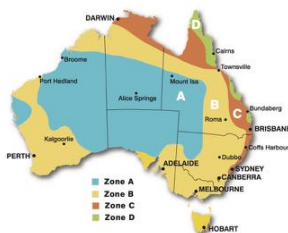
### S7: Material basics

Key differences in practice between wood and other materials, and between different species or types of wood.

### S8: Material properties

Properties of timber and wood products in relation to the major performance requirements for buildings and structures.

## Section overview



### S9: Performance requirements

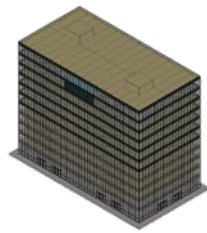
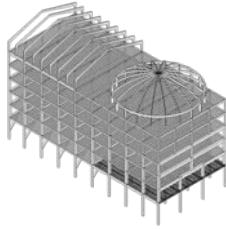
Regulatory requirements established through the NCC and its referenced standards, and the fit-for-purpose requirements that relate to building established under the Australian Consumer Law

### S10: Aspects of using AS 1720

AS 1720 sets out the limit states design methods for the timber's use in structures.



## Section overview



### **S11: Worked examples**

Two worked examples, one seven storeys and the other ten storeys, provide an applicable, step-by-step approach to designing timber components in multi-storey timber buildings.

### **S12: Glossary**

Definition of key terms.

## Other WoodSolutions guides



### Timber-framed Construction for Multi-residential Buildings Class 2 & 3

*Design and construction guide for BCA compliant  
sound and fire-rated construction*

Technical Design Guide issued by Forest and Wood Products Australia



### Timber service life design

*Design guide for durability*

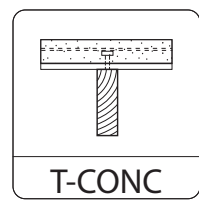
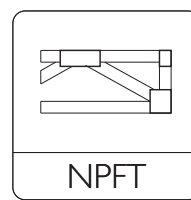
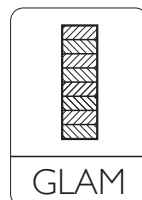
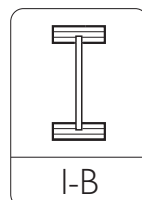
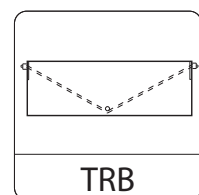
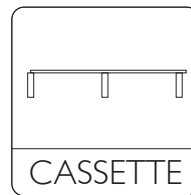
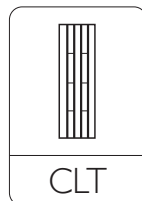
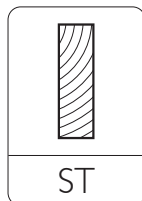
Technical Design Guide issued by Forest and Wood Products Australia

## Design with a natural resource



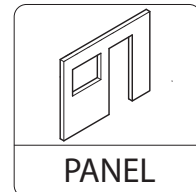
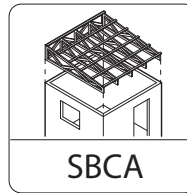
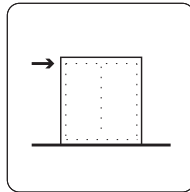
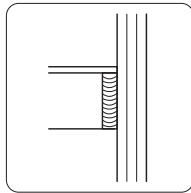
Australia's forest and wood products industries provide a wide range of highly-workable products made from varied species.

## Icons: Material and assemblies



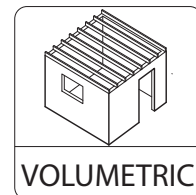
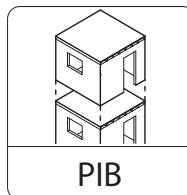
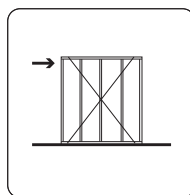
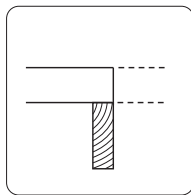


## Icons: Construction options



SBCA

PANEL



PIB

VOLUMETRIC

## Generating a conceptual design for a timber-rich structure



## Conceptual design



Conceptual design is the process of generating and assessing a range of alternative solutions for the structure that may satisfy its performance requirements.

This is an iterative process that includes:

- Selecting a number of options for each category of structural element.
- Establishing basic alternative frameworks for the structure using these options.
- Determining load paths to carry vertical and lateral loads to the foundations.



## Considerations during conceptual design



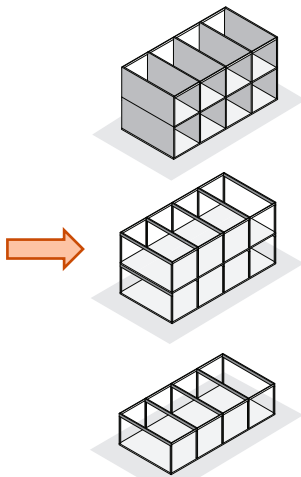
- The type of building.
- Options for the structural systems' components.
- Options for connecting the components.
- The materials available to make the components.
- Options for assembling the components into a building.
- Approaches to satisfying the buildings' and the components' performance requirements.



## The type of building



### Building typologies



#### Closed frame

A closed frame system typically has walls that enclose discrete functional areas and provide lines of support at regular intervals. Floor spans are relatively short at 4-5 metres.

#### Open frame

An open frame system typically has columns, beams and floors acting as a frame structure to provide open and flexible functional areas. Columns are regularly spaced on a grid whose spacing is based on efficient beams and floor spans.

#### Single level system

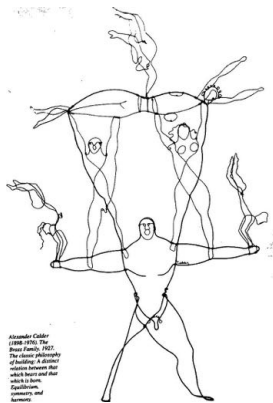
A single level structural system typically has a roof structure spanning between wall or columns to provide an open and flexible functional area. The roof elements may be exposed or concealed.



## Options for the structural systems' components



### Structural solution components types



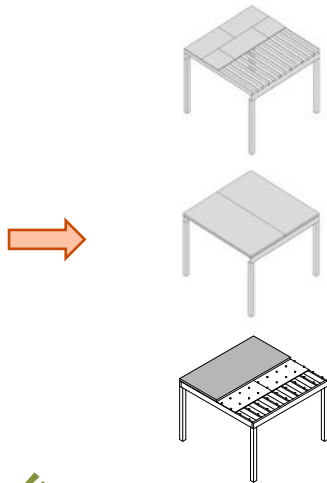
Most structural solutions have three component types:

- **Spanning systems** that bridge horizontal distances to carry vertical loads to the support system.
- **Support systems** that receive loads from the spanning systems and transfer them to the ground.
- **Lateral resistance systems** that resist that resist horizontal forces from the wind, earthquakes or similar sources

When combined, selections for these systems can generate one of several alternative solutions for review and assessment.



## Spanning systems: floors



### Floors: Joist and flooring deck

- Joist span range: Up to 8 m
- Joist span to depth ratio: 17 to 1

### Floors: Massive timber

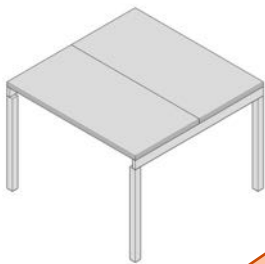
- Panel span range: Up to 6 m
- Panel span to depth ratio: 25 to 1

### Floors: Concrete and timber composites

- Panel span range: Up to 8 m

Each of these options then has particular characteristics.

## Floors: Massive timber



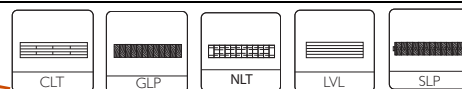
### Regular beam options



#### Notes

Glulam is available in wide sections.

### Regular panel options



#### Notes

Stress laminated panels are generally used in civil construction such as bridge decks.

### Regular construction and prefabrication options



#### Construction notes

Beams and all floor panel systems can be fully prefabricated.



#### Prefabrication notes

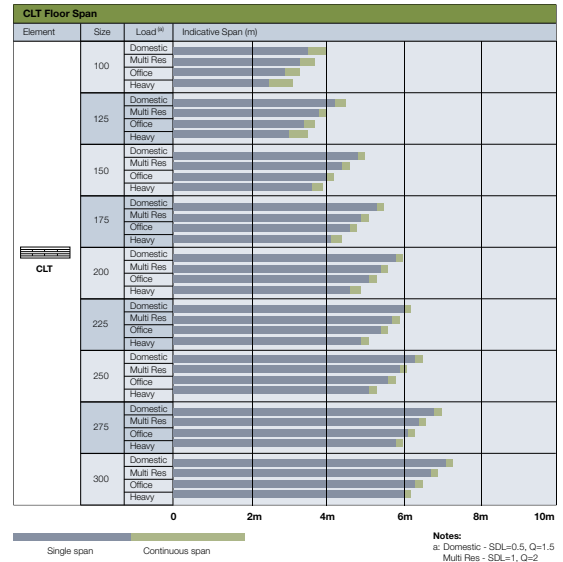
Panels and beams can be fully prefabricated for the project.



## Floors: Indicative span tables



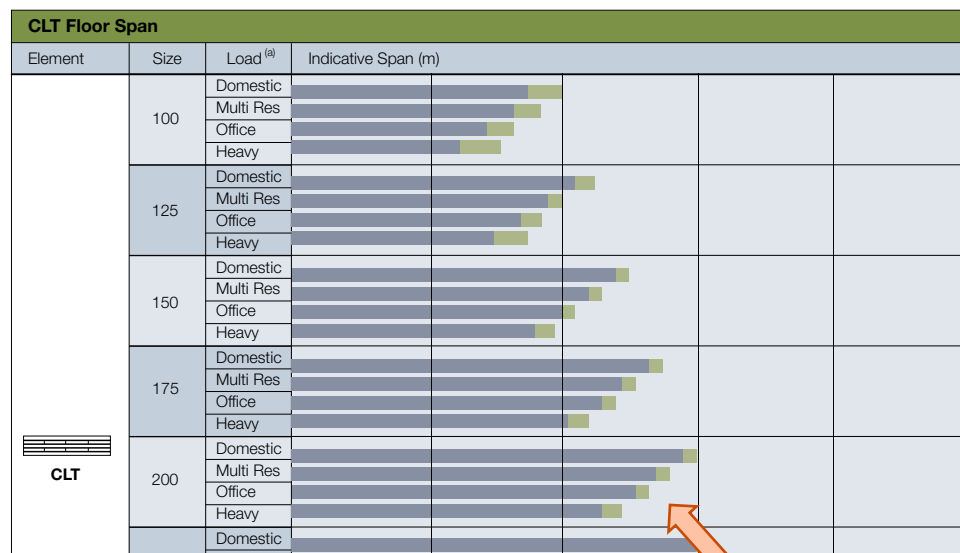
Table 13: Indicative span – CLT floor panels



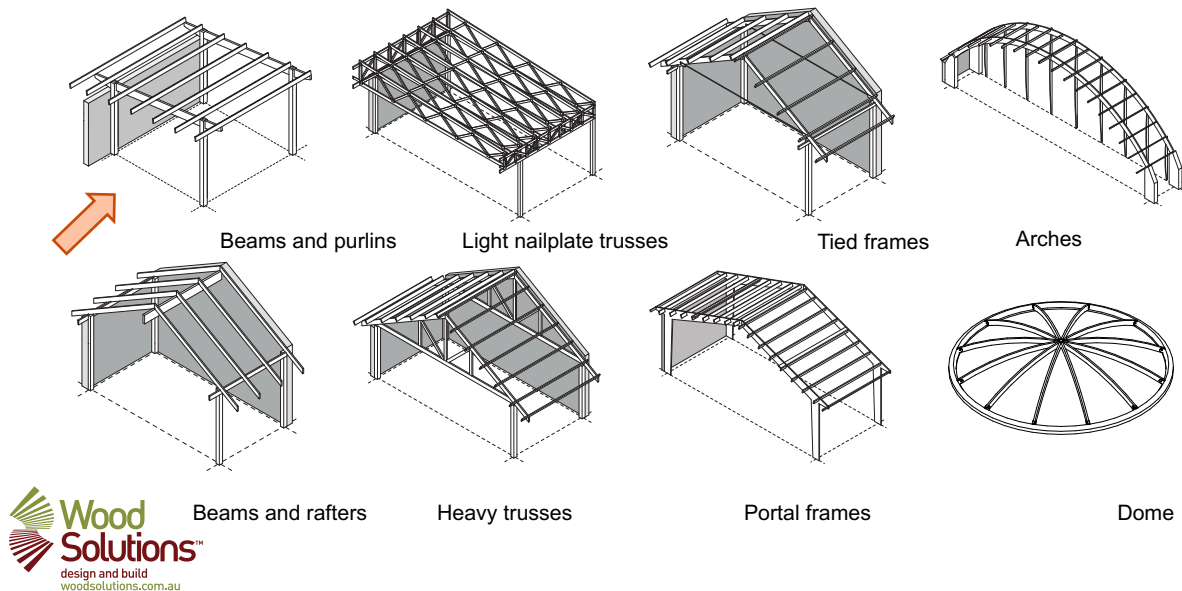
## Floors: Indicative span tables

Table 13: Indicative span – CLT floor panels

4m 6m



## Spanning system: roofs



## Roofs: Beams and purlins

**Form options**

**Regular beam or rafter options by span**

<5 m	5 m +
ST NPT I-B NPFT	LVL GLAM B-B NPTRx2

**Regular purlin options and configuration**

ST	NPT	LVL	I-B	NPFT
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**Assembly options**

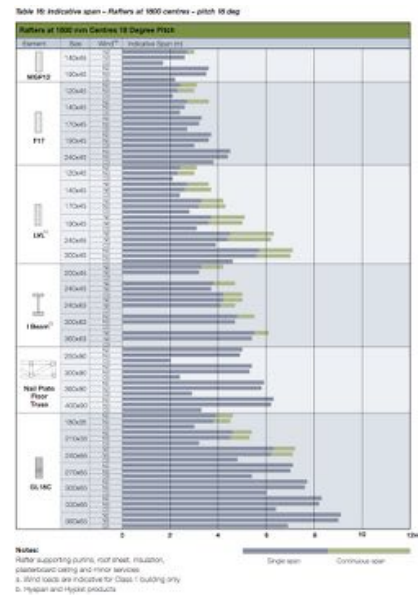
**Notes**  
Purlin span to depth ratio is nominally 24 to 1. Options reduce considerably for spans over 4.8 m.

**Assembly notes**  
Purlins set between beams provide them with lateral restraint while continuous spans allow for a smaller purlin section.

Beam span range: 30 m+  
Beam span - depth ratio: 20 to 1

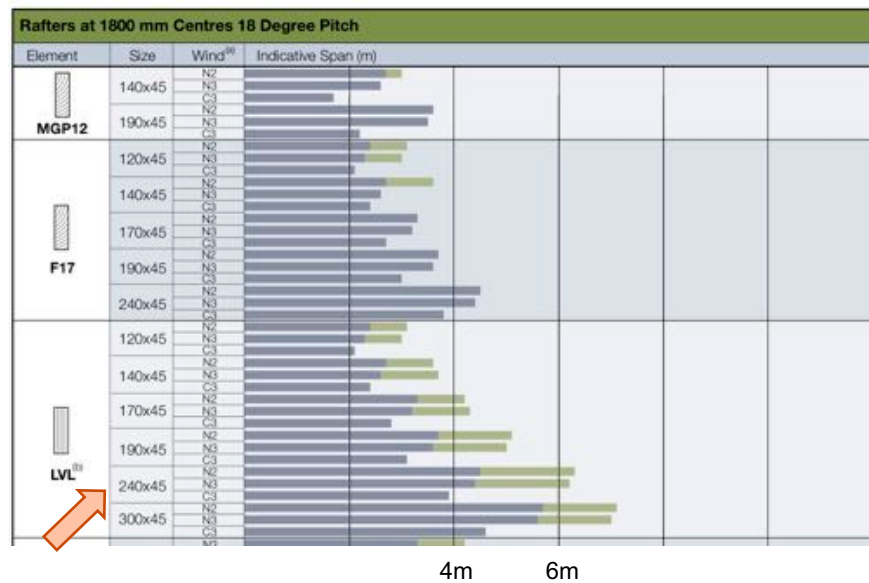
Wood Solutions™  
design and build  
woodsolutions.com.au

## Roofs: Indicative rafter span



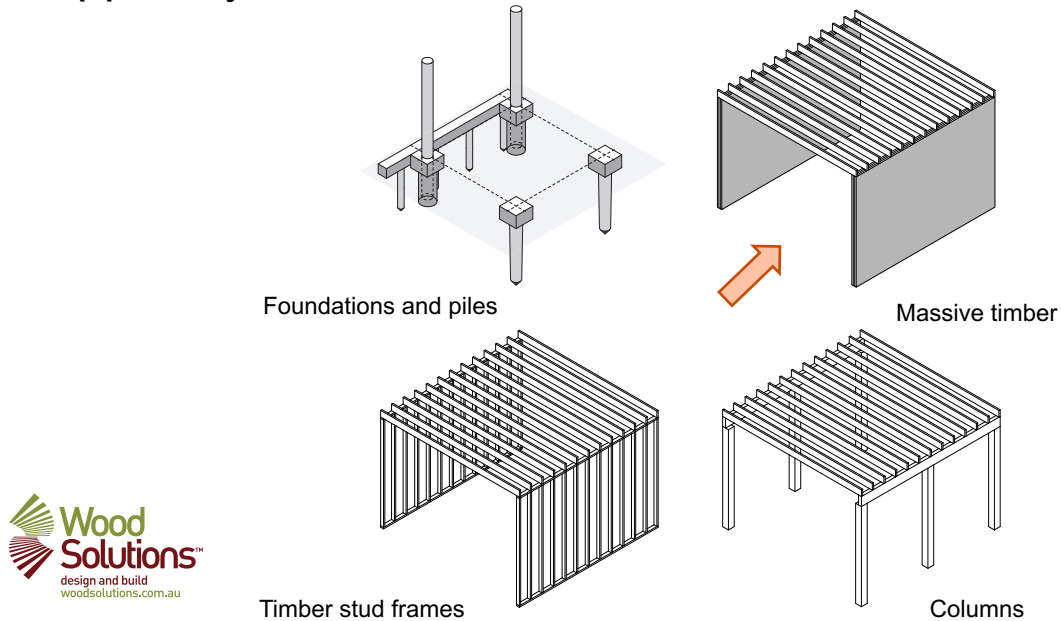
## Roofs: Indicative rafter span

Table 16: Indicative span - Rafter at 1800 centres - pitch 18 deg

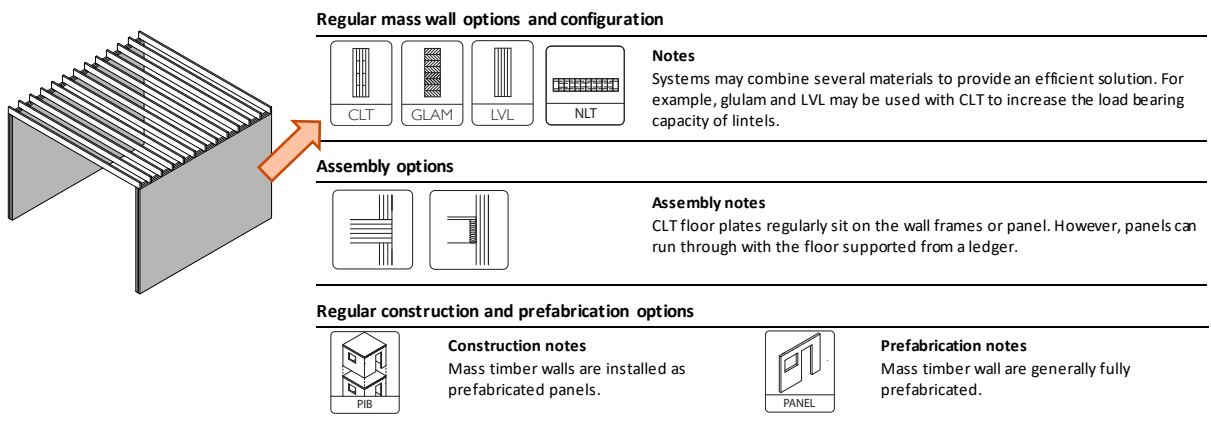




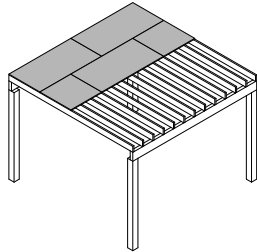
## Support systems



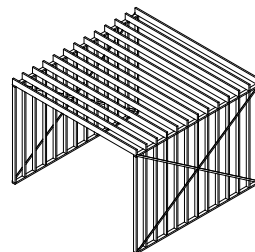
## Support systems: massive timber



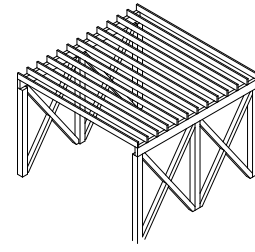
## Lateral resistance systems



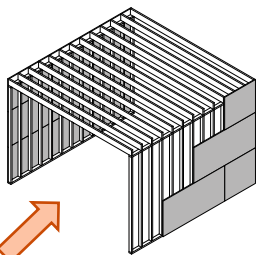
Floor and roof diaphragms



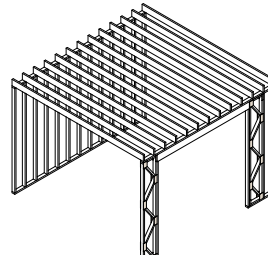
Strap braced panels



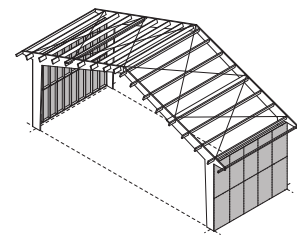
Timber or steel rod bracing



Wall diaphragms



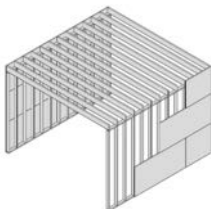
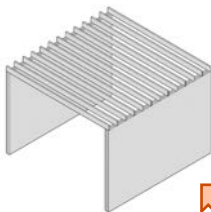
Truss panels



Moment-resisting frame



## Lateral resistance systems: Wall diaphragms



### Regular sheeting options



### Notes

Bracing capacity from sheet material relates to the sheet's continuity, its thickness, the number and type of fixings that secure it to the frame and the frame's fixing to the surrounding structure.



## Options for connecting the components



### Connection options



The main groups of mechanical connection options for timber elements are:

- **Timber-timber contact** connections.
- **Timber-fastener** connections.
  - Loads move between timber elements through mechanical fasteners such as nails, screws or bolts.
- **Timber-connector-fastener** connections.
  - Loads move from a timber element to a connector such as a gusset through fasteners, and then back from the connector into other timber elements.



## Connection types

**Table 21: Load transfer through the joints by connection type**

Connection type	Timber-timber contact	Timber-fastener	Timber-connector-fastener
Contact transfer	■	□	□
Fasteners		■	
Gusset plate with fasteners	□		■
Nail and nail-on plates	□		■
Fin plates with fasteners	□		■
Epoxy dowels	□		■
Interlocking housing	■	□	□
Transfer blocks	□	■	

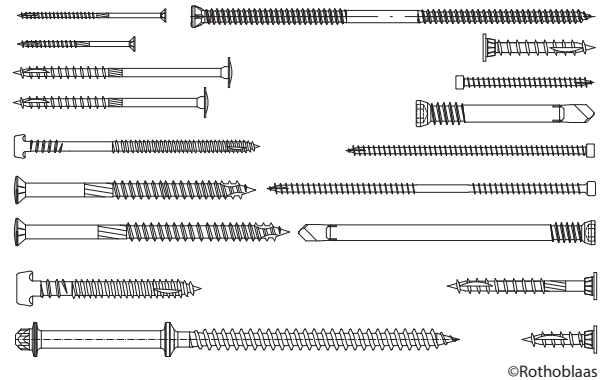
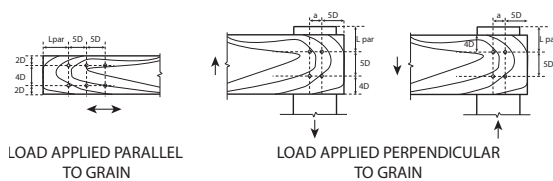
Legend: Primary load transfer method ■ Regular secondary load transfer method □



Each connection type may include:

- Fasteners, such as dowels, screw and bolts
- Connectors of wood, metal, or plastics.

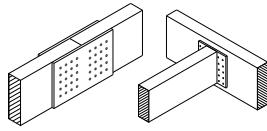
## Fasteners



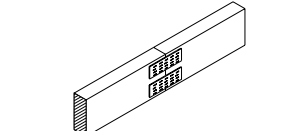
©Rothoblaas



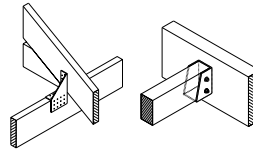
## Regular connector types



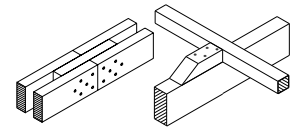
Wood gussets



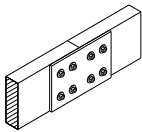
Nailplates



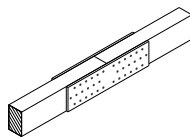
Brackets



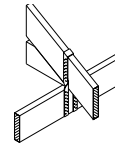
Timber blocks



Metal gusset plates



Nail-on plates and brackets



Straps and ties



## Connection type: Timber-fastener



In-line join	Truss node	Rafter to a column
Beam to post	Beam to post	Truss node
Frame apex	to the ground	



## Connection type: Fin plates and fasteners



Rafter to beam	In-line join	Truss node
Beam to post	Column to the ground	Truss node
Beam to post	Column to the ground	

## Materials available to make the components



## Material supply options

Supply options	Description
Generic	<b>Generic elements</b> are produced to standard sizes and grades and available from multiple suppliers for general use in building.
Fabricated	<b>Fabricated elements</b> are usually made for the project by general or specialist fabricators from combinations of generic elements.
Site assembled	<b>Site assembled elements</b> are usually constructed on site from combinations of generic and fabricated timber elements and other materials.



## Material options



Section	Element group	Diagram
4.1	<b>Timber rounds</b> , including logs shaved into rounds or in their natural form	
4.2	<b>Sawn timber and assembled elements</b> , such as sawn framing, glulam, cross laminated timber (CLT), and nailplate assembled elements	
4.3	<b>Veneer-based elements</b> , such as plywood and laminated veneer lumber (LVL)	





## Material options



4.4	<b>Strands, particles and fibre based elements</b> , such as oriented strand board (OSB) and high density fibre board (HDF)	
4.5	<b>Combination elements</b> assembled from several types of wood products	
4.6	<b>Composite elements</b> assembled from timber and other materials acting in combination	



## Sawn structural timber

Table 30: Standard softwood sections – Nominal sawn, unseasoned or treated

Width	Depth							
mm	75	100	125	150	175	200	225	250
38	■	■	■	■	□	□		
50	■	■	■	■	■	□	□	□
75	■	■	■	■	■	□	□	□
100	■	■	□	□	□	□	□	□
125			■	□		□		
150				■				
200						■		

Legend: Commonly available ■; Available on order □; In limited supply □

Table 31: Standard softwood sections – Machined, seasoned

Width	Depth							
mm	42	70	90	120	140	190	240	290
35	□	■	■	■	■	■	□	□
45		■	■	■	■	■	■	■
90			■					

Legend: Commonly available ■; Available on order □; In limited supply □

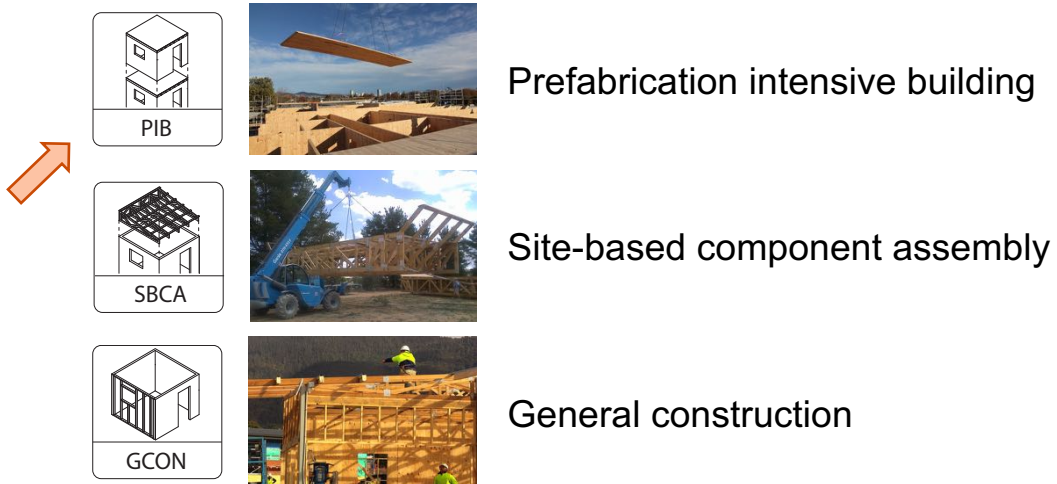
- Description is provide for the material, its applications, grades, sizes, standards, and supply



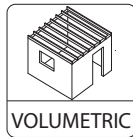
## Options for assembling the components into a building



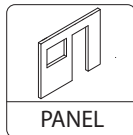
### Construction process options



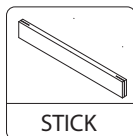
## Prefabrication approaches



Volumetric modules



Panels



Sticks



**Approaches to satisfying the buildings' and the components' performance requirements.**



## Design approaches for performance

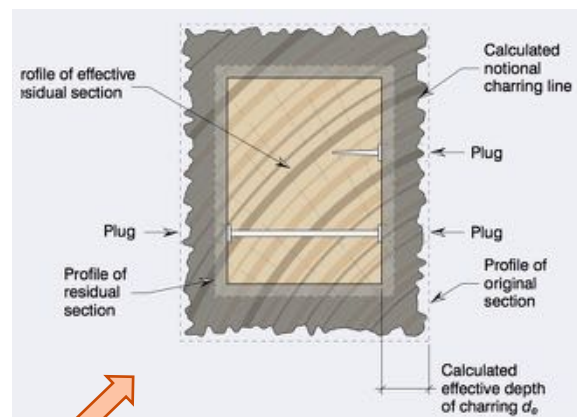
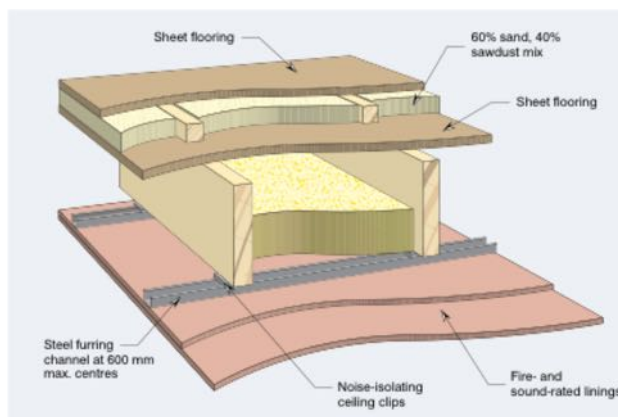


The designer has to ensure that the alternative structural solutions developed during conceptual design stage satisfy its performance requirements:

- Structural performance
- Moisture content control
- Fire resistance
- System durability
- Acoustic separation
- Thermal performance
- Environmental performance
- Procurement



## Fire resistance



This section regularly references other specialist WoodSolutions design guides.

## Conceptual design considerations are covered.



- The type of building.
- Options for the structural systems' components.
- Options for connecting the components.
- The materials available to make the components.
- Options for assembling the components into a building.
- Approaches to satisfying the buildings' and the components' performance requirements.



## Worked Examples

Worked Example 1: Seven Storey Mixed-Use Building

Worked Example 2: Ten Storey Mixed-Use Building



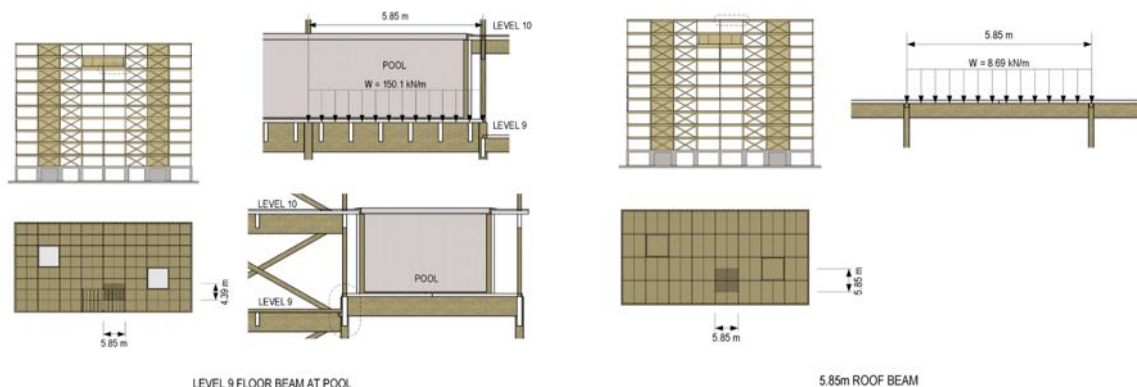


## Worked Example 2: Ten Storey Mixed-Use Building



- Dimension limitations: Height: 37m, Width 24m, Depth: 47.4m
- Structural Importance Level: 3
- Open concept design where possible
- Level ten contains an inset pool
- Floors are supported with columns on a 5.85m x 5.85m grid
- Floor height requirements are:
  - Ground Floor: 4m floor to top of level one
  - Level one - ten: 3.3m floor to floor with 105mm floor thickness between the beams.
- Building materials consist of:
  - Ground floor and level one: design material is concrete. This design is outside the scope of this sample.
  - Levels two - ten & Roof: design material is Cross Laminated Timber (CLT)
  - Horizontal beams throughout: design material is glue laminate beams (glulam)
  - Columns & Braces throughout: design material is glue laminate members (glulam)

## Worked Example 2: Ten Storey Mixed-Use Building





## Summary

This guide:

- Aims to assist practicing structural engineers and other building design professionals confidently develop conceptual structural designs for timber-rich buildings and structures.
- Takes a whole-of-process approach to the selection of timber-rich structural systems. It explores: available structural systems, connections and material options and design approaches.
  - It includes *regular* options for systems and materials, and two worked examples.



## Questions

