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Structural Computer Design Approaches for Mid-rise Timber Buildings

Citius, Altius, Fortius ?
Do it with timber.



HOW ?

HOW WILL YOU USE TIMBER STRUCTURES FOR YOUR NEXT PROJECT ?



OVERVIEW

Structural timber design software

- **Structural Analysis Considerations**
- Modelling Approaches For Different Building Elements
- Review Of International And Local Computer Software Available

Structural Analysis Considerations

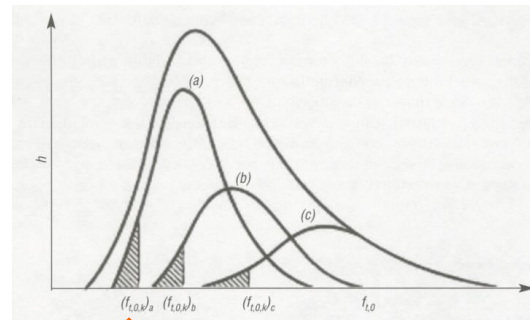
Design Assumptions

Pathways for approval:

- Prescriptive DTS Solution (eg for Class 1)
- Engineered DTS Solution (ref. to Standards)
- Performance Solution (equivalent to a DTS)

Material properties:

- Never zero for timber
- Vary with moisture and loading time

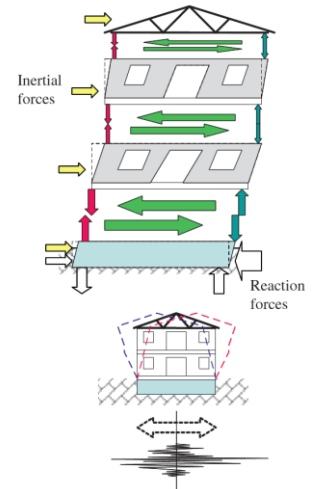


Structural Analysis Considerations

Low-rise issues

Low-rise:

- Main issue is horizontal shear flow
- Low overturning forces
- Mode shapes are simple
- Detailing is NOT similar for wind and seismic
- AS 1720 full coverage

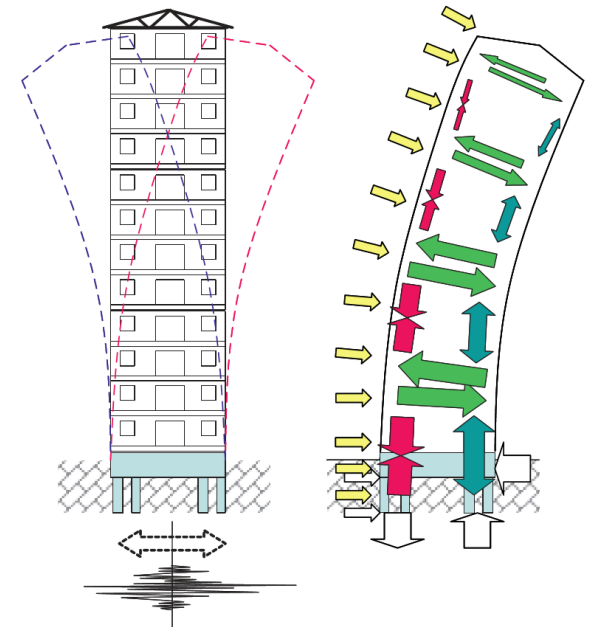


Structural Analysis Considerations

Mid-rise issues

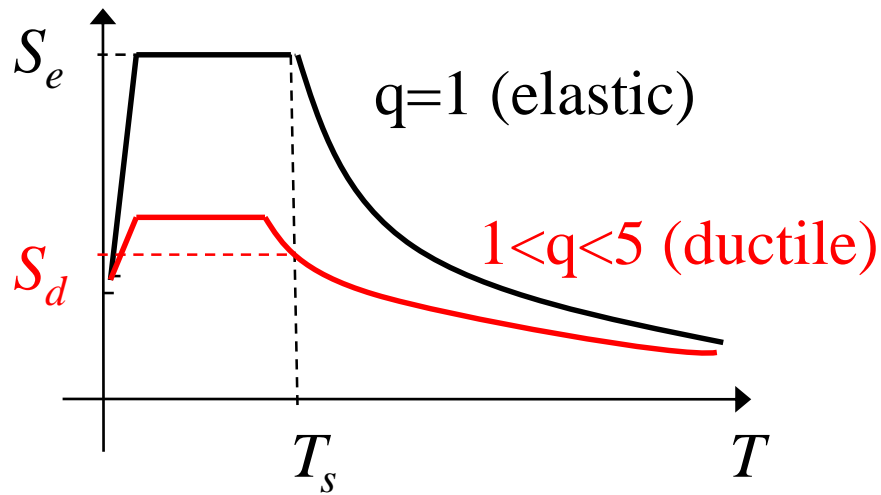
Mid-rise:

- Main issues are uplift and compression in walls, plus horizontal shear flow
- Large overturning forces
- Mode shapes can be complex
- Detailing is similar for wind and seismic
- AS 1720 partial coverage



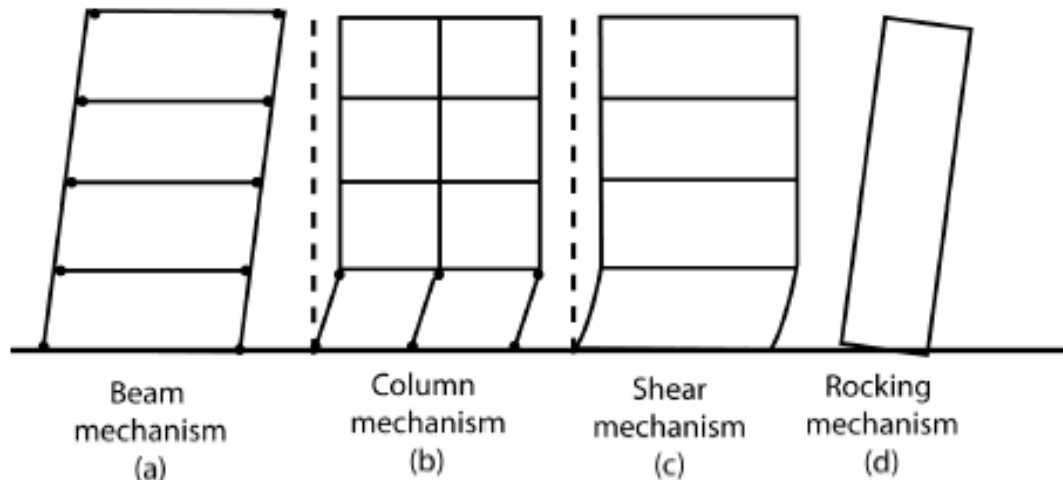
Structural Analysis Considerations

General building behaviour



Basic choices:

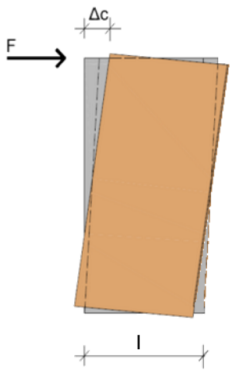
- Elastic or ductile
- Failure mode



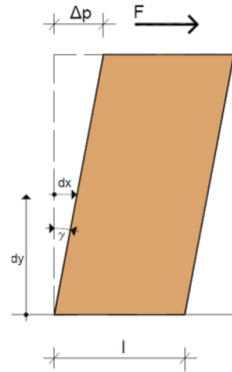
Structural Analysis Considerations

Assumed component behaviour

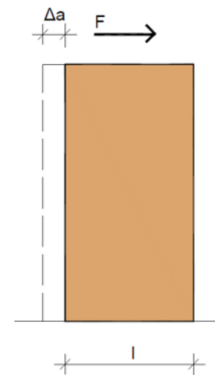
Shear walls



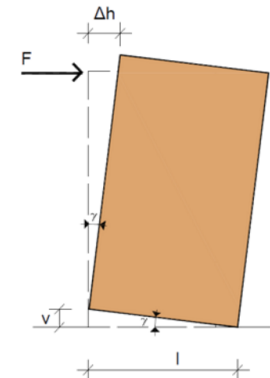
Displacement due to the connections between the sheathing and the frame



Displacement due to the sheathing panels



Displacement due to the rigid body translation



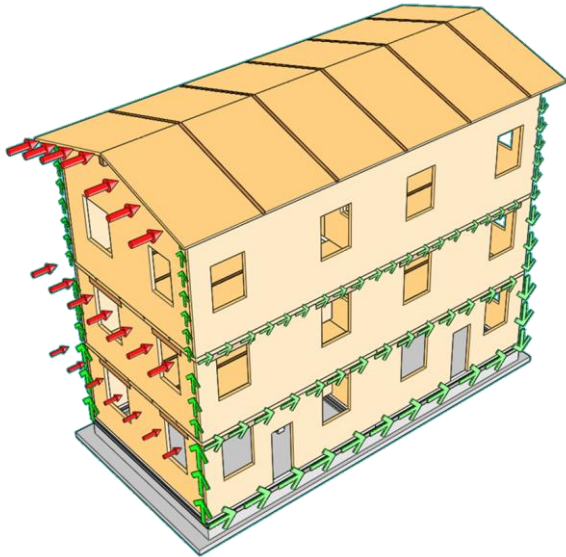
Displacement due to the rigid body rotation

Floor diaphragms influence the wall behaviour

- Stiff in-plane and to buckling (best)
- Flexible (acceptable in most cases)

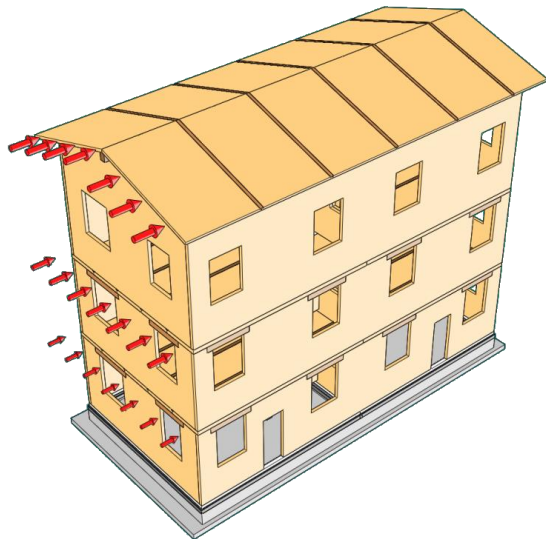
Structural Analysis Considerations

Type of analysis and related tools



Non-linear, static or dynamic:

- For every design/shape
- Hierarchy of resistances
- Modal (response spectra)
- Needs full 3D models



Linear static (elastic):

- Only for “regular” designs
- Simple 2D tools

Structural Analysis Considerations

Assign elements to Brittle or Ductile

Brittle

- Sawn timber
- Glulam, LVL
- Welded joints

Ductile

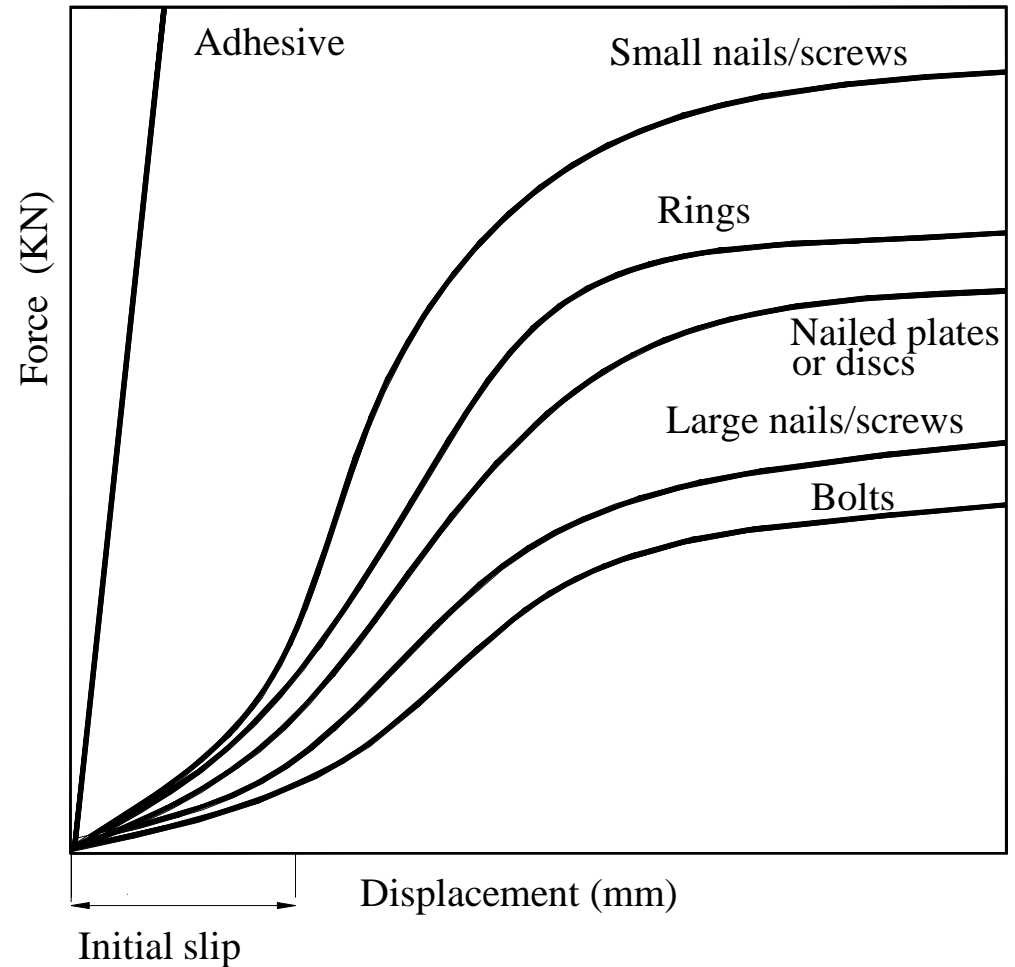
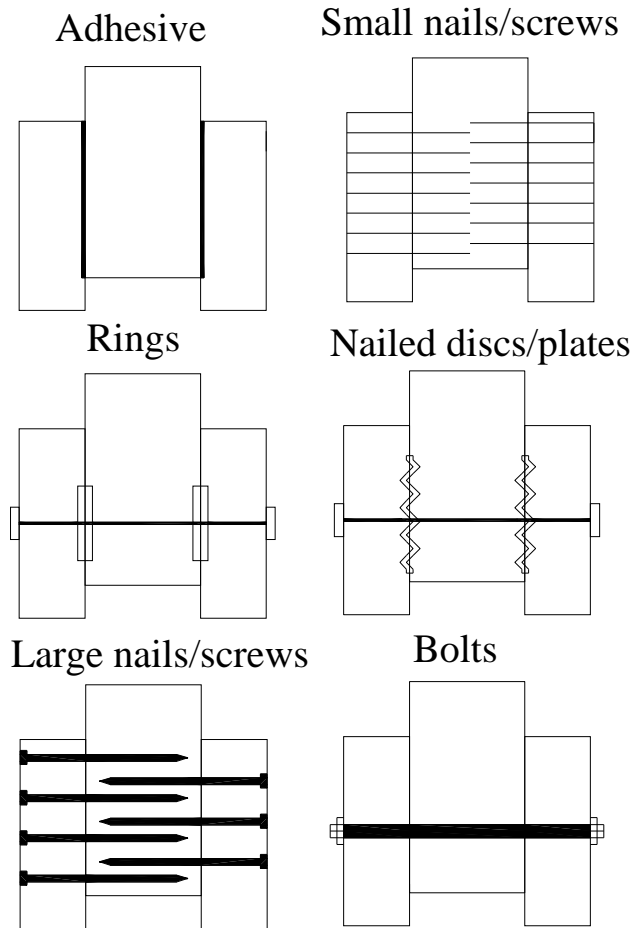
- CLT, plywood, OSB
- Connections
- Structural steel

SMALL
VOLUMES
TAKE LARGE
AMOUNTS OF
ENERGY



Structural Analysis Considerations

Importance and effect of connections

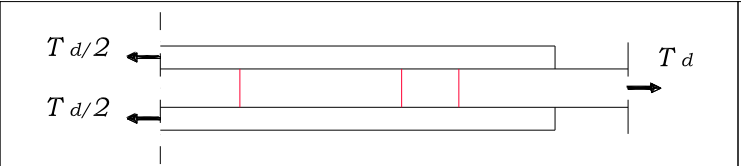
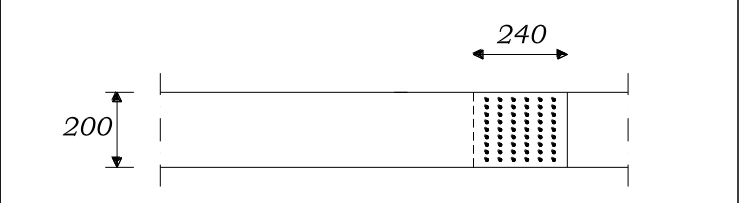
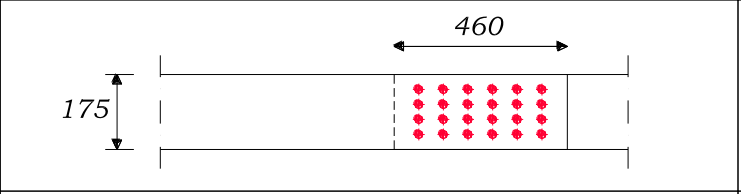
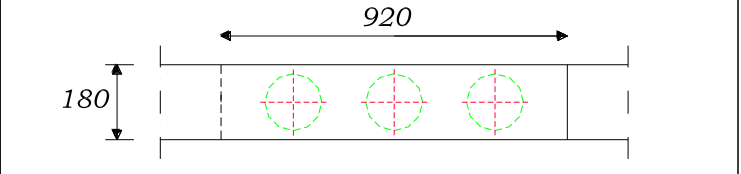


Structural Analysis Considerations

Connections often govern design

Influence of connections:

- Performance
- Constructability, costs

		T_d (kN)
108 nails Ø 5mm		150
24 dowels Ø 10mm		159
6 rings Ø 120mm		142



**NO
DAMAGE
DESIGN,
CONNECTORS
MAY BE
ADDED**

OVERVIEW

Structural timber design software

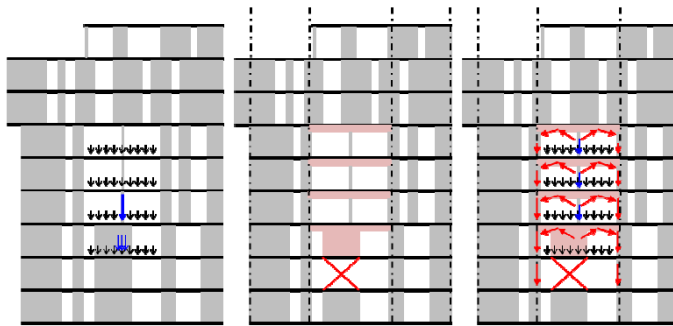
- Structural Analysis Considerations
- **Modelling Approaches For Different Building Elements**
- Review Of International And Local Computer Software Available

Modelling approaches

Consider typical “timber” features

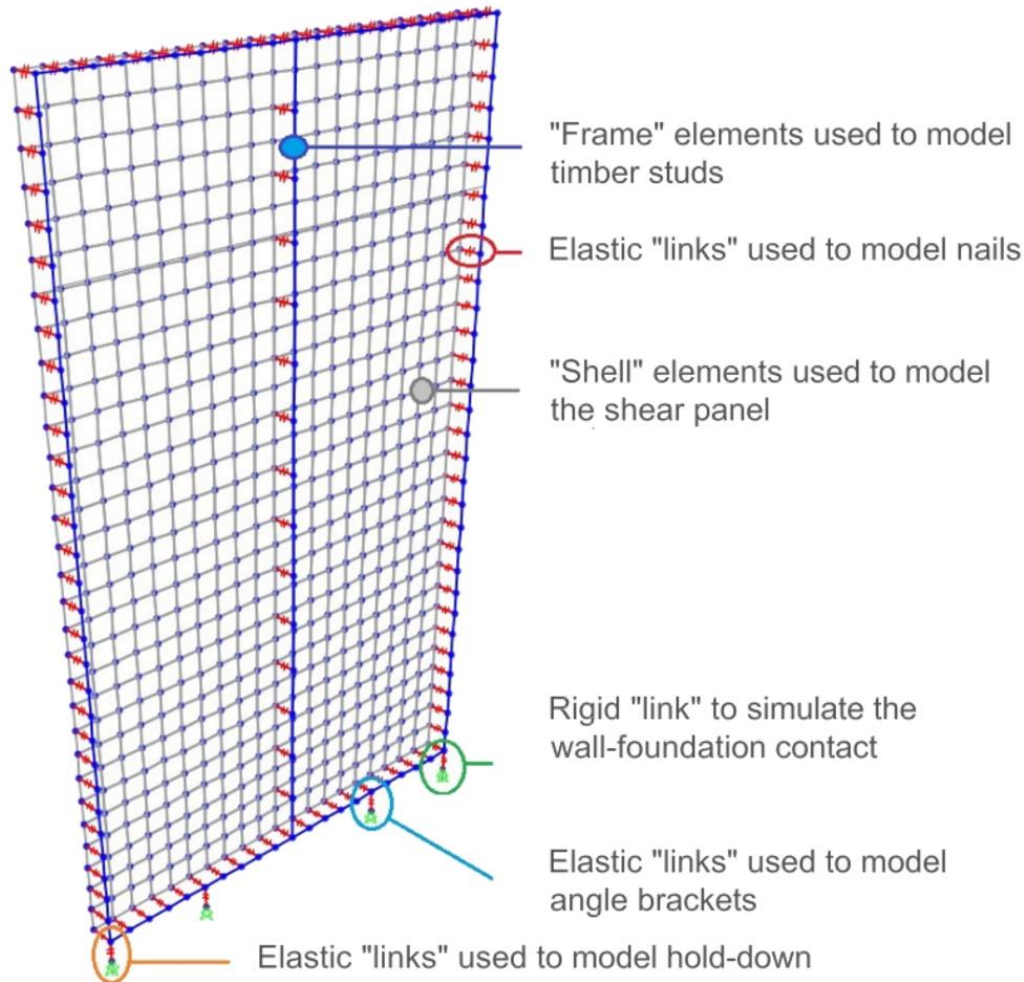
Relevant to mid-rise construction:

- Effect of load combinations on the whole
- Differential & incremental settling
- Design for constructability & maintenance
- Effect of load time and exposure
- Keep in mind fire & acoustic (if not DTS)
- Robustness (disproportionate collapse)



Modelling Approaches

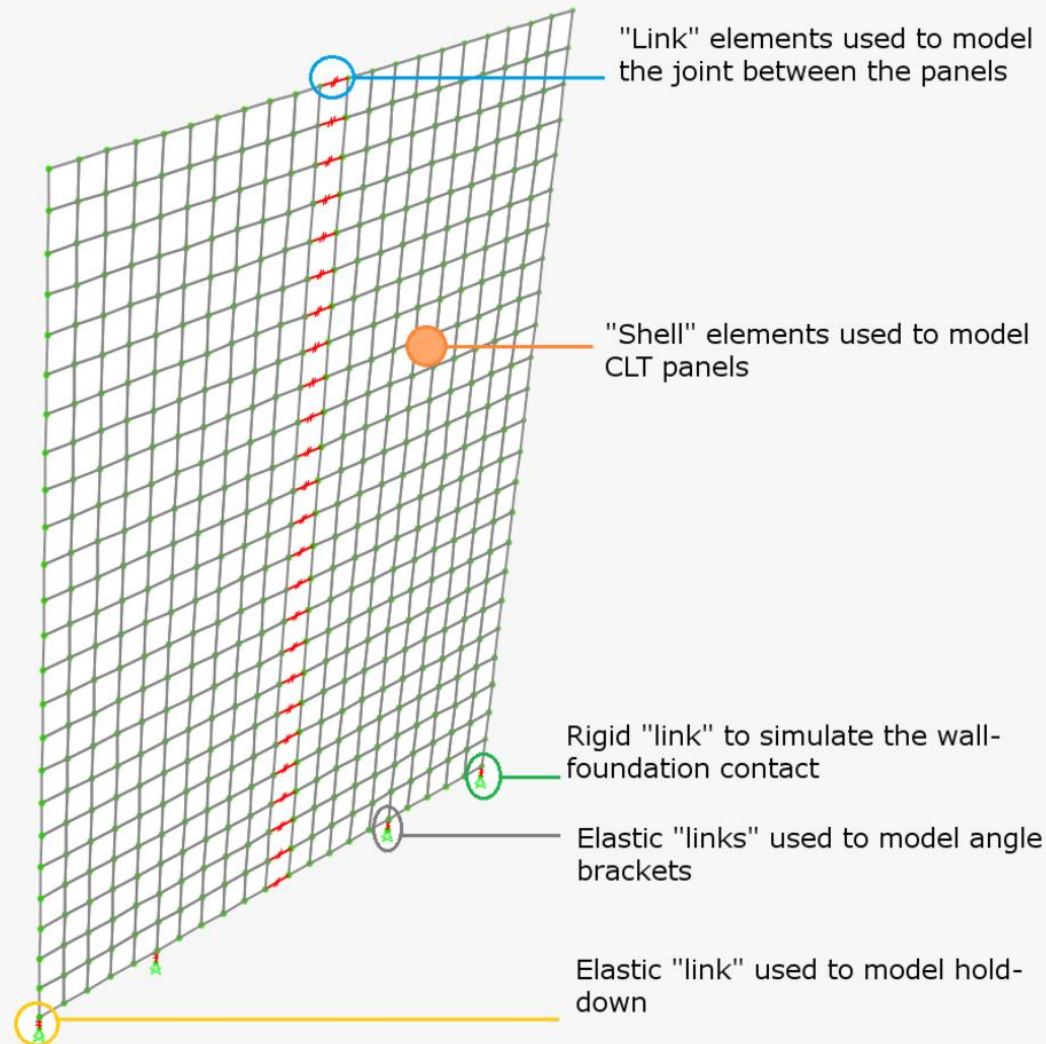
Light Frame Shearwalls



Finite Element Model Light Frame

Modelling Approaches

CLT Shearwalls



Finite Element Model CLT

Modelling Approaches

A single model for all cases

A: labile frame for horizontal loads

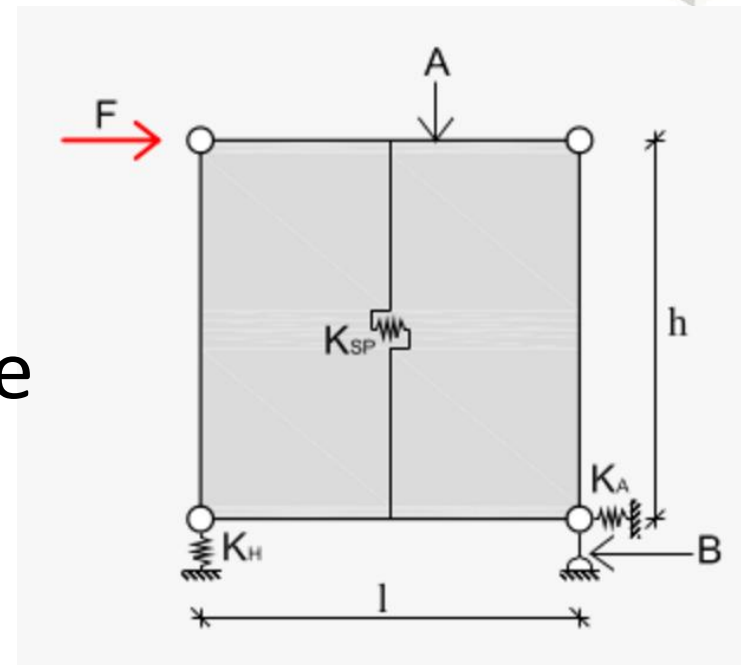
K_{SP} : stiffness of sheathing

K_H : hold-down stiffness

K_A : angle bracket stiffness

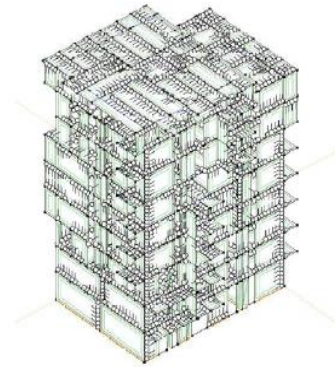
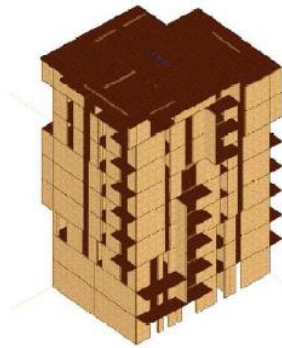
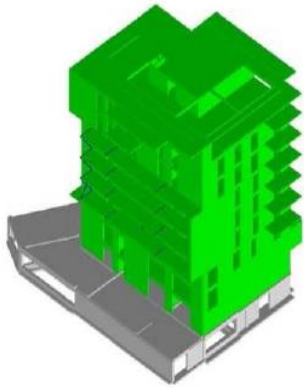
B: connection of pressed angle

MODEL
"UNITS"
CAN BE
SAVED
IN SOME
SUITES

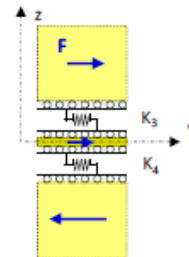
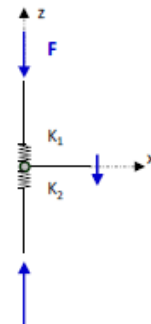
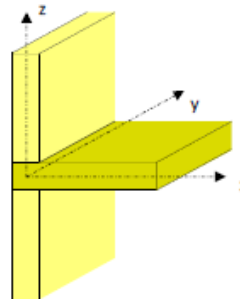
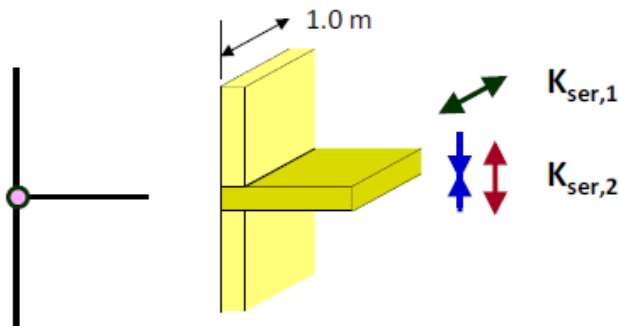


Modelling Approaches

Compare alternatives, understand sensitivity



MODELS
q=1 AND q=2
JOINT STIFFN.
K_{ser}=EC5 AND
EC5/20

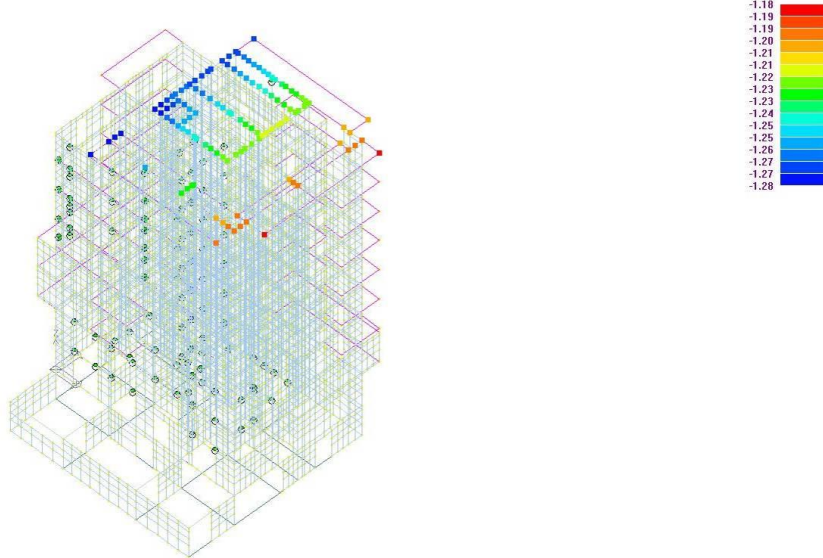


Modelling Approaches

Might need to check for “new” features



RISULTATI 048) Comb. SLE(rara) 48
Traslazione Y [cm]



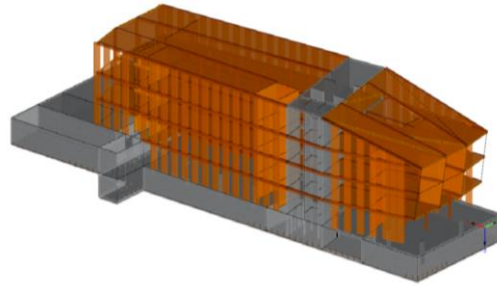
TORRE_B_SOLAIO_SOFFICE.PSP
MILANO VIA CENNI
SPOSTAMENTO MAX NODO SOMMITA' 12.8 mm [1/2000 H]

**CHECK OF
WIND GUSTS:
FIRST TIME ON
A TIMBER
RESIDENTIAL
BUILDING**

**TOP FLOOR:
- deformation
13mm (28)
- acceleration
26mm/s²
(40)**

Modelling Approaches

Modelling & Analysis typical sequence



- Assumptions and materials (also connectors)
- Rough dimensioning for FEM
- Model(s), eventually with different tools
- Sensitivity, alternatives, optimisation
- Connectors, fire, acoustic

OVERVIEW

Structural timber design software

- Structural Analysis Considerations
- Modelling Approaches For Different Building Elements
- **Review Of International And Local Computer Software Available**

Review Of Available Software

Types (freeware, proprietary, commercial)

Relevant to mid-rise construction:

- Span tables / connector designers
- Single-element design (may include joints)
- 2D structural analysis
- 3D structural analysis

Review Of Available Software

Desirable features

- Easy and quick user interface
- Large and flexible material database
- Simple and colourful viewer
- Efficient file import/export
- Code(s) compliance (AS1720 ?)
- Automatic load generation
- Full analysis & checks capacity
- Optimizer, automatic correction
- Other materials
- Complete report, BoQ, dwgs



Review Of Available Software

Is there any one-stop solution ?

NOT YET:

- Powerful and versatile 3D suites typically lack quick element predimensioning tools and post-processors for connections
- Easy and quick 2D suites are not flexible enough for smart architectures
- Single-element design tools lead to excessive overdimensioning (no load sharing)

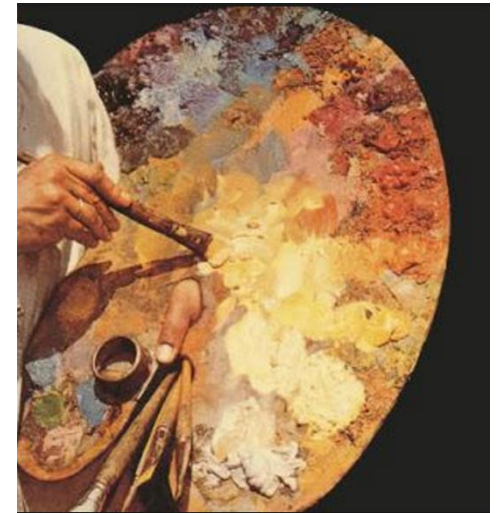
Review Of Available Software

So, what ?

Tools can be complementary

- *Quick* for quotations
- *Flexible* for early design
- *Complete* for advanced design
- *Accurate* for final checks
- *Reliable* for documenting

USE MORE
THAN 1 TOOL
AND ADD
RESULTS INTO
THE REPORT

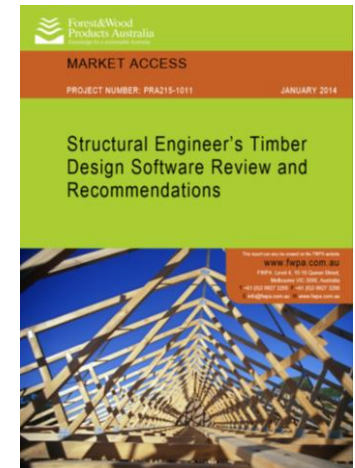
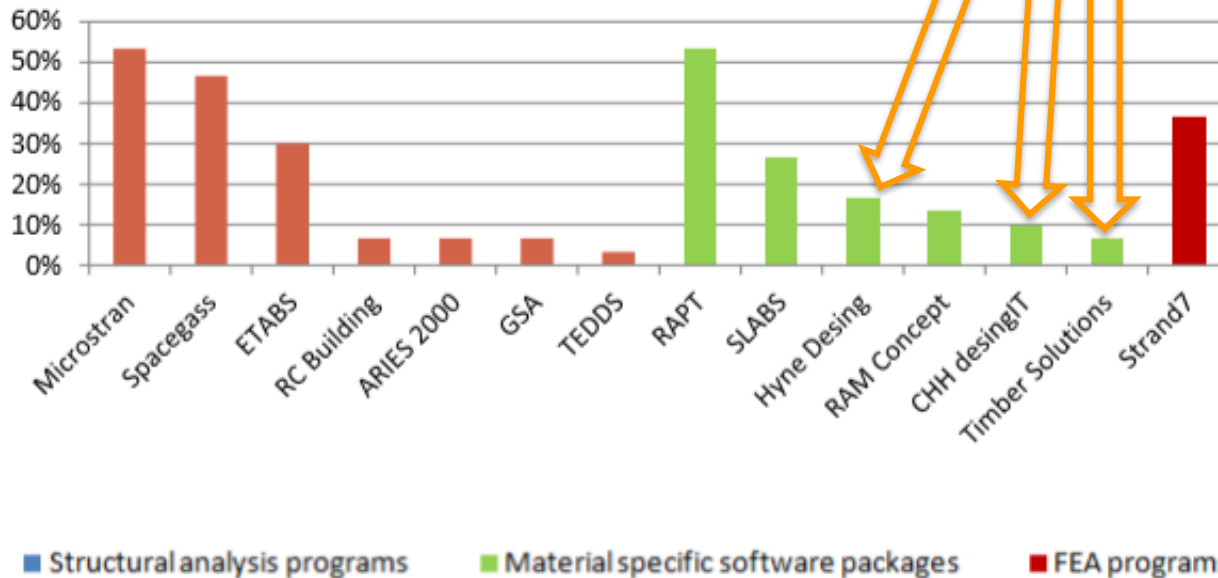


Review Of Available Software

Survey in 2013 (30 engineering firms)

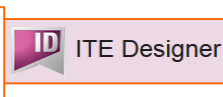
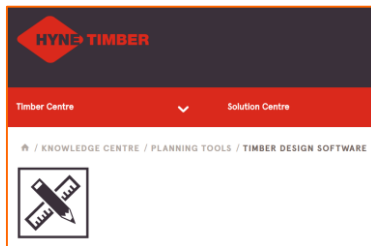
VERY FEW
WERE USING
TIMBER
SPECIFIC
DESIGN SW

Structural software usage



Review Of Available Software Update – Proprietary & Freeware

- More & improved tools
- Start considering whole houses and mid-rise



Review Of Available Software Update – Commercial

Timber-specific:



2D single element, easy, AS 1720

2D assemblies, easy and flexible, EC5

3D, almost complete, EC5

2D, almost complete, CAN/US connectors, EC5

With timber modules/databases:



3D suite, US/CAN

3D suite, EC5

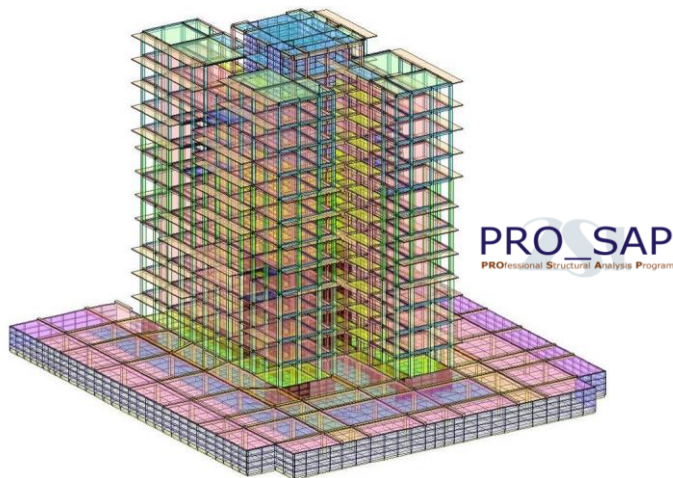
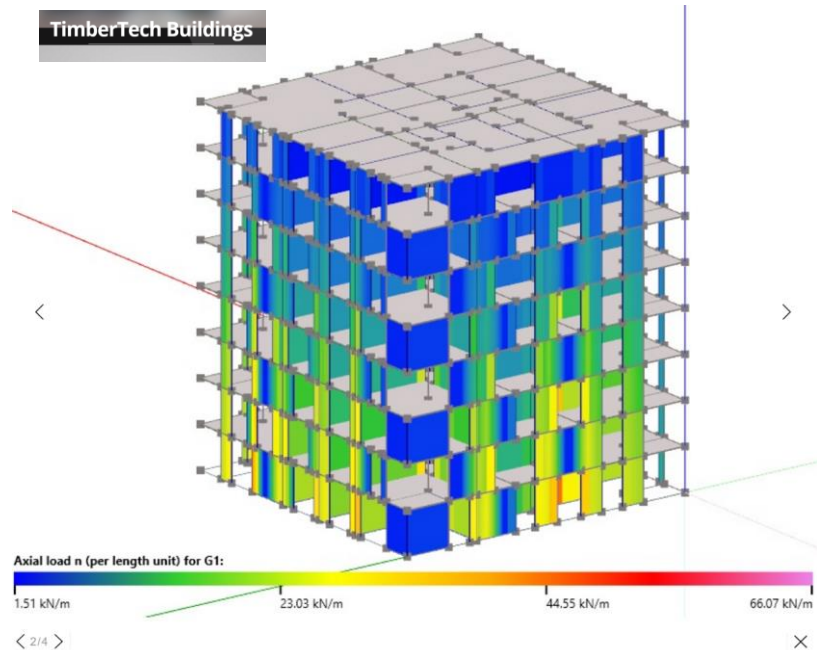
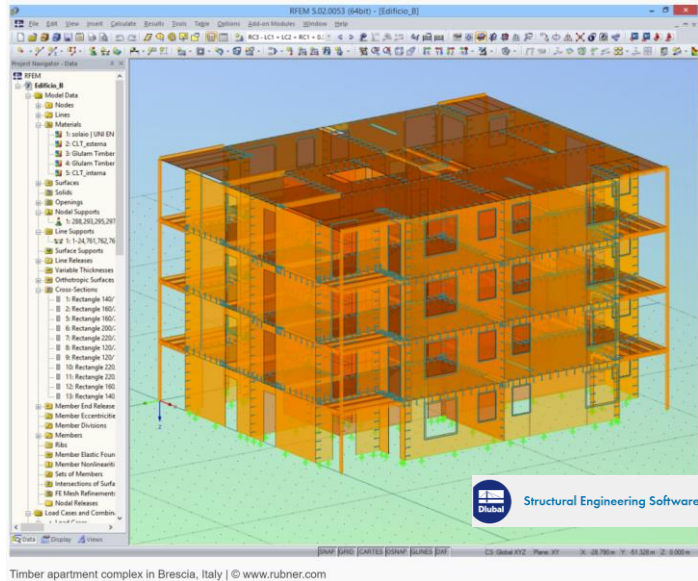
3D suite, EC5

3D suite, multicode



Review Of Available Software

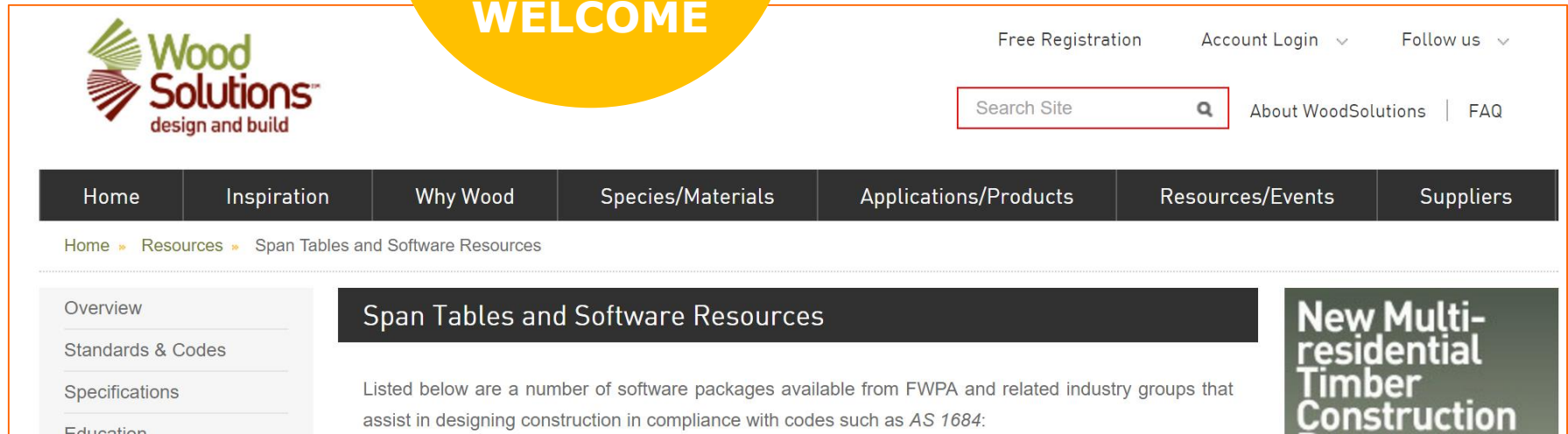
A few pics in mid-rise...



Review Of Available Software

Our software webpage

**YOUR
COMMENTS
AND UPDATES
ARE VERY
WELCOME**



The screenshot displays the Wood Solutions website interface. At the top left is the logo for Wood Solutions, featuring a stylized green and brown fan-like graphic next to the text 'Wood Solutions™ design and build'. To the right of the logo are links for 'Free Registration', 'Account Login' (with a dropdown arrow), and 'Follow us' (with a dropdown arrow). Below these is a search bar labeled 'Search Site' with a magnifying glass icon, and links for 'About WoodSolutions' and 'FAQ'. A horizontal navigation bar contains the following links: 'Home', 'Inspiration', 'Why Wood', 'Species/Materials', 'Applications/Products', 'Resources/Events', and 'Suppliers'. Below the navigation bar, a breadcrumb trail reads 'Home » Resources » Span Tables and Software Resources'. On the left side, there is a sidebar menu with the following items: 'Overview', 'Standards & Codes', 'Specifications', and 'Education'. The main content area has a dark header for 'Span Tables and Software Resources'. Below this header, the text states: 'Listed below are a number of software packages available from FWPA and related industry groups that assist in designing construction in compliance with codes such as AS 1684:'. To the right of the main content area is a promotional banner for 'New Multi-residential Timber Construction'.

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design and build

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Home » Resources » Span Tables and Software Resources

Overview
Standards & Codes
Specifications
Education

Span Tables and Software Resources

Listed below are a number of software packages available from FWPA and related industry groups that assist in designing construction in compliance with codes such as AS 1684:

New Multi-residential Timber Construction

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- **THANK YOU**