Paolo.Lavisci@woodsolutions.com.au

Structural Computer Design Approaches for Mid-rise Timber Buildings

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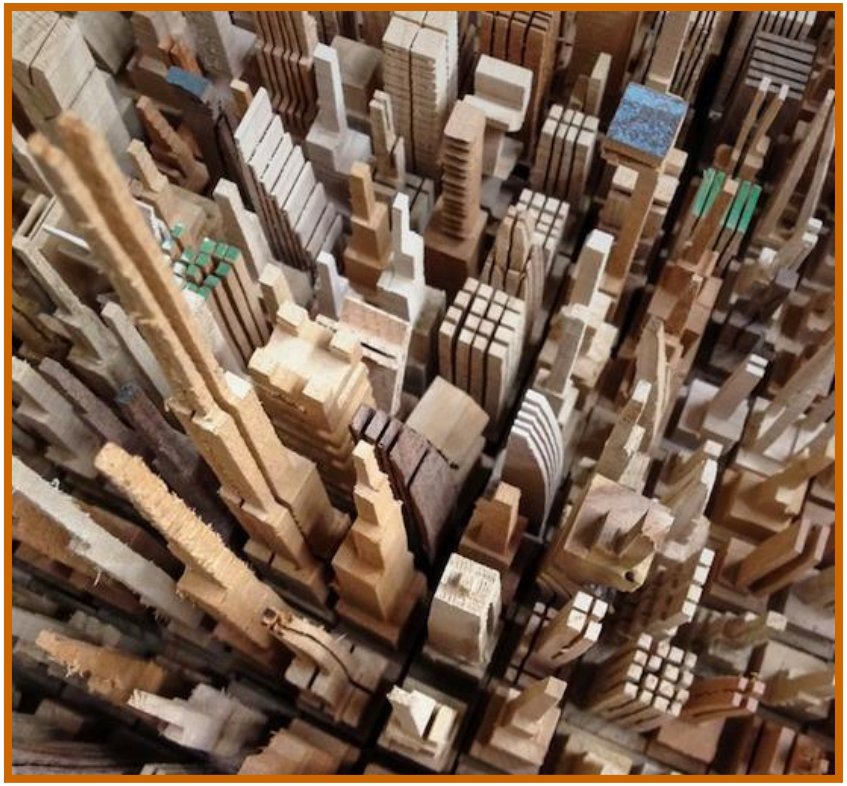
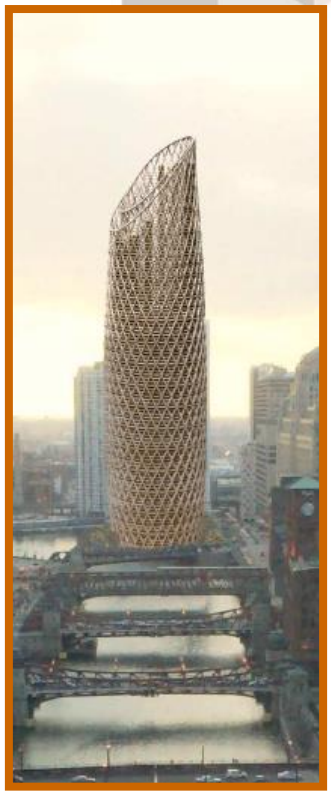
Citius, Altius, Fortius ?
Do it with timber.





HOW ?

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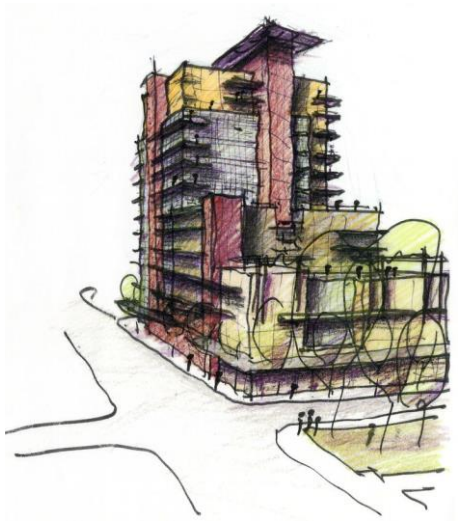
HOW WILL YOU USE TIMBER STRUCTURES FOR YOUR NEXT PROJECT ?



OVERVIEW
Structural timber design software

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

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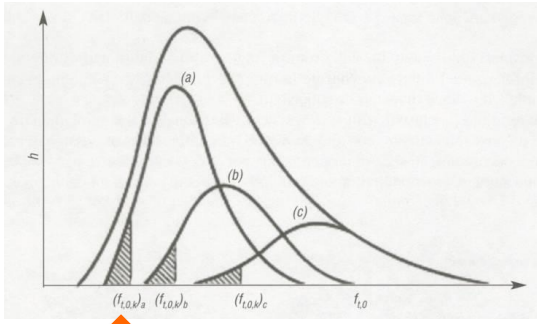
Structural Analysis Considerations
Design Assumptions

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



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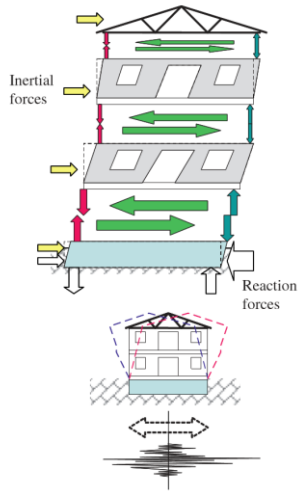
Structural Analysis Considerations
Low-rise issues

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



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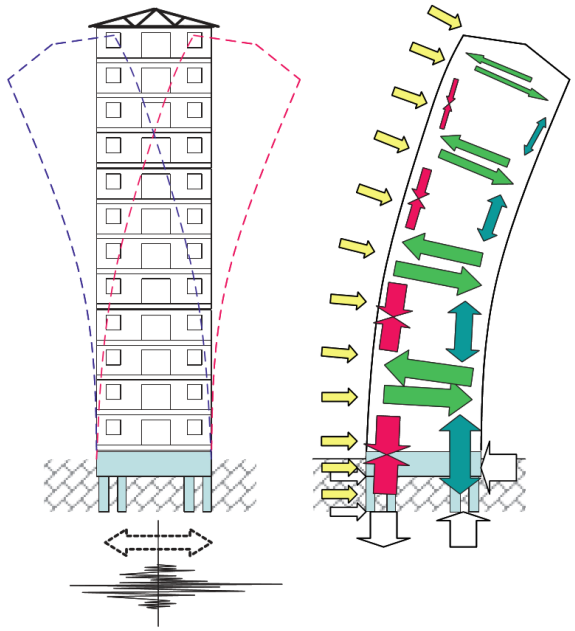
Structural Analysis Considerations
Mid-rise issues

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



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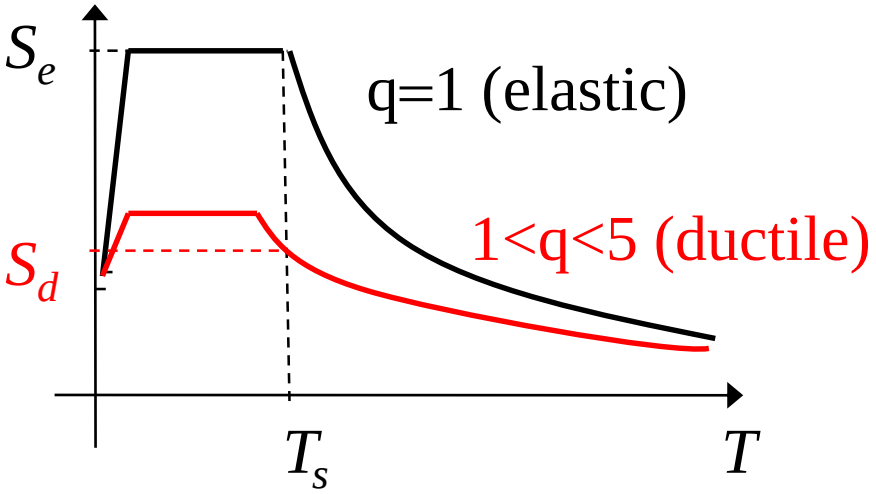
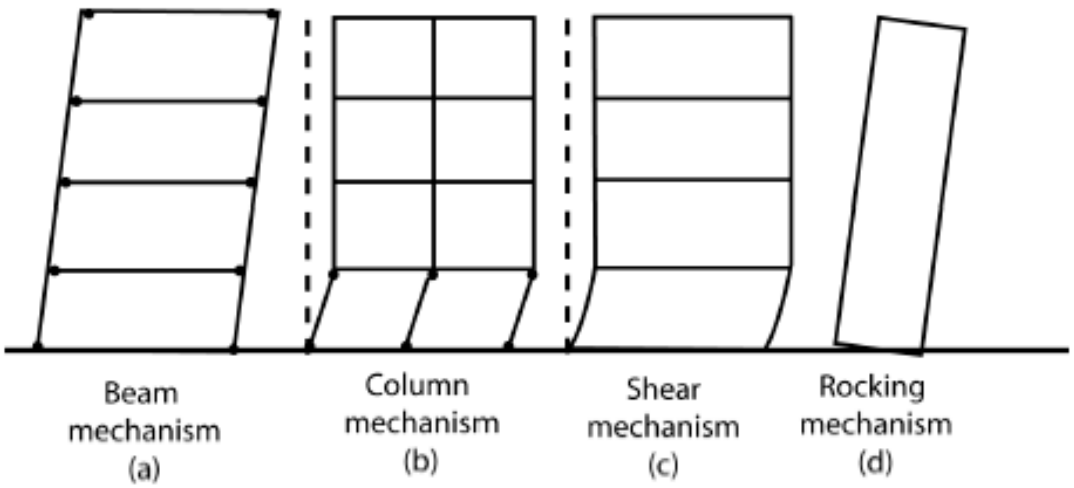
Structural Analysis Considerations
General building behaviour



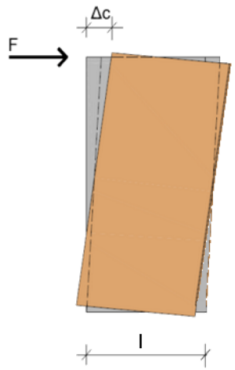


Basic choices:

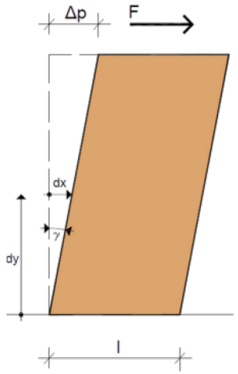
- Elastic or ductile
- Failure mode

Structural Analysis Considerations
Assumed component behaviour

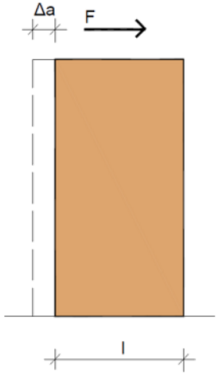
Shear walls



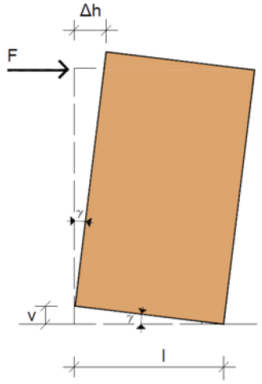
Displacement due to the connections between the sheathing and the frame



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)

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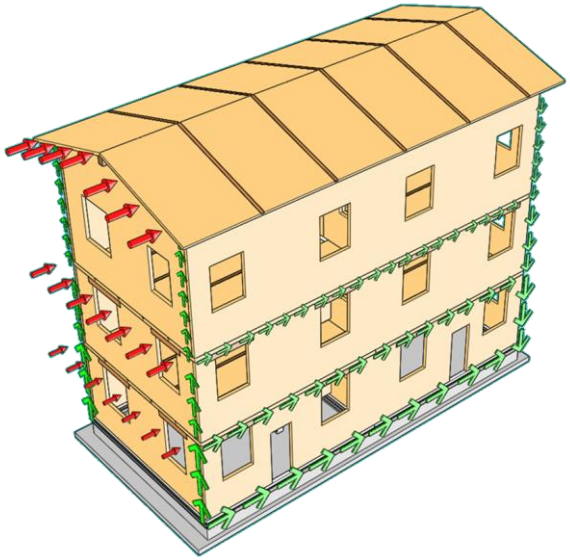
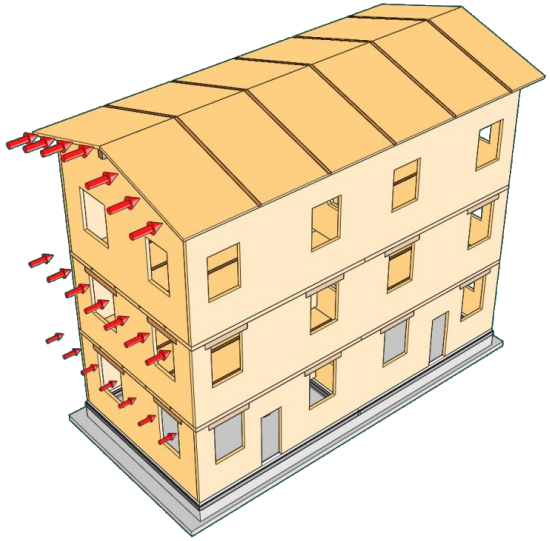
Structural Analysis Considerations
Type of analysis and related tools





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

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Structural Analysis Considerations
Assign elements to Britte or Ductile

Brittle

- Sawn timber
- Glulam, LVL
- Welded joints

Ductile

- CLT, plywood, OSB
- Connections
- Structural steel

SMALL VOLUMES TAKE LARGE AMOUNTS OF ENERGY

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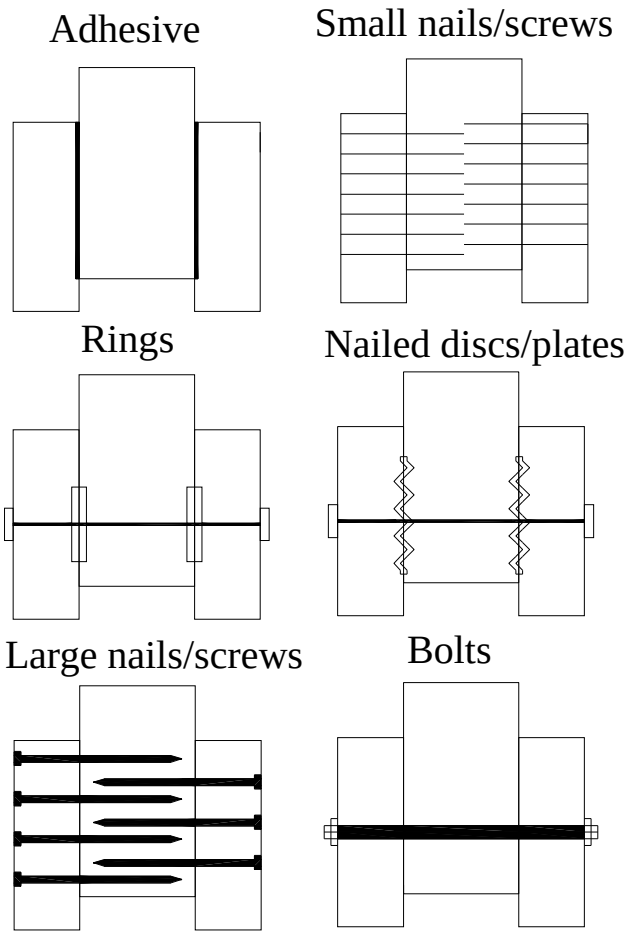
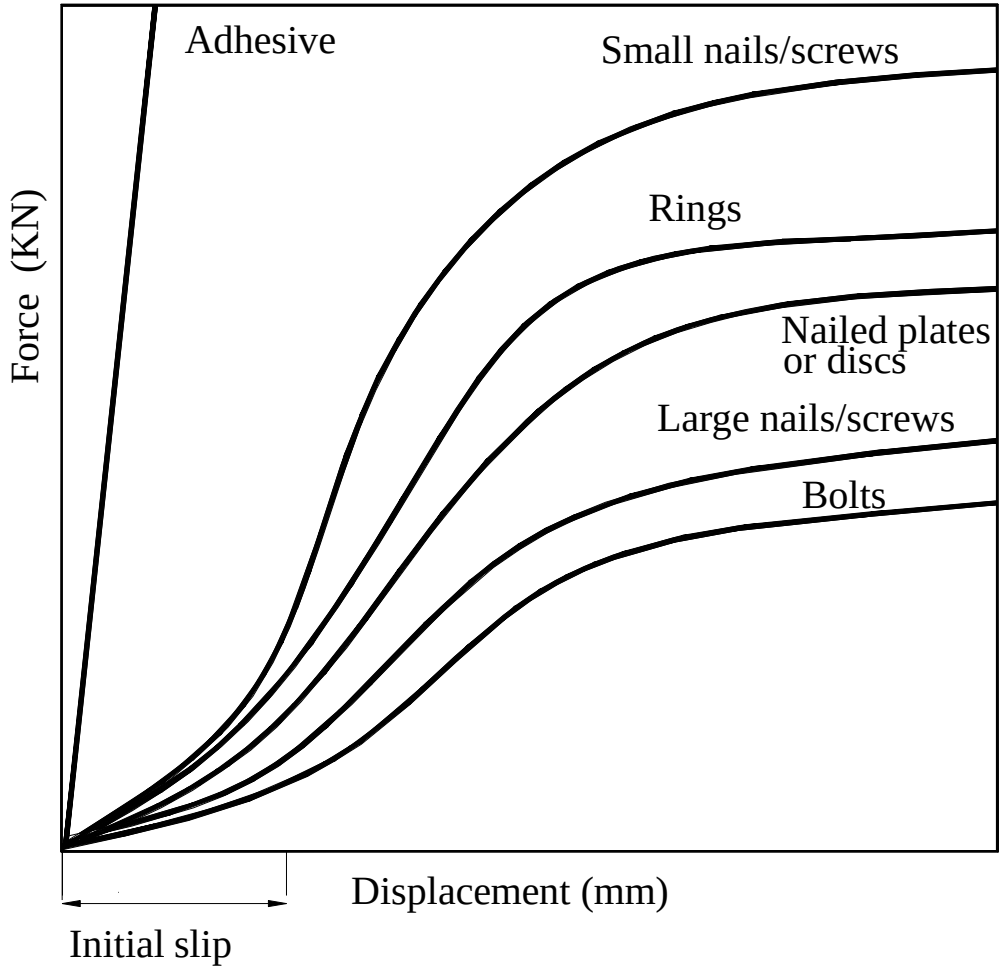
Structural Analysis Considerations
Importance and effect of connections

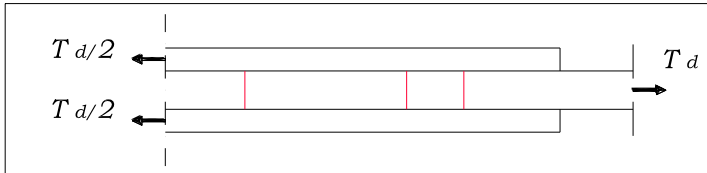
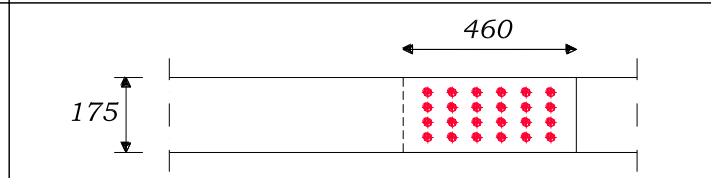
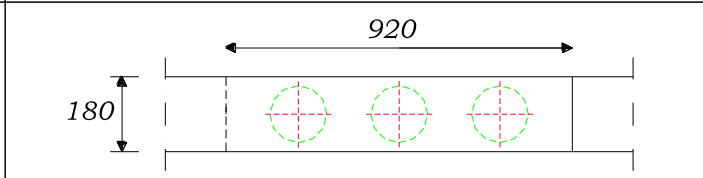




Structural Analysis Considerations
Connections often govern design

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

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OVERVIEW
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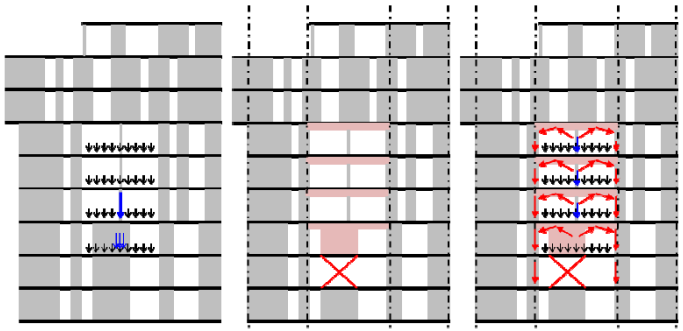
Modelling approaches
Consider typical “timber” features

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)



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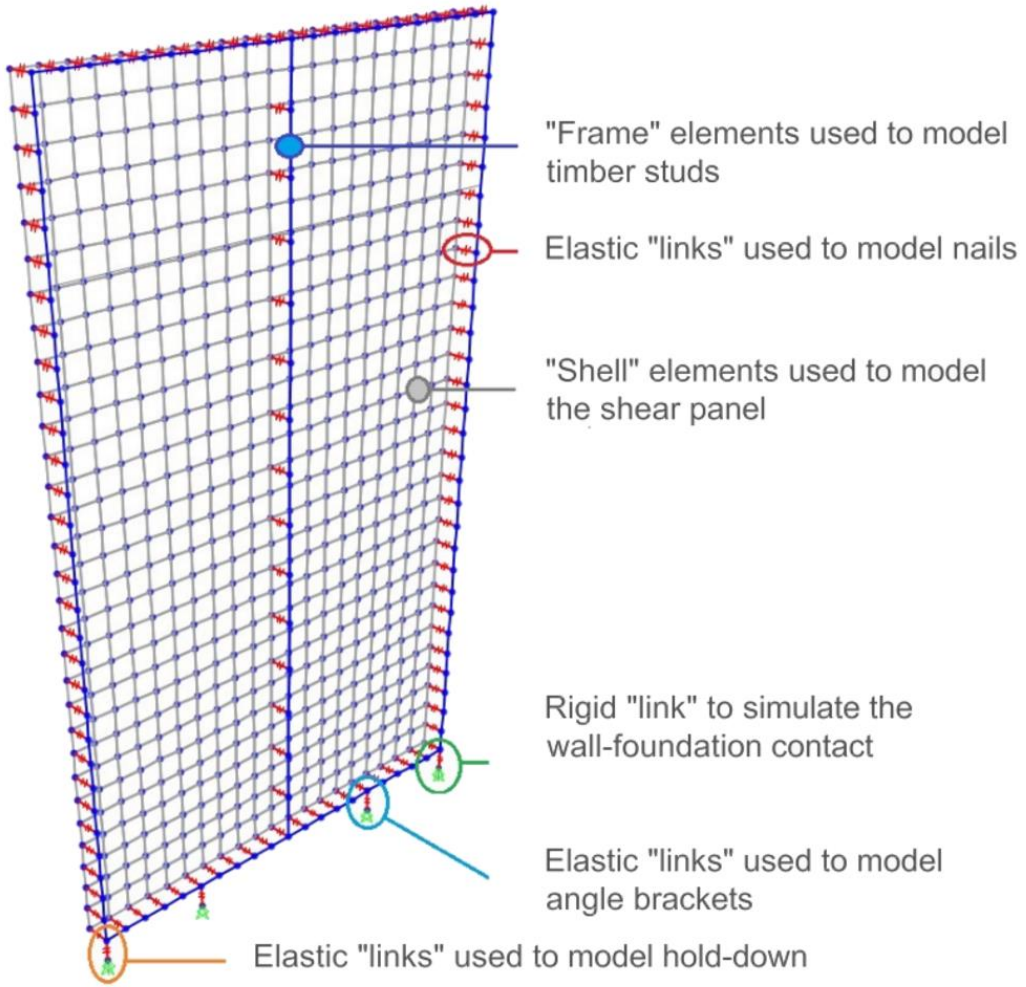
Modelling Approaches
Light Frame Shearwalls



Finite Element Model

Light Frame

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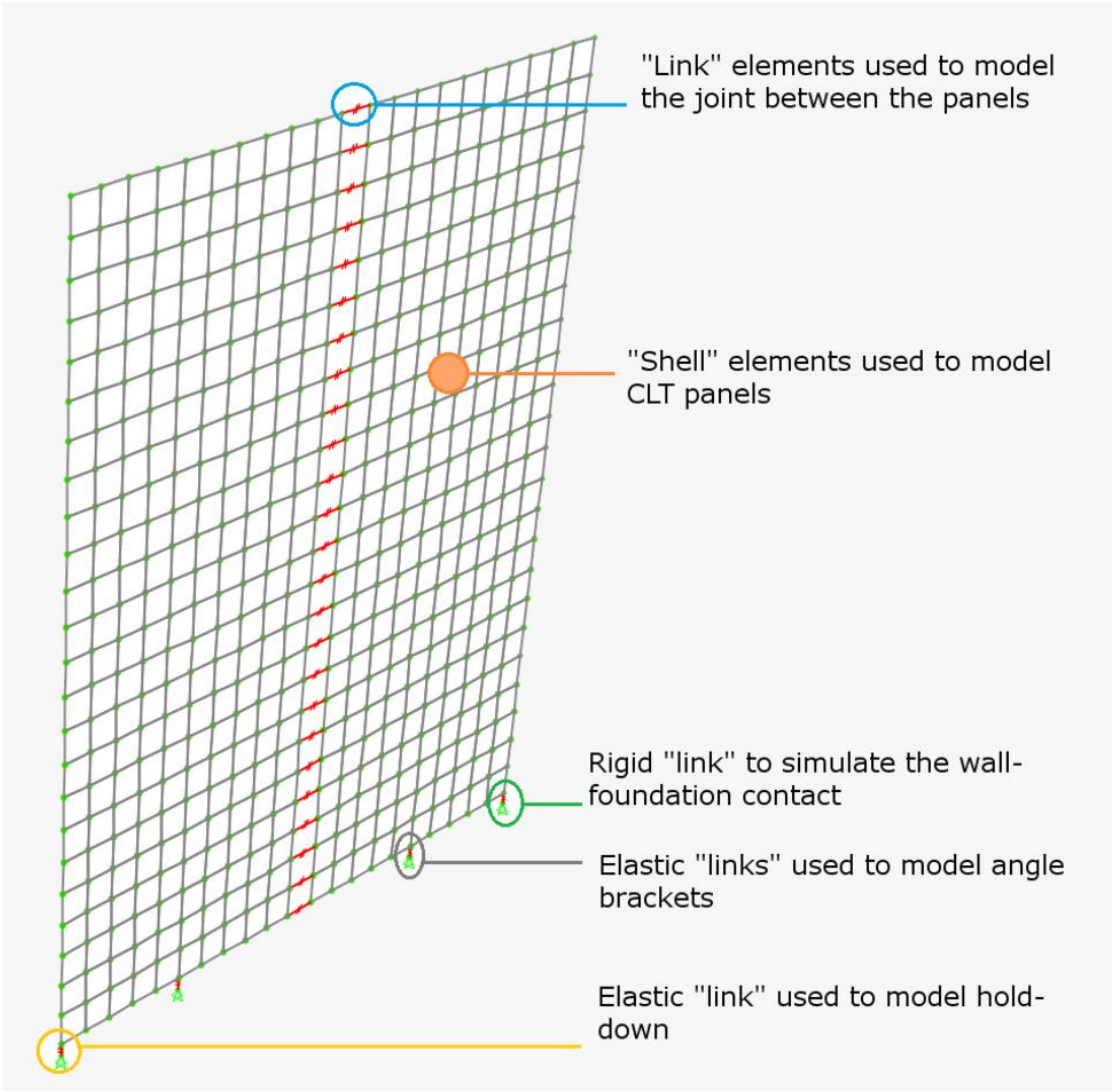
Modelling Approaches
CLT Shearwalls



Finite Element Model

CLT

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Modelling Approaches
A single model for all cases

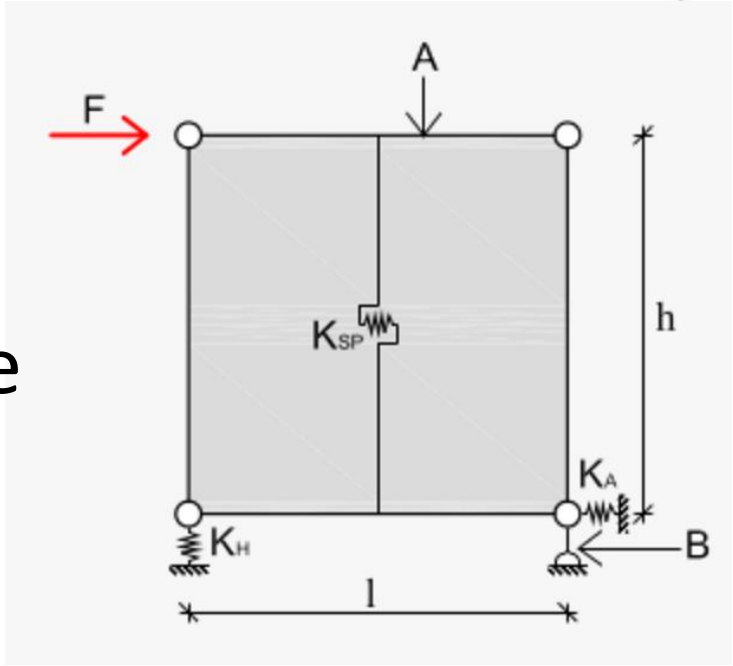
A: labile frame for horizontal loads

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

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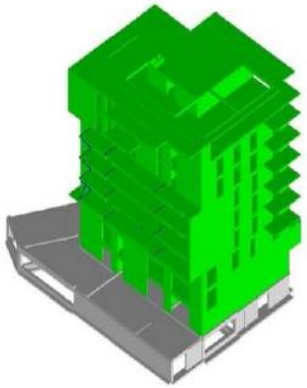
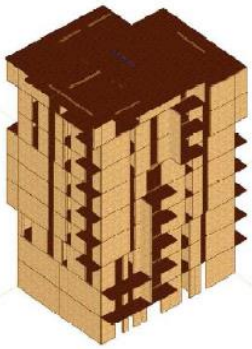
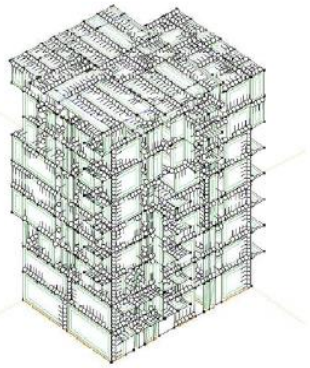
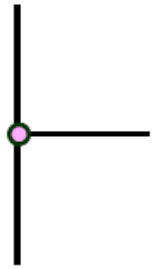
Modelling Approaches
Compare alternatives, understand sensitivity

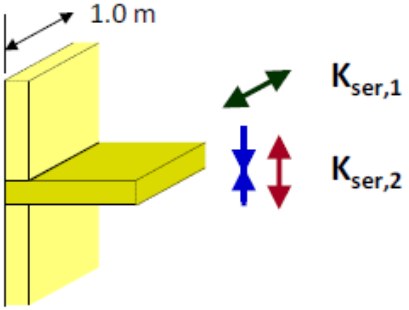


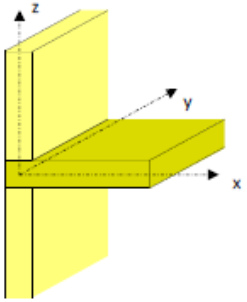


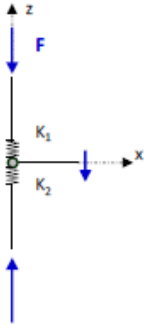


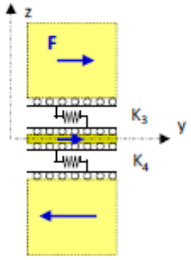
MODELS q=1 AND q=2 JOINT STIFFN. Kser=EC5 AND EC5/20











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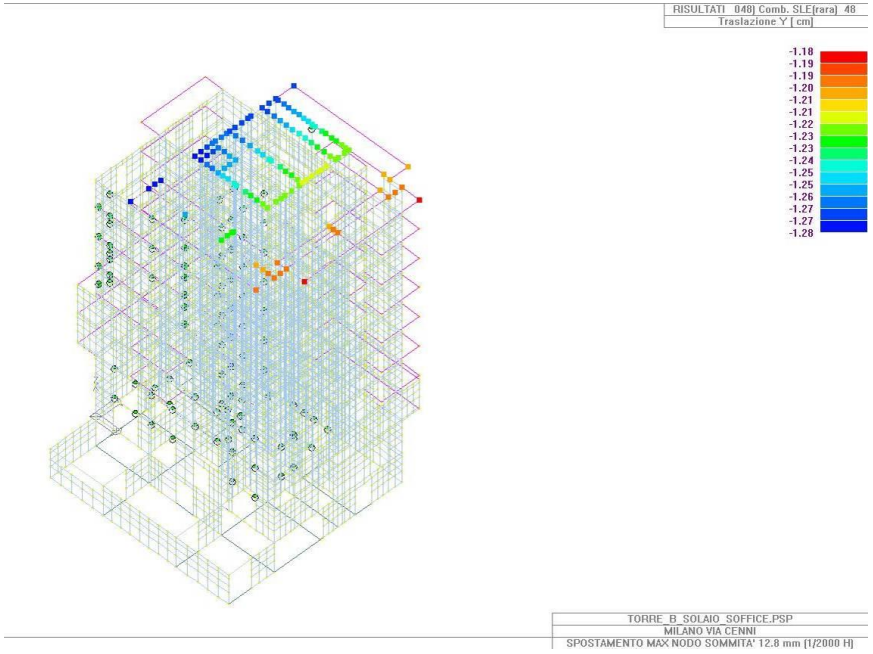
Modelling Approaches
Might need to check for “new” features



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

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

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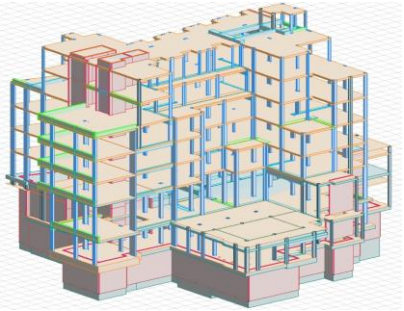
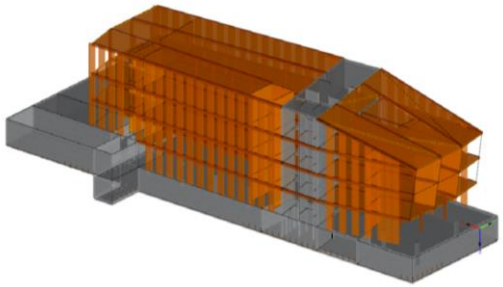
Modelling Approaches
Modelling & Analysis typical sequence





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

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OVERVIEW
Structural timber design software

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

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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

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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)

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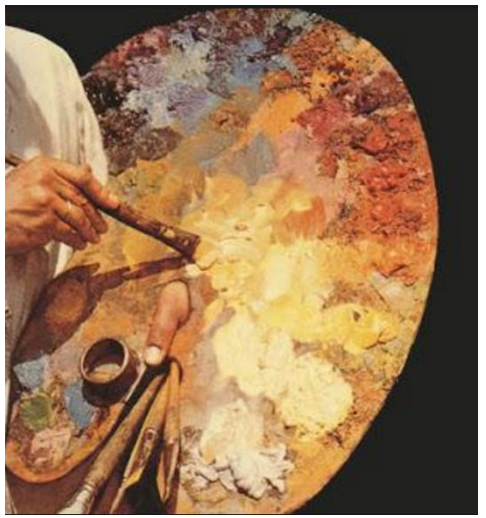
Review Of Available Software
So, what ?

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

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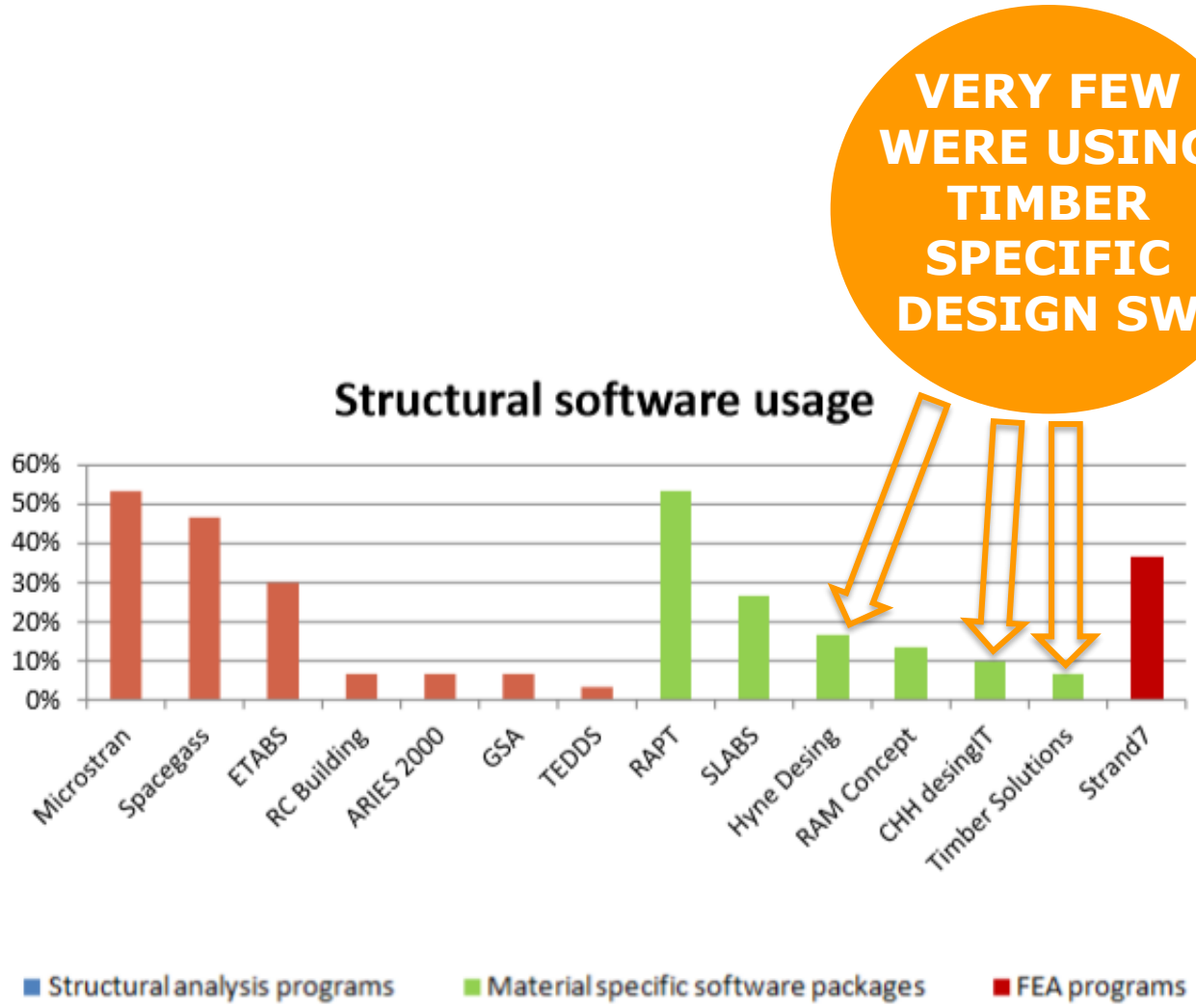
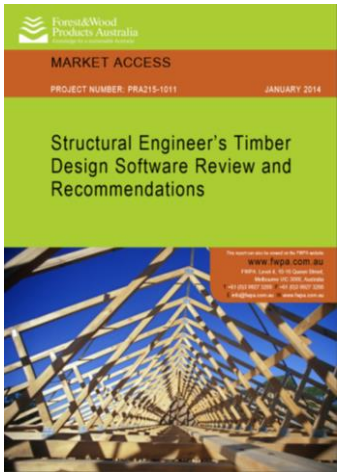
Review Of Available Software
Survey in 2013 (30 engineering firms)





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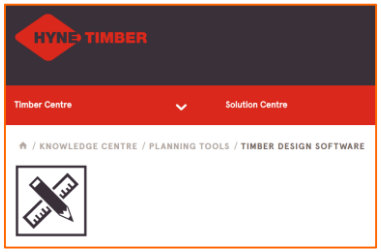
Review Of Available Software
Update – Proprietary & Freeware

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



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Review Of Available Software
Update – Commercial

Timber-specific:

2D single element, easy, AS 1720

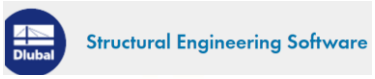
2D assemblies, easy and flexible, EC5

3D, almost complete, EC5

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

With timber modules/databases:

3D suite, US/CAN

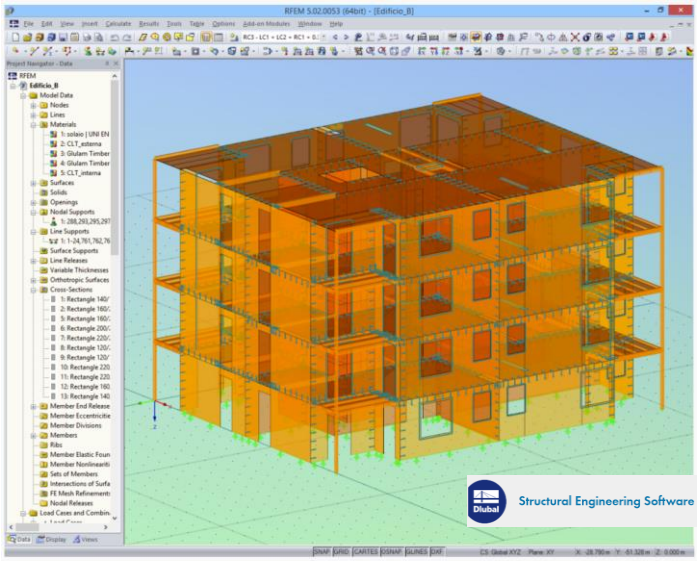


3D suite, EC5

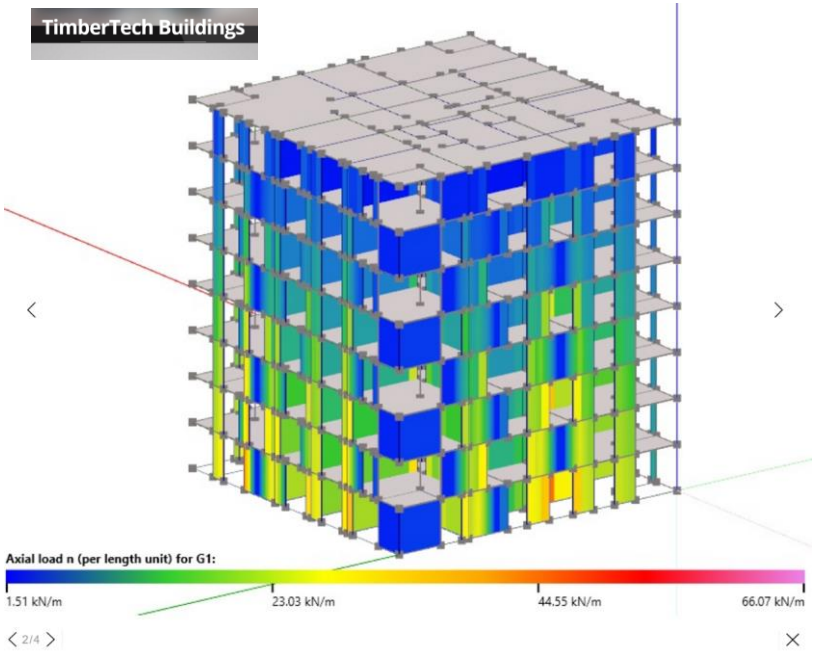
3D suite, EC5

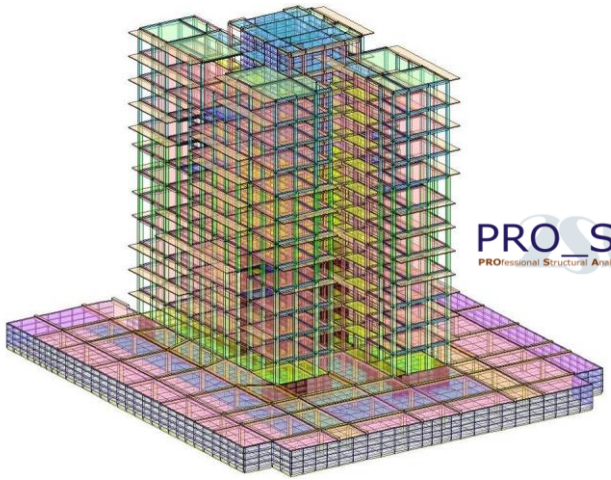
3D suite, multicode

Review Of Available Software
A few pics in mid-rise…



Timber apartment complex in Brescia, Italy | © www.rubner.com





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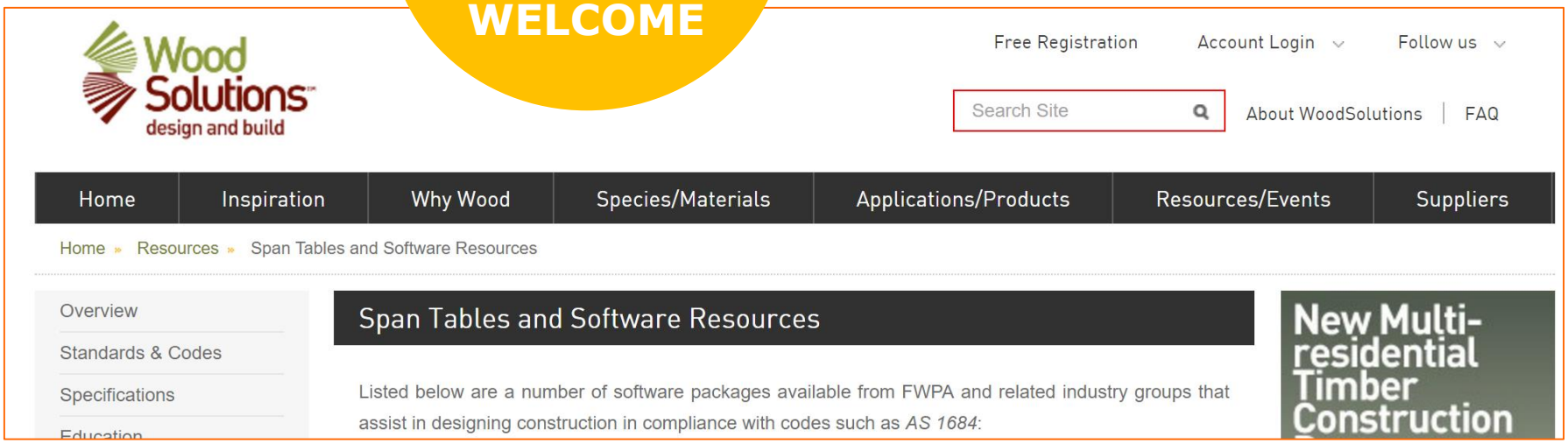
Review Of Available Software
Our software webpage

YOUR COMMENTS AND UPDATES ARE VERY WELCOME



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- **THANK YOU**

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