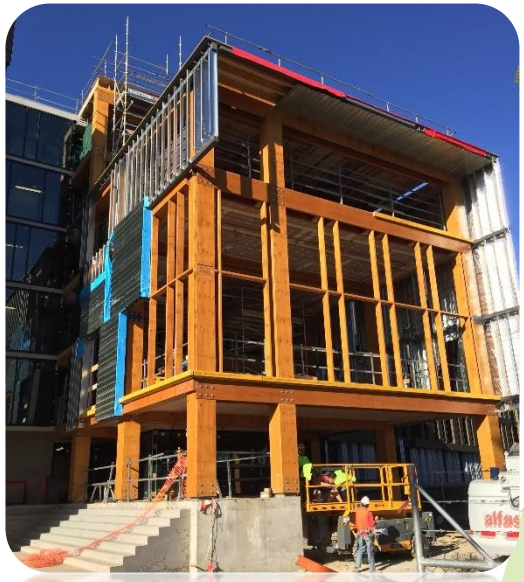
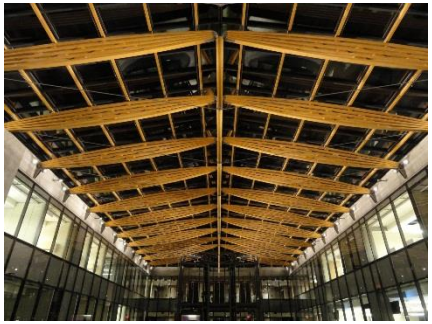
GENERAL RULES OF THUMB FOR MID-RISE TIMBER BUILDINGS

DUNCAN BOURKE, P.Eng



Duncan Bourke, B.Eng, P.Eng (BC, Canada)

- **Structural Engineer -** Fast + Epp, Vancouver, 2007-2012
  - Specialized in timber design-build projects
  - Worked closely with StructureCraft Design-Builders



- **Timber Design and Fabrication Manager -** Timber Imagineering, 2013-present
  - Timber Imagineering specializes in timber design-build & hybrid structures



“RULES OF THUMB”

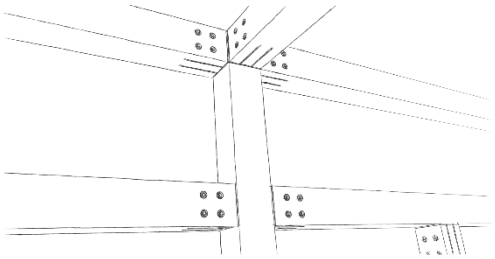
- DEFINITION
  - “A ROUGH, PRACTICAL METHOD OF PROCEDURE”
  - PRIMARILY USED IN DESIGN DEVELOPMENT

- CAVEAT
  - USE ONLY AS A ROUGH GUIDE
- WHAT DOES THIS HELP WITH?
  - CHOOSE APPROPRIATE TIMBER FRAMING SYSTEM(S)
  - DETERMINE FLOOR DEPTHS
  - DETERMINE WALL THICKNESSES
  - PRELIMINARY MEMBER SIZING
  - SOURCE AVAILABLE MEMBERS, CONNECTIONS, ETC.
  - PRELIMINARY DESIGN AND DETAILING
  - PRELIMINARY COSTING

WANT TIMBER? PLANT THE SEED

- **THINK TIMBER EARLY**

- AVAILABLE RESOURCES
  - WOODSOLUTIONS
  - DESIGN-BUILDERS
  - SUPPLIERS, FABRICATORS
  - INDUSTRY EXPERTS
- APPLYING “RULES OF THUMB”
  - SOIL CONDITIONS - TIMBER IS *LIGHT*
  - BUILDING HEIGHTS
  - LAYOUT/SPANS
  - DESIGN & DETAILING
  - ACOUSTICS/FIRE



- DIFFERENT MID-RISE TIMBER SYSTEMS
  - LIGHTWEIGHT
  - MASSIVE TIMBER
  - POST + BEAM

MID-RISE TIMBER SYSTEMS

- LIGHTWEIGHT TIMBER FRAMING
  - Stud walls, timber joists, roof trusses
  - Typically 1-6 storey residential/office structures

- MASSIVE TIMBER FRAMING
  - ALL MEMBERS >75mm DEPTH & WIDTH
  - CLT - CROSS-LAMINATED TIMBER
  - LVL - LAMINATED VENEER LUMBER
  - TCC - TIMBER CONCRETE COMPOSITE
  - Typically 4-9 storeys, sky is the limit!

- POST + BEAM TIMBER FRAMING
  - GLULAM
  - LVL
  - Often used in hybrid with lightweight or massive

WHICH SYSTEM IS RIGHT?

LIGHTWEIGHT

- READILY AVAILABLE
- ECONOMICAL
- KNOWN TO TRADES
- LOWER LATERAL RESISTANCE
- LIMITS ON HEIGHT/SPANS
- TYPICALLY MAX 6 STOREYS

MASSIVE TIMBER

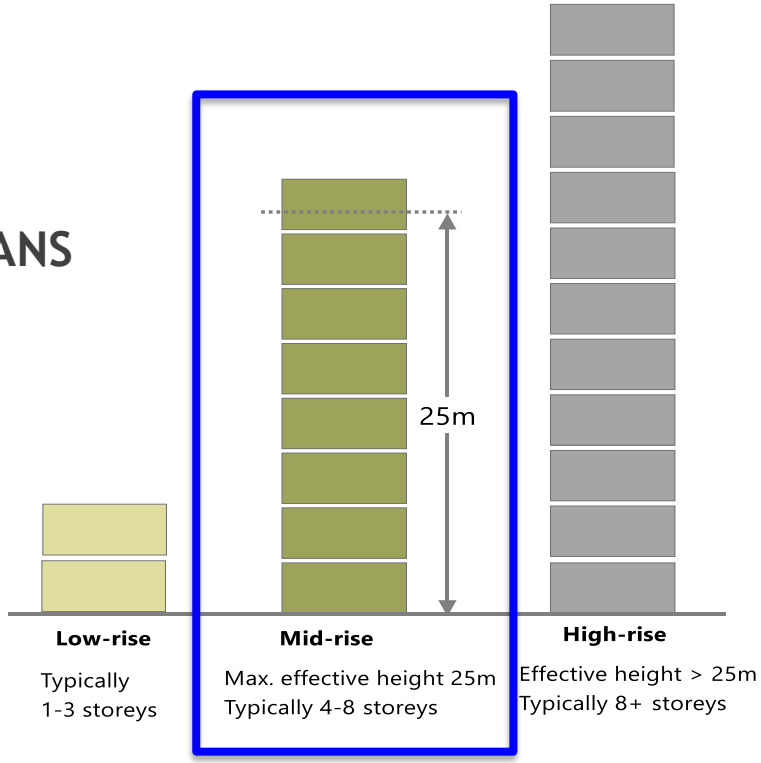
- LIMITED, BUT INCREASING SUPPLY
- INNOVATIVE CONNECTIONS
- ADVANTAGES OF PREFABRICATION
- HIGHER LATERAL RESISTANCE
- TYPICALLY 4-9 STOREYS
- SKY IS THE LIMIT

- OFTEN THE BEST SOLUTION IS A HYBRID OF LIGHTWEIGHT, MASSIVE TIMBER, POST + BEAM, CONCRETE AND/OR STEEL

WHICH SYSTEM IS RIGHT?

DECIDING FACTORS

- BUILDING HEIGHT
- LAYOUT & MEMBER SPANS
- GRAVITY LOADS
- FIRE/ACOUSTICS
- AVAILABILITY
- AESTHETICS



- LATERAL LOADS
  - LIGHTWEIGHT CAN BE LIMITED BY LATERAL LOADS
  - <9 STOREYS CAN HAVE A MASSIVE TIMBER LATERAL SYSTEM
  - >9 STOREYS INCORPORATE A CONCRETE LIFT CORE
- TYPICALLY 2:1 H:W RATIO IS MANAGEABLE

WHEN I SAY BUILD YOU SAY “HOW HIGH?”

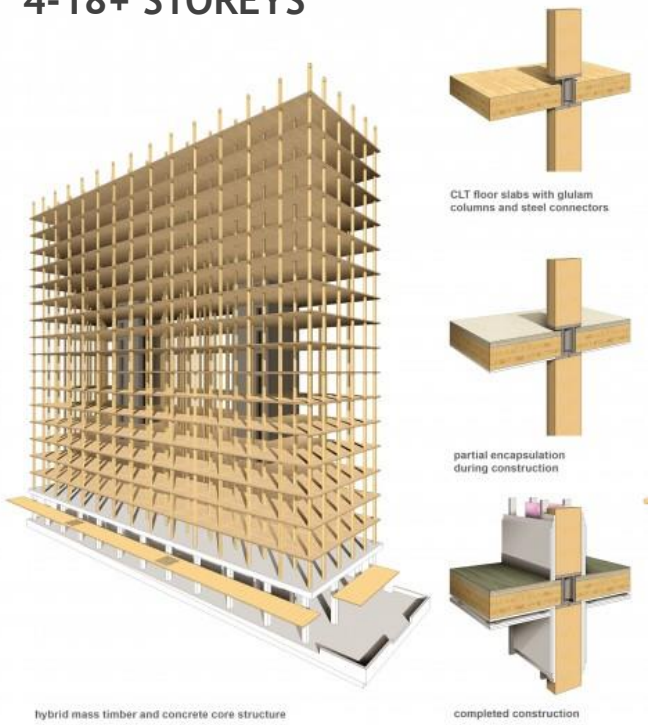
LIGHTWEIGHT

- 4-6 STOREYS

- GOVERNED BY HIGH, CONCENTRATED FORCES

MASSIVE TIMBER

- 4-18+ STOREYS



- MID-RISE UP TO 25m PER CHANGES TO DEEMED TO SATISFY PROVISIONS

(FIRE PROTECTED LIGHTWEIGHT AND MASSIVE TIMBER SYSTEMS ONLY)

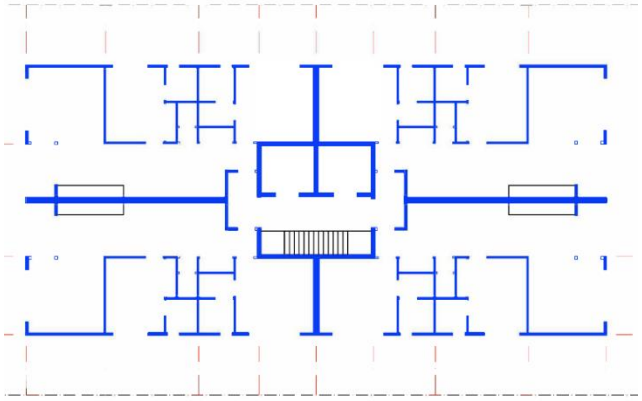
LAYOUT & SPAN CAPABILITIES

LIGHTWEIGHT

- LIGHT STRUCTURE
- TYPICALLY 4-6m SPANS
- LOTS OF WALL SUPPORT
- ALINING STRUCTURE
- LIMITED SPANS
- MID-RISE RESIDENTIAL/OFFICE

MASSIVE TIMBER

- RELATIVELY LIGHT STRUCTURE
- IDEALLY 4-6m SPANS, BUT CAN ACCOMMODATE LONGER
- MORE VERSATILE LAYOUTS
- CAN BE SIMILAR TO CONCRETE
- MID-RISE RESIDENTIAL/OFFICE

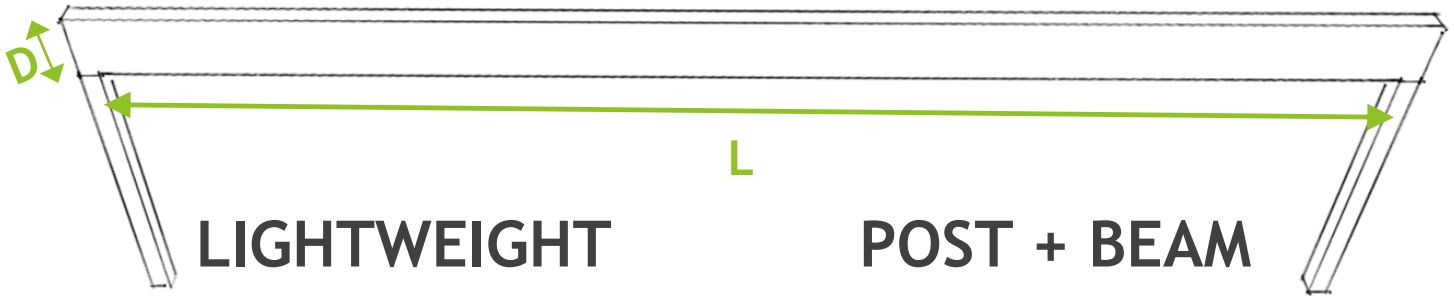


POST + BEAM

- CAN BE USED TO ACCOMMODATE LARGER SPANS

SPANS

LIGHTWEIGHT, POST + BEAM



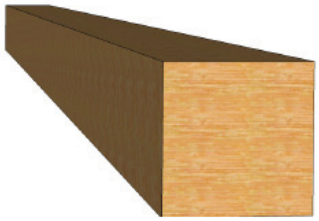
LIGHTWEIGHT

- BEAMS/LINTELS
  - 6m MAX
  - L/D = 10-14
- SOLID JOISTS
  - 6m MAX
  - L/D = 14-18
- ENGINEERED I-JOISTS
  - 8m MAX
  - L/D = 16-20

POST + BEAM

- GLULAM/LVL BEAMS
  - 18m MAX TYPICAL
  - L/D = 12-16
- GLULAM/LVL JOISTS
  - 8m MAX TYPICAL
  - L/D = 16-20
- DEPTH/WIDTH
  - D/W = 2<4<6

SPANS
TIMBER COLUMNS



PC-S ProColumn (LVL10)

181 - ~STOREY HEIGHTS
284 - ~L/30 RATIOS

Axial Capacities

ϕN_c (kN) k_1=1.0

Leff (m) / SIZE (mm)	1.0	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	ϕM_x (kN-m)
90x90	231	68.8	44.0	30.6	22.5	17.2	13.6								4.6
120x120	512	218	139	96.7	71.0	54.4	43.0	34.8	28.8	24.2					10.6
140x140	741	401	258	179	132	101	79.6	64.5	53.3	44.8	38.2	32.9			16.5
150x150	851	515	340	236	173	133	105	85.0	70.2	59.0	50.3	43.3	37.8		20.1
190x190	1365	1083	842	608	446	342	270	219	181	152	129	112	97.2	85.4	39.3
200x200	1512	1253	1000	746	548	420	332	269	222	186	159	137	119	105	45.5
240x240	2177	2048	1744	1439	1135	870	687	557	460	387	329	284	247	218	76.4
300x300	3402	3402	3200	2820	2439	2059	1678	1359	1124	944	804	694	604	531	144.2
360x360	4899	4899	4899	4608	4152	3695	3238	2782	2330	1958	1668	1438	1253	1101	242.3
400x400	6048	6048	6048	6028	5520	5013	4505	3998	3491	2984	2542	2192	1910	1678	327.0
450x450	7655	7655	7655	7655	7486	6915	6344	5774	5203	4632	4061	3511	3059	2688	457.2
525x525	10419	10419	10419	10419	10419	10300	9634	8968	8302	7636	6971	6305	5639	4981	709.0
600x600	13608	13608	13608	13608	13608	13608	13562	12801	12040	11279	10518	9757	8996	8235	1036.7

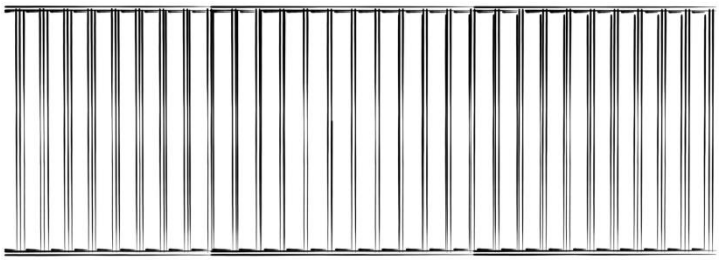
Custom sizes and materials are available, contact Timber Imagineering for more information.

SPANS

LIGHTWEIGHT WALL FRAMING

STUD WALL SIZES

- BASED ON
  - HEIGHT
  - FLOOR LOAD WIDTH
  - COST



		Single Stud FLW = 5.25 m	Single Stud FLW = 3.38 m	Single Stud FLW = 4.38
Level 7	Plates	M10 90 x 45	M10 70 x 35	M10 90 x 35
	Studs	M10 90 x 45 @ 450 crs	M10 70 x 45 @ 450	M10 90 x 45 @ 600
Level 6	Plates	M10 90 x 45	M10 90 x 35	M10 90 x 35
	Studs	M10 120 x 45 @ 450 crs	M12 90 x 45 @ 450	M10 120 x 45 @ 600
Level 5	Plates	M10 140 x 35	M10 120 x 35	LVL 130 x 35
	Studs	M12 140 x 35 @ 450 crs	M12 120 x 35 @ 450	LVL 130 x 35 @ 600
Level 4	Plates	LVL 130 x 35	M10 120 x 35	LVL 130 x 35
	Studs	LVL 130 x 35 @ 450 crs	M12 120 x 45 @ 450	LVL 130 x 35 @ 600
Level 3	Plates	SD3 F17 130 x 35	LVL 130 x 35	SD3 F17 130 x 35
	Studs	LVL 130 x 35 @ 450 crs	LVL 130 X 35 @ 450	LVL 130 x 35 @ 600
Level 2	Plates	CLT plate or nogging plate	LVL 130 x 35	CLT plate or nogging plate
	Studs	LVL 130 x 35 @ 450 crs	LVL 130 X 35 @ 450	LVL 130 x 35 @ 600
Level 1	Plates	CLT plate or nogging plate	LVL 130 x 35	CLT plate or nogging plate
	Studs	**LVL 130 x 35 @ 450 crs**	**LVL 130 X 35 @ 450**	**LVL 130 x 35 @ 600**

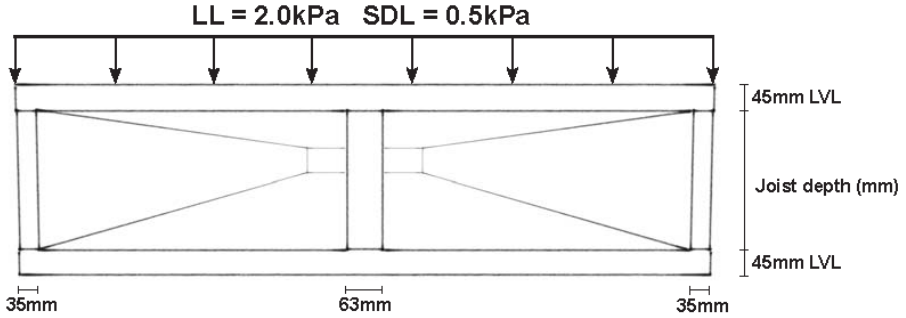
SOURCE: Andrew Dunn

SPANS
PANEL SYSTEMS

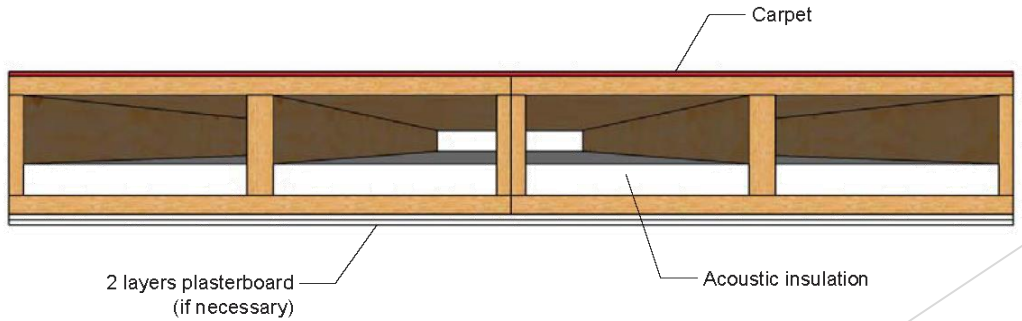
CASSETTE PANELS

- L/D = 24-30

SPAN TABLES - 45-45 PROPANEL



PANEL TYPE	45-130-45	45-150-45	45-170-45	45-200-45	45-240-45	45-270-45	45-300-45
Span (m)	6.5	6.8	7.2	7.7	8.3	8.7	9.1

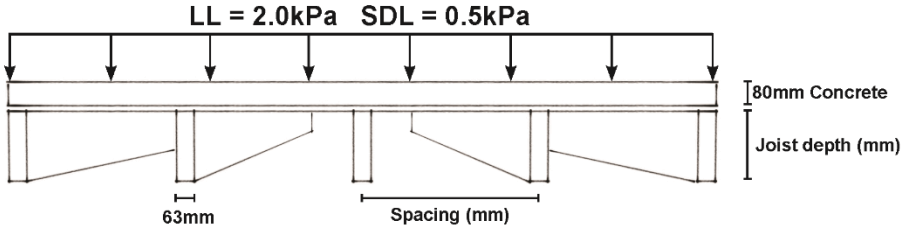


PANEL SECTION

SPANS
PANEL SYSTEMS

TIMBER CONCRETE COMPOSITE

- L/D = 12-20



SPAN (m)	Joist Depth (mm)							
Spacing (mm)	150	200	240	300	360	400	450	600
300	**5.0**	**5.9**	**6.4**	**7.2**	**7.9**	**8.3**	**8.8**	**10.4**
400	**4.7**	**5.5**	**6.1**	**6.8**	**7.5**	**7.9**	**8.5**	**9.9**
600	**4.2**	**4.9**	**5.5**	**6.3**	**6.9**	**7.4**	**7.9**	**9.3**
800	**4.0**	**4.5**	**5.1**	**5.9**	**6.5**	**6.8**	**7.4**	**8.8**

- EXCLUDES SERVICES, FIRE, ACOUSTIC REQUIREMENTS

SPANS
MASSIVE TIMBER

CLT FLOOR SYSTEMS

- L/D = 24-36

CLT PANEL[1] (mm)	CONCRETE SLAB (mm)	SPAN[2] (mm)	L/D
90	135	3200	36
105	150	3700	35
139	190	4500	32
175	215	5100	29
191	235	5600	29
243	260	6400	26
245	275	6600	27
315	315	7600	24

1. EXCLUDES SERVICES, FIRE, ACOUSTIC REQUIREMENTS
2. SINGLE SPAN, TYPICALLY VIBRATION CONTROLLED

- ROOF PANELS L/D = 36-48

SPANS
MASSIVE TIMBER

CLT/LVL WALL SYSTEMS

- L/D = 30-50
- HIGH VARIABILITY DUE TO:
  - GRAVITY LOADS
  - NUMBER OF FLOORS
  - WIND LOADS
  - FLOOR-FLOOR HEIGHTS
- EXAMPLE: 5 STOREY RESIDENTIAL BUILDING, 3m STOREYS
  - 105mm LVL (125mm CLT) LOWER LEVEL WALL LVL THICKNESS
  - 75mm LVL (OR 90mm CLT) UPPER LEVEL WALL LVL THICKNESS
- CONSULT SUPPLIER/ENGINEER FOR PRELIM WALL SIZES
- EXCLUDES SERVICES, FIRE, ACOUSTIC REQUIREMENTS

AVAILABILITY
LIGHTWEIGHT, POST + BEAM

- LIGHTWEIGHT - WHAT'S AVAILABLE?
  - CONSULT WOODSOLUTIONS, INDUSTRY RESOURCES
  - SIZES – WIDTH, DEPTH, LENGTH
  - MATERIALS
  - GRADES

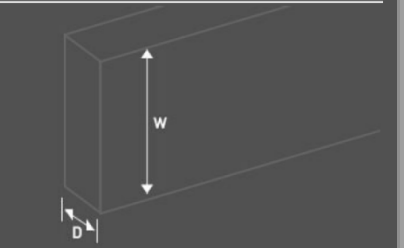
- POST + BEAM - EXAMPLE TIMBER DIMENSIONS – GLULAM AND LVL

Unilam® GL18 Hardwood (F27) Specifications

Availablein the following sizes:

AUSTRALIAN TASMANIAN OAK / VIC ASH

Depth	38mm	65mm	85mm	115mm
150mm				
180mm				
210mm				
240mm				
270mm				
300mm				
330mm				
360mm				
390mm				
420mm				
450mm				
480mm				
510mm				
540mm				
570mm				
600mm				



SOURCE: Laminated Timber Supplies

hySPAN traditional size range

hySPAN solutions range†			
35 mm	45 mm	63 mm	75 mm
Section Depth			
90	90	90	-
120	120	-	
130	130	130	-
140	140	-	
150	150	150	150
170	170	170	-
190	190	-	
200	200	200	-
240	240	240	-
290	290	-	
-	300	300	300
-	360	360	-
-	400	400	400
-	-	450	-
-	-	-	525
-	-	600	600

hySPAN+ (F17 graded LVL) hySPAN

Available in both hySPAN+ and hySPAN

†Available H2-S Termite Treated and Untreated

SOURCE: Carter Holt Harvey

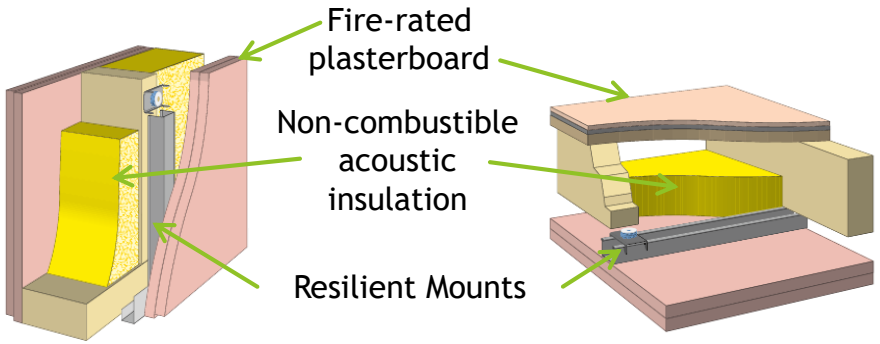
AVAILABILITY
MASSIVE TIMBER

- CLT

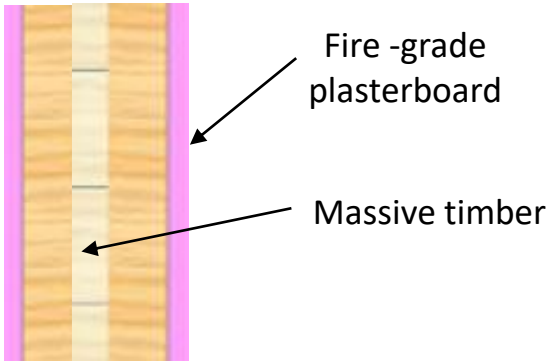
- LVL
  - UP TO 105mm THICK
  - 1200mm WIDE (AUSTRALIA)
  - 2400mm WIDE (IMPORTED)
  - 18m LONG

FIRE/ACOUSTICS

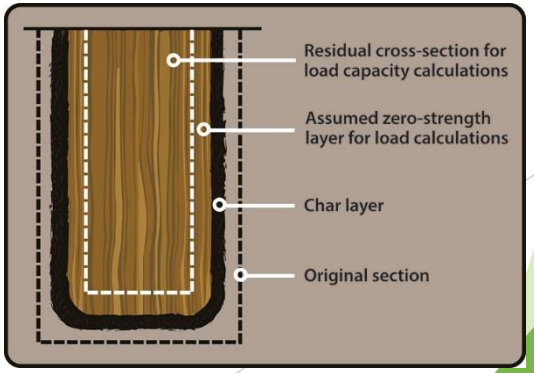
- LIGHTWEIGHT FRAMING



- CLT/LVL



- POST + BEAM - FIRE
  - REDUCED SECTION & LOADS
  - ALTERNATIVE SOLUTION



FABRICATION

- SOME PRACTICAL THINGS TO KEEP IN MIND

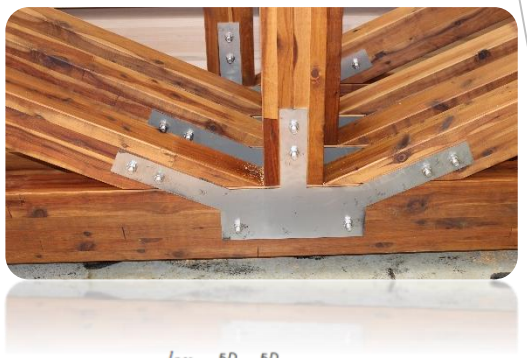
- CONSTRUCTABILITY
  - HOW IS THIS GOING TO BE BUILT?
  - FABRICATION SEQUENCE

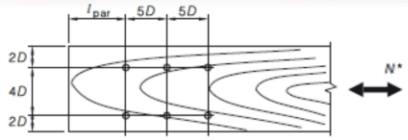
- ADVANTAGES OF PREFABRICATION
  - SPECIALIZED
  - PARALLEL CONSTRUCTION
  - CONTROLLED ENVIRONMENT
  - QUALITY ASSURANCE
  - THE FULL PACKAGE

- TOLERANCE
  - NEVER PERFECT, EVEN WITH CNC
  - NEED TO BUILD IN TOLERANCE
  - DEALING WITH TIMBER SHRINKAGE IN DETAILS

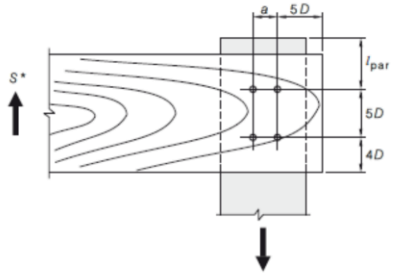
DETAILING

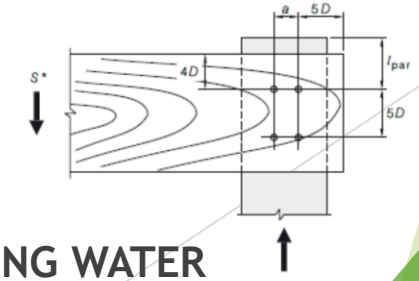
- STAINLESS STEEL vs GALV, ZP
  - SS CAN BE 3-5x MORE EXPENSIVE
- M16 vs M20 BOLTS
  - M16 - F=0.80
  - M20 - F=0.65
  - SIMILAR CAPACITES
  - M16 MUCH EASIER TO WORK WITH
- BOLT SPACINGS
  - AS1720.1
- ALLOW FOR SHRINKAGE OF TIMBER
- ALLOW FOR DRAINAGE & AVOID STANDING WATER





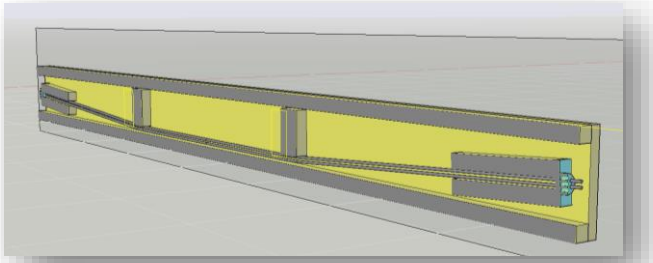
(a) Load applied parallel to grain





LOOKING TO THE FUTURE

- INNOVATIVE CONNECTIONS AND FASTENERS



- POST-TENSIONED TIMBER FRAMES

- CNC FABRICATION

- MODULAR CONSTRUCTION

THANK YOU!

QUESTIONS?