

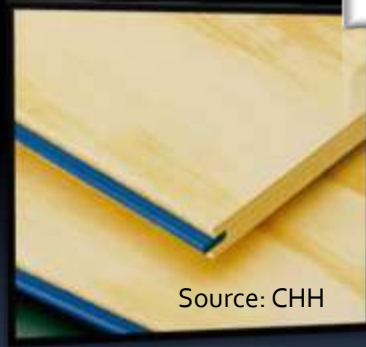
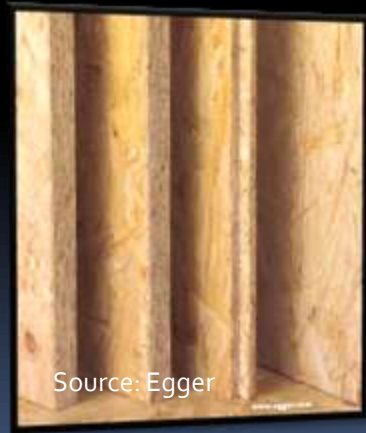
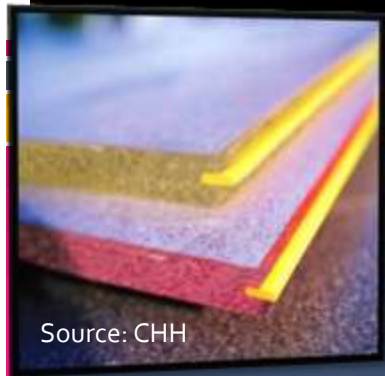
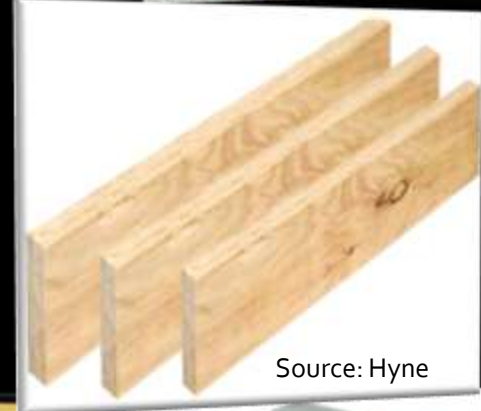


Gluing Structural Timber Products
Stephen Bolden
2 November 2011

GLUING STANDARDS

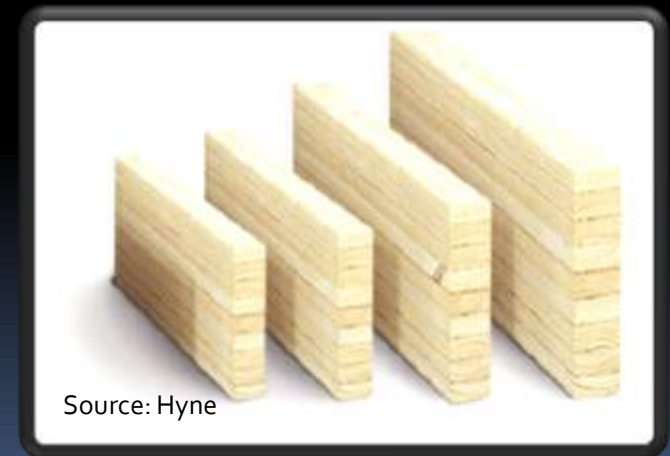
WHAT'S ETP

Engineered Timber Products (ETP) are wood based products bonded together with adhesives, typically manufactured from wood fibre, particles, strands, flakes, veneers, solid wood sections, or any combination of these



History of adhesives in ETP

- Traditional use of PRF
- Broad code and user acceptance as durable structural adhesive
- Emergent desire for suitable structural adhesives to achieve:
 - High production
 - Lower costs
 - Ease of use



Adhesive Requirements

- Capable of successful bonding of structural timber:
 - Finger jointing lamination feedstock
 - Face lamination
- Durable bond to Service Class 3:
 - AS/NZS 4364, AS/NZS 1328, AS/NZS 5068
 - Expected 50 year design life glued timber product
- Structural performance wrt:
 - Creep
 - Fire
- Appearance



Hierarchy of standards for glulam

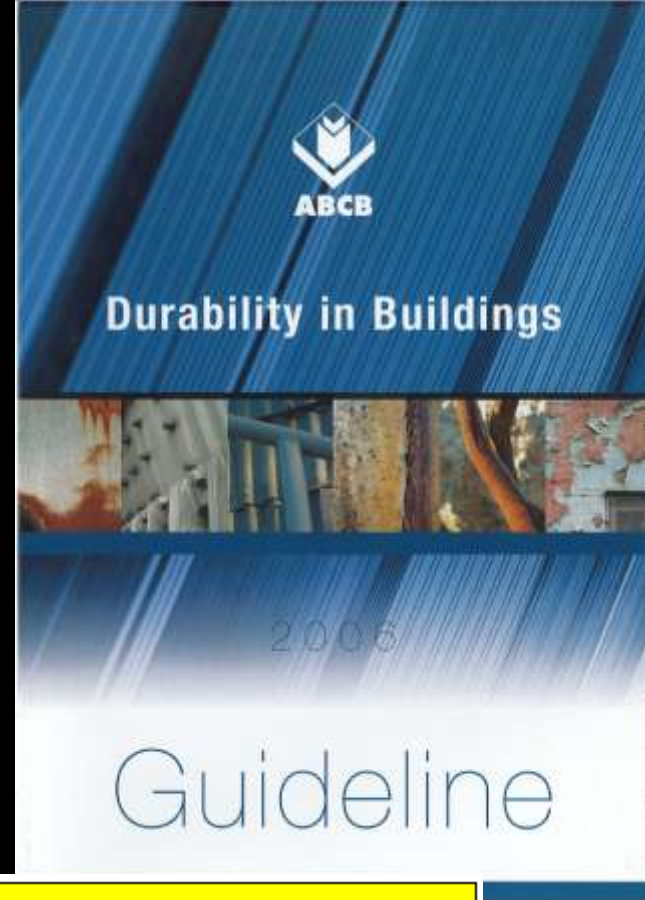
Standard / code	Description
Building Code of Australia (BCA)	Called up by relevant State Building Act
AS 1720.1-2010 <i>Timber structures Part 1: Design methods</i>	Primary reference standard to the BCA. Contains deemed to comply design properties and specifies manufacture to AS/NZS 1328
AS/NZS 1328-1998 <i>Glued laminated structural timber</i>	Specifies performance requirements for glued laminated timber members including adhesive types I and II as defined in AS/NZS 4364
AS/NZS 5068-2006 <i>Timber – Finger joints in structural products – production requirements</i>	Specifies performance requirements for finger joints in glued laminated timber members including adhesive types I and II as defined in AS/NZS 4364
AS/NZS 4364-2010 <i>Timber – Bond performance of structural adhesives</i>	Specifies performance requirements for adhesives according to their suitability for use for load bearing timber structures in defined climatic exposures

Code requirements for Glulam

- Performance based solution to BCA
 - Deemed to satisfy
- Structural design performance requirements
 - *AS1720.1:2010 Timber Structures – Part 1: Design methods*
 - Primary reference standard
- Glulam lamination
 - *AS/NZS 1328.1:1998 Glued laminated structural timber – Part 1: Performance requirements and minimum production requirements*
- Finger jointing
 - *AS/NZS 5068:2006 Timber – Finger joints in structural products – Production requirements*
- Adhesives
 - *AS/NZS 4364:2010 Timber – Bond performance of structural adhesives*

BCA Design life of buildings and components

- Building Code inferred durability requirements



Design life of buildings (dl), (years)		Design life of components or sub-systems (years)		
Category	No. of years	Category		
		Readily accessible and economical to replace or repair	Moderate ease of access but difficult or costly to replace or repair	Not accessible or not economical to replace or repair
Short	1<dl<15	5 or dl (if dl < 5)	dl	dl
Normal	50	5	15	50
Long	100 or more	10	25	100

Notes:

1. Extracted from ABCB *Durability in Buildings*.
2. The design life of buildings should be taken as "Normal" for all building importance categories unless otherwise specified.

AS/NZS 4364-2010

- Used by adhesive manufacturer
- Adhesive classified as Service Class 1, 2 or 3
- Performance tests:
 - Resistance to biological degradation
 - pH of cured adhesive
 - Resistance to shear
 - Resistance to delamination
 - Resistance to creep
- Manufacturer should provide certificate

Service Class

- Adhesive shall be classified as suitable for appropriate Service Class
- AS/NZS 4364 – Table 6.1.1

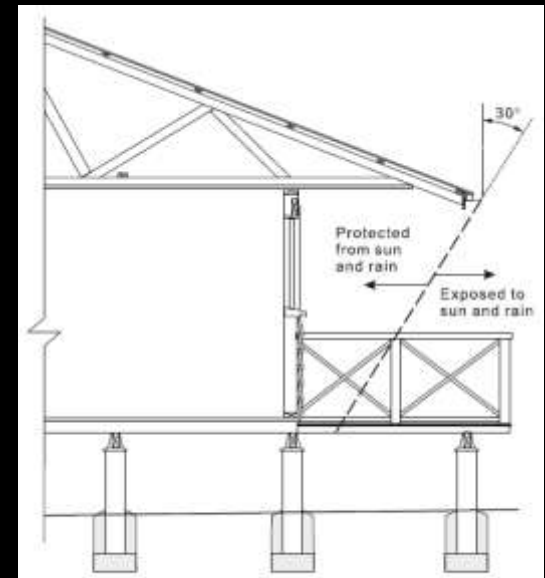


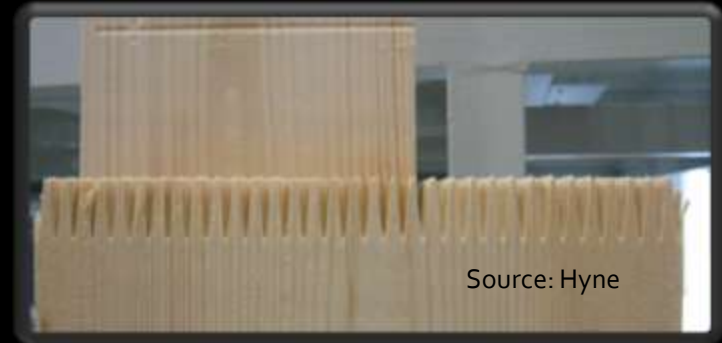
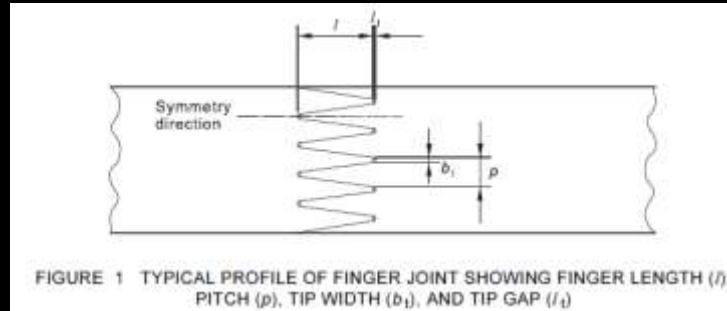
FIGURE 2 TIMBER DIRECTLY EXPOSED TO SUN AND RAIN

ADHESIVE FOR GIVEN SERVICE CONDITIONS

Service Class	Description	Timber equilibrium moisture content (EMC)	Temperature	Suitable adhesive type*
1	Interior	≤12%	<50°C	II
2	Exterior but protected	Untreated timber—≤18%;	<50°C	II
		Multi-salts treated softwood—≤20%	Any	I
3	Exterior	Any	Any	I

* The adhesive type is referenced in the EN Standards referred to in Method B procedures of this Standard and also in AS/NZS 1328.1 and AS 5068.

AS5068 Requirements



- Requirements for timber, adhesive, moisture content, cutting, bonding and treatment.
- Assumes feedstock for glulam (proposed amendment)

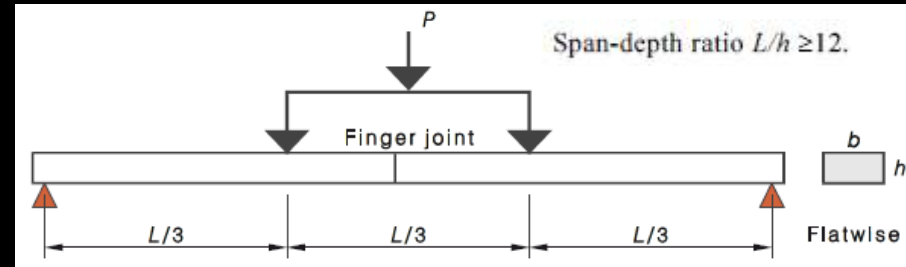
Glued laminated timber	Finger jointed timber
(i) $f_{b,ff} \geq 0.74 f'_{b,timber}$ or	(i) $f_{b,ff} \geq f'_{b,timber}$ or
(ii) $f_{t,ff} \geq 0.85 f'_{t,timber}$	(ii) $f_{t,ff} \geq f'_{t,timber}$

- Timber durability / treatment (AS1604) matching service class and application.
- Manufacturing to align with adhesive manufacturer's spec. - documented

AS5068 Requirements

- Strength - FJ strength assessment
 - Bending or tension testing of 3 FJ per batch
 - Exceed characteristic strength

- Integrity - Adhesive bond durability (SC2-3)
 - Wet conditioning of specimens (4/month)
 - Assessment of wood fibre failure (WFF)



WOOD FAILURE

percent

	Average	Minimum
Hardwood	40	20
Softwood	60	30

NOTE: The values are to be interpreted as the average for all fingers.

AS/NZS 1328.1 Requirements

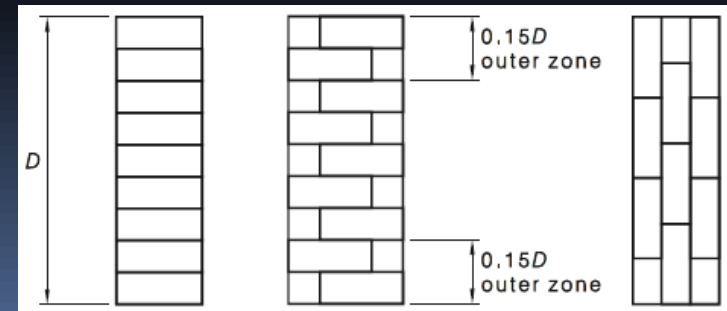
- Requirements for glulam members and production
- Part 2 provides a guide for Part 1
- Timber stress graded to
 - AS/NZS1748, AS2082, AS2858 or NZS3631
 - Structural properties to AS/NZS4063
- Adhesives: strong & durable joints for intended life
- Requirements are given for initial qualification and on-going routine testing of:
 - End joint strength & integrity to AS5068
 - Completed glulam beam properties
 - Facelam glue-line integrity



AS/NZS1328.1 Completed glulam

- Characteristic values for MOE, bending, tension, shear, compression
- Initial qualification for new process or significant change
 - Method 1 – test finished beams to AS/NZS4063
 - Method 2 – from lamination properties

$$f'_b = 0.75 (1 + 0.05 S_{\min}) f'_{b,ej} \leq f'_{b,stock}$$
$$f'_t = 0.75 (1 + 0.05 S_{\min}) f'_{t,ej} \leq f'_{t,stock}$$



Face lamination integrity testing

TABLE 2.1
QUALIFICATION AND ROUTINE TEST PROCEDURES

Service	Class 1		Class 2		Class 3
Qualification test	Type I adhesive	Type II adhesive	Type I adhesive	Type II adhesive	Type I adhesive only
	Delamination test method A Appendix C	Delamination test method C Appendix C	Delamination test method A Appendix C	Delamination test method C Appendix C	Delamination test method A Appendix C
Routine tests	Type I and Type II adhesives		Type I and Type II adhesives		Type I adhesives only
	Delamination test method C Appendix C OR Block shear Appendix D OR Dry cleavage Appendix B		Delamination test method C Appendix C OR Block shear Appendix D OR Dry & wet cleavage Appendix B		Delamination test method A or method B Appendix C OR Dry and wet cleavage Appendix B

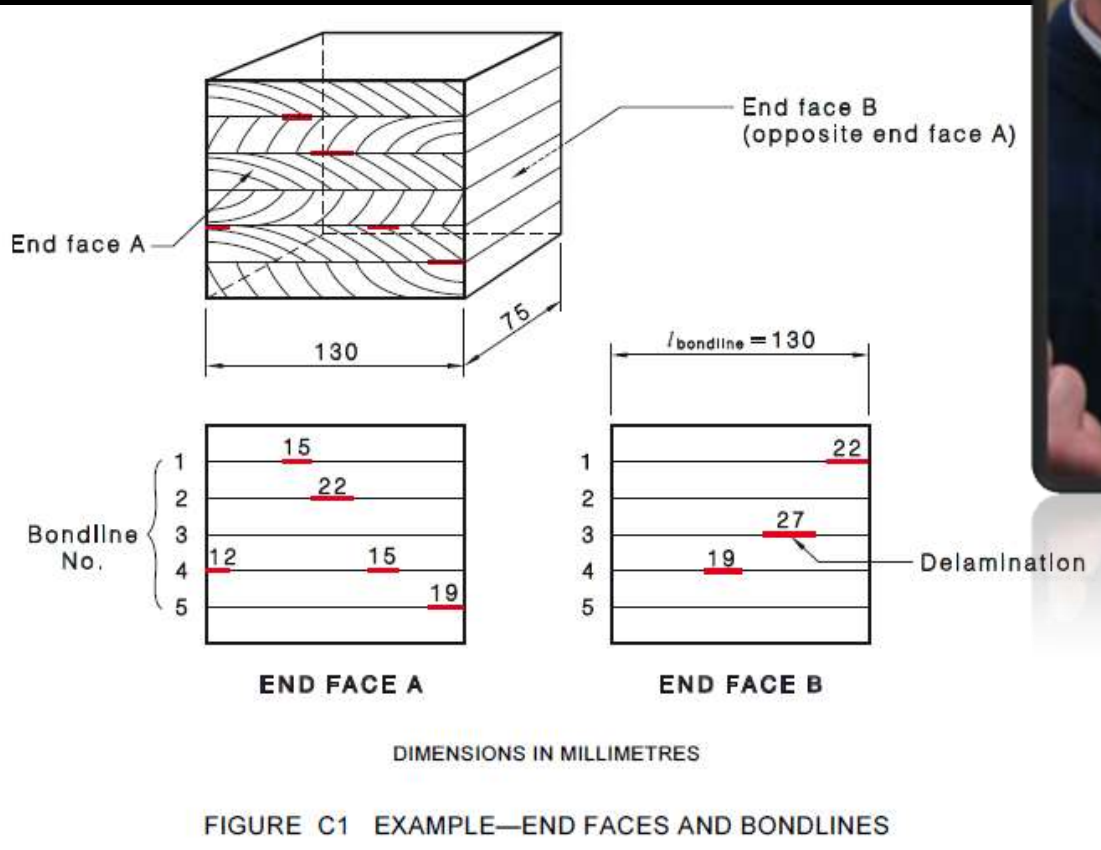
NOTE: Where dry and wet cleavage is performed two full cross sections are required.

Delamination test

- Assess glueline delamination after wet vacuum – pressure cycle then oven dry



Source: Hyne

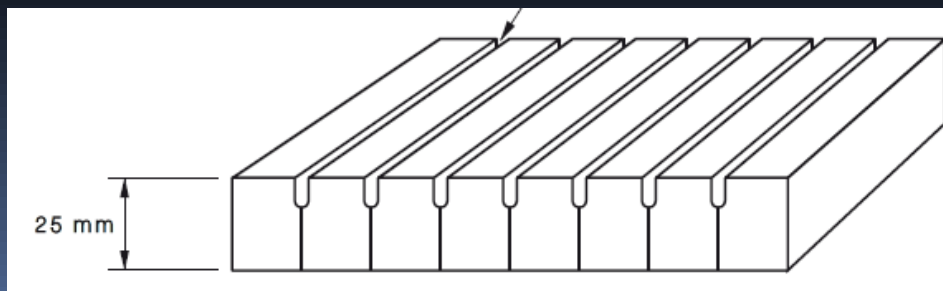
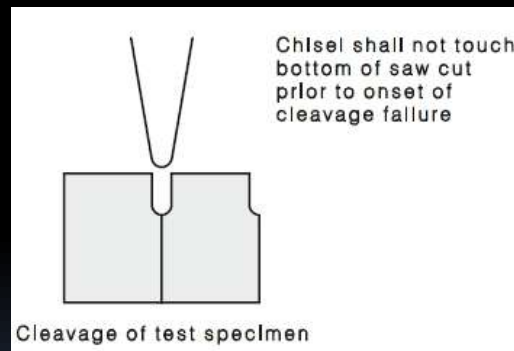
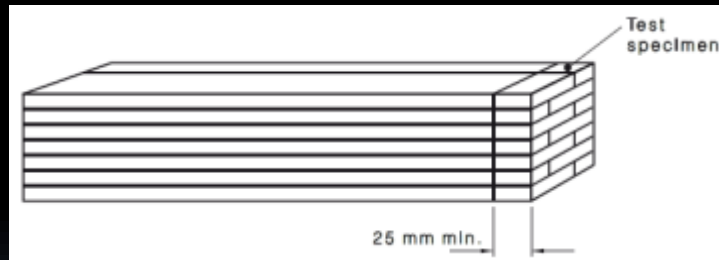


$$100 \times \frac{l_{\text{tot,delam}}}{l_{\text{tot,glueline}}}$$

$$100 \times \frac{l_{\text{max,delam}}}{2 l_{\text{glueline}}}$$

Wet cleavage test

- Wet cleavage acceptance criteria:
 - Average wood failure $\geq 60\%$ all gluelines
 - Min. Wood failure $\geq 30\%$ any glueline
- Autoclave required!



AS1720.1

- Primary reference document to BCA
- Glulam manufactured to AS/NZS1328
- Section 7 covers glulam design (GL grades)

TABLE 7.1

CHARACTERISTIC VALUES FOR STRUCTURAL DESIGN—GL-GRADES

Stress grade	Characteristic values, MPa					
	Bending (f'_b)	Tension parallel to grain (f'_t)	Shear in beam (f'_s)	Compression parallel to grain (f'_c)	Short duration average modulus of elasticity parallel to the grain (E)	Short duration average modulus of rigidity for beams (G)
GL18	45	25	5.0	45	18500	1230
GL17	40	20	4.2	33	16700	1110
GL13	33	16	4.2	26	13300	900
GL12	25	11	4.2	22	11500	770
GL10	22	8	3.7	18	10000	670
GL8	19	6	3.7	14	8000	530

NOTE: The characteristic values for tension for GL grades apply for tension members with the larger cross-sectional dimension not greater than 150 mm. For tension members with a cross-sectional dimension greater than 150 mm, the characteristic values are determined by multiplying the value in the table by $(150/d)^{0.167}$, where d is the larger cross-sectional dimension of the section.

Other performance issues

- Creep performance
 - GLTAA design assumes ($j_2 = 1.5$)
 - >50mm thick, protected environment
- Fire performance
 - AS1720.4 prescriptive requirement for PRF
 - BCA requires wide range of buildings fire-rated
- Timber durability

Code requirements for Glulam

Summary

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