



Glulam

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Introduction

Glulam (glued-laminated timber) is a structural timber product manufactured by gluing together individual pieces of dimension lumber under controlled conditions. The attributes of this wood product account for its frequent use as an attractive architectural and structural building material.

In the manufacture of glulam, the wood pieces are end jointed and arranged in horizontal layers or laminations.

Laminating is an effective way of using high strength lumber of limited dimension to manufacture large structural members in many shapes and sizes. Glulam is used for columns and for beams and frequently for curved members loaded in combined bending and compression.

Vertically laminated beams, which are made by nailing or gluing together dimension lumber so that the narrow faces of the laminations are oriented perpendicular to the load sharing systems (built-up beams) and are not to be confused with glulam as shown in Figure 1 below.

Glulam is manufactured at certified plants where standards governing lumber grading end joining, gluing and finishing are used to control quality. Qualified manufacturers can supply a certificate of conformance for their products upon request.

The lumber used for the manufacture of glulam is a special grade (lamstock) which is purchased directly from lumber mills. It is dried to a maximum moisture content of 15 percent and it is planed to a closer tolerance than that required for dimension lumber.

Canadian glulam is manufactured in three species combinations: Douglas Fir-Larch, Hem-Fir and Spruce-Pine as shown in Table 1.

Figure 1: Comparing Glulam to Nail-Laminated Beam

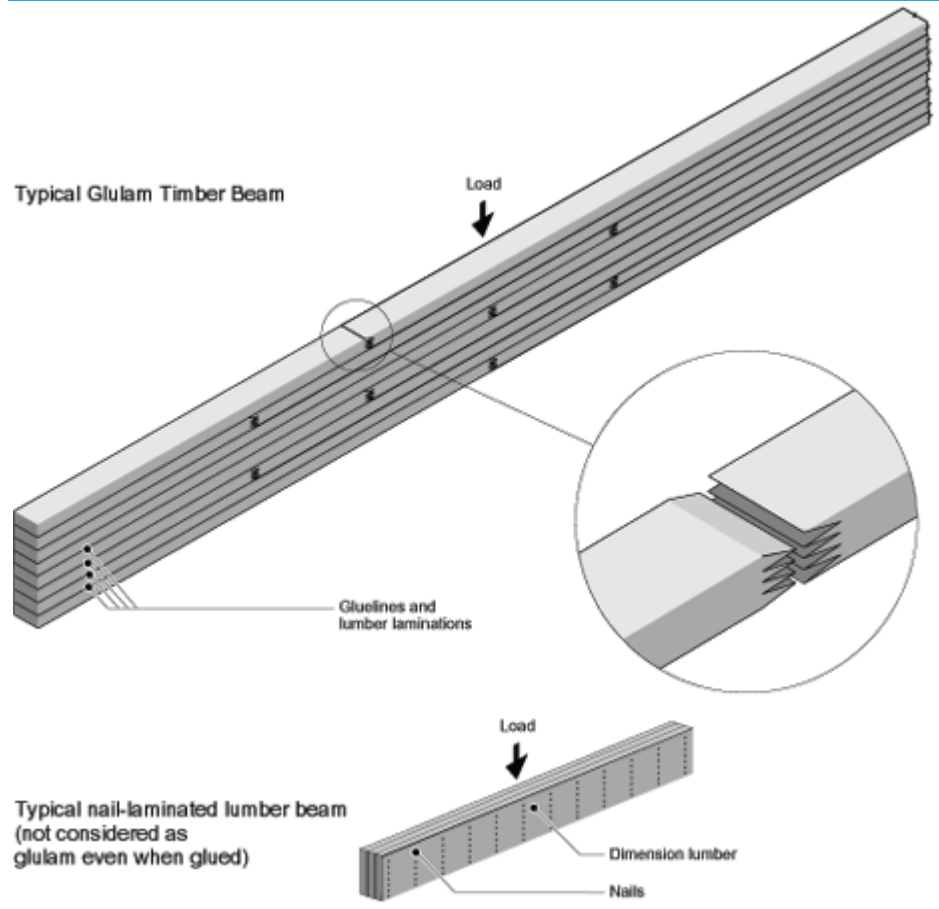


TABLE 1: Canadian Glulam - Commercial Species		
Commercial Species Group Designation	Species in Combination	Wood Characteristics
Douglas Fir-Larch (D.Fir-L)	Douglas fir, western larch	Woods similar in strength and weight. High degree of hardness and good resistance to decay. Good nail holding, gluing and painting qualities. Colour ranges from reddish-brown to yellowish-white.
Hem-Fir	Western hemlock, amabilis fir, Douglas fir	Lightwoods that work easily, take paint well and hold nails well. Good gluing characteristics. Colour range is yellow-brown to white.
Spruce-Pine	Spruce (all species except coast sitka spruce), lodgepole pine, jack pine	Woods of similar characteristics, they work easily, take paint easily and hold nails well. Generally white to pale yellow in colour.

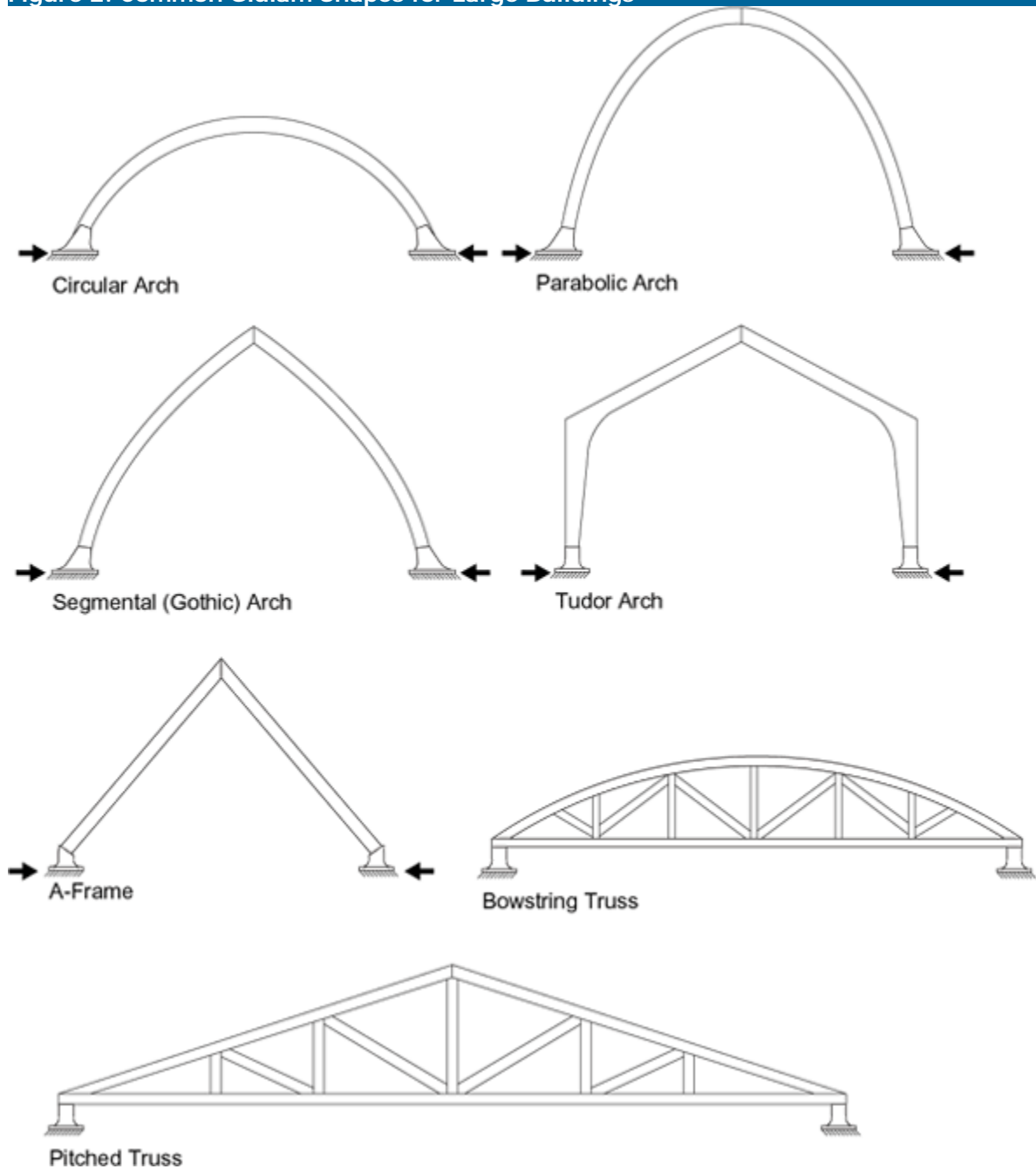
All Canadian glulam is manufactured using waterproof adhesives for end jointing and for face bonding and is therefore suitable for both exterior and interior applications. However, the specified strengths used in design will depend upon whether the service condition is wet or dry.

Uses

Glulam is a structural product used for headers, beams, girders, columns, and for heavy trusses. It is often used where the structure of a building is left exposed as an architectural feature.

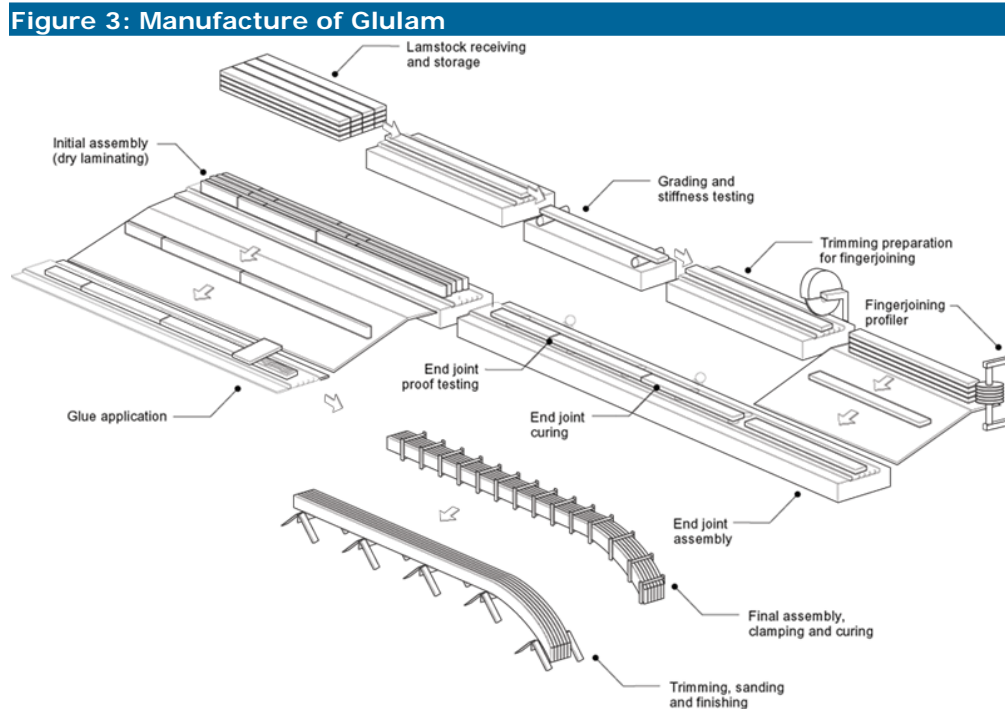
Glulam can be manufactured to an almost limitless variety of straight and curved configurations (see Figure 2 below). It offers the architect artistic freedom without sacrificing structural requirements.

Figure 2: Common Glulam Shapes for Large Buildings



Manufacture

The special grade of lumber used for glulam, lamstock, is received and stored at the laminating plant under controlled conditions (see Figure 3 below).



Prior to glulam fabrication, all lumber is visually graded for strength properties and mechanically evaluated to determine the modulus of elasticity (E). These two assessments of strength and stiffness are used to determine where a given piece will be situated in a beam or column.

For example, high strength pieces are placed in the outermost laminations of a beam where the bending stresses are the greatest. This blending of strength characteristics is known as grade combination and ensures consistent performance of the finished product.

Once graded, the individual pieces of lamstock are end joined into full length laminations of constant grade and each endjoint is proof tested. Then, the laminated lengths are arranged according to the required grade combination for the product being manufactured.

Each lamination then moves through a glue applicator and the pieces are reassembled into the desired configuration at the clamping area. Hydraulic or manually activated clamps are placed around the member, and are brought into contact with steel jigs which have been pre-anchored to the floor to provide the desired curvature or pattern.

As pressure is applied, the laminations are adjusted for proper alignment in a level plane to minimize the amount of stock which will be lost when the member is surface planed to a smooth finish. Once full clamping pressure is reached, the member is stored at a controlled temperature until the glue is fully cured.

When glue curing is complete, the members are moved to the finishing area where basic surface planing, patching, and end trimming is done. Depending on what the client has ordered, drilling and notching for connections, sanding, and staining and varnishing may also be done. Because of specialized equipment and mass production, these functions can usually be performed in the shop cheaper than at the building site.

As a final step, glulam members are wrapped in readiness for shipping.

Strength and Appearance

In specifying Canadian glulam products, it is necessary to indicate both the stress grade and the appearance grade required.

The specification of the appropriate stress grade depends on whether the intended end use of a member is for a beam, a column, or a tension member as shown in Table 2 below.

For the bending grades of 20f-E, 20f-EX, 24f-E and 24f-EX, the numbers 20 and 24 indicate allowable bending stress for bending in Imperial units (2000 and 2400 pounds per square inch). The f refers to flexure and E indicates that most laminations must be tested for stiffness by machine.

Stress grades with EX designation (20f-EX and 24f-EX) are specifically designed for cases where bending members are subjected to stress reversals. In these members the lamination requirements in the tension side are the mirror image of those in the compression side.

Similarly the descriptions for compression grades, 16c-E and 12c-E, and tension grades, 18t-E and 14t-E indicate the allowable compression and tension stresses.

Glulam is manufactured in three appearance grades: Industrial, Commercial, and Quality as shown in Table 3 below.

Unlike visually graded sawn timbers where there is a correlation between appearance and strength, there is no relationship between the stress grades and the appearance grades of glulam since the exposed surface can be altered or repaired without affecting the strength characteristics.

The appearance of glulam is determined by the degree of finish work done after laminating and not by the appearance of the individual lamination pieces.

Table 2: Canadian Glulam - Stress Grades			
Stress Grade		Species	Description
Bending Grades	20f-E and 20f-EX	D.Fir-L or Spruce Pine	Used for members stressed principally in bending (beams) or in combined bending and axial load.
	24f-E and 24f-EX	D.Fir-L or Hem-Fir	Specify EX when members are subject to positive and negative moments or when members are subject to combined bending and axial load such as arches and truss top chords.
Compression Grades	16c-E 12c-E	D.Fir-L Spruce Pine	Used for members stressed principally in axial compression, such as columns.
Tension Grades	18t-E 14t-E	D.Fir-L Spruce Pine	Used for members stressed principally in axial tension, such as bottom chords of trusses.

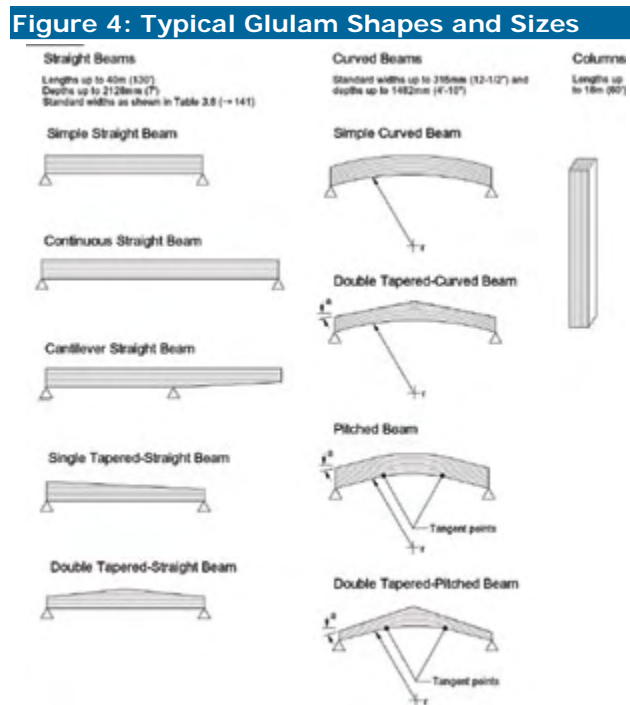
TABLE 3: Glulam Appearance Grades	
Grade	Description
Industrial Grade	Intended for use where appearance is not primary concern such as in industrial buildings; laminating stock may contain natural characteristics allowed for specified stress grade; sides planed to specified dimensions but occasional misses and rough spots allowed; may have broken knots, knot holes, torn grain, checks, wane and other irregularities on surface.
Comercial Grade	Intended for painted or flat-gloss varnished surfaces; laminating stock may contain natural characteristics allowed for specified stress grade; sides planed to specified dimensions and all squeezed-out glue removed from surface; knot holes, loose knots, voids, wane or pitch pockets are not replaced by wood inserts or filler on exposed surface.
Quality Grade	Intended for high-gloss transparent or polished surfaces, displays natural beauty of wood for best aesthetic appeal; laminating stock may contain natural characteristics allowed for specified stress grade; sides planed to specified dimensions and all squeezed-out glue removed from surface; may have tight knots, firm heart stain and medium sap stain on sides; slightly broken or split knots, slivers, torn grain or checks on surface filled; loose knots, knot holes, wane and pitch pockets removed and replaced with non-shrinking filler or with wood inserts matching wood grain and colour; face laminations free of natural characteristics requiring replacement; faces and sides sanded smooth.
Note:	

Glulam Sizes

Standard sizes have been developed for Canadian glued-laminated timber to allow optimum utilization of lumber which multiplies of the dimensions of the lamstock used for glulam manufacture. Suitable for most applications, standard sizes offer the designer economy and fast delivery. Other non-standard dimensions may be specially ordered at additional cost because of the extra trimming required to produce non-standard sizes.

Standard finished widths of glulam members and common widths of the laminating stock they are made from are given in Table 4 below.

Size possibilities for glulam shapes are shown in Figure 4 below.



[Click photo to enlarge it.](#)

Single widths of stock are used for the complete width dimension for members less than 275mm (10-7/8") wide. However, members wider than 175mm (6-7/8") may consist of two boards laid side by side. All members wider than 275mm (10-7/8") are made from two pieces of lumber placed side by side, with edge joints staggered within the depth of the member.

Members wider than 365mm (14-1/4") are manufactured in 50mm (2") width increments, but will be more expensive than standard widths. Manufacturers should be consulted for advice.

Standard depths for glulam members range from 114mm (4-1/2") to 2128mm (7') or more in increments of 38mm (1-1/2") and 19mm (3/4").

A member made from 38mm (1-1/2") laminations costs significantly less than an equivalent member made from 19mm (3/4") laminations. However, the 19mm (3/4") laminations allow for a greater amount of curvature than do the 38mm (1-1/2") laminations as shown in Table 5.

Laminating stock may be end jointed into lengths of up to 40m (130') but the practical limitation may depend on transportation clearance restrictions. Therefore shipping restrictions for a given region should be determined before specifying length, width or shipping height.

For long straight members, glulam is usually manufactured with a built in camber to ensure positive drainage by negating deflection. This ability to provide positive camber is a major advantage of glulam. Recommended cambers are shown in Table 6 below.

Table 4: Standard Glulam Widths			
Initial width of glulam stock		Finished width of glulam stock	
mm.	in.	mm.	in.
89	3-1/2	80	3
140	5-1/2	130	5
184	7-1/4	175	6-7/8
235 (or 89 + 140)	9-1/4 (or 3-1/2 + 5-1/2)	225 (or 215)	8-7/8 (or 8-1/2)
286 (or 89 + 184)	11-1/4 (or 3-1/2 + 7-1/4)	275 (or 265)	10-7/8 (or 10-1/4)
140 + 184	5-1/2 + 7-1/4	315	12-1/4
140 + 235	5-1/2 + 9-1/4	365	14-1/4

Notes:

- Members wider than 365mm (14-1/4") are available in 50mm (2") increments but require a special order.
- Members wider than 175mm (6-7/8") may consist of two boards laid side by side with longitudinal joints staggered in adjacent laminations.

Table 5: Minimum Radius of Curvature for Laminations						
Lamination Thickness			Minimum Radius of Curvature			
			Tangent Ends		Curved Ends	
mm	in.		m	ft.-in.	m	ft.-in.
38	1-1/2	Standard	8.4	27'-6"	10.8	35'-6"
19	3/4	Standard	2.8	9'-4"	3.8	12'-6"

Notes:

- For economy, curved members should be designed using standard lamination thicknesses. Members made from 38mm (1-1/2") laminations cost less than an equivalent member made from 19mm (3/4") laminations.
- Non standard laminations less than 19mm (3/4") thick are made by resurfacing 19mm (3/4") stock which results in more waste material.

Non-standard lamination sizes also exist, for more information, consult the manufacturer.

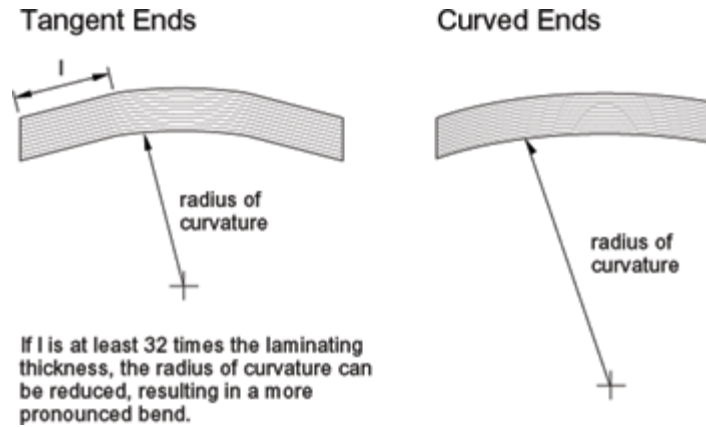


Table 6: Camber recommendations for Glulam Roof Beams

Type of Structure	Recommendation
Simple Glulam Roof Beams	Camber equal to deflection due to dead load plus half of live load or 30mm per 10m (1" per 30') of span; where ponding may occur, additional camber is usually provided for roof drainage.
Simple Glulam Floor Beams	Camber equal to dead load plus one quarter live load deflection or no camber.
Bowstring and Pitched Trusses	Only the bottom chord is cambered. For a continuous glulam bottom chord; camber in bottom chord equal to 20mm per 10m (3/4" in 30') of span.
Flat Roof Trusses (Howe and Pratt Roof Trusses)	Camber in top and bottom glulam chords equal to 30mm per 10m (1" in 30') of span.

Glulam Quality Control

Glulam is an engineered wood product requiring exacting quality control at all stages of manufacture.

Canadian manufacturers of glulam are required to be qualified under *CSA Standard 0177*. This standard sets mandatory guidelines for equipment, manufacturing, testing and record keeping procedures.

As a mandatory manufacturing procedure, tests must be routinely performed on several critical manufacturing steps, and recording of test results must be done. For example, representative samples are tested for adequacy of glue bond and all end joints are stress tested to ensure that each joint exceeds the design requirements. Each member fabricated has a quality assurance record indicating glue bond test results, lumber grading, end joint test and laminating conditions for each member fabricated, including glue spread rate, assembly time, curing conditions and curing time.

In addition, mandatory quality audits are performed by independent certification agencies to ensure that in-plant procedures meet the requirements of the manufacturing standard.

A certificate of conformance to manufacturing standards for a given glulam order is available upon request.



Glulam Moisture Control

The checking of wood is due to differential shrinkage of the wood fibres in the inner and outer portions of a wood member. Glulam is manufactured from lamstock having a moisture content of 7 to 15 percent. Because this range approximates the moisture conditions for most end uses, checking is minimal in glulam members.

Proper transit, storage and construction methods help to avoid rapid changes in the moisture content of laminated members. Severe moisture content changes can result from the sudden application of heat to buildings under construction in cold weather, or from exposure of unprotected members to alternate wet and dry conditions as might occur during transit and storage.

Canadian glulam routinely receives a coat of protective sealer before shipping and is wrapped for protection during shipping and erection. The wrapping should be left in place as long as possible and ideally until permanent protection from the weather is in place.

During on-site storage, glulam should be stored off the ground with spacer blocks placed between members. If construction delays occur, the wrapping should be cut on the underside to prevent the accumulation of condensation.



Glulam Preservative Treatment

Preservative treatment is not often required but should be specified for any application where ground contact is likely. Advice on suitable preservative treatment should be sought from the manufacturer.

Untreated glulam can be used in humid environments such as swimming pools, curling rinks or in industrial buildings which use water in their manufacturing process.

Where the ends of glulam members will be subject to wetting, protective overhangs or flashings should be provided.



In applications where direct water contact is not a factor, a factory applied sealer will prevent large swings in moisture content.

Since wood is corrosion-resistant, glulam is used in many corrosive environments such as salt storage domes and potash ware-housing.

Final Trimming and Finishing

With the large specialized equipment present in a glulam plant, it is possible to trim large members to close tolerances which would be difficult to attain under field conditions. Installation of connectors such as shear plates and split rings can be accomplished under factory conditions leaving only minor adjustments for the field.

Sanding and filling in accordance with the appearance grade specified, and additional staining and varnishing (when specified) can be done in the factory.

When properly designed, glulam members will be erected without the need for field trimming or cutting. If field adjustments are necessary, they should be permitted only with the approval of the designer.

Glulam Fire Safety

Because glued-laminated timber is readily manufactured in large sizes, it is often used in Heavy Timber construction to meet minimum size and fire-resistance rating requirements of North American building codes.

For more information, please refer to the Fire Safety Design in Buildings book which provides basic information on the minimum sizes and arrangement of glulam members necessary to meet code requirements for Heavy Timber construction. Information is also provided on the means for calculating the fire resistance of glulam beams and columns.

Ordering

When designing large glued-laminated timber structures or members, it is advisable to consult a glulam manufacturer early in the design process. This will result in spacing and configuration recommendations which allow the product to be used to its maximum efficiency and ensure timely delivery. This is especially the case where unusual shapes or very large sizes are required.

Advice on connection design and detailing which may have a substantial effect on overall economy and in-service performance can also be obtained from the manufacturer.

Except for some common sizes held in stock, glulam is custom manufactured. Scheduling should make allowance for shop drawing preparation and review, product manufacture, and shipping.

Delivery should be co-ordinated by both contractor and manufacturer to ensure unloading equipment is available at the job site.

General Guidelines

For the best economy and efficiency when ordering glulam members, specifiers should:

- Select the section with the smallest cross-sectional area or the least weight required for the job.
- Use 38mm (1-1/2") laminations and standard depths whenever possible.
Use 38mm (1-1/2") laminations in straight members and in all curved members with radius of curvature of 8400mm (27') or more.
- Limit the size of glulam members to those which can be shipped economically and legally. This applies to both lengths and heights, since local overall shipping height limitations, usually about 4 to 6m (14' to 20'), may restrict arch sizes.
- Use the proper appearance grade for the project by matching the appearance and thus the cost premium to the requirements for appearance and visibility.
- In some instances, using larger than necessary members may simplify overall economy by simplifying connection details. Consult the manufacturer.
- Shop applied sealer is intended as a temporary finish only. Depending on the application, an appropriate paint or coating system is required to protect the glulam.
- Outline protection measures to be taken during erection to protect the members from damage, including provision for temporary bracing.
- All nuts, bolts, and other hardware should be zinc electro-plated to prevent staining of the wood.
- Steel connections should be painted to prevent rust from staining the wood. They should be galvanized for high humidity service conditions.

Links

Western Archrib

Structurlam

Timber Systems

Goodfellow

Weyerhaeuser

APA

Nordic