Exposed Laminated Timber

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Saint Joseph Church, Connecticut

Ask any structural engineer to name the project that he or she is most proud of designing, and more than likely it will be a project with an architecturally exposed structure. Usually, the structural framing of the buildings we design is hidden behind ceilings or walls, and is only on view to the world for a brief time during construction. But, every now and then we have an opportunity to design structures that are architecturally exposed. These projects allow the structural engineer to collaborate with the project architect on the key design elements of the building.

Glue Laminated Timbers, commonly referred to as **glulams**, have been used for over half a century for architecturally exposed roof framing in public buildings such as churches, schools, museums and libraries. Few structural materials rival the warm aesthetic appeal of glulam timbers.

Glulams are preferred over solid sawn timbers for long span roof structures where the higher allowable stresses of the timbers result in a more delicate frame. Since glulams are manufactured from dried lumber, they experience far less shrinkage, checking, and twisting than green timbers. The individual laminations are made up of 2x dimension lumber that can be milled from relatively small trees, and do not require the logging of old growth forests.

Although glulams can be manufactured from a wide variety of wood species, the vast majority of structural applications utilize either Douglas Fir or Southern Pine. Knots are usually more prominent in Southern Pine timbers. Douglas Fir timbers are manufactured from 1 ½" thick laminations, while Southern Pine timbers use 1 3/8" thick laminations. Consequently, the standard member sizes are different for the two species.

Glulam timbers that will be subject primarily to flexural bending stresses are manufactured with an unbalanced lamination layout. This layout positions low grades of lumber at mid depth of the member, and the highest grade of lumber on the bottom of the member to resist tension. If the timber must resist significant negative moments, such as with cantilever beams or continuous beams, a balanced layout with tension laminations on both the top and bottom of the member should be specified. The most common stress grades used for structural glulams are 24F-V4 (unbalanced) and 24F-V8 (balanced) for Douglas Fir and 24F-V3 (unbalanced) and 24F-V5 (balanced) for Southern Pine. These stress grades have an allowable bending stress of 2,400 psi.

Parhump Library, Nevada

There are four standard Appearance Grades for glulam timbers; Framing, Industrial, Architectural and Premium. Only Architectural and Premium Appearance Grades are suitable for architectural exposed structures. With both of these grades, the timbers are planed smooth with eased edges, and surface defects are filled with a wood filler or wood inserts. Textured surfaces can be specified if a more rustic appearance is desired. If the timbers are stained, the wood filler may not take the stain. Sealers applied to the timbers by the fabricator may also be incompatible with the stain used.

Curved laminated timbers can be used to form graceful arches. Unless the radius of curvature is large, ¾" thick laminations are used. On the Beaverton City Library in Oregon, curved glulam columns were clustered together to create a structure that resembles a forest of trees.

Beaverton City Library, Oregon

Laminated tongue and groove wood decking is still the most commonly used roof deck with glulam timber structures. Unless the decking is stained to contrast with the glulams, the face ply of the decking should be the same wood species as the timbers. In some instances, laminated decking exhibits poor diaphragm performance. On the Beaverton City Library, it was necessary to apply plywood over the decking to resist wind and seismic loads.

Structural Insulated Panels (SIP) are gaining in popularity for roof decks over timber structures. SIP roofs do not need rigid insulation installed in the field, and they have impressive energy performance. Other roof deck options over timber structures include Tectum panels and metal roof deck.

Glulam roof structures perform well in fires. The timbers burn much more slowly than light wood framing, and they maintain their strength longer than unprotected steel structures. On the Parhump Library in Nevada, timber framing was selected over structural steel because the steel alternative would have required fireproofing.

Graceful roof trusses can be created using glulam timbers for compression members and steel rods for the tension members. This technique was employed on the LaVista Library in Nebraska.

Roof Structures

Often the most challenging part of designing a timber structure is engineering the connections. While some engineers will delegate responsibility for connection design to the fabricator, they should be detailed by the Engineer of Record when the aesthetics of the connections are important. The most common timber connections use steel gusset plates and bolts similar to those used on the Dee Brown Library in Arkansas. Often the Architect will want the connections to be concealed, and this requires far more effort and ingenuity. On the Saint Joseph Church in Connecticut, all of the roof truss connections were concealed. Connection plates were hidden inside kerf cuts in the timbers, and all bolts were countersunk and plugged.

Dee Brown Library, Arkansas

On the Dee Brown Library, glulam timbers were used to frame wide eave overhangs, an entry canopy and sidewalk canopy. When timbers are exposed to the weather, special precautions need to be taken to prevent deterioration. Decay resistant wood species can be used or the timbers can be preservative treated. The most common preservative for glulams is Pentachlorophenol (Penta) in light solvents. The timbers should be treated after fabrication. The end grain of timbers exposed to the weather should be protected with metal flashing.

LaVista Library, Nebraska

Working drawings for exposed timber roof structures are sometimes best drawn using 3D CAD since it can be difficult to describe the structure with 2 dimensional drawings. This allows the structure to be viewed from different perspectives. Complex connections and joints can be drawn as exploded isometrics. This may require a little extra effort but attention to detail is important with exposed structures.

Project information and photos provided by Don Jaenicke, Jaenicke Marketing Works, agency for the American Institute of Timber Construction (AITC).

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Credits:

Beaverton City Library – Beaverton, Oregon
Structural Engineer – KPFF Consulting Engineers
Architect – Thomas Hacker and Associates Architects Inc.

Pehrump Library – Pahrump, Nevada
Structural Engineer and Architect – Leo A. Daley & Assoc.

LaVista Public Library – LaVista, Nebraska
Structural Engineer – Nielsen Baumert Engineering
Architect – Zenon Beringer Mabrey Partners, Inc.

Dee Brown Southwest Library – Little Rock, Arkansas
Structural Engineer – Engineering Consultants, Inc.
Architect – Fennell Purifoy Hammock Architects

Saint Joseph Church – Brookfield, Connecticut
Structural Engineer – DeStefano Associates
Architect – Antinozzi Associates

For additional information see the following websites:

American Institute of Timber Construction
www.aitc-glulam.org

APA – The Engineered Wood Association
www.apawood.org