AMERICAN INSTITUTE OF TIMBER CONSTRUCTION

SUPERIOR FIRE RESISTANCE

Glulam

Because of its beauty, strength and ease of construction, wood has long been in demand as a building material. Today, structural glued laminated timbers (known as glulam) offer additional reasons to select wood as a structural material.

Glulam is fabricated using individual pieces of high-strength, kiln-dried lumber, laminated together under pressure to form large timbers that retain the traditional beauty of wood along with engineered strength and extraordinary fire resistance, thermal efficiency, and dimensional stability. Glulam is typically manufactured using Douglas fir, Hem-Fir, Southern pine, Spruce-Pine-Fir, Alaskan Yellow cedar and Ponderosa pine.

These large, laminated timbers can be fabricated in almost any straight or arched configuration for long-span conditions. This allows for the design of large, open spaces with minimal columns. Long-length glulam are appropriate for complete structural systems in many types of buildings including churches, gymnasiums, auditoriums and recreational spaces. Everyday uses in smaller buildings include ridge beams, garage door headers, door and window headers, long-span girders, stair treads and stringers, and heavy timber trusses.

Efficient, Cost-Effective Fire Protection

In the United States, the use of glulam is widely accepted as one of the most efficient and least expensive ways to meet the recognized criteria for fire protection as set forth in the U.S. model building codes.

Advances in test methods and fire technology have increased our understanding of how glulam responds to fire exposure. This knowledge, in turn, has led to the development of design procedures that further improve fire performance.

FIREPROOF VERSUS FIRESAFE

Fireproof buildings do not exist. The contents of most buildings are combustible. As such, it is often a building's contents, not its structural components, which pose the greatest potential fire hazard to life and property. Fire occurrences in the contents of so-called "fireproof" buildings can be so severe that a building constructed with non-combustible framing can collapse.

The fire in Chicago, Illinois' McCormick Place exhibition hall is a classic example. All structural members of this large exhibition hall, including interior non-bearing walls, were constructed of non-combustible materials. In 1967, a fire quickly spread through the contents of the hall, generating temperatures so high that steel beams, girders and trusses buckled in the heat and the entire roof collapsed. The building was a total loss at a cost of $150 million.

With this lesson and others, the goal has become "fire safe" design, rather than "fireproof," and it can be achieved with combustible structural materials as long as building code regulations are met. In addition to structural materials, considerations include the combustibility of contents and furnishings, interior finishes, the degree of protection provided by interior sprinklers, and the availability of adequate firefighting equipment. A reliable smoke detector with an alarm system and easily accessible exits are also vital in protecting a building and its occupants.

LEFT: Two tiers of glulam arches rise to more than 24 metres at the highest point in the Great Buddha Hall in Carmel, NY.

ABOVE: Aftermath of the fire at Turbotech, Inc. in Vancouver, Washington (USA). Glulam remained standing while the rest of the so-called "fireproof" building collapsed.

Performance of Large Timbers in Fires

When exposed to fire wood retains its strength for a longer period of time than metal. Unprotected metals quickly lose their strength and collapse suddenly, often with little warning. In contrast, wood loses strength slowly and only as material is lost through surface charring.

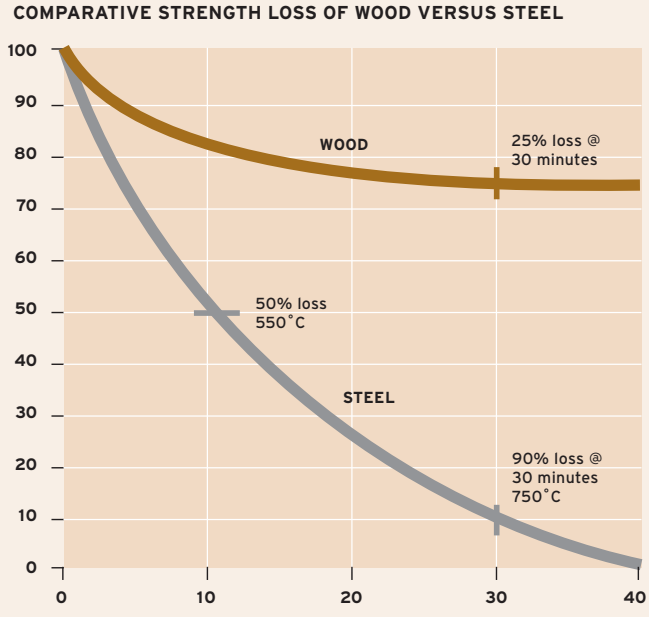
Average building fire temperatures range from approximately 700° to 900° Celsius. Steel weakens dramatically as its temperature climbs above 230°C, retaining only 10% of its strength at about 750°C.

As a rule, wood will not ignite until it reaches a temperature of around 250°C. Once it catches fire, wood typically develops char at the rate of 0.64mm per minute under severe fire conditions. The char naturally insulates the wood and raises the temperature level it can withstand. Thus, in a 30-minute fire, only 19mm of each exposed surface of the glulam is lost to charring, leaving most of the original cross section intact.

FIRE SAFETY

In nearly every country, one or more regulatory agencies concern themselves with the fire safety of building materials and systems. In the U.S., these include:

- **Model Building Code organizations** — develop design requirements, compliance criteria and regulatory oversight for building construction. Regulatory agencies participate in the development of these provisions.
- **American Society of Testing Materials (ASTM)** — promulgates fire test methods for building materials and systems.
  - **ASTM Test Method E-119** approximates actual fire conditions for building assemblies (beams, walls and connectors) and results in the development of fire-resistance ratings for building assemblies.
  - **ASTM E-84** ***Standard Test Method for Surface Burning Characteristics of Building Materials*** provides data on flame-spread ratings/ classifications and smoke-developed indexes for materials.



Results from test sponsored by National Forest Products Association at the Southwest Research Institute

ABOVE (top): Steel beams have melted and collapsed over charred timber beam, which, despite heavy damage, remains in place.

ABOVE (middle): 406mm, 60 kg/m steel beam (#W16x40) and 178mm x 533mm glulam beam following fire testing under full load. Steel beam collapsed after only 30 minutes of exposure while the glulam member remained straight and true, charring on 19mm on exposed surfaces.

Guide to Fire Performance

Buildings constructed with large structural timbers have excellent fire-resistive qualitites. U.S. model building codes recognize these qualities and provide guidelines for fire-resistive, heavy timber construction approaches. Two distinct approaches are included in the U.S. model building codes: *Heavy Timber Construction* and *Fire-Resistive Construction*.

HEAVY TIMBER CONSTRUCTION

In Heavy Timber Construction, limitations are placed on the minimum size, including depth and thickness, of all load-carrying wood members. The design avoids concealed spaces under floors and roofs, and regulations require the use of approved fastenings and construction details. When properly sized, glulam systems meet the criteria set forth in U.S. model building codes for Heavy Timber Construction.

The performance of heavy timber structures under fire conditions is markedly superior to most unprotected "non-combustible" construction. Fire fighting is easier and safer due to the elimination of concealed spaces and the inherent structural integrity of large laminated timbers.

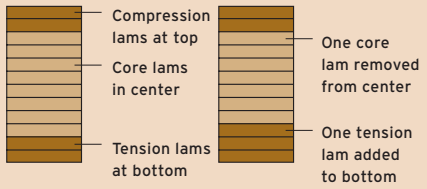
FIRE-RESISTIVE CONSTRUCTION

Fire resistance is the length of time a structural member can support its load before collapsing. The goal of fire-resistive construction is to provide adequate time for occupants to evacuate a building safely.

The results of ASTM fire tests for building assemblies, sponsored jointly by the American Forest & Paper Association and the American Institute of Timber Construction (AITC), enable designers to calculate specific fire ratings for glulam members. Calculations are based on a consideration of member size, degree of fire exposure, and loads on the member.

Additionally, fire-resistance ratings for glulam beams require lay-up modifications. For example, a simple-span glulam beam, having a cross section of 170mm x 340mm and exposed to fire on three sides, can be sized for a one-hour fire rating. To qualify for this rating, an inner or core lamination is removed from the beam at the time of manufacture and replaced by adding an additional tension lamination to the bottom of the beam (as shown in the figure above right).

ADAPTING STANDARD BEAM LAY-UP TO MEET ONE-HOUR FIRE RESISTANCE



The basic lam lay-up can easily be modified to qualify for 1-hour fire rating by removing one core lam from center of member and adding one additional tension lam to tension face, assuming all requirements are satisfied.

ABOVE (middle): Typical glulam beam enveloped in flames during standard ASTM E-119 fire test.

ABOVE (bottom): Typical glulam beam following fire testing: the outer surface of the beam has charred while the inner areas remain unburned. The charred outer material acts as an insulator during fire, reducing the rate at which the inner material will burn.

For additional information related to calculating a fire rating for heavy timber members, please refer to AITC Technical Note No.7 *Calculation of Fire Resistance of Glued Laminated Timbers* (www.aitc-glulam.org) and to AF&PA Technical Report 10 *Calculating the Fire Resistance of Exposed Wood Members* (www.awc.org). These publications are available in English.

Other Fire-Resistance Considerations

FIRE-RETARDANT TREATMENTS AND COATINGS

Pressure impregnated, fire-retardant treatments are not recommended for large timber or glulam construction. These treatments do not increase the fire-resistance rating of the large timber or glulam.

Fire-retardant chemicals reduce the design properties of the wood. In addition, for engineered wood products, the treatments may not be compatible with the adhesives used. The designer is cautioned to verify the effects of fire-retardant treatments (with the supplier) on the strength and performance of any wood product prior to specifying.

Fire-retardant paints and stains can effectively reduce flame spread when properly applied. While typically applied to large expanses of interior wood surfaces such as panel products, they can be applied to timber members when a specific flame-spread rating is required per design regulation. However, it is important to understand these coatings do not increase the fire-resistance rating for large timber or glulam members.

SPRINKLER SYSTEMS

Automatic sprinkler systems have an excellent record of improving fire safety and reducing losses. Many fire codes require that automatic sprinkler systems be installed in commercial buildings, and in some cases, added to existing buildings.

Such sprinkler systems may improve the fire-resistance and flame-spread ratings for a building's structural system. As a result, an additional storey of height or an increased building area may be permitted (by the codes) for buildings with sprinklers. Sprinkler systems also reduce insurance premiums—with the result that a sprinkler system often pays for itself within a matter of years, depending on the value of the building and its contents.

FIRE INSURANCE RATES

Most insurance companies recognize the excellent fire resistance of heavy timber construction and adjust their insurance rates accordingly. However, in some case, insurance premiums for "noncombustible" construction may be lower than for heavy timber construction. In such instances, the reduced cost of glulam construction generally offsets any additional insurance cost.

In addition, the more expensive construction methods required for noncombustible materials increase the cost of financing a project. Increased financing costs generally exceed any potential savings on insurance. Thus, using more expensive construction methods, in order to gain lower insurance rates, may actually result in increased overall costs.

INCREASING ALLOWABLE AREAS FOR HEAVY TIMBER CONSTRUCTION

U.S. building codes place height and area limitations on buildings to safeguard building occupants. While wood construction is typically assigned the lowest, basic allowable heights and areas, the model building codes also provide many options for increasing allowable areas. The following list provides suggestions for how to increase, under U.S. model building codes, the allowable areas for wood construction while maintaining life safety for building occupants:

1. Provide one-hour fire-resistive ratings for structural members and assemblies.
2. Install automatic sprinkler systems.
3. Maintain separation between buildings where possible.
4. Seek unlimited areas where appropriate, for specific types of building uses, by providing open spaces around the building combined with the use of automatic sprinklers.
5. Install properly constructed area-separation walls with protected openings.

RIGHT: Long-span glulam reduce the need for interior columns in the second-floor office space of Green Gables Timber Frame Barn, Lake Geneva, WI.

Quality Control and Inspection

AITC provides Quality Marks and Certificates of Conformance to licensed glulam manufacturers. Only AITC-licensed glulam producers are permitted to use these Quality Marks and Certificates to identify products conforming to ANSI/AITC A190.1.

AITC strives to bring together all aspects of the engineered timber industry through providing proper specifications and oversight on products for safe, long-lasting, high-quality timber construction.

AITC's Quality Control and Inspection Program for structural glued laminated timber works to:

- Standardize production, testing, inspection, identification, and certification of structural glued laminated timber.
- Improve economies through wider utilization of standards.
- Ensure the manufacture of reliable products.

The Program consists of three basic elements:

- Licensing of qualified glulam manufacturers whose personnel, procedures and facilities comply with the requirements of the *American National Standard for Wood Products—Structural Glued Laminated Timber*—ANSI/AITC A190.1.
- Continuous maintenance of the qualified manufacturer's quality control system in accordance with ANSI/AITC A190.1.
- Periodic inspection and verification, by the AITC Inspection Bureau, of the licensed laminator's quality control system, procedures and production.

SOFTWOOD EXPORT COUNCIL

AITC and its member glulam manufacturers support the Softwood Export Council (SEC) which is a non-profit trade council of U.S. softwood grading agencies, industry trade associations, state export development agencies and others interested in the promotion of U.S. softwood products internationally.

The SEC website provides information on member organizations, services and companies as well as a directory of literature and supporting information on products. Most publications, many available in multiple languages, may be ordered directly from the nearest SEC field office.

International field offices and SEC representatives are located in Tokyo, Seoul, Beijing, Madrid, London and Vera Cruz, Mexico. Details are provided on the SEC website.

Softwood Export Council
USA
email: info@softwood.org
website: www.softwood.org

ABOVE: Glulam are a popular choice for the structural systems in recreational spaces. Boathouse, Princeton University.

FRONT COVER: Glulam may be fabricated in variety of configurations to meet specific design requirements. Public Library, Beaverton, OR.

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