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Glue-Laminated Timber

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What is Glulam?

Glue-laminated timber or glulam, is an engineered wood product consisting of several parallel layers of small pieces of lumber stacked and glued together under pressure to make a large timber structure (APA, 2019). Glulam is commonly used for structural components like columns, beams, and arches of mid to high-rise buildings. Glulam provides strength, stability, and various length options to facilitate design flexibility. Glulam adds beauty to the exposed structure section, like rafters and ridge beams. However, most of the beams are used as floor beams and headers and are invisible. Stock beams are the common types of glulam readily available in North America. Stock beams are used as floor beams, door or window headers, ridge and rafter beams, and columns.

Manufacturing of glue-laminated timber

The overall procedure of glulam manufacturing is shown in Figure 1. Logs are harvested and sawn to produce structural lumber. All sawn lumber is dried in a control system to the required moisture content of 16% and less, machine-graded, and sorted for lumber grade. All available softwood species and some hardwood species, like yellow poplar (Liriodendron tulipifera) are used to manufacture glulam in the US. Lumber is finger-jointed to get an ideal length of glulam and sent to surfacing before applying glue to form desired layups. Lumber is glued under pressure to form a solid wood product. After complete pressing, glulam is surfaced, packed, and sent to market. The major glulam manufactures form the US are listed in Table 1.

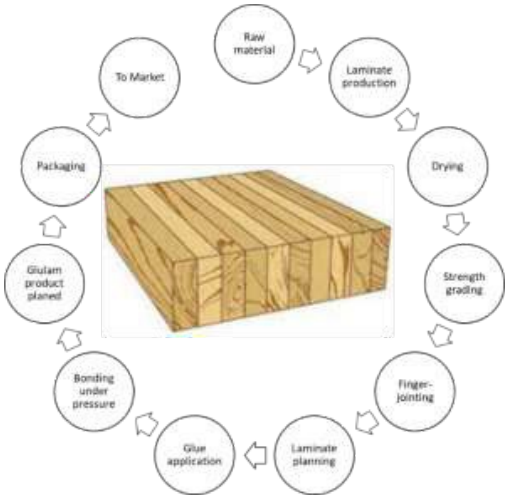

Figure 1: Glulam manufacturing. Adopted from (Swedish Wood, 2021) Picture source: (Naturally Wood, 2021).

Table 1: Major Glulam manufactures from the US

Manufacturers	City	State
Timber Technologies	Colfax	WI
Structural Wood Systems	Greenville	AL
Unalam	Unadilla	NY
Arizona Structural Laminators	Eagar	AZ
Boozer Laminated Beam Company	Anniston	AL
Laminated Erectors	Trafalgar	IN
Northway Industry Inc	Middleburg	PA
Green Valley Beam & Truss Co.	Denton	TX

Unadilla Laminated Products	Sidney	NY
JR Lumber Company	Conneaut	OH
84 Lumber	Dover	DE
Mississippi Laminators	Shubuta	MS
Dafor Heavy Timber Fabricators	Greenville	AL
Calvert Company	Vancouver	WA
Metkote Laminated Products Inc	Taylor	PA
US Glu-Lam	Calumet	IL
Kilby Truss Inc	Gray	TN

Environmental impacts of glulam

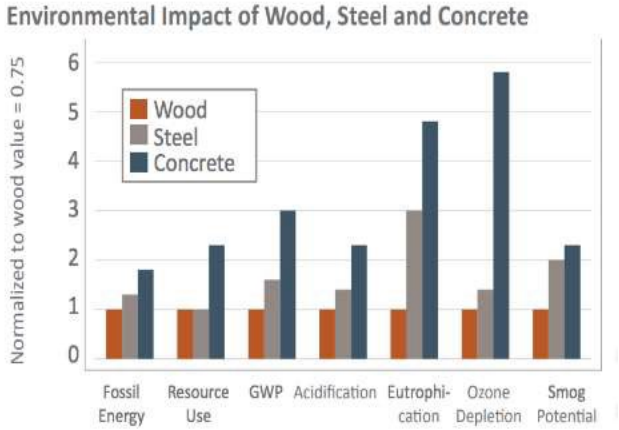

Figure 2: Environmental impact of construction material (Architizer, 2019).

Glulam is manufactured from locally available timber, so it is an environmentally sustainable construction material that helps in forest management. It promotes the wood industry at the local level. Thus, glulam adds minimum impact to the environment. The environmental impact of glulam is significantly less than steel and concrete. See Figure 2. Wood accumulates CO_2 during its growth and sequestrates it in a structure for years. On the other hand, the production of steel and concrete only emits CO2 and negatively helps in the sequestration process.

Advantages of Glulam

One of the design advantages of the glulam is the ease of bending into the desired curve shape and into long lengths. Glulam is manufactured by pressing small-length and specific width lumber through finger jointing. It can be set up to bend on the desired curve of any length and dimension for structural use. The ability to produce glulam of the required shape and size provides design flexibility and architectural and aesthetic beauty. The fire resistance of glulam timber is similar to normal wood as glulam acts as a thick wood member. See Figure 4. When the surface is ignited, the fire begins to penetrate the wood quickly. However, as the fire continues and a layer of char forms, the burn rate gradually decreases because the char acts as insulation, and also produces off-gassing that displaces the oxygen.

Figure 3: Glulam manufactured to meet curve design. Source:(Aicher & Stapf, 2014).

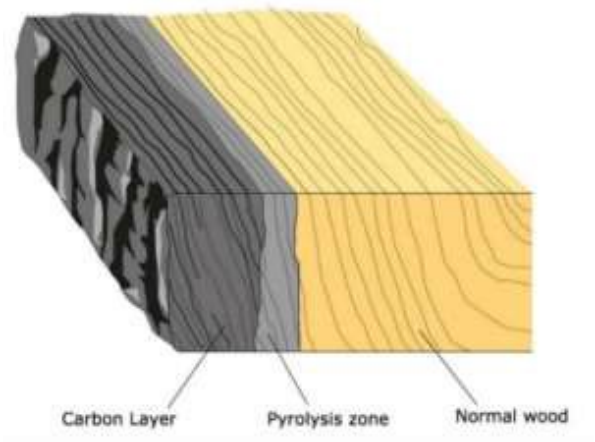

Figure 4: Glulam performance when exposed to fire. Source:(Setra Group, 2021).

Availability of the product and variation in the dimension and shape is another advantage of glulam. Glulam is commercially available from 45 mm x 45 mm cross-section up to 250 mm x 1800 mm over 30 m lengths. The common glulam dimension based on its component is presented in Table 2. Additionally, based on lumber grade used to manufacture glulam, it is classified by stress class, as shown in Table 3. Working flexibility is another advantage of glulam. Due to its manufacturing advantage it can be used as beam and columns at any angle based on design specifications. See Figure 5. Also, glulam can be manufactured using different wood types (APA, 2008) that add additional texture, color, and character.

Table 2: Commercially available dimension of glulam components. Source (SCS, 2021)

Glulam components	Spans (m)	Width (mm)	Height (mm)
Parallel beams	6-32.5	100-260	Max 2000
Double glued beams	6-32.5	280-480	Max 2000
Pre-cambered beams	6-32.5	100-260	1000-1840
Pent roof beams	6-32.5	100-260	Max 2000
Sloped beams with a straight bottom chord	6-32.5	100-260	Max 2000
Sloped beams with an arched bottom chord	6-32.5	100-260	Max 4500
Curved beams	6-32.5	100-260	Max 4500
Fish beam	6-32.5	100-260	Max 2000
Trusses	15-50	100-260	1000-1849
Free shapes	6-32.5	100-260	-

Table 3: Classification and design properties of glulam used in commercial construction Source: (APAEWS, 2004)

Stress Class	Fbx+ (Kpa)	Fbx- (Kpa)	Fc⊥x (Kpa)	Fvx (Kpa)	Ex X106 (Kpa)
1 6F- 1 .3E	11031	6377	2171	1344	8
20F- 1 .5E	13789	7584	2930	1447	10
24F- 1 .7E	16547	9997	3447	1447	11
24F- 1 .8E	16547	9997	4481	1827	12
26B 1 .8E	17926	13444	4481	1827	13
28F- 1 .8E	19305	15857	5102	2068	14
30F-2.l E SP	20684	16547	5102	2068	14
30F-2.l E LVL	20684	20684	3516	2068	14

Glulam has 2-3 times higher durability than steel and concrete (James, 2020); on increasing pressure and tension, the wood gets adjusted to changing force due to its flexibility and withstands stress without damage. See Figure 6.

Figure 5: Glulam used as column and beams
Source: (Anthony Forest Products Co., 2021; CE Center, 2020)

Figure 6: Performance of Glulam under pressure
Source: (Spartz, 2013)

Glulam boards have better mechanical strength than other wood products and higher resistance to rot and fire.

Disadvantages of Glulam

There are some disadvantages of glulam, among them:

- Due to associated production costs, the Glulam price can be higher than other timber products.
- Availability of the product is another limitation as there are limited producers manufacturing glulam in the US.
- Glulam has lower moisture resistance than steel and concrete, thus it is designed with larger dimension components to reduce the moisture impact. Using larger dimension products adds more cost and material.
- Another limitation is the difficulty of repairing if required.

Acknowledgment

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