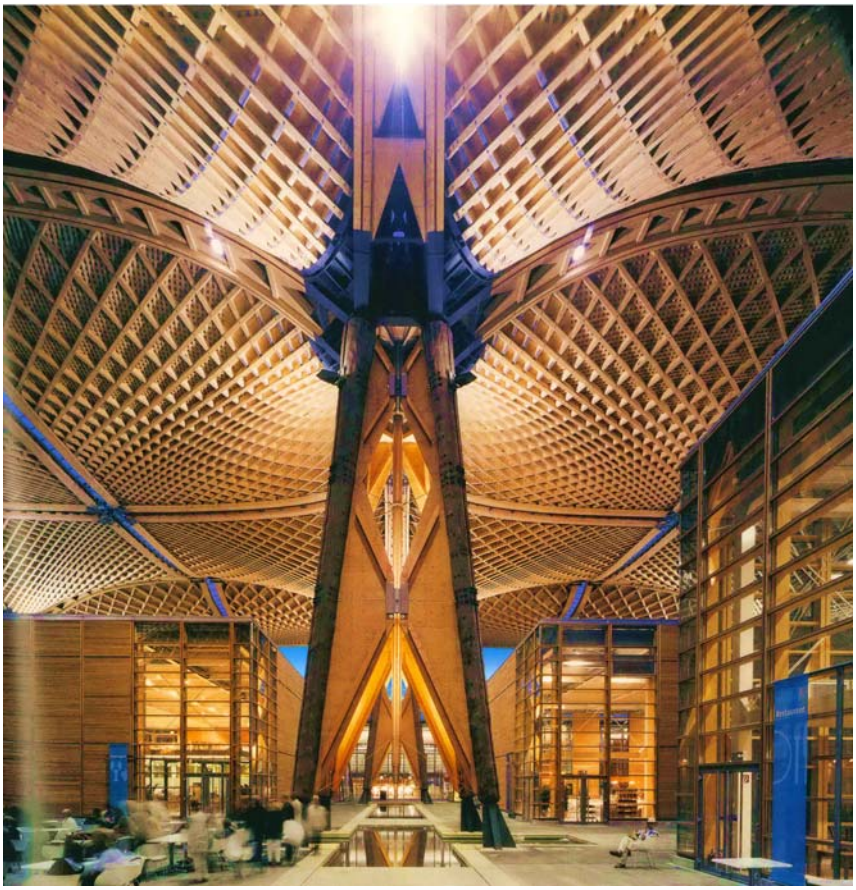
Technical paper

Glulam engineered timber

On some projects requirements for dry timber, long lengths or perhaps regular curves mean that timber in its natural form just doesn't work. However we can enhance its natural properties, and in this document we look at glue laminated timbers or 'glulam'.



The canopy at the Expo 2000 site, Hanover, Germany. We have been working with glulam for many years and use it extensively in commercial and timber engineering projects.

Glulam availability in the UK

There are no large commercial manufacturers of glulam timbers in the UK. However there are a lot of merchants stocking standard glulam beams (manufactured abroad) with predetermined performance specifications. These are useful if you want to incorporate the odd beam into a scheme but generally not much help for bespoke projects.

For projects requiring small volumes of glulam timber we will hand laminate. Samples are independently tested to ensure compliance with the demands of the structure.

For higher but still fairly modest volumes we work with a UK manufacturer who produces a very nice product in straight and curved laminated beams often from locally sourced timber and less mainstream timbers such as sweet chestnut, oak, Douglas fir and larch as well as industry standard whitewood.

For large volume commercial projects we import directly from manufacturers in France, Austria and Germany, depending on the project specification.

Project requirements

Whether it is timber durability, span or grading, different projects impose different demands on a structural timber frame. Here we look at some of the characteristics that determine the most suitable timber for the purpose

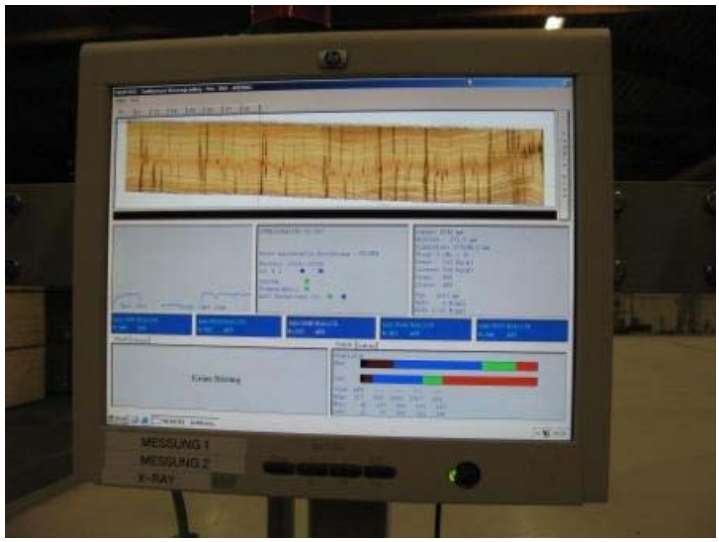
Section sizes and dry timber.

Due to the difficulty of drying large sections of timber to the core, the maximum thickness of dry natural timber for construction is specified for softwood (BS 4978) and hardwood (BS 5756) as 100mm. For sections bigger than this, the timber has to be either fresh sawn, known as green timber (graded wet) or laminated from small sections (graded dry). We are always cautious of brokers selling large sections of natural timber as 'seasoned'. It is only the outside that is dry and once cut into it is as wet as green timber in the centre of the section and they will charge a premium price for it. We've also experienced client supplied timber where it has been cut and allowed to dry for many years. It is without exception twisted and fissured, and can only be successfully used if it is re-sawn to a smaller section. In summary if a structural member is over 100mm x 100mm **and** it needs to be dry timber then it needs to be glulam.

Strength graded timber

Large sections of natural softwood and hardwood need to be manually graded to BS 4978 and BS 5756 respectively. To do this the timber is laid out to allow a detailed visual inspection of each face by a BS registered grader. This inevitably involves additional labour and often a forklift to turn the timbers. This is a costly and time consuming process to be avoided unless it is absolutely vital for highly stressed members in tension. However the small section timbers used for glulam are machine graded automatically at lightning speed.

Glulam is stronger and more predictable than green timber so the section sizes and factors of safety can be smaller. For example for a glulam beam made from all C24 material, BS5268 allows the engineer a 30% to 40% higher bending stress than the equivalent size of green timber. For structural efficiency and economy, we would normally consider glulam for the longest beams in a structural timber frame. It's not unusual in a structure to mix natural timber, finger jointed timber and glulam dependant on the timber size and function it has to perform.



Large clear spans

The maximum dimensions of green timber are limited by tree size up to the first branch i.e. clean clear trunk. Although these can be surprisingly long (we see managed oak up to 30m long) green timber over long spans does suffer from self load deflection.

For large spans, glulam becomes the most viable option. Dimensions and lengths are only limited by the ability to transport them. Up to 13.6m long, 2.4m wide and 2.6m high timber sections can be transported by standard transport means. Bigger than this requires special transport that is subject to approval of national and international traffic rules and regulations, and commands a premium cost.

Dimensional stability

Whilst we build many structures from green timber it does shrink and fissure and these characteristics are not always desirable. If the design calls for a joinery finish or dimensional instability is likely to cause problems then glue laminated frame members are the solution. Because they are manufactured from multiple layers of small section dry timber they are stable and the internal stresses that create twist and deflection in green timbers simply don't exist.

Durability

The development of rot in timber is dependent on humidity. If the moisture content of the timber is below 20% (service class 1 & 2) it will not rot, and have an unlimited life. At these moisture levels glues don't breakdown and there is no requirement for chemical treatment. We seem to have an obsession in the UK (that the rest of Europe doesn't seem to share) for chemically treating timber whether it needs it or not. The majority of projects do not require chemical treatment.

Where the moisture content of the timber in service is likely to exceed 20% for extended periods of time (service class 3) we recommend using more durable timber such as oak or if the risk is particularly high to chemically treat it.

With glulam there are three options. The most common and most economic is to apply a treatment as part of the factory applied base coats of the final finish. Other options are to pressure treat the lamella before gluing. In this case we would generally specify pine as it has better absorption qualities than spruce. The alternative to this is to pressure treat the finished beams after machining. The size of members that can be treated is limited by the available tank size. As manufacturers in mainland Europe tend not to treat timber, tank sizes are limited. However in the UK there is a much more prolific chemical treatment industry and some sizable tanks are available.

External structures such as bridges offer considerable savings in maintenance costs through good detailing principals, chemical preservatives and high performance micro porous wood stains. *

Curved timbers

Curved timbers with tight radii are very difficult and sometimes impossible to source in natural timber. Glulam however can be produced down to a radii of 1m and it is also possible to curve in two directions by re-sawing, regarding and re-gluing. However, tight radii generally mean more thinner layers with the obvious implications on cost.

Fire performance

Perhaps surprisingly, glulam offers excellent fire performance. It is predictable, calculable and, unlike steel, remaining section maintains its strength in a fire. With a charring rate of 0.7mm per min, (without surface treatment) simple over sizing will accommodate charring. Alternatively surface treatments can be applied to give the fire resistance required. Glulam buildings that have been in a fire have been very successfully sandblasted to remove charring, the remaining section assessed and then deemed safe to continue in service.

Some glulam facts

Standard constructional glulam

Most off the shelf glulam members are manufactured from spruce. Other timbers commercially available are:

- Siberian larch (used for external applications)
- Douglas fir (for visual qualities and greater durability)
- Pine (used for chemical treating for external applications)
- Hardwood glulam such as oak and teak (commonly used in furniture and is available for construction. It is manufactured by much smaller more specialist laminators and commands very high prices in comparison to softwood glulam, and natural timber)

Glulam strength grades

Glulam is graded by strength in the following categories, GL24h, GL24c, GL28c, GL32c, GL36c (the higher the number the higher the strength) - GL24h (homogeneous) is made up from all C24 timbers, GL24c (combined) is made up from a combination of C24 & C18 timbers, GL28c a combination of C24 & C30 timbers, GL32c a combination of C40 & C30 timbers and so on.

Moisture content

10 – 12% (+/- 2%) on delivery, which equates to the equilibrium moisture content at a room temperature of 20^0C, and a relative humidity of 65%.

Density

450kg/m2

Lamella thickness

The standard thickness for the lamella in glulam beams is 40mm, although thinner lamellas can be specified for certain situations such direct exposure to weather or sunlight, or high demands for type of use e.g. bakeries, car wash facilities or composting halls. The lamella thickness for curved beams is calculated by dividing the radius by two hundred.

Surface quality

Glulam beams generally come with two finishes – visible or industrial. Unlike industrial beams, visible beams will have anomalies such as knot and resin holes cut out and sound timber 'patches' inserted. It will be planed on four sides and all four edges are chamfered.

Dimensions

Off the shelf dimensions vary between manufacturers. It is often more economical to accept the nearest standard size to requirements rather than absorb the extra cost of re-sizing. Widths vary but typically they run from 6cm to 28cm in 2cm intervals with depths from 10cm to 220cm in 2cm intervals.

Colour of glued joints

Generally light melamine adhesive is used for spruce or dark for pine or Douglas fir.

Wrapping

Glulam is normally wrapped in plastic to keep it clean and dry during transport and while it sits on site before erection.

Applied finishes

Glulams are generally finished in the factory with either a clear or pigmented lacquer.

Machining

Bespoke and more complex glulam members are often cut on computer numeric controlled machines. For these we prepare CAD component drawings in machine readable format for machining at the glulam factory...

or for more complex carpentry we'll do it by hand in our workshops

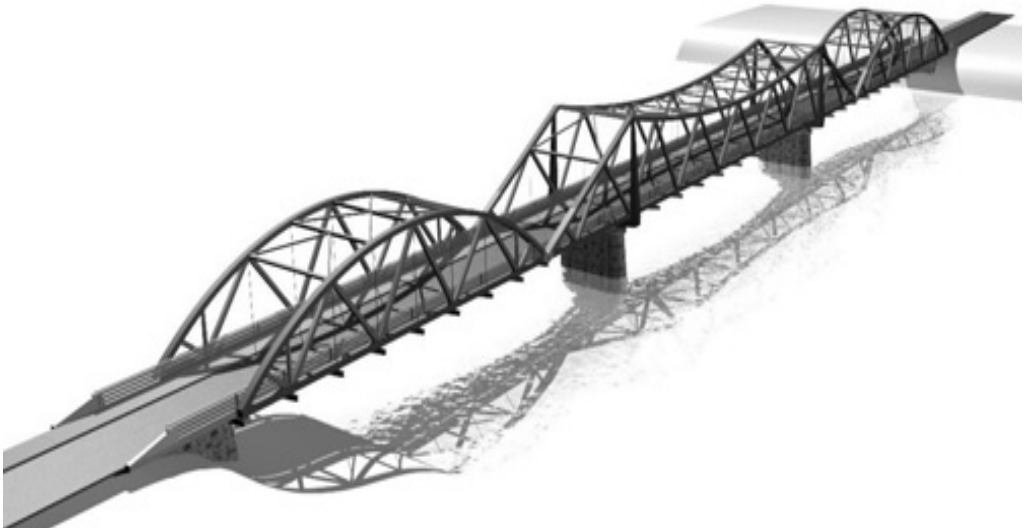
Early glulam

Glulam has been around a long time. The first recorded glulam structure in the world (by many years) is in Britain, the assembly hall of King Edward College Southampton in 1860. This also emphasises the earlier points about durability!

Durability case studies

Filsa bridge, Norway

Opened in 2003, this is the world's longest timber bridge designed for full traffic loads. It has the longest clear span at 70m and one of the longest in total length at 196m. The trusses and parapets are constructed using glulam and the deck plate uses a stress laminated sawn timber principal. The Public Roads Administration in Norway requires all permanent bridges (including timber bridges) to be designed for a 100 year service life with only a minimum of maintenance needed. The lamella were given a pressure treatment using CCA (copper, chromium, arsenic – nasty stuff that should never be used where it will come in contact with people) then the completed beams (after machining and drilling) were pressure treated with creosote (also very nasty stuff but very effective) which reduces cracking and makes the timber water repellent.



Road bridge Krúsrak in Sneek (NL)

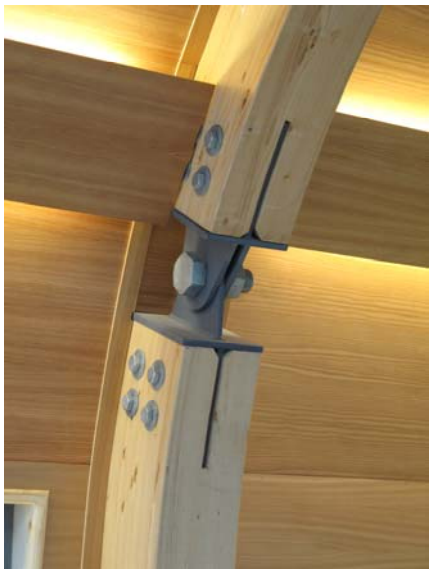
A more modern approach to the same issue of long term minimal maintenance timber durability.

Double curvature glulam using Accoya®timber, which is a chemically modified timber which vastly reduces the ability of the treated timber to absorb water, and changes the sugars that the rot causing fungi need to survive into something they can't digest thereby increasing the life expectancy immensely

Extract from Accoya® literature:

Historically, the use of inherently durable tropical hardwoods and the application of toxic chemicals to non-durable wood have provided partial solutions to the problem of durability. However, the wood's dimensional stability is not improved and toxins create a disposal problem. If an alternative existed which was sourced from sustainable forests, had zero toxicity and provided dimensional stability and durability that exceeded even the best tropical woods, a perfect material would have been found.

Accoya® wood is the world leading solution with properties that match those of the best tropical hardwood. Accoya® is manufactured using a non-toxic treatment and uses fast growing timber from sustainable sources.



For more information about our timber engineering projects

Please contact Scott Fotheringham of Carpenter Oak & Woodland, on 01225 743089 or email scott.fotheringham@cowco.biz

Also visit our web site www.carpenteroakandwoodland.com

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